LOGISTICS FOR THE PUBLIC SECTOR TRAINING COURSE

Project 02
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National Center for Freight & Infrastructure Research & Education
College of Engineering
Department of Civil and Environmental Engineering
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<tr><td colspan="4">16. Abstract

The primary purpose of the Course is to provide information to public sector—DOT and Metropolitan Planning Organization —staff who work with freight providers or in freight planning on logistics. This information will help them better understand the needs of the freight community and help them better perform their daily activities. More details on the Coalition efforts are posted to the Coalition website (http://www.mississippivalleyfreight.org).</td></tr>
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Executive Summary

This project deals with development of a short logistics training course for public sector freight planners. Public freight system planning and operations have a goal of serving the freight community in product and raw materials distribution and delivery. Freight demand is a just derivative of the logistics practices in the private sector. Therefore it is very important that the public freight planners know the logistics theories and practices in order for them to better understand the shipping needs of the freight community.

A short logistics training course has been developed with a total duration of twelve hours with two sections, each of which accounts for 6 hours per day. The first section introduces basic logistics practices and freight processes. The second section provides more details on logistics theories and practices. An emphasis of this course is to unveil the relationship between freight system performance and logistics efficiencies. An online offering is available at www.wistrans.org/cfire. Power point presentations for each module can be played online with narration. Video clips of interviews with private sector speakers are also available.

Background

This project was approved by the Mississippi Valley Freight Coalition (MVFC) in July 2006, and was funded through the MVFC pooled fund. Through a preliminary survey of state Departments of Transportation (DOT) and Metropolitan Planning Organizations (MPO), it was revealed that most public sectors freight planners have been educated in engineering, especially in civil engineering. A very small percentage of them have experiences in the private sector. Enhancing their understanding of industry practices in logistics management would definitely enhance public sector freight planning.

As the coordinator of the Mississippi Valley Freight Coalition, the National Center for Freight and Infrastructure Research and Education (CFIRE) at the University of Wisconsin – Madison undertook this project. Dr. Teresa M. Adams (Principle Investigator) and Dr. Bruce X. Wang (Co-Investigator) worked with Mr. Ernie Wittwer to have developed this course.

Process

The project started with a survey of stakeholders. 140 people from various organizations and agencies were surveyed, of whom 62 responded. They answered questions about their level of understanding of various areas of transportation and logistics practices and theories. They also provided their preferences regarding course structure and desired duration of the course offerings. Based on the survey results, the research team structured the course

and decided to provide an option of an online course with narrated and downloadable PowerPoint presentations.

In the process of developing the course materials, the research team also invited industry speakers to participate in recorded video interviews. These video clips are also made available to course participants online. Speakers ranged from port and terminal executives, a short line rail president, and a research engineer in a national trucking firm. Their talks cover freight transportation challenges, issues, and technologies, to name a few.

The pilot version of this course was also offered at the March 2008 Mississippi Valley Freight Coalition Workshop in Indianapolis, Indiana. Over twenty participants, largely from state DOTs, participated in a face to face class. Due to time limit, a condensed version of this course was offered within a period of about three and half hours. Feedback was also collected during the offering.

Deliverables

The deliverables include four modules of narrated PowerPoint presentation in Part I, including lecture notes; five modules in Part II, including lecture notes; and four video clips based on industry interviews. The lecture notes are attached at the end of this report.

Acknowledgements

In developing this short course, help and support are acknowledged from the staff and student assistants at the National Center for Freight and Infrastructure Research and Education (CFIRE). In addition, we would like to specially thank the speakers in our interviews. They are Adolph Ojard, Director of the Duluth Seaway Authority, Brian Nutter, Port Director of Indiana-Jeffersonville, Mark Wegner, President of Twin Cities and Western Railroad, and Bob Gremley, Senior Engineer at Schneider National. Libby Ogard helped introduce some of the speakers. Special thanks go to Bill Holloway, graduate research assistant at CFIRE, for narrating Section II and for preparing many components of this final document.

Chapter One: Literature Review of Logistics Training Courses

Supply chain management (SCM) has been a fast growing area of both research and practice in the past two decades. It has shifted the focus from each individual area such as transportation, warehousing and order management, to coordination of the entire supply chain with a total cost concept. Within the supply chain system, transportation logistics is an important component, playing a critical role in the SCM system efficiency.

In the recent past, there have been progresses in various areas of supply chain management. These developments have shaped the operation of industries. Transportation as a means to support the supply chain operation has also experienced its changes in response to the new SCM development such as Just In Time (JIT) and demand driven manufacturing/dispatching. It is therefore important for transportation planners to become aware of the new practices and concepts in SCM in order to understand the driving forces behind freight demand. The logistics course is designed for this purpose. In this way, we hope freight system planners will have a better understanding of how to meet the needs of the freight industry and plan for an efficient and reliable freight system.

There have been numerous course materials on general supply chain management and logistics. They typically cover the generic concepts from procurement, warehousing, distribution, inventory management, supply chain strategies (e.g. assemble-to-order, demand driven manufacturing, vendor management inventory, revenue management), logistics network design, global supply chain/international logistics, outsourcing/third part logistics, and information technology. Some relevant literature on each of these topics will be provided below. Due to the massive need for logistics training, many schools and organizations are offering short courses through the internet. Examples are Georgia Tech [3], University of North Texas [4] and Council of Supply Chain Management [5]. But these are just miniatures of their longer version counterparts.

However, it appears that those course materials are all developed primarily from the supplier/vendor’s perspectives. Although those courses are essential to presenting a panoramic view, transportation planners are particularly more interested in how the supply chain operation/concepts relate to transportation planning and operation. We have not been able to find an available training course of logistics particularly for transportation planners at the state DOT or MPO level.

It might worth a mention of the training courses currently available for transportation planners. The current training mainly focuses on transportation related functions such as those offered by the Transportation Curriculum Coordination Council of FHWA (see http://www.fhwa.dot.gov/infrastructure/tccc/train.cfm), which focus on techniques in pavement and other technical areas. Safety courses offered by National Highway Institute of FHWA are also available (see http://safety.fhwa.dot.gov/training/pro_courses.htm). Safety courses cover road lightning, work zone safety inspection, carrier safety assistance, and traffic signalization to name a few. The Freight Professional Development Program of the Traffic Operations of FHWA has an objective of building the knowledge base and skills of freight transportation and planning professionals. It realizes the need for transportation planners to understand the logistics process. It references the training opportunities we mentioned above.

Realizing the need to tailor the training materials specifically for transportation planners at state DOTs and MPOs, especially for the Mississippi Valley Region, we plan to categorize the literature according to functional areas of the supply chain, trying to emphasize their implications to freight transportation (infrastructure), while maintaining a complete picture of the supply chain activities. In what follows, we make an effort to identify available literature in each major area. Note that the identified literature only represents what we believe could shed light on elementary topics. The literature here does not go into depth beyond what is generally considered elementary level. Therefore, it might not reflect the most up to date development in terms of sophisticated modeling and ideas. Nor does it represent the best fit to the according topic. Better materials may be identified down the road as we continue to research the topic.

In general, each of the books [1~31] in the bibliography covers a wide range of the areas listed below. Some of the books have a focus on research, and therefore are not suitable for tutorial purposes. Worthy of a special mention are [1], [26], which cover almost every topic listed below and are generally good for educating in basic logistics. One may find they are relevant and useful to almost every topic area.

In what follows, we associate each topic area some relevant literature that could be used to organize this logistics course. Annotation is made to indicate their relevancy.

- Logistics overview
    - Chapter 2 of [2] on ‘overview of supply chain management and logistics strategy’ explains some basic terms.
    - Chapter 1 of [26] on ‘understanding the supply chain’ (*defines SC, provides examples of supply chain, process view, and decision phases of SCM*).
- Procurement and outsourcing strategies
    - Chapter 2 of [2] on ‘acquisition management’ (*note: somewhat outdated*)
    - Chapter 13 of [26] on ‘sourcing’
- Logistics process [1], [4]
    - Inventory management
        - Chapter 10-12 of [26]
    - Warehousing [18]
    - Distribution [4], [31]
    - Reverse logistics
- Logistics network design [4]
    - Chapter 7 of [8]: ‘integrated production and distribution operations’ (*Note: Mostly the chapter focuses on modeling. Insights are also available.*)
    - Chapter 4, 5, 6 of [26] on ‘designing the distribution network in a supply chain’. (*Note: good material*)
    - [1] on logistics and distribution.
- Supply chain strategies
    - (*Note: Concepts are scattered throughout. No single good material is usable.*)
- Modal and intermodal transportation
    - Chapter 14 of [26], ‘Transportation in the Supply Chain’. (*Note: it is a very good fit to this course. It exposes transportation in the context of SCM.*)
- Information technologies in logistics
    - Chapter 2 of [8] covers game theory. Chapter 5, 6, and 7 of [8] covers auctions. (*Note: too theoretical*)
    - Chapter 17 of [26] on IT and SC
    - Chapter 18 of [26] on E-Business and SC
    - [5] specially deals with Enterprise Resource Planning (ERP).
- Challenges and future of logistics [23]

The subsequent customer surveys generally followed this format of knowledge structure. This categorization proved helpful in developing the entire logistics training course. It is our hope that the referenced materials and documents would provide additional help to those readers interested in learning more in the according particular topic area.

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Chapter 2: Survey on Logistics Knowledge and Proposed Course Structure

The research team adopted a customer oriented approach in developing the course materials. The underlying reason was that there are many unknowns in the course development.

- The public freight planners' knowledge about logistics.
- Differentiation between planners in terms of logistics knowledge.
- Course duration acceptable to the planners' work schedules and deliverance means (e.g. online or face to face).
- Logistics coverage (what planners know well, what not).

An electronic survey was designed and sent to a total of 140 state agency and local planning professionals in the region. 62 responses, approximately 45% of the total, were received. It turned out that this customer survey helped us structured the entire course.

The survey is mainly on the following aspects: background information of participants, appraisal of their logistics knowledge, comparison of theirs with their peers, preferred course structure and delivery. In the survey, we broke the logistics management into the following areas: general supply chain structure and objectives, outsourcing and procurement, distribution, new logistics practices and theories, IT technologies, and modal transportation. In addition, the participants' background is generally about their education/training, current position/role, logistics experiences, etc. Course structure is surveyed through their opinion on the course duration and means (face-to-face vs. online).

Knowledge of the freight planners' logistics background is critical to the development of this course. A satisfactory and convincing gauge of their knowledge is not available unless a quiz is taken, which is practically impossible. Their self-assessment within a reasonable time appears the only practical means in this study. However, such self-assessment often raises concerns of systematic biases. To offset this concern, a question is added about assessment of close colleagues by each participant as compared to her or himself. The rational is that if one overestimates him/her-self, this person would tend to underestimate the peers; and if he/she underestimates him/her self, this person tends to overestimates the peers. By combining the assessment of themselves and their peers, a better gauge is expected about their knowledge as a team.

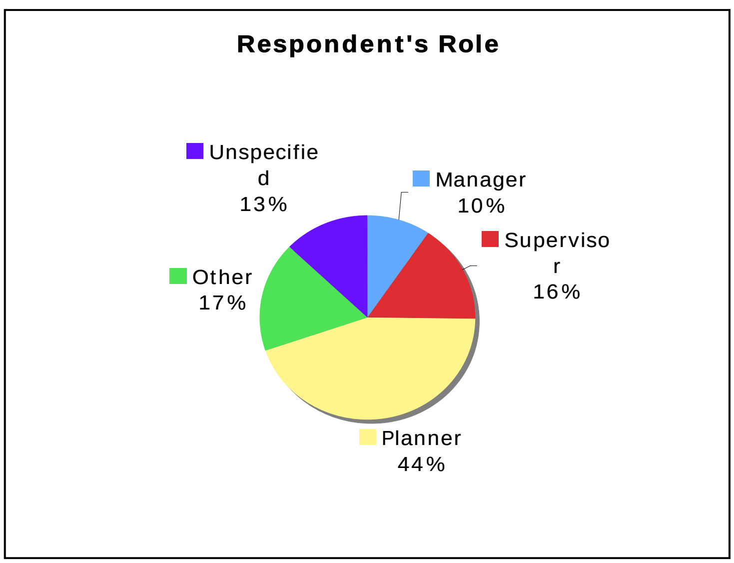
In the following, we summarize the major findings in this survey.

Who Responded?

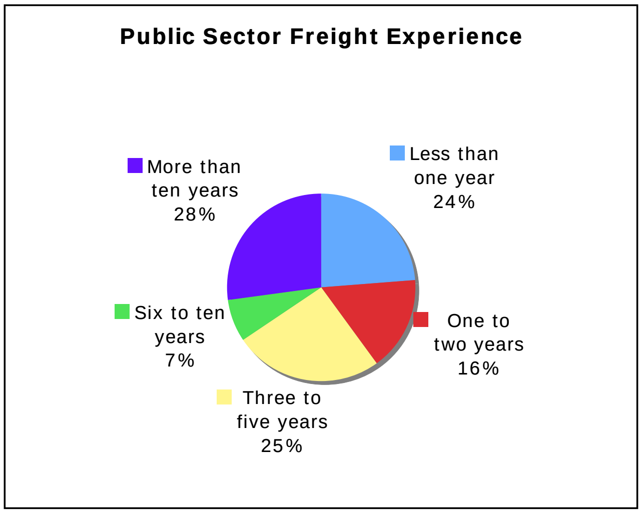
The bulk of the respondents are from state transportation agencies. MPO employees made up the next largest group. A small number came from other public and quasi-public agencies. Thirteen percent failed to answer the question.

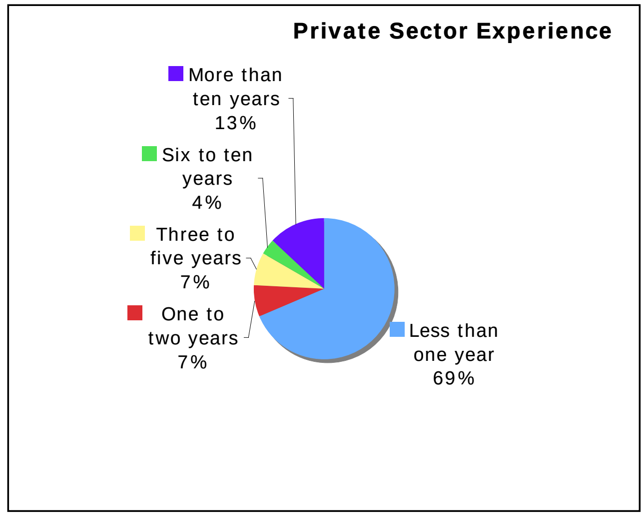
In terms of position, planning professional is the role of half of the respondents. Managers and supervisors make up most of the balance.

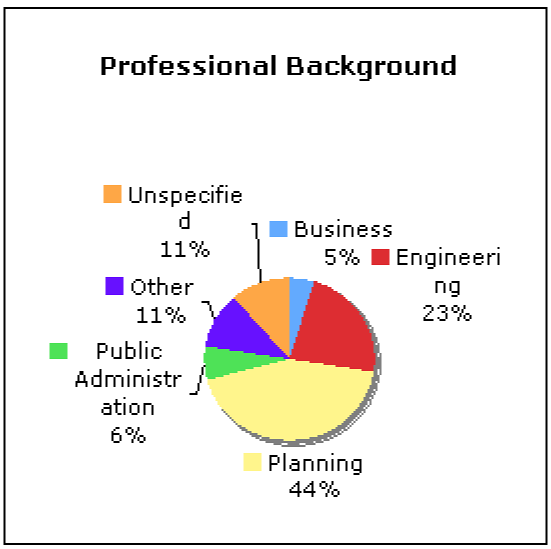
Experience varies markedly among the respondents. Forty-one percent have five years or less experience in the public sector; twenty seven percent have more than ten years public sector experience in freight.



Private sector experience in freight experience is very limited. Sixty-nine percent have less than one year of private experience (this would include many with no such experience).







Professional background and training is largely in the planning area, with some engineering, public administration and others.

Overall Comparison with Their Co-workers

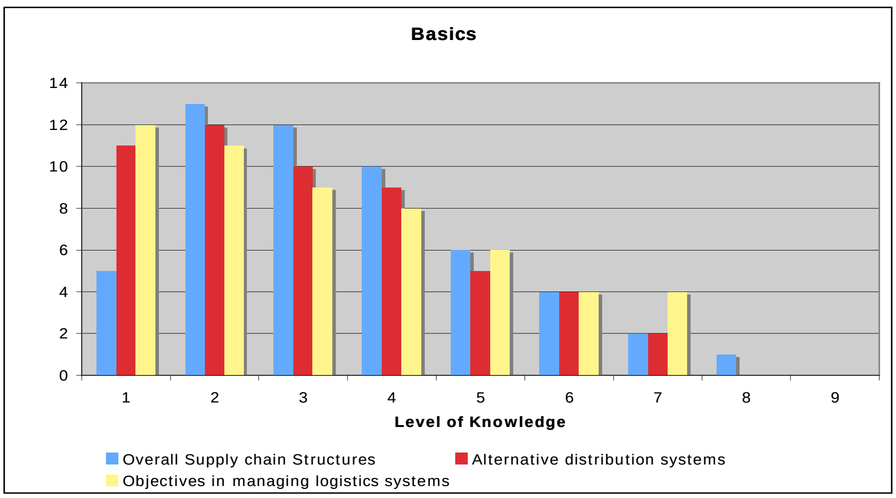
Since the heart of the survey was a self-assessment of freight knowledge, it is interesting to note that sixty-eight percent of the respondents say they have a higher level of knowledge than their co-workers; another twenty-two percent rate themselves as having comparable knowledge to co-workers; only ten percent say they have a lower knowledge level than co-workers. This could lead to one of two conclusions: 1) the respondents may rate their knowledge level higher than it really is; or 2) the overall knowledge of logistics in the agencies is much lower than this survey suggests. These two conclusions are consistent. This question is used as a qualitative indicator.

Only seventeen percent of the respondents have taken a logistics course. This despite thirty-one percent saying they had access to such a course.

