Multi-Criteria Decision Making Analysis of Optimal Service Delivery Technique Using AHP

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Abstract **– In this paper, we evaluate the most optimal service delivery method that can be implemented by both governmental and private sectors to an effective delivery service to customers. They include conventional service delivery, E-services (online), M-services (smart phones), and robotic process automation (RPA). Benefits and costs were considered in the evaluation process. Benefits were technical feasibility, efficiency, security, reliability, and innovation. The costs included complexity, human resources, facilities management, and maintenance costs. AHP was used to facilitate the multi-criteria decision-making process. Results show that RPA is the least expensive and most beneficial method to delivery services in UAE.**

Keywords **– *M*ulti-criteria; decision-making process.**

1. Introduction

Service delivery constitutes a core matter that influences the success of both government and private sector in terms of effective engagement with relevant stakeholders such as public and customers [1].

In an effort to enhance the competitiveness of its economy regionally and globally, the UAE has sought to complement conventional service delivery methods with information communication technology (ICT)-based methods.

The ICT methods that have also gained popularity in the private sector include e-services (electronic online services), m-services (using mobiles or smart phone devices) and robotic process automation (RPA). These service delivery methods are part of the country's National Innovation Strategy that was unveiled in 2014. Also, it can be noted that a substantial proportion of government and private sector services are repetitive and rules-based [2]. Accordingly, they render themselves capable of automation thus increasing efficiency, speed, accuracy and transparency when serving the public, private sectors, and other government organizations. Within the above context, ICT-based methods of service delivery can no longer be considered as alternative channels. They have become increasingly the single most important point of contact between government and the various stakeholders [3]. Therefore, the effective enactment of these channels has a tremendous effect on the performance of the government and economy. As such, it is important to compare the relative performances of each of these channels from a cost-benefit perspective. Surely, this can help identifying the different channels that the government and private sectors can best rely on to services delivery. Currently, there is a dearth in studies that investigate this area in the specific context of UAE. The Analytic Hierarchy Process (AHP) has been demonstrated to be an effective and practical approach for addressing such cost-benefit concerns in various applications [4],[5],[6],[7],[8],[9],[10],[11]. In this paper AHP has been used to evaluate the most optimal service delivery method that can be implemented by both United Arab Emirates (UAE) government and the country's private sectors to an effective delivery service to citizens and customers.

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2. Analytic Hierarchy Process (AHP)

AHP constitutes one of the common methods that can be applied in multi-criteria decision making. The method as developed by Saaty [12], involves decomposing a complex multi-criteria decision problem into a hierarchy that can be used for purposes of decision-making, ranking and prioritizing of problems. Saaty [13-14] further indicated that AHP is effective when weighing the priorities is complicated. This is the case in the present research since the ICT channels such as e-government, m-government and RPA share various similarities. As such, the AHP method can be effective in situations that require the resolution of choice problems in a multi-criteria context [15]. The application of AHP in relation to government service delivery channels, as a result of its flexibility thus, can allow us not only to manage but also to formulate the hierarchy model based on the UAE context. In addition, AHP allows for sensitivity analysis and hence the ability to evaluate how the alternative solutions would weigh and rank when changes in criterion weights are made [14]. The various comparison values used on AHP can be collected from a range of relevant inputs such as surveys or taking measurements from experts while using fundamental scaling [16]. In our findings, the data were obtained from an expert specializing in service delivery channels. While conducting AHP, one needs to engage in structuring of the decision hierarchy and pairwise comparison of each criterion and sub-criteria. Subsequently, this allows for discovery of the ratio scale of each value [13]. Judgement scales are based on a 9-point scale that ranges from 1 (equal importance) to 9 (extreme importance) and in between as described in Table 1. The pairwise comparison is followed by checking of the consistency of material judgements; application of eigenvector in the computation of weights; and aggregation of weights in order to determine the rank of the decision alternatives [17], [18].

Table 1. AHP pairwise comparison scale

Judgement	***Value***
1	Equal importance
2	Weak or slight importance
3	Moderate importance
4	Moderate plus importance
5	Strong importance
6	Strong plus importance
7	Very strong importance
8	Very, very strong importance
9	Extreme importance

3. Methodology

The identification of the best channel for delivering services by both the government and private sector was based on a cost-benefit analysis. Figures 1 and 2 show the benefit and cost hierarchy diagrams associated with these channels respectively. The benefit criterion was based on an initial assessment of the benefits sought by both the service providers and recipients with respect to service delivery. Five key benefits were identified including (i) technical feasibility, (ii) efficiency, (iii) security, (iv) reliability, and (v) innovation. For example, optimal service delivery channel be characterized by minimal technical limitations and complexity (i.e. technical feasibility); should save time and effort for both customer and employees (i.e. efficiency); should guarantee data confidentiality (i.e. security); reduce business constrains, by culturally mature in terms of customer acceptance and allows for management decision support (i.e. reliability); and should be innovative by allowing for new and advanced methods of service delivery.

