

Implications of Carbon Management on Supply Chain Design Issues

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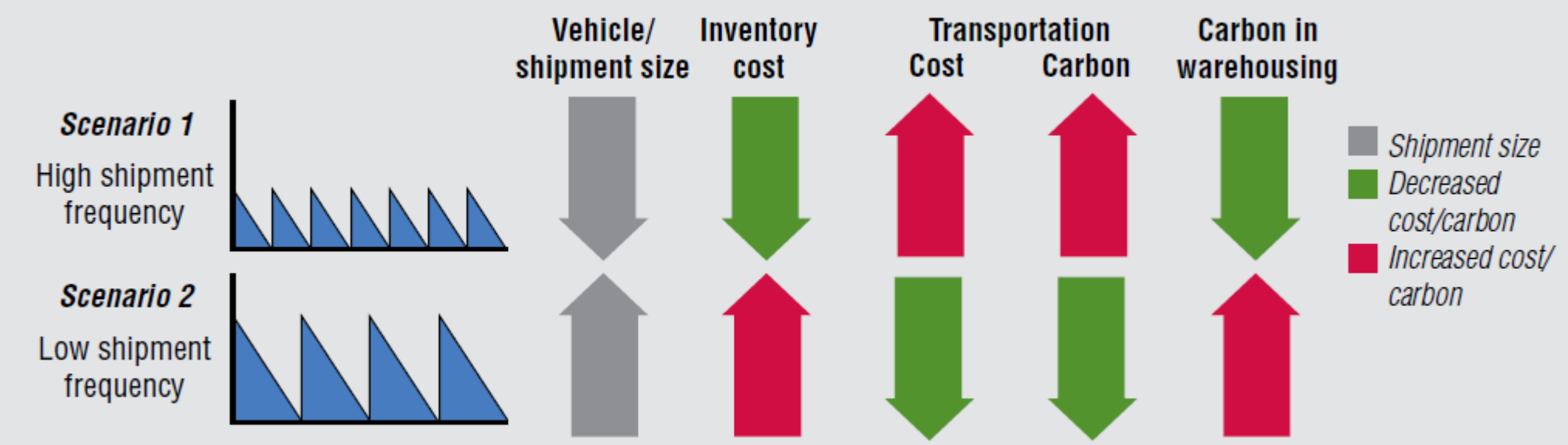
Green Supply Chain Focus in Practice

- 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.**

Carbon Emission Trade-offs in Logistics

Action to Reduce Carbon Emission	Related Issues
Reduce shipment frequency	To maintain the service level, the inventory level has to be increased.
Increase the lot size so that the products can be shipped by larger trucks and the carbon emission per product will be reduced	→ Need larger warehouse and keep a single product longer in warehouse
Change to a low-carbon transportation mode	The lead time may be longer due to slower shipment

Carbon's impact on shipment scenarios.