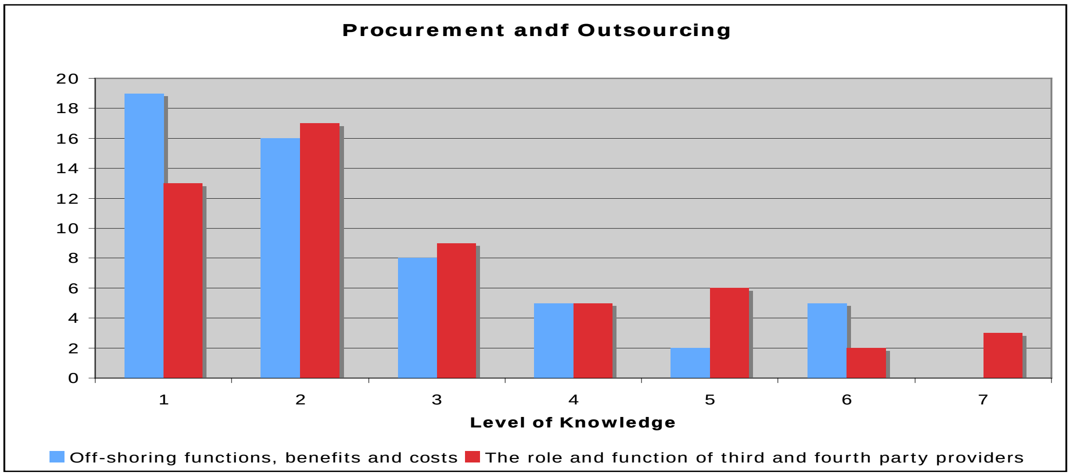
What is the Knowledge Level?

Respondents were asked to assess their knowledge of thirty-one topics in logistics. These topics were grouped into seven broad categories that might be considered as modules in a course. The ratings ranged from one to nine, with one being the lowest level and nine the highest.

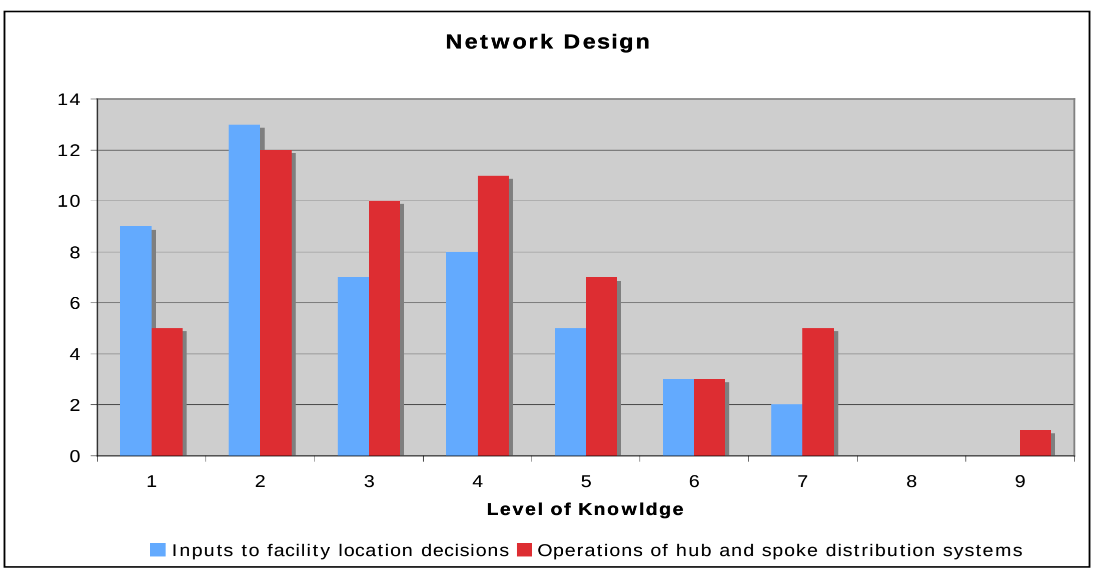
The first category consisted of the basics: overall supply chain structure, alternative distribution systems and objectives in managing logistics. Most respondents rated their knowledge near the lower end of the scale.



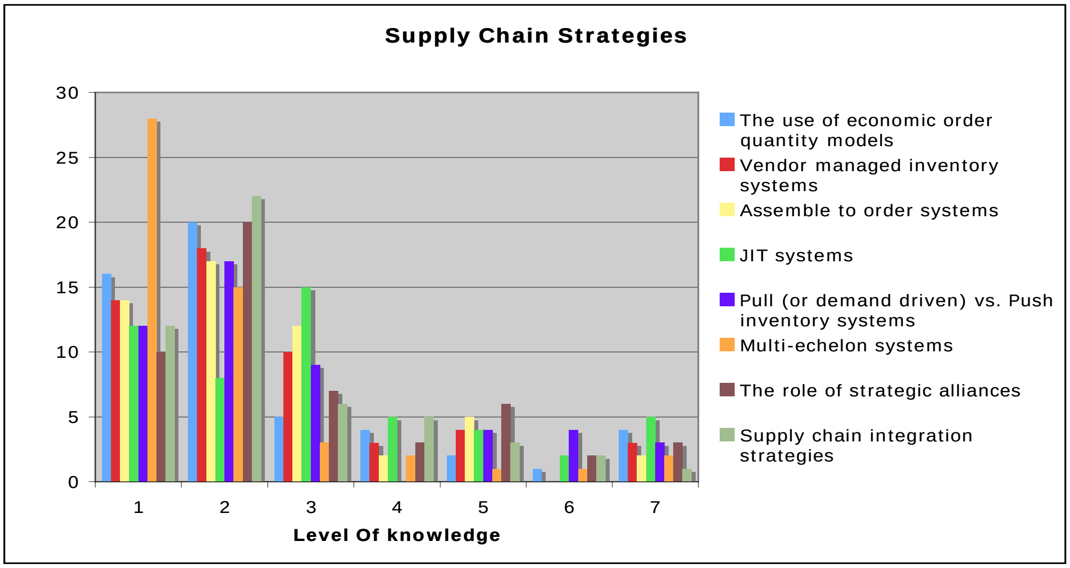
Procurement and outsourcing was the next category, which included the role and function of third and fourth party providers and outsourcing. Again, overall ratings tend to be at the lower range.



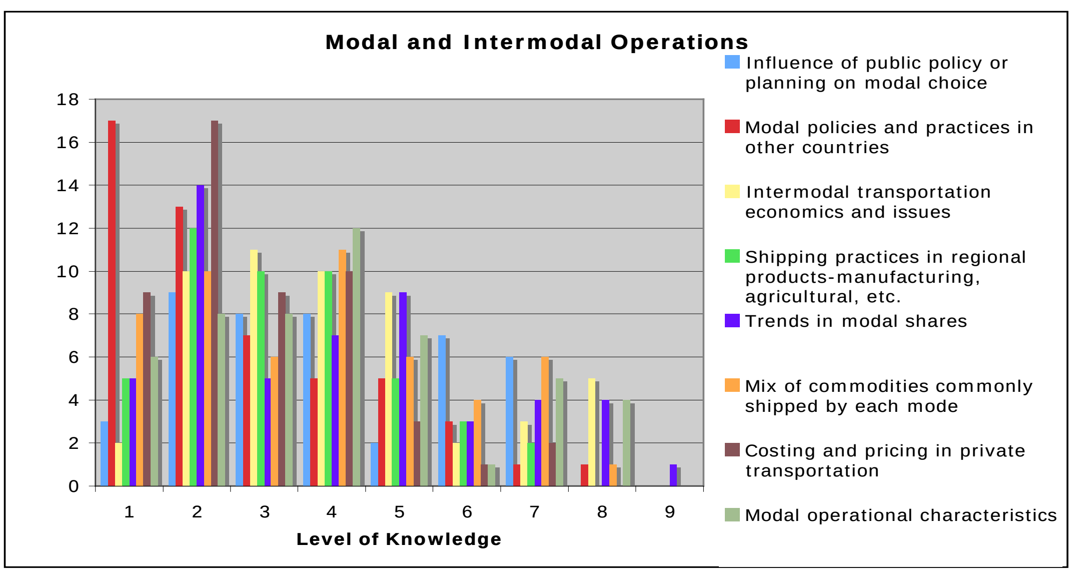
Network design, which included location decision-making and hub and spoke systems, received a somewhat more even distribution in ratings, although they also tended toward the lower end of the scale.



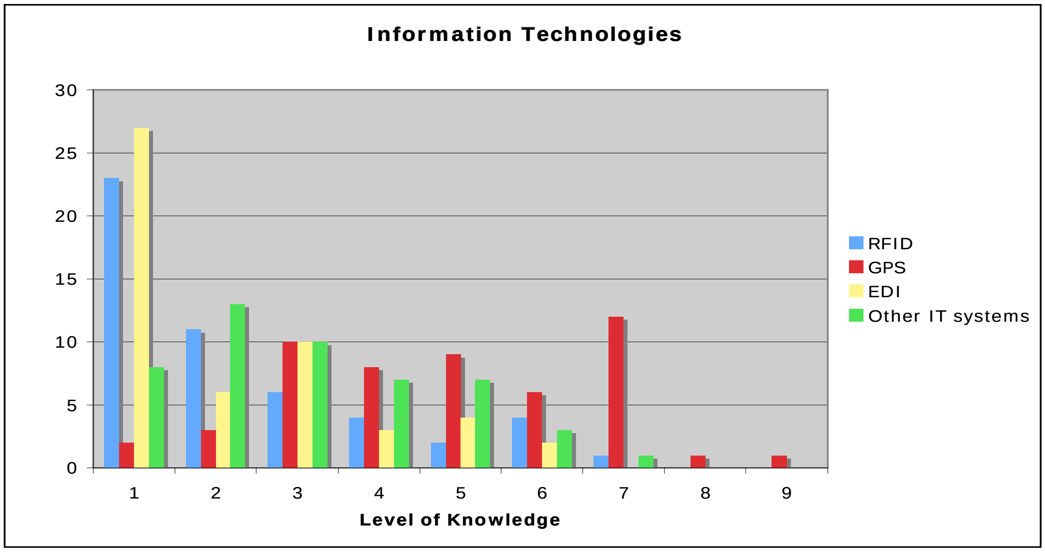
Supply chain strategies included seven common approaches to logistics management. Ratings tended to cluster in the range of one to three.



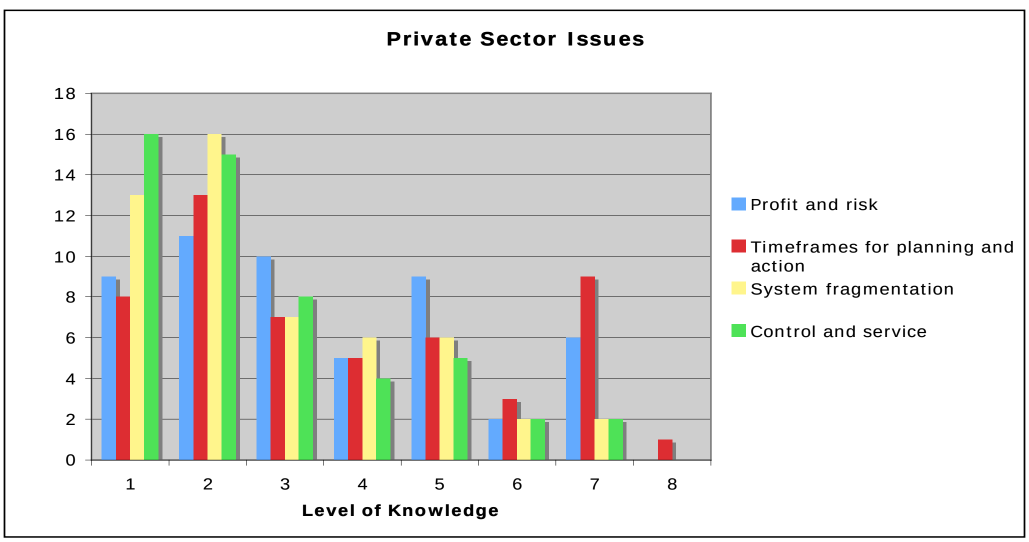
Modal and intermodal operations included seven issues related to how individual modes operate, their costs and typical uses. Knowledge levels were assessed somewhat higher than on the previous questions.



Knowledge of information technologies is more evenly distributed across the range. GPS applications are particularly well known.



Private sector issues—profit and risk, timeframes, system fragmentation, and control and service—also received a fairly balanced assessment of knowledge, although some issues were rated lower.



Finally, respondents were asked to rate the importance of the seven categories for their work. One was the least important; seven the most. While the range was not large, two categories do stand apart from the rest: private sector issues and modal and intermodal operations. Other issues were grouped in the 3.5 to 3.9 range of average importance. None could be eliminated based on this assessment of importance.

Respondents' Course Structure Preferences

The majority (73%) said the course should range from four to twelve hours, or about the normal short course length.

Fifty-two percent said it should be offered in a face-to-face format. We did not ask if state budgets would allow for time and travel for a face-to-face course. Structured distance learning and on demand each received slightly more than twenty percent of the vote.

A course should either be offered all at once (52%, which is similar to the response for a face-to-face offering) or on demand (23%).

Proposed Course Structure

Based on the above, some conclusions can be tentatively reached:

- A course in the range of twelve hours seems appropriate.

- The bulk of the effort should be at producing basic understanding of logistics for people with a fairly low current understanding.

- A limited number of people in the agencies have much experience and knowledge. Some effort should be made to appeal to that higher level of knowledge, both to enhance it and to tap it to help other less experienced people.

- We should prepare a face-to-face short course, but do it in such a way that the materials can be used in a structured distance format as well.

- While all seven categories should be covered, particular attention and time should be given to three: basics, private sector issues and modal and intermodal operations.

- An outline of the course following the above outline should be shared with a small group of people from the region for their reaction.

An outline is developed tentatively based on the survey. The outline is intended to be used to garner feedback from freight planners in order to fine tune it. The outline is attached.

This order and allocation of time seems to work. It starts with the basics as an introduction. It then moves to increase the understanding of the problems and objectives of the private sector. The later modules really offer examples of things the shippers and carriers do to try to solve their issues.

One of the items earlier suggested doing something to both use and enhancing the experience and knowledge of the area experts. Sponsoring several web-based conferences of perhaps an hour each might meet this objective. Each event could be focused on a specific issue or practice. A panel of “experts” from the region could share their experience and ideas with each other and with the less experienced.

The conclusions on which this is based were labeled tentative and one bullet said that the outline and approach should be tested with some of the folks around the region. This can be done in several ways. The best would be to appoint the oversight panel; meet individually with its members and then have a call to compare final notes.

Chapter 3: Course Development, Delivery and Final Remarks

Based on the proposed course structure, the course content was finalized. The course materials have been developed. Appendix B and C are for Section I and II respectively.

The final table of contents of this course is as follows.

- Section I Transportation and Logistics

  Module 1 Course Introduction and Total Cost Competition

  Module 2 Managing Inventory

  Module 3 Managing Transportation

  Module 4 European Experiences and Conclusion

- Section II More on Logistics Management

  Module 1 Logistics Strategies

  Module 2 Logistics Network Design

  Module 3 Outsourcing and Third Party Logistics

  Module 4 Information Technology in Logistics

  Module 5 Highlights and Conclusion

An interesting feature in this course was involvement of speakers from industry. Four speakers were invited for an interview. They are Adolph Ojard, Director of the Duluth Seaway Authority, Brian Nutter, Port Director of Indiana, Mark Wegner, President of Twin Cities and Western Railroad, and Bob Gremley, Senior Engineer at Schneider. The purpose of these interviews is to provide a wide perspective for the public sector planners to know the concerns, issues and new practices in industry. The video clips are available online at www.wistrans.org/cfire. The video clips were edited with help from the Media Services of the College of Engineering at the University of Wisconsin.

A pilot offering was made during the March 2008 Mississippi Valley Freight Coalition workshop in Indianapolis, Indiana. Due to time limit, a condensed version of three and half hours was offered. About 20 of the workshop participants were in the audience of this short offering. A survey for their feedback was proposed and used. Regarding their evaluation of relevancy of each module to freight planning, an overwhelming answer is high relevancy. One or two in the class rated the relevancy at four on a ten point scale, a little too low to us.

In the class survey, one of the comments on the survey collected back was a suggestion to relate the logistics course more closely to the freight planning practices. Definitely, this comment was relevant and important. However, public freight planning has many different aspects. To tailor a short course to specially feature the public freight planning probably is impossible. Furthermore, the relation between logistics management theories and practices and public freight planning is so intricate and complicate that makes it difficult to characterize, especially in such a short time period. It is our hope that through this course, participants will be able to have a better understanding of practices and underlying theories in logistics management that drive the flow of freight on the road.

Appendix A: Survey

Survey on Logistics Training Needs

The Center for Freight Infrastructure Research and Education at the UW—Madison has been asked by the Mississippi Valley Freight Coalition to develop a short course on "Logistics for the Public Sector". This survey is intended to help in the development of that course by estimating the current level of knowledge among the potential users of the course. Please answer the following questions, and please pass the survey along to others in your organization that might benefit from a greater understanding of logistics. The more responses received, the better we will be able to define the course.

Background

1. Which best describes your organization?
    a. State transportation agency
    b. Metropolitan Planning Organization
    c. Local transportation agency
    d. Other,
    Please explain____
2. Which best describes your role in the agency?
    a. Manager with freight-related responsibility
    b. Supervisor with freight-related responsibility
    c. Planning professional
    d. Other freight-related professional
    e. Other,
    Please explain____
3. How much experience do you have in freight issues?
    a. Less than one year
    b. One to two years
    c. Three to five years
    d. Six to ten years
    e. More than ten years
4. Which best describes your professional background and training?
    a. Business
    b. Engineering
    c. Planning
    d. Public administration
    e. Other,
    Please explain____

For each of the following questions, please rate your level of knowledge from one to nine: One: I have no idea what this is. Nine: I could qualify for a PhD. in this subject.

