AN AHP VARIATION MODELLING APPROACH FOR PERFORMANCE MEASUREMENT OF SUPPLIERS OF INFORMATION COMMUNICATION TECHNOLOGY PRODUCTS

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ABSTRACT

Selecting suitable suppliers of ICT products is always a challenging task for a procuring entity since it requires the consideration of multiple, competing, tangible and intangible criteria in determining optimal suppliers of a given product. This study investigated the evaluation criteria of suppliers of ICT products used by Moi University with a view to developing a multicriteria decision analysis model for evaluating the performance of suppliers of ICT products. Hence, the study was guided by a variation of Saaty's Analytical Hierarchy Process theory of measurement and targeted a population of 55 respondents comprised of 33 ICT staff and 22 procurement staff. Seventeen companies who bid to supply ICT products were targeted. Purposive sampling was used to select 7 companies who supply ICT products as per their prequalification status and there were 16 respondents; 11 from the Procurement unit and 5 from the ICT directorate respectively. Data was collected using questionnaires and documentary reviews. The study findings demonstrated that quality and transport and communication logistics were the most preferred evaluation criteria and sub criteria respectively, and the respondents had different preferential treatment on suppliers of ICT products as per the evaluation sub criterions. It is recommended that the model be adopted to assist the procurement unit in evaluating suppliers of ICT products and be customized for use in evaluating suppliers of other products at the University and other public institutions in Kenya.

Keywords: AHP; AHP variations; ICT product; Multicriteria Decision Analysis; performance evaluation; Suppliers of ICT products

1. Introduction

The selection of ICT suppliers is done in two phases. The first phase is the registration which is normally preceded by appraisal of potential suppliers through analysis of responses to questionnaires for registration in accordance with Regulation 8(3) of the Public Procurement and Disposal Regulations. The second phase is the pre-qualification of ICT suppliers. The purpose of this phase is to enhance short listing of the suppliers for specific procurements as per Regulation 23 of the Public Procurement and Disposal Regulation 2006 (G.O.K, 2009)

Dickson (1966) conducted a study to determine, identify and analyze the criteria used in the selection of suppliers and came up with twenty three evaluation criteria that have evolved over time the industry changes. A case in point is the dynamic ICT industry where hardware and software produced to the market change periodically. Samoei et al. (2016) observed that the suppliers of such products should be appraised continuously so as to determine their performance as per user preference criteria.

Shalle et al. (2014) noted that buyer-supplier evaluation is the process of evaluating and approving potential suppliers by factual and measurable assessment with the aim of identifying a portfolio of the best class of suppliers. In addition, Belton (2006) argued that the evaluation challenge is concerned with a choice between discretely defined alternatives. He also noted that multicriteria decision analysis(MCDA) is applicable in situations which necessitate the consideration of different courses of action based on various values. Similarly, suppliers of ICT products should be selected from a pool of suppliers in the market or from a prequalified list taking into consideration a set of evalution criteria. The supplier selected would be deemed optimal having met the set of evaluation criteria. This is in aggrement with Drucker (2002) who posited that, "A decision is a judgement which is a choice between alternatives. It is rarely a choice between right or wrong. It is at best a choice between "almost right" and "probably wrong"-but more often a choice between two courses of action neither of which is provably nearly right than the other" (p. 150).

2. Statement of the problem

An organization is required to maintain a reliable, efficient and effective supply-chain in order to achieve its core and non-core values and to maintain its competitive advantage in the market. The main categories of factors that make the decision of supplier selection complex are multiple qualitative and quantitative criteria, conflicting objectives of the criteria, involvement of many alternatives because of high competition and internal and external constraints imposed on buying process (Mwikali & Kavale, 2012). Any firm or organization must therefore have effective procedures for selecting suppliers of its goods and services. At Moi University, the evaluation and selection of vendors to supply ICT products is done by the Procurement unit and the ICT directorate.

Selecting suitable suppliers of ICT products is always a challenging task. A procuring entity must therefore consider multiple, competing, tangible and intangible criteria

before choosing an optimal supplier for a given product. The supply of ICT products needs to take into account the high procurement lead times because the rapid change in computing technology can render some ICT requests that are delivered late, obsolete. Cases of supply of ICT products which do not match the user specifications are prevalent, leading to their rejection during the testing and verification process. In such instances, implementation of ICT projects is frequently delayed. Such delays lead to non-realization of optimal utilization of the ICT investments in the long run.

The monetary value arising from such capital intensive ICT infrastructure needs to be considered when evaluating the suppliers of ICT products, so that only trusted and reliable suppliers are selected. Further, it is a popular saying that, "you cannot manage what you cannot measure" and further "if you cannot measure it, you cannot improve it."

Samoei et al. (2016) observed that the challenges inherent in selecting and maintaining suppliers of ICT products can be minimized by adopting a continous appraisal process. Thus, for public institutions like Moi University to reap maximum returns on the tangible and intangible ICT investments, they ought to adopt a model that measures both quantitative and qualitative criteria being aware of the fact that the lowest bidder is not always the optimum choice.

