Digital Transformation of Local Government: A Case Study from Greece

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***Abstract*— Digital transformation in the public sector means new ways of working with stakeholders, building new frameworks of service delivery and creating new forms of relationships . However, beyond the availability of consultancy reports, there is little systematic empirical evidence about the way that public administrations are currently defining digital transformation in their day-to-day practices, how they are approaching digital transformation projects, and what the expected outcomes are. Moreover, existing works have focused on the central government; digital transformation in local authorities is an underexplored area. However, municipalities have a daily direct contact to citizens, while the adoption of digital technologies is quite slow. This paper presents a research based on empirical data aiming at identifying the current status and the potential of digital transformation in municipalities. It presents a case study from Greece and based on the results, it identifies the challenges of adopting digital technologies in the public sector, and particularly in local governments, and concludes in the steps to be followed towards digital transformation.**

Keywords—e-government, public sector, fuzzy AHP, fuzzy Delphi, multi-criteria.

I. Introduction

Digital transformation in the private sector change citizens' expectations towards the demand of high-value digital services from the public administration. At the same time, public services struggle with changing their mode of operation in order to improve service delivery, operations design, and achieve increased transparency, interoperability, and citizen satisfaction [1]. However, the government services rely on its legacy IT, isolated storage silos and paper-based processes, holding them back from digital transformation and e-government services.

Apart from technology, strategic and organizational disruptions are also required aiming at yielding the capability of generating new paths for value creation [2]. Digital transformation in the public sector means new ways of collaboration with stakeholders, building new frameworks of service delivery and creating new forms of relationships [3]. To this end, understanding the particularities, the barriers and the potential of each country's digital transformation in various domains of the public sector is of outmost importance. This understanding will enable the identification of how digital transformation differs based on the size of the country, its history, and context as well as how these dimensions might have an impact on their digital transformation efforts [1].

Apart from some consultancy reports, there is little systematic empirical evidence about the current practice, the expectations, and the potential as well as the priorities and the critical success factors of digital transformation of public administration [2]. In addition, the vast majority of existing academic literature and business reports has focused on the central government digital services or on the public sector as a whole. Local public administration is an underexplored area which faces additional challenges in terms of its digital transformation due to, among others, their dependence on the central government policies, limited investments capabilities, everyday direct contact with citizens and enterprises, and high variability of the offered services.

According to the Digital Economy and Society Index (DESI) 2019 report published by the European Commission on 11 June 2019, overall Greece is ranked at the 25th position in digitization of public administration, while it is ranked 24th in electronic service availability, 26th in the use of e-documents, 21st in digital post and 28th in e-ID [4]. The level of the adoption of digital technologies is even lower in local public administration. The current research work presents an empirical study on digital transformation of local government aiming at identifying the current status, the maturity readiness, the barriers and the priorities/ critical success factors. The evidence presented herein was derived from a case study in Greece following a methodology based on Fuzzy Analytic Hierarchy Process (FAHP) and Fuzzy Delphi Method (FDM).

The rest of the paper is organized as follows: Section II presents a literature review regarding digital transformation with a focus on the public sector and particularly on local authorities. Section III describes the background of the FAHP and Section IV the background of the FDM. Both of them are used in the adopted methodology in order to conclude in the results of Section V. Section VI discusses the results, while Section VII concludes the paper and sets the directions for future work.

II. Literature Review on Digital Transformation

A. Definitions of Digital Transformation

Digital transformation is a complex and radical form of enterprise transformation and refers to a disruptive process that change profoundly the way companies compete, interact and create value [5]. It is defined as "the use of technology to radically improve performance or reach of enterprises" [6]. Another well-known, more holistic definition of the term is that it can be understood "as the changes that digital technology causes or influences in all aspects of human life" [5].

Finally, digital transformation can also be defined as the third and ultimate level of digital literacy that "is achieved when the digital usages which have been developed enable innovation and creativity and stimulate significant change within the professional or knowledge domain" [7]. This last description additionally explores the motivation and consequences of the digital transformation [8]. What most definitions have in common, is that they refer to digital

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transformation as a (massive) change process that organizations undergo due to the emergence of new technologies and its social and economic implications [9,10].

There are multiple potential benefits of digitization including productivity increases, innovations in value creation, as well as novel forms of interaction with customers; consequently, it is able to affect various industries and business domains [10,11]. The incorporation of emerging technologies and data processing infrastructures not only improve and disrupt existing business processes, but also facilitate the adoption of new business models [12]. Some research works deal with literature reviews on certain facets of digital transformation, e.g. concepts [13], impact areas [14], drivers, success factors, implications [15], or the IT of organizations [16].

B. Frameworks for Digital Transformation

Several frameworks for the digital transformation have been proposed in the industrial and academic realms. Two of the most widely accepted theoretical frameworks are briefly reviewed in this Section.

In [17], the author discusses the impact of technologies on organizations through an institutional perspective. She differentiates between objective and enacted technologies. Objective technology incorporates innovations, whereas enacted technology entails the use, design and perception of those technologies by individuals within the organization. The perception and usage of technology is constrained by institutional arrangements, but enacted technology also influences the organization. The role of technology therefore differs and is dependent on the organization and what individuals within the organization make out of it.

