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Research Article

IT Outsourcing Vendor Selection for Digital Transformation Projects in Public Sector using Interval-Valued Spherical Fuzzy AHP

Murat Levent Demircan

Galatasaray University, Faculty of Engineering and Technology, Department of Industrial Engineering, İstanbul, Türkiye, ldemircan@gsu.edu.tr

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ABSTRACT

Digital transformation projects have started to be implemented intensively in private sector companies, government institutions, and the public sector. In addition to its benefits, such as increased efficiency and cost reduction, digital transformation also creates high citizen satisfaction and public value for public institutions. However, as in the private sector, the public sector's biggest problem is achieving success in digital transformation projects, which is the biggest problem facing political leaders and public administrators. Public administrators must realize a profound learning revolution and change management in the internal organizational culture. They also need to choose the right outsourcing companies and succeed in implementing IT projects. Consequently, determining the selection criteria of the outsourcing companies that will take part in digital transformation projects in the public sector and the selection methodology to be applied is of great importance. It may be necessary to make a more complex and holistic evaluation when dealing with digital transformation projects in the public sector due to public institutions' unique norms, internal political balance, and culture. For this reason, a perspective and methodology covering all organizational stakeholders should be applied in decision-making processes. This study presents a Spherical Fuzzy AHP-based selection methodology framework for IT outsourcing vendor evaluation processes to enable public sector decision-makers to make better decisions.

1. Introduction

The concept of digital transformation is a concept that has made a name for itself not only on a local scale but also in the international business arena. We have heard the concept of digital transformation frequently in the public and business sectors in recent years. Almost all organizations carry out digital transformation projects, and those who have not yet done so are planning digital transformation projects. Digital transformation departments have started to be established within the organizational structure of many institutions. However, business professionals often use the concept of digital transformation and digitalization interchangeably.

Is this usage correct? Or is it the difference between the concepts of digital transformation and digitization? Before we examine the concept of digital transformation, the innovative business model approaches it brings, and its economic and commercial effects, we must distinguish between digital transformation and digitalization concepts. There are two basic principles of digital transformation. The first pillar is that institutions that do not evolve into technology companies cannot survive. The other is the metaphor of destroying themselves instead of waiting for

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someone to destroy their business. The first of these analogies reminds businesses that whether they are a holding company that owns dozens of companies or a small neighborhood shopkeeper, they will not be able to survive unless they offer technology in their products and services. In short, they do not sell technology.

It is not just large-scale corporations that make technology a part of their business. Many small businesses on a micro-scale have already started using technology. Even beggars in China have started accepting money from the WeChat app [1]. Indeed, the element of competition, which we will focus on frequently, goes beyond the product and service level and lives at the platform level, making it mandatory for all small and large businesses to reshape their product and service processes from the technology perspective.

On the other hand, the analogy of businesses destroying themselves reminds us of the intense digital competition we face and the potential of the startup and entrepreneurial economy. It is quite possible in the digital commerce world that we are in that even a startup company that has not been established yet would buy and swallow a well-established business, no matter how deep and significant it is. Just think about the applications we use every day on mobile phones and the size of these companies.

Most of these applications belong to companies established 8-10 years ago or less. So, it is essential not only for private sector companies but also for public institutions to understand the concept of digital transformation correctly and adequately distinguish the relationship between digital transformation and digitalization. We can place innovative business models at the top of the list as the first benefit of digital transformation. We can think of innovative business models under the umbrella of any business process change, revision, or collaboration that can scale the potential of our existing business processes. Such as establishing our digital platform, applying growth hacking tactics and principles in digital commercial channels, entering the network of other digital platforms, or tactics that increase sales volume such as upsell, or cross-sell provided by digital technology.

When we work with new and innovative business models, there will naturally be revisions, changes, and innovations in the value propositions we will offer to our customer base. The new value propositions will affect the digital experience journey. Thanks to this digital experience journey proposed, both the number and frequency of interaction with users would increase. Customer interaction would bring the digital scaling of the business or services. We should consider this situation, which we mentioned above for the private sector, as the public service processes and the "public value and benefit" will provide for the public sector [2].

At this point, it will be helpful to compare the concepts of "digital scaling" and "economies of scale" that we all hear in different environments: Economies of scale is a concept based on sustainable growth. We can say that with the increase in the sales volume and number of transactions, an enterprise uses its capacity and investment more efficiently and thus decreases the unit marginal costs. However, we can define digital scaling as using digital technologies as financial leverage and reducing marginal costs to zero. The study continues with a very up-to-date literature about digital transformation and its applications in public sector. The aim to cover such a wide literature is to understand the dyanmics and motivation of public decision-makers' selection criteria. Literature review leads us to a more holistic approach that should enable the participation of public stakeholders to decision-making processes. That is why the subsequent section, which presents the methodology of the study covers the spherical fuzzy AHP. The framework section seeks to present a standardization.

2. Literature Review

2.1. IT Oursourcing

Dutta et al. [3] have explored information technology outsourcing strategy and vendor selection patterns by prioritizing the high and low internal IT capabilities of more than 200 outsourcing firms. In their work with a global perspective, Hong and Pavlou [4] examined information technology outsourcing decisions based on IT development and reputation level. The study concluded that decision-makers prefer outsourcing firms with high IT development backgrounds. Faisal and Raza [5] examined the factors of IT outsourcing selection processes in academic institutions in Gulf Cooperation Council countries. Their questionnaire-based study reveals essential factors in decision-making processes from an academic management perspective. They have also developed an MCDM model to facilitate the selection process of the best suitable vendor.

Das and Grover [6] have investigated the biased mechanisms addressing the vulnerabilities of human decision-making by considering the economic side of IT outsourcing. The overconfidence of professionals, unfortunately, often causes security vulnerabilities and can drive a cost above the expected earnings. Having mentioned the economic gain side of IT outsourcing selection, we should also cite the study of Watjatrakul [7]; in this study, Watjatrakul discussed how the qualification scores and bid prices of vendors affect the evaluation process. The study also compares weighted criteria evaluation techniques based on mixed qualification and bid offers scores. Their results have proved that methods' outcomes are highly correspondent to each other.

Moreover, they have argued that criteria proportions significantly affect selection. The findings of their study also lead us to consider the importance of methodology construction to be used for the selection procedure. If decision-makers think that the "targeted public value" would have more importance over the cost or vice versa, the strategy of evaluation methodology would significantly be affected by decision makers' preferences.

Ebrahimnejad et al. [8] presented a state-of-the-art decision-making approach using IVHFSs to overcome the disadvantages stated in previous studies. In their study, Linguistic terms are used in order to covey decision makers' thoughts and choices, and they have provided a real-life numerical application with a comparative analysis to evaluate the findings. Qiang and Li [9] have presented a fuzzy linear programming method to solve and evaluate the vendor selection problem. Decision makers' preferences are represented as trapezoidal fuzzy numbers (TrFN). They have also demonstrated an implementation of the methodology they have proposed.

