International Journal of Computer and Organization Trends
ISSN: 2249 – 2593 / https://doi.org/10.14445/22492593/IJCOT-V12I1P307
Volume 12 Issue 1, 37-48, Jan-Apr 2022
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Original Article

Webometrics User Ranking Analysis Model Development and Validation

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Received Date: 18 March 2022
Revised Date: 27 April 2022
Accepted Date: 29 April 2022

Abstract *- The webometrics user ranking analysis model was developed and validated. The need for the model arose as directorates of ICT in Kenyan Universities were assigned the challenge of improving their university's webo ranking. Webo ranking is the preferred method of the universities to showcase their niche and what they do to the global community. There are no published models for webometrics ranking. This leads to each university taking different approaches. In this paper, a model has been developed and validated.*

Keywords *- Webometrics, Ranking, Model, Attributes, Validation.*

I. INTRODUCTION

Kenya university's performance is measured based on Webometrics ranking, performance contracting, and quality assurance based on ISO: 9001:2015 standard [1]. The standard gives a guideline of what the university should do to acquire and retain the certification. In performance contracting, there are Performance Contracting Guidelines [2] that outline what should be done and away of self-evaluation. None of these exists as far as webometrics ranking is concerned.

The existing literature has made recommendations on indicators used to evaluate webometrics ranking and best practices to be considered for improved webometrics ranking [3]. However, there is no published model for guiding university's ICT departments to realize improved webometrics ranking.

II. RESEARCH METHODOLOGY

The target population for the study was the top 5 universities in the January 2020 edition of webometrics ranking in Kenya. In this research, universities are identified as Varsity1 to Varsity5 as they appear in the January 2020 webometrics ranking.

The study used a mixed research method where survey and quasi-experiment were used. The study employed both quantitative and qualitative data that allowed the study to explore relationships that exist between multidimensional research questions [4]. Survey design employs both quantitative and qualitative data [5] collection for primary and secondary data used in the study. In the study, primary data was collected by using questionnaires to identify website attributes that constitute user webometrics ranking experiences.

Experiment design is characterized by one or more independent variables that are manipulated by the researcher (as treatments), subjects are randomly assigned to different treatment levels (random assignment), and the results of the treatments on outcomes (dependent variables) are observed [6][7]. There are various types of experimental designs. These include Pre-experimental, quasi-experimental, and true experimental designs.

In a pre-experimental research design, various dependent groups are observed for the effect of the application of an independent variable that is presumed to cause change. Still, there is no control group (the group that remains fixed). In quasi-experiments, subjects are not randomly assigned to treatments. It is used in settings where randomization is difficult or impossible. True experimental designs employ randomization to control the effects of variables. It uses statistical analysis to support or reject a hypothesis [8]. In this research, a quasi-experiment will be used to assess and evaluate websites' usability and analyze Google scholar citations.

A.Questionnaires

Questionnaires were used as an instrument of data collection. They were developed based on specific objectives. Questionnaires were administered to staff of the selected universities. Closed-ended questions were used to collect data.

B. Quasi-experiment

The quasi-experiment was also used as an instrument of data collection. Web analysis tools such as Google scholar citation tool, Pingdom speed test, website Grader, and Ahrefs were used to analyze and evaluate university websites and citations. Simulation of the study was done between June 14th, 2021 to August 14th, 20214][9]
The quasi-experiment procedure entailed:

i. Open web analysis tool example: https://www.woorank.com/, https://website.grader.com/, and https://ahrefs.com/ on any browser

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ii. Log in to the page if required.
iii. In the displayed textbox, enter the university URL and press enter button on the keyboard to analyze a website attribute.
iv. Website attribute performance scores were loaded after a while.
v. Performance scores for various attributes were recorded for analysis.

III. RELATED STUDIES

In this section, we look at existing models to check on limitations. We also look at user experience at Kibabii University.

A. Existing Models

Cybermetrics Lab, a Spanish National Research Council, has been ranking the Web of World Universities (Webometrics) since 2004 to motivate institutions of higher education and scholars to have a significant web presence that showcases their activities [10].

INDICATORS	MEANING	METHODOLOGY	SOURCE	WEIGHT
PRESENCE	Public knowledge shared	Size (number of **pages**) of the main webdomain of the institution. It includes **all the subdomains** that share the same (central/main) webdomain	*Google*	5%
VISIBILITY	Web contents Impact	Number of **external networks** (subnets) linking to the institution's webpages (normalized and then average value)	*Ahrefs Majestic*	50%
TRANSPARENCY (or OPENNESS)	Top cited researchers	Number of **citations** from **Top 110 authors** (excl. 10 outliers) See Transparent Ranking for additional info	*Google Scholar Profiles*	10%
EXCELLENCE (or SCHOLAR)	Top cited papers	Number of **papers** amongst the top 10% most cited in the 26 disciplines Data for the five year period: **2013-2017**	*Scimago*	35%

Fig. 1 Webometrics ranking indicators

Webometrics ranking is strongly linked to the quality and volume of the web content published by higher education institutions. The institution's web data is usually collected between the 1st and 20th of January or July, depending on the Webometrics ranking edition. The publication of webometrics rank is done about late January or July, usually not before the 28th.

