



An approach to export process management in a wood product enterprise

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ABSTRACT

Integration in the context of supply chain management is fundamental for achieving more resilient supply chains. The complexity of export processes challenges integration efforts, augmenting the need for specialized decision support systems to organize and systemize export decisions. The goal of this paper is to introduce an approach for the design of a decision support system that supports the wood product export process of a Chilean enterprise. The approach is focused on minimizing cost and obtaining a better global service level. The different actors involved in the wood export process are studied, with a particular focus on the negotiation process between the wood enterprise and shipping companies. The decision support system relies on an order management model for the logistics management of the enterprise to adequately solve the supplier selection and order allocation problems. The order management model relies on lexicographic goal programming to account for the multi-criteria nature of the underlying decision process. A case study is used to illustrate the benefits of the proposal.

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1. Introduction

Chile is one of the top timber-producing countries; Chilean wood is exported to the United States, China, Japan and some European countries. Additionally, the timber market is extremely important in the United States, as timber is in demand for house construction. Because of that, internal production is not enough and it is necessary to import timber from other countries. In this scenario Chile has in USA a strategic partner in the timber production.

After production takes place, the export process begins, it consists in consolidating the wood product into containers and its shipment by maritime transportation to ports that are nearby clients. This process includes gathering, negotiating and selecting offers from maritime shipping companies. These activities in current practice are loosely structured and managers are seldom supported by any tool or methodology to optimize their realization, making this subject an interesting and complex problem for research. Selecting an offer from a shipping company is a difficult decision and has an impact on the cost structure of wood companies and in customer satisfaction. Managers have to evaluate the tradeoffs between maritime shipping cost, land transportation from port to clients and possible tardiness for not fulfilling orders

within due dates. Moreover, the need to incorporate the policy of order splitting, that is separating an order's quantity into two or more shipments is considered as a possibility of improving costs and efficiency, but it augments the complexity of the shipping process.

In the literature, there are different optimization based proposals that consider different supply chain distribution planning aspects of the timber industry. Nevertheless, to the best of the authors knowledge none of them considers those aspects simultaneously. This work introduces a proposal to fill this gap, where the transportation cost (land and maritime), tardiness costs and the possibility to split orders to further reduce cost and times are considered in a holistic approach.

In this context, a Decision Support System (DSS) enabling a timber company to gather, organize and select offers from maritime shipping providers and also to optimize the decisions involved is required. A DSS as such can provide synergy between the different actors involved in the export process. To fulfill service-level agreements with customers, the DSS must take a holistic approach to the entire export process, including the collaborative and coordinated tasks performed by the actors in the export chain.

This work relies on a multi-criteria optimization problem, that properly embedded on the context of a specifically designed and described DSS proves to be a solution capable to guide decision makers in the context of the timber export and shipping processes. The proposal is validated using a real-world case study. In this case study, the company lacks this type of decision support tool. The company makes decisions based on an analysis of offers made by

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shipping companies, which does not properly fulfill its business requirements. Inspired in this scenario, this work proposes a mathematical model-based approach for a DSS that will aid this and other timber production companies in planning their distribution.

The remainder of this work is organized as follows. The next section provides a brief literature review with a focus on how a DSS is relevant for a resilient supply chain (SC). Section 3 defines the problem and the actors involved. The solution is described in Section 4, and case study analysis and discussion is shown in Section 5. Conclusions and future works are given in Section 6.

2. Related work

Supply chain management (SCM) impacts organizational performance in terms of both competition (based on price and quality) and flexibility in an evolving global market. These two properties are important in the ability to remain resilient whilst satisfying customer demand.

Decision Support Systems play a crucial role within SCM to guide decision processes, for this purpose having a holistic view is relevant as these processes involve multiple resources and stakeholders. In recent years this problem has been the subject of many research projects. This research area is very active with many groups working to design and develop different DSS oriented to decision process related with planning, operation, selection of supplier among other subjects (Ngai et al., 2014; Montoya-Torres and Ortiz-Vargas, 2014; Taticchi et al., 2015). Some characteristics of a DSS are as follows:

- It is oriented to support less structured decision processes;
- It includes a combination of models and techniques for recovery and data access;
- It was developed for ease of use;
- It supports flexibility and adaptability.