Another framework which evaluates organizational change enabled by technologies is the "Digital Era Governance" approach [18]. The authors argue that under the influence of the new public management paradigm, technological change enables change in public sector organizations in several ways. Their core argument is that technology per se does not change organizations, rather the way organizations work and their use of technologies changes work practices. In addition, they consider the effects of change in technologies in a broader way. They focus on organizational change, organizational culture, and the new ways society handles information and new demands for government services.

C. Characteristics of Digital Transformation

The literature describes digital technologies as inherently disruptive [19]. Digital transformation is associated with a number of important structural changes, such as: organizational structure, organizational culture, leadership, and employee roles and skills [2]. The main objectives of digital transformation include transformations of service delivery, organizational culture, relationships with citizens, and value creation [20].

Digital disruption has usually to face several barriers with respect to the technology adoption and the value creation process: limited budget for investment to new technologies make organizations struggle to make a convincing economic case that can be approved when finances are tight; fixed and unrealistic timelines and milestones make infeasible the effective implementation; large-scale and complex transformations may add high uncertainty and lack of commitment from the top management; resistance to change by employees may slow down digital disruption [1,20,21].

D. Public Services and E-government

Low digital maturity of the public sector contributes to the realization of time-consuming, ineffective and even unreliable processes within public institutions. On the other hand, citizens and businesses expect not only government information to be readily available online, but also to interact and be served with the use of modern technology. Governments have many reasons to meet these expectations by investing in a comprehensive public-sector digital transformation. While previous waves of digitization focused on the transition from analog to digital services, digital transformation aims to redesign and reengineer government services from the ground up to fulfill changing user needs [22]. At the center of these efforts are users — both internal and external — of the digital services. Related terms such as e-government, digital government or transformational government are used and thereby conflating the meaning of different approaches. The concepts themselves are interrelated and share a common ground: the examination on how the public sector uses ICT to enhance service delivery, change organizational processes and impact on value creation [1].

Digital transformation in public services needs to be understood from a whole organization perspective [23]. This includes the notion that IT is not the means to support change, rather, processes, people, policies, and especially leadership need to be fundamentally changed to accomplish digital transformation in the public sector [1]. E-government aims at making more convenient and more efficient to work with the governmental institutions, thus potentially increasing the satisfaction of the citizens and other stakeholders [24]. The customer-centered private sector services also create higher expectations to public services, setting the demand for customer-centered or customer-oriented services [25]. Towards this direction, e-government concepts and technologies are able to provide improved public services, administration and social value [26].

One of the largest challenges of digital transformation in the public sector is to achieve integration in the various information systems that are in place, since there is fragmentation of the different departments and their functions [24]. Even though stored data (e.g. related to employees, citizens, financial management, etc.) are needed for various directorates and departments, they might have a different emphasis. For example: financial management processes citizen data related to taxes, while sports department processes citizen data related to their participation to the sports activities; human resources management handles absence permissions by employees, while all the functions need to know the available personnel to schedule their activities, etc.

A crucial aspect for digital transformation of the public sector is the clear ownership of the information systems [27]. One department should take the main responsibility for the system, even when multiple departments use it. For example, if a municipality has a strong IT department, it could be the driver and owner of the change. Another viable plan of action could be creating an ad hoc committee from various departments to take responsibility of the change [27]. Top management support is also vital. The processes of all departments need consideration, thus expertise is needed from each of these functions during the development.

Digital transformation within the public sector is not a task to be fulfilled by public administrations alone [28]. The change in the relationship between public administration and citizens implies that citizens have a more active part: they are not just seen as a client of public administrations, but as a partner that helps to transform public organizations by actively participating in public service delivery enabled by new technologies. To do this, they should be trained in the use of digital technologies. By securing greater participation of citizens it is easier for a governmental institution to achieve long term goals and have a substantial impact [28].

The literature includes several research works related to digital transformation in the public sector, in applications such as healthcare [29], higher education [30], welfare [31], ministry processes [32], and procurement [33]. However, in practice, there are very few successful use cases, while the digital transformation of local government is an unexplored area.

E. Indexes for Digital Transformation and E-government

Aiming at measuring the level of digital transformation, not only from a technological perspective, but also from the human perspective, several indexes have been proposed for benchmarking of countries. Two of the most well-known are: the Digital Economy and Society Index (DESI) and the E-Government Development Index (EGDI).

The DESI is a composite index that summarizes relevant indicators on Europe's digital performance and tracks the evolution of EU member states in digital competitiveness [34]. Fig. 1 depicts the 2019 ranking of countries according to the DESI. It includes 6 main dimensions: Connectivity (measuring the development of physical internet network infrastructure and its quality), Human Capital/Digital skills (measuring the abilities of a country's human resources to take advantage of the opportunities offered by a digital society), Use of Internet Services by citizens (refering to the variety of activities carried out by people online), Integration of Digital Technology by businesses (determining the level of business digitalization and the exploitation), Digital Public Services (measuring the digitalization of public services laying emphasis on e-Government), and Research and Development ICT. The International Digital Economy and Society Index (I-DESI) mirrors and extends the EU Digital Economy and Society Index by utilising 24 datasets to enable trend analysis and comparison of the digital performance of 45 countries.