Webometrics ranking is evaluated based on four indicators with different weights, as shown in Fig. 1. The presence indicator is the total number of web pages hosted in the main web domain (including all the subdomains and directories) of the university as indexed by the largest commercial search engine (Google), having a 5% weight [10]. The visibility indicator is the total number of external networks (backlinks) linking to the institution's domain. "The final indicator is obtained from the product of square root of the number of backlinks and the number of domains originating those backlinks (favoring link diversity)"[11]. This indicator weighs 50%.

The openness indicator is the number of citations Google scholar from the top 110 researchers in a university, excluding 10 outliers. Openness data weights 10%. The excellence indicator is the number of papers researchers have published in high-impact international journals for five years (2013 to 2017). The data provider for the excellence indicator is the Scimago group. The excellence indicator weighs 35%. However, the Google Scholar citation is not provided with reference to the size of the institution's staff wise. Apart from stating the indicators and their weights, they have not published the model for users to predict their ranking and determine ways to improve the same.

Unibank university's ranking is evaluated based on five indicators; Moz domain authority, Alexa global rank, Similarweb global rank, Majestic referring domains, and Majestic trust flow[12]. Moz domain authority indicator evaluated the institution's domain authority. Alexa global rank indicator

Evaluates the institution's website traffic. Similarweb global rank indicator evaluates website traffic, and it is used to complement and enhance the Alexa global rank score. The majestic referring domains indicator evaluates referring backlinks to the university domain, and the Majestic trust flow indicator evaluates the quality of the referring backlinks. However, there is no publication of the model that would assist users in determining improvement areas in advance.

B. Kenya University Webometrics Ranking Experiences

Kibabii University has been keeping track of her performance in webometrics ranking since July 2018, as shown in Table 1. Lower rank values denote better performance.

In the January 2017 edition of the webometrics ranking, Kibabii University was ranked position 62 in Kenya; due to this ICT directorate held a meeting on 2nd March 2017 to deliberate on the way forward in improving webometrics ranking for the university [13].

Table 1. Kibabii university ranking

Month	Presence	Impact	Openness	Excellence	Kenyan Rank	Global Rank
January 2020	3681	12872	4393	6084	19	9060
July 2019	5659	11660	4764	6115	16	8786
January 2019	8870	9787	5817	6033	14	7819
July 2018	3033	6119	7391	5974	10	6441

Several strategies were put in place and implemented. During July 2018 webometrics ranking, Kibabii University was in position 10. Kibabii University community is passionate about its performance in webometrics ranking. Strategies have been made towards improved webometrics ranking over the years; these include; Registering academic staff to Google scholar, Creating backlinks with other institutions, Increasing web content upload frequency, and changing kibabii university. ac.ke URL to kibu.ac.ke among other [14].

IV. MODEL DEVELOPMENT AND VALIDATION.

A model can be defined as a simplified representation of a physical system. To solve a problem, a description of the system configuration must be informed and amenable to analysis, design/development, and validation [15].

The model was developed and validated both empirically and by expert opinions. Suppose the model has not gone through basic out-of-time validation tests. In that case, it might be possible that the model is an overfitted model which performed well on the development sample but fails on unseen data hence the need for validation [16][17].

A. Model Development

Models can be statistical or probabilistic. Probabilistic models integrate random variables and probability distributions into an event or phenomenon model. The probabilistic model gives a probability distribution as a solution. These models consider the fact that we can rarely know everything about a situation. There's nearly always an element of randomness to consider [18][19]. Statistical modeling uses mathematical models and statistical assumptions to generate sample data and make predictions about the real world. Statistical models provide spontaneous visualizations of data that aid in identifying relationships between variables and making predictions [20]. The study used a statistical model. The developed model was then evaluated empirically and by experts in the field of study. Models can be developed based on descriptive data and inferential data.

B. Model Development Process

In this study, a statistical model was appropriate and adopted.

a) Statistical Model of the Website Attributes:

Table II depicts influence levels of the website attributes to webometrics ranking based on the mean results [21]. Influence levels were derived from calculating individual website attribute mean divided by the total attributes mean.

