SYMPOSIUM ON    OPTIMIZATION IN SUPPLY CHAINS

Organized by

INDUSTRIAL ENGINEERING & OPERATIONS RESEARCH
**Indian Institute of Technology, Bombay**
27th October 2007
**Venue: Electrical Engineering Seminar Hall (EESH), Next to EE Building**

## Schedule of Events

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|---|---|---|---|---|
| 08:15am - 08:45am | Registration & Tea | | 12:55pm - 02:15pm | Lunch at Gulmohar |
| 08:45am - 09:00am | Inauguration | | 02:15pm - 03:45pm | **SESSION III** |
| 09:00am - 10:15am | **SESSION I** | | 03:45pm - 04:15pm | Tea break |
| 10:15am - 10:40am | Tea break | | 04:15pm - 05:45pm | **SESSION IV** |
| 10:40am - 12:55pm | **SESSION II** | | 05:45pm - 06:15pm | Valediction & Tea |

Dear Participant,

I welcome you to this Symposium on 'Optimization in Supply Chains' organized by IEOR, IIT Bombay. The theme of this symposium is on modeling and analysis of optimization problems arising in supply chain management. A spectrum of talks have been put together on different aspects of supply chain, such as global manufacturing, forecasting, capacity planning, logistics, chain formation, closed-loop behavior, pricing decisions, quality of service and co-ordination of decisions. The focus of the talks will be on the quantitative techniques that are employed, such as non-linear programming, mixed integer models, network flow models, simulation and mechanism design, in tackling the different issues. I am sure you will enjoy all the talks of the Symposium.

I thank all the speakers for agreeing to give talks. I also thank my colleagues Narayan Rangaraj, N. Hemachandra, and Mallikarjuna Rao for their help in organizing this Symposium. I thank all student volunteers who have helped realize this Symposium. We thank the Industrial Research and Consultancy Center (IRCC), IIT Bombay for the financial support to organize the Symposium.

-Jayendran Venkateswaran, Symposium Coordinator

## Introduction

A supply chain is a collection of business units (suppliers, manufacturers, distributors, retailers, transporters) that interact with one another to transform raw materials into finished goods and distribute finished goods to the customers. The flow of materials is downstream from the supplier towards the customer or upstream when intermediate products are returned to plants for rework or reusable products are returned for recycling. Similarly, the flow of information is upstream from the customer (e.g. order placement) or downstream (e.g. dispatch advice or availability forecasts or advance schedule information). Supply chains are not restricted to manufacturing organizations; they also extend to service industries such as banking, and the ITeS sector. Supply chain management seeks to integrate processes across multiple firms, and hence better manage the supply chain as a whole.

Optimization models in supply chains have a number of dimensions, ranging from:
- Operational decisions, such as deciding on inventory levels, timing of orders or supplies,
- Medium term decisions, such as location decisions for key facilities (e.g. warehouses), and

- Long term decisions, such as structuring of supply chains (levels and spread) in both procurement and distribution.

A number of techniques of optimization, ranging from linear programming, integer programming, dynamic programming, stochastic optimization, network flow models and general search methods for combinatorial and non-convex optimization have been proposed and used for supply chain applications. Simulation and other methods of analysis are also useful for supply chain optimization.

## About IEOR @ IITBombay

Industrial Engineering and Operations Research (IEOR) programme at IIT Bombay conducts research and offers M.Tech and Ph.D. programmes. The discipline offers a blend of theory, modeling and application, drawing from traditional as well as modern areas of operations research, together with a systems view derived from long-standing principles of industrial engineering. This approach provides a backdrop for technically sound decisions at operational and tactical levels and occasionally at the strategic level, for a variety of organizations. With increase in availability of different types of data, the design of appropriate decision-making algorithms that use these data are the steps for the future. Correspondingly, the role of theory to provide some insight into the trade-offs involved in decision making becomes significant.

Research activities of the group include a breadth of *techniques* (Optimization, Stochastic models, Stochastic control, Simulation, Artificial intelligence based methods, Game theory, and Statistical methods) and *application areas* (Supply chain analysis, Logistics & transportation, Financial engineering, Service sectors, Manufacturing systems, and Quality control).

