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Project Title – Analyzing the Impact of Carbon Regulatory Mechanisms on Supply Chain Management
University – University of Florida
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Start and End Dates – 7/1/12 to 7/1/14
Brief Description of Research Project – The objective of this project is to develop a toolset for designing and managing cost efficient and environmentally friendly supply chains. The goal is to provide insights and direction to guide companies on making sustainable logistics management and transportation decisions.
Describe Implementation of Research Outcomes (or why not implemented) – The models should satisfy the demand for perishable products over the time horizon using different replenishment modes such that the total costs and total emissions of the supply chain are minimized. We anticipate that these models will be used to assess the impacts that potential carbon regulatory policies, such as carbon caps, carbon taxes, carbon cap-and-trade, and carbon offsets have on transportation mode selection decisions and overall emissions levels in the supply chain. The models minimize the total of transportation and inventory holding costs in the supply chain, while accounting for carbon emissions due to transportation and other logistics and supply chain-related activities. These models provide insights and direction to guide companies on making sustainable logistics management and transportation decisions.
Place Any Photos Here –

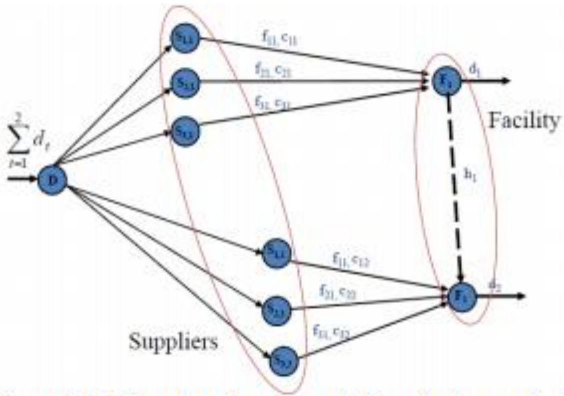


Figure 1-1. The network representation of a two-period, three-supplier problem.

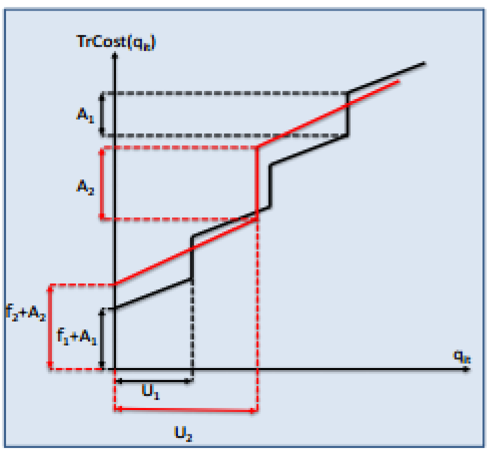


Figure 2-1. A multiple setup cost function.

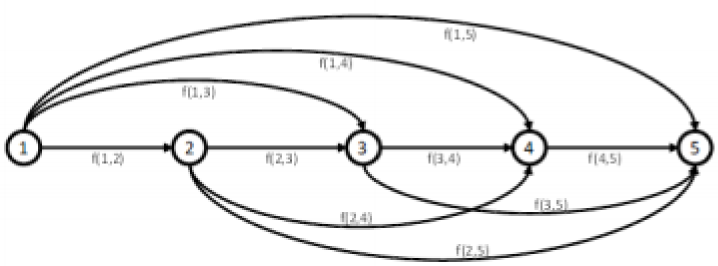


Figure 3-1- Network representation for dynamic programming algorithm (T = 4).

Table 4.2 Transportation mode assignment scheme

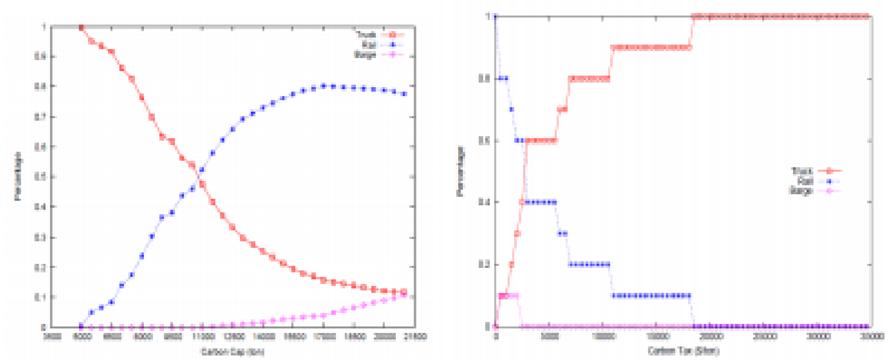
Distance (in miles)	Truck (in %)	Truck & Rail (in %)	Truck & Rail & Barge (in %)
U[5-25]	100	0	0
U[25-100]	50	50	0
U[100-500]	0	50	50
U[500-1,000]	0	30	70
U[1,000-1,500]	0	0	100