Table 2. Influence levels of website attributes to webometrics ranking

Website Attribute	N	Maximum	Sum	Mean	Influence	Influence %	Rank
Responsiveness	108	5	504	4.66667	0.05911	5.91	1
Website content utility performance	108	5	503	4.65741	0.059	5.9	2
Domain Backlinks	108	5	501	4.63889	0.05876	5.88	3
Website Speed	108	5	496	4.59259	0.05818	5.82	4
Uptime	108	5	493	4.56482	0.05782	5.78	5
Website traffic	108	5	493	4.56482	0.05782	5.78	5
Website Accessibility	108	5	488	4.51852	0.05724	5.72	7
Search Engine Optimization	108	5	486	4.5	0.057	5.7	8
Broken Links	108	5	479	4.43519	0.05618	5.62	9
URL structure	108	5	475	4.39815	0.05571	5.57	10
Indexed webpages	108	5	473	4.37963	0.05548	5.55	11
Website design	108	5	468	4.33333	0.05489	5.49	12
Number of Subdomains	108	5	465	4.30556	0.05454	5.45	13
Browser compatibility	108	5	420	3.88889	0.04926	4.93	14
Color contrast	108	5	411	3.8 0556	0.04821	4.82	15
Website compression	108	5	399	3.69444	0.0468	4.68	16
Content Management System	108	5	270	2.5	0.03167	3.17	17
Domain Authority	108	5	249	2.30556	0.02921	2.92	18
Website Age	108	5	237	2.19444	0.0278	2.78	19
Hosting company	108	5	216	2	0.02533	2.53	20
Total	108	5	8526	78.9445	1	100	

The statistical model of the twenty website attributes based on the mean was represented by:

Website attributes=Y_1, Y_2 ….. Y_{20}

Mean=μ_1, μ_2…..μ_{20}

Therefore the metric

$X_1 = Y_1 \mu_1 + Y_2 \mu_{2.....} + Y_{20} \mu_{20}$ Equation (1)

When $Y_1=Y_2=Y_3…..Y_{20}=1$, then

$X_1=78.94445$ Equation (2)

$X_{1=}$ website attribute metrics

The equation shows that the higher the mean of a given attribute, the higher the contribution to the overall output. The website attribute model is shown in Fig. 2.

The website attribute model in Fig. 2 measures the inference of website attributes in Webometrics ranking. Users of the model can assess the level of their ranking by checking the number of website attributes that are in place. The minimum reading would be 0 (zero) when there is no attribute in place. When all attributes are in place, maximum reading would be 78.94445. Combining all attributes, values will lie between 0 and 78.94445.