The EGDI is biannually presented by the United Nations Department of Economic and Social Affairs (UN DESA) [35]. The EGDI is a composite indicator that consists of three indexes (Online Service Index, Telecommunication Index and Human Capital Index) that are equally weighted and cover a broad range of topics that are relevant for e-government. It measures countries' use of information and communications technologies to deliver public services and thus, their e-government development. In the 2018 ranking, Denmark, Australia, and Republic of Korea came out on top, while Greece was ranked at the 35th position. For the first time, the 2018 study also focused on local e-Government development in 40 cities across the world. This included assessment of municipal portals of 7 cities in Africa, 6 in Americas, 13 in Asia, 12 in Europe, and 2 Oceania with the top three leaders among them being Moscow, Cape Town and Tallinn.

III. The Fuzzy Analytic Hierarchy Process

The FAHP is an extension of AHP introduced by [36]. Fuzzy logic is introduced to AHP by utilizing linguistic variables and fuzzy numbers in order to deal with uncertainty in judgments. FAHP prioritises the relative importance of a list of criteria and sub-criteria through pair-wise comparisons by experts [37].

The extent analysis method introduced by [38] is a popular method to solving MCDM problems with FAHP [39-42]. Assume that $A = (a_{ij})_{nxm}$ is a fuzzy pair-wise comparison judgment matrix and $M = (l, m, u)$ is a Triangular Fuzzy Number (TFN). According to the FAHP, each object is taken and extent analysis for each goal (g_i) is performed respectively. Therefore, m extent analysis values for each object can be obtained, with the following notation:

$$M_{g_i}^1, M_{g_i}^2, \ldots, M_{g_i}^m, \ i = 1,2,\ldots,n \tag{1}$$

where all the $M_{g_i}^j \ (j = 1,2,\ldots,m)$ are triangular fuzzy numbers.

The steps used for the FAHP are as follows:

i. The value S_i of the fuzzy synthetic extent with respect to the ith object is defined as:

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} \tag{2}$$

$$\text{s.t.} \sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \tag{3}$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right) \tag{4}$$

Next, compute the inverse of the vector in Eq. (4) such that:

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) \tag{5}$$

The TFN value of $S_i = (l_i, m_i, u_i)$ is calculated using Eq. (2)-(5).

ii. The degree of possibility of $S_j = (l_j, m_j, u_j) \geq S_i = (l_i, m_i, u_i)$ is defined as follows:

$$V(S_j \geq S_i) = \sup_{y \geq x} \left[\min(\mu_{S_i}(x), \mu_{S_j}(y)) \right] \tag{6}$$

which can be equivalently expressed as follows:

$$V(S_j \geq S_i) = height(S_i \cap S_j) = \mu_{S_j}(d)$$

$$= \begin{cases} 1, & \text{if } m_j \geq m_i \\ 0, & \text{if } l_i \geq u_j \\ \dfrac{l_i - u_j}{(m_j - u_j) - (m_i - l_i)}, & \text{otherwise} \end{cases} \quad (7)$$

where d is the ordinate of the highest intersection point D between μ_{S_i} and μ_{S_j} (Fig. 1).

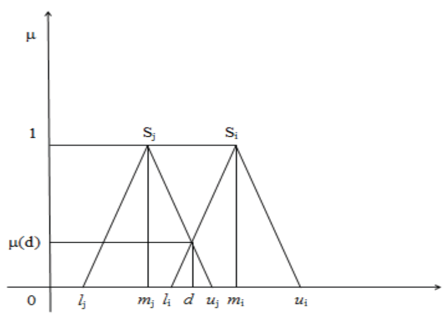

Fig. 1. The intersection of μ_{S_i} and μ_{S_j}.

In order to compare the S_i and S_j, we need both the values of $V(S_i \geq S_j)$ and $V(S_j \geq S_i)$.

iii. The minimum degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers S_i (i = 1, 2,…, k) can be defined by:

$$V(S \geq S_1, S_2, ..., S_k) = V[(S \geq S_1) and (S \geq S_2) and ... and (S \geq S_k)] = \min V(S \geq S_i),\ i = 1,2,3,...,k. \quad (8)$$

Assume that

$$d'(A_i) = \min V(S_i \geq S_k), \quad for\ k = 1,2,...,n\ and\ k \neq i \quad (9)$$

Then the weight vector is given by:

$$W' = (d'(A_1), d'(A_2), ..., d'(A_n))^T \quad (10)$$

where A_i (i=1,2,…,n) are n elements.

iv. Obtain the normalized weight vectors as follows:

$$W = (d(A_1), d(A_2), ..., d(A_n))^T \quad (11)$$

where W is a non-fuzzy number and it represents the priority weights of one alternative over another.

v. Calculating the Consistency Ratio (CR)

The CR is calculated by adopting the approach used in [43], who computed CR for modal values of the fuzzy numbers in the pair-wise matrices. Therefore, this paper computes the CR according to the following formulas of the classical AHP method:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (12)$$

$$CR = \frac{CI}{RI(n)} \quad (13)$$

where,

λ_{max} is maximum eigenvalue of the pairwise matrix A made out of modal values of fuzzy numbers,

n, is the number of rows of matrix A, i.e. the number of criteria used in the FAHP model, and

RI, is the random index of inconsistency, the values of which are shown in Table I [36].

