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Quantitative Approach for Research Chairs Evaluation in King Saud University

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Abstract: Research activities are considered prominent part of innovation and consequent wealth generation in any advanced country, thus the need for policy makers and wider public to get insight into the quality of research outputs is legitimate. However, qualitative evaluation techniques meet a number of difficulties. This paper addresses a novel quantitative methodology to indicate a measure of the performance of research chairs in King Saud University (KSU). It proposes an Evaluation Criteria (EC) assures sustainable competition among different Research Chairs (RCs). The best RC - if compared to the remaining RCs - is the one achieves more considerable scientific events (activates) with less cost and within shorter period of time. The study aims to be a further contribution to the assessment of a road map toward an equal internationally shared, quantitative evaluation system.

Key words: Bibliometric indicators, King Saud University (KSU), non-bibliometric indicators, performance evaluation, quantitative indicators, Research Chairs (RCs)

INTRODUCTION

Given the burgeoning increase in the use of quantitative measures to evaluate research performance, it is surprising that there is scant literature summarizing assessments of their use in this context. Reviews have usually been confined to quantitative indicators (Narin, 1976; Moed *et al*., 2004). They do not cover the boarder range of quantitative indicators, and do not touch on many important issues that must be understood before they can be applied in the assessment of research. The sociology of science, which should have provided important background information about relationships between indicators and the research process, has not been interested in quantitative indicators for more than twenty years. With its constructivist turn, researchers in the discipline questioned the validity of quantitative indicators on very basic principles (Gilbert and Woolgar, 1974; Woolgar, 1991) and has since ceased to make contributions to the topic. A recent trend is the emergence of a body literature produced by scientist for outside science studies who have become interested in performance indicators. The authors of this study merge different concepts from engineering, statistics and accounting to develop an integrated quantitative measure to evaluate the performance of research chairs in KSU.

QUANTITATIVE INDICATORS

Quantitative indicators are divided into bibliometric and non-bibliometric. Bibliometric indicators are based on published literature in all its forms-journal articles, monographs, book chapters, conference papers, patents, and the like- and the references these publications contain (i.e., citations). Non-bibliometric measures encompass all other readily quantifiable indicators, such as ability to attract external funding and measures of esteem (honors and awards, editorship of journals, keynote addresses, etc). they also cover rapidly expanding ventures into web-link analysis.

Most researchers see quantitative indicators being used, not to replace the peer evaluation, but rather to make the results of research assessment debatable and to offer experts additional information (Van-Raan and Van-Leeuwen, 2002). Peer review can become more 'transparent' by using quantitative indicators and can counterbalance the shortcomings of the peer review (Van-Raan, 1996; Tijssen, 2003; Aksnes and Taxt, 2004). Quantitative indicators are also seen by scientists as a useful resource in cases of doubt within panel discussions of peers (Moed and Van Raan, 1988). In addition, they can be used to highlight gaps in the knowledge of peers-as "triggers to the recognition of anomalies" (Bourke

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et al., 1999). Where the indicators do not align with peer evaluation, then the reasons must be sought. It may be due to problems with the indicators, or it may be that the experts have an incomplete knowledge of the research they are assessing (Bourke and Butler, 1995). In consistencies between quantitative data and peer review are likely to trigger additional, deeper analyses of the performance of units being by those conducting the assessment.

Research chairs in KSU: KSU has lunched the Research Chairs Program as a means to put together research apparatuses in major strategic, scientific, and technological fields in order to accomplish excellence in the areas of research, development, and knowledge economics. The initiative has been undertaken in light of the above facts and of the close monitoring of research progress throughout the world. Research chairs are unique scientific initiatives functioning within a well-defined time framework (assigned life period). Each chair is entrusted to distinguished scholar in a particular scientific discipline in order to carry out extensive and original and applied research amenable to securing effectiveness and competitiveness within the economic and social sectors. Research chairs are created in the scientific disciplines and areas of knowledge that best serve the university's mission, support scientific research and knowledge-based national economy, and cater for the needs of the funding parties. Currently, the major scientific fields of research chairs are:

- Engineering
- Medicine and pharmacy
- Sciences and agriculture
- Humanities and economics

The research chairs are funded through one of the following:

- Research chairs program budget or university endowments
- Financial support from the higher education fund.
- Donations wills and gifts

Research chairs are operative means of putting together research apparatuses in major scientific fields in ordertodevelop them and optimize their innovative powers as well as utilize their output to serve the community in such a way that helps advance national development and promote the country's potentials. In this sense, monitoring and evaluating methodology should be established to evaluate the performance of research chairs in KSU.

Quantitative indicators for research chairsin KSU: Research chairsin KSU cover many activities. The quantitative indicators for research chairs activities are divided into bibliometric and non- bibliometric as given in Table 1.

Since each indicator has different strengths and weaknesses, it has been suggested that evaluations should always incorporate more than one indicator, and that indicators should never be used in isolation, especially if applied to individual groups. In this study, we use bibliometric indicators to express the scientific events (activities) for a specific chair.

Basic definitions: According to a pre-determined evaluation plan, each RC reports its Scientific Events (SEs) regularly every six months. After submission of all reported events, the scientific board of research chairs uses a proposed EC - we will explain it in next section – to produce two measures. The produced measures express the "average achievement level" of each RC and its "performance value". Before mathematical description of the proposed EC, we should define the following important terms:

- Amount of Allocated Fund for ith RC ($AAFRC_i$): is the allocated money for ith RC to carry out its scientific events.
- Assigned Life Period for ith RC ($AAFRC_i$): is a pre-determined time frame for ith RC. The ith RC should fund itself through profits of its activities after passing of its $AAFRC_i$.
- Ratio of Time Elapsed for ith RC ($RTERC_i$): is the ratio of passing time from initiation of ith RC to its $ALPRC_i$ at the moment of evaluation.
- Ratio of Money spent for ith RC ($RMSRC_i$): is the ratio of money, the researchers in ith RC spent to the $AAFRC_i$ at the moment of evaluation.

Mathematical description of the proposed EC: The jth scientific event for specific major field is denoted as . SE_j Weassigntwopositiveintegernumbersforeach SE_j; they are:

$WCSE_j$: Weight of completed SE_j.
$WCSE_j$: weight of the ongoing $_{Sej}$.

$WCSE_j$ and $WCSE_j$ values are dependent on the importance of SE_j. Relative higher weights of specific SE_j means more import SE_j. this with respect to the remaining events.

We count the number of completed and ongoing activities for each SE_j; they are:

$CCSE_j$: count of completed activities for SE_j.
$COSE_j$: count of ongoing activities $_{Sej}$.

The following steps describe the proposed EC:

Step 1: Calculate the value of scientific event jfor ith RC, denoted (VSE_{ji}); such that:

Table 1: The bibliometric and non- bibliometric indicators for research chairs in KSU

Bibliometric indicators	Non-bibliometric indicators
Number of authored books	Effect of the chair in the diversity of sources and the provision of water consumption
Number of translated books	Effect of the chair in the protection of the community earnings.
Number of published papers in ISI journals	Effect of the chair in environmental protection.
Number of published papers in International conferences	Effect of the chair in the development of natural resources.
Number of published papers in national conferences	Effect of the chair in the development of engineering resources.
Number of registered patents	Completeness of the chair on the Web site.
Number of researchers	Output level of technical reports.
Number of students (Ph.D., M.Sc., B.Sc.)	Cooperation between the chairs in different disciplines.
Number of scientific trips	Honors and awards.
Number of conferences/ workshops/ lectures	
Number of brochures, printouts and reports	
Number of contracts	
Number of media events .	

$$VSE_{ji} = (WCSE_{ji} \times CCSE_{ji}) + (WOSE_{ji} \times COSE_{ji}) \quad (1)$$

Step 2: Calculate the value of achievement level for ith RC, denoted $ALRC_i$;; such that:

$$ALRCi = \sum_i \sum_j^z \left[(WCSEJI \times CCSEJI) + (WOSEJI \times COSEJI) \right] \quad (2)$$

where; z: Number of scientific events which is fixed for specific major field.