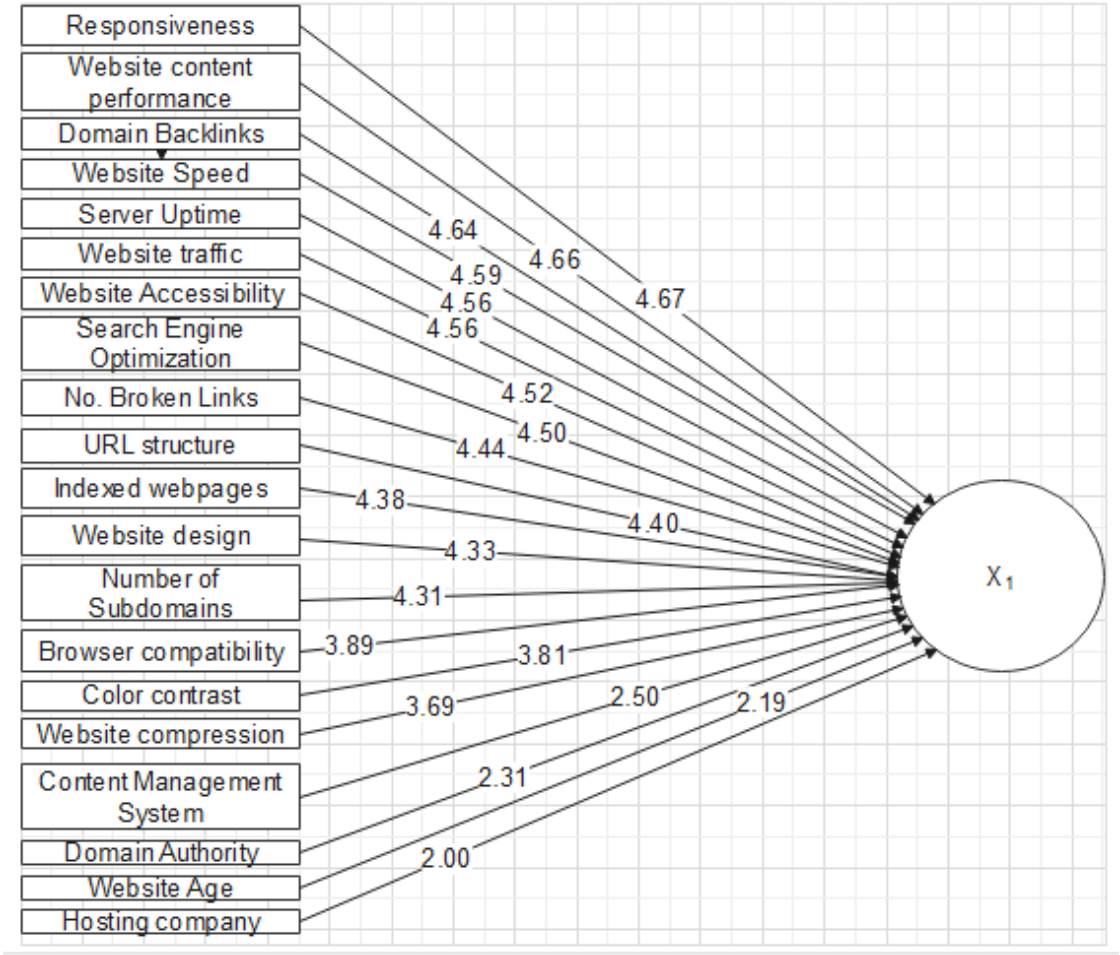

Fig. 2 Website attributes model

Fig. 2 shows that the higher the mean of a given attribute, the higher the contribution to the overall output. The website usability evaluation model is shown in Fig. 2.

b) Statistical Model of Website Usability Evaluation:

Table III depicts usability evaluation of the website attributes for the five sampled universities with reference to Harvard University since it was ranked the best university globally in the July 2021 webometrics ranking edition.

The mean value for each website attribute was calculated by dividing individual website attributes for the five Kenyan Universities by the expected maximum total (five hundred). The mean value was used to derive the influence value. The influence value was derived by calculating the individual website attribute mean divided by the total attributes mean. It was not possible to quantify website content management system and website hosting company attributes because the sample size was not big enough for possible statistical estimation [22].

The statistical model of website usability evaluation based on the mean was represented by:

Website attribute evaluation $=Y_1, Y_2 \ldots. Y_{18}$

Mean$=\mu_1, \mu_2 \ldots . \mu_{18}$

Therefore the metric

$X_2= Y_1\ \mu_1+ Y_2\ \mu_{2\ldots.}+ Y_{18}\ \mu_{18}$ Equation (3)

When $Y_1=Y_2=Y_3 \ldots . Y_{18}=1$, then

$X_2=6.188835$ Equation (4)

$X_{2=}$ website attribute evaluation metrics

Table 3. Usability evaluation

Website Attributes	Harvard University	Varsity 1	Varsity 2	Varsity 3	Varsity 4	Varsity 5	Total	Mean (total/500)	Influence	Influence %
Website URL	90%	90%	89%	82%	75%	90%	426	0.852	0.137667	13.77
Website Age	100%	61%	53%	58%	56%	61%	289	0.578	0.093394	9.34
Website Uptime	100%	100%	100%	100%	100%	100%	500	1	0.161581	16.16
Content Management System	WORD PRESS	DRUPAL	JOOMLA	JOOMLA	JOOMLA	WORD PRESS	0	0	0	0.00
Website Hosting Company	FASTLY	KENET	KENET	KENET	KENET	UNIFIED LAYER	0	0	0	0.00
Website Responsiveness	100%	100%	96%	100%	86%	100%	482	0.964	0.155764	15.58
Website Browser Compatibility	98%	95%	93%	98%	98%	95%	479	0.958	0.154795	15.48
Website Color Contrast	164.44 %	-0.67%	-48.89%	-37.56%	-11.33%	-74.22%	-172.667	-0.3453	-0.0558	-5.58
Domain Authority	94%	60%	39%	55%	38%	47%	239	0.478	0.077236	7.72
Domain Backlinks	100%	0.40%	0.49%	0.09%	0.09%	0.01%	1.0842	0.00217	0.00035	0.04
Website Traffic	100%	1.49%	0.14%	1.24%	0.21%	0.54%	3.6231	0.00725	0.001171	0.12
Website Broken Links	100.00 %	99.99%	99.7242	99.7869	99.8263	98.3931	497.7176	0.99544	0.160844	16.08
Website Subdomains	100%	1.63%	0.32%	0.40%	0.33%	0.22%	2.9028	0.00581	0.000938	0.09
Website Speed	58.80%	-62.40%	-47%	-151.60 %	-741.20 %	73.20%	-929	-1.858	-0.30022	-30.02
Indexed Webpages	100%	72.28%	2.42%	5.21%	4.87%	0.67%	85.4567	0.17091	0.027616	2.76
Website Compression	78%	0%	0%	0%	0%	75%	75	0.15	0.024237	2.42
Search Engine Optimization	69.90%	44.90%	44.60%	44.80%	51.60%	45.50%	231.4	0.4628	0.07478	7.48
Website Content Performance	62.50%	56.10%	67.80%	50.70%	50.40%	52.80%	277.8	0.5556	0.089775	8.98
Website Design	81.90%	63.80%	55.70%	43%	62%	63.80%	288.3	0.5766	0.093168	9.32
Website Accessibility	100%	66.40%	66.40%	66.40%	58%	60.60%	317.8	0.6356	0.102701	10.27
Total							3094.418	6.188835	1	100