Basics

5. ___ Overall supply chain structures
6. ___ Alternative distribution systems
7. ___ Objectives in managing logistics systems

Procurement and Outsourcing

8. ___ The role and function of third and fourth party providers
9. ___ Off-shoring functions, benefits and costs

Logistics Network Design

10. ___ Inputs to facility location decisions
11. ___ Operations of hub and spoke distribution systems

Supply Chain Strategies

12. ___ The use of economic order quantity models
13. ___ Vendor managed inventory systems
14. ___ Assemble to order systems
15. ___ JIT systems
16. ___ Pull (or demand driven) vs. Push inventory systems
17. ___ Multi-echelon systems
18. ___ The role of strategic alliances
19. ___ Supply chain integration strategies

Modal and Intermodal Transportation

20. ___ Modal operational characteristics
21. ___ Costing and pricing in private transportation
22. ___ Mix of commodities commonly shipped by each mode
23. ___ Trends in modal shares
24. ___ Shipping practices in regional products—manufacturing, agricultural, etc.
25. ___ Intermodal transportation economics and issues
26. ___ Modal policies and practices in other countries
27. ___ Influence of public policy or planning on modal choice

Information Technologies in Logistics

28. ___ RFID
29. ___ GPS

30. ___ EDI
31. ___ Other IT systems

Private Sector Planning and Implementation Issues

32. ___ Timeframes for planning and action
33. ___ Profit and risk
34. ___ System fragmentation
35. ___ Control and service

Relative Importance of Topics

The bold headings above treat seven broad topics in logistics and freight. Please rate them as to their importance to your work: Seven being the most important and one being the least.

36. ___ Basics

    ___ Procurement and outsourcing strategies

    ___ Logistics network design

    ___ Supply chain strategies

    ___ Modal and intermodal operations

    ___ Information technologies in logistics

    ___ Private sector planning and implementation issues

Course Delivery Methods

37. Which of the following methods of delivering the short course would you most prefer? (Check only one)
    a. ___ Face-to-face workshop
    b. ___ Structured distance learning: defined times use of phone and web conferencing
    c. ___ Online modules available on-demand
    d. ___ Printed materials
    e. ___ Other

Appendix B: Lecture Notes on Part I: Transportation and Logistics

Introduction

This training course was developed to help members of the public sector understand the motivations and constraints of their private sector counterparts in the movement of freight. Our economy is now more than ever dependent upon the efficient movement of freight. Figure 1 illustrates how Gross domestic Product (GDP) and total employment have historically tracked very closely to changes in measures of freight movement. Truck vehicle miles of travel (VMT) and intercity truck ton miles both parallel the changes in GDP and employment.

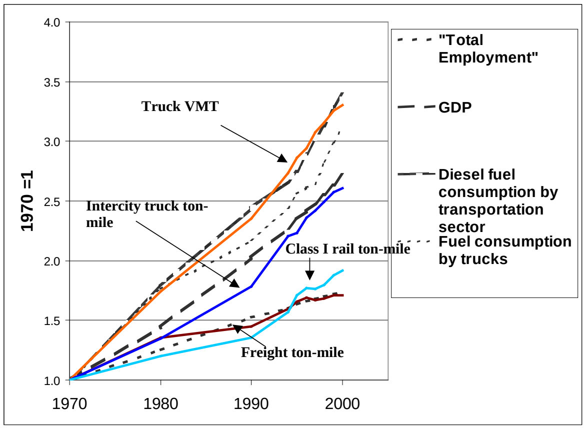


Figure 1. Freight and the Economy *(Source: MRUTC)*

While our economy has always been dependent upon the movement of goods, the 21st Century brings with in new and growing challenges. Figure 2 is a map prepared by the Federal Highway Administration (FHWA) that illustrates the routes across the nation that were operating at or near capacity based on 1998 data.

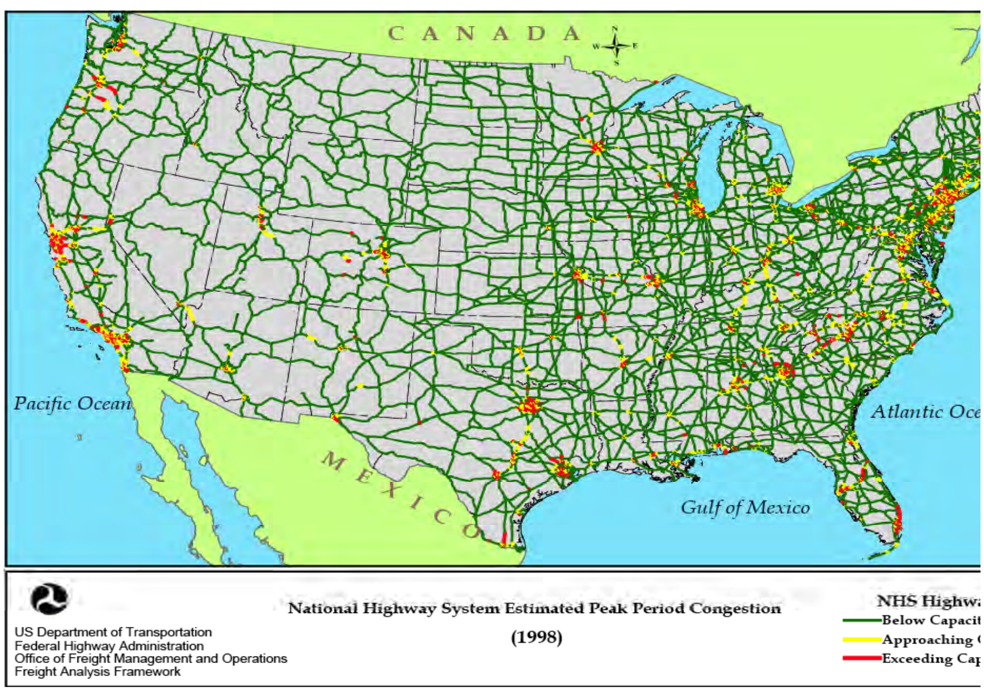


Figure 2 National Highway Congestion--1998

As Figure 2 illustrates, many routes in our major urban centers had exceeded their design capacity in 1998. While congestion is measured based on all vehicles in the traffic stream, trucks are a growing percentage of that stream and they do present unique challenges for the flow of traffic. But growth in freight did not stop in 1998. The Bureau of Transportation Statistics (BTS) recently released a report subtitled: *A Decade of Growth.* In it they outlined the change in national ton miles for the decade of 1996 to 2005. The sidebar at right provides a definition of a ton mile. Over those ten years, ton miles grew by more than 20%. With the largest growth in rail and trucking, see Figure 3.

What is a ton-mile?
A ton-mile is defined as one ton of freight shipped one mile and, therefore, reflects both the volume shipped (tons) and the distance shipped (miles). Ton-miles provide a key measure of the overall demand for freight transportation services, which in turn reflects the overall level of industrial activity in the economy. In addition, ton-miles are used to calculate other measures of transportation system performance, such as energy efficiency and accident, injury, and fatality rates.

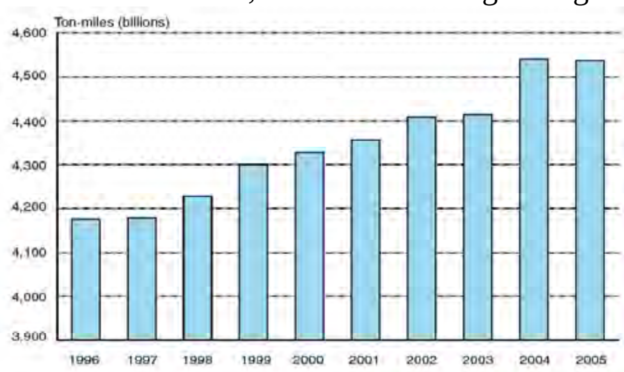


Figure 3 Growth in Ton Miles

Source: BTS Decade of Growth

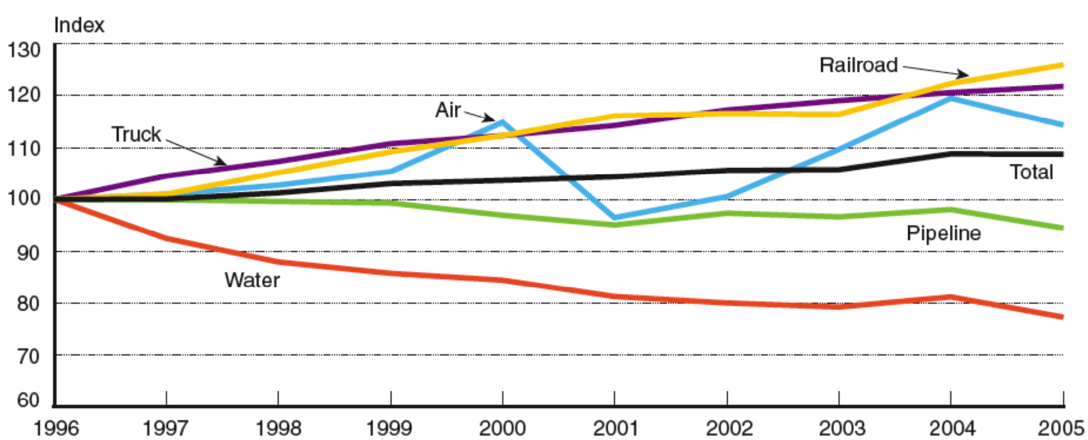


Figure 4 Modal Share Trends

Rail, truck and air increased over the period while pipeline and water decreased. Figure 4 illustrates these trends graphically.

Later, we will look at some of the details of the modal share trends to try to understand their significance for the public sector practitioner.

The result of this growth and its expected continuation in the future is illustrated in Figure 5. As projected by the FHWA, many more miles of American highways will be operating near or beyond their design capacity by the year 2020.

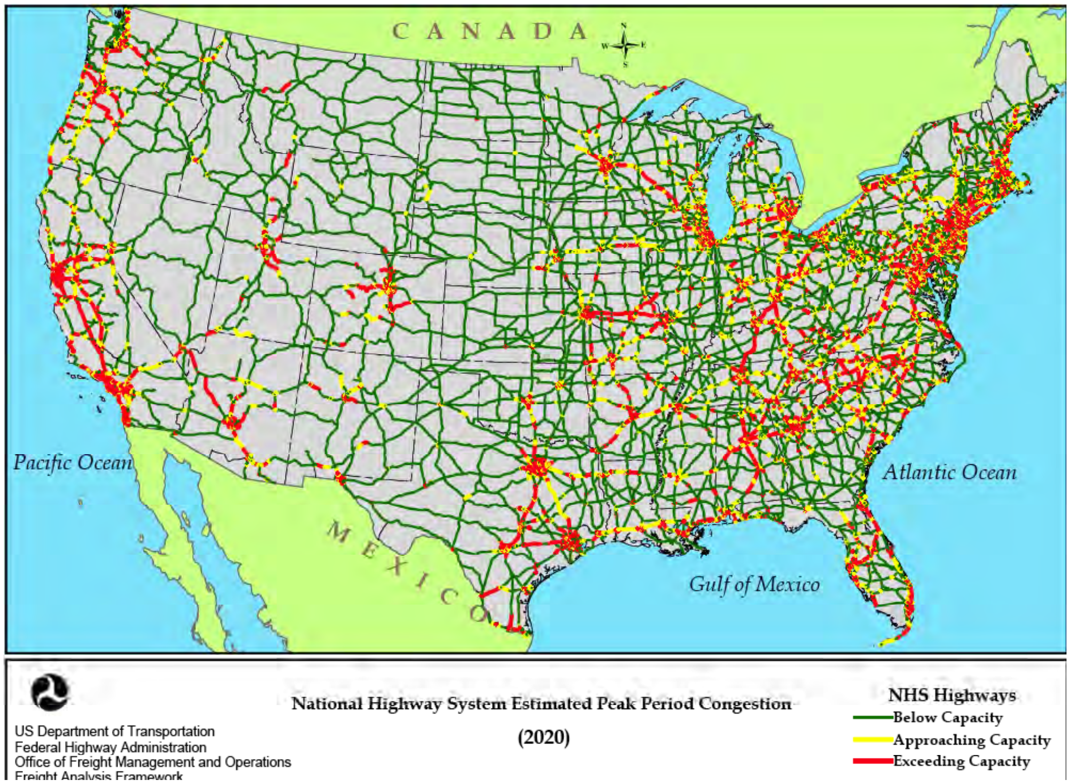


Figure 5 Highway Congestion--2020

Highway congestion in and of itself is a challenge for public sector agencies, but in the future the historic responses alone will not suffice. The public sector will have to seek new solutions, many in concert with other public agencies and with the private sector. Doing this will require a deep understanding of the objectives and challenges that guide and confront private sector companies, both shippers and carriers, as they pursue their businesses. This course should be a useful first step for many public sector people in gaining that understanding. For others, it may be a useful fifth or sixth step.

A Quiz

Before we go deeper into the topic, a short quiz may help you to assess your current level of understanding of the freight, logistics and supply chain world.

1. According to FHWA, what portion of the average state truck tonnage simply passes through the state?
2. In 2002 what percent of the 19.3 trillion tons of freight shipped in the US was domestic?
3. Which country is the US's largest trading partner?
4. In 2002 how many people were employed by American railroads?
5. In 2002 what was the total revenues of class I railroads?
6. In 1997 what portion of the US GDP was involved in international trade?
7. What is generally used as the haul length needed to make rail economic?
8. Between 1980 and 2000, which grew fastest: overall VMT, truck VMT, lane miles of highway?
9. How many trucks would it take to carry the load of one Columbia River barge?
10. What is the value of an average ton of freight moved by air relative to that of truck?

Answers are located at the end of Appendix B

Logistics and Supply Chains

Figure 6 Supply Chain Management

The title of this course is Logistics for the public sector. Understanding two key terms is a way to start. Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies, see Figure 6.

Figure 7 Logistics Management

Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements, see Figure 7.

Logistics is considered part of the supply chain management concerning materials movement and storage. Of course, supply chain has other components such as partnership management. Transportation is part of the logistics activities. In this course, we mainly focus on logistics activities. But some supply chain concepts are also introduced as they provide the background of logistics management.

A Supply Chain

A supply chain is all of those organizations and processes that are involved in moving a product from raw material to market. Figure 8 illustrates a fairly simple supply chain.

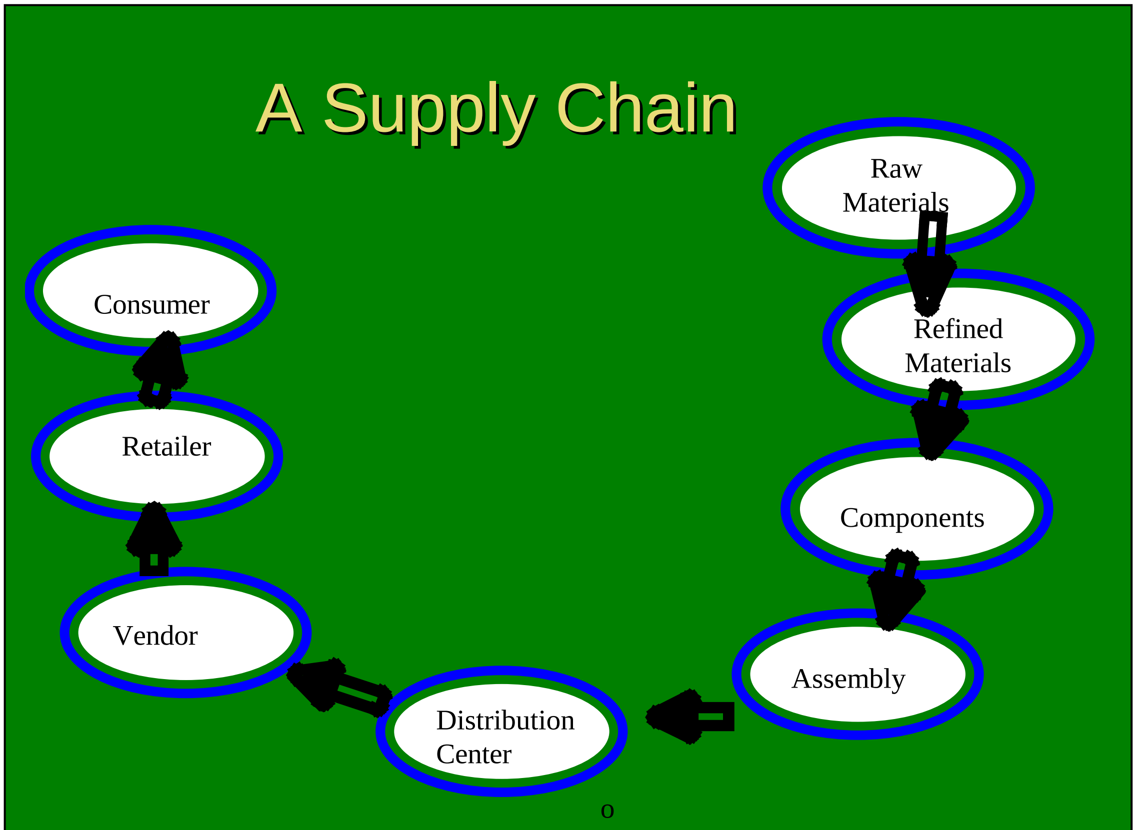


Figure 8 A Supply Chain

Think of this model in terms of the auto industry. Raw materials in the form of iron ore, coal, petroleum and other items are mined. These raw materials are refined into various types of steel, plastics and rubber. These refined materials are transformed into fenders, frames, engines, dashboard and tires. The components are then assembled into finished automobiles. Some companies, such as Ford, ship finished autos to staging areas, much like distribution centers. From these centers, they are shipped to dealers, who generally combined the functions of the retailer and the vendor. The retailer then moves the autos to customers.

We could track this further. As autos are scrapped, they become raw materials for other products, and the cycle is restarted.

The supply chain may be fairly simple and small or it may be very complex, as it the case of the Boeing Dreamliner, which is summarized in the following:

The Boeing Dreamliner

Boeing's new Dreamliner is an illustration of globalization. It has parts from ten countries and nineteen manufacturers. Figure 1 demonstrates the origin of each of the planes parts.