Table 4.3 Variable cost for truck transportation

Distance (in miles)	Unit cost ($/(mile*ton))
[0-25]	U[0.0801 - 0.2401]
[25-100]	U[0.0457 - 0.1857]
> 100	U[0.0346 - 0.1746]

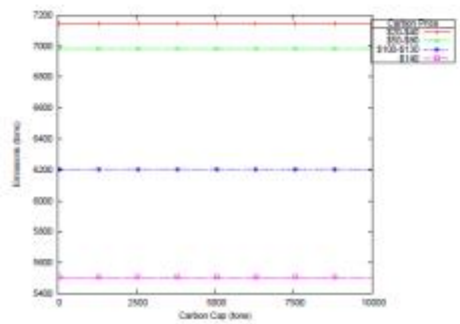
Table 4.4 Problem parameters

Supplier	Replenishment mode	Replenishment unit cost (p)	Fixed order cost (s)	Fixed cargo Cost (A)	Capacity of mode (W)	Fixed emissions ($\hat{A}$)	Variable emissions ($\hat{c}$)	Lead time (L)
1	LTL	15	50	0		30	1	1
2	Non refrigerated FTL	10	50	U[45,55]	25	50	1	2
3	Refrigerated FTL	12	50	U[45,55]	25	50	1.5	3

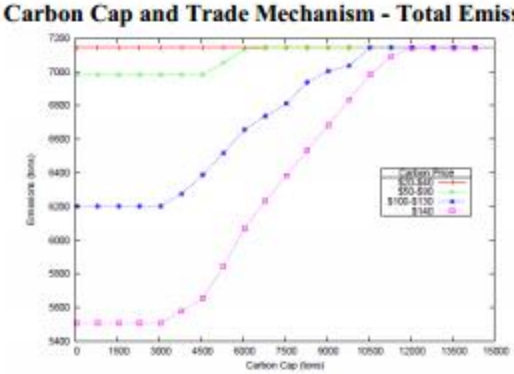


(a) (b)

(a) Carbon cap mechanism (b) Carbon tax mechanism



4-2 Carbon Cap and Trade Mechanism - Total Emissions.



4-3 Carbon Offset Mechanism - Total Emissions.

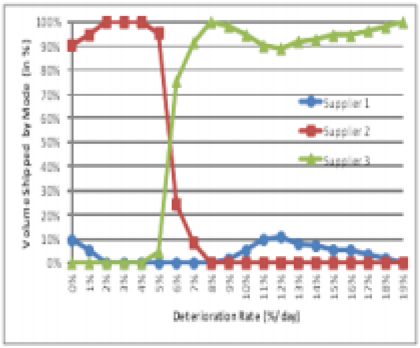
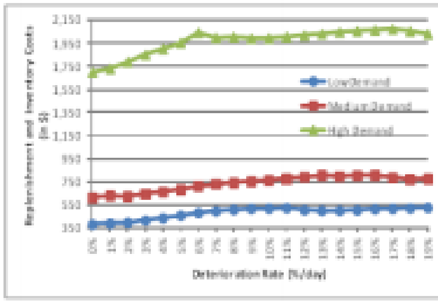
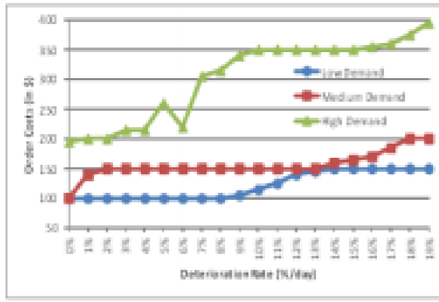


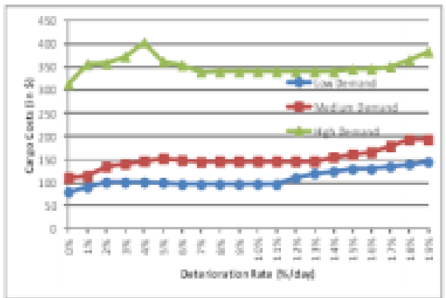
Figure 4-4 Replenishment mode selection for deteriorating products when demand is low.



(a) Replenishment and Inventory Costs



(b) Order Costs



(c) Cargo Costs

Figure 4-5 Total Cost Distribution.

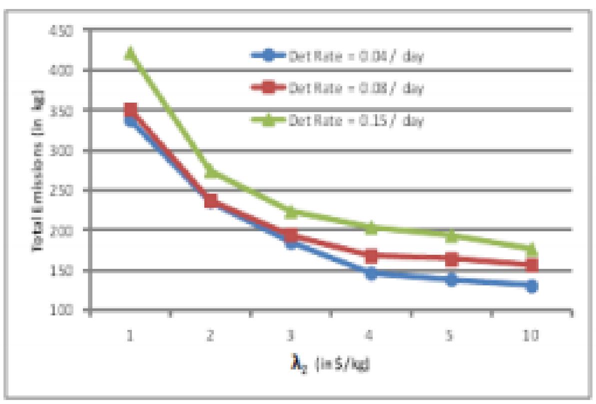


Figure 4-6 Total Emissions versus λ_2 (multiplier we use for emissions in the objective function when implementing the weighted sum method.).

