Abstract

This dissertation is the outcome of dual motivations: first, the growing interest of efficiency evaluation of the higher education sector in India, and second, to address the limitations of input importance variable weight of sub-units of DMUs in DEA. Higher Education in India is managed by the union government and state governments. Although, 43% of public expenditure on higher education comes from the central government, 90% of the total students in higher education are enrolled in HEIs managed/regulated by state governments. The role of the MHRD in India is limited to regulating central institutions, supervising and maintaining quality, providing financial support to state and private institutions through its autonomous agencies like UGC, AICTE, NAAC, etc. The Department of Higher Education in every state is responsible for policy formulation and implementation as per the guidelines provided by the MHRD or its agencies. State governments regulate universities, colleges, and institutions through various acts and agencies. Majority of the decisions with respect to the number of colleges to be set up, the location of colleges/universities, the number of teachers, the salary of staff, etc. in a state are taken by the state's higher education department. After the introduction of the UGC's regulation of Mandatory Assessment and Accreditation of Higher Educational Institutions and the establishment of the NIRF under the MHRD, the efficiency of HEIs is going to play a crucial role in funding existing institutions, ranking, attracting bright talent (students, faculty members, and staff), and setting up new institutions by the government. Therefore, the problem of efficiency evaluation has become central to the performance improvement of higher education sector in India. Enrollments in higher education is one of the key parameters used by policy makers. AISHE is an initiative by MHRD to collect enrollment data directly from primary sources, i.e. HEIs. Rashtriya Uchchatar Shiksha Abhiyan is an initiative by MHRD to drive enrollment in regions with low GER[1] and CD[2]. It identifies educationally backward districts (in

[1]Enrollment in higher education per 100 people of age-group 18-23 years.
[2]Number of colleges per 1 lakh people of age-group 18-23 years.

terms of GER and CD) and provides support for establishment of new colleges and for capacity expansion of existing colleges. AICTE's guidelines for the closure of colleges are also based on enrollment. For example, less than 30% enrollment in five consecutive sessions qualifies for progressive closure, it means no further enrollment in concerned colleges. XII Five Year Plan (2012-13 to 2106-17) projected for increment in GER from 17.9 in 2011-12 to 25.2 in 2016-17. It is evident that policy makers in India make many important decisions such as fund allocation, new courses/HEIs openings, closure of HEIs, etc. based on the enrollment status in HEIs. Therefore, keeping the importance of enrollments in mind, in this dissertation, enrollment based efficiency is evaluated, i.e., an attempt has been made to investigate how effectively decision makers utilize their resources to generate enrollment.

Researchers, in the past, have used different methodologies, such as DEA, Stochastic Frontier Analysis, Analytic Hierarchy Process, etc., to evaluate the efficiency of HEIs. DEA is one of the popular methodologies. DEA is mathematical programming approach of efficiency evaluation of DMUs having multiple inputs and multiple outputs. Conventional DEA models focus only on initial inputs and final outputs for efficiency evaluation. Thus, these models treat the production process as a 'black box', i.e., they do not take into account how exactly inputs are related to outputs. Various models that came later take care of internal processes of DMU. The existing models of internal processes for sub-units consist of three stages: the first stage calculates the relative weights of sub-units, the second stage calculates the efficiencies of sub-units, and in the third stage efficiencies of sub-units are aggregated as the efficiency of DMU. It is observed that when existing models of internal processes are applied to *non-homogeneous parallel sub-units*, in the first stage, the weight assigned to the maximum efficient sub-unit becomes one and to other sub-units becomes zero. This implies that the efficiency of a DMU is equal to the maximum of efficiencies of its sub-units indicating that the efficiency of a DMU is not sensitive to the efficiencies of sub-units other than the sub-unit with maximum efficiency.

Existing models, for efficiency evaluation of DMUs with *homogeneous parallel sub-units*, have limitations as the production process of a DMU is compared with the production possibility set of all production units. And same set of input/output weights is used to evaluate the

efficiency, and projected inputs/outputs of a DMU and all its production units. As a result, production units having input output mix different from that of a DMU are penalized, and all production units of a DMU are treated equal. This means, all the production units of a DMU operate in a similar way in the long run as if they are not separate production units but one single entity.

This dissertation titled "Efficiency Measurement of Higher Education Sector in India: Evaluation with DEA" is aimed to address the following research problems:

Efficiency evaluation of DMUs having non-homogeneous parallel sub-units: This work proposes a single stage DEA approach where the efficiency of a DMU and its sub-units can be measured simultaneously. The proposed approach addresses the limitations of existing methodology as mentioned earlier. The advantage of the proposed approach is that the efficiency of a DMU is sensitive to the changes in the efficiency of its sub-units, and weights of sub-units can be assigned a priori by the decision maker. Since state acts as a decision maker, therefore it is taken as a DMU. Further exploration reveals that the functions of universities, colleges, and SAIs are not homogeneous in nature. The motive of establishment of an institution differentiates it from other types of institutions. For example, the idea behind setting up of a college is to provide more of undergraduate courses, while that of a university is to provide all types of higher education courses along with research programs, and that of SAIs is to provide predominantly career oriented courses. Hence, universities, colleges, and SAIs are considered as three non-homogeneous parallel sub-units of a DMU.

