Need for objective, quantitative and inclusive performance matrix for research design

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In the rapidly evolving and transforming science of the current era, it is extremely useful to maintain dynamism in the research programmes of R&D organizations. This requires identification of less important or less relevant areas for better focus and optimum utilization of limited resource; it is equally important to identify (or better still, initiate) new areas, both for sustained relevance and for leadership. Such dynamism necessarily requires, for limited human and infrastructure resources, shedding of some research programmes, while inducting new ones. The so called SWOT (strength, weakness, opportunity and threat) analysis is a recognized methodology to identify areas/programmes for such dynamism. Yet a SWOT analysis can be hardly effective unless it provides specific and actionable inputs for policy makers. However, the conventional SWOT analyses often fail to provide such effective inputs; a particular obstacle is either intentional or unintentional ambiguous or non-specific inputs to the SWOT analysis by the participating scientists. It would be certainly desirable to carry out a SWOT analysis by an independent third party, at least at the first level (like a first assessment); however, such an independent analysis requires objective, quantitative and unambiguous data. Thus well designed SWOT analysis for an objective, quantitative and inclusive performance (OQIP) index, based on which policy may be implemented, is necessary.

There are a number of reasons why the conventional (non-quantitative, and often non-inclusive) SWOT analyses fail. The major challenges in design and implementation of OQIP evaluation are:

1. *Legacy:* Essentially for any research organization, areas finally connect to some institutional groups, perhaps established long ago; thus, any attempt to shed areas often result in subjective and defensive approach, especially by scientists who do not have the flexibility to change.

2. *Quality:* A non-quantitative measure is prone to manipulation and biased interpretation, especially if the group's/ individual's performance is not defendable.

3. *Performance parity:* There are many performance indices even for a single group engaged in research; these may include research publications, impact factor of publication, citation of publications, patents, etc. The performance indices do not always reflect the contributions and the aspirations of all the participants.

However, most of these challenges can be met through an objective, quantitative and inclusive procedure, outlined below:

Inclusive identification of parameters: It is necessary and easy to identify a comprehensive (and logical) set of performance parameters by including inputs from all the members; for an agency, these parameters can be identified to include all relevant parameters like *SCI* publications, patents, physical model, algorithms, copyrights, and so on.

Transparent and objective procedure: The list of parameters should be predetermined and known in advance so that inputs can be carefully prepared by the participants, and the outputs are verifiable.

Quantification: Each performance parameter is quantified following a pre-determined procedure (such as the number of *SCI* publications over a period, the total impact factor over a period, etc.). The score assigned to each parameter should be known to all before the analysis for transparency and objectivity.

To crystallize the above ideas, let us consider $1 \times N$ performance matrix, P, defined as

$$P = \begin{pmatrix} P_1 \\ P_2 \\ P_3 \\ . \\ . \\ . \\ P_N \end{pmatrix}. \qquad (1)$$

The positive definite scalar performance measure for the ith member (an institution, activity such as a project or a programme or an individual) then can be defined through the scalar product

$$P_S(i) = \begin{pmatrix} P_1 \\ P_2 \\ P_3 \\ . \\ . \\ . \\ P_N \end{pmatrix} (S_1(i) \cdots S_N(i)))$$

$$= \sum_{j=1}^{N} P_j S_j(i), \qquad (2)$$

where $S_j(i)$ is the score of a member (an institution, activity or an individual) corresponding to the P_j.

In case P_S needs to be evaluated for a group of individuals of M members, it can be simply defined as

$$P_M = \frac{1}{M} \sum_{i=1}^{M} P_S(i). \qquad (3)$$

This definition can be easily extended to include additional considerations like time (residency period) weighted inputs, such as performance per capita per day. Such inclusion will ensure that time spent in activities not related to the activities/measures under P do not bias the performance measure. It will also avoid bias due to recently recruited members who would not have had enough time to contribute. The group measure like P_M can be easily extended to analysis of institutions, disciplines, national or global analysis.

A major, but addressable, issue in such an OQIP analysis is the identification of quantifiable performance measures. For example, the following may be a generic performance vector for a research activity/group individual or institution engaged in computing-based research.

$$P = \begin{pmatrix} N_P \\ N_L \\ N_C \\ N_I \\ N_T \\ N_{HPC} \\ N_S \end{pmatrix} =$$

Number of *SCI* publications impact factor
Number of *SCI* publications as lead author
Number of *SCI* publications as corresponding author
Number of *SCI* publications with citations > 10
Number of *SCI* publications registered patents/copying
Number of *SCI* publications with HPC
Number of strategic projects

The above example is not meant to be either exclusive or exhaustive. Quite clearly, the identification of the elements of *P* vector, and their quantification, will depend on the discipline/institution/group or the individual under consideration.

The proposed procedure is inclusive, transparent, objective and quantitative, with verifiable results, and thus immune to manipulation and subjectivity. To begin with, the identification of the elements of the *P* vector can be a completely inclusive process, with as many logical elements as necessary to avoid any bias or feeling of marginalization. Secondly, the OQIP analysis itself is completely objective, quantitative and verifiable at any time through archived data; this eliminates possibility of manipulation. Finally, an OQIP framework can be objectively scrutinized and revised at any time. To be sure, an OQIP analysis in itself is not the end of a policy process; but it does provide critical inputs.

It is possible to apply an OQIP analysis to design institutional research without the typical pitfalls of a conventional analysis. For example, the following steps may be followed: (a) grade all the identified areas based on the adopted OQIP metric; this stage is completely inclusive, objective (within practical and logical limits) and transparent; (b) areas with low grades (either relative or cut-off) are identified for first candidates for shedding/redesign; once again, this procedure is completely objective and transparent; (c) prepare final recommendations on areas to be shed and included consistent with the SWOTS analysis and taking into account issues like emerging trends, sustainability, societal relevance and strategic importance.

For research organizations, the areas to be shed and included should be also based on long-term perspective, implementation and application. Thus extended SWOT analysis to SWOTS (strength, weakness, opportunity, threats and scalability and sustainability) is required. For example, policy planning involving non (weak) stake holders will be of little effectiveness in terms of realization; thus emphasis should be in the middle-level scientists who can provide independent and fairly unbiased inputs. Implementable of a SWOTS analysis with surgical precision can help realize the potential of India's research organizations. Non-application of such a SWOT operation, on the other hand, can lead to stagnant and non-innovative research.

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