Step 3: Calculate$ALRC_i$ for all chairs from i = 1 to i = N. where; N: Number of RCs belongs to specific major field.

Step 4: Calculate the average number for specific completed scientific event ($ANSE_j|_C$) and for specific ongoing scientific event ($ANSE_j|_O$); such that:

$$ANSE_j|_C = \frac{\sum_J \sum_{i=1}^N \left(CCSE_{ji} \right)}{N}$$
$$ANSE_j|_O = \frac{\sum_j \sum_{i=1}^N \left(COSE_{ji} \right)}{N} \quad (3a)$$

Step 5: Calculate $ANSE_j$for all scientific events (completed and ongoing) from j = 1to j = z..

Step 6: Calculate the weighted average of completed and ongoing scientific event j, denoted ($WASE_j|_C$) and $WASE_j|_O$, respectively; such that:

$$WAE_J.C = ANSE_JC \times WCSE_j \quad (4a)$$
$$WASE_jO = ANSE_jO \times WOSE_j \quad (4b)$$

Step7: Calculate $WASE_j$ for all scientific events (completed and ongoing) from j = 1to j = z.

Step 8: Calculate the summation of all weighted averages for all scientific events, denoted (swase), such that:

$$SWASE = \sum_{j=1}^{Z} WASE_j|_C + \sum_{j=1}^{z} WASE_j|_O \quad (5)$$

Step 9: Calculate the average achievement level for ith RC, denoted ($AALRC_i$);; such that

$$AALTC_j = ALRC_i / SWASE \quad (6)$$

Step 10: Calculate($AALTC_j$) forallRCs from i=1 to i= N.

Step 11: Normalize the values of average achievement levels to be enclosed within interval from zero to one, the resulted value is the normalized average achievement level for ith RC ($NAALRC_i$); such that:

$$NAALRC_i = \frac{\underset{i=1:N}{Max}\left(AALRC_i \right) - AALRC_i}{\underset{i=1:N}{Max}\left(AALRC_i \right) - \underset{i=1:N}{Min}\left(AALRC_i \right)} \quad (7)$$

Step 12: Calculate $NAALRC_i$ for all RCs from i=1toi=N.

Step 13: Calculate the performance value for ith RC, denoted($PVRC_i$) ; such that:

$$PVRC_i = \frac{1 - NAALRC_i}{RTERC_i + RMSRC_i} \quad (8)$$

Step 14: Calculate ($PVRC_i$) for all RCs from i=1toi=N.

CASE STUDY

To evaluate the performance of the proposed EC, we introduce a sample of ten research chairs belonging to a specific major field. Table 2 illustrate the SEs with weights of both completed (WCSE) and ongoing (WOSE) activities for chairs sample.

The main idea is to check the sensitivity of the proposed EC against the change of the following parameters:

Table 2: Weights of completed and ongoing scientific events

SE_j	$WCSE_j$	$WOSE_j$
Authered books	10	5
Translated books	5	2
Published papers in ISI journals	40	20
Published papers in international conferences	3	1
Published papers in national conferences	2	1
Registered patents	20	10
Contracts	10	5
Students (Ph.D., M.Sc., B.Sc.)	10	5
Ph. D. researchers	4	2
M. Sc. researchers	3	1
B. Sc. researchers	2	1
Scientific trips	5	2
Implemented conferences	10	5
Implemented workshops	5	2
Implemented lectures	1	1
Brochures	1	1
Printouts	1	1
Reports	1	1
Media events	1	1