Several studies state that DSS can dramatically improve organizational functions and thus the SC (Vacik and Lever, 2013; Romañach et al., 2014). Vacik and Lever (2013) analyzed the need for tools that support decision-making processes related to different levels of planning.

Toppinen and Kuuluvainen (2010) highlighted that decision makers need tools that support different activities, such as: modeling product demand and supply, price analysis, market demand and price forecasting, inventory planning and management, production scheduling, supplier selection, SC design and re-configuration, location problems and production technology.

Benyoucef et al. (2003) and Songhori et al. (2011) considered integrated supplier selection and order allocation problems. A solution for these problems is important for both designing and operating SCs. This decision is often influenced by concerned stakeholders, including suppliers, plant operators and customers at different tiers. The problem of supplier selection and order allocation is highly related to the proposal of this work which after gathering maritime transportation offers it allocates orders to these offers but also considers other important distribution aspects such as land transportation at destination, order splitting and tardiness which are related to shorter planning horizons.

The aforementioned works are focused in the benefits of DSS to Supply Chain Management, in particular wood and timber supply chains have a set of relevant characteristics that need to be addressed. In this context, Rönnqvist et al. (2015) present a set of challenges in the forestry industry and establish the need for more operations research aided decision making processes. In their work, the most relevant methodological challenges are outlined,

amongst them are: uncertainty in demand and processes, hierarchical planning and multi-criteria decision analysis for forest resource planning. In the same reasoning, Larsson et al. (2016) examine the potential of supply chain management to address challenges associated with the wood processes from harvesting to selling.

An approach in the context of wood logistics networks is developed by Li et al. (2014). In their work an optimal transportation control scheme is presented. The focus is reducing transportation cost using a utility function. The model, based in the utility function definition, produces optimal configurations and minimizes transportation cost. This work is related with the approach of this work as their goal to reduce the logistics cost, and find optimal solutions with a rigorous approach. Despite those benefits, the approach of this work extends the scope of the transportation problematic by considering other aspects of the maritime transportation scenario, as vessels schedule, available cargo capacity and order splitting.

Kong and Rönnqvist (2014) analyze the coordination problem between strategic management and tactical logistics and production planning. Their approach is based on a mathematical model and propose two heuristics to obtain an optimized allocation of resources, considering an internal pricing mechanism for communication between participants. This coordination problem is related to the approach of this proposal, but it proceeds through a specialized matching between customers' orders and offers from shipping companies.

An integrated production and distribution planning approach for pulp manufacturing is considered by (Gunnarsson and Rönnqvist, 2008). They propose a DSS which is enabled by a periodic mathematical model that considers different kinds routes for ships and possible terminal locations. The model decides on production mix, terminal use and contracts. Sanei et al. (2016) propose a model for integrated planning (harvesting, procurement, production, distribution and sales) in lumber SCs. In their paper the problem is modeled as a mixed integer programming which is solved with the aid of heuristic for real-world cases.

The strategy in these two aforementioned proposals is related to the approach of this work. However, this work reduces the scope and complexity of the mathematical model but improves the business perspective and applicability. This broader applicability is due to assume production is already set and focusing only on transportation aspects. In this fashion, the features of supplier selection, order splitting, land transportation at destination and due date aspects are included.

A mathematical model for optimizing timber road transportation in Brazilian wood SCs is developed by Zanetti et al. (2016). Perez et al. (2016) work in a similar problem with the adding of CO₂ emissions in considerations in north eastern Portugal. The focus of these last two proposals is detailed and optimized land transportation of wood products. The approach of the work presented in this paper considers land transportation costs but from an aggregated perspective. This allows integrating efficiently maritime and land transportation of wood products.

This work presents a holistic DSS for order allocation to maritime shipping offers that allows timber companies to create optimized distribution plans to satisfy overseas clients. The proposal has several features that to the best of the authors knowledge have not been considered simultaneously yet. Among these features, the possibility to split orders, the focus on maritime shipping without neglecting land transportation and due date satisfaction stand out. Moreover, planning decisions need to consider multiple criteria to satisfy business goals. Assuming this fact, this work proposes its mathematical model with four different objective functions that are used in a lexicographic goal programming approach. In the next section, the problem solved is described and

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