Another real-life application comes from the study of Liu and Quan [10], where they have presented an MCDM method for IT procurement processes of hospitals in which they have used the linguistic preferences of decision-makers. Fusiripong et al. [11] focused on IT outsourcing projects from an efficiency and effectiveness point of view. Their study aimed to standardize the vendor evaluation criteria to ensure the sustainable development of outsourcing processes. Fusiripong et al. [12] concentrated their efforts in their subsequent study by proposing a comparative weighted AHP analysis (focusing on criteria weights). They have tried to improve IT vendor selection processes. Hyvonen et al. [13] have conducted empirical research on a global IT outsourcing project. Their study has revealed many specific and interesting impact sources on vendor selection evaluation. In their third study on the same subject, Fusiripong et al. [14] discussed the importance of identifying standard criteria for vendor outsourcing selection. Articles of Fusiripong et al. [11, 12, 14] endeavor to create common standards for IT outsourcing selection; for this reason, they need to be considered the leading resources for researches.

2.2. Digital transformation and public sector

Many researchers argue that the best digital transformation practices in the public sector positively affect business growth, citizen engagement, and economic development. Alvarenga et al. [15] conducted a questionnaire-based study with Portuguese government employees' participation to present the characteristics of public sector digital transformation projects and its correlation with knowledge management. Their findings show that the success of digital transformation project applications in the public sector is highly related to the quality of the organizations' knowledge management.

Margel et al. [16] concentrated on digital transformation efforts of the public sector from a citizen experience journey point of view. Their study discusses the redesign and reengineering of government services considering the cooperation between governmental institutions, internal (government employees), and external (citizens) users of digital transformation projects. Jonathan [17] has stated that despite the pressure and support from political leaders, many digitalization initiatives are failing. So, to reveal and identify the success factors from leaders' point of view, he conducted interviews with senior government executives aiming to create a list of factors that highly affect the digitalization success.

Ylinen and Pekkola [18] have pointed out the importance of IT management processes that would play technologic leverage for digital transformation. Their study reveals that governmental IT departments need to make adjustments and revisions in management and their daily operations to better respond to the public service units. Faro et al. [19] have highlighted the gap between organizational needs and the drivers of public sector digital transformation. The study discusses how public-sector organizations can develop their competencies to adapt to changes that digital transformation drivers create, e.g., digital governance of laws and policies.

Besides technological challenges, there are also political power dynamics in the public sector, so we cannot think of public digital transformation endeavors apart from the politics within institutions. Based on a South African case study, Manda [20] has discussed the effects of power dynamics and politics on digital transformation. The study reveals that political power balances highly affect digital transformation efforts in the public sector. They require a holistic view of institutions as social, economic, and political organizations.

Another international case comes from Uzbekistan; Kuldosheva [21] collected data from several survey-based sources (mainly from citizens and government-related institutions) to evaluate e-government efforts' progress. The study is unique since it focuses evolutionary stages of digitalization endeavors of one of the Commonwealth Independent States. The study discusses the digital citizen experience gaps because of inconsistencies between digital process design and public service needs. Jonathan et al. [22] have argued that successful digital transformation initiatives need a shared IT strategic vision, conducive organizational culture, awareness, and digital literacy contrary to what is expected. Their study, focusing on an Ethiopian governmental case, emphasizes the critical role of qualified communication between departments, information security awareness, and digital resources allocation to foster digital transformation projects in the public sector. Despite public efforts to redesign public service processes, unleashing new channels to interact with citizens, governments have a hard time meeting citizens' increasing and continuous demand for more efficiency and transparency.

Nachit et al. [23] have stated no clear roadmap for governments to approach digital transformation initiatives. The study highlights the drivers and obstacles of digital transformation, focusing on a Maroccan government case. Bjerke-Busch and Aspelund [24] have presented a Norwegian governmental case from an institutional perspective thru change management theory. The study implies that each institution has its norms, and this situation creates a barrier to digital transformation. The study also proposes that a nationwide digital transformation should be applied to overcome this defacto challenge.

Another survey-based study conducted in Greece focuses on exploring the factors that affect users' institutionalization of IT projects. In this study, Ioannou et al. [25] have highlighted the importance of citizens' digital experience design process in the public sector. As a complementary study to the literature cited so far, Hamish [26] has discussed the same subject from a sociotechnical standpoint, presenting a case from New Zealand. His study argues that governance mechanisms such as culture, political ecosystem, and institutional interdependencies play an essential role. This role eventually leads the digital transformation to enable sociotechnical change. Frössling and Ek [27] have put forth the terms of integrative capability and institutional logic. They have propounded how these two terms have a significant impact on digital transformation with their study.

Routzouni et al. [28] have emphasized the importance of institutional culture in their work. Their study analyzes how innovative design thinking methodology can contribute to building digital policies in the public sector based on a participatory approach. They have used the value proposition design framework in a Greek government case to formulate their approach. Far from a theoretical concept, in their study, Wichmann et al. [29] have discussed omnipresence and dynamic customer needs from an innovation perspective. The study also exemplifies these digital endeavors by applying an urban environment digital transformation process from Germany. Lindgren and van Veenstra [30] have brought a different dimension to public digital transformation efforts. Their study illustrates how e-government initiatives can trigger public and social values changes. The study suggests that governments should also consider the institutional aspects to ensure sustainable and healthy digital change. They need to support the efforts by issuing new laws and policies to ensure public governance. Lastly, the paper of Escobar et al. [31] should be cited because their study conducts a broad literature review regarding critical implementations and views on digital transformation in the public sector.

3. Methodology

As explained in the introduction chapter, digital transformation projects fail because they are not understood and applied correctly. Even in the private sector, despite the wide range of application areas and commercial opportunities, there are many failures in IT projects. These failures are forcing business and government institutions to reconsider their digital positions. In order to do this, before realizing the digital transformation projects of the enterprises, They need to decide (1) exactly what needs to change, (2) why they need change, and (3) how to prepare for that change. It is a fact that the issue of digital transformation is the most important issue followed by all business leaders in the world.

According to IDC; 65% of worldwide GDP would be used in digital transformation projects by 2022, This means that the sum of all digital transformation investments made and to be made from 2020 to 2023 in the world would exceed 7 trillion dollars. [32]. Statistically, it is observed that 80% of this significant investment in digital transformation projects around the world has failed. We can state the first reason for this failure: businesses cannot establish a common digital corporate culture and direct their employees toward the same goal. The other reason is that the corporate culture does not embrace the change and difference brought by digital transformation.
As we mentioned in the literature section, digital transformation's applications and success criteria in the public sector are pretty wide and can vary. On the other hand, government institutions mainly outsource and implement digital transformation projects, which are IT projects in the public sector. In such a scenario, the success of digital transformation applications in the public sector depends on the correct selection of the project success factors and the correct selection of the IT outsourcing company to be preferred. When we are faced with a managerial problem that is not so clear, and the relativity of success factors comes to the fore, applying fuzzy decision-making methods in decision-making processes can be one of the solutions. The fuzzy AHP method provides a holistic view of all success factors and considers the subjective views of decision-makers. That is why it may be the correct methodology to apply. Spherical fuzzy sets, which offer a wider preference domain to decision-makers, would be the right choice when using the fuzzy AHP method.

