Implications of Carbon Management on Supply Chain Design Issues

Green Supply Chain Focus in Practice
- The transportation is usually the focus of company to reduce their carbon emission because it is implementable in a short period.
- Honda use marine or railway transportation to save energy, change the import seaport in Japan to reduce mileage on land.
- Toyota worked with their partner to restructure routes and increase load density.
- Norris et al. (2002) and Weber et al. (2007) suggested that carbon emission from international transportation and wholesaling/retailing are significant.
- A long-term strategy may make more impact on the whole supply chain.

Research Questions
- What are the trade-offs between reducing transportation emission and other supply chain activities?
- Some actions that reduce the emission from transportation will increase the inventory level in the warehouse.
- Is bigger warehouse better as traditional supply chain literature review suggested?
- How the relationship between cost and carbon emission affects the optimal supply chain design?

Carbon Emission from Supply Chain Activities

Factors of Carbon Emission

<table>
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<tr>
<th>Activity</th>
<th>Assumption on Estimation</th>
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| Transportation                   | Fuel efficiency: Speed Weight  
Transportation mode (Air freight, rail, or truck freight)  
Outbound logistics: (carbon emission factors) * (travel distance) * (total weight of loading products)  
Inbound logistics: Fixed carbon emission per shipment + variable carbon emission per unit product per distance |
| Warehouse operation              | Construction material, equipment in the warehouse, size of the warehouse, inventory level, and so on |
| Warehouse construction           | Construction technology, construction material, size of the warehouse |

Numerical Analysis Results and Conclusion
- In general, a sparse supply chain is better than a centralized supply chain when minimizing the total supply chain carbon footprint.
- There exist solutions that firms can save significant amount of carbon emissions without increasing too much cost (Figure 1).
- If firms only consider short-term strategy for reducing carbon emissions (no change of DCs location), only 20% of carbon potential in supply chain network can be achieved (Figure 2).

Carbon emissions from transportation account for a significant proportion of total supply chain network emissions. Hence, a sparse supply chain that can reduce the total shipping distance is preferred when minimizing total carbon emissions.

There exist complicated trade-offs in green supply chain network design problem.