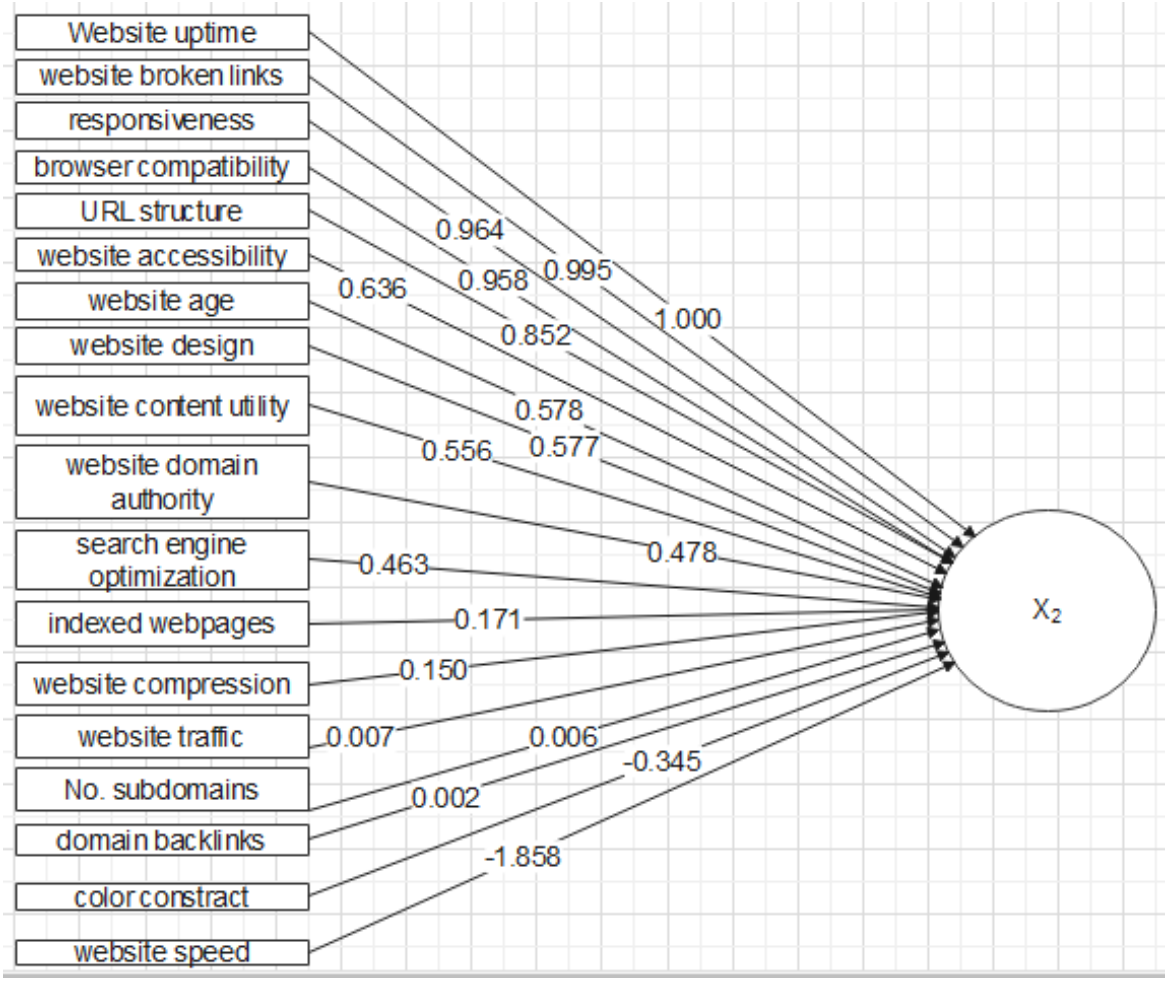

Fig. 3 Website usability evaluation model

The website usability evaluation model in Fig. 3 measures the inference of website usability evaluation in webometrics ranking. Users of the model can assess the level of their ranking by checking the number of evaluated website attributes that are in place. When there is no evaluated website attribute in place, the minimum reading would be 0 (zero). When all evaluated website attributes are in place, maximum reading would be 6.188835. Combining all attributes, values will lie between 0 and 6.188835.

c) Statistical Model of Google Scholar Citation:

Table IV depicts an analysis of Google Scholar citations for the five sampled universities concerning Harvard University based on the mean.