3.1. Interval-Valued Spherical Fuzzy Sets (IVSFSs): Preliminaries

Decision makers can use Spherical Fuzzy Sets (SFSs) to obtain a more extensive range to define membership degrees for both criteria and sub-criteria. Because SFSs allow the squared sums to be 1.0 at most so, decision-makers have an opportunity to explain the hesitancy concept unassisted in an SFSs domain. For example, we can define our fuzzy preference as (0.6, 0.4, 0.5), where the sum would exceed 1 whereas the sum of squares is 0.77. Gündoğdu and Kahraman [33, 34, 35, 36] have developed SFSs as an inference of Pythagorean Fuzzy Sets. SFSs are described as:

Definition 3.1 In a universal set of U, a single-valued SFS As is described as,

$$\tilde{A}_S = \{\langle u, (\mu_{\tilde{A}_S}(u), \nu_{\tilde{A}_S}(u), \pi_{\tilde{A}_S}(u)) | u \in U \rangle\} \quad (1)$$

Where

$\mu_{\tilde{A}_S}: U \rightarrow [0,1], \nu_{\tilde{A}_S}: U \rightarrow [0,1], \pi_{\tilde{A}_S}: U \rightarrow [0,1]$ and $0 \leq \mu^2_{\tilde{A}_S}(u) + \upsilon^2_{\tilde{A}_S}(u) + \pi^2_{\tilde{A}_S}(u) \leq 1 \; \forall u \in U$. For each , the numbers $\mu_{\tilde{A}_S}(u)$ is degree of membership and $\nu_{\tilde{A}_S}(u)$ is non-membership. Finally, $\pi_{\tilde{A}_S}(u)$ is the hesitancy of u to $\bar{A}_S$.

Gündoğdu and Kahraman [37] describe the arithmetic calculation of IVSFSs. They also present the formulas to defuzzfy and aggregate IVSFSs.

Definition 3.2 An IVSFS $\tilde{A}_S$ of the universal set U is defined as in Eq. (2).

$$\tilde{A}_S = \left\{ u, \begin{pmatrix} [\mu^L_{\tilde{A}_S}(u), \mu^U_{\tilde{A}_S}(u)], \\ [\upsilon^L_{\tilde{A}_S}(u), \upsilon^U_{\tilde{A}_S}(u)], \\ [\pi^L_{\tilde{A}_S}(u), \pi^U_{\tilde{A}_S}(u)] \end{pmatrix} | u \in U \right\} \quad (2)$$

where $0 \leq \mu^L_{\tilde{A}_S}(u)\ (u) \leq \mu^U_{\tilde{A}_S}(u) \leq 1$, $0 \leq \upsilon^L_{\tilde{A}_S}(u) \leq \upsilon^U_{\tilde{A}_S}(u) \leq 1$ and $0 \leq \left(\mu^U_{\tilde{A}_S}(u)\right)^2 + \left(\upsilon^U_{\tilde{A}_S}(u)\right)^2 + \left(\pi^U_{\tilde{A}_S}(u)\right)^2 \leq 1$.

For each $u \in U$, $\mu^U_{\tilde{A}_S}(u)$ is the upper degrees of membership and $\upsilon^U_{\tilde{A}_S}(u)$ is non-membership. Finally, $\pi^U_{\tilde{A}_S}(u)$ is the hesitancy of u to $\tilde{A}_S$. For an IVSFS $\tilde{A}_S$, an interval-valued spherical fuzzy number is defined as; $\langle [\mu^L_{\tilde{A}_S}(u), \mu^U_{\tilde{A}_S}(u)], [\upsilon^L_{\tilde{A}_S}(u), \upsilon^U_{\tilde{A}_S}(u)], [\pi^L_{\tilde{A}_S}(u), \pi^U_{\tilde{A}_S}(u)] \rangle$

For convenience, the pair;

$\langle [\mu^L_{\tilde{A}_S}(u), \mu^U_{\tilde{A}_S}(u)], [\upsilon^L_{\tilde{A}_S}(u), \upsilon^U_{\tilde{A}_S}(u)], [\pi^L_{\tilde{A}_S}(u), \pi^U_{\tilde{A}_S}(u)] \rangle$ is denoted by $\tilde{\alpha} = \langle [a,b], [c,d], [e,f] \rangle$ where $[a,b] \subset [0,1], [c,d] \subset [0,1], [e,f] \subset [0,1], b^2 + d^2 + f^2 \leq 1$.

3.2. Extension of Spherical Fuzzy AHP (SFAHP)

SFAHP comprises the phases below;

Phase 1. We start with the classical steps of AHP. First, we develop a 3-level structure. The very first level represents selection alternatives. The second and third levels represent main and sub-criteria, respectively.

Phase 2. We develop a measurement reference based on the linguistic preferences of decision-makers, as shown in Table 1. This IVSFSs based measurement reference would be used to construct pairwise comparisons.

Table 1. Linguistic expressions for SFSs

Linguistic terms $\tilde{\alpha} = \langle [a,b], [c,d], [e,f] \rangle$	**Score Index**
Definitely Extreme Significance (DES) ([0.85,0.95],[0.10,0.15],[0.05,0.15])	9
High Extreme Significance (HES) ([0.75,0.85],[0.15,0.20],[0.15,0.20])	7
Extreme Significance (ES) ([0.65,0.75],[0.20,0.25],[0.20,0.25])	5
Slightly More Significance (SMS) ([0.55,0.65],[0.25,0.30],[0.25,0.30])	3
Equally Significance (ES) ([0.50,0.55],[0.45,0.55],[0.30,0.40])	1
Slightly Small Significance (SSS) ([0.25,0.30],[0.55,0.65],[0.25,0.30])	1/3
Small Significance (SS) ([0.20,0.25],[0.65,0.75],[0.20,0.25])	1/5
Very Small Significance (VSS) ([0.15,0.20],[0.75,0.85],[0.15,0.20])	1/7
Definitely Small Significance (DSS) ([0.10,0.15],[0.85,0.95],[0.05,0.15])	1/9

Phase 3. We should check the consistency ratio of the pairwise comparison matrix. To do this control, we follow the conventional steps and must ensure that CRs are below 10%. If any CR is above 10%, we should revise the decision-makers linguistic preferences till we reach the expected CR.

For example, the pairwise comparison matrix

$J = \begin{matrix} C_1 \\ C_2 \\ C_3 \end{matrix} \begin{vmatrix} ES & SSS & ES \\ SMS & ES & HES \\ SS & VSS & ES \end{vmatrix}$ is converted to

$J = \begin{matrix} C_1 \\ C_2 \\ C_3 \end{matrix} \begin{vmatrix} 1 & 1/3 & 5 \\ 3 & 1 & 7 \\ 1/5 & 1/7 & 1 \end{vmatrix}$ and the CR is figured as 0.048, meaning the pairwise comparison matrix ensures consistency.

