CHAPTER 1. INTRODUCTION

This chapter is divided into four sections; the first section states the objectives of the research, the second section gives the motivation behind conducting this research, the third section provides a brief overview of the methodology while the fourth section describes the organization of the document.

1.1 OBJECTIVES OF THE RESEARCH

An interface between data envelopment analysis (DEA) and multi-objective linear programming (MOLP) is developed. There are three main objectives of this research. The primary objective of this research is to relate the contribution of the individual processes to the overall production-planning target of the plant, the process performance with respect to its targets and to evaluate the line balance between serial production processes. This is accomplished by developing a serial-manufacturing goal-programming model (SMGP). The second objective is to evaluate the technical efficiencies of the individual processes using standard DEA analysis and to measure the technical efficiency of the overall plant using aggregate inputs and outputs. The third objective is to develop SAS programs for the DEA and goal programming models. The models developed will be used to analyze the performance of a printed circuit board-manufacturing firm.

Also, one of the main objectives of this research is to establish that DEA and goal programming provide complementary evaluation frameworks in performance analysis. One could gain more insight into performance related issues by using these tools simultaneously than using them independently. Issues like effectiveness (achieving the overall plant targets), process effectiveness (achieving process targets) and line balancing (achieving line balance among processes) can be simultaneously addressed. These are critical pointers in determining the overall performance of a manufacturing plant.  

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1.2 MOTIVATION

The complicated structure of organizations operating with multiple levels of decision making requires effective planning and coordinating mechanisms to resolve the conflicting objectives/interests of units within the organization. There are three principal problems of policy making in multi-level environments:

- Interdependencies among the components of the system;
- Conflicts among various priorities, objectives and targets within individual components of the system;
- Conflicts among the priorities, objectives and targets among the various components of the system;

Based on these three characteristics, Nijkamp and Rietveld (1981) advocated the usefulness of multi-objective programming methods. According to Joro (1996) and more recently by Korhonen (1998), DEA and MOLP are structurally very close to each other. In both models, technically speaking, the purpose is to identify efficient points in a certain space and suggest projections of inefficient points on the basis of such information. In DEA, the projection is performed by letting a mathematical program determine weights that associate the analyzed point with the best possible efficiency score. In MOLP, the direction of the projection is based on the use of weights (more generally, parameters), which the decision-maker can directly or indirectly influence reflecting his/her preference structure.

This research was motivated in part by research that developed a budgeting system for local authorities in Greece. In the paper by Athanassopoulos (1995), goal programming and data envelopment analysis are used as instruments for group decision making. Thanassoulis and Dyson (1992) provide a goal programming model for estimating efficient input/output targets for individual units. Their research develops models, which can be used to estimate alternative input-output levels to render relatively inefficient organizational units efficient. The models can incorporate preferences with respect to the potential improvements to individual input and output levels so that the resultant target levels reflect the user's preferences.

The above ideas can be used to evaluate the performance of a manufacturing firm. Though the application scenarios are different, the general nature of the problem
addressed remains the same, i.e., to resolve conflicting objectives within the organization operating at multiple levels of decision making. Process improvement policies for multi-level manufacturing facilities always involve multiple objectives. This justifies the use of a goal programming technique in the analysis. The multiple objectives are the achievement of global plant targets, individual process targets and line balance of serial production processes. The proposed model seeks to provide rich insights into the performance of a serial-manufacturing firm while addressing multiple objectives simultaneously. The model also incorporates the serial process dependencies among the processes. Necessary suggestions can then be offered to improve the overall plant efficiency. A description of the processes for the application studied in this research is given in Chapter 5.

1.3 OVERVIEW OF THE PROPOSED RESEARCH METHODOLOGY

The following are the steps involved in the research methodology.

- Data for the processes are available for a two-year period from September 1994 to July 1996 as studied by Paul Otis (1999).
- The first step is the identification of the input and output variables which adequately represent the processes for the manufacturing facility.
- The next step is to measure efficiency of individual processes using radial and non-radial efficiency measures by programs developed in SAS.
- The overall plant efficiency using the aggregate inputs and outputs is also evaluated using DEA. Data for the aggregate plant inputs and outputs are also available for a two-year period as studied by Paul Otis (1997).
- The next step is to develop the formulation of the goal-programming model that is appropriate for a manufacturing facility that has serial production processes.
- Computer applications for goal programming are developed using SAS.
- Insights gained regarding the efficiency performance of the production processes, contribution of the processes to the plant goals, performance of the processes with respect to its goals and line balancing issues are reported. Sensitivity analysis issues are also addressed.
- Conclusions and recommendations for future work are then stated.
1.4 ORGANIZATION OF THE DOCUMENT

Chapter 1 provides an introduction and overview of the research. Chapter 2 gives an overview of data envelopment analysis and linear goal programming. Chapter 3 discusses the research methodology of Thanassoulis and Dyson (1992) and Athanassopoulos (1995). Chapter 4 describes the serial-manufacturing goal-programming analysis model (SMGP) developed for the research. Chapter 5 has a detailed plant description of the processes involved in the printed circuit board manufacturing and also describes the input and output variables. Chapter 6 presents the results obtained in this research and an analysis of the results. Chapter 7 concludes the document with suggestions for future research.