Koç-IBM Supply Chain Research Center

The goal of the Supply Chain Research Center is to develop novel approaches to supply chain management and logistics that include consideration of sustainability and humanitarian aspects in addition to traditional financial objectives.

F. Sibel Salman - Metin Türkay > Industrial Engineering

We concentrate our research effort to develop models and solution algorithm with the objective of establishing sustainable supply chain and logistics systems. Our effort has been recognized by IBM Corporation. Koç University became the first Turkish university to be awarded the IBM Shared University Research Award that is offered annually to a limited number of universities world-wide to promote projects on the frontiers of science and technology. The project proposed by Industrial Engineering faculty member Assoc. Prof. Metin Türkay on Innovation in Supply Chain is the only recipient of this prestigious award in Turkey. In addition, Koç-IBM Supply Chain Research Center will be established in the College of Engineering for future research projects coordinated by Assoc. Prof. Metin Türkay and Asst. Prof. Sibel Salman with IBM Turk University Relations Manager Jale Akyel.

Supply chain management is the process of planning, implementing, and controlling the operations of the complex supply chain networks that includes supplier, production centers, distribution centers, retailers and customers with the purpose of satisfying customer requirements as efficiently as possible. Supply chain management includes the planning and management of in sourcing, procurement, production and logistics activities as well as the coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers.

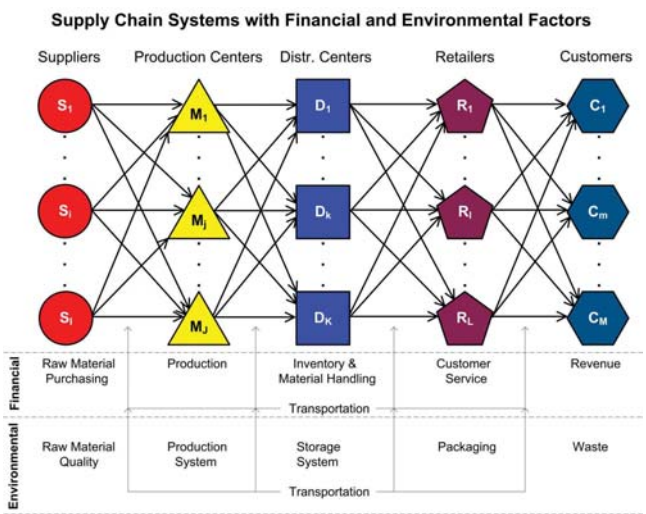

Figure1 - Schematic representation of supply chain networks with financial flows and environmental effects.

The main objective of supply chain systems has been to satisfy the customer demand to maximize the financial gains from the operations of the supply chain. The financial concerns primarily include: the cost of raw material purchasing from the suppliers, the production cost at the production/manufacturing centers, the inventory and material handling costs at the distribution centers, the cost of customer service at the retailers and the cost of transportation incurred by the movement of material/goods throughout the supply chain system and the revenue generated from the customers as shown in Figure 1.

An efficient and responsive supply chain system needs to include environmental and social considerations for sustainability. The environmental performance of supply chain and logistics systems can be achieved by focusing on better management of resources available in the supply chain. The quality of raw materials has significant effects on the environmental performance of the supply chain systems. Raw materials contain impurities that may be harmful to the environment. The production systems usually generate waste in gaseous, liquid or solid from although some of this waste is treated, majority of the waste is released to the environment.

The storage and material handling systems at the distribution centers generate environmentally harmful substances during their operation. The retailers usually sell the products in packages that are attractive to the customers. Majority of the packaging material usually ends up in nature without properly being recycled or treated in waste disposal facilities. The customer generates waste after consuming the products. The waste from the product is usually harmful to the environment. The transportation system also generates environmentally harmful substances through emissions from the vehicles. Social aspects of supply chain systems include generation of value and distribution of this value to different segments of the population, minimizing the risks of operations to the population and responding to disasters effectively and on a timely manner. We can achieve sustainability of supply chain systems by integrating financial, environmental and social objectives seamlessly.

We examine the environmental issues in supply chain systems in three categories:
1. Product centric approaches (closed loop supply chains),
2. Production system centric approaches (environmentally conscious production),
3. Transportation system centric approaches (sustainable transportation).

The product centric approaches focus on the design of the product for minimizing the use of environmentally harmful materials in the product and the recovery and reuse of the product after it has been consumed by the end user. The objective in the product centric approaches is to eliminate the product becoming a waste after the product has completed its life time. These approaches include closed loop supply chains where the product is recovered for reuse/recycle and reverse logistics that includes the planning of the logistics infrastructure of the products.