Phase 4. The decision-maker's preferences are considered to figure out the numeric importance of IVSFSs. We use the Eq. (6) of IVSWAM to calculate the criteria and sub-criteria weights.

$IVSWAM_{\omega}(\tilde{a}_1, \tilde{a}_2 \dots, \tilde{a}_k) = \omega_1.\tilde{a}_1 \otimes \omega_2.\tilde{a}_2 \otimes \dots \otimes \omega_k.\tilde{a}_k$
where w?1/n (Eq. 6).

Phase 5. We comprise the structure of the established hierarchy to calculate the global weightings. For each level of the hierarchy, we aggregate the preference importance of IVSFSs to obtain the score ranks. At this point, there are two computational approaches the first one is to use partial IVSFAHP (described in Eqs. (3-6)), and the second one is to use the complete IVSFAHP approach (described in Eqs. (7-8)). In this study, we have used the first approach. We finally use Eq. (3) at this phase to defuzzfy the criteria weightings, so where

$$Score\left(\tilde{\omega}_j^S\right) = S\left(\tilde{\omega}_j^S\right),$$

$$S\left(\tilde{\omega}_j^S\right) = \frac{a^2 + b^2 - c^2 - d^2 - \left(e/2\right)^2 - \left(f/2\right)^2}{2} + 1 \quad (3)$$

Eq. (4) normalizes the criteria weights:

$$\bar{\omega}_j^S = \frac{S\left(\tilde{\omega}_j^S\right)}{\sum_{J=1}^{n} S\left(\tilde{\omega}_j^S\right)} \quad (4)$$

Eq. (5) is used for weighting the decision matrix where $\tilde{\alpha}_{S_{ij}} = \bar{\omega}_j^S.\tilde{\alpha}_{S_i}$,

$$\tilde{\alpha}_{S_{ij}} = \left\{ \begin{matrix} \left[\left(1-\left(1-\alpha_{S_i}^2\right)^{\bar{\omega}_j^S}\right)^{\frac{1}{2}}, \left(1-\left(1-b_{S_i}^2\right)^{\bar{\omega}_j^S}\right)^{\frac{1}{2}}\right], \\ \left[c_{S_i}^{\bar{\omega}_j^S}, d_{S_i}^{\bar{\omega}_j^S}\right], \\ \left[\begin{matrix} \left(\left(1-\alpha_{S_i}^2\right)^{\bar{\omega}_j^S} - \left(1-\alpha_{S_i}^2 - e_{S_i}^2\right)^{\bar{\omega}_j^S}\right)^{\frac{1}{2}}, \\ \left(\left(1-b_{S_i}^2\right)^{\bar{\omega}_j^S} - \left(1-b_{S_i}^2 - f_{S_i}^2\right)^{\bar{\omega}_j^S}\right)^{1/2} \end{matrix}\right] \end{matrix} \right\} \quad (5)$$

In this study, the SFAHP scores are calculated using Eq. (7) fuzzy addition arithmetics for possible options considering the preference importances. As an alternative, to defuzzify the final scores the computational approach in Eq. (8) can also be used.

$$IVSWAM_{\omega} = \left\{ \begin{matrix} \left[\left(1-\prod_{j=1}^{k}\left(1-a_j^2\right)^{\omega_j}\right)^{1/2}, \left(1-\prod_{j=1}^{k}\left(1-b_j^2\right)^{\omega_j}\right)^{1/2}\right], \left[\prod_{j=1}^{k} c_j^{\omega_j}, \prod_{j=1}^{k} d_j^{\omega_j}\right], \\ \left[\left(\prod_{j=1}^{k}\left(1-a_j^2\right)^{\omega_j} - \prod_{j=1}^{k}\left(1-a_j^2-e_j^2\right)^{\omega_j}\right)^{1/2}, \left(\prod_{j=1}^{k}\left(1-b_j^2\right)^{\omega_j} - \prod_{j=1}^{k}\left(1-b_j^2-f_j^2\right)^{\omega_j}\right)^{1/2}\right] \end{matrix} \right\} \quad (6)$$

$$\tilde{F} = \sum_{j=1}^{n} \tilde{\alpha}_{S_{ij}} = \tilde{\alpha}_{S_{i1}} \otimes \tilde{\alpha}_{S_{i2}} \dots \otimes \tilde{\alpha}_{S_{in}} \forall i$$

$$i.e. \tilde{\alpha}_{S_{11}} \otimes \tilde{\alpha}_{S_{12}} = \left\{ \begin{matrix} \left[\begin{matrix} \left(\left(a_{\tilde{\alpha}_{S_{11}}}\right)^2 + \left(a_{\tilde{\alpha}_{12}}\right)^2 - \left(a_{\tilde{\alpha}_{S_{11}}}\right)^2\left(a_{\tilde{\alpha}_{S_{12}}}\right)^2\right)^{\frac{1}{2}}, \\ \left(\left(b_{\tilde{\alpha}_{S_{11}}}\right)^2 + \left(b_{\tilde{\alpha}_{S_{12}}}\right)^2 - \left(b_{\tilde{\alpha}_{S_{11}}}\right)^2\left(b_{\tilde{\alpha}_{S_{12}}}\right)^2\right)^{\frac{1}{2}} \end{matrix}\right], \left[c_{\tilde{\alpha}_{S_{11}}} c_2, d_{\tilde{\alpha}_{S_{11}}} d_2\right], \\ \left[\begin{matrix} \left(\left(1-\left(a_{\tilde{\alpha}_{12}}\right)^2\right)\left(e_{\tilde{\alpha}_{S_{11}}}\right)^2 + \left(1-\left(a_{\tilde{\alpha}_{S_{11}}}\right)^2\right)\left(e_{\tilde{\alpha}_{S_{12}}}\right)^2 - \left(e_{\tilde{\alpha}_{S_{11}}}\right)^2\left(e_{\tilde{\alpha}_{S_{12}}}\right)^2\right)^{\frac{1}{2}}, \\ \left(\left(1-\left(b_{\tilde{\alpha}_{12}}\right)^2\right)\left(f_{\tilde{\alpha}_{S_{11}}}\right)^2 + \left(1-\left(b_{\tilde{\alpha}_{S_{11}}}\right)^2\right)\left(f_{\tilde{\alpha}_{S_{12}}}\right)^2 - \left(f_{\tilde{\alpha}_{S_{11}}}\right)^2\left(f_{\tilde{\alpha}_{S_{12}}}\right)^2\right)^{\frac{1}{2}} \end{matrix}\right] \end{matrix} \right\} \quad (7)$$

$$\prod_{j=1}^{n} \tilde{\alpha}_{S_{ij}} = \tilde{\alpha}_{S_{i1}} \otimes \tilde{\alpha}_{S_{i2}} \ldots \otimes \tilde{\alpha}_{S_{in}} \forall i$$