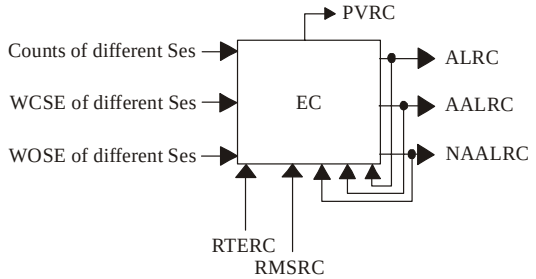

Fig.1: Simplified EC scheme with inputs and outputs for specific RC

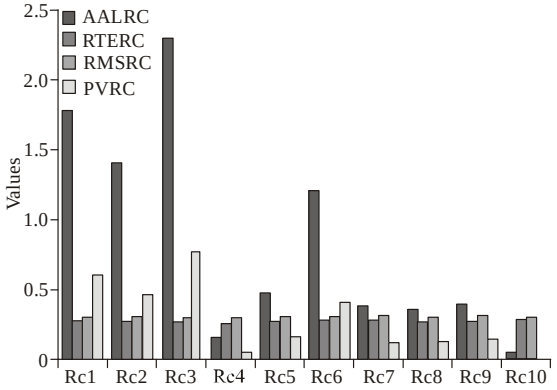

Fig. 2: Evaluation situation for different research chairs in case 1

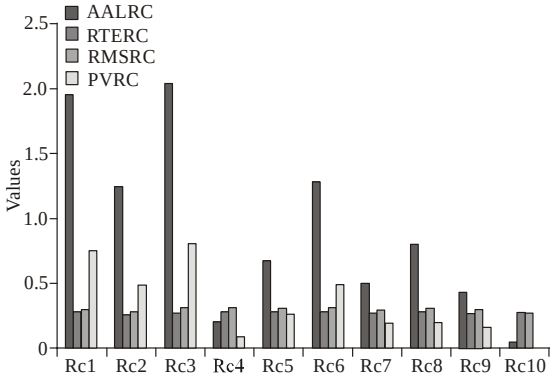

Fig. 3: Evaluation situation for different research chairs in case 2

- Weights of completed and ongoing scientific events (WCSE, WOSE)
- Achievement Level (AL) with consequent Average Achievement Level (AAL) and Normalized Average Achievement Level (NAAL)
- Ratio of time elapsed (RTE)
- Ratio of Money spent (RMS)

We mean - by sensitivity - studying the effect of change of any of the above parameters on PVs and RCs ranking.

RESULTS AND CONCLUSION

Every RC submits the count of its different SEs. Based on given weights (WCSE) and (WOSE) for each SE, the EC calculates AL, AAL, and NAAL for all Rcs. Moreover, data base of managerial system submits both RTE and RMS fo r every chair to EC. The EC processes the data which it receives to produce PV for each specific chair. Figure 1 depicts a simplified EC scheme with inputs and outputs for specific RC. To check the sensitivity of the proposed EC, we assume four cases:

Case1: For all RCs, we propose identical RTEs and identical RMSs. We feed the counts of different SEs to the EC. Based on (WCSE) and (WOSE) given in Table 2, EC calculates ALs, AALs, NAALs, and PVs for all RCs. Table 3 lists the

Table 3: ALRCs, AALRCs, NAALRCs, PVRCs, and ranking for case 1

RC	ALRC	AALRC	NAALRC	RTERC	RMSRC	PVRC
RC1	561	1.789474	0.650685	0.273973	0.3	0.608592
RC2	441	1.406699	0.725405	0.273973	0.3	0.478412
RC3	721	2.299841	0.551059	0.273973	0.3	0.782165
RC4	48	0.15311	0.970112	0.273973	0.3	0.052072
RC5	150	0.478469	0.9066	0.273973	0.3	0.162725
RC6	382	1.218501	0.762142	0.273973	0.3	0.414407
RC7	120	0.382775	0.92528	0.273973	0.3	0.13018
RC8	115	0.366826	0.928394	0.273973	0.3	0.124756
RC9	123	0.392344	0.923412	0.273973	0.3	0.133435
RC10	11	0.035088	0.993151	0.273973	0.3	0.011933