This study assessed the preferences in terms of the criteria and sub criteria used in evaluating suppliers of ICT products with a view towatd developing a multi criteria decision model based on the Analytical Hierarchy Process framework (AHP) for evaluating and measuring the performance of the suppliers of ICT products at Moi University (Saaty,1980). Consequently, the supplier evaluation and selection issue was addressed based on a hierarchy of criteria and sub criteria upon which the respective suppliers of ICT products are evaluated.

The AHP based multi-criteria decision making model developed, if adopted by the Procurement unit and ICT directorate to evaluate the suppliers of ICT products, could simplify the complex evaluation process used in determining optimal suppliers based on both quantitative and qualitative criteria. Subsequently, this will ensure that the procuring entity upholds the principles of procurement which encompasses professionalism, transparency, accountability, competitiveness, fairness and ethics as embodied in the Public Procurement and Disposal Act (G.O.K, 2015).

3. Methodology

The study adopted the AHP general theory of measurement, albeit with a variation, since it is an ideal decision making method for ranking alternatives when multiple criteria and sub-criteria are presented in the decision making processes (Tahriri, 2008). In the case of the supplier of ICT products the goal is to evaluate and rank suppliers as per their performance scores on the distinct criteria and sub criteria. Tam and Tummala (2001) applied AHP in vendor selection of a telecommunication system, which was a complex, multi-person, multi-criteria problem. They established that AHP was very useful since the situation involved several decision makers with different objectives to arrive at a consensus decision. Likewise, selection of suppliers of ICT products involves users from the ICT directorate who provide the product specifications and the procurement unit who source the suppliers. The decision is to

choose an effective supplier based on weighting of the criteria and sub criteria upon which their performance measurement priorities are derived.

The following steps, developed by Saaty (2008) for applying AHP were followed in the evaluation of criteria and Suppliers of ICT products:

Step 1: Problem definition and goal determination: The goal was to rate the suppliers of ICT products as per their score on various criteria

Step 2: Identification of all the criteria which affect the research problem: This was realized through literature review and interviewing experts. The criteria were separated in accordance with the level of internal relevance and individual independence.

Step 3: Structuring the problem hierarchically: This was from the top (the objectives as per procurement and ICT decision makers' point of view) through the intermediate levels (criteria on which subsequent levels depend) to the lowest level which contains the list of alternatives.

Step 4: Construction of a set of pair-wise comparison matrices (size n x n): This was done for each of the lower levels with one matrix for each element in the level immediately above by using the relative scale measurement shown in Table 1.

Table 1
Saaty's (1-9) scale for comparing criteria, sub-criteria and suppliers of ICT products relative to sub-criteria

Reference Level	Numerical Value
Equally preferred	1
Equally to moderately preferred	2
Moderately preferred	3
Moderately to strongly preferred	4
Strongly preferred	5
Strongly to very strongly preferred	6
Very strongly preferred	7
Very strongly to extremely preferred	8
Extremely preferred	9

Source: (Saaty, 1980)

The pair-wise comparisons are done in terms of which element dominates the other. If there are "n" criteria in one hierarchy, decision makers will be required to make n ((n -1)/2) judgments in order to develop the set of matrices as per step 4. Contrary, reciprocals are automatically assigned in each pair-wise comparison thus:

$$a_{ij} = 1/a_{ji} \text{ for } i,j = 1,2 \ldots n. \quad (1)$$

The AHP variation used in this study involved using a survey approach to rate the criteria and using the responses to build a perfectly consistent pairwise comparison matrix. This is not classical AHP since we did not question the experts in order to compare the criteria, but rather asked them to rate the criteria, then took an average to build the pairwise comparison matrix. The advantage of this approach is that it avoids the problem of overall inconsistency since the matrix built by calculating the weights as the ratio of the average score of each criteria is perfectly consistent.

Step 5: Hierarchical synthesis: The purpose of this step is to determine weights of the eigenvectors based on the weights of the criteria. The sum is taken over all weighted eigenvector entries corresponding to those in the next lower level of the hierarchy. This is as demonstrated by Equations 4 and 5.

Step 6: Consistency test: The purpose of this step is to determine whether the calculation fit the condition for the transitivity in priority. Consistency ratio (CR) is used to verify the credibility and reasonability of evaluation and to check whether there is inconsistency principal right in subjective judgments. The CR is acceptable if it does not exceed 0.1(Saaty, 1980). The consistency is determined by using the eigenvalue, λ_{max}. Consistency index (CI) –which was 0 in our study- and Consistency ratio (CR) are calculated thus:

$$CI = \frac{(\lambda_{\max} - \mathrm{n})}{\mathrm{n} - 1} \qquad (2)$$

$$\mathrm{CR} = \left(\frac{\mathrm{CI}}{\mathrm{RIn}}\right) \qquad (3)$$

The positive reciprocal matrix generated by the evaluation process yields different CI values at each level referred to as random indexes. λ_{max} is the maximized eigenvector of a pair wise comparison matrix, *n* is an attribute of the matrix, and RI_n is a random index as shown in Table 2 (Saaty, 1980).

Table 2
Saaty's Random Index Table

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.90	1.12	1.25	1.32	1.41	1.45	1.49	1.54	1.48	1.56	1.57	1.59

Source: (Saaty, 1980)

Step 7: Synthesis via Normalization: Because the PWC was perfectly consistent, the study normalized the weights of the internal level(s) and connected the local weight to acquire the global weights of the criteria in each hierarchy after calculating the weights of all criteria. The application of the aforementioned 7 steps is illustrated in Tables 4.1 to 4.1.2 in the determination of respondent's consistency in judgment on the seven evaluation criteria.