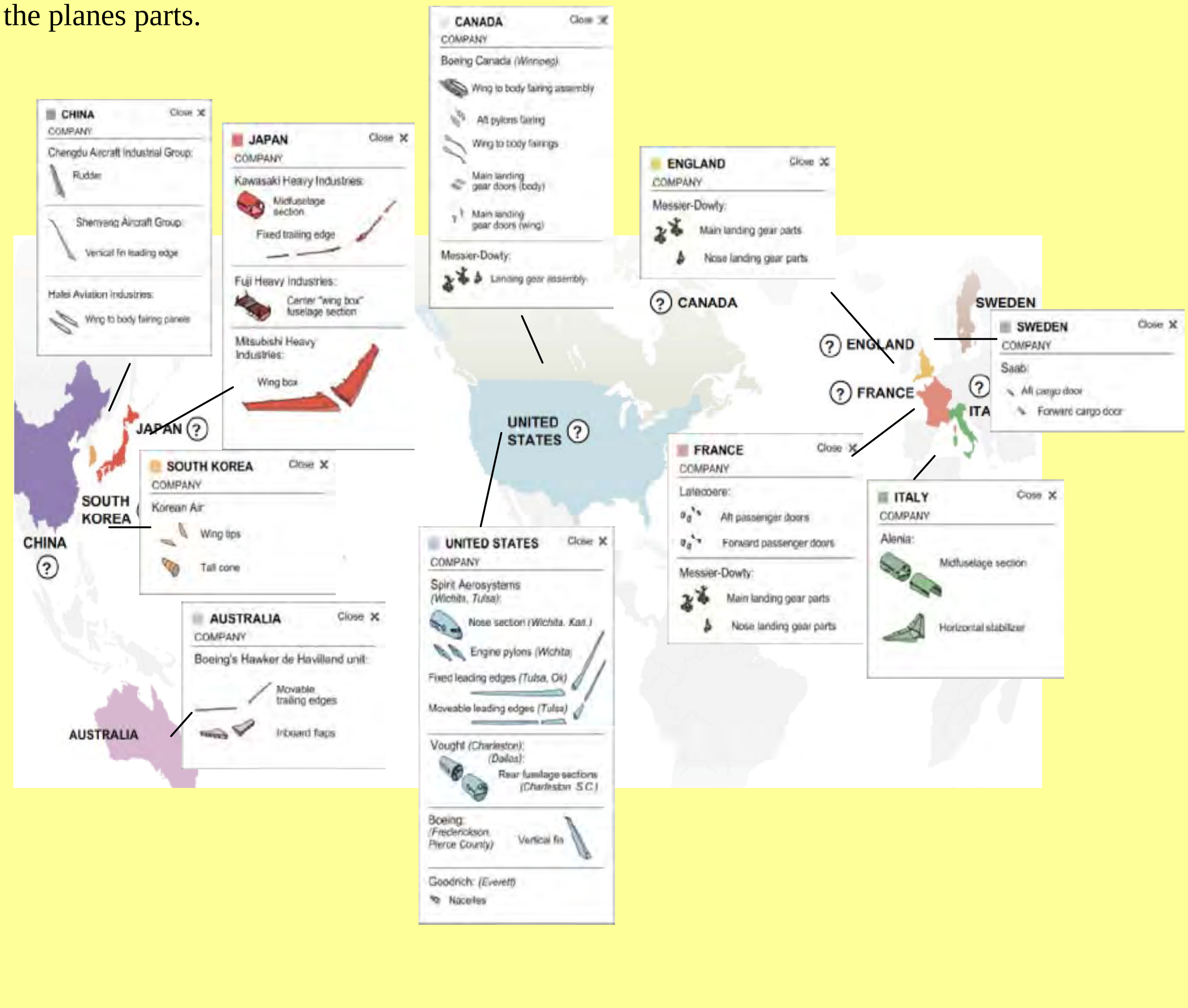


Figure 9 Dreamliner Countries of Origin

This distributive manufacturing is particularly surprising since historically both companies and nations have held aircraft technology very closely. In fact this is the first time Boeing has outsourced the production of key parts such as wings.

Figure 10 illustrates the assembly of the plane.

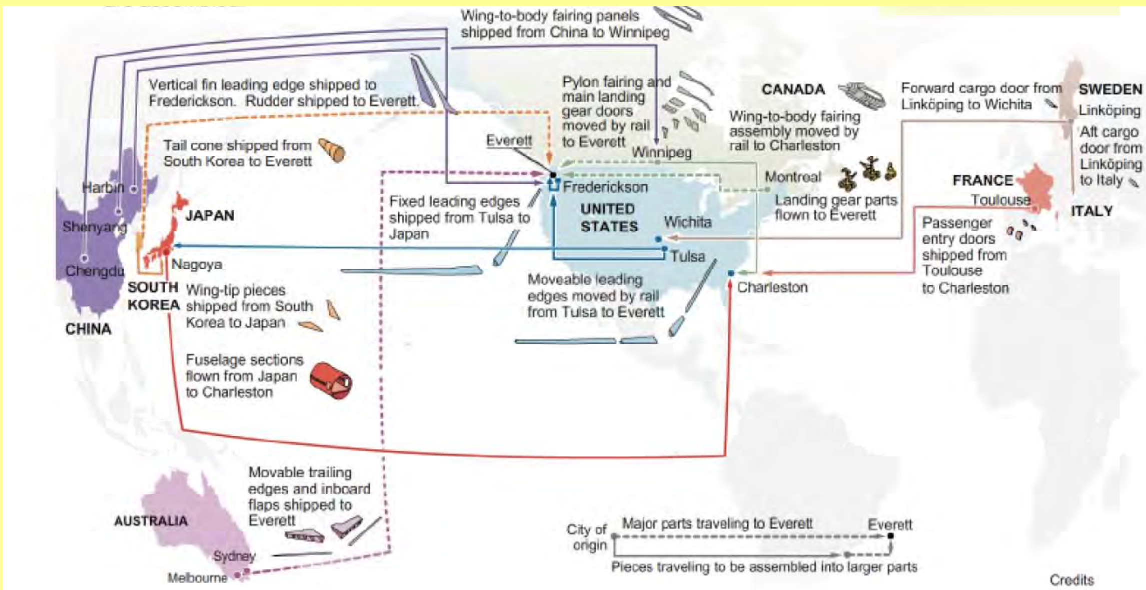


Figure 10 Dreamliner Assembly

As shown above, many of the parts make stops for subassembly at many places across the country and the world before coming to Everett, Washington for final assembly.

Source: The Seattle Times

Total Cost Competition

Businesses exist to serve the needs of their customers. To stay in business, they have to make a profit. To make a profit, they must hold down costs. Cost are incurred in each of the supply chain steps shown above, see Figure 9.

Extraction, that is obtaining raw materials, and manufacturing are fairly clear cost issues. Mining or drilling or harvesting involves the use of capital and labor—they are a source of costs. Transportation is also a fairly clear cost item. To move a product or material from one place to another involves the use of energy, labor and capital equipment. Inventory, administration and information technology are more subtle, but they are equally important.

Transportation costs occur throughout the supply chain. If we look at the supply chain again in Figure 10, each of the arrows represents some transportation effort. It may be from one building to the next in a manufacturing complex, or it may be across a continent or an ocean, as in the Dreamliner example.

Inventory and administration costs exist throughout the supply chain. Capital costs involved in inventory are easy to understand. Every dollar tied up in inventory that is either in the inventory itself or the cost of storing the inventory, is not available for other more productive uses. Capital costs are only one of the several cost associated with inventory, as shown in Figure 11. Shrinkage is simply the cost of breakage, theft and loss throughout the supply chain. Uncertainty is a calculation of risk. For example, buying a large inventory of Christmas stock assumes that the holiday season will be economically robust. Selecting a large supply of a specific toy assumes that the toy will be popular. If either of these assumptions is wrong, the merchandise may go unsold, or sold at a substantial discount. Finally, obsolescence is a source of cost when a product suddenly becomes less desirable to consumers. If you were a computer wholesaler or retailer, you would not want a large supply of Mac G 3s when the G 4 hit the market. Similarly, if you are in the auto business, you probably do not want a lot full of SUVs when the price of fuel hits $4 per gallon.

Figure 11 Supply Chain Costs

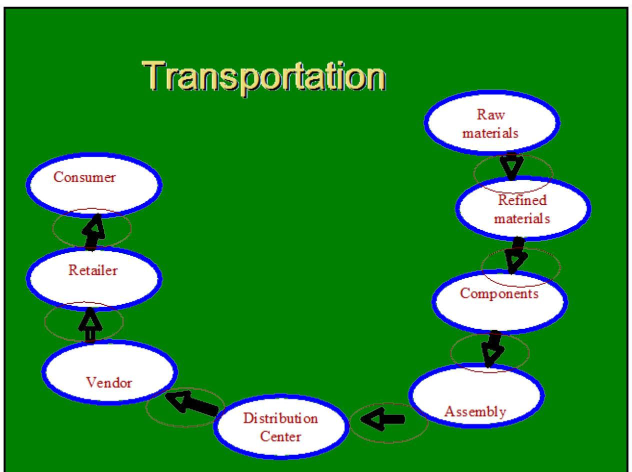


Figure 12 Transportation Costs

Logistics experts usually estimate the cost of inventory to be between 10% and 25% of purchase price, depending on the product involved.

Administrative costs are also fairly straight forward, but business practices can force higher or allow lower administrative cost. For example, the cost of procurement can be very high if a truly competitive process is used for each item procured. It may be lower if longer-term relationships are built with suppliers.

- Capital
- Shrinkage
- Uncertainty
- Obsolescence

Figure 13 Inventory Costs

All of these costs are significant because companies do not compete only on the cost of production; they compete based on their cost as it reaches the customer. Figure 13 illustrates this with the costs associated with growing and marketing soybeans in the US in South America. The three countries have very different costs of production, but the costs of transportation and marketing are sufficiently different that the cost at market is similar. This table is significant because a decade earlier the same information would have totaled to a significant US advantage in final costs because the South American cost of transport was much higher. Recent investments in transportation infrastructure by those countries have reduced those transportation costs significantly.

- Procurement
- Accounting
- Transfer management
- Finance
- Customs clearance
- Personnel
- IT

Figure 14 Administration Costs

Figure 14 is a hypothetical example of total cost competition that relates back to the cost items discussed earlier. Figure 14 demonstrates how the low cost producer can be the total cost loser if other costs are uncontrolled.

Since logistics is primarily concerned with transportation and inventory as items of cost concern, we will focus on those two items.

	US	Brazil	Argentina	
Cost Item ($/bu.)	**Hinterland**	**Mato Grasso**	**Parana**	**Santa Fe**
Production cost	5.11	4.16	3.89	3.92
Internal transport & marketing cost	0.43	0.85	1.34	0.81
Cost at border	5.54	5.01	5.23	4.73
Freight to Rotterdam	0.38	0.57	0.57	0.49
Price at Rotterdam	5.92	5.58	5.80	5.22

Figure 15 Cost of Soybeans Delivered To Rotterdam

Source: North Dakota

Figure 15 illustrates a predictable cyclical inventory pattern. In this example, inventory is always used at the same rate and replenished at the same interval to the same level. This would be a fairly easy inventory to manage while meeting both competing objectives.

	Case #1	Case #2	Case #3
Extraction	$5.00	$5.00	$5.00
Manufacturing	$10.00	$8.00	$12.00
Product cost	$15.00	$13.00	$17.00
Transportation	$5.00	$5.00	$3.00
Inventory	$3.00	$4.00	$1.00
Administration	$3.00	$5.00	$1.00

Figure 16 Total Cost Competition

Figure 16 illustrates another approach to managing the same inventory. Again, the inventory is always consumed at the same rate. It is replenished at regular intervals and always to the same level. The difference is that now the intervals are shorter and the maximum inventory levels are lower. The manager is reducing the cost of holding inventory, but probably increasing costs related to transportation and administration, since deliveries would be more frequent and handling of orders and deliveries would also be more frequent.

The following summary of the life of a t-shirt helps to illustrate how total cost competition can move raw materials and finished products over long distances.

The T-Shirt

The simple souvenir t-shirt that many of us buy while on vacation may well have traveled all around the world. Writer Pietra Rivoli traced the history of a t-shirt she bought in Fort Lauderdale, Florida. It was a typical beach scene t-shirt, but she was surprised to find that it was born in Lubbock, Texas, took form in Shanghais, China, and was finished in Miami, Florida. Figure 1 outlines the travels of the t-shirt.

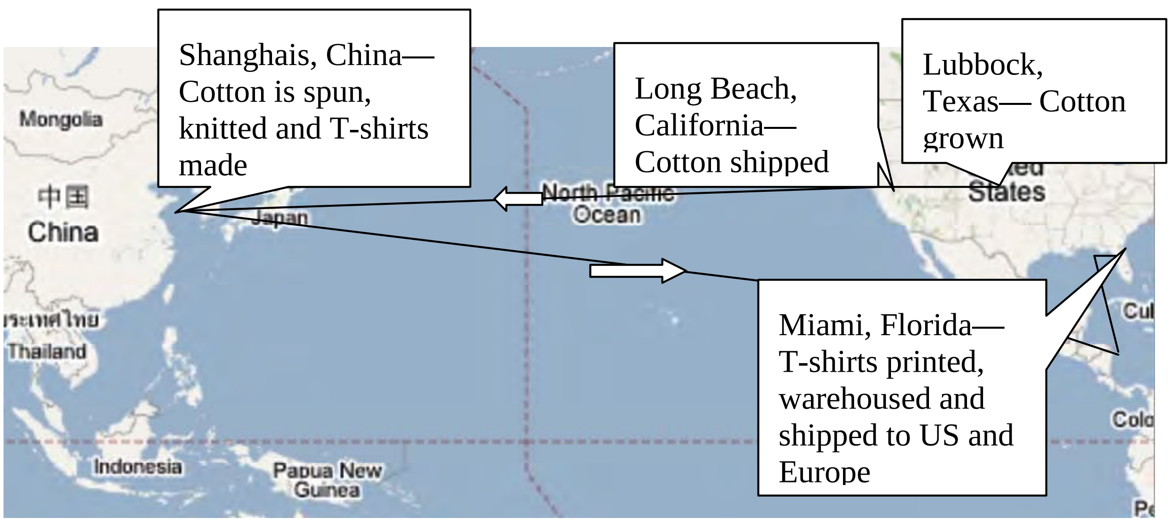


Figure 17 T-shirt Journey

The cotton that will become the t-shirt is grown near Lubbock, Texas. There it is ginned, cleaned and baled. The baled cotton is shipped by truck to Long Beach. At Long Beach it is put on a ship and shipped to Shanghais.

In Shanghais, it is cleaned again, spun into thread, knitted into fabric and sewn into t-shirts. The t-shirts are made for a company in Miami, which has contracted for them. Shanghais is only one location from which the company contracts for t-shirts.

The finished t-shirts are loaded onto ships that cross the Pacific, move through the Panama Canal and them to Miami. In Miami, the shirts are finished with artwork depicting beach scenes, mountains or rivers, warehoused and shipped to tourist spots across the US and Europe. *Source: Rivoli*

Figure 17 summarizes these trade-offs. More frequent shipping reduces inventories and inventory cost, but it requires higher transportation services and costs and higher cost associated with managing more frequent orders and deliveries. Larger inventories have the opposite impact.

Managing Inventory

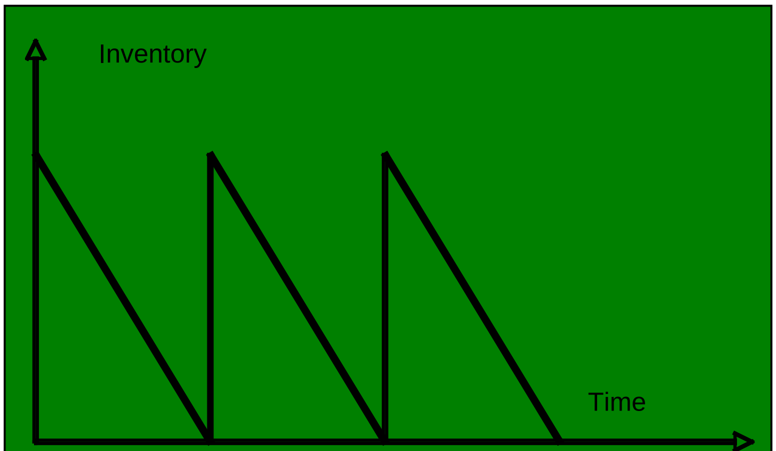


Figure18 A Cyclical Inventory

Managing inventory involves two competing objectives: Minimizing the cost of owning and storing inventory and having a sufficient supply available to meet the needs of customers or of production.

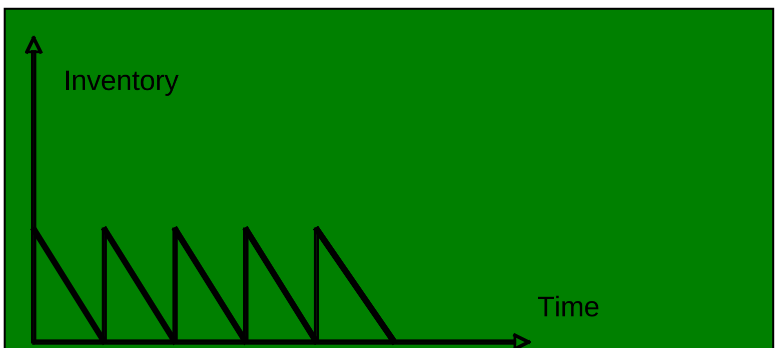


Figure 19 Alternative Cyclical Inventory Pattern

More frequent shipping

- Reduces inventory costs
- Increases transportation costs
- Increases service requirements

Larger order quantities

- Reduce transportation costs
- Increase inventory costs

Figure 20 Inventory Management Trade-offs

Figure 20 lists the key issues that must be considered in finding a safety stock level. Uncertainty in demand and in time of delivery will tend to increase the levels estimated as a needed safety stock. While the cost of holding the inventory, transportation and administration will tend to hold the level down. Ultimately, the issue comes down to the level of risk the manager is willing to take in not meeting the needs to customers or of production and the costs of failing to meet those needs.

Unfortunately, inventory patterns are rarely as uniform as the previous illustrations might suggest. Figure 21 outlines a more erratic pattern. Inventories are used over shorter and longer periods of time. This would make management more difficult, because the goal is to always have enough products on hand to meet demands while having as little inventory as possible to hold down the costs.