$$i.e. \tilde{\alpha}_{S_{11}} \otimes \tilde{\alpha}_{S_{12}} = \left\{ \begin{array}{c} \left[a_{\tilde{\alpha}_{S_{11}}} a_2, b_{\tilde{\alpha}_{S_{11}}} b_2\right], \left[\begin{array}{c} \left(\left(c_{\tilde{\alpha}_{S_{11}}}\right)^2 + \left(c_{\tilde{\alpha}_{12}}\right)^2 - \left(c_{\tilde{\alpha}_{S_{11}}}\right)^2 \left(c_{\tilde{\alpha}_{S_{12}}}\right)^2\right)^{\frac{1}{2}}, \\ \left(\left(d_{\tilde{\alpha}_{S_{11}}}\right)^2 + \left(d_{\tilde{\alpha}_{S_{12}}}\right)^2 - \left(d_{\tilde{\alpha}_{S_{11}}}\right)^2 \left(d_{\tilde{\alpha}_{S_{12}}}\right)^2\right)^{\frac{1}{2}} \end{array} \right], \\ \left[\begin{array}{c} \left(\left(1 - \left(c_{\tilde{\alpha}_{12}}\right)^2\right)\left(e_{\tilde{\alpha}_{S_{11}}}\right)^2 + \left(1 - \left(c_{\tilde{\alpha}_{S_{11}}}\right)^2\right)\left(e_{\tilde{\alpha}_{S_{12}}}\right)^2 - \left(e_{\tilde{\alpha}_{S_{11}}}\right)^2 \left(e_{\tilde{\alpha}_{S_{12}}}\right)^2\right)^{\frac{1}{2}}, \\ \left(\left(1 - \left(d_{\tilde{\alpha}_{12}}\right)^2\right)\left(f_{\tilde{\alpha}_{S_{11}}}\right)^2 + \left(1 - \left(d_{\tilde{\alpha}_{S_{11}}}\right)^2\right)\left(f_{\tilde{\alpha}_{S_{12}}}\right)^2 - \left(f_{\tilde{\alpha}_{S_{11}}}\right)^2 \left(f_{\tilde{\alpha}_{S_{12}}}\right)^2\right)^{\frac{1}{2}} \end{array} \right] \end{array} \right\} \quad (8)$$

Phase 6. In this phase, calculation and defuzzification of each alternative are conducted.

Phase 7. This phase is the final step of the procedure, where we figure out the best final decision.

4. Numerical Analysis

After presenting the theoretical background of IVSF-AHP in the previous section, we will exemplify this theoretical explanation with the numerical application of IT outsourcing selection from the public sector. However, before moving on to numerical calculations and the application of IVSF-AHP, it would be appropriate to discuss how the criteria we determined were chosen. As it is known, procurement processes are operated and managed in every outsourcing selection, not only in IT.

In this article, since our primary goal is to construct an approach model that can be applied by every public institution in the selection of IT outsourcing, we have tried to choose the main criteria from those that are more general and inclusive. We reviewed the articles of Demircan and Acarbay [38], and Fusiripong et al. [39, 40, 41] to prepare the main criteria and sub-criteria. We tried to compile and present the criteria presented in these studies. Thus, we came across four main criteria and their subsequent sub-criteria that each public institution can use as selection criteria in their digital transformation projects shown in Figure 1. Below you may also find brief summaries of criteria.

Background (C_1): The background, experience, and other opportunities of the selected company are essential for digital transformation projects to be successful. We need to detail the relevant fields by dividing this feature into four sub-criteria. (*i*) *Experience on DX* (C_{11}): The company's experience in digital transformation projects, the projects it is involved in, and the quality and quantity of information of the projects it has completed before should be among the evaluation criteria. (*ii*) *Experience in Public Sector* (C_{12}):

Figure 1. Criteria and Sub-Criteria

As we mentioned in the introduction and other sections, digital transformation success factors for the private and public sectors may differ. In particular, the company to be selected should know the dynamics of public institutions and be familiar with the norms, which will affect the project's success. (*iii*) *Access to Best Practices* (C_{13}): We made a clear and precise distinction between digital transformation and digitalization concepts and revealed the differences between them. With a straightforward definition, while digitalization is a passive phenomenon based on technical purchasing processes, digital transformation is the approach of business and service models with an innovative perspective.

For this reason, digital transformation projects need previously successful, innovative, and different perspectives for inspiration. It is essential to reach best practices and have the opportunity to examine them. (*iv*) *Training Ability* (C_{14}): Just because the outsourcing firm fulfills its responsibilities does not mean the digital transformation project has been completed. Increasing digital literacy in the relevant public institution, spreading digital awareness, and providing training will also ensure that the digital project is embraced and internalized by the institution's stakeholders.

Capabilities (C_2): Although the criteria related to digital culture and digital approaches are essential, the success of any computing project largely depends on the technical capabilities of the project team. We can exDESne these abilities under four sub-criteria. (*i*) *Software and Hardware Capabilities* (C_{21}): These capabilities, which we will specify under the software and hardware capabilities sub-criterion, are the essential competencies that the outsourcing company must have to realize the project. (*ii*) *System Integration Capabilities* (C_{22}): Capabilities related to technical works such as making the developed technical infrastructure available to the institution and its stakeholders, completing database migrations without data loss, and installation/deployment.

(*iii*) *Information Security Capabilities* (C_{23}): The information processing security that has been provided with a holistic perspective of the project is also a sub-criteria that should be considered in reducing project risks and ensuring project sustainability. (*iv*) *Project Management Skills* (C_{24}): Although the project team of the outsourcing firm has the technical knowledge, the firm's lack of basic project management methods and techniques will jeopardize the project's success.

Service Quality (C_3): Apart from technical capabilities, this criterion covers project communication, coordination, and how the firm directs the public institution and manages relations. (*i*) *Transparency* (C_{31}): It is company behavior such as documenting the processes, preparing them following the standards determined for the project, and adequately informing the public institution, namely the customer, at every stage of the project. (*ii*) *On-Time Delivery* (C_{32}): It is the issues such as the timely delivery of the project, rewarding or penalizing for early or late deliveries, and making certain decisions by the project owners. (*iii*) *Technical Performance* (C_{33}):

It is the sub-criterion in which features such as the project's level of delivery and operation in a "bug-free" way, the speed of use, and the digital user experience journey are evaluated. (*iv*) *Account Management* (C_{34}): It refers to the management of the relationship between the outsourcing firm and the public institution. It is the level of providing necessary and sufficient information, evaluating the requests, giving feedback, and the level of harmony and harmony that the company will create with the public institution throughout the project process.***Cost*** (C_4): Although it is not mentioned only in public institutions but also in the private sector, quality is at the forefront. However, the cost factor is a primary criterion for every business. Businesses always tend to prefer the low-cost one among similar projects. (*i*) *Project Budget Bid* (C_{41}): It is the first planned budget proposal for the project. (*ii*) *Change Request/Maintenance Fees* (C_{42}): Although digital transformation projects are managed with traditional project management methods and approaches, the concept of digital transformation is continuous. For this reason, developments, revisions, and new demands and requests will inevitably occur after the end of the project. From this point of view, digital transformation can be compared to a never-ending journey.