For information about IE & OR academic programs, people, research work and other related activities, please visit `http://www.ieor.iitb.ac.in`.

## ABSTRACTS

### SESSION I (9.00 AM – 10.15 AM)

**Intro to optimization in supply chains**
Prof. Tapan P. Bagchi - *IEOR, IIT Bombay*
09:00 am - 09:25 am

An introductory talk on supply chain management & the motivation for optimizing the supply chains.

**Forecasting of short life cycle products and parts in Dell using non-linear optimization**
Dr. K. Raghava Rau - *Dell, Bangalore*
09:30am - 10:15am

Forecasting of a new product with a short life-cycle is very challenging and traditional forecasting approaches are of limited use due to their data requirements. Moreover due to short life-cycle and longer lead-times, it is even more important to have a good long range forecasting for better procurement and inventory decisions. This talk gives theoretical framework for addressing long range forecasting using different variations of Bass diffusion model. In the context of short life-

cycle products, the bass models are adapted to capture relevant forecasting characteristics from past product histories and utilizes the information for long range forecasting of a new product. Another interesting application of using Bass model for addressing the product transition problem will be presented in the talk.

### SESSION II (10.40 AM – 12.55 PM)

**Pricing shared resources with QoS guarantees in some logistics models**
Mr. Sudhir Sinha - *IEOR, IIT Bombay*
10:40 am - 11:25 am

The resources in a supply chain face random demands and therefore can be shared among different classes of customers. The shared resource resembles a server serving a multi-class queue with heterogeneous service level expectation. The study considers an operational setting where a resource is shared between two different types of customers; the primary customer (existing customer) and secondary customers (new firm). The pricing

scheme, which is a combination of price charged and service level offered, adopted for the secondary customer and the relative priority among the two classes of customers are mechanism to control the traffic intensity at the resource. We model a constrained optimization problem that selects a suitable pricing policy for the secondary customer as well as optimal priority queue management at the resource that will maximize the revenue while ensuring the agreed upon service levels for the primary customers. The study has implications in settings where a new firm enters into business requiring high infrastructural set up cost. A specific example is the entry of private firms into the inland rail container movement in India who can be considered as secondary customers with facility owner Concor as primary customer.

## Decision models for global manufacturing footprint planning
Dr. K. Ravikumar, *GM (India) Research Labs, Bangalore*
11:25 am -12:10 pm

Global manufacturing footprint design has become an economic and strategic imperative for many companies to stay competitive. Historically, companies rarely adjusted their footprint because costs involved in readjusting supply chains outweighed the operational benefits. But today's business conditions- better logistics, improved technology infrastructure, less vertical integration, emergence of high-productivity nations, and increasing competitive pressures- have led companies to rethink about their manufacturing network. This talk discusses some challenging research issues in global footprint design and sheds light on a few pertinent decision models for strategic planning.

## Decentralized supply chain formation using an incentive compatible mechanism
Prof. N. Hemachandra - *IEOR, IIT Bombay*
12:10 pm -12.55 pm

We consider a decentralized supply chain formation problem for linear, multi-echelon supply chains when the managers of the individual echelons are autonomous and rational. At each echelon, there is a choice of service providers and the specific problem we solve is that of determining a cost-optimal mix of service providers so as to achieve a desired level of end-to-end delivery performance. Such

a design problem can be broken up into two sub-problems, following a mechanism design approach: (1) Design of an incentive compatible mechanism to elicit the true cost functions from the echelon managers; (2) Formulation and solution of an appropriate optimization problem using the true cost information. We develop a mechanism design framework for addressing this problem and first describe a mechanism which we call SCF-DSIC (Supply Chain Formation – Dominant Strategy Incentive Compatibility) in our mechanism design framework. Existing solutions in the literature belong to the SCF-DSIC class and are based on the classical Vickrey-Clarke-Groves mechanisms. They require significant incentives to be paid to the echelon managers for achieving incentive compatibility. Motivated by this, we propose a novel Bayesian incentive compatible mechanism for eliciting the true cost functions from the echelon managers. The proposed solution, which we call SCF-BIC (Supply Chain formation with Bayesian Incentive Compatibility), significantly reduces the cost of supply chain formation. We illustrate the efficacy of the proposed methodology using the example of a three echelon manufacturing supply chain.