3.1 Modelling the suppliers of ICT products decision problem

Figure 1 is the AHP hierarchical structure that guided the evaluation and selection of suppliers of ICT products at Moi University. The problem hierarchy had four levels, namely; level 0, level 1, level 2 and level 3. Level 0 represents the goal of the evaluation

which was to rate the research alternatives based on their performance scores as per criteria. Level 1 ranged from **i-1** to **i+1** and level 2 ranged from $(i\text{-}1)_1$ to $(i+1)_2$ representing the criteria and sub criteria respectively that were used in the rating of the alternatives. Level 3 represented the alternatives which were the various suppliers of ICT products. The lines between levels indicated the relationship amongst the given levels.

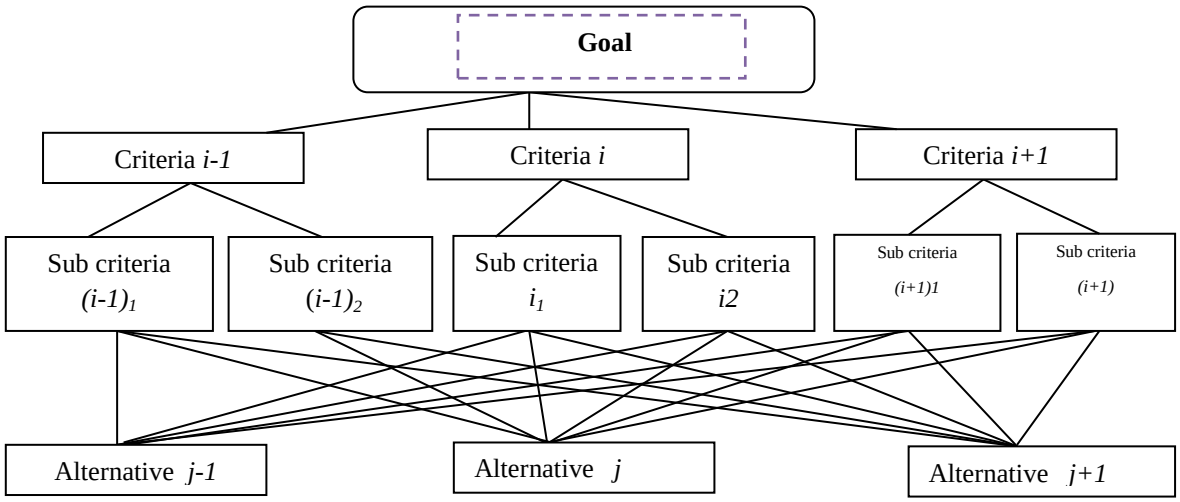

Figure 1. Adapted AHP hierarchical structure (Samoei, 2016)

Figure 2 illustrates the conceptualization of the evaluation and selection of suppliers of ICT at Moi University as an AHP multi-criteria hierarchical decision problem. The study structured the evaluation and selection problem into four levels namely: the goal, the criteria, the sub-criteria and alternatives. The goal (level 0) was to rate the suppliers of ICT products according to their score on the given performance sub criterions under study. At level one of Figure 2, seven criteria (7) were selected and rated in the study. These were delivery (D), quality (Q), supplier status (SS), supplier culture (SC), flexibility (F), financial stability (FS), and commercial interest (CI).

The second level of the hierarchy was the sub criteria. A total of twenty seven (27) sub criteria were considered thus: the delivery sub criterions were geographical location (GL) and transport and communication logistics (TCL); the quality sub criterions were quality of product (QP), percentage of on time deliveries (PTD), response to customer requests (RCR) and after sale services (ASS); the supplier status sub criterions were its employees (E), reputation in the market (RM),reference clients (RC) and existing relationships (ER); the supplier culture sub criterions were trust (T),integrity (IG), professionalism (P), innovation (IN) and understanding of organizational goals (UOG); the flexibility sub criterions were capacity (C), technical capability (TC),information sharing capability (IS) and availability (A); the financial stability sub criterions were business turnover (BT), cash flow (CF) and tax compliance (TxC) and finally the commercial interest sub criterions were competitive pricing (CP), ownership structure/history (OSH), intellectual property rights (IPR), non-disclosure of information(NDI) and currency stability (CS).

Finally, the third level of the AHP conceptual model had seven alternatives (Suppliers of ICT products to be rated based on criteria and sub criteria). These were coded as Supplier A, Supplier B, Supplier C, Supplier D, Supplier E, Supplier F and Supplier G respectively (Figure 2). Table 3 is a description of the seven criteria (level 1) and twenty seven respective performance sub criterions(level 2) and the seven suppliers (level 3) sampled for the study (Tables 8 and 9).