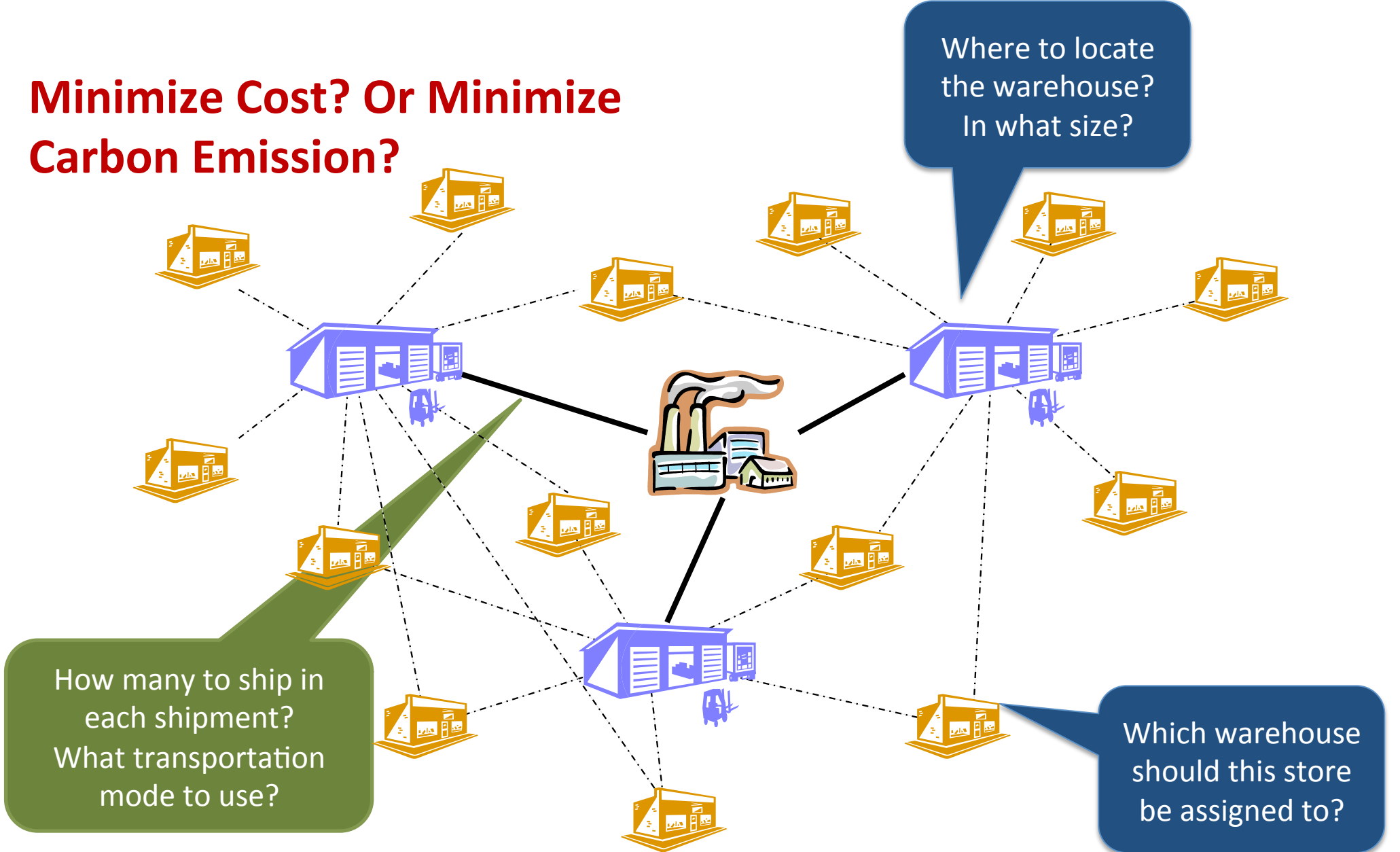
Source: Butner et al. (2008)

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?

A study that consider the cost and carbon emission of inventory and transportation is needed to understand the above questions