## SESSION III (2.15 PM – 3.45 PM)

### Network flow optimization in Stolt Tank Containers
Mr. Barry McNally - *Stolt Nielsen Transportation Group, Netherlands*
Dr. Siddartha Sengupta - *Tata Consultancy Services, Mumbai*
2:15 pm - 3:00 pm

*Mr. Barry McNally: Part 1*
STC's optimized tank container repositioning system is used to reposition the company's fleet of 20,000 tank containers between 99 inventory locations spread around the world in order to meet forecasted customer demand. The implementation of this optimized repositioning system in 2004 resulted in a 24% decrease in Stolt's total repositioning spend - the equivalent of US$4 million annual savings. STC's demand forecasting system and yield management tools have enabled the company to double its profitability in the last two years. These systems have all been fully implemented and are providing considerable value to the company.

Mr. McNally will describe how Stolt Tank Containers (STC), a division of Stolt-Nielsen S.A., has used operations research to improve its strategic and tactical planning and its operational efficiency; how these optimized decision support systems have been used as a basis for dynamic pricing on trade lanes. He will describe the repositioning, budgetary planning and pricing systems that STC has developed in partnership with Tata Consulting Services. He will describe some of the challenges faced and the benefits gained.

*Dr. Siddartha Sengupta: Part 2*
Third Party Logistics (3PL) plays an important role in the competition between global industrial supply chains. To enable 3PL providers to enhance their contribution in the chain, they need to not only improve their operational efficiencies but also optimize their own returns to sustain such initiatives. The talk would expand on these two critical elements of 3PL business enhancement. The 3PL shipping/container industry would be used as the reference. The talk would also use the example of the rail transport and US automobile industry to show how collaboration can often be a critical and important element of such strategic evolution.

## Some models in closed loop supply chains
Prof. Jayendran Venkateswaran - *IEOR, IIT Bombay*
3:00 pm – 3:45 pm

Closed Loop Supply Chain (CLSC) has gained widespread importance today in the world of increasing environmental concerns and stringent regulations on the wastage caused right from inception of a product, through its life period and after it. CLSC can be seen as a combination of (traditional) forward and reverse supply chains. System dynamics model of the CLSC is being attempted to better understand the production-inventory dynamics in the presence of recycled products. This looks at the impact of recycling within a single player as well as the impact across the supply chain. In a second branch of related work, the collection of used products from the customers has been studied. The uncertainty associated with the quantity and quality of collected products from consumers has been captured by using number of probabilistic distributions which depend upon the life period of a product. Experimental results using simulation show some indications to help time promotions and exchange offers.

## SESSION IV  (4.15 PM – 5.45 PM)

### Capacity requirements planning in a services supply chain
Mr. Milind Padalkar- *Patni Computer Systems, Mumbai*
4:15 pm – 5:00 pm

Human resource capacity management in services supply chains like IT and ITeS industry is a very complex phenomenon due to continuous transformation of resources through internal as well as external learning process. Also there is a limited and logical flexibility associated with each resource and it has to be considered while deploying the resources on different tasks. This paper focuses on the human resource rationalization, codification and capacity requirement planning in a services supply chain. We develop Learning Flexibility Matrix to consider the learning difficulty while moving from one skill set to another and Cost Matrix for addressing the cost incurred during the skill transformation process. Further these matrices are used in allocation of resources in the Integer Programming formulation of the capacity planning engine. The capacity planning engine developed in this paper will help ITeS and similar companies to make strategic decisions like resource acquisition and operational decisions like identifying training needs in a more scientific way.

### Pricing as a means of co-ordinating supply chain decisions
Prof. Narayan Rangaraj - *IEOR,IIT Bombay*
5:00 pm – 5:45 pm

Pricing of various types (of products, of resources and of penalties related to service delivery or service obligation) are important signals to supply chain players to plan their own operations. We provide a perspective on strategic aspects of supply chain formation and also provide examples of medium term co-ordination by taking the example of the double marginalization phenomenon and its consequences. More broadly, we examine the role of contracts and the role of prices defined over different time horizons, which result in the achievement of supply chain goals. In the process, our analysis covers both short term assets (inventories) and long term assets (capacities).