A matrix A is consistent if the corresponding CR<0.1.

TABLE I. VALUES OF RI INDEX IN RELATION TO *N*

n	1,00	2,00	3,00	4,00	5,00	6,00	7,00	8,00	9,00	10,00
RI	0,00	0,00	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49

The AHP and the FAHP methods have been extensively used in MCDM problems such as assessing national competitiveness [41], performance evaluation [37,44,45] selection decisions [42,46,47], in medical diagnosis and therapy assessment [40], etc. With respect to the experts' group sizes used in AHP or FAHP, expert group sizes range from 1 [49] to 5 [47], 9 [40], 20 [39], and 24 experts [41].

More recently, FAHP was also applied in customer satisfaction evaluation in logistics services [50] and in developing a hierarchical customer satisfaction framework in rail transit systems [51]. Also, [52] and [53] used FAHP in order to evaluate customer satisfaction in telecommunications industry in China and in automotive industry respectively.

IV. THE FUZZY DELPHI METHOD

The FDM has been extensively used in many studies seeking expert consensus on MCDM problems such as developing performance appraisal indicators for mobility of the service industries [54], for logistics and supplier evaluation [55], for lubricant regenerative technology selection [49], and for developing road safety performance indicators [56]. FDM was proposed [57] as an integration of fuzzy logic with the traditional Delphi Method (DM) [58]. The experts' consensus is reached after a series of up to four sessions, in which experts without direct confrontation, have the opportunity to express their opinions [59]. Experts also receive feedback reports with important information, like medians, averages and deviation from the previous rounds and thus improve their opinions [60]. As a result, experts reform their opinions towards the average [61].

The traditional DM though, suffers from low convergence of experts' opinions, high execution cost and from possibly filtering out particular expert opinions [54]. Instead, FDM engages experts in only one round and their opinions are represented by membership degree functions. Previous research usually employed triangular fuzzy number (TFN), trapezoidal fuzzy number and Gaussian fuzzy number [49] for membership degree functions. Fuzzy numbers work best for consolidating fragmented expert opinions [44]. Different methods have been used to aggregate experts' opinions such as mean, median, max, min, mixed operators [62]. Expert consensus, in MCDM methods such as the FDM or the FAHP, is usually calculated using the geometric mean, which is assumed to capture expert consensus more accurately [49,54,56,63]. This paper uses TFNs with geometric means to represent expert consensus. A TFN is denoted simply as a triple ($l_{i,j}, m_{i,j}, u_{i,j}$), where:

$$l_{i,j} = \min(e_{i,j}), \quad (14)$$

represents the lowest of all experts' judgment,

$$m_{i,j} = \sqrt{\prod_{i=1}^{n} e_{i,j}}, \quad (15)$$

is the geometric means of $e_{i,j}$, indicating the aggregation of all experts' judgments, and

$$u_{i,j} = \max(e_{i,j}), \quad (16)$$

represents the highest of all experts' judgment, where *i* =1,…,n and *j*=1,…,k represent the number of experts and the number of criteria respectively, and the $e_{i,j}$ represents the response of the *i*th expert regarding the *j*th criterion.

There is no consensus regarding the experts' panel size required by DM or FDM, [64]. The experts group sizes range from 5 to 31 experts [49,54,56,61,65] and extends to low hundreds of experts and even thousands [66]. However, a heterogeneous panel (i.e. a panel that includes members with the same degree of expertise but from different social of professional scale) would require fewer experts, i.e. in the range of 5 to 10 [61].

V. Methodology and Results

The aim of this paper is to identify the priorities/ critical success factors of digital transformation to local government and to evaluate them with the use of FDM and FAHP respectively. This research is based on empirical data, which was collected in January 2020 in a municipality of Attica region in Greece. Managers and teams of key users (head of departments or employees) of the information systems from all the 15 municipality directorates and independent offices were examined. The expert opinions were captured through survey questionnaires and interviews. The resulting model was validated by comparing its results against previous cases of successful employment.

The directorates and independent offices are the following: Environment and Life Quality, Support of Municipality Political Councils, Legal Affairs, Financial Management, Construction Services, General Secretary, Total Quality Management, Urban Planning, Citizen Support, Resource Planning and Development, Waste and Recycling, Informatics and Communications, Sports and Culture, Management and Human Resources, Municipal Property and Purchasing.

