

# Global Supply Chain

## Configuration and Management of Globally Efficient Supply Chains

### Summary

Increasingly, supply chains involve facilities and channels in different countries. This requires that management must recognize country-specific tax laws, tariffs, environmental regulations, and exchange rates. One major goal of this research is to identify the main types of supply chain configurations that exist within the U.S. paper industry, and to identify the processes and characteristics where value is added in the supply chain. This study of the container sector will identify factors affecting global trade, drivers, objectives, and factors that impact supply chain location, efficiency, and flexibility

A major step in this project was an industry-wide survey of the containerboard industry which was distributed in August 2002. Extremely poor response to this survey has delayed significant progress in identification of supply chain structures, relevant international factors, and global drivers of value creation/destruction. This project is approximately 50% complete.

### Key Questions

- ▶ What is the current state of global supply chains (GSCs) in the container sector of the pulp and paper industry?
- ▶ What are drivers and objectives for globalization, and which are the critical areas where value is added to products in the global supply chain?
- ▶ What factors, such as tariffs and other trade barriers, government policies towards foreign investments etc., impact the location, efficiency and flexibility of the supply chain?

### Value Proposition

*Savings from taking a global perspective and deploying a scientific methodology are typically 10 % of the supply chain costs or profits over the life of the project. Range of expected profit or loss is cut to 30 % of the range without the model application.*

### Key Results to Date

Casual empirical observations suggest that there are many different configurations of supply chains in the U.S. paper industry: global, international, regional or largely domestic. After discussions with several industry experts, a detailed survey was developed for distribution in August 2002. This survey was designed to gather information on supply chain structure, relevant international factors, and the manner in which they affect profitability of GSCs. It is hoped that this survey will identify corporate perceptions on the key global drivers of value creation and destruction in the industry, as well as the main objectives a company desires to maximize (profits, flexibility, etc.) in configuration of their GSCs.

Industry response to this survey was extremely poor, which necessitated a change in data collection strategy. Selected companies will be contacted by phone to complete this survey. This campaign is expected to begin in January 2004.

Through CPBIS and other funding, two models for the configuration of domestic

and global supply chains that are consistent with international corporate financial accounting have been developed. The first model focuses on the minimization of the annual before-tax costs and the second model focuses on the maximization of the after-tax net cash flow of a global corporation. Since strategic supply chain configurations must be determined before future economic conditions are known with certainty, both models include explicitly the impact of uncertainty and the variability of model parameters by using a large number of scenarios. The resulting models are two-stage stochastic programs with complete recourse that have binary configuration variables in the first stage and continuous material flow variables in the second stage.

Models with the above structure could previously not be solved for realistically sized instances. These models have been solved using a combination of accelerated primal Benders decomposition and sampled average approximation (SAA) within a reasonable amount of computing time for two industrial case studies. For these two cases studies the mean-value solution is Pareto-dominated by the solutions to the stochastic models. The solutions to the stochastic models are more robust when the variability or uncertainty of the data parameters is increased. The combination of the modeling and solution methodology provides for the first time a scientific method to evaluate the financial tradeoff between additional investment cost and more stable operational costs when configuring industrial global supply chains. This method allows global corporations to balance high profit strategies against the robustness required to deal with real-world change.

The proposed stochastic programming model and its solution algorithm are capable

of solving supply chain network design problems of a realistic scale. Existing approaches for these problems are either restricted to deterministic environments or can only address a modest number of scenarios for the uncertain problem parameters. Our solution methodology integrates a recently proposed sampling strategy, the Sample Average Approximation scheme, with an accelerated Benders decomposition algorithm to quickly compute high quality solutions to large-scale stochastic supply chain design problems with a huge (potentially infinite) number of scenarios. A computational study involving two real supply chain networks are presented to highlight the significance of the stochastic model as well as the efficiency of the proposed solution strategy.

### **Implications for Industry**

The main focus of this project is the containerboard sector of the paper industry. Information from contacted companies should enable us to benchmark the current practices in the industry and develop alternate recommendations, based on the state-of-the-art developments in the literature. The industry will learn what the important factors in GSC configuration are and derive significant savings from resulting changes. Typical savings from using a scientific methodology are 10 % of the supply chain costs or profits over the life of the project. In addition, by applying the model the range of possible profit or loss is reduced by 30% which reduces supply chain uncertainty and risk.

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## **Anticipated Results and Implications**

The primary sources of data and information will be drawn from a detailed survey that will help us to understand the existing GSC practices in the industry and the industry perspective regarding the importance of global factors. A secondary source of data is a comprehensive review of the literature in management science, industrial engineering, and economics on the factors and models relevant in the configuration of GSCs.