After defining the criteria and sub-criteria, it is time to apply these criteria to alternatives. We selected the alternatives from companies with different characteristics to experience a more general selection process. The first alternative (*A*) is a company with international digital transformation project experience, has a project team equipped with advanced talents and resources, but is just as expensive in terms of project budget and cost. The second alternative (*B*) is a local firm with extensive IT project experience in the public sector. The human resource profile of this alternative consists of experienced and knowledgeable people but has limited access to internationally inspiring best practices. Project budgets and costs are at a level that can be reasonable for local public institutions. Our last alternative (*C*) is a startup company with limited digital transformation experience with an enthusiastic and passionate team that has high-end technical skills. The last company, as a new comer to the sector with a talented team, has limited project management knowledge but is willing to offer low project budgets to gain references and customers.

5. Results and Sensitivty Analysis

After stating criteria and sub-criteria, each of them has been carefully evaluated by 3 decision makers who have experience IT outsourcing management experience on both corporate and public sectors. We calculate the CR figures of IVSFSs pairwise comparison matrix using related linguistic indices presented in Table 1. Tables 2-20 depicts the pairwise comparison and IVSFSs weights. The CR values are also presented on tables. Table 21a includes the final ranking scores of corresponding competing alternative outsourcing IT companies.

Table 2. Overall pairwise comparison

	C_1	C_2	C_3	C_4	$\tilde{w}_S$	w_S
C_1	*ES*	*SS*	*ES*	*VSS*	([0.93,0.91],[0.82,0.86],[0.90,0.86])	0.183
C_2	*ES*	*ES*	*ES*	*SS*	([0.87,0.81],[0.67,0.71],[0.86,0.78])	0.286
C_3	*ES*	*SS*	*ES*	*VSS*	([0.93,0.91],[0.82,0.86],[0.90,0.86])	0.183
C_4	*HES*	*ES*	*HES*	*ES*	([0.81,0.73],[0.62,0.67],[0.80,0.70])	0.349

CR=0.077

Table 3. Pairwise comparison of the main criteria: Background

	C_{11}	C_{12}	C_{13}	C_{14}	$\tilde{w}_S$	w_S
C_{11}	*ES*	*DES*	*HES*	*HES*	([0.74,0.85],[0.18,0.24],[0.16,0.23])	0.371
C_{12}	*DSS*	*ES*	*SS*	*SSS*	([0.31,0.36],[0.61,0.71],[0.23,0.31])	0.153
C_{13}	*VSS*	*ES*	*ES*	*ES*	([0.50,0.57],[0.42,0.50],[0.25,0.33])	0.246
C_{14}	*VSS*	*SMS*	*ES*	*ES*	([0.46,0.53],[0.44,0.53],[0.26,0.35])	0.230

CR=0.067

Table 4. Pairwise comparison of the main criteria: Capabilities

	C_{21}	C_{22}	C_{23}	C_{24}	$\tilde{w}_S$	w_S
C_{21}	*ES*	*ES*	*SS*	*SMS*	([0.47,0.53],[0.43,0.51],[0.27,0.35])	0.243
C_{22}	*ES*	*ES*	*SS*	*SMS*	([0.47,0.53],[0.43,0.51],[0.27,0.35])	0.243
C_{23}	*ES*	*ES*	*ES*	*HES*	([0.65,0.75],[0.23,0.29],[0.21,0.27])	0.341
C_{24}	*SSS*	*SSS*	*VSS*	*ES*	([0.32,0.37],[0.57,0.67],[0.25,0.32])	0.173

CR=0.027

Table 5. Pairwise comparison of the main criteria: Service Quality

	C_{31}	C_{32}	C_{33}	C_{34}	$\tilde{w}_S$	w_S
C_{31}	*ES*	*SS*	*SSS*	*ES*	([0.40,0.44],[0.52,0.62],[0.27,0.36])	0.203
C_{32}	*ES*	*ES*	*SMS*	*ES*	([0.59,0.69],[0.26,0.32],[0.24,0.30])	0.322
C_{33}	*SMS*	*SSS*	*ES*	*SMS*	([0.49,0.57],[0.35,0.42],[0.26,0.33])	0.272
C_{34}	*ES*	*SS*	*SSS*	*ES*	([0.40,0.44],[0.52,0.62],[0.27,0.36])	0.203

CR=0.015

Table 6. Pairwise comparison of the main criteria: Cost

	C_{41}	C_{42}	$\tilde{w}_S$	w_S
C_{41}	*ES*	*ES*	([0.58,0.67],[0.30,0.37],[0.25,0.32])	0.613
C_{42}	*SS*	*ES*	([0.39,0.44],[0.54,0.64],[0.26,0.35])	0.387

CR=0.000

Table 7. Pairwise comparison of companies for the criterion: C_{11}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*SMS*	*HES*	([0.62,0.72],[0.26,0.32],[0.23,0.29])	0.430
B	*SSS*	*ES*	*ES*	([0.51,0.59],[0.37,0.45],[0.25,0.32])	0.355
C	*VSS*	*SS*	*ES*	([0.33,0.38],[0.60,0.71],[0.24,0.32])	0.215

CR=0.056

Table 8. Pairwise comparison of companies for the criterion: C_{12}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*SMS*	*HES*	([0.62,0.72],[0.26,0.32],[0.23,0.29])	0.430
B	*SSS*	*ES*	*ES*	([0.51,0.59],[0.37,0.45],[0.25,0.32])	0.355
C	*VSS*	*SS*	*ES*	([0.33,0.38],[0.60,0.71],[0.24,0.32])	0.215

CR=0.056

Table 9. Pairwise comparison of companies for the criterion: C_{13}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*DES*	*DES*	([0.78,0.90],[0.17,0.23],[0.14,0.21])	0.502
B	*DSS*	*ES*	*SMS*	([0.44,0.52],[0.46,0.54],[0.24,0.32])	0.290
C	*DSS*	*SSS*	*ES*	([0.34,0.38],[0.59,0.70],[0.24,0.32])	0.208

CR=0.056

Table 10. Pairwise comparison of companies for the criterion: C_{14}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*SMS*	*ES*	([0.57,0.66],[0.28,0.35],[0.25,0.31])	0.413
B	*SSS*	*ES*	*SMS*	([0.46,0.53],[0.40,0.48],[0.27,0.34])	0.338
C	*SS*	*SSS*	*ES*	([0.35,0.40],[0.54,0.64],[0.26,0.34])	0.249

CR=0.032

Table 11. Pairwise comparison of companies for the criterion: C_{21}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*ES*	*SSS*	([0.44,0.49],[0.48,0.58],[0.29,0.38])	0.300
B	*ES*	*ES*	*SSS*	([0.44,0.49],[0.48,0.58],[0.29,0.38])	0.300
C	*SMS*	*SMS*	*ES*	([0.53,0.62],[0.30,0.37],[0.27,0.33])	0.399