The statistical model of Google scholar citation based on mean was represented by:

Google Scholar Citations $=Y_1$

Mean$=\mu_1$,

Therefore the metric $X_3= Y_1\ \mu_1$ Equation (5)

This implies that the higher the mean, the higher the contribution

Based on Table 3, the total mean for Google scholar citations is 0.005545 hence

$X_3=0.005545$ Equation (6)

$X_{3=}$ Google scholar citations metrics

Figure 4 shows that the higher the mean of Google scholar citations, the higher the contribution to the overall output. The Google scholar citation model is shown in Fig. 4.

Table 4. Analysis of google scholar citations

	Harvard University	Varsity 1	Varsity 2	Varsity 3	Varsity 4		Varsity 5	Total	Mean(Total/500)	%	Influence
Google Scholar	100%	1.619673%	0.034421%	0.471955%	0.256733%		0.389832%	2.772614	0.005545	0.554523%	1

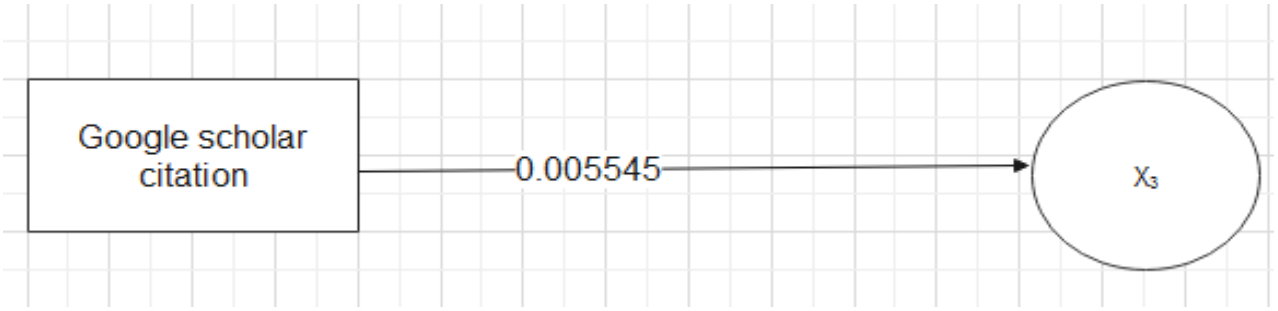

Fig. 4 Google citations model

The Google scholar citations model [23] in Fig. 4 measures the inference of Google scholar citations in webometrics ranking. Users of the model can assess their ranking by checking the number of Google Scholar citations that are in place. When there are no Google scholar citations in place, the minimum reading would be 0 (zero). When Google Scholar citations are in place, the maximum reading would be 0.005545.

d) Statistical Model of Webometrics User Ranking Analysis Model:

After all the individual website attribute model, website usability evaluation model, and Google scholar citation model have been developed, the researcher after developing the overall webometrics user ranking analysis model.

Based on the finding in Equation 2, X_1 was found to be 78.94445
Based on the finding in Section Equation.4, X_2 was found to be 6.188835
Based on the finding in Equation .6, X_3 was found to be 0.005545
Substituting the values in the general equation
$F=\mu_1X_1+\mu_2X_2+\mu_3X_3+\varepsilon$ Equation .7

The statistical model would be:
$F=78.94445X_1+6.188835X_2+0.005545X_3+\varepsilon$ Equation .8
Where
F is the dependent variable webometrics ranking

X_1 represents website attributes
X_2 represents website usability evaluation
X_3 represents Google scholar citations
Ɛ represent error
µ1...µ3 represent the mean values of the three components

Fig. 5 shows that the mean value among the three components (website attributes, website usability evaluation, and Google scholar citations) made it possible for the additive aspect in the metric. The Google scholar citation model is shown in Fig. 4.

For the ideal scenario in Fig. 5, the maximum F value should be 100. However, taking the case of floor and ceiling in Equation .8
$F=78.94445X_1+6.188835X_2+0.005545X_3+\varepsilon$
Equation 8
When X_1 is present=1
X_1 is not present=0
When $X_1=X_2=X_3=0$
Then minimum value
$F = 78.94445*0+6.188835*0+0.005545*0+\varepsilon$
F=0
When $X_1=X_2=X_3=1$
Then maximum value
$F = 78.94445*1+6.188835*1+0.005545*1+\varepsilon$
F=85.13883

Hence $100=85.13883+\varepsilon$
$\varepsilon=100 - 85.13883$
$\varepsilon=14.86117$