The production system centric approaches consider the selection of raw materials and the design of the production systems for minimizing the environmental impact. The objective of the production system centric approaches is to design the production system so that the production system is flexible enough to eliminate or reduce the generation of waste. One of the mechanisms is the use of different raw materials. Other mechanisms include changing the configuration of the equipment or the operating conditions of the process system to reduce generation of waste.

Transportation centric approaches consider the use of different transportation systems that would reduce the environmental effects. For example, whenever possible using rail or sea transportation could reduce the emission of Green House Gases. Another aspect of transportation centric approaches is the humanitarian logistics. Disasters, either natural or man-made, pose significant threats to societies. They have the potential to cause severe human and economic loss, and to disrupt the day-to-day activities of humans by crippling the functionality of critical infrastructures and service systems. These infrastructures include habitats, industrial structures, and engineering lifelines such as transportation networks, power systems, water networks, and communication networks. The essential service systems affected may include among others the medical services, food and consumer product distribution networks, financial markets, and mail delivery. The functionality of infrastructure networks is critical for effective disaster mitigation and response. While these networks are vulnerable to failure under natural or man-made disasters, their vulnerability can be reduced by engineering activities that enhance their components structurally leading to higher survival probabilities.

The goal of the Supply Chain Research Center is to develop novel approaches to supply chain management and logistics that include consideration of sustainability and humanitarian aspects in addition to traditional financial objectives. The modeling approaches and solution algorithms developed in the center will be applied in a number of projects to determine their feasibility and potential benefits. In addition, one of the activities of the center is to prepare new course contents that will be taught at universities world-wide to promote this approach to sustainability. Currently, the sustainability and humanitarian aspects of supply chain management and logistics is being applied on four different projects with the participation of undergraduate and graduate students as well as doctoral candidates. The details of these projects are as follows:

Sustainable Energy Supply Chain: Energy, a necessity for modern life, is vastly consumed in the industrial commercial and service sectors as well as in social activities. Unfortunately, a majority of this energy comes from the widespread use of fossil fuels that causes considerable detrimental effects to the environment. Energy production systems are traditionally based on burning fossil fuels emitting greenhouse gases that contribute to global warming.

This project, sponsored by TÜBİTAK, aims to address sustainability of energy supply chains by considering techno-economic analysis of emerging energy production methods, development of mathematical models and optimization algorithms. The development of simulation and optimization models for carbon capture and sequestering systems that will be a major approach to curbing carbon emission in the near future had been completed. In addition, modeling and optimization studies to integrate bio-fuels into energy supply chains have been completed.

Development of techno-economic models for photovoltaic cells used to convert solar energy into electricity is under study. Last, development of algorithms to solve mixed-integer multi-objective optimization problems is being addressed. The models and solution algorithms developed in this project will be used to analyze sustainable energy supply chains through optimization and scenario studies.

Disaster Logistics: Every year, around 500 natural or man-made disasters affect 200 million people, causes around 75,000 deaths, and material damage that is measured in billions of dollars. The human and economic losses can be reduced by improved planning, preparations, and coordination. Disaster Logistics focuses on undertaking the necessary planning and precautionary steps to respond to a disaster. During the pre-disaster phase, relief supplies such as dry food and blankets should be stored at critical points, coordination and distribution plans should be established based on possible disaster scenarios. We are all aware that Istanbul faces the risk of being hit by a serious earthquake. A scientific study published in 2000 estimated that the possibility of experiencing a strong earthquake in Istanbul is 62.6±15% over a 30 year period. Earthquake scenarios and damage estimates developed in 2003 propose 30-40 thousand fatalities, 120.000 heavy injuries and 1.2 milion homeless people, indicating the magnitude of the required logistics activities. To coordinate the post-disaster logistics activities, several Disaster Response and Distribution Centers (DRDC) are planned to be built by the Istanbul Metropolitan Municipality (IMM) throughout the city.

This project, which is sponsored by the IMM Disaster Coordination Center, develops methods for the selection of the locations of these centers. In selecting the locations, the first factor to be taken into consideration is the ability to distribute supplies effectively in the event of a disaster. The objective is to reach the maximum number of victims within the shortest time. We developed a mathematical model to find the DRDC locations that minimize the weighted time to distribute supplies to affected residential areas while making sure each affected area is close enough to a DRDC. Using damage estimates, the inputs of the mathematical modeling have been generated from the collected data and several DRDC locations have been identified out of the 39 potential areas. We are working on identifying the amount of relief items to be stocked at the facilities as well as the suppliers of these facilities. One more problem is on identifying post-disaster travel times. We are also analyzing the required capacity and location of field hospitals to be built in affected areas.