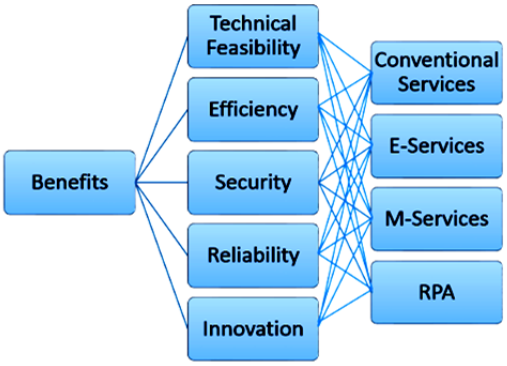

Figure 1. Benefits hierarchy diagram

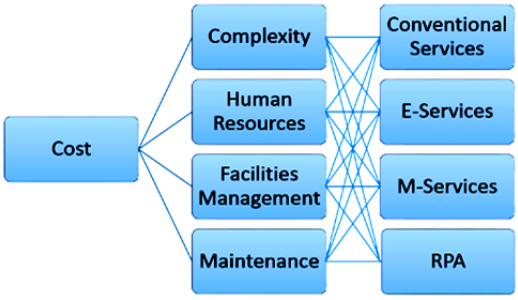

Figure 2. Costs hierarchy diagram

The cost criterion was, on the other hand, based on five items including (i) complexity, (ii) human resource, (iii) facilities management, and (iv) maintenance cost. Complexity related costs are associated with implementation of the service model; human resource relates to the need for employees to facilitate operation of the model; facilities management takes into account the costs associated with facilities where the service is delivered; while maintenance cost takes into account aspects such as

renovation. Based on the scale developed by Saaty [12] a pairwise comparison was conducted between the five attributes that constitute the benefits associated with the service delivery methods. Table 2 shows the relational scoring and relative weights derived from this pairwise comparison. On the other hand, Table 3 provides a pairwise comparison of the benefits of the service delivery methods with respect to each other. In the last column of the matrix the relatively weight of the priorities is calculated. It can be seen from the table that security is considered the most important followed by reliability, innovation, efficiency and technical feasibility. All consistency ratios (CI) were less than 0.10 and hence acceptable [14]. The procedure for determining various relative weights is described in the Appendix A.

Table 2. Rational scoring and relative weights of different methods of delivering services with respect to benefits

(a) Technical feasibility					
Type of Service	Conventional services	E-services	M-services	RPA	Relative weight
Conventional Services	1	8	8	9	0.669
E- services	1/8	1	3	7	0.198
M-services	1/8	1/3	1	3	0.090
RPA	1/9	1/7	1/3	1	0.043
(b) Efficiency					
Type of Service	Conventional services	E-services	M-services	RPA	Relative weight
Conventional Services	1	1/6	1/8	1/5	0.051
E- services	6	1	4	3	0.518
M-services	8	1/4	1	1/2	0.197
RPA	5	1/3	2	1	0.233
(c) Security					
Type of Service	Conventional services	E-services	M-services	RPA	Relative weight
Conventional Services	1	1/7	1/7	1/5	0.046
E- services	7	1	1/3	5	0.306
M-services	7	3	1	5	0.521
RPA	5	1/5	1/5	1	0.126
(d) Reliability					
Type of Service	Conventional services	E-services	M-services	RPA	Relative weight
Conventional Services	1	4	4	6	0.541
E- services	¼	1	3	5	0.227
M-services	¼	1/3	1	7	0.182
RPA	1/6	1/5	1/7	1	0.050
(e) Innovation					
Type of Service	Conventional services	E-services	M-services	RPA	Relative weight
Conventional Services	1	1/5	1/5	1/7	0.051
E- services	5	1	1/2	1/3	0.178
M-services	5	2	1	1/5	0.217
RPA	7	3	5	1	0.554

The weights calculated in Tables 2 and 3 were then used to calculate the overall relative weight factor for the pairwise combination of delivery service methods and benefits. The results are shown in Table 4. It can be seen from this table that M-services has the highest benefits followed by RPA and E-services. Conventional services have the lowest benefits at an overall weight of 0.174 (i.e. 17.4%).