The reason why the specific municipality was selected as a use case is that it gathers some distinctive characteristics that are conducive for digital transformation:

- It has a relatively high population (75,000 citizens), comparing to other municipalities.

- It is one of the major commercial regions of Athens, with a large number of companies (in sectors such as entertainment, retail, restaurants, etc.) which need to get in contact with the local government very often for various services and involved municipality directorates.

- Almost 2/3 of the maternity hospitals in Athens are located within its borders, something that adds a high complexity in birth certificates, since they need to be processed by the municipality's functions.

- It investigates building of a strategic digital culture and attempts towards digital transformation, such as the mobile app for the communication of the citizens with the local government.

A. Definition of the Priorities/Critical Success Factors for Digital Transformation

The selection of the criteria and the evaluation of their importance is a critical step in every multi-criteria decision process, including the FAHP. Aiming at avoiding a large number of criteria which results in long and discouraging questionnaires, we included an initial step where all criteria are evaluated in an objective scale. The less important ones are then removed, keeping a small number of the most important ones.

Therefore, the first step was the definition of the most important priorities/success factors (criteria) for the implementation of digital transformation in local government in order to build the evaluation criteria hierarchy. All candidate criteria were identified through an extensive review of the related literature, resulting in 29 criteria. A primary survey was then conducted, where these criteria were evaluated based on a questionnaire by the top management of the participating municipality. The participants were asked to evaluate each criterion in Likert scale with 5 response values: 1=Not at all important, 2=Not important, 3=Neutral, 4=Important and 5=Very important. The survey was conducted in a physical meeting with 6 participant experts, applying the FDM. The evaluations given by the experts were then analyzed in order to select the most important criteria which will be included in the AHP process.

TABLE II. The Selected Criteria Ranked in Terms of their Absolute Importance

Order	Criterion	Geomean
1	Strategic Digital Culture	4.973
2	Citizen-centred Services	4.864
3	Digital Skills of Employees	4.735
4	Interoperability	4.592
5	Technology Procurement	4.588

An initial picture regarding which criteria were evaluated as the most important was obtained by assigning numerical values 1 to 5 to the 5 levels of the evaluation scale and comparing the geometrical mean of all expert evaluations per criterion. The results for the most important criteria (i.e. priorities for digital transformation) derived with the use of the geometrical mean of all expert evaluations per criterion after having assigned numerical values of 1 to 5. The analysis concluded to the selection of the 5 out of 29 criteria, which are listed in the order of their ranking in Table II.

B. *Evaluation of the Priorities/Critical Success Factors*

The FAHP hierarchy of digital transformation assessed in this study is shown in Fig. 2. The goal of this step is to estimate the relative importance matrix A [26] and the weight coefficients of each criterion.

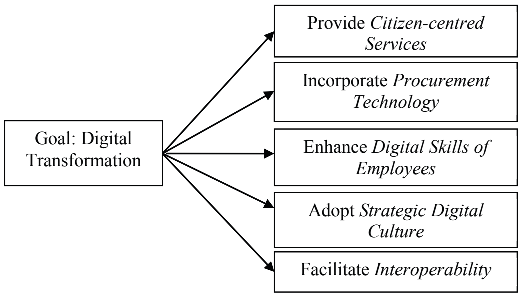

Fig. 2. The FAHP hierarchy of digital transformation in local government.

TABLE III. LINGUISTIC SCALES AND CORRESPONDING TFNS

Linguistic scale	**Triangular fuzzy scale**	**Triangular fuzzy reciprocal scale**
Equally important	(1, 1, 1)	(1, 1, 1)
Weakly important	(2/3, 1, 3/2)	(2/3, 1, 3/2)
Fairly more important	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
Strongly more important	(5/2, 3, 7/2)	(2/7, 1/3, 2/5)
Extremely more important	(7/2, 4, 9/2)	(2/9, 1/ 4, 2/7)

The relative importance of the critical success factors involves a high degree of subjectivity. Since it is closer to human thinking to express judgments in intervals [40], TFNs were used to capture the experts' opinions. Several linguistic scales have been used in FAHP studies. The choice of the most appropriate scale is a critical issue in both the AHP and in FAHP, with researchers suggesting that selection of the scale depends on the person and the decision problem [40,41]. The linguistic scales and their corresponding TFNs adopted in this study are shown in Table III.

The group of experts participated in this study was asked to use the linguistic scales and make pair-wise comparisons of the critical success factors with respect to the goal which is digital transformation. Then, the linguistic scales were converted to TFNs. All valid experts' responses were aggregated in order to obtain their consolidated opinions in the pair-wise matrix. This paper adopts the geometric mean, using the formulas (14-16) which according to the literature reflects the consolidated experts' judgment better [39,49,54,56]. The aggregated pair-wise matrix is shown in Table IV.

The λ_{max} =5.0472, the CI=0.0118 and the CR=0.010536<0.1, are calculated by using formulas (12-13), thus indicating the aggregate pairwise matrix is consistent. Similarly, all individual pairwise matrices were found consistent. The values of the fuzzy synthetic extent with respect to the five priorities/critical success factors for digital transformation in local government are denoted by S_{C1}, S_{C2}, S_{C3}, S_{C4} and S_{C5}. They are calculated by using formulas (3-5) and the results are shown in Table V.