Inter-Modal Transportation and the Use of Ro-La System in Marmaray: One of the most important steps in logistics is transportation that uses different diverse modes including sea, rail, road, air and pipeline. Some of these modes are economical while others have the advantage of being more environmentally friendly. This project involves modeling and optimization in the design and operation of inter-modal transportation systems. The project is supported by TÜBİTAK and Istanbul Metropolitan Municipality. The objective in this project is to develop scheduling and facilities planning models to integrate capacity planning with the operations. These models are being used to analyze the establishment of Ro-La system in Marmaray.

Automotive Logistics Planning in Marmara Region: The Marmara region requires significant logistics improvements in order to meet the transportation demand in supplying raw materials and spare parts to its automotive manufacturing industry, and to effectively transfer finished goods to demand points in different parts of the globe. The objective of this project, which is supported by the Automotive Industry Association, is to analyze the current logistics infrastructure and provide insights into establishments of a sustainable logistics system for automotive industry in the Marmara region.

In addition to these projects, we are planning to start two new projects in the near future:

Establishing a Reverse Logistics System and a Recovery Facility for Used Batteries: Batteries are used to power many electronic devices. After the energy content of batteries is depleted, they are disposed of in landfills that greatly harm the environment for centuries. This problem can be reduced by initiating city-wide recycling programs and facilities to recover useful metals in batteries without harming the environment. This project is supported by both TÜBİTAK Marmara Research Center, Ministry of Environment and Istanbul Metropolitan Municipality. In this project, mathematical models will be developed and optimization studies will be conducted to design a reverse logistics system for batteries. In addition, a recycling facility for batteries will be designed to extract useful materials from used batteries and recycle back them to industrial use. The production planning and scheduling for the constructed facility will also be addressed. Eventually, a waste battery recycling facility will be built and operated in the near future in Istanbul.

Optimization of Water Consumption in Boron Plants: Large quantities of water is consumed during the mining and processing of the boron mineral which is one of Turkey's leading industrial minerals. It is important to improve the mining technologies to reduce water consumption and also develop efficient systems for recycling water during operations in boron processing plants for sustainability. This project in collaboration with Eti Mining General Management and TÜBİTAK Marmara Research Center intends to design an efficient water usage network which limits water usage by minimizing fresh water consumption and generation of waste water in boron mining and processing facilities.

Supply chain management and logistics is a central theme for industrial and commercial sectors. Due to the accelerating pace of globalization, the financial, environmental and social effects of supply chain and logistics systems are observed at every corner of the globe creating concern regarding sustainability of these systems. Sustainability of supply chain and logistics systems can be achieved by an integrated analysis of financial, environmental and social objectives. The Koç-IBM Supply Chain Research Center seeks innovative approaches for modeling, optimizing, and analyzing sustainable supply chain and logistics systems. The methods developed at the center will be applied in real life problems illustrating their effectiveness.

REFERENCES

1. Türkay, M. "Environmentally Conscious Supply Chain Management", Process Systems Engineering, vol 3: Supply Chain Optimization, L. Papageorgiou and M. Georgiadis (Eds.), 87-105, WILEY-VCH, Heidelberg (2008).

2. Türkay, M. and U. Kaplan, "Integrated Planning and Scheduling", Encyclopedia of Optimization, 2nd ed., C.A. Floudas and P.M. Pardalos (Eds.), 81, Springer, Dordrecht, The Nederlands (2008).

3. Mestan, E., M. Türkay and Y. Arkun, "Optimization of Operations in Supply Chain Systems Using Hybrid Systems Approach and Model Predictive Control", Ind. Eng. Chem. Res., 45(19), 6493 - 6503 (2006).

4. Soylu, A., C. Oruç, M. Türkay, K. Fujita, and T. Asakura, "Synergy Analysis of Collaborative Supply Chain Management in Energy Systems using Multi-Period MILP", European Journal of Operational Research, 174(1), 387-403 (2006).

5. Türkay, M. and A. Soylu, "Synergy Analysis of Collaboration with Biofuel Use for Environmentally Conscious Energy Systems", Computer-Aided Chem. Eng., vol 21B: ESCAPE-16, W. Marquardt and C. Pantelides (Eds.), 1827-1832, Elsevier, Amsterdam (2006).

6. Türkay, M., C. Oruç, K. Fujita, and T. Asakura, "Multi-Company Collaborative Supply Chain Management with Economical and Environmental Considerations", Comput. Chem. Eng., 28(6-7), 985-992 (2004).