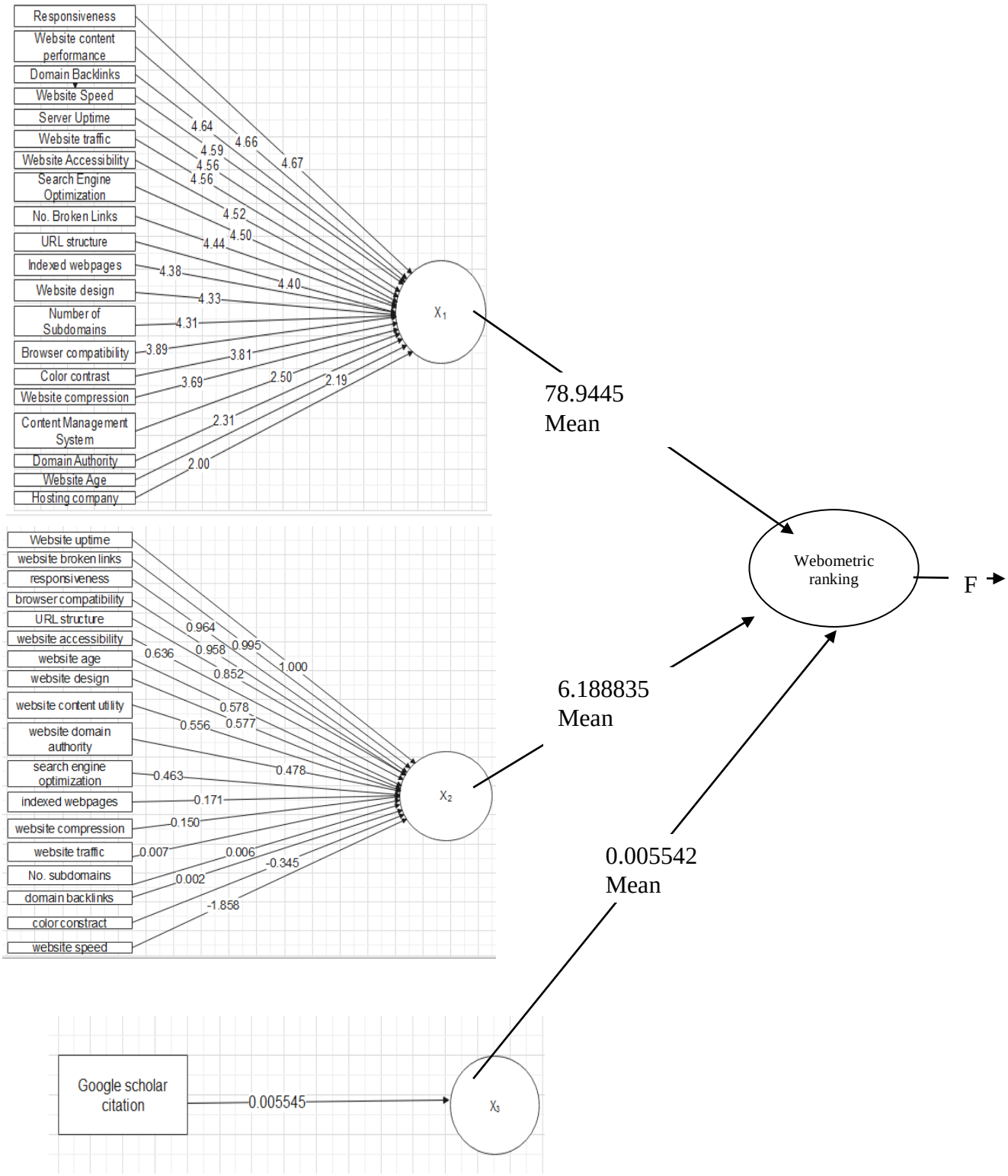

Fig. 5 Website Usability analysis Model

When the independent variables (website attributes, website usability evaluation, and Google scholar citations) are not present, the minimum reading would be 14.86117. When all the independent variables are present, the maximum reading would be 100 (85.13883+ ε). From the model, it can be seen that the number of attributes considered affects the metrics. The higher the number, the higher the metrics and the higher the webometrics ranking. Hence use of the model will lead to an improved webometrics ranking.

C. Validation of the Developed Model

The ultimate goal of model development is to attain satisfactory model applicability through model validation.

a) Empirical Validation of the Model:

From general model equation $F=\mu 1X_1+\mu 2X_2+\mu_3X_3+\varepsilon$ in section 5.2.4, it was established as Equation 5.8

$F=78.94445X_1+6.188835X_2+0.005545X_3+\varepsilon$

Equation .8

Taking the case of floor and celling the variable X_1 can have two values

When X_1 is present=1

X_1 is not present=0

When $X_1=X_2=X_3=0$

This based on floor and ceiling concept [24].

Then minimum value F = $78.94445*0+6.188835*0+0.005545*0+\varepsilon$

F=0

When $X_1=X_2=X_3=1$

Then maximum value F = $78.94445*1+6.188835*1+0.005545*1+\varepsilon$

F=85.13883

F is within the expected percentage range of 0-100.

b) Experts Validation of the Model:

Five website practitioners from Kibabii University and Jomo Kenyatta University of Agriculture and Technology were identified and subjected to the webometrics user ranking analysis model validation. These experts had knowledge and experience in website development and webometrics ranking analysis. Questionnaires were designed and administered to the experts [25].