Table 3. Rational scoring and relative weights for benefits of different methods of services against each other

Type of Benefit	Technical feasibility	Efficiency	Security	Reliability	Innovation	Relative weight
Technical feasibility	1	1/4	1/5	1/4	1/5	0.048
Efficiency	4	1	1/3	1	1/2	0.154
Security	5	3	1	1/2	1/2	0.223
Reliability	4	1	2	1	1/3	0.192
Innovation	5	2	2	3	1	0.383

Table 4. Overall relative weights for benefits of different methods of delivering services

Type of Service	Relative weight
Conventional Services	0.1736
E- services	0.2693
M-services	0.2689
RPA	0.2878

The same approach was followed for the cost hierarchy. Table 5 indicates the relative Weight for each of the service delivery methods with implementation and operational cost. In Table 6 a pairwise comparison of the relative costs of the different methods of delivering services against each other is conducted. It indicates that a high level of importance is attached to operation cost relative to implementation cost.

Finally, Table 7 provides a computation of the overall relative weights for costs of the different methods of delivering services. It indicates that conventional services are characterized by highest cost followed by M-services and E-services. RPA has the least cost.

Table 5. Relational scoring and relative weights of the different methods of services with respect to costs

(a) Complexity cost					
Type of Service	Conventional services	E-services	M-services	RPA	Relative weight
Conventional Services	1	1/3	1/5	1/5	0.067
E- services	3	1	1/4	1/2	0.144
M-services	5	4	1	5	0.564
RPA	5	2	1/5	1	0.225
(b) Human resource cost					
Type of Service	Conventional services	E-services	M-services	RPA	Relative weight
Conventional Services	1	6	6	7	0.652

E- services	1/6	1	1/2	2	0.115
M-services	1/6	2	1	1/2	0.119
RPA	1/7	1/2	2	1	0.114
(c) Facilities management cost					
Type of Service	Conventional services	E-services	M-services	RPA	Relative weight
Conventional Services	1	6	6	7	0.644
E- services	1/6	1	2	2	0.149
M-services	1/6	1/2	1	4	0.142
RPA	1/7	1/2	1/4	1	0.064
(d) Maintenance cost					
Type of Service	Conventional services	E-services	M-services	RPA	Relative weight
Conventional Services	1	7	7	6	0.659
E- services	1/7	1	2	3	0.166
M-services	1/7	1/2	1	1/2	0.071
RPA	1/6	1/3	2	1	0.104

Table 6. Relational scoring and relative weights of costs of the different methods of services against each other

Type of Cost	Complexity	Human resource	Facilities management	Maintenance	Relative Weight
Complexity	1	1/3	1/5	5	0.173
Human resource	3	1	6	7	0.542
Facilities management	5	1/6	1	1	0.210
Maintenance	1/5	1/7	1	1	0.076

Table 7. Overall relative weights for cost of the different methods of delivering services

Type of Service	Relative weight
Conventional Services	0.504
E- services	0.131
M-services	0.195
RPA	0.119

4. Results and Discussion

Based on the results of the benefit hierarchy, conventional services score the highest in terms of technical feasibility. This can be attributed to the lower need for technical requirements such as hardware and software while using this method of service delivery. Conventional services also score highest in terms of reliability relative to other methods thus suggesting that users could have concerns over the availability of the technology-based delivery methods. In terms of efficiency, E-services are the most efficient followed by RPA and M-services. In addition, M-services are ranked highest in terms of security followed by E-services. Based on the results, innovation is the highest in RPA followed by M-services and E-services. With respect to the cost hierarchy, cost incurred during the normal process of delivering the service is substantially higher than implementation cost for the service delivery methods. This explains why conventional services which are characterized mainly by use of human resources to provide service delivery have the highest costs. Overall, the ICT-based service delivery methods have almost similar benefits RPA (29%), E-services (27%) and M-services (27%) while conventional services have lowest benefits at 17%. The costs, on the other hand, vary between E-services (13%) and M-services (20%), and RPA (12%). However, conventional services have the highest overall cost of more than 50%. Overall, the normalized cost/benefit analysis reveals that most optimal service delivery methods are RPA with a low cost-to-benefit ratio of 9%, E-services at 11% and 16%. In contrast, Conventional services have a high normalized C/B ratio of 64%. In essence, the lower costs for ICT based service delivery methods can be attributed to the lower need for human resources and physical infrastructure such as in the case of conventional service delivery. This means that both the government and private sector can achieve significant benefits and cost reduction through adoption of ICT based service delivery methods.