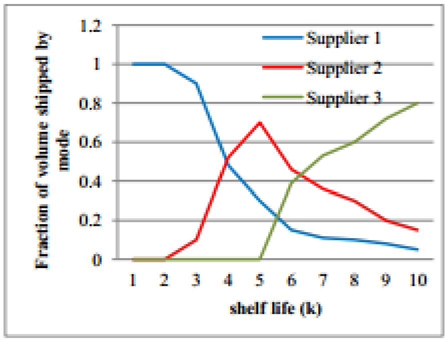


Figure 4-7 Replenishment mode selection.

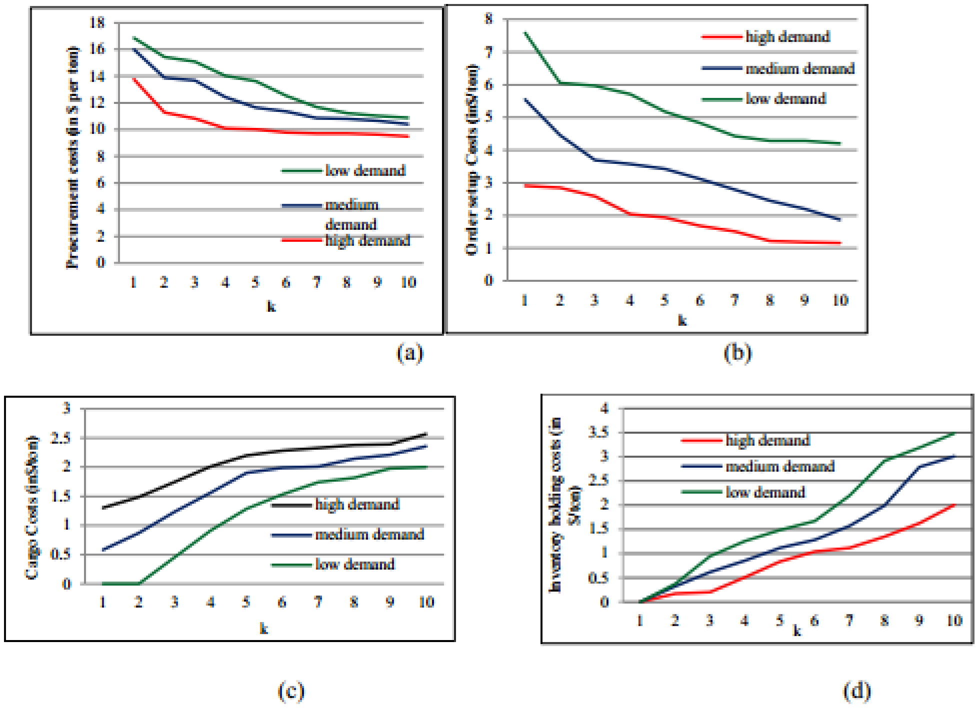


Figure 4-8 Replenishment-related costs versus product shelf life.

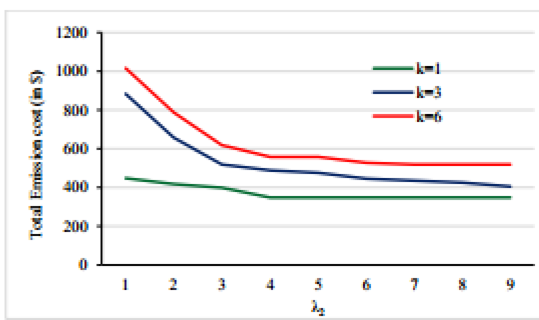


Figure 4-9 Total emissions versus λ_2.

Impact/Benefits of Implementation (actual, not anticipated) - Experimental results provide some interesting insights about the impacts of carbon regulatory mechanisms on supplier and transportation mode selection decisions in the supply chain. We provide a number of mathematical models and solve these models using algorithms which were developed based on the knowledge we created about the properties of optimal solutions to these problems. For example, we developed dynamic programming algorithms to solve some special cases of the cost-minimization models for products which deteriorate with time. One of the algorithms

solves the problem assuming that the Zero Inventory Order policy holds. The other algorithm solves the problem with a single replenishment mode, stationary cargo costs and a no speculative cost structure. The bi-objective optimization models are solved using the ε-constraint and the weighted sum methods. The following are some important observations for replenishment decisions for perishable products: deterioration rate and product shelf life impacts the supplier selection decisions in the supply chain, the frequency of shipments, emissions and costs in the supply chain.
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