Table 4: ALRCs, AALRCs, NAALRCs, PVRCs, and ranking for case 2

RC	ALRC	AALRC	NAALRC	RTERC	RMSRC	PVRC
RC1	461	1.95339	0.559273	0.273973	0.3	0.767853
RC2	301	1.275424	0.712237	0.273973	0.3	0.501353
RC3	481	2.038136	0.540153	0.273973	0.3	0.801165
RC4	48	0.20339	0.954111	0.273973	0.3	0.07995
RC5	160	0.677966	0.847036	0.273973	0.3	0.2665
RC6	302	1.279661	0.711281	0.273973	0.3	0.503019
RC7	120	0.508475	0.885277	0.273973	0.3	0.199875
RC8	115	0.487288	0.890057	0.273973	0.3	0.191547
RC9	103	0.436441	0.90153	0.273973	0.3	0.171559
RC10	11	0.04661	0.989484	0.273973	0.3	0.018322

Table 5: ALRCs, AALRCs, NAALRCs, PVRCs, and ranking for case 3

RC	ALRC	AALRC	NAALRC	RTERC	RMSRC	PVRC
RC1	461	1.173775	0.559273	0.410959	0.3	0.619904
RC2	461	1.173775	0.559273	0.09589	0.3	1.113254
RC3	461	1.173775	0.559273	0.273973	0.3	0.767853
RC4	461	1.173775	0.559273	0.232877	0.3	0.82707
RC5	461	1.173775	0.559273	0.191781	0.3	0.896185
RC6	461	1.173775	0.559273	0.136986	0.3	1.008559
RC7	461	1.173775	0.559273	0.178082	0.3	0.921864
RC8	461	1.173775	0.559273	0.260274	0.3	0.786627
RC9	461	1.173775	0.559273	0.547945	0.3	0.519758
RC10	461	1.173775	0.559273	0.821918	0.3	0.392833

Table 6: ALRCs, AALRCs, NAALRCs, PVRCs, and ranking for case 4

RC	ALRC	AALRC	NAALRC	RTERC	RMSRC	PVRC
RC1	461	1.173775	0.559273	0.547945	0.200	0.58925
RC2	461	1.173775	0.559273	0.547945	0.150	0.631463
RC3	461	1.173775	0.559273	0.547945	0.100	0.680191
RC4	461	1.173775	0.559273	0.547945	0.010	0.78991
RC5	461	1.173775	0.559273	0.547945	0.450	0.441634
RC6	461	1.173775	0.559273	0.547945	0.900	0.304381
RC7	461	1.173775	0.559273	0.547945	0.180	0.605439
RC8	461	1.173775	0.559273	0.547945	0.165	0.618177
RC9	461	1.173775	0.559273	0.547945	0.800	0.326962
RC10	461	1.173775	0.559273	0.547945	0.600	0.383926

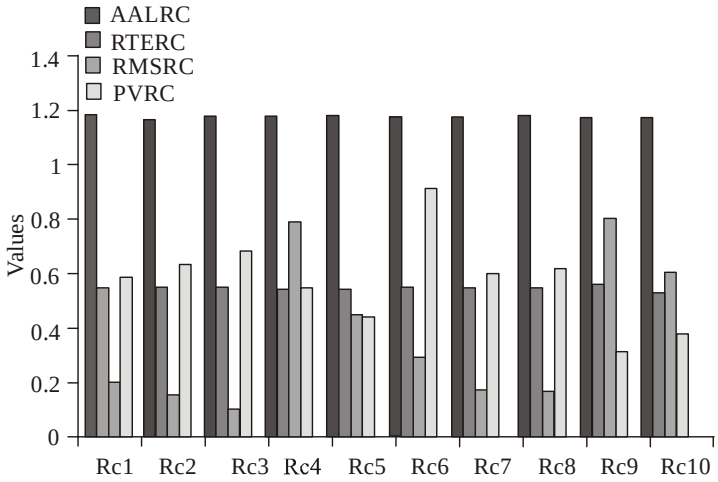

Fig. 4: Evaluation situation for different research chairs in case 3

resulted values and ranking of different chairs. Figure 2 depicts evaluation situations for different chairs.