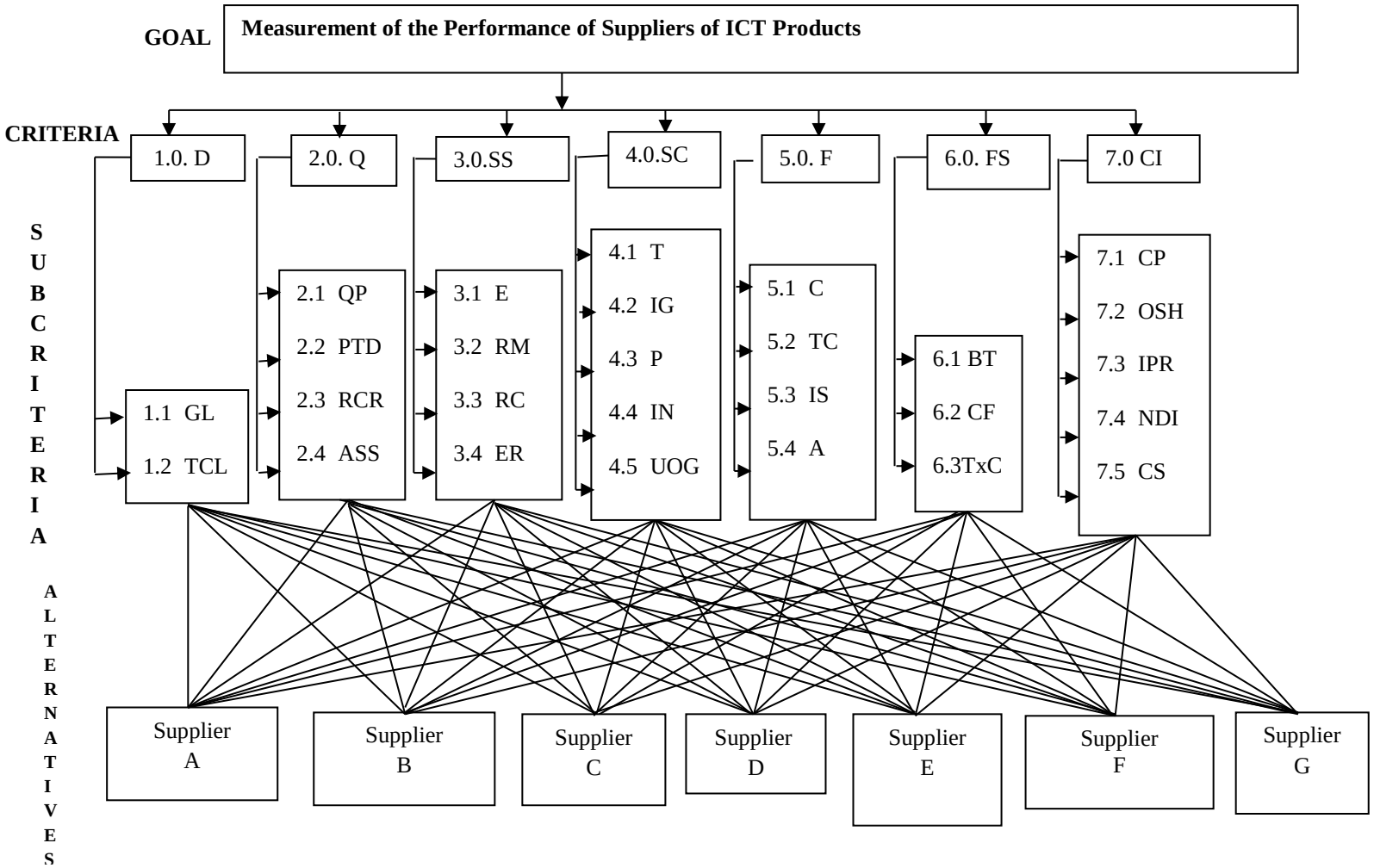

Figure 2. An AHP decomposition of the suppliers of ICT products Multicriteria Decision problem
Adapted with modifications from Samoei (2016)

Table 3
Performance evaluation criteria for suppliers of ICT products

S/N	Criteria	Abbreviation	S/N	Sub-criteria	Abbreviation	Description
1.0	Delivery	D	1.1	Geographical Location	GL	Location of the supplier relative to the procuring entity
			1.2	Transport and Communication Logistics	TCL	The nature of transport and communication network
2.0	Quality	Q	2.1	Quality of Product	QP	Quality of the ICT product delivered relative to user per specifications
			2.2	Percentage of On time deliveries	PTD	The amount of deliveries made on time
			2.3	Response to customer requests	RCR	The ability of the supplier to attend to client's requests/queries
			2.4	After sale services	ASS	The support services rendered to the procuring entity by the supplier
3.0	Supplier Status	SS	3.1	Employees	E	The number and quality of supplier's employees
			3.2	Reputation in the market	RM	The supplier's standing in the ICT market
			3.3	Reference clients	RC	The nature of clients that the supplier has rendered services
			3.4	Existing relationships	ER	The nature of ties/bond that exist between the supplier and the university
4.0	Supplier Culture	SC	4.1	Trust	T	Trustworthiness of the supplier
			4.2	Integrity	IG	Commitment to the process of due diligence.
			4.3	Professionalism	P	The ability of the supplier to render services professionally
			4.4	Innovativeness	IN	The ability of the supplier to provide innovative/unique solutions
			4.5	Understanding of Organizational goals	UOG	The supplier's understanding of the organizations goals/strategic direction