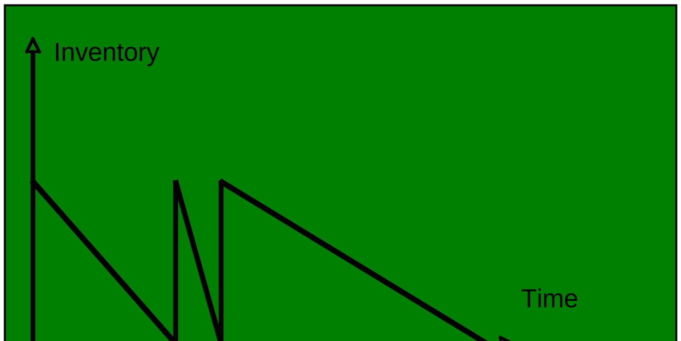


Figure 21 Uneven Inventory Cycle

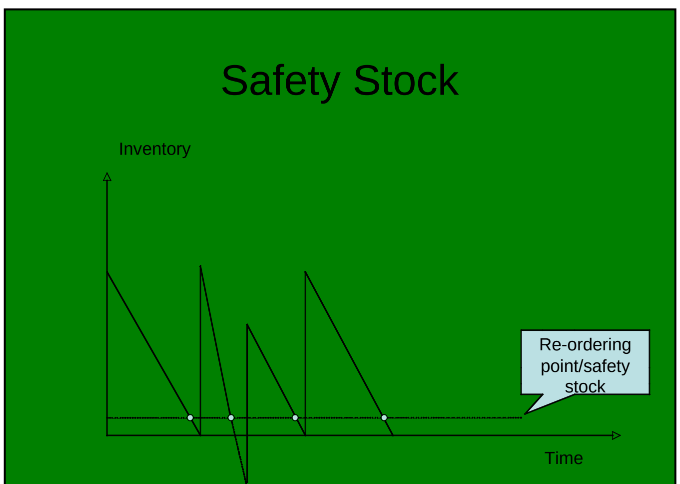


Figure 22 Safety Stock

The manager seeks to avoid the problems suggested by Figure 22 by maintaining a safety stock. This is the minimum stock level that is needed to meet higher than expected demands before a new order can be received: If it takes two days for an order to be received once it is placed and the most that will reasonably be consumed is six units per day, a new order should be placed when the inventory reaches twelve.

- Uncertainty in demand
- Uncertainty in delivery
- Cost of holding
- Cost of transportation
- Cost of administration

Figure 23 Issues in Safety Stock

Because they compete on a total cost basis, many companies have adopted some form of Total Cost Inventory Management system. This may be known as Total Cost of Acquisition or Total Cost of Ownership. By whichever name, it is an acquisition and inventory management system that regularly evaluates all of the costs listed in Figure 23 and places orders in places and at times that will minimize total cost.

- Targeted delivery window
- Little room for error
- Severe consequence of error

Figure 24 JIT Constraints

Inventory and production managers have developed a number of strategies for meeting competing needs of holding down costs while assuring adequate inventory. We will consider briefly three of those strategies: Just-in-time (JIT), Pull logistics and on-demand manufacturing.

JIT is probably the best known strategy. It involves substituting a high level of transportation services for inventory. In the extreme an assembly plant might hold no safety stock at all. The inventory would be held in trucks until it was needed. Trucks would always be at the unloading docks. Components would move directly from the truck to the assembly line. Trucks become the rolling warehouse for the industry. While this strategy does minimize inventory costs, it does have some shortcomings. Figure 24 lists the three major issues. The window within which delivery can be accepted may be very narrow. If the truck arrives too soon, the dock will not be available and no parking may be available. If it arrives too late, production may have to stop for want of parts. If the production process is at all complex, the delivery windows for dozens of components may have to be coordinated. The consequence of error can be extreme. If, for example, if an incident closes a key freeway link for several hours, delaying deliveries, much production time may be lost with significant costs in non-productive labor and machine time.

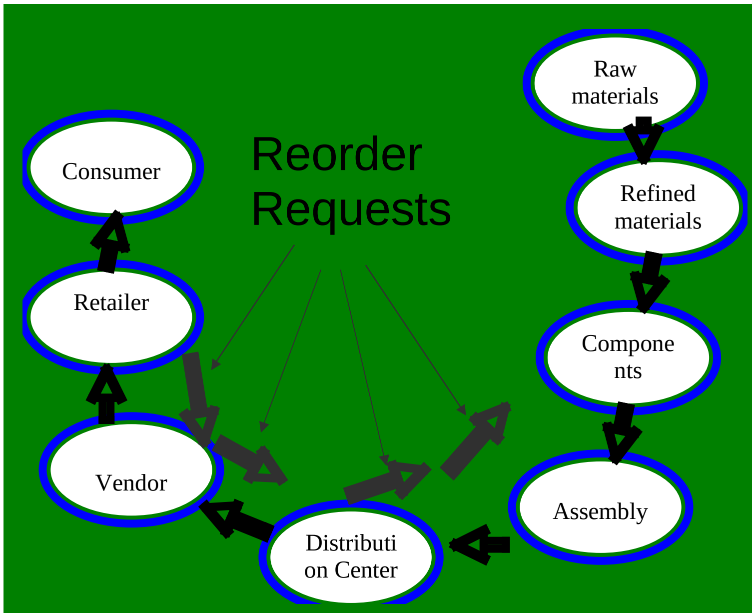


Figure 25 Pull Logistics

Another popular inventory management strategy is pull logistics, illustrated in Figure 25. It uses sophisticate information management systems to trigger reorder requests back through the supply chain to maintain planned inventory levels. In the extreme example, as you check out at a retailer, the cash register transaction will update the inventory. If the remaining inventory is at or below a set level, a reorder is automatically sent to the supplier. As inventory is removed from the supplier's warehouse, the inventory there is updated. Again, if it is at a trigger level, a reorder will be sent to the next supplier in the chain. Such a system always maintains the desired inventory. It can also be used to communicate changing levels of desired inventory throughout the supply chain, thus minimizing unused or unwanted production

Pull logistics is often contrasted with Push logistics. In the latter case the manufacturer sent, or pushed, product to distribution centers, vendors and retailers in the hope that it would be sold. To some degree, we can still see this used in the auto industry. Autos are produced and shipped, to some degree without regard for immediate demand. If the demand does not materialize, the inventory must be reduced through discounts and other incentives to purchasers.

Successful pull systems are very dependent on sophisticated information management systems. They usually require long-term, more managed, relationships between the members of the supply chain. They also require higher transportation service levels, since shipment quantities will tend to be smaller and at less predictable intervals.

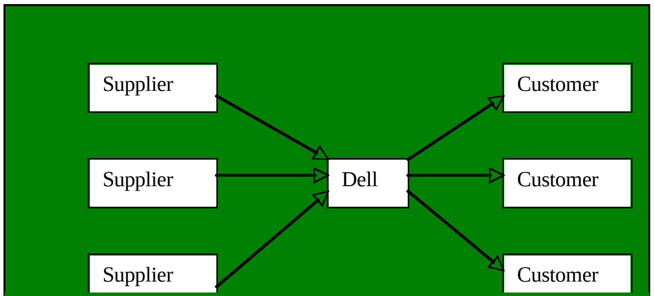


Figure 26 Dell Computer's On-demand Manufacturing

On-demand manufacturing can be seen as an extreme version of pull logistics. Figure 26 outlines the use that Dell Computer makes of on-demand manufacturing. Suppliers move components to Dell, who assembles them based on orders directly from customers. The finished product can then be shipped directly to the customer, removing several layers from the supply chain.

The advantages of this arrangement are obvious. Several layers of administration and profit are removed from the system, giving more profit to the manufacturer and lower prices to the consumer. Inventory costs are kept down because final product is shipped when manufactured and manufactured when ordered. A potential downside of the approach is that product is shipped to the customer, which means more local freight pick-up and delivery trips. Another potential downside is the dependence on quality transportation services from the suppliers.

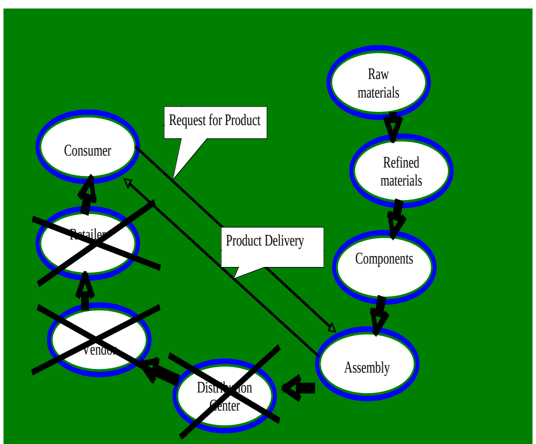


Figure 27 Manufacturing on Demand

With recent advances in information and manufacturing technology, manufacturing on demand has become more common. For example, if you have a size 14 neck and a size 44 waist, you can now get shirts made to order to fit you figure. On demand publishing is also a form on manufacturing on demand. Unusual or low-demand books can be printed when they are ordered and shipped directly to the customer. Another application can be found at John Deere, the largest agricultural implement maker in the world. Nearly all of its US-made large tractors are made based on orders from dealers. Those orders usually are committed to a specific customer.

Figure 28 Inventory Management Implications for the Public Sector

All of these strategies have impacts on the transportation system, particularly on the highway system, and thus have implications for how the public sector operates, see Figure 28. If these techniques are to work, the transportation system must be extremely reliable, facilitating closely timed deliveries. It also tends to move more freight to truck and require more truck movements.

Managing Transportation

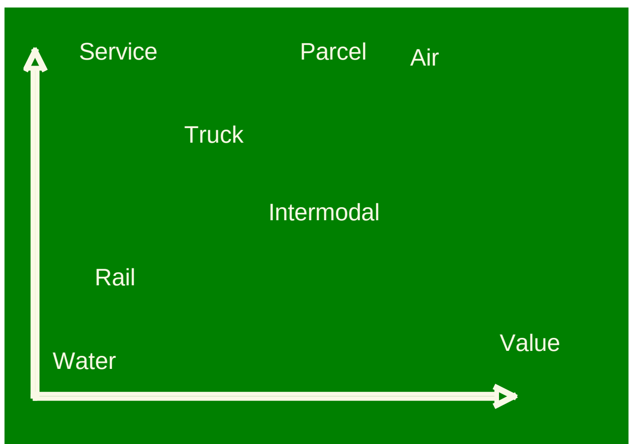


Figure 29 Service/Value Characteristics by Mode

Inventory strategies have a great impact on how transportation is managed. Service requirements tend to lead to mode choices. The operating characteristics and objectives of each of the modes tend to influence the service that can be provided.

Mode	Average value per Ton
Truck	793
Rail	166
Water	131
Air (includes truck and air)	70,468
Parcel, U.S.P.S. or courier	38,715
Intermodal (truck and rail)	1,627
Truck and water	616
Rail and water	32

Figure 30 Average Value of Cargo per Ton

Source: NCHRP 08-40

Figure 30 shows the average value per ton of freight moved by each of the modes, based on the 2002 Commodity flow Survey.

The value/service/mode relationship is borne-out when we look at the type of products typically moved by each mode. Figure 28 shows the 2006 tonnage and commodity originated on rail. Coal is more than 40% of the total. Farm products, chemicals, metallic and non-metallic ores, and other low value products with low service requirements account for another 30%.

A similar picture can be seen in the maritime mode. Low value products with low service requirements account for much of the freight moved along our coasts, across the great Lakes and on our rivers, see figure 30. Moreover, also as shown in Figure 31, the volume of many of the commodity items decreased between 2004 and 2005, which supports the generally downward trend in water's modal share shown earlier in Figure 4.

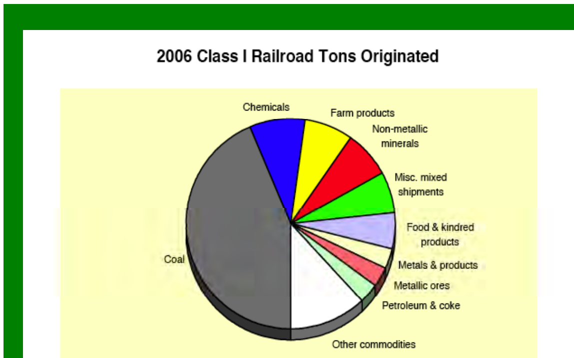


Figure 31 Class I Railroad Tons Originated

Source: AAR

U.S. Waterborne Traffic by Major Commodities in 2005
(Millions of Short Tons[1] and Change from 2004)

	Domestic							
	Coastwise		Lakewise		Internal		Total	
Commodities[2]	Tons	%	Tons	%	Tons	%	Tons	%
Total[3]	**213.7**	**-3.1**	**96.2**	**-7.1**	**624.0**	**-0.4**	**1,028.9**	**-1.7**
Coal	9.8	0.0	21.2	5.9	181.9	6.2	228.9	6.1
Coal Coke	**	0.0	0.7	-5.0	5.1	-11.5	6.3	-10.3
Crude Petroleum	44.9	-6.5	**	0.0	33.0	-4.8	79.4	-5.9
Petroleum Products	112.0	-1.4	1.4	-18.0	120.6	3.8	283.3	0.8
Chemical and Related Prod.	10.3	-9.8	0.2	-12.1	50.3	-4.2	72.7	-4.1
Forest Prod., Wood & Chips	2.3	6.9	**	1429.3	6.3	-3.6	9.3	-4.0
Pulp and Waste Paper	**	-64.8	**	0.0	**	-80.2	**	-32.9
Sand, Gravel and Stone	8.4	-14.4	26.6	-11.4	85.3	-0.2	128.8	-4.1
Iron Ore and Scrap	0.7	4.1	40.3	-11.4	10.8	-18.5	55.0	-12.9
Non-Ferrous Ores & Scrap	**	-99.9	**	-100.0	6.2	-10.2	6.2	-12.1
Sulphur, Clay and Salt	0.3	79.8	1.1	40.8	7.6	-9.2	9.2	-4.0
Primary Manuf. Goods	9.1	-0.1	3.9	-0.2	30.7	6.0	44.9	4.5
Food and Farm Products	6.1	8.7	0.3	206.6	70.9	-12.1	77.7	-10.6
All Manuf. Equipment	9.6	-0.7	**	40.1	9.9	-1.6	20.2	-2.1
Waste and Scrap, NEC	**	-80.6	**	-100.0	1.5	14.3	2.0	-34.5

Figure 32 Waterborne Commodities

Source: Navigation Data Center

Figure 32 provides a simple view of freight service and typical cargo value by mode. Water tends to move low value products with low service requirements. Rail provides a higher level of service and tends to move higher value products. At the other extreme air provides the highest level of service and attracts the highest value products.

Obviously, the cost of shipping by air or parcel service is high, so only high value products move by those modes, but the service typically required for high value product is also high. Part of the service characteristic that is important to shippers is the presence, or perception of the existence, of a custodian of the cargo. A truck driver is the typical custodian, but air carriers and parcel carriers are also seen as having high security, which is desired for high value product.

The following summary of the Kansas meat packing industry illustrates the importance of the custodial issues in mode choice. Fresh meats move by truck in part because of the custodial issue, in part because of service issues and in part because of the specialized equipment that is required.

Meat Processing in Southwest Kansas

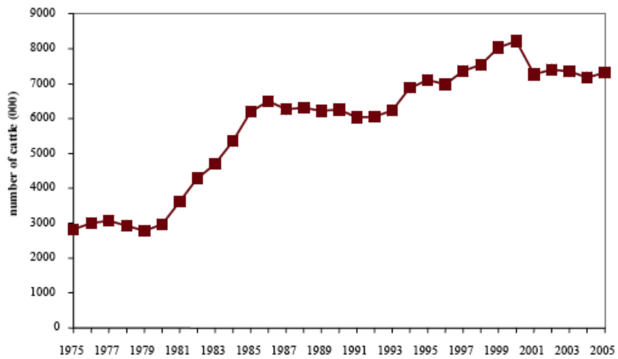


Figure 33 Cattle Slaughtered in Kansas

Kansas is the third largest meat producing state in the country, with about 17% of the nation's output. The meatpacking industry in Kansas is centered on Southwestern Kansas. Each year about 3.7 million cattle are finished in 369 feedlots in that part of the state. Many more are shipped from nearby states to processing plants in Kansas. Figure 1 illustrates the growth in meatpacking in Kansas in recent years. Researchers predict that the trend line will remain fairly flat in the foreseeable future.

The supply chain for cattle feeding is shown in Figure 34.

Cattle from Texas, Missouri, Oklahoma, Kentucky, Tennessee**,** New Mexico, California and Oregon are trucked to Kansas for finishing. Kansas is a desirable location for feeding because it is close to the source of feed grains and has a climate that allows cattle to prosper. Four of the nation's major meat packers are located in the region.

In addition to cattle, the major input in the feeding operation is feed. Each animal consumes about 28 pounds of feed per day.

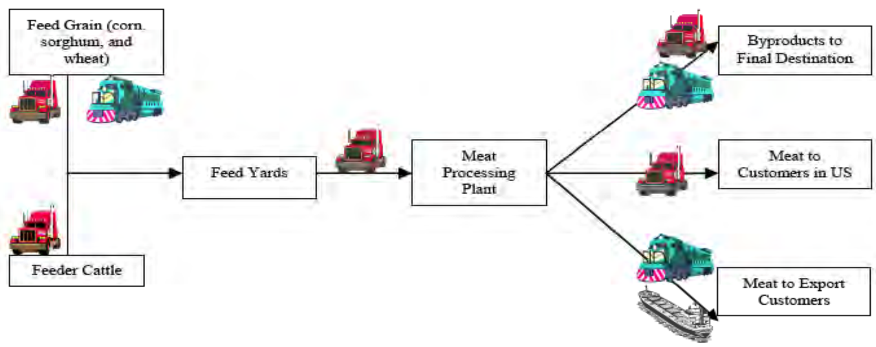


Figure 34 Meat Processing Supply Chain

Alfalfa Hay (Lbs./day)	Corn (Lbs./day)	Grain Sorghum (Lbs./day)	[a]Supplements (Lbs./day)	Total (Lbs./day)
3.4	14.4	9.6	0.8	28.2

Figure 35 Daily Feed Consumption per Animal

A typical animal spends 150 days in the feedlot so many pounds of feed are consumed:

3,700,000*150*28.2=15,651,000,000 pounds.

While some grain is moved into the state by train most moves entirely by truck and all moves ultimately by truck.

Once the cattle are at market weight they are shipped by truck to the processing plants. The output of the plants are boxed beef for the domestic market, which moves entirely by truck; boxed beef for the export market (about 10% of the total), which moves by rail and ship to its final market; and byproducts, which move about 50% by truck and 50% by rail. The final destinations for domestic meat include all of the major population centers of the country. Byproducts move to most parts of the country and to Mexico.

Adding all of the inputs and outputs together yields nearly 700,000 annual truckloads moving to and from feedlots and processing plants in Southwest Kansas.

	Annual Truck Loads
Feeder Cattle	49,614
Feed	365,392
Finished Cattle KS	82,392
Finished Cattle Out state	56,416
Processed Meat	107,308
Byproducts	35,760
Total	**696,882**

Figure 36 Annual Truck Loads in the SW Kansas Meat Industry

Trucking is the preferred mode of transporting live cattle and processed meat because the higher service characteristics of the mode, the specialized equipment needed and the perception of greater security-- a truck is attended by a driver, while a train is not attended. Service is also the driver of the choice of trucking for the movement of grains.

