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A relational database approach to a linear programming-based decision support system for production planning in secondary wood product manufacturing

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Abstract

Secondary manufacturers in the forest products industry face a complex production planning process. Linear programming (LP)-based applications have addressed this production planning issue. However, most models have been developed for a specific plant configuration and cannot readily be applied to others. A relational database approach was used to create an integrated linear programming-based decision support system that can be used to analyze production planning issues in a wide variety of secondary wood product manufacturers. The flexibility of the resultant system indicated the potential to analyze production strategies in the highly dynamic environment characteristic of secondary manufacturers.

Keywords: Decision support system; Linear programming; Flexibility; Relational database; Production planning; Secondary wood product manufacturing

1. Introduction

The expansion of the secondary manufacturing industry is a common interest for the major timber producing, importing and exporting regions of the world [19]. Governments recognize the potential of the secondary industry to stimulate economic development through job creation and economic diversification in forest dependent economies [6,20,21]. Furthermore, rationalization in the primary manufacturing sector has resulted in fewer but larger more efficient sawmills in the ECE region (Europe, North America and the CIS) [19]. This has resulted in downward pressure on employment in the primary manufacturing industry and may exacerbate the need for increased activity in the secondary industry to support these economies.

Secondary manufacturers are typified by a wide variety of raw materials, manufacturing processes and potential products. Consequently, the production planning process can be highly complex. This complexity is further increased by the dynamic nature of the market environment [16].

A limited number of linear programming (LP)-based applications have addressed this complex

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production planning issue in secondary manufacturing. However, most models have been developed for a specific application domain and cannot readily be applied to others [2,3,5,12,15]. This may help explain an observation made by Carino and Willis [4] regarding the lack of optimization modeling applications in small and medium forest products companies. Srinivasan and Sundaram [18], and Muhanna and Pick [11] convey the importance of flexible approaches to model design, in order to broaden the scope of potential applications. Furthermore, Olhager and Rapp [14] suggest that specific operations research applications may have a short life span due to the highly dynamic nature of the manufacturing environment.

The research objective was thus to develop a generic linear programming-based modeling application that will provide a flexible DSS for production planning in a wide variety of secondary manufacturing plants. The DSS was implemented and validated in a secondary manufacturing operation in British Columbia, Canada and is currently being used for production planning purposes at this operation. This paper presents the architecture of the resultant DSS and the mathematical formulation to the underlying LP.

Examples of generic operations research models that incorporate a high degree of application flexibility can be found in a variety of manufacturing environments. Metaxiotis et al. [10] present an object oriented approach to an advanced DSS that is integrated with a Management Information System. The software package was integrated with a management information system in a customized industrial environment in Greece, and uses dynamic simulation techniques to provide production planning and scheduling on a daily basis. Fourer [7] implemented a generic linear programming model via a database system for production planning in the American steel industry. The design of the database is closely related to the structure of the mathematical formulation. Gazmuri and Arrate [8] discuss the development of a system to build optimization models for a variety of applications. They employed a number of software tools from a prototype of a modeling system, and implement a general production-planning model in an appliance manufacturer in Chile.

Zhang [22] provides the only example found by the authors in the secondary manufacturing sector of the forest products industry by developing a multi-period model for furniture manufacturing. Flexibility is provided by viewing the manufacturing operation as a number of processing stages that possess generic attributes, rather than focusing on the specific attributes of each. The model incorporates a user interface programmed in Fortran that generates the linear programming model from user inputs and creates an optimal solution report.

The work presented in this research is similar to that carried out by Zhang in that the manufacturing process is considered in general terms. However, a relational database approach is employed to utilize the data management and manipulation capability offered by modern database systems [9,13].

2. DSS structure

The architecture of the DSS is shown in Fig. 1. The foundation of the DSS is the database management software, Microsoft (MS) Access. The rationale for this was based on the popularity of MS Office that includes Access as a standard component. The MS Access components are linked to the LP optimizer (XA) by an external program named XAEZ. XAEZ instantiates and transfers the model from the database to the optimizer for solving. XAEZ is also responsible for transferring the LP results back to the database. The external programs are shaded grey in Fig. 1. Each component of the DSS is described in the following sections.

2.1. Relational database

The relational database is responsible for storing and managing all model data. The design of the relational database adheres to the principles of *normalization* [17] focusing on data handling efficiency and flexibility. This contrasts with the work carried out by Fourer [7] who designs a database system that is directly related to the structure of the mathematical model (in terms of variables, constraints and coefficients).

Our database design relates both to the data required to build the LP and the way in which we define the structure of a secondary manufacturing plant. Any plant may be represented as a system of machine centers, with linkages that facilitate the transfer of