TABLE IV. THE EXPERTS AGGREGATED PAIR-WISE COMPARISON MATRIX.

	C1	**C2**	**C3**	**C4**	**C5**
C1	(1.000, 1.000, 1.000)	(0.667, 0.445, 4.500)	(0.667, 2.355, 1.500)	(0.667, 0.422, 3.500)	(0.667, 0.445, 3.500)
C2	(0.222, 2.249, 1.500)	(1.000, 1.000, 1.000)	(0.667, 2.676, 1.500)	(0.667, 0.483, 3.500)	(0.667, 0.462, 4.500)
C3	(0.286, 2.165, 1.500)	(0.286, 2.281, 1.500)	(1.000, 1.000, 1.000)	(0.667, 0.465, 3.500)	(0.667, 0.442, 4.500)
C4	(0.286, 2.337, 1.500)	(0.286, 2.212, 1.500)	(0.286, 0.438, 3.500)	(1.000, 1.000, 1.000)	(0.667, 0.429, 3.500)
C5	(0.222, 2.263, 1.500)	(0.286, 2.276, 1.500)	(0.222, 0.488, 3.500)	(0.286, 2.264, 1.500)	(1.000, 1.000, 1.000)

TABLE V. FUZZY SYNTHETIC EXTENT ANALYSIS

$\sum_{i=1}^{n}$	$\sum_{j=1}^{m} M_{g_i}^{j} =$	$\left(\sum_{j=1}^{m} l_j\right.,$	$\sum_{j=1}^{m} m_j ,$	$\left.\sum_{j=1}^{m} u_j\right)$
$i=1$	C1	3.667	4.667	14.000
$i=2$	C2	3.222	6.870	12.000
$i=3$	C3	2.905	6.352	12.000
$i=4$	C4	2.524	6.416	11.000
$i=5$	C5	2.016	8.291	9.000
	$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j} =$	14.333	32.596	58.000
		$\sum_{i=1}^{n} l_i$	$\sum_{i=1}^{n} m_i$	$\sum_{i=1}^{n} u_i$

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) = \left(\frac{1}{58.000}, \frac{1}{32.596}, \frac{1}{14.333}\right)$$

Then the application of formula (2) returns the following results.

$$S_{C1} = (3.667, 4.667, 14.000) \otimes (1/58.000, 1/32.596, 1/14.333)$$
$$S_{C2} = (3.222, 6.870, 12.000) \otimes (1/58.000, 1/32.596, 1/14.333)$$
$$S_{C3} = (2.905, 6.352, 12.000) \otimes (1/58.000, 1/32.596, 1/14.333)$$
$$S_{C4} = (2.524, 6.416, 11.000) \otimes (1/58.000, 1/32.596, 1/14.333)$$
$$S_{C5} = (2.016, 8.291, 9.000) \otimes (1/58.000, 1/32.596, 1/14.333)$$

The S_i values are compared using formula (7), in order to calculate the degree of possibility that $V(S_i \geq S_j)$. The results are shown in Table VI.

TABLE VI. CALCULATION OF THE VALUES OF $V(S_i \geq S_j)$

V(SC1>=Sj)	**V(SC2>=Sj)**	**V(SC3>=Sj)**	**V(SC4>=Sj)**	**V(SC5>=Sj)**
V(SC1>=SC2)	V(SC2>=SC1)	V(SC3>=SC1)	V(SC4>=SC1)	V(SC5>=SC1)
0.932	1.000	1.072	1.082	1.245
V(SC1>=SC3)	V(SC2>=SC3)	V(SC3>=SC2)	V(SC4>=SC2)	V(SC5>=SC2)
1.000	1.000	0.980	0.981	1.082
V(SC1>=SC4)	V(SC2>=SC4)	V(SC3>=SC4)	V(SC4>=SC3)	V(SC5>=SC3)
1.000	1.000	1.000	1.000	1.115
V(SC1>=SC5)	V(SC2>=SC5)	V(SC3>=SC5)	V(SC4>=SC5)	V(SC5>=SC4)
1.000	1.000	1.000	1.000	1.109

By using formula (9) the minimum degree of possibility is calculated as follows:

$$d'(C1) = minV(S_{C1} \geq S_{C2}, S_{C3}, S_{C4}, S_{C5}) = 0.932$$

$$d'(C2) = minV(S_{C2} \geq S_{C1}, S_{C3}, S_{C4}, S_{C5}) = 1.000$$

$$d'(C3) = minV(S_{C3} \geq S_{C1}, S_{C2}, S_{C4}, S_{C5}) = 0.684$$

$$d'(C4) = minV(S_{C4} \geq S_{C1}, S_{C2}, S_{C3}, S_{C5}) = 0.712$$

$$d'(C4) = minV(S_{C4} \geq S_{C1}, S_{C2}, S_{C3}, S_{C5}) = 0.427$$

By using formula (10), we obtain the weight vector:
W'= (0.932, 1.000, 0.684, 0.712, 0.427)^T

Therefore, the normalized weight vector (W) is obtained by using formula (11): W = (0.932, 1.000, 0.684, 0.712, 0.427)^T that reflect the relative importance of the priorities/critical success factors of digital transformation. Thus, the importance weights for each service derived from the FAHP analysis are: $FAHP_{C1}$=0.243, $FAHP_{C2}$=0.295, $FAHP_{C3}$=0.171, $FAHP_{C4}$=0.192 and $FAHP_{C5}$=0.099.