Table 3 continued

S/N	Criteria	Abbreviation	S/N	Sub-criteria	Abbreviation	Description
5.0	Flexibility	F	5.1	Capacity	C	The ability of the supplier varying volumes of requests
			5.2	Technical Capability	TC	The ICT technical infrastructure available
			5.3	Information sharing capability	IS	The ability and willingness of the supplier to share product information with customer
			5.4	Availability	A	A measure of supplier's willingness to avail services when needed
6.0	Financial Stability	FS	6.1	Business turnover	BT	The amount of sales made in a given period of time
			6.2	Cash flow	CF	The supplier's liquidity
			6.3	Tax compliance	TxC	The percentage of tax compliance made to Kenya Revenue Authority
7.0	Commercial Interest	CI	7.1	Competitive Pricing strategies	CP	The strategies adopted to remain competitive in the ICT market
			7.2	Ownership structure/History	OSH	The organization structure
			7.3	Implementation of Intellectual property rights		The ability to implement relevant software and hardware intellectual property rights
			7.4	Non-disclosure of information	NDI	The ability to maintain client's confidential information
			7.5	Currency stability	CS	The stability supplier's trading currency
			7.1	Competitive Pricing strategies	CP	The strategies adopted to remain competitive in the ICT market

Adapted from Samoei (2016)

3.2 Data collection and sampling

Documentary reviews were carried out to determine the criteria and sub criteria used by the ICT directorate and procurement unit during the evaluation of suppliers of ICT products where seven criteria and their respective27 sub criteria as shown in Table 3 were selected for modelling the evaluation and selection problem (Figure 2). Based on the 7 criteria, 27 sub criteria and the 7 suppliers of ICT products sampled for the study (Figure 2) , an AHP questionnaire was structured where respondents ticked the desired options from a scale of 1 to 9 (Saaty, 1980). Fourteen questionnaires were distributed and ten valid questionnaires were returned representing a 71% response rate (Table 4) .The respondents who returned the questionnaires was a good representation of the population in relation to the unit of service (Table 4).

Table 4
Response rate

Unit	Issued	Returned	Response Rate
ICT	4	3	75%
Procurement	10	7	70%
Total	14	10	71%

Adapted from Samoei (2016)

3.3 Hierarchy structure analysis

This involved the computations of the priority weights of the proposed AHP measurement model based on the four levels as illustrated in Figure 2. This was done through pair wise comparisons of the criteria, sub criteria and supplier of ICT products at each level as per nine-point scale as indicated in Table 1(Saaty, 1980). Hence, Tables 6 to 8 illustrate the steps followed in the computation of priority weights of criteria based on the respondents average ratings shown in Table 4. The consistency test for the evaluation criteria was 0 indicating a consistency in judgement.

Table 5
Average rating of criteria based on the rating survey

Criteria	D	Q	SS	SC	F	FS	CI
Rating	4	5.25	4.75	3.75	3.88	4.6	5.125

Adapted from Samoei (2016)

Table 6
Criteria pair wise comparison matrix

	D	Q	SS	SC	F	FS	CI
D	D/D	D/Q	D/SS	D/SC	D/F	D/FS	D/CI
Q	Q/D	Q/Q	Q/SS	Q/SC	Q/F	Q/FS	Q/CI
SS	SS/D	SS/Q	SS/SS	SS/SC	SS/F	SS/FS	SS/CI
SC	SC/D	SC/Q	SC/SS	SC/SC	SC/F	SC/FS	SC/CI
F	F/D	F/Q	F/SS	F/SC	F/F	F/FS	F/CI
FS	FS/D	FS/Q	FS/SS	FS/SC	FS/F	FS/FS	F/CI
CI	CI/D	CI/Q	CI/SS	CI/SC	CI/F	CI/FS	CI/CI

Adapted from Samoei (2016)

Table 7
Criteria pair wise comparison matrix

	D	Q	SS	SC	F	FS	CI
D	1	0.7619	0.8421	1.0667	1.0309	0.8696	0.7805
Q	1.3125	1	1.1053	1.4	1.3531	1.1413	1.0244
SS	1.1875	0.9048	1	1.2667	1.2242	1.0326	0.9268
SC	0.9375	0.7143	0.7895	1	0.9665	0.8153	0.7317
F	0.9700	0.7390	0.8168	1.0347	1	0.8435	0.7571
FS	1.1500	0.8762	0.9684	1.2267	1.1856	1	0.8976
CI	1.2813	0.9762	1.0789	1.3667	1.3209	1.1141	1
Sum	**7.8388**	**5.9724**	**6.5974**	**8.3615**	**8.0812**	**6.8164**	**6.1181**

Adapted from Samoei (2016)

3.4 Normalized Relative Weight of criteria

The Normalized relative weight criteria are obtained by dividing each element in the matrix in Table 7 with the column sum.