CR=0.032

Table 12. Pairwise comparison of companies for the criterion: C_{22}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*SMS*	*SSS*	([0.46,0.53],[0.40,0.48],[0.27,0.34])	0.338
B	*SSS*	*ES*	*SS*	([0.35,0.40],[0.54,0.64],[0.26,0.34])	0.249
C	*SMS*	*ES*	*ES*	([0.57,0.66],[0.28,0.35],[0.25,0.31])	0.413

CR=0.032

Table 13. Pairwise comparison of companies for the criterion: C_{23}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*SMS*	*ES*	([0.52,0.59],[0.37,0.45],[0.28,0.37])	0.363
B	*SSS*	*ES*	*SS*	([0.35,0.40],[0.54,0.64],[0.26,0.34])	0.249
C	*ES*	*ES*	*ES*	([0.56,0.63],[0.34,0.42],[0.27,0.35])	0.388

CR=0.025

Table 14. Pairwise comparison of companies for the criterion: C_{24}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*ES*	*HES*	([0.65,0.75],[0.24,0.30],[0.22,0.28])	0.448
B	*SS*	*ES*	*SMS*	([0.45,0.53],[0.42,0.50],[0.26,0.33])	0.321
C	*VSS*	*SSS*	*ES*	([0.34,0.39],[0.57,0.67],[0.25,0.33])	0.231

CR=0.056

Table 15. Pairwise comparison of companies for the criterion: C_{31}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*SMS*	*HES*	([0.62,0.72],[0.26,0.32],[0.23,0.29])	0.430
B	*SSS*	*ES*	*ES*	([0.51,0.59],[0.37,0.45],[0.25,0.32])	0.355
C	*VSS*	*SS*	*ES*	([0.33,0.38],[0.60,0.71],[0.24,0.32])	0.215

CR=0.056

Table 16. Pairwise comparison of companies for the criterion: C_{32}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*SMS*	*SMS*	([0.53,0.62],[0.30,0.37],[0.27,0.33])	0.395
B	*SSS*	*ES*	*SMS*	([0.46,0.53],[0.40,0.48],[0.27,0.34])	0.340
C	*SSS*	*SSS*	*ES*	([0.36,0.41],[0.51,0.61],[0.27,0.35])	0.265

CR=0.056

Table 17. Pairwise comparison of companies for the criterion: C_{33}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*ES*	*SSS*	([0.44,0.49],[0.48,0.58],[0.29,0.38])	0.300
B	*ES*	*ES*	*SSS*	([0.44,0.49],[0.48,0.58],[0.29,0.38])	0.300
C	*SMS*	*SMS*	*ES*	([0.53,0.62],[0.30,0.37],[0.27,0.33])	0.399

CR=0.056

Table 18. Pairwise comparison of companies for the criterion: C_{34}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*SMS*	*ES*	([0.57,0.66],[0.28,0.35],[0.25,0.31])	0.413
B	*SSS*	*ES*	*SMS*	([0.46,0.53],[0.40,0.48],[0.27,0.34])	0.338
C	*SS*	*SSS*	*ES*	([0.35,0.40],[0.54,0.64],[0.26,0.34])	0.249

CR=0.032

Table 19. Pairwise comparison of companies for the criterion: C_{41}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*SSS*	*DSS*	([0.34,0.38],[0.59,0.70],[0.24,0.32])	0.212
B	*SMS*	*ES*	*VSS*	([0.45,0.52],[0.44,0.52],[0.25,0.33])	0.302
C	*DES*	*HES*	*ES*	([0.74,0.86],[0.19,0.25],[0.17,0.23])	0.486

CR=0.068

Table 20. Pairwise comparison of companies for the criterion: C_{42}

	A	B	C	$\tilde{w}_S$	w_S
A	*ES*	*SSS*	*DSS*	([0.34,0.38],[0.59,0.70],[0.24,0.32])	0.212
B	*SMS*	*ES*	*VSS*	([0.45,0.52],[0.44,0.52],[0.25,0.33])	0.302
C	*DES*	*HES*	*ES*	([0.74,0.86],[0.19,0.25],[0.17,0.23])	0.486

CR=0.0

Table 21a. Final spherical fuzzy global priority weights

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}
A	([0.45, 0.53], [0.54, 0.60], [0.18, 0.25])	([0.24, 0.29], [0.85, 0.87], [0.10, 0.14])	([0.44, 0.56], [0.67, 0.72], [0.09, 0.20])	([0.28, 0.34], [0.77, 0.80], [0.14, 0.19])	([0.22, 0.25], [0.84, 0.88], [0.15, 0.21])	([0.23, 0.27], [0.81, 0.84], [0.14, 0.19])	([0.34, 0.39], [0.68, 0.73], [0.20, 0.27])
B	([0.36, 0.42], [0.64, 0.70], [0.19, 0.25])	([0.19, 0.22], [0.89, 0.91], [0.10, 0.14])	([0.22, 0.26], [0.84, 0.87], [0.13, 0.18])	([0.22, 0.26], [0.83, 0.86], [0.14, 0.18])	([0.22, 0.25], [0.84, 0.88], [0.15, 0.21])	([0.17, 0.20], [0.87, 0.90], [0.13, 0.18])	([0.22, 0.26], [0.79, 0.84], [0.17, 0.23])
C	([0.23, 0.26], [0.80, 0.85], [0.16, 0.23])	([0.12, 0.13], [0.94, 0.96], [0.09, 0.12])	([0.16, 0.19], [0.89, 0.92], [0.12, 0.17])	([0.16, 0.19], [0.88, 0.91], [0.13, 0.17])	([0.27, 0.33], [0.76, 0.79], [0.15, 0.20])	([0.30, 0.35], [0.75, 0.78], [0.14, 0.20])	([0.37, 0.43], [0.66, 0.72], [0.19, 0.26])

	C_{24}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}
A	([0.28, 0.34], [0.81, 0.84], [0.11, 0.16])	([0.29, 0.35], [0.79, 0.82], [0.12, 0.17])	([0.34, 0.40], [0.64, 0.69], [0.18, 0.24])	([0.24, 0.27], [0.81, 0.86], [0.17, 0.23])	([0.26, 0.31], [0.80, 0.83], [0.13, 0.17])	([0.28, 0.31], [0.71, 0.79], [0.20, 0.27])	([0.20, 0.23], [0.84, 0.88], [0.15, 0.20])
B	([0.18, 0.22], [0.88, 0.90], [0.11, 0.15])	([0.23, 0.27], [0.84, 0.87], [0.12, 0.17])	([0.29, 0.34], [0.71, 0.76], [0.18, 0.24])	([0.24, 0.27], [0.81, 0.86], [0.17, 0.23])	([0.20, 0.24], [0.85, 0.88], [0.13, 0.17])	([0.37, 0.43], [0.58, 0.65], [0.21, 0.28])	([0.27, 0.32], [0.75, 0.80], [0.16, 0.22])
C	([0.14, 0.16], [0.92, 0.94], [0.10, 0.14])	([0.14, 0.16], [0.92, 0.94], [0.11, 0.14])	([0.22, 0.26], [0.78, 0.84], [0.17, 0.23])	([0.30, 0.36], [0.72, 0.75], [0.16, 0.22])	([0.15, 0.17], [0.90, 0.93], [0.12, 0.16])	([0.64, 0.76], [0.34, 0.41], [0.16, 0.24])	([0.49, 0.61], [0.56, 0.62], [0.13, 0.22])

Table 21b. Score values and rankings of alternatives

Outsourcing Options	Scores	Ranks
A	0.3419	2
B	0.3104	3
C	0.3477	1

Table 21b presents score values and rankings of each alternative. As stated, the resulting scores of the first two alternatives are similar. We need to conduct a sensitivity analysis to analyze and elaborate on the difference between these two alternatives. As mentioned above, we anticipate that a sensitivity analysis should be performed with the ranking results of A and B alternatives being close. To observe which criteria or sub-criteria caused this slight difference between the A and B alternatives, a sensitivity analysis was carried out between the criteria and the sub-criteria.