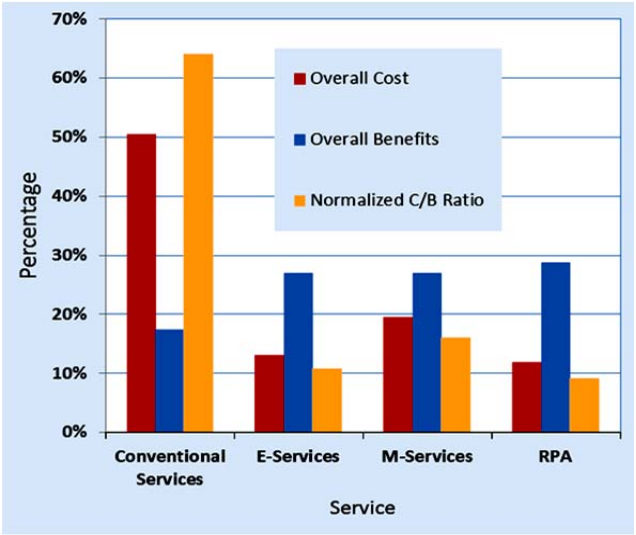

Figure 3. Comparison of benefits and costs of service delivery methods

5. Conclusions

Based on the AHP analysis, it has been demonstrated that robotic process automation (RPA) is the least expensive method that the government and private sector companies can use to delivery services in the UAE. Conventional services are the most expensive and have the least benefits. E-services and M-services are also beneficial methods as evident from the higher benefits compared to costs. However, it can be noted that each method of service delivery has its own benefits and hence may not be eliminated by both government and private sectors.

Accordingly, an optimal approach would be to make extensive use the ICT-based service delivery methods while using conventional services for complementary purposes at a relatively lower scale.

Appendix A

In this section, we will describe the procedure on how to calculate various relative weights presented in the paper. Other examples are given in the following references [7, 12, 17, 18].

I. Using the AHP pairwise comparison scale is outlined in Table A-1, the following scales are assigned for "Technical feasibility" criterion, against each other.
II. The next step is to normalize the values in the above table, by dividing each value by its corresponding sum, thus Table A-2 is produced.

Table A-1. "Technical feasibility" scales against each other

Type of Service	Conventional services	E-services	M-services	RPA
Conventional Services	1	8	8	9
E- services	1/8	1	3	7
M-services	1/8	1/3	1	3
RPA	1/9	1/7	1/3	1
Sum	**1.36**	**9.48**	**12.33**	**20**

Table A-2. Normalizing the "Technical feasibility" criterion, against each other

Type of Service	Conventional services	E-services	M-services	RPA
Conventional Services	0.735	0.844	0.649	0.450
E- services	0.092	0.106	0.243	0.350
M-services	0.092	0.035	0.081	0.150
RPA	0.082	0.015	0.027	0.050

III. The following step is taking the average of each row to calculate the relative weight of each system, as follows:

Table A-3. The calculated relative weights

Type of Service	Relative Weight
Conventional Services	0.669
E- services	0.198
M-services	0.090
RPA	0.043

IV. Similarly, the same procedure is followed to complete Tables 2 and 5, above.
V. Similar procedure is followed in determining the relative weights if Tables 3 and 6, above.
VI. The final step is to calculate the overall relative weights for benefits and costs as presented in Tables 4 and 7. The calculated overall relative weights is presented in Table A-4.
VII. Finally, the consistency index (CI) and consistency ratio (RI) are calculated to be smaller than 10% [12].

Table A-4. The calculated overall relative weights

Type of Service	Relative Weight
Conventional Services	0.669×0.048 + 0.051×0.154 + 0.046×0.223 + 0.541×0.192 + 0.051×0.383 = **0.1736**
E- services	0.198×0.048 + 0.518×0.154 + 0.306×0.223 + 0.227×0.192 + 0.178×0.383 = **0.2693**
M-services	0.090×0.048 + 0.197×0.154 + 0.521×0.223 + 0.182×0.192 + 0.217×0.383 = **0.2689**
RPA	0.043×0.048 + 0.233×0.154 + 0.126×0.223 + 0.050×0.192 + 0.554×0.383 = **0.2878**

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