Table 8
Normalized Relative Weight of criteria

	D	Q	SS	SC	F	FS	CI	Sum	Average
D	0.1276	0.1276	0.1276	0.1276	0.1276	0.1276	0.1276	0.8932	0.1276
Q	0.1674	0.1674	0.1675	0.1674	0.1674	0.1674	0.1674	1.1719	0.1674
SS	0.1515	0.1515	0.1516	0.1515	0.1515	0.1515	0.1515	1.0606	0.1515
SC	0.1196	0.1196	0.1197	0.1196	0.1196	0.1196	0.1196	0.8373	0.1196
F	0.1237	0.1237	0.1238	0.1238	0.1237	0.1237	0.1237	0.8661	0.1237
FS	0.1467	0.1467	0.1468	0.1467	0.1467	0.1467	0.1467	1.0270	0.1467
CI	0.1635	0.1635	0.1635	0.1635	0.1635	0.1634	0.1634	1.1443	0.1634
Sum	**1**	**1**	**1**	**1**	**1**	**1**	**1**		

Adapted from Samoei (2016)

The Principal Eigenvector is obtained by getting the average across the rows as shown in Table 8.

3.5 Consistency test

Determination of Principal Eigen Value (λ_{max})

$$\boldsymbol{\lambda_{max}} = [7.8388 \;\; 5.9724 \;\; 6.5974 \;\; 8.3615 \;\; 8.0812 \;\; 6.8164 \;\; 6.1181] \times \begin{pmatrix} 0.1276 \\ 0.1674 \\ 0.1515 \\ 0.1196 \\ 0.1237 \\ 0.1467 \\ 0.1635 \end{pmatrix}$$

$$= 1.000+0.999+0.999+1.000+0.999+0.999+1.000$$

$$= 6.999$$

$$\tilde{} \; 7.000$$

Determination of Consistency Index (CI)

$$CI = (\lambda max - n)/(n-1) \quad \textit{(Refer to equation 1)}$$

$$= (7-7) / (7-1)$$

$$= 0$$

Since, CR<0.1, it implies that the respondents evaluation about suppliers of ICT products criteria preference is consistent (Saaty, 1980).

3.5.1 Criteria level weights and ranking

The ranking of the seven criteria was based on the normalized principal eigen vector (priority vector) as computed in Table 7 and their ranking is as shown in Table 9.

Table 9
Criteria level weights and ranking

Criteria	Priority Weight	Rank
Quality(Q)	0.16733	1
Commercial Interest(CI)	0.16335	2
Supplier Status(SS)	0.15139	3
Financial Stability(FS)	0.14741	4
Delivery(D)	0.12749	5
Flexibility(F)	0.12351	6
Supplier Culture(SC)	0.11952	7

3.5.2 Sub criteria level weights and ranking

The global weight (priority weight) of the sub criteria was calculated thus:

$$\text{Sub criteria Global weight} = \text{Criteria Priority weight} \times \text{Sub criteria Local weight} \quad (4)$$

Hence, Table 10 shows the global weights of each sub criteria and the ranking within their respective sets of criteria.

Table 10
Sub criteria level weights and ranking

Criteria	Priority Weight	Sub-criteria	Local Weight	Global Weights	Ranking
Delivery(D)	0.12749	Transport and Communication Logistics	0.444	0.07083	1
		Geographical Location	0.556	0.05666	2
Quality(Q)	0.16733	Quality of Product	0.288	0.04816	1
		Percentage of On time deliveries	0.249	0.04163	2
		Response to customer requests	0.233	0.03898	3
		After sale services	0.230	0.03857	4
Supplier Status(SS)	0.15139	Reputation in the market	0.286	0.04326	1
		Existing relationships	0.280	0.04235	2
		Reference clients	0.250	0.03785	3
		Employees	0.185	0.02794	4
Supplier Culture(SC)	0.11952	Professionalism	0.233	0.02782	1
		Integrity	0.219	0.02618	2
		Trust	0.216	0.02586	3
		Innovativeness	0.172	0.02060	4
		Understanding of Organizational goals	0.159	0.01906	5
Flexibility(F)	0.12351	Technical Capability	0.283	0.03493	1
		Availability	0.263	0.03244	2
		Capacity	0.247	0.03056	3
		Information sharing capability	0.207	0.02557	4
Financial Stability(FS)	0.14741	Tax compliance	0.403	0.05940	1
		Cash flow	0.306	0.04510	2
		Business turnover	0.291	0.04290	3
Commercial Interest(CI)	0.16335	Competitive Pricing strategies	0.221	0.03604	1
		Currency stability	0.207	0.03374	2
		Implementation of Intellectual property rights	0.197	0.03221	3
		Non-disclosure of information	0.192	0.03144	4
		Ownership structure/History	0.183	0.02991	5

NB: In all the cases the inconsistency ratio (CR= 0) implying that the respondents judgements were perfectly consistent.

The results of AHP analysis through Expert Choice Professional Version 9.48S25 on the preference of the sub criteria by the respondents as shown in Table 10 is summarised thus:

- Delivery Sub Criterions**:** The results indicated that of the two sub criterions considered, transport and communication logistics (TCL) was the most preferred over geographical location (GL) (Table 10).
- Quality Sub Criterions: The order of preference of the four quality sub criterions in a descending order was: quality of product (QP), percentage of on time deliveries (PTD), and responses to customer requests (RCR) and after sale service (ASS) (Table 10).