The researchers are identifying the key drivers of globalization through primary and secondary data collection and developing a semantic GSC model that will describe in detail the various components of a GSC, their interactions, and the points at which value creation and value destruction could potentially take place. This model will foster increased understanding of the global supply chain issues and opportunities for economic efficiencies by all companies in the pulp and paper industry.

The outputs of this research are especially geared towards addressing key issues related to the increasing globalization of supply chains in the paper industry and its impact on the profitability of U.S. firms. The development of the semantic GSC model in a user-friendly format will enhance greatly the industry's understanding of GSCs and their impact on profitability. Analysis of global supply chains explicitly includes change in tariff and non-tariff barriers as well as tax structures, exchange rates and risk factors. Hence, firms using this analysis can project and forecast the impact of different trade and tax policy scenarios, exchange rates, and risk factors in optimally configuring their supply chains. This analysis will also enable firms to increase their flexibility, reduce their response time and take advantage of opportunities that result from international policy changes, thus enhancing value creation at the firm and industry levels. It can also provide valuable insight regarding the optimal degree of vertical integration, which is

important in the light of recent spate of mergers and acquisitions.

The project has been extended to May 2004, so that researchers, working in cooperation with their industry liaison panel, may elicit greater response to their survey.

## **Industry Involvement and Impact**

A key aspect of this project is the support and feedback from the industry liaison panel. Minimal response to a survey distributed in June 2002 has delayed the project substantially from its initial target completion date of August 2002. Upon further review of the survey, the list of industry contacts was revised and the survey reworked. It was also decided that the focus should be on containerboard.

The researchers are looking for industrial partners in the paper industry to conduct a case study using their model.

## **Publications**

- ▶ Santoso, T., S. Ahmed, M. Goetschalckx, and A. Shapiro, (2003), "A stochastic programming approach for supply chain network design under uncertainty," Research Report, School of Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta, Georgia.
- ▶ Santoso, T., (2003), "A comprehensive model and efficient solution algorithm for the design of global supply chains under uncertainty," Unpublished Doctoral Dissertation, School of Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta, Georgia.
- ▶ Goetschalckx, M., S. Ahmed, A. Shapiro, and T. Santoso, (2001), "Designing Flexible and Robust Supply Chains," Proceedings of the IEPM Conference, August 20-23, 2001, Quebec City, Quebec, Canada, pp. 539-552.
- ▶ Marc Goetschalckx, Usha Nair-Reichert, Shabbir Ahmed, and Tjendera Santoso, "A review of the state-of-the-art and future research directions for the strategic design of global supply chains," Proceedings of the 2002 Material Handling Research Colloquium, Portland, Maine, June 1-5, 2002.

- ▶ Goetschalckx, M., U. Nair-Reichert, S. Ahmed, and T. Santoso, "A review of the state-of-the-art and future research directions for the strategic design of global supply chains," submitted to the Special Issue on Global Logistics of the Transportation Research E.
- ▶ Santoso, T., S. Ahmed, M. Goetschalckx, and A. Shapiro, (2003), "A stochastic programming approach for supply chain network design under uncertainty," Submitted to European Journal of Operational Research.
- ▶ Santoso, T. and M. Goetschalckx, (2003), "Models and Solution Algorithms for the Strategic Design of Robust Supply Chains under Uncertainty," submitted to IIE Transactions.

## Presentations

- ▶ Goetschalckx, M. and T. Santoso, "Modeling and Design of Flexible and Robust Supply Chains," INFORMS 2000 Annual Meeting and Conference, San Antonio, Nov. 5-8, 2000.
- ▶ Goetschalckx, M., S. Udoka, S. Ahmed, A. Shapiro, and T. Santoso, "A reference model and optimization methodology for the analysis and design of robust and flexible logistics supply chains," Industrial Engineering Research Conference (IERC), Dallas, Texas, May 20-23, 2001.
- ▶ Goetschalckx, M., T. Santoso, S. Ahmed, and A. Shapiro, "Design of Stochastic Strategic Supply Chains," Invited Presentation at Aladdin Integrated Logistics Workshop, Carnegie-Mellon, March 27-29, 2003.

## For additional information, please contact:

Marc Goetschalckx, *School of Industrial and Systems Engineering, Georgia Tech*  
Tel. 404-894-2317

[marc.goetschalckx@isye.gatech.edu](mailto:marc.goetschalckx@isye.gatech.edu)

Usha Nair-Reichert, *School of Economics, Georgia Tech*

[usha.nair@econ.gatech.edu](mailto:usha.nair@econ.gatech.edu)