While performing this sensitivity analysis, the evaluations of linguistic values were increased by one unit for the relevant criterion analyzed and kept constant for other criteria. Sensitivity analysis results are given in Figures 2-15. When the analysis was evaluated, it was observed that C_{41} (Project Budget Bid with 3.55%) and C_{23} (Information Security Capabilities with 3.05%) were the most influential sub-criteria on the final scores, while the least significant sub-criteria were C_{24} (Project Management Capabilities with 0.50%) and C_{12} (Experience in Public Sector with 0.46%).

We see that the most sensitive criteria for the selection decision are cost and information security. This result shows that institutions attach importance to information security in their outsourcing processes and cost. Contrary to these results, another inference is that institutions do not seek outsourcing consultancy firms with significant project management experience and experience in the public sector.

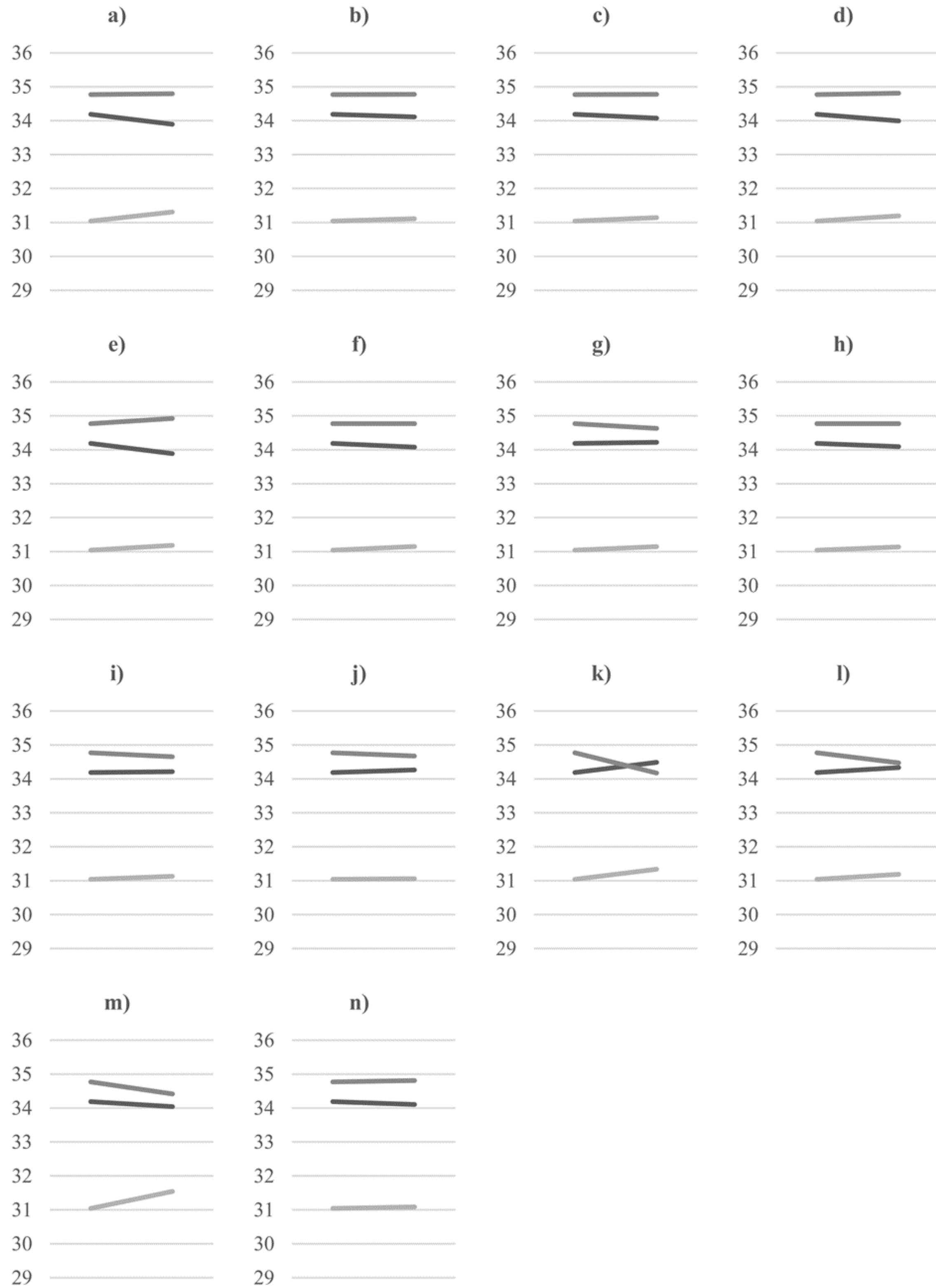

Figure 2. a) C_{11}, b) C_{12}, c) C_{31}, d) C_{32}, e) C_{13}, f) C_{14}, g) C_{33}, h) C_{34}, i) C_{21}, j) C_{22}, k) C_{41}, l) C_{42}, m) C_{23}, n) C_{24} sensitivity (The dark-colored, light-colored and moderate-colored lines represent A, B and C alternatives, respectively)

6. Conclusion

This study focused on criteria and sub-criteria, such as Background, Capabilities, Service Quality, and Cost, and successfully applied the Fuzzy AHP to assess alternative IT outsourcing firms for digital transformation projects. The results show that both public and private sector organizations' decisions to outsource are heavily influenced by information security capabilities and cost considerations. Whereas, project abilities and experience in the public sector received less attention, indicating a possible research for future selection process development. Study also aims to identify the elements that are important to select outsourcing partners and helps businesses improve their standards to better suit their strategic goals. These insights are essential to reach successful collaborations and project outcomes in a digital business ecosystems surrounded by digital transformation initiatives.

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The Declaration of Research and Publication Ethics
The author of the paper declare that he complies with the scientific, ethical and quotation rules of SAUJS in all processes of the paper and that they do not make any falsification on the data collected. In addition, he declares that Sakarya University Journal of Science and its editorial board have no responsibility for any ethical violations that may be encountered, and that this study has not been evaluated in any academic publication environment other than Sakarya University Journal of Science.

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