- Supplier Status Sub Criterions**:** The order of preference of the four supplier status sub criterions in a descending order was: reputation in the market (RM), existing relationship(ER), reference clients (RC) and employees (E) (Table 10).
- Supplier Culture Sub criterions: The order of preference of the five supplier culture sub criterions in a descending order was: professionalism (P), integrity (I), trust (T), innovativeness (IN) and understanding of organizational goals (UOG) (Table 10).
- Flexibility Sub Criterions: The order of preference of the four flexibility sub criterions in a descending order was technical capability (TC), availability (A), capacity (C) and information sharing capability (IS) (Table 10).
- Financial Stability Sub Criterions: The findings indicated that the order of importance of the three financial stability sub criterions in a descending order was: tax compliance (TXC), cash flow (CF) and business turnover (BT) (Table 10).
- Commercial Interest Sub Criterions**:-**The findings showed that the order of preference of the five commercial interest sub criterions in a descending order was: competitive pricing strategies (CP), currency stability (CS), implementation of intellectual property rights (IPR), non-disclosure of information (NDI) and ownership structure/history (OSH) (Table 10).

Thus, from the aforementioned analysis, transport and communication logistics (7.083 %), quality of product (4.816%), reputation in the market (4.326%), professionalism (2.782%), technical capability (3.493 %), tax compliance (5.94%) and competitive pricing strategies (3.604%) were the highest ranked sub criteria within their respective sets (Table 10).

3.5.3 Sub criteria priority ranking

Table 11 shows the descending order of sub criteria ranking as derived from Table 10.

Table 11
Sub criteria overall ranking

Sub criteria	Global Weight	Rank
Transport and Communication Logistics	0.07083	1
Tax compliance	0.05940	2
Geographical Location	0.05666	3
Quality of Product	0.04816	4
Cash flow	0.04510	5
Reputation in the market	0.04326	6
Business turnover	0.04290	7
Existing relationships	0.04235	8
Percentage of On time deliveries	0.04163	9
Response to customer requests	0.03898	10
After sale services	0.03857	11
Reference clients	0.03785	12
Competitive Pricing strategies	0.03604	13
Technical Capability	0.03493	14
Currency stability	0.03374	15
Availability	0.03244	16
Implementation of Intellectual property rights	0.03221	17
Non-disclosure of information	0.03144	18
Capacity	0.03056	19
Ownership structure/History	0.02991	20
Employees	0.02794	21
Professionalism	0.02782	22
Integrity	0.02618	23
Trust	0.02586	24
Information sharing capability	0.02557	25
Innovativeness	0.02060	26
Understanding of Organizational goals	0.01906	27

3.6 Measurement of the performance of the suppliers of ICT products

The next level was assessing performance of the alternatives (level 3) as per the developed AHP conceptual model (Figure 2) who were the 7 suppliers of ICT Products at Moi University who had been randomly selected for the study. They were evaluated based on the sub criterions (level 3).The global weights of each supplier were computed thus:

$$\text{Supplier of ICT Products Global weight} = \text{Supplier's Local Weight} \times \text{Sub criteria Global weight} \quad (5)$$

The findings showed that each of the 7 suppliers performed differently on each of the 27 rating sub criterions (Table 7) demonstrating the different preferential treatment by the respondents. The summation of the 27 global weights for each of the 7 individual suppliers gave the performance score of the supplier of ICT Products at Moi University as shown in Table 12.