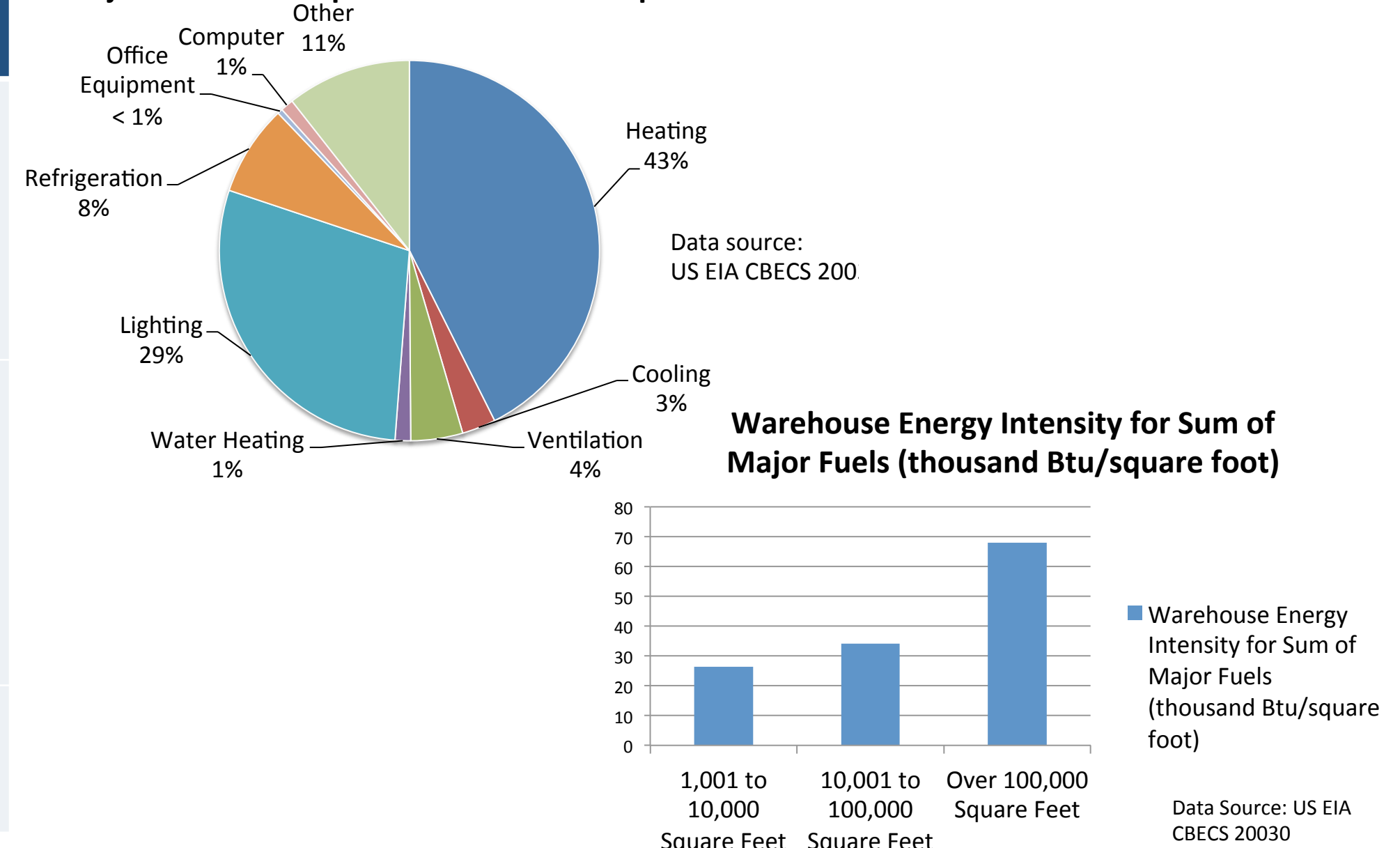
3-Tier Supply Chain Structure



Carbon Emission from Supply Chain Activities

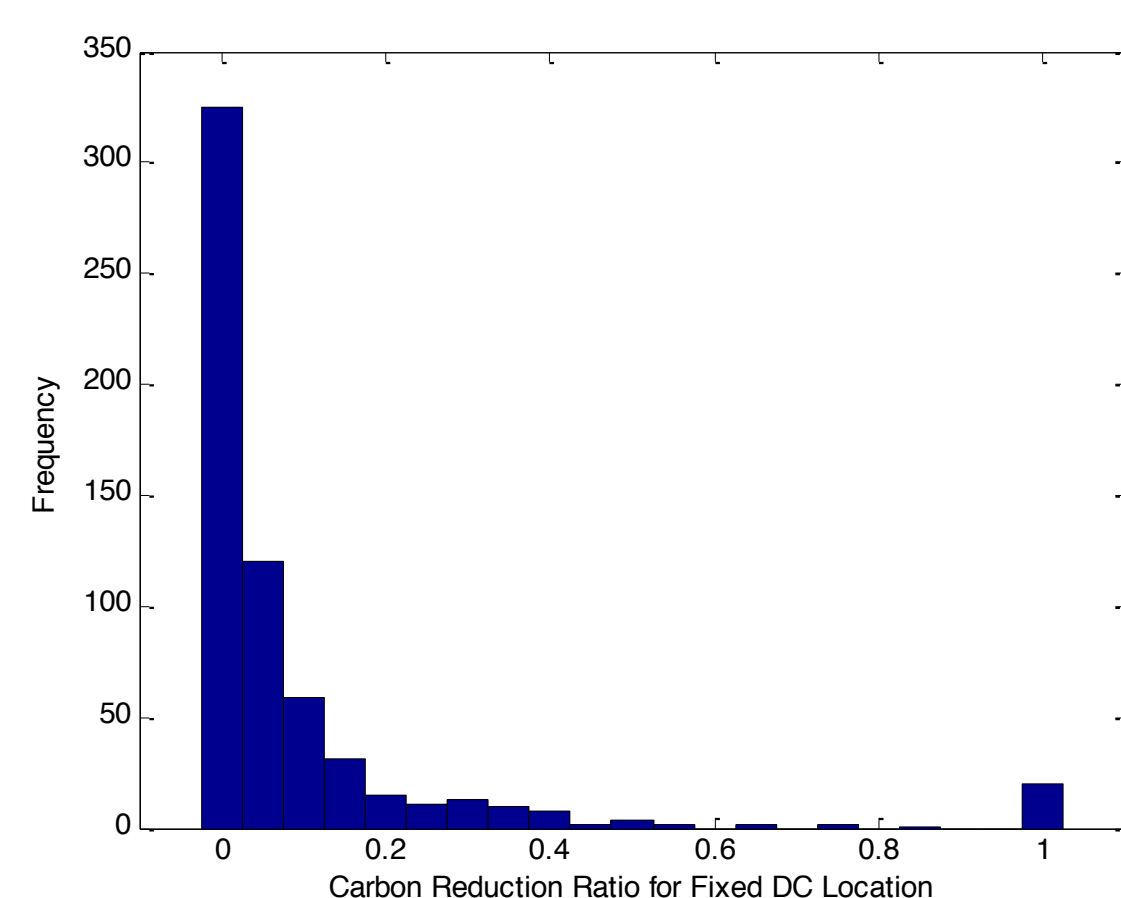
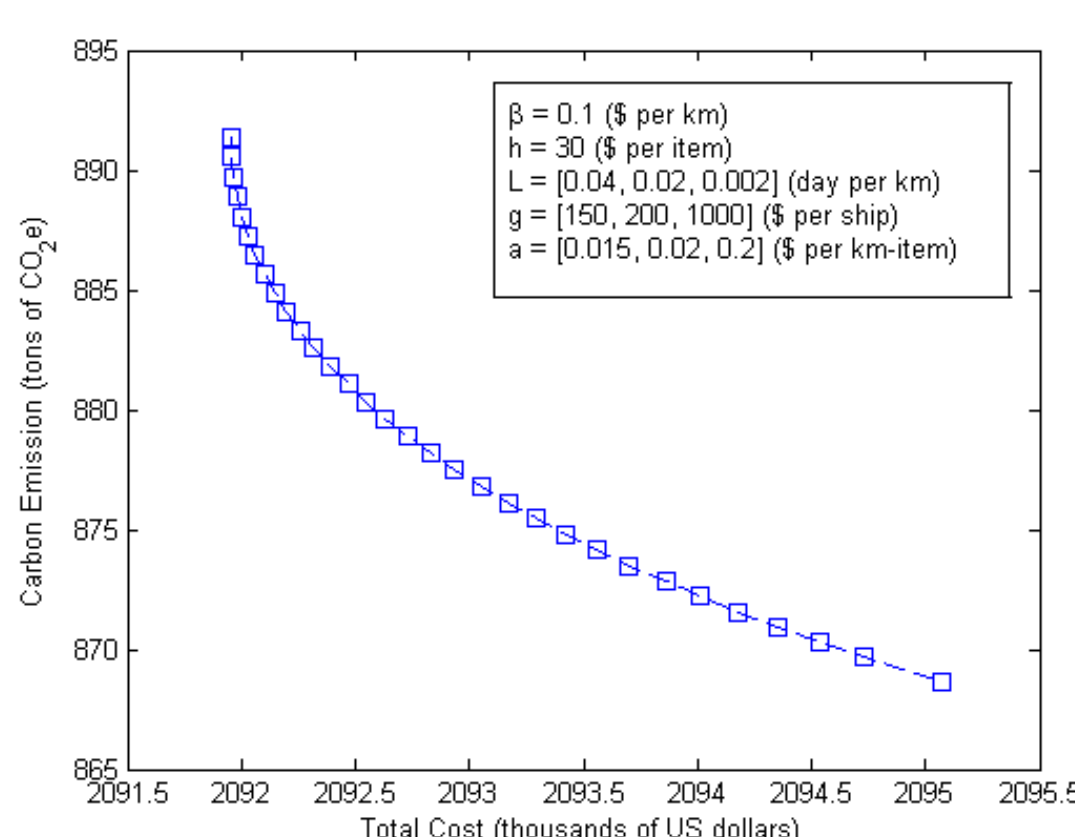
	Factors of Carbon Emission and Energy Consumption	Assumption on Estimation
Transportation	fuel efficiency: Speed Weight Transportation mode (Air freight, rail, truck, or ocean freight)	Outbound logistics: (carbon emission factors) * (travel distance) * (total weight of loading products) Inbound logistics: Fixed carbon emission per shipment + variable carbon emission per unit product per distance
Warehouse Operation	construction material, equipments in the warehouse, size of the warehouse, inventory level, and so on	The inventory in a non-refrigerated warehouse has small effect on energy consumption and is assumed can be ignored. The warehouse operation energy consumption is assumed an exponential function in warehouse size based on regression analysis on data from CBECs 2003.
Warehouse Construction	construction technology, construction material, size of the warehouse	The energy consumption of construction phase is assumed as concave function of building size.

Major Fuel Consumption of Warehouse Operation



Numerical Analysis Results and Conclusion

- In general, a sparse supply chain is better than a centralized supply chain when minimizing the total supply chain network 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 design 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.