In the movement of byproducts, which are less time sensitive, price tends to be the determining factor in the choice of modes.

Source: Bai

The relative importance of the several factors that influence mode choice has been debated on many occasions. Figure 37 presents the Maslow-like hierarchy used in NCHRP 8-42.

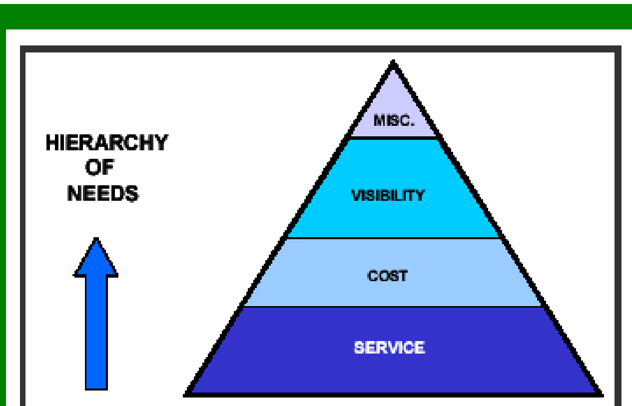


Figure 37 A Shipper's Hierarchy of Needs

Source: NCHRP 80-42

In this model, service is the basic requirement. Once service requirements are met, cost becomes a consideration. At first glance, this may seem counter-intuitive. Earlier, we discussed total cost competition, in which transportation figures as a cost item. The reality is that transportation is a smaller cost item than inventory in most situations. If more expensive transportation is required to make an inventory management strategy work, the trade-off will usually fall in the favor of the inventory strategy. If service requirements are low or if the service provided is similar, cost becomes a deciding factor, as in the case of meat by-products in the above example.

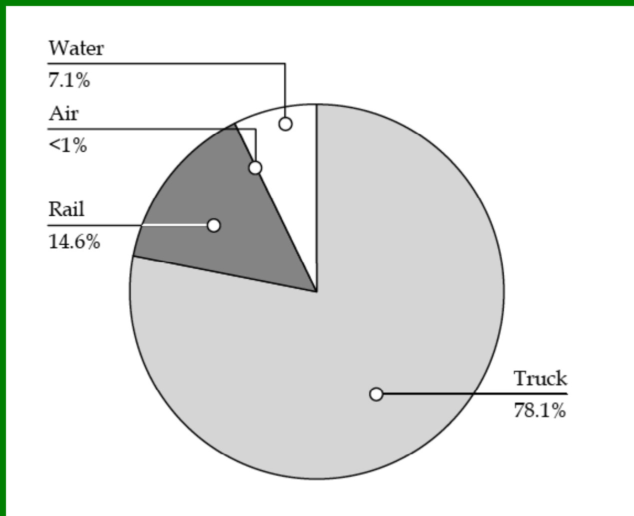


Figure 38 Freight Trips Generated.

Source: FHWA, Financing Freight

Trucking is by far the most used freight mode in terms of trips generated (see Figure 38) in part because of service issues. This may seem confusing, but freight can be measured in terms of ton miles, by this measure rail leads. It can also be measured in tonnage, value and trips. By these last three, trucking leads.

Service can be a somewhat subjective concept. Good service may depend upon the circumstances and upon the desires of the customer. As used here, it simply describes the ability of a mode or carrier to meet the reliability and frequency of delivery criteria that is usually associated with the inventory management strategies outlined earlier. Based on these criteria, truck, air and parcel usually have a distinct advantage over water and rail.

The following example illustrates how service can literally create a market. Californian's use air cargo to move agricultural products to distance markets. Making fresh produce and similar products available in markets they might not otherwise reach.

Air Cargo and California's Agricultural Exports

Air Cargo is usually associated with very high value commodities, or with emergency delivery of products when the surface modes break down. California's agricultural export business demonstrates a field in which the availability of airfreight significantly enhances the value of a product. It allows fresh produce to be delivered to distant markets while it is still at its peak of value.

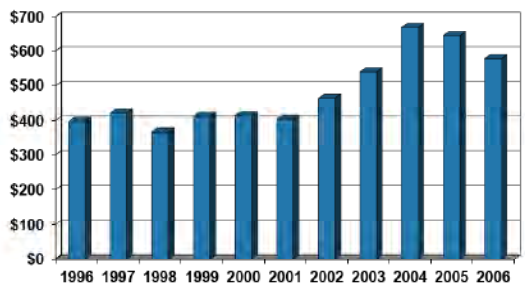


Figure 39 California's Air Borne Agricultural Exports in Millions of Dollars

Figure 39 shows the growth in air borne agricultural exports from California over the past eleven years. In inflation adjusted terms the value of this trade grew by nearly 25% over those years.

Much of the market for air borne agricultural products is in Japan, but the UK, Australia and Italy.

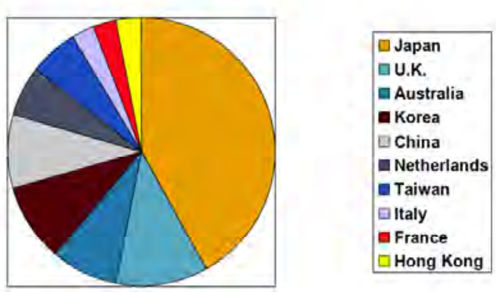


Figure 40 Top Destinations for Air Freighted Agricultural Products from California

- Food Preparations NESOI ($105.3 million)
- Seeds for Sowing Vegetables ($82.2 million)
- Fresh Cherries ($73.1 million)
- Fresh Strawberries ($35.8 million)
- Purebred Breeding Animals ($26.4 million)
- Fresh Grapes ($22.1 million)
- Asparagus ($19.0 million)
- Seeds for Sowing Flowers ($17.7 million)
- Bovine Semen ($15.9 million)
- Wine (14.8 million)
- Fruit Seeds for Sowing ($12.4 million)
- Lettuce ($9.5 million)
- Onions and Shallots ($8.8 million)
- Live Horses ($8.6 million)
- Fresh Miscellaneous Berries (7.9 million)
- Fresh Fruit NESOI ($7.6 million)
- Peaches and Nectarines ($6.9 million)
- Fresh Tomatoes ($4.7 million)
- Chicory ($3.8 million)
- Guavas and Mangoes ($1.9 million

Figure 41 Top Air Borne Agricultural Exports over a Three-Year-Average Period

The products moved in this way range from live horses, to fresh produce and seeds, see Figure 41.

While air moves only a small part of the total California agricultural exports (between five and seven percent), without air, this portion of the market would likely not exist.

Source: O’Connell and Mason

Figure 42 Rail Revenue Ton Miles

Source: BTS Rail Revenue Ton Miles

Item	2004	2006
Freight Revenue per Mile	2.354c	2.840c
Freight Revenue	$39 B	$50 B
Return on Equity	6.16%	11.3%

Figure 43 Freight Rail Economics

Source: AAR

To understand the reasons for this advantage, we need to look at the nature of the modes and the companies involved. Rail companies are private businesses. They must replenish and maintain their capital stock while making a profit. By most measures class I rail companies are more profitable now than they have been in decades. Figure 42 shows revenue producing ton-miles for class I rail companies over a 17-year period. The trends are sharply up. Moreover, freight revenue per ton-mile has increased by 21% between 2004 and 2006. Overall freight revenues for the class I rail companies increased by 28% over the same period; and return on equity nearly doubles over those years (See Figure 43). Rail companies are healthier financially than they have been since the heyday of rail.

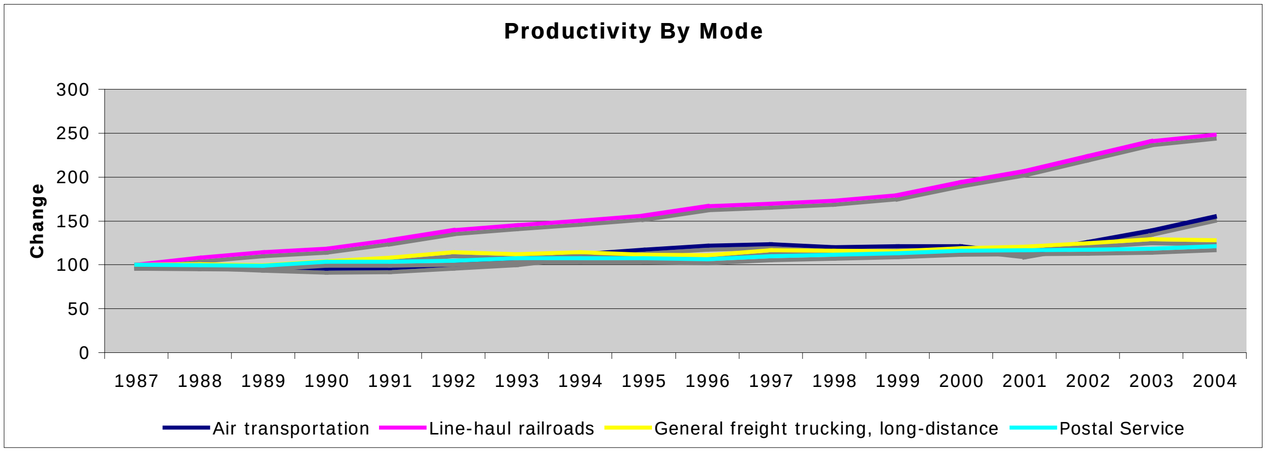


Figure 44 Productivity per Employee

Source BTS

In large part they have attained this health by becoming more efficient. Figure 44 shows the trends in productivity for each mode. By the measures of production per employee**,** rail companies have steadily increased their output, while other modes have remained constant or made more modest gains. They have done this by focusing more traffic into fewer corridors, using longer trains.

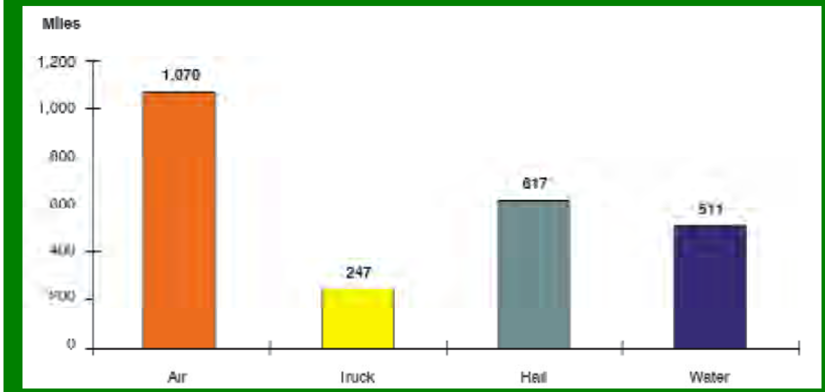


Figure 45 2002 Average Length of Haul

Source: AASHTO Freight Rail Bottom Line Report

Figure 45 illustrates the average length of haul by mode using 2002 date. The average length of a haul by rail is more than double that of truck.

Rail companies have become economically successful by focusing on what they do best: Moving product over long distances in dense corridors, LA/Long Beach to Chicago or NY/NJ to Chicago or the coal fields of Wyoming to the Midwest or the East.

Corridor density is another issue that must be understood. It is simply an expression of the amount of freight that moves in a given corridor between two points.

One river tow is equal to 2.25 unit trains or 870 trucks. One unit train is thus equal to 386 trucks. Consider the amount of product that would be required to fill 386 trucks. Consider the delay as a shipper waited to fill the last truck before any could move. This is essentially what happens with a rail shipment. The first car cannot move until the last is filled, or the first truck cannot move until the 386th is filled. The amount of freight moving in a corridor must be enormous for rail to provide frequent departures and thus, based on the criteria of the inventory management strategies outlined earlier, good service.

Figure 46 Modal Capacity Equivalents

Very few corridors in the US have the density that is required for frequent rail service which makes best use of rail's inherent advantages in moving large amounts of cargo long distances and at low cost. But the tonnage in those corridors is large enough to keep rail's share of total cargo high and to make rail companies profitable.

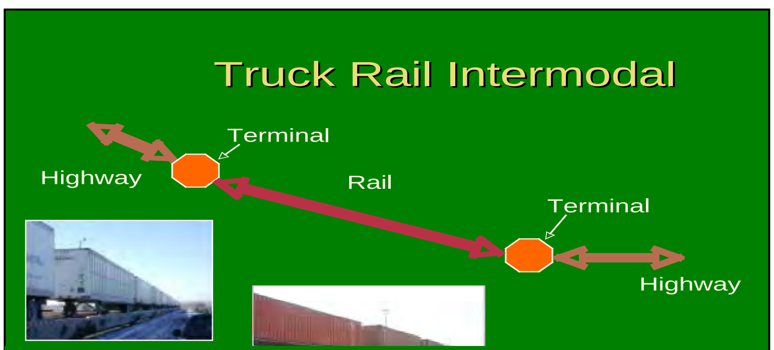


Figure 47 Basic Truck Rail Intermodal

Truck rail intermodal is a fast growing mode of transporting freight that is often seen as a way to get the benefits of both rail and truck. Figure 47 illustrates a truck rail intermodal approach.A cargo is drayed to a terminal by truck, transferred to a train and moved over a long haul to another terminal where it is transferred to truck for final delivery. This can be accomplished by putting a truck trailer on a flatcar, see Figure 48, or by using containers, see figure 49.

Figure 48 Trailer on Flatcar Intermodal

Figure 49 Container-based Truck Rail Intermodal

Containerized intermodal has a major advantage over trailer on flatcar because it can take advantage of double stacking, which essentially doubles the capacity of a train. Because of the advantage that containerization has, many of the larger trucking companies involved in intermodal have moved to containers.

While truck rail intermodal is growing and it does hold promise for the future, it does have some drawbacks. First of all, the cost savings associated with the use of rail over the long haul has to offset the cost of handling the cargo from truck to train and back to truck. As shown in Figure 50, NCHRP 8-42 found that nearly 75% of the total cost of an intermodal trip was consumed by drayage and lift costs in short distance moves. Short distance in this case is up to 699 miles.

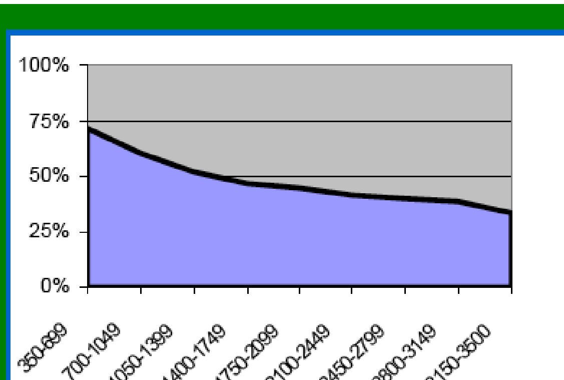


Figure 50 Drayage and Lift Share of Total Cost by Trip Distance

Source: NCHRP 8-42

This cost equation makes truck-only very competitive with truck-rail intermodal in those shorter hauls. The literature normally uses 600 miles as the minimum distance in which rail could be considered. For the Western railroads, that serve long distances, the number is probably closer to 1,000 miles.

Cost is not the only issue to consider in evaluating truck rail intermodal. Figure 51 lists several other important issues. Will intermodal provide an equivalent service to truck? As we noted earlier, service is the basic issue in modal choice. Next, does the shipper have access to an intermodal terminal? If a 300 mile trip by truck is necessary for a 700 mile total trip, the choice may well be to truck the entire distance.

Market Viability	Institutional Readiness	Public Barriers
1. Equivalent Service	1. Capacity	1. Public Acceptance
2. Access Limitation	2. Capital	2. Competitive Reckoning
3. Interoperability	3. Institutional Commitment	
4. Density	4. Institutional Structure	
	5. Sustained Performance	

Figure 51 Obstacles to Diversion to Rail

Source: NCHRP 8-42 Guidebook

An instructive example of the intricate nature of capacity and its interference with diversion comes from a Class I railroad in 2004. A premium intermodal train for a major motor carrier, designed to produce highly competitive three-to-four-day transcontinental service, created system congestion and delays for other trains. Limitations of track, siding, signaling and labor capacity, coupled with the need to create headroom (a clear lane) for the much faster intermodal train, created cascading disruption for other operations, which lasted up to a week.

Source: NCHRP 8-42 Guidebook

Interoperability simply refers to the of the rail carrier to interact with the trucking system. Are equipment and operating issues compatible? Can the two interact smoothly and efficiently?

Density is the issue discussed previously. Does a corridor have sufficient freight traffic to support good rail service, even in an intermodal form?

Capacity should be an obvious issue. Class I rail lines are operating many corridors at or near track and terminal capacity. Is there sufficient space in the system to support an intermodal service? What will be the impact on other services, if intermodal is introduced? The sidebar, above to the right, points up some secondary impacts that have occurred.

Other institutional issues, such as capital and commitment are clearly needed. If the companies do not have the capital to add cars, locomotives and other capital needed for the service, it cannot happen.

Public acceptance is an issue that too often is not considered with rail service, but if the number or length of trains in a given corridor increases significantly, it will likely create a public response. Homeowners and business people do not want the noise, vibration and inconvenience of many long trains.

The bottom line is that putting more reliance on rail freight, even in the form of intermodal, may not be as easy as it might seem at first blush. The service has to be good. The economics have to work. And the public has to accept a change in train movements.

Another transportation management approach that is being used by some trucking companies is the use of transfer or staging points, as illustrated in Figure 52.

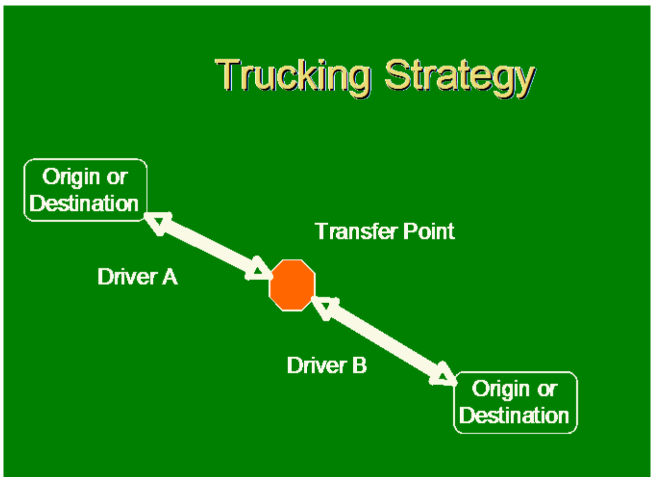


Figure 52 Using Transfer Points

Trucking companies who are attempting to address driver shortages by creating conditions in which drivers can be home every night, or at least more often have often used this strategy. Under this approach two or more drivers begin from opposite directions. They meet at a transfer point in the middle and exchange loads and head back in the direction they started from. The result is less time away from home and, it is hoped, a more attractive working experience.