TABLE VII. IMPORTANCE WEIGHTS AND FINAL RANKING OF CRITERIA

Order	Criterion	Weight
1	Citizen-centered Services	0.295
2	Strategic Digital Culture	0.243
3	Interoperability	0.192
4	Digital Skills of Employees	0.171
5	Technology Procurement	0.099

VI. DISCUSSION

In this Section, we discuss each one of the 5 priorities/critical success factors for the digital transformation of local government. More specifically, we describe the main obstacles related to these priorities that arose in the context of the case study, while we also discuss their causes and the overall status in local public administration.

A. Citizen-centered Services

The physical presence of citizens at the municipality premises is required for most services, especially to those related to transactions. They can be served remotely only in cases they need some information that can be retrieved by phone or by e-mail. In addition, the lack of digital technologies causes obstacles to the timely and reliable service of the citizens. Overall, there is lack of a citizen-centered approach, mainly due to the introversion of local government processes. E-services are designed from the in-house perspective of public services, rather than of the service of citizens / businesses one. Consequently, rather than a transparent and accessible citizen-centered approach at a local level, as suggested by best practices in the private sector and related studies on e-government [67,68], e-services are designed through a procedural perspective, which ignores the big picture, that it is to serve the beneficiary citizen or business.

To develop citizen-oriented e-government services that achieve cost savings implies that local governments seek to meet citizen expectations and needs. Moreover, the variability of citizen groups is a crucial factor to be taken into account. For example, in a municipality region, there are: citizens, local government employees, enterprises, hospitals, schools, etc. Even within these groups, there are great differences, e.g. citizens may just need the basic local government services, while others need additional ones such as social welfare, etc. However, all this information usually does not exist, something which leads to ineffective e-government services and increases of costs.

Local government agencies do not engage citizens in the development of their e-government services, while they do not systematically solicit service quality, outcome, or other evaluation data. Rather, many applications are internally driven to meet cost savings and other government mandates regarding efficiency. Typically, “top-down” or systems-based e-government design fails to adequately consider citizen information needs, since they may result in elegantly designed and technically sophisticated e-government systems that completely miss the intended users’ needs. The top down approach is often less costly than conducting a range of user-based needs assessments and other strategies; however, it significantly adds high costs on the long-term due to citizens dissatisfaction and digital technologies obsolescence.

B. Strategic Digital Culture

Although it seems that the municipality under examination tries to formulate a strategic digital culture and the resistance to change existing as an obstacle in other cases does not exist, the digital transformation management is still at its early stages. For example, the need and requirements in digital technologies are not recorded systematically. Public administration, and especially local government, is still characterized by costly, time-consuming and inhospitable services, complex procedures, and bureaucracy. In some cases, there are some attempts in the context of e-government (e.g. the mobile app of the case under examination for citizen communication), although with strong fragmentation, lack of coordination and collaboration among stakeholders, and significant time lag between start-up and delivery of a project.

Overall, there is lack of timeless and clear vision for e-government in the country over time, although fragmented visionary goals are sometimes recorded. Local government does not have a history of continuous investment in keeping up-to-date ICT infrastructure, while the level of the required investment is typically high. Effective project management and realistic planning is a crucial enabler for the implementation of a strategic digital culture. Digital transformation does not have to do only with emerging technologies but also with conventional technology, such as databases, ERP, CRM, etc. It is often easier to achieve impact with technologies already in widespread use than it is with emerging technologies.

Compared to the waterfall methodology that is used extensively in the Greek public sector, agile software development follows a progressive approach and offers the necessary flexibility and adaptability of ICT projects. Adopting agile methodologies as part of digital transformation allows municipalities to start gaining value without an enormous upfront cost for a project that takes years to implement. Creating value iteratively allows risk-averse public sector entities to see the benefits of digital transformation initiatives quickly.

C. Interoperability

The municipality under examination has 11 different software solutions in the various directorates provided by 7 different suppliers as well as 5 additional software solutions provided by the central government. These solutions are mainly used to store documents and information. However, there is not a common storage from where the requested information can be retrieved by any involving directorate. The fact that the automatic electronic interchange of information is limited results in the use of high amounts of paper forms. Despite the recent updates and refurbishments of the hardware infrastructures, their computational capabilities are still limited according to the system requirements. This applies especially in the Urban Planning Directorate which uses solutions such as CAD, GIS, etc. Therefore, the systems suffer from malfunctions and long processing times due to the poor hardware infrastructure. The poor technical interoperability among the various information systems as well as their limited capabilities results in repetitive and time-consuming processes. The technical interoperability is not aligned to the enterprise interoperability and the actual business processes. The business processes of the municipality are complicated with several loops of information among the directorates. This fact occurs due to, on the one hand, the strict regulations (e.g. for purchasing, urban planning, etc.) and, on the other hand, due to the lack of integrated software solutions. Since the organizational interoperability is not represented in the information systems, most of the work is conducted "in parallel" to the software solutions.

