Assessing Transportation Investment Priority Using Data Envelopment Analysis (DEA)

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Abstract

Transportation provides the guide way for economic activities and development. In order to pave the way of future development, huge amount of investment is being made in transportation projects all over the world. Considering scarcity of the resources required, priorities are being set on the basis of different criteria which include economic indicators like net present value (NPC), benefit cost ratio (B/C), internal rate of return (IRR) as well as other environmental and social factors. Integration of all these dimensions of decision making into a single yardstick of choice usually becomes one of the most challenging tasks for the planners. This paper presents a methodology of integrating multi-criteria decision-making framework into a single efficiency parameter by using Data Envelopment Analysis (DEA) technique. It deals with estimation of the change of regional efficiency induced by the change of accessibility caused by transportation investment. The paper also deals with measurement of accessibility on regional basis thereby capturing a broader spectrum of the investment in transportation sector.

METHODOLOGY

Data Envelopment Analysis, first introduced by Charnes et al. in 1978, can identify optimal allocations of investments through the measure for relative efficiency, which is given by the following expression

$$Efficiency\ \ of\ \ Decision\ \ Making\ \ Unit\ \ j = \frac{Output}{Input} = \frac{u_1 y_{1j} + u_2 y_{2j} + .. + u_k y_{kj}.}{v_1 x_{1j} + v_2 y_{2j} + .. + v_l y_{lj}.} \le 1 \qquad (1)$$

Where, u_k = endogenously determined weight of output indicators
y_{kj} = value of output k from region j
v_l = endogenously determined weight of input l
x_{lj} = amount of input l to unit j

The model described above is rather complex to solve. For solution purpose the model is simplified and resulting linear programming model is shown below:

Model 2: $$Max \quad h_0 = \sum_r u_r y_{rj_0} \qquad (2)$$

Subject to, $$\sum_i v_i x_{ij_0} = 1$$

$$\sum_r u_r y_{rj_0} - \sum_i v_i x_{ij_0} \le 0, \qquad j = 1, 2, \ldots n$$

The method is applied in this study to measure the relative economic efficiency of different regions (districts) of Bangladesh and to examine the efficacy of transportation infrastructure investment with respect to other production factors in achieving the efficiency level.

Input and Output Variables

As mentioned earlier, regional efficiencies are measured as a weighted ratio of output and input elements. In the following sections these elements are illustrated in more detail.

Input Variables: The input variables considered in the analysis include regional population, usable land resources, regional public and private capital and accessibility. Data regarding population and land area are obtained from national census report (BBS, 2001). Accessibility is measured as a composite impedance function given by Equation 3.

$$A_i = \sum_j P_j \exp(-\mu t_{ij}) \qquad t_{ij} = \frac{-1}{\lambda_{ij}} \ln \sum_m \exp(-\lambda_{ij} t_{ijm}) \tag{3}$$

Here λ_{ij} and μ are scale factors. T_{ijm} is the travel impedance for the m-th mode between zone I and j. The travel impedance between two zones is estimated by using a transportation model.

Output Variables: The output variable considered in the analysis includes Gross Domestic Product (GDP) in current market price of each of the regions (districts). For the purpose of the analysis GDP is further classified into three categories, which include primary (agricultural) sector GDP, secondary (manufacturing) sector GDP and tertiary (service) sector GDP.

RESULTS

The method is applied to assess the effectiveness of some major transportation projects currently in the final stage of the planning process. The results suggest that several projects, raking among highest in the conventional analysis, demonstrate poor performance in improving the efficiency level on regional basis.

CONCLUSION

The paper deals with multivariate, multi-criteria decision making framework using Data Envelopment Analysis (DEA) technique and its application in transportation policy formulation. The results of the analyses suggest that the framework can be successfully applied in transportation investment priority assessment.

REFERENCES

Charnes, A., Cooper, W.W., Rhodes, E. (1978), ' Measuring Efficiency of Decision Making Units', European Journal of Operations Research, Vol.2, 429-44.

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