Responses obtained from the experts are displayed in Table V.

Upon inquiry, if the components included in the developed model are applicable for webometrics ranking, 40% agreed while 60% strongly agreed. This implied that components in the model correspond with indicators used for webometrics ranking. 80% of the respondents strongly agreed that the model is easily understood, and 20% agreed with the statement. The study sought to establish whether the model is clear and easy to implement. 60% of respondents strongly agreed, and 40% agreed with the statement. On whether the model is technologically and operationally viable, 80% of respondents strongly agreed, and 20% agreed with the statement that the model is technologically and operationally viable. 80% of respondents strongly agreed that the model is appropriate for improving webometrics ranking for an institution, and 20% agreed with the statement.

Concerning Fig. 6, the overall mean of responses was 4.52, and the maximum expected mean was 5. The average mean of 4.52 translated to 90.4% acceptance (4.52/5)*100. This was an indication that most respondents believed that the model was appropriate and applicable for the area of study.

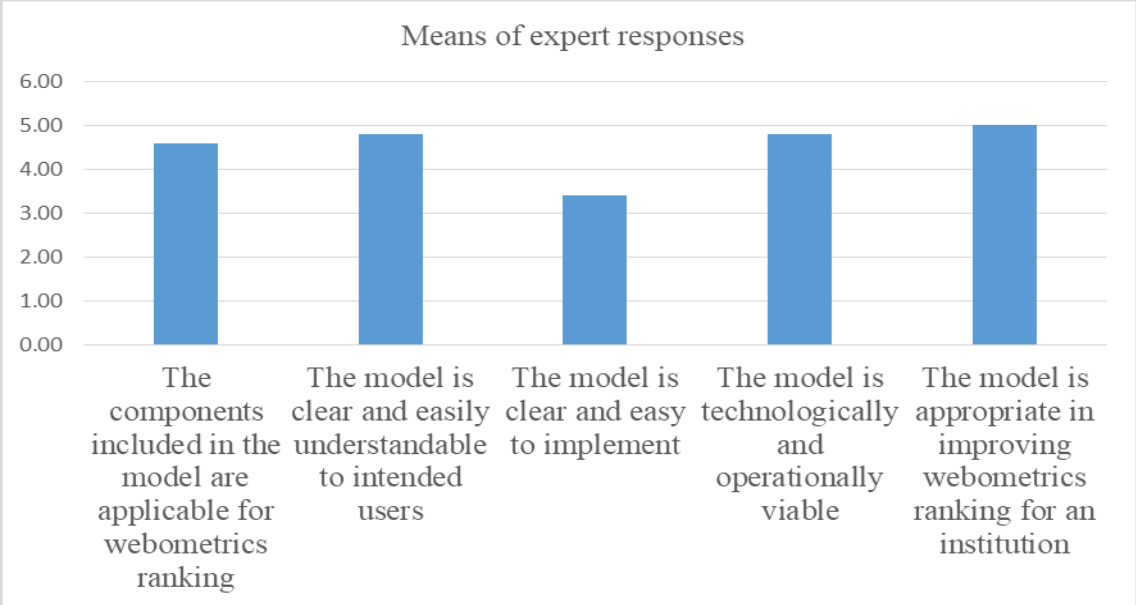

Fig. 6 Means of the responses

Table 5. Expert View On The Proposed Model

The components included in the model are applicable for webometrics ranking.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	2	40.0	40.0	40.0
	Strongly Agree	3	60.0	60.0	100.0
	Total	5	100.0	100.0	
The model is clear and easily understandable to intended users.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	1	20.0	20.0	20.0
	Strongly Agree	4	80.0	80.0	100.0
	Total	5	100.0	100.0	
The model is clear and easy to implement					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	20.0	20.0	20.0
	Disagree	1	20.0	20.0	40.0
	Agree	1	20.0	20.0	60.0
	Strongly Agree	2	40.0	40.0	100.0
	Total	5	100.0	100.0	
The model is technologically and operationally viable.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	1	20.0	20.0	20.0
	Strongly Agree	4	80.0	80.0	100.0
	Total	5	100.0	100.0	
The model is appropriate for improving webometrics ranking for an institution.					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Agree	5	100.0	100.0	100.0

V. CONCLUSION

The research recorded findings and discussions that enabled the webometrics user ranking analysis model development. The model was validated empirically and by experts who had knowledge and experience in website development.

The model was developed based on summary statistics, and it would be important to model using inferential statistics.

VI. ACKNOWLEDGMENT

I would like to acknowledge the Five Universities that took part in the study.

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