Organizational, semantic, and technical interoperability is a widely common challenge of public services and especially to those related to local government. Bureaucratic and time-consuming procedures are a well-known and recognized problem of the Greek public administration. Process steps are not always clearly described, even within the directorates. One key reason is that recording them requires navigating the complex legal framework, in which changes and amendments at regular intervals are common, sometimes without consistency or continuity. The result is the inability of information systems to fully support complex processes and a discrepancy between the processes supported electronically by the procedures followed in practice. There is also application fragmentation combined with the storage and processing of data in isolated silos, incompatible to each other. To this end, there is the need for data and interface standards which can contribute to better interoperability of the systems. Arguably, Enterprise Architecture (EA) is a potential significant tool for digital transformation and business process re-engineering, since it provides the methodologies needed to address the complexity of digital transformation. It provides a coherent set of principles, methods and models used in the design and realization of an enterprise's organizational structure, business processes, information systems and infrastructure [28]. It contributes to a better alignment between business and IT domains, while it can also consider political drives [69].

D. Digital Skills of Employees

Although resistance to change is considered to be a major obstacle in digital transformation, especially in the public sector [2,72], in our research there is high acceptance of the disruption from the adoption of digital technologies and integrated information systems. This fact provides a high potential for the success of the transformation from the conventional municipality to the digital municipality. However, the level of employees' skills in digital technologies is quite low, among others, due to the complete lack of relevant training and education. The daily routines and habits of those who live within a bureaucratic culture lead to safety and conformity, and therefore the modification of these working habits will result in anxiety and discomfort [71]. This is why employees generally prefer not to incorporate new ways of understanding their work. However, when internal pressure pushes public sector organizations to engage in digital transformation projects, they focus on change of the bureaucratic culture and organization to deliver public services [70]. In this sense, public administrations are aware of the need to adapt to the new demands and technologies. Adoption of digital skills should be a core aspect of a strategic digital culture in order to systematically define education courses for the employees according to their directorate, background, and job function. Additional training is required for the actual use of the information systems. The latter can be provided by the respective technology suppliers, while the directorate of Informatics can play a central role.

E. Technology Procurement

The time consuming and inelastic procurement process, the obsolescence of new systems and the commitment to them are considered to be major obstacles towards digital transformation of local government. There are large monolithic systems with extremely long time-to-market cycles, which become obsolete until they are operational, also leading to complex and closed systems with vendor lock-in and continuous contract extensions.

The inaccurate way of implementing large IT projects also engages the public in potentially inefficient IT providers, since declaring one supplier as a discount or replacing it with another is rarely a realistic option at the stage of implementing a project. Some public suppliers exploit these weaknesses by delivering and pushing for projects of significantly lower quality, while they may be unreliable with respect to the system delivery and maintenance. Moreover, the criteria for selecting a technology supplier are not always rational due to the political drives affecting such decisions.

Public procurement was always set as an attractive target for corruption. Digital transformation should exploit the availability of e-procurement technologies which, apart from the reduction of procurement costs, enable dissemination of information, transparency and accountability in procurement, making the information accessible to all interested parties. In this way, it is able to contribute to the decrease of corruption [73].

VII. Conclusions and Future Work

Digital transformation approaches outside the public sector are changing citizens' expectations of public administrations' need to deliver high-value digital services. Digital transformation in the public sector means new ways of working with stakeholders, building new frameworks of service delivery and creating new forms of relationships. Up to now, there is little systematic empirical evidence about digital transformation in public administration, while the vast majority of existing literature and business reports has focused on the central government digital services or on the public sector as a whole. Local public administration is an underexplored area which faces additional challenges. In this paper we presented an empirical study on digital transformation of local government. The evidence presented herein was derived from a case study in Greece. A multi-criteria decision model was developed based on FAHP and FDM. More specifically, FDM was used in order to define the priorities/ critical success factors for digital transformation in local government which reduced the necessary length of the primary data collection questionnaire. Then, FAHP was used to evaluate the aforementioned priorities/ critical success factors and to derive the final ranking of criteria. On the basis of these results, the paper discussed the main obstacles related to these priorities, their causes and the overall status in local public administration in Greece. Future work will focus on increasing the complexity of the model structure, thoroughly testing its accuracy on wide real-world datasets and comparing it with other promising methods. Moreover, we aim to examine additional municipalities in Greece aiming at further generalizing the results. Finally, we plan to develop an enterprise architecture targeting to the digital transformation of local governments in the modern information and data age of ICT.

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