Case2: We keep the same conditions as in case 1 except minor change in WCSE and WOSE. We interchange the weights of published papers in ISI journals and registered patents by each other. We demonstrate the new results in Table 4 and Fig. 3.

Case3: For all RCs, we propose identical RMSs. We feed identical numbers of different SEs to EC, this assures identical ALs, AALs, NAALs for all RCs. We assign different random RTEs. Table 5 and

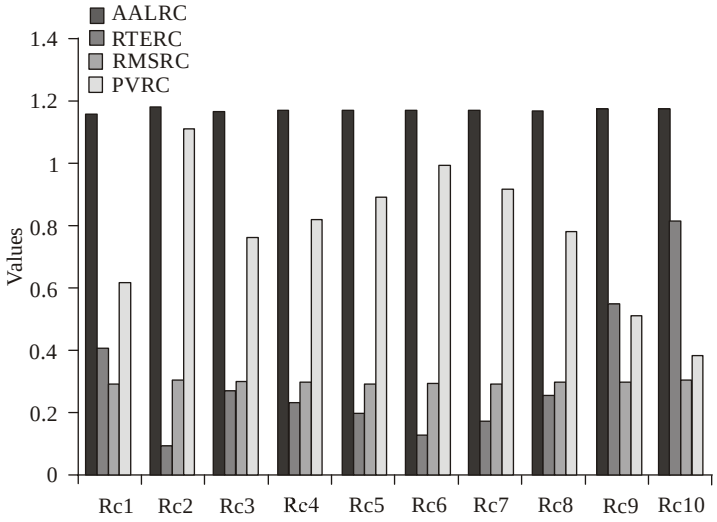

Fig.5: Evaluation situation for differentresearch chairs in case 4

Fig. 4 presents the results and evaluation situations for different RCs in case 3.

Case4: We keep the same conditions as in case 3 but with identical RTEs and random assigned RMSs for different RCs. Table 6 and Fig. 5 scrutinize the results and evaluation situations for different RCs in case 4. The results of all cases prove the effectiveness of the proposed EC. PVs and ranking of different RCs change remarkably with changing of any input parameter. Even incaseofidenticalALs,thevaluesofRTEsandRMSspinpointhePVsandrankingofdifferentRCs.TheRCswithlesser RTEs and/or RMSs have higher ranking in case of identical Als.

ABBREVIATIONS

KSU : King Saud University
RC_i : ith Research Chair
AL : Achievement Level
EC : Evaluation criteria
$AAFRC_i$: Amount of Allocated Fund for RC_i
$ALPRC_i$: Assigned Life Period for RC_i
SE_j : jth Specific Event for RC_i
$RTERC_i$: Ratio of Time Elapsed for RC_i
$RMSRC_i$: Ratio of Money spent for RC_i
$ECSE_j$: Weight of completed
$WOSE_j$: Weight of the ongoing S_{ej}
$CCSE_j$: Count of completed activities for SE_j
$COSE_j$: Count of ongoing activities $_{Sej}$.
VSE_{ji} : Value of scientific event jfor RC_i
$ALRC_i$: Value of achievement level for RC_i
Z : Number of scientific events, which is fixed for specific major field
N : Number of RC sbelongsto specific major field
$ANSE_j$ | C : Average number for specific completed scientific event
$ANSE_j$ | O : Average number for specific ongoing scientific event
$WASE_j$ | C: Weighted average of completed scientific event
$WASE_j$ | O: Weighted average of ongoing scientific event
SWASE : Summation of all weighted averages for all scientific events
$AALRC_i$: Average achievement level for RC_i.
$NAALRC_i$: Normalized average achievement level for RC_i.
$PVRC_i$: Performance value for RC_i

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