Cross-efficiency based ranking of DMUs having non-homogeneous parallel sub-units: Efficiency is relevant not only in business environment but also in non-business environment. Efficiency serves as an important indicator for comparing and ranking various operational units. Various examples of ranking can be observed in India, for example, ranking of cities on cleanliness, ranking of railway stations, ranking of HEIs by NIRF etc. These performance measurements and rankings are used as a tool for further policy development by policy makers. In standard DEA models (CCR and BCC) usually more than one DMU is efficient, therefore, these models do not discriminate and rank the efficient DMUs. Further, these models use different

facets of frontier, hence DMUs cannot be ranked. As pointed out in literature, efficiency score of a DMU is based on self-appraisal, and the same DMU can have lower efficiency score on peer appraisal. Various researches, on DEA based ranking of DMUs, can be traced to either super-efficiency approach or cross-efficiency approach. Super-efficiency approach evaluates efficiency of a DMU w.r.t. the efficiency frontier formed by all other DMUs. The cross-efficiency approach is based on the self and peer appraisal of DMUs. Cross-efficiency approach has been applied to rank DMUs having non-homogeneous sub-units, and adopted various alternate secondary goals. Same data set is used as in previous research problem, and ranks of states based on cross-efficiency are obtained. Ranks obtained from all models are compared using Wilcoxon signed rank test for similarity between ranks. It is found that difference between ranks are not statistically significant at 0.05 level. It is also observed that the cross-efficiency of a DMU is equal to the convex combination of the cross-efficiencies of its sub-units. It is also noted that in general, cross-efficiency of aggressive formulation is lower than that of benevolent formulation, however, counter examples are also found, where cross-efficiency of aggressive formulation is more than that of benevolent formulation.

Efficiency evaluation of DMUs having homogeneous parallel sub-units: To address the limitations mentioned earlier, an aggregation approach has been proposed to evaluate the efficiency of DMUs. Two efficiency measures are also introduced, i.e., Weighted Average Efficiency and System Efficiency. As opposed to the existing methodology, different set of weights are used to evaluate efficiency of different sub-units of a DMU. This chapter evaluates efficiency of seven state public universities of Bihar. There are differences in various indicators of HEIs in states across India. For example, in the state of Bihar, the reach of higher education is less than the national average; GER in Bihar is 11.2, whereas the national GER is 21.1 and the same for Tamil Nadu is 42; CD of Bihar is 6.3, against the pan-India CD and Andhra Pradesh's CD of 25.3 and 48.3 respectively. 84.4 percent of the total enrolled students in Bihar are in colleges; the respective percentage at national level is 67.9. The above facts necessitate efficiency evaluation of colleges/universities in Bihar. Colleges are considered as homogeneous sub-units of respective DMU, i.e. universities.

Impact of categorical variables on efficiency of DMUs: In this research problem, impacts of categorical variables on efficiency of colleges have been evaluated by decomposing efficiency of college into efficiency due to college only and efficiency due to categorical variable. Two types of categorical variables, university affiliation and location, have been considered at two levels for this study. For example, in the first level, DMUs belonging to a category (either of university or location) from all DMUs is considered. In the second level, DMUs belonging to a category are further divided into category, for example, DMUs belonging to rural location are grouped on the basis of university affiliation. Efficiency due to categorical variable of all DMUs within a category is averaged to get the average impact of category on efficiency of DMUs belonging to that category. This average impact is tested against null hypothesis that average is not significant. Dataset from previous research problem is used. Colleges are considered as DMUs.

The dissertation consists of six chapters. Chapter 1 describes the background and the motivation for the work. This chapter also discusses brief overview of higher education system in India, introduces basic DEA methodologies, and presents literature review of the related work. Chapter 2 proposes DEA methodology for efficiency evaluation of DMU having non-homogeneous parallel sub-units, and evaluates enrollment based efficiency of states of India. Chapter 3 applies cross-efficiency DEA approach to rank DMUs having non-homogeneous parallel sub-units, and states of India are ranked. Ranking obtained from different secondary formulations are compared. Chapter 4 develops DEA methodology for efficiency evaluation of DMUs having homogeneous parallel sub-units. Enrollment efficiency of colleges are aggregated as weighted average efficiency and system efficiency. Chapter 5 determines the impact of categorical variable on efficiency of DMUs. Impacts of university affiliation and location on efficiency of colleges are evaluated. Finally, in Chapter 6, the overall contributions and managerial implications of the dissertation have been summarized. The limitations of the present work have also been listed along with the possible directions for the future research.