Table 12
Performance of the suppliers of ICT products

				Supplier A		**Supplier B**		**Supplier C**		**Supplier D**		**Supplier E**		**Supplier F**		**Supplier G**	
Criteria	Sub-criteria	Global Weight	Rank	Local Weight	Global Weight	Local Weight	Global Weight	Local Weight	Global Weight	Local Weight	Global Weight	Local Weight	Global Weight	Local Weight	Global Weight	Local Weight	Global Weight
D	GL	0.05666	3	0.164	0.009292	0.174	0.009859	0.126	0.007139	0.141	0.007989	0.115	0.006516	0.156	0.008839	0.123	0.0069692
	TCL	0.07083	1	0.166	0.011758	0.163	0.011545	0.154	0.010908	0.152	0.010766	0.105	0.007437	0.141	0.009987	0.118	0.0083579
Q	QP	0.04816	4	0.170	0.008187	0.170	0.008187	0.155	0.007465	0.160	0.007706	0.086	0.004142	0.152	0.007320	0.108	0.0052013
	PTD	0.04163	9	0.165	0.006869	0.162	0.006744	0.177	0.007369	0.145	0.006036	0.100	0.004163	0.145	0.006036	0.106	0.0044128
	TCR	0.03898	10	0.170	0.006627	0.175	0.006822	0.177	0.006899	0.153	0.005964	0.075	0.002924	0.147	0.005730	0.102	0.003976
	ASS	0.03857	11	0.198	0.007637	0.167	0.006441	0.149	0.005747	0.152	0.005863	0.090	0.003471	0.121	0.004667	0.121	0.004667
SS	E	0.02794	21	0.166	0.004638	0.169	0.004722	0.165	0.004610	0.165	0.004610	0.091	0.002543	0.127	0.003548	0.118	0.0032969
	RM	0.04326	6	0.164	0.007095	0.153	0.006619	0.157	0.006792	0.157	0.006792	0.109	0.004715	0.141	0.006100	0.117	0.0050614
	RC	0.03785	12	0.167	0.006321	0.146	0.005526	0.152	0.005753	0.171	0.006472	0.106	0.004012	0.147	0.005564	0.111	0.0042014
	ER	0.04235	8	0.155	0.006564	0.160	0.006776	0.173	0.007327	0.170	0.007200	0.085	0.003600	0.150	0.006353	0.106	0.0044891
SC	T	0.02586	24	0.158	0.004086	0.168	0.004344	0.161	0.004163	0.158	0.004086	0.091	0.002353	0.144	0.003724	0.120	0.0031032
	I	0.02618	23	0.173	0.004529	0.163	0.004267	0.155	0.004058	0.155	0.004058	0.104	0.002723	0.144	0.003770	0.107	0.0028013
	P	0.02782	22	0.168	0.004674	0.154	0.004284	0.148	0.004117	0.159	0.004423	0.120	0.003338	0.139	0.003867	0.112	0.0031158
	INN	0.02060	26	0.151	0.003111	0.171	0.003523	0.166	0.003420	0.168	0.003461	0.102	0.002101	0.129	0.002657	0.113	0.0023278
	UOG	0.01906	27	0.159	0.003031	0.164	0.003126	0.168	0.003202	0.151	0.002878	0.110	0.002097	0.138	0.002630	0.110	0.0020966
F	C	0.03056	19	0.165	0.005042	0.160	0.004890	0.166	0.005073	0.163	0.004981	0.099	0.003025	0.141	0.004309	0.108	0.0033005
	TC	0.03493	14	0.172	0.006008	0.162	0.005659	0.160	0.005589	0.162	0.005659	0.099	0.003458	0.140	0.004890	0.105	0.0036677
	ISC	0.02557	25	0.158	0.004040	0.170	0.004347	0.147	0.003759	0.150	.038360	0.130	0.003324	0.157	0.004014	0.089	0.0022757
	A	0.03244	16	0.165	0.005353	0.165	0.005353	0.165	0.005353	0.154	0.004996	0.112	0.003633	0.137	0.004444	0.101	0.0032764
FS	BT	0.04290	7	0.177	0.007593	0.159	0.006821	0.160	0.006864	0.160	0.006864	0.105	0.004505	0.138	0.005920	0.132	0.0056628
	CF	0.04510	5	0.181	0.008163	0.153	0.006900	0.149	0.006720	0.136	0.006134	0.109		0.163	0.007351	0.109	0.0049159
	TXC	0.05940	2	0.166	0.009860	0.166	0.009860	0.165	0.009801	0.165	0.009801	0.103	0.006118	0.130	0.007722	0.103	0.0061182
CI	CPS	0.03604	13	0.165	0.005947	0.160	0.005766	0.158	0.005694	0.166	0.005983	0.101	0.003640	0.144	0.005190	0.107	0.0038563
	OSH	0.02991	20	0.176	0.005264	0.148	0.004427	0.146	0.004367	0.174	0.005204	0.113	0.003380	0.138	0.004128	0.105	0.0031406
	IIP	0.03221	17	0.176	0.005669	0.147	0.004735	0.144	0.004638	0.155	0.004993	0.132	0.004252	0.135	0.004348	0.111	0.0035753
	NDI	0.03144	18	0.159	0.004999	0.167	0.005250	0.164	0.005156	0.134	0.004213	0.130	0.004087	0.117	0.003678	0.130	0.0040872
	CS	0.03374	15	0.190	0.006411	0.130	0.004386	0.152	0.005128	0.178	0.006006	0.101	0.003408	0.135	0.004555	0.113	0.0038126
SUPPLIER'S SCORE					**0.16877**		**0.16118**		**0.15711**		**0.15697**		**0.10388**		**0.14134**		**0.111767**
SUPPLIER'S RANKING					**1**		**2**		**3**		**4**		**7**		**5**		**6**

Table12 shows the descending order of performance of the suppliers of ICT products being Supplier A (0.16877),Supplier B (**0**.16118),Supplier C (0.15711),Supplier D (0.15697), Supplier E (0.14134), Supplier F (0.111767) and Supplier G (0.10388).

4. Conclusion

This study investigated and assessed the criteria used to evaluate suppliers of ICT products with a view to developing an AHP-variation based multi criteria decision model for measuring the performance of suppliers of ICT products. The AHP variation used in this study consisted in using a survey approach to rate the criteria and using the responses to build a perfectly consistent pairwise comparison matrix to calculate the criteria weights. This solves the problem of obtaining inconsistent pairwise comparison matrices when surveying many respondents. The study findings showed that the performance of a supplier of ICT products is dependent on an individual score on the varied criteria and respective sub criteria as demonstrated by the AHP modelling approach. Based on the evaluation results, a supplier would be deemed optimum if he is extremely preferred on each and every criteria/sub criteria used in the evaluation process, in addition to being rated highly on the highest ranked sub criterions. Hence, the AHP-variation multi-criteria decision making model developed can enable a procuring entity to select or reject suppliers of ICT products based on the score attained on a given criteria or set of criteria depending on the type of hardware, software or ICT service being procured. Applied consistently, the model can enable public procuring entities to enhance transparency in the procurement processes.

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