The obvious challenge in this strategy is the need for close coordination between drivers and loads. They must arrive at the transfer point on a planned schedule, or downtime will be the result.

International Experience

We tend to see the experience of the US as a model of what can be done, but other countries have taken steps to change their historic transportation network. The European Union (EU) is a prime example. It has articulated its approach in a policy statement dealing with its proposed, and partially implemented transportation system:

> Modern economies cannot generate wealth and employment without highly efficient transport networks. This is particularly true in Europe where, for goods and people to circulate quickly and easily between Member States, we must build the missing links and remove the bottlenecks in our transport infrastructure. The trans-European transport network is a key element in the re-launched Lisbon strategy for competitiveness and employment in Europe for that reason alone: to unblock major transport routes and ensure sustainable transport, including through major technological projects. (Trans-European Transport Network: TEN-T Priority Axes and Projects, 2005)

The EU is dealing with increased demand for transportation, in keeping with the above vision, in several ways. The first is an effort to diversify its system to move more goods from highways to rail and water. As Figure 53 indicates, it has been partially successful in that effort. While road (red line) remains near the top in terms of growth, short-sea-shipping (dark blue line) has responded to the effort the EU has placed on the promotion of the mode. Inland waterways and rail also seem to be responding in the later years.

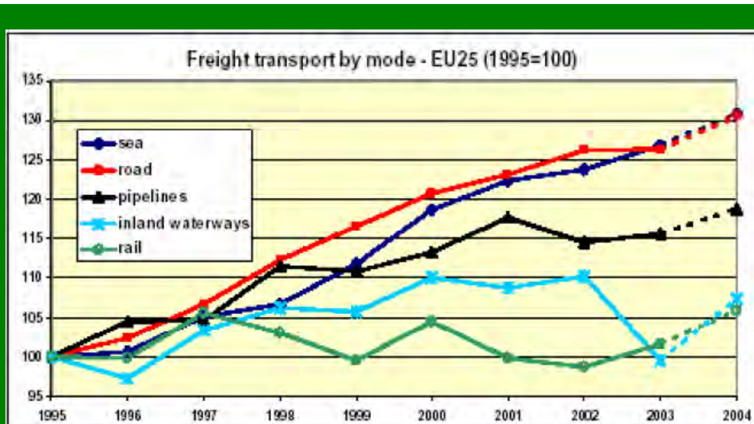


Figure 53. Freight transport modal split in the EU25

Source: Consultation document on logistics for promoting freight

The EU has also devoted much energy to promoting intermodal freight (short-sea, rail, inland waterway and truck) through a program called Marco Polo. Through this program the EU is funding projects that will better connect the modes.

Closely tied to the Marco Polo program is Galileo, the EU's version of the Global Positioning System (GPS). Unlike America's GPS, Galileo was designed primarily with transport in mind. When completed, it will allow transit times to be monitored, allowing advanced warning of road system breakdowns. It will also assist in tracking goods, making intermodal more attractive.

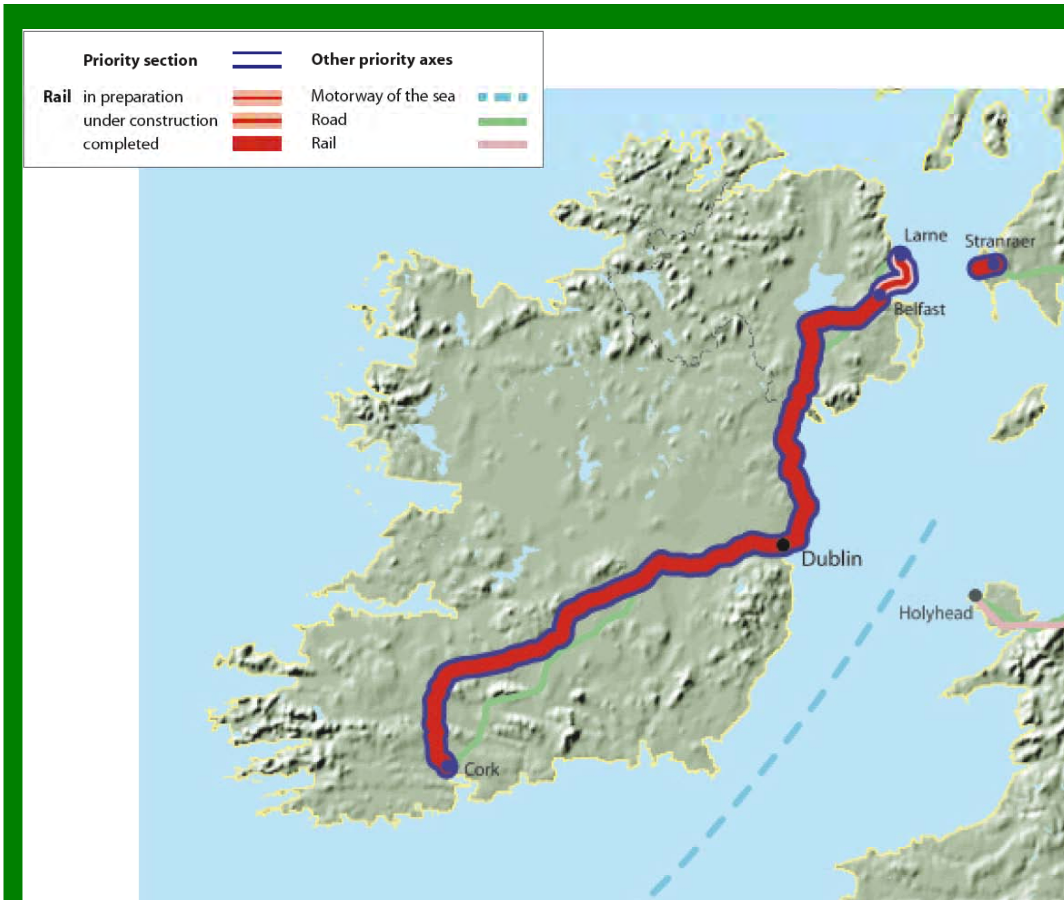


Figure 54. Priority projects in Ireland

Source: Trans-European Transport Network: TEN-T Priority Axes and Projects, 2005

It also has ambitious plans for improved roadway, rail, inland waterway and short sea shipping connections between its member countries. This has become a higher priority with the recent and continued expansion of the EU. Efficient transport is needed to bring the benefits of membership to all parts of the continent. Budget constraints have slowed the implementation of these plans, but progress is being made. For example, the map of Ireland in Figure 54 shows sections of completed and under construction railways.

Similar efforts are underway throughout the EU. Roads, waterways and railways are being improved to bring the continent closer together and to improve its productivity and competitive position.

The EU is not alone. Japan, Korea, China, India and Brazil are all countries that have made a commitment to improving and changing their transportation systems.

They are taking actions through public investment and public policy to encourage the building of the kind of system they see as most beneficial. Each is proceeding within its historic structure and societal constraints, but they are taking steps to shape their future.

Summary

The US is facing a major challenge in the movement of freight. With a little hyperbole, AASHTO has referred to it as the coming tsunami of freight. Since our economic well- being depends on the movement of freight, we must find ways of meeting this coming challenge. A first step is for the public sector to gain a better understanding of the needs, motivations and constraints of their private sector counterparts as they attempt to do their jobs.

- Cost reduction is the major objective of private firms that drives much of what happens in the movement of freight. Total cost competition forces companies to hold down all costs. Just-in-time, pull logistics and manufacturing on demand are all inventory management structures that relate to this basics need.

- All of the inventory management systems in use now tend to require dependable, more frequent and timed deliveries. They also tend to put more freight on trucks.

- Mode choice is driven by many factors. Most observers find service to be the highest consideration in reaching a mode decision. In this context, service is simply the ability of a mode to make the timely, planned deliveries needed to allow modern inventory management systems to operate.

- Rail companies are private businesses that have to make a profit while renewing their physical assets. They are very profitable now relative to the recent past. In large part they have gotten that way by focusing on what they do best—moving freight over long distances in long trains.

- Doing what they do best has limited their ability to provide the types of services needed to make modern inventory practices work. They must operate in high- density corridors.

- Trains and water tend also to move lower value products, coal, grains, non-metallic ores, etc., with relatively low service demands. Truck, air and parcel services tend to move products with higher values and higher service demands.

- Truck-rail intermodal is often seen as a way of gaining the benefits of both truck and rail, but the cost of drayage and transfer, as well as the service challenges of rail, have made it operate effectively only in long-haul situations, typically 600 miles or more.

All of these factors and others point to nee challenges and roles for the public sector:

- First of all, the historic response to congestion, building more roads, will still be needed, but it will have to be used in concert with other efforts as well.

- Among those efforts will be better system management and operations to ensure that the movement of trucks and other vehicles is reliable and able to meet the needs of industry.

- It will also be necessary to build better working relationships with the private sector. In many cases, being reactive will not suffice. Some states have reported that they are now making an effort to become involved as businesses are making site decisions, so that they can find the best transportation solutions.

- It will also be necessary to think about transportation from a more holistic perspective. Efforts will have to be made to better connect the modes and to use the best feature of each mode.

- But this holistic view must not be a field of dream view. It must be taken with a realistic understanding of the strengths of each mode and the constraints under which they operate.

- This leads to another role that will be new to many public sector transportation professionals in the world of freight. Increasingly, the role will be that of facilitator. Bringing people together to solve problems will be a major challenge.

- The solutions found may also be quite different from what we have used in the past. Innovative institutions between public agencies will be required, as they will between public and private agencies.

- Financial arrangements will also probably be more intricate than they have in the past, as private and public agencies are forced to recognize that they share an interest and a responsibility for solving transportation problems.

The above are but some of the reasons for the public transportation official and professional to better understand private sector issues in logistics management.

Quiz Answers

1. According to FHWA, what portion of the average state truck tonnage simply passes through the state?

   A. 43%

2. In 2002 what percent of the 19.3 trillion tons of freight shipped in the US was domestic?
   A. 91%

3. Which country is the US's largest trading partner?

   A. Canada

4. In 2002 how many people were employed by American railroads?
   A. 177,000

5. In 2002 what was the total revenues of class I railroads?
   A. $35.3 billion

6. In 1997 what portion of the US GDP was involved in international trade?
   A. 25%

7. What is generally used as the haul length needed to make rail economic?
   A. 600 miles

8. Between 1980 and 2000, which grew fastest: overall VMT, truck VMT, lane miles of highway?
   A. Truck VMT (89%); overall VMT (80%); lane miles (3.8%)

9. How many trucks would it take to carry the load of one Columbia River barge?
   A. 134, or 35 rail cars

10. What is the value of an average ton of freight moved by air relative to that of truck?
    A. About 90 to one

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Appendix C: Lecture Notes on Part II Logistics Practices and Theories

Supply Chain Strategies

"*All this will not be finished in the first 100 days. Nor will it be finished in the first 1000 days, nor in the life of this Administration, nor even perhaps in our lifetime on this planet. But let us begin*." – J.F. Kennedy

To integrate freight system planning with logistics and supply chain activities is a long term goal. A satisfying integration will not happen within a foreseeable future. However, to position freight activities in the context of logistics management is rewarding to public freight planners. From this section, additional supply chain practices will be introduced while trying to illustrate the implications of freight to logistics wherever possible.

Supply chain management mainly involves the coordination of inventory/distribution management and other associated activities between the interest parties in the system. The primary objective is to reduce the inventory redundancy and increase the system wide efficiency while maintaining the level of services. As explained in Section 1, the entire supply chain cost includes costs in warehousing and distribution as well as associated management and service activities. Many strategies to reduce the supply chain cost have been developed in the recent decades. These developments have been motivated by the fact that supply chain cost accounts for a significant portion of the national GDP. The improvements have had a significant impact on economic efficiency in enhancing the global competitiveness of the US products.

Before we talk about logistics strategies, let take a look at the logistics cost break down and see what role transportation plays in the logistics process in terms of cost.

In the US, the supply chain costs account for about 10.5% of the national GDP, in which transportation costs contribute a significant portion of this 10.5%. Table 2.1 below illustrates the breakdown in the USA (Financial Times, 1998).

Cost Item	Percentage of The Total Logistics Cost
Transport	46
Storage/Warehousing	22
Inventory Carrying	22
Administration	10
TOTAL	**100**

Table 2.1 Logistics cost breakdown in the US

The figures above are believed to remain comparable to today's situation. It is easily seen that transportation represents a large component of the overall logistics cost.

However, the role of transportation varies with different commodity. Different commodities might have different cost breakdowns. The cost breakdown could vary greatly as seen in Table 2.2.

Main Business	Transport Cost	Warehousing/Depot	Inventory Holding	Administration	Overall (% of total cost)
Office Equipment	3.2	10.7	0.87		14.77
Health Supply	1.36	9.77	0.66	0.19	11.98
Beer	8.16	2.82	0.56	2.19	13.74
fashion	0.38	1.31	0.33		2.02
Cement	25.2	9.1	7.1	4.6	46
Auto Parts	2.07	6.35	1.53		9.96
Computer Supply	0.65	0.78	0.09		1.52

Table 2.2 Logistics cost breakdown for different commodities.

In Table 2.2, the last column represents the logistics cost as percent of total final product cost (total retail cost). This variation across sectors generally determines the difference in logistics strategy among different commodities and across different industry sectors. As seen in the above table, transportation cost is a very significant portion of the total logistics cost for bulk commodities such as cement. Understandably, bulk commodities rely on economies of scale in transportation. The higher the value, the less significant the transportation cost. For commodities such as fashion items, transportation cost is very low in percentage. Transit time duration and reliability of ground shipping would definitely prove to be critical. Interestingly, among the shelf items in chain stores, such as Wal-Mart, logistics managers attempt to differentiate the fast moving items from the rest. Obviously, different shelf items deserve different attention and therefore possibly different ordering and sorting strategies at distribution and warehousing.

In this chapter, we briefly review some popular strategies and tactics that have had impact in practices. First of all, we will cover inventory management, which will demonstrate how shift of inventory along the supply chain is made. We will also demonstrate the impact of transportation on inventory cost. Then, we will introduce the vendor managed inventory (VMI), assemble-to-order system (ATO), just-in-time (JIT) system, and pull/push system. This will be followed by a brief introduction to the multi-echelon system.

Inventory Management

The movement of inventory along the supply chain generates freight on the transportation system of highways, railways, air, pipelines and waterways. One may view the logistics system as a system of inventory holding points (warehouses, distribution centers and vendors) with inventory flows between these points. Inventory management policies decide how much to order and when to order from and for these holding points. The inventory policy directly relates freight traffic to supply chain management. There are numerous inventory policies and models. In what follows, we will introduce the EOQ model that is generally considered the most basic and considered to have had greatest impact in practice.

Economic Order Quantity (EOQ) Model

The EOQ model tries to make a balance between ordering cost and inventory holding cost. If less is ordered each time and orders are placed more frequently, the average inventory will be lower. One might think this would decrease the average inventory carrying cost and is most preferable. This does lead to a lower average inventory. However, there is a trade-off here with administrative cost, called ordering cost. The ordering cost is a fixed cost associated with placing an order: direct labor time/cost for paperwork, equipment leasing (e.g. for shipping), documentation of ordered items, unloading, etc.

The EOQ model is the most basic model for deciding the optimal order quantity that balances these costs.

$$Q^* = \sqrt{\frac{2KD}{h}}$$

Where D = Demand; K = fixed ordering cost; h = inventory carrying cost per unit; Q = optimal order quantity.

Example

A distribution center (DC) manages distribution of a product. The unit value of this product (purchase cost) is $50.00. The annual demand for this product that goes through the distribution center is 4000 units. A cost of placing the order each time is $400. If the inventory carrying cost is 20% of the tied inventory value, how many units shall be ordered each time?

Solution

Here D=4000; K=400; h=$50x20%=$10.00. Therefore,

$$Q^* = \sqrt{\frac{2KD}{h}} = \sqrt{\frac{2*400*4000}{10}} \approx 568 \text{ (units).}$$

To conclude, the optimal ordering size is 568 units each time. The order frequency is determined by the total annual demand and order size.

At first glance, the EOQ model does not appear to capture the effect of transportation. In fact, transportation does not affect the quantity ordered each time. The EOQ model introduced might leave readers with an impression that logistics activities are independent of transportation. One might suspect that the shipping behavior has been driven by other factors than transportation: transportation cost is not considered in the EOQ model. This is true in that transportation is only one component of a very large supply chain system. Shipping decisions are often not affected by transportation cost. However, if the shipping volume dramatically changes the freight rate so that the shipping cost could differ significantly, say from 5% to 15% of the total product value, then EOQ model might not apply, or a different model might need to be developed. If it is only a difference between 5% to 7% of the total cost, application of the EOQ model should be fairly accurate.

Transportation cost might not affect the ordering policy in the application of the EOQ model. However, it affects the constantly carried inventory, the safety stock. This is obvious as a longer transit time would increase the risk of running out of stock (stockout) and necessitate the need for more safety stock. Therefore, transportation affects the total logistical costs in a very fundamental way.

We have an example to demonstrate this point based on the optimal inventory policies.

Example

Suppose that an inventory policy is needed for a consumer product (e.g. TV set). Assume that whenever an order is placed for replenishment, the ordering cost is $4,500, which is independent of the order size. Each unit of product has a cost of $250, and the annual inventory cost is 18% of the product cost. Lead time (from order placing to order arrival) is about two weeks. The support data and optimal decision are given below.

Before we present the optimal policy for the example above, we should introduce more about the inventory policy with uncertain lead time and demand.

(s, S) Policy for Inventory Management

An effective policy for inventory management is referred to as (s, S) policy. Whenever the inventory drops to below s, an order is placed to make the inventory position to S. Here S=s+Q, where s is called re-order point, Q order quantity and S order-up-to level.

Note that s is composed of two parts: safety stock to prevent stockout and average demand during lead time. If everything is 'normal', the inventory level shall be equal to the safety stock at the arrival of an order. If the demand is not as 'regular' as expected during the lead time, the safety stock is used to prevent stockout.

