ABSTRACT

EFFICIENCY BASED PRODUCTION PLANNING AND CONTROL

1.0 Rationale for the study

Production Planning and Control (PPC), an important managerial function determines the quantity of outputs to be produced, the expected levels of inventory and work force or any other resources required for the planning period. The mathematical programming approaches for PPC involve minimizing a cost function subject to constraints on resource availability (technology) and demand. This requires data on procurement costs of inputs, processing costs, selling prices of outputs and demand forecasts. The traditional approach can, in general, be said to be one of maximizing profits.

However, in not-for-profit sector comprising public utilities and voluntary organizations, the primary goal might not be profit maximization. Moreover, the cost of inputs consumed and/or the price of outputs produced are not readily available. Similarly, in public sector, goods and services produced often have captive markets and are sold at administered prices (coal and electricity supplied by public utilities). In many cases, inputs might be obtained at administered prices (crude oil supplied to public sector refineries). In other situations, sister concerns within a conglomerate might resort to transfer pricing. Pricing mechanisms, both administered and transfer, being externally decided might induce bias in decision making.

Various other situations could also be identified where data on costs of inputs or prices of outputs are not reliably available. Yet, planning for higher productivity is important in these sectors. Consequently,alternate methods of production planning which do not require data on cost of inputs and price of outputs are desirable. However, a survey of literature on production planning and control, clearly show the overwhelming bias of traditional production planning approaches towards optimizing profits/costs. This provides the rationale for the dissertation.

2.0 Objective and Significance

An alternate approach to production planning could be to optimize on some operational parameter, such as *efficiency* of the production process. For a firm to be technically efficient, it should produce more outputs for less inputs. Data Envelopment Analysis (DEA)

is a technique to assess the efficiency of production units relative to a set of similar units. The objective of the dissertation is to propose models within the framework of efficiency and DEA for production planning.

The application of DEA as a quantitative tool, in assessing the relative efficiency of production units in a non parametric manner is well known. DEA also finds application in benchmarking to determine the best practices and in analysing the time series variation of efficiency of production units. However, the application of DEA as a planning tool is limited in literature. DEA based models for resource allocation available in literature plan for allocation of resources for one time period ahead of a set of observed production periods, such that the planned period is not inefficient with respect to the observed ones. But while planning production for many time periods, there is the need to incorporate demand satisfaction as also the possibility of inventory/backorder across time periods. Moreover, all available models of resource allocation are constrained in that they can be used only when a single output is produced. New models are proposed in the dissertation within the frame work of DEA, overcoming these identified shortfalls.

Efficiency based approach to production planning is significant because of the following reasons :

- A pursuit of cost minimization might lead to the production being inefficient despite being profitable, in monopolistic situations. This hides inefficiency and prevents the organization from attempting improvement.
- The cost of production can be kept low by efficient utilization of resources, leading to competitive advantage for the firm by a cost leadership strategy.
- It has been shown mathematically that under certain assumptions, efficient production also satisfies profit maximizing motive of the firm.

3.0 New Models for Production Planning and Control

In the absence of data on cost of inputs and price of outputs, DEA provides a mechanism for aggregating the multiple inputs and outputs by assigning variable weights. The optimal weights make each production unit maximal efficient relative to the set of units being evaluated. A similar approach is adopted in the proposed efficiency based production planning and control models also (EBPPC). However, since, in addition to finding optimal weights, optimization also involves finding the quantity of outputs to be produced, the

models are nonlinear. The presence of terms involving product of variables makes them non-convex also.

Various models for EBPPC are suggested in the dissertation which differ in the following : *(1)* Availability of previous operational data; and *(2)* Orientation. Data of previous operations could either be observed inputs and outputs or observed inputs, outputs and costs. New models have been suggested which determine, in the former case, appropriate aggregating weights for the planning horizon, and in the latter case, aggregating weights and/or parameters of an assumed cost function from the observations. A direct comparison of one of the latter models with the classical HMMS quadratic cost model shows that even in situations where price and cost data are available, optimizing efficiency might lead to a better plan. As per the theory of DEA, there can be two possible orientations, output and input. Output orientation attempts to achieve efficiency by maximizing the output for a given input, while input orientation involves minimizing inputs to produce a given output. EBPPC models have been proposed taking care of both the orientations. Extensions to the basic models to take care of the possibility of procurement by DMUs as well as substitutability of inputs and a Varying Returns to Scale in technology have also been considered.

Analysis and solution of nonlinear, nonconvex models is difficult. The various approaches considered in the dissertation for solution of EBPPC models include solution by standard algorithms like GRG (available as CONOPT solver along with GAMS) and a heuristic procedure taking advantage of Bilinearity of the models. The theoretical results discussed in the dissertation include Pareto optimality of optimal production plans.

This research can be considered as one of the earliest in EBPPC and consequently the emphasis is on DEA based modeling. Considerable scope exists for further work, both from the point of view of modeling as also in overcoming difficulty due to nonconvexity of the nonlinear models.

4.0 Implications of Study :

An alternate approach for production planning and control applicable to situations where cost of inputs and price of outputs are unreliable has been proposed. This would have utility in planning production in public sector and not-for-profit organizations. The proposed models are based on the technique of DEA. With theoretical research extending the

applicability of DEA considerably beyond the initially intended not-for-profit sector the new approach promises to be an alternative to traditional aggregate production planning methods which optimize costs subject to suitable aggregation/disaggregation.

The new approach lays stress on maximizing technical efficiency of utilizing inputs to produce outputs. Hence, the models are useful in gaining and sustaining competitive advantage by a cost leadership strategy. Moreover, the models viewed in the context of a hierarchical production planning system provides the foundation for the new paradigm of efficiency based production planning and control system, which could be used for production planning in the absence of data on costs and/or prices, as also in sectors like not-for-profit voluntary agencies, which are outside the purview of traditional profit based production planning and control.

The dissertation extends the applicability of DEA from its well established role of ex post facto efficiency analysis of production to one of planning for efficient production. Thus, if the traditional DEA models stressed on identifying the best performance and analyzing the gap with respect to the best performer, the proposed models help in developing a plan for better performance.