Freight impacts inventory costs primarily through affecting the safety stock. Safety stock is determined by the uncertainty of demand during lead time. Obviously, the uncertainty of demand during a longer lead time is larger. As a result, a longer lead time is associated with a higher safety stock. Of course, the nature of demand itself (variation of demand within a unit time, or predictability of demand) affects the overall demand during the lead time. In addition, a practical factor in determining the safety stock is the ability of the vendor to accept a stockout. The vendor may refer the customer to another store close by, or to satisfy the demand with substitutable products. Measuring all the outcomes, the stockout cost could be quantified to deciding the inventory policy.

In the following, we illustrate how the lead time, demand and their associated uncertainty affect inventory cost through affecting the safety stock.

Systems with a fixed lead time and a stochastic demand

Safety stock = $z \times STD \times \sqrt{L}$; ($z$ is the safety factor, and is decided by a preset service level, or tolerable stockout risk, α; L, lead time; STD, standard deviation of demand)

Re-order point = $L \times AVG + z \times STD \times \sqrt{L}$ (where AVG is the average demand per unit time period)

An implicit rule here is observed.

Probability {demand during lead time > $L \times AVG + z \times STD \times \sqrt{L}$ }=1- α.

Order quantity Q is calculated with the EOQ model (economic lot size method).

The following table shows the relationship between desired service level α and safety factor z.

Service level	90%	95%	99%	99.90%
z	1.29	1.65	2.33	3.08

Table 2.3 Service level factors

Systems with variable lead time and stochastic demand

$s = AVG \times AVGL + z\sqrt{AVGL^2 \times STD^2 + AVG^2 \times STDL^2}$ (the first term accounts for the average demand during lead time and the second safety stock)

Here, AVGL is the average lead time, STDL standard deviation of the lead time.

The order up-to level is S=s+Q as before.

Solution to Example Exercise

Using the equations above, we have the following optimal inventory policy.

Average weekly demand	Standard deviation of weekly demand	average demand during lead time	reorder point	Safety stock	order quantity
44.58	32.08	89.16	176	86.2	679

Table 2.4 Demand information and optimal order.

However, if we associate a variance to the lead time, the inventory will have to increase to hedge against the risk of stockout. The average inventory increase in relation to the lead time variance is tabulated in the following.

Standard Deviation (in days)	Re-order Point (units)	Inventory increase (percentage)
2	179	0.78%
3	183	1.72%
4	188	2.97%
5	194	4.49%
6	202	6.23%
7	210	8.14%
8	219	10.20%
9	228	12.38%

Table 2.5 Inventory increase with variance of lead times.

The standard deviation roughly means that within one standard deviation of the given lead time (two weeks), e.g. from one standard deviation below to one standard deviation above, the chance of delivering the order is about 70%.

Lead time duration also has an impact on the optimal inventory carried. After calculation using the equations introduced above, the table below illustrates the average inventory change according to the average lead time change. One can easily see the inventory increase with longer lead times.

Lead Time (days)	Demand During Lead Time	Safety Stock	Re-order Point	Average Inventory Change
24	153	113	266	6.26%
23	146	110	257	5.70%
22	140	108	248	5.13%
21	134	106	239	4.55%
20	127	103	230	3.95%
19	121	100	221	3.34%
18	115	98	212	2.71%
17	108	95	203	2.06%
16	102	92	194	1.40%
15	96	89	185	0.71%
14	89	86	175	0.00%
13	83	83	166	-0.74%
12	76	80	156	-1.50%
11	70	76	146	-2.30%
10	64	73	137	-3.14%

Table 2.6 Inventory increase with lead time changes.

It appears that lead time variance has a larger impact than the average duration on the carried inventory[1].

Pull/Push System

The supply chain management revolves around efficient integration of suppliers, manufacturers, warehouses and stores. The challenge in supply chain integration is in coordination of activities across the supply chain to: reduce cost, increase service level, reduce the bullwhip effect (explain later), better utilize resources, and effectively respond to changes in the market place (e.g. resilience).

[1] Formulas for the calculation are from Simichi-Levi, et al. (2000), and are not required in this course.

Traditional supply chain strategies may be categorized along the line of push or pull. A push based supply chain makes production and distribution decisions based on long term forecasts. Typically the manufacturer makes demand forecasts based on previous orders received from retailer's warehouses or distribution centers. A pre-scheduled manufacturing plan is carried out and products are 'pushed' down the supply chain into its vendors' inventories, often times irrespective of its up-to-date demand information. The disadvantages of this push system include:

- The inability to meet changing demand patterns
- The likely obsolescence of supply chain inventory as demand for certain products disappears.

The so-called bullwhip effect often occurs in the push system. Backward along the supply chain, the suppliers place larger and larger orders to account for the uncertainty of its down stream demand in order to meet their service requirements, making the entire system unstable. In such a system, service levels are low as the system is not responsive to market changes, inventories are excessive, and often products become obsolete.

In a pull based supply chain system, the production and distribution decisions are driven by customer demand. In an ideal pull system, no inventory is held until an order comes. This is enabled by fast information flow mechanisms to transfer information about customer demand to the various supply chain participants. Pull systems are intuitively attractive since they lead to many advantages such as:

- Low inventory
- Stable supply chain system

In practice, no perfect push or pull systems exist. Often times, a supply chain is usually operated as a combination of both. The following diagraph illustrates different products that fit different strategies (Simchi-levi, Kaminsky and Simchi-Levi, 2003), where demand uncertainty and economy of scale constitute the two axes. As indicated in the figure below, high demand uncertainty encourages a high level of pull strategy while a high economy of scale gives incentive to a high degree of push system.

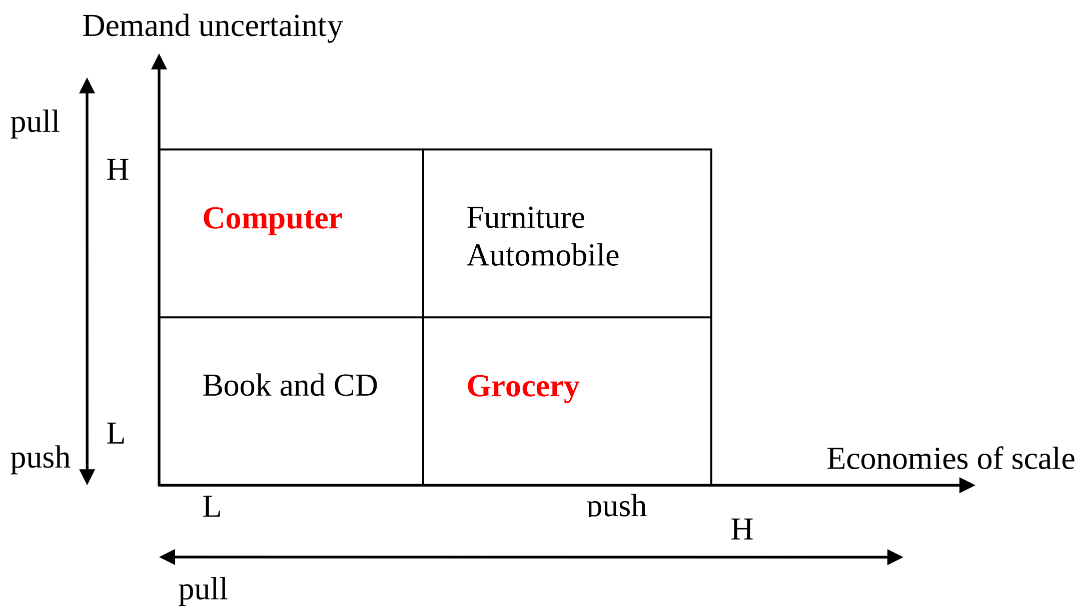


Figure 2.1 Commodities on a push-pull scale.

It is clear that a pull strategy fits the computer industry while grocery welcomes a typical push strategy. In addition, the automobile uses a mix of push and pull strategies. As the quote below suggests, it may be moving more toward the pull model.

A typical auto manufacturer offers a large number of similar products distinguished by functionality, motor power, shape, color, number of doors, sports wheels and so on. In addition, the demand uncertainty for a particular model is very high. Delivery cost is high as well. Traditionally, the industry has employed a push based supply chain strategy, building inventory for the dealer distribution systems. Recently however, GM announced a dramatic vision for restructuring the way it designs, builds and sells its products. The goal is to allow customers to customize and order cars on-line and have the cars delivered to the customer's door within 10 days. GM is moving exactly towards a build-to-order strategy. (pp 125, Simchi-levi, Kaminsky and Simchi-Levi, 2003)

Demand driven production and distribution is also seen in the airline industry. In the airline industry, supply refers to the aircraft capacity on a flight while demand represents the passenger/cargo flow. As demand is uncertain in the market, early fleet assignment onto flights may loose revenue opportunities as the expectedly smaller market could turn out to have a larger demand occasionally. Therefore, airlines purposely leave aircraft assignments on the flight network as undecided until the total demand is known. In a typical demand driven practice, two aircraft of different seating capacities are tied together for potential swap in order to better accommodate market demand.

A pull system, or demand driven system, heavily depends on information and automatic computing power for system optimization and decision making in real time. Development of the IT technology and availability of rich market and production information has been enablers of the push system. A demand driven manufacturing or distribution system emphasizes the value of flexibility for future changes in production planning. The value of flexibility is often key to a successful operation of a pull system.

Vendor Managed Inventory

Traditionally inventory management is divided based on ownership across the supply chain. Manufacturers, distributors, and vendors each manage their own inventory and develop their own inventory policy. Isolation of these operations and their myopic decisions cause excessive production and supply. Distributor and vendor collaboration in terms of information sharing and inventory management has been a rewarding area and has motivated profitable practices in the past decade. Some suppliers have developed policies with their retailers such as buy-back-at-a-discount, in which unsold products by a certain time will be allowed to return at a discount price. In this way, suppliers assume partial responsibility of assisting inventory management for the retailers. In the following, we are going to introduce a special type of vendor-retailer relationship: Vendor-Managed-Inventory (VMI).

Vendor-Managed Inventory (VMI) is a planning and management system that is not directly tied to inventory ownership. Under VMI, instead of the retailer monitoring its sales and inventory for the purpose of replenishment order placement, its vendor (e.g. supplier) assumes responsibility for these activities. Note that retailers are also called customers (of the vendor) here. In the past, many suppliers operated vendor-stocking programs where a representative of the vendor visited a customer a few times a month and restocked their supplies to an agreed-upon level. Popularized by Wal-Mart, VMI replaces these visits with information gathered from cash registers and transmitted directly to a supplier’s computer system via Electronic Data Interchange (EDI). Now, suppliers can monitor sales of their products and decide when to initiate the re-supply procedure. This is not an inexpensive proposition for suppliers. Investments must be made in new systems, software, and employee training.

What are the advantages of the VMI to customers?

In the article "Integrating Vendor-Managed Inventory into Supply Chain Decision Making," Mary Lou Fox (Fox, 1996) outlines four advantages of VMI:

1. Improved customer service. By receiving timely information directly from cash registers, suppliers can better respond to customers' inventory needs in terms of both quantity and location.
2. Reduced demand uncertainty. By constantly monitoring customers' inventory and demand stream, vendors are not challenged by large, unexpected customer orders. By watching over several retailers, the aggregate demand becomes smoother.
3. Reduced inventory requirements. By knowing exactly how much inventory the customer is carrying, a supplier's own inventory requirements are reduced since the need for excess stock to buffer against uncertainty is reduced or eliminated.

While these are all potential benefits of VMI, the most important ones were not cited.

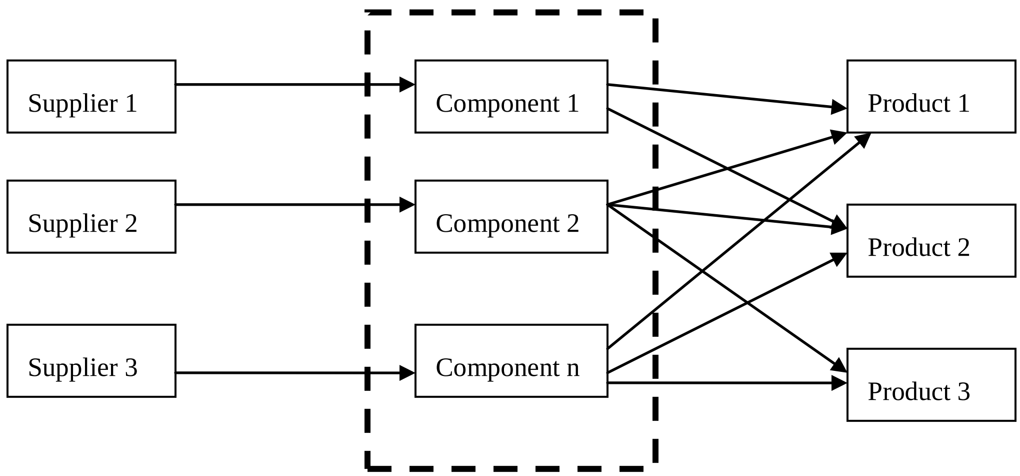
4. Improved customer retention. Once a VMI system is developed and installed, it becomes very costly for a customer to change suppliers.
5. Reduced customers' reliance on forecasting. With customers for whom a supplier runs VMI programs, the need to forecast their demand is eliminated, or at least reduced.

The vendor managed inventory implies that the replenishment of inventory is timely, and that excessive supply of inventory is not likely. Here, the agreed upon inventory level plays an important role in deciding the delivery frequency. In addition, retailers/vendors have the capability of differentiating fast moving items from slow ones. Vendors have to take into account the differences in sales volume in deciding delivery frequencies for the different items. Means of delivery in terms of truckload or less-than-truckload then could be well related to this delivery frequency.

Assemble to Order System

When excessive inventory is costly as in the PC industry, where new models replace current ones very quickly, a special demand driven manufacture-distribution system has been widely adopted in order to reduce the high inventory cost. This special system is called assemble-to-order. In this system, multiple products share the same inventory of components. For instance, PCs of different configurations use the same set of components such as hard drive, memory chips, monitors, keyboards, etc. Customers have various specifications on the products that they demand. Some may need a hard drive of 50GB, some 120GB; some a 29 inch flat panel, and some 21 inch. An assemble-to-order system has all these components in inventory. PCs are assembled according to customer specifications in their orders. In this way, inventory cost is significantly reduced.

Assemble-to-order systems involve value-added activities in the warehouses such as assembling, labeling, and packaging. The following graph illustrates the process of an assemble-to-order system.



Warehouse

Figure 2.2 An illustrative assemble to order system.

The assemble-to-order system is not a new invention in concept. In many large hardware stores such as Home Depot, sales of paint and stain offer an assemble-to-order system. Mix of the elementary inputs generates paints or stains of different colors as specified by customers. Imagine the inventory to carry all those paint colors premixed in every possible finish!

Multi-Echelon System

The multi-echelon system represents a perspective towards the structure of the supply chain system. Take a look at a distribution system as demonstrated in Figure 2.3. The product is manufactured at a plant. The manufacturer is considered as the most upstream echelon. The product is then supplied to its immediate next *echelon*, a distribution center, from where the product is further distributed to its vendors, after which the most downstream echelon, retailers receive the product for sale.

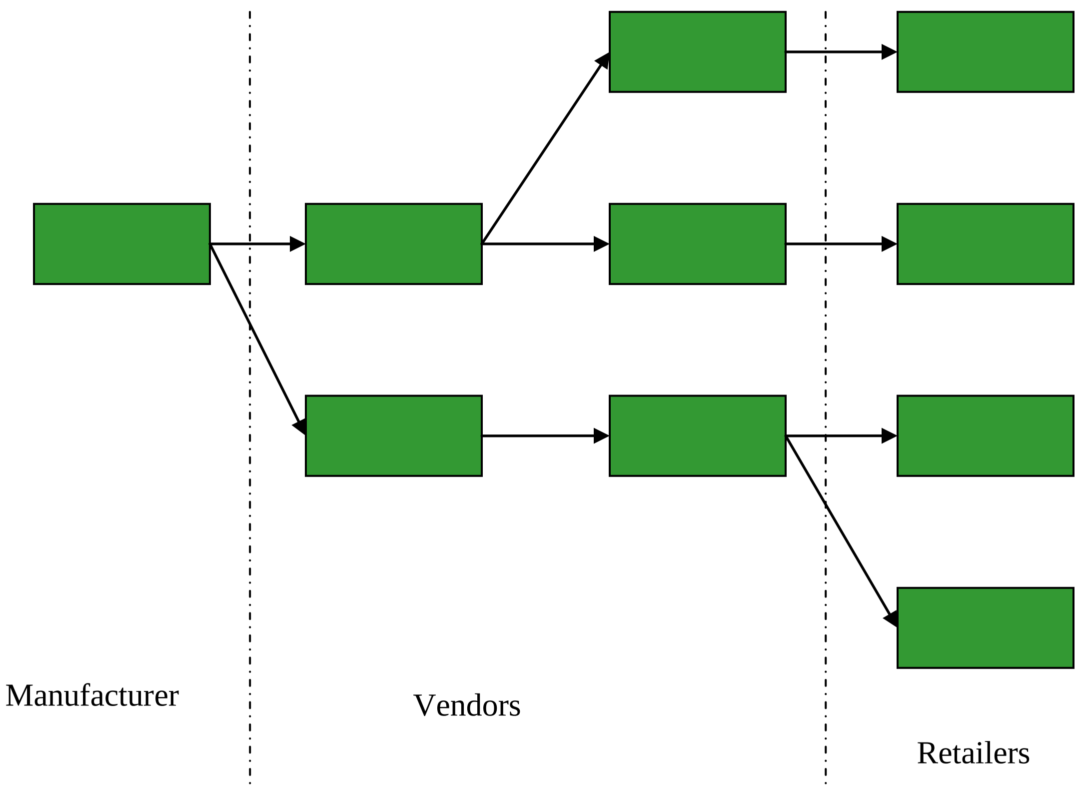


Figure 2.3 A multi-echelon system of distribution

Retail products imported from the East Asian countries go through a multi-echelon system. First, the products are manufactured in the East Asian countries. Secondly, They are shipped to large warehouses/distribution centers in the US via ocean and the major West Coast ports over a long distance and through export and import customs of two countries. The products are further shipped to regional distribution centers from where they are distributed to retail stores.

The multi-echelon system of assembly represents another example as shown below. Components are assembled into semi-products which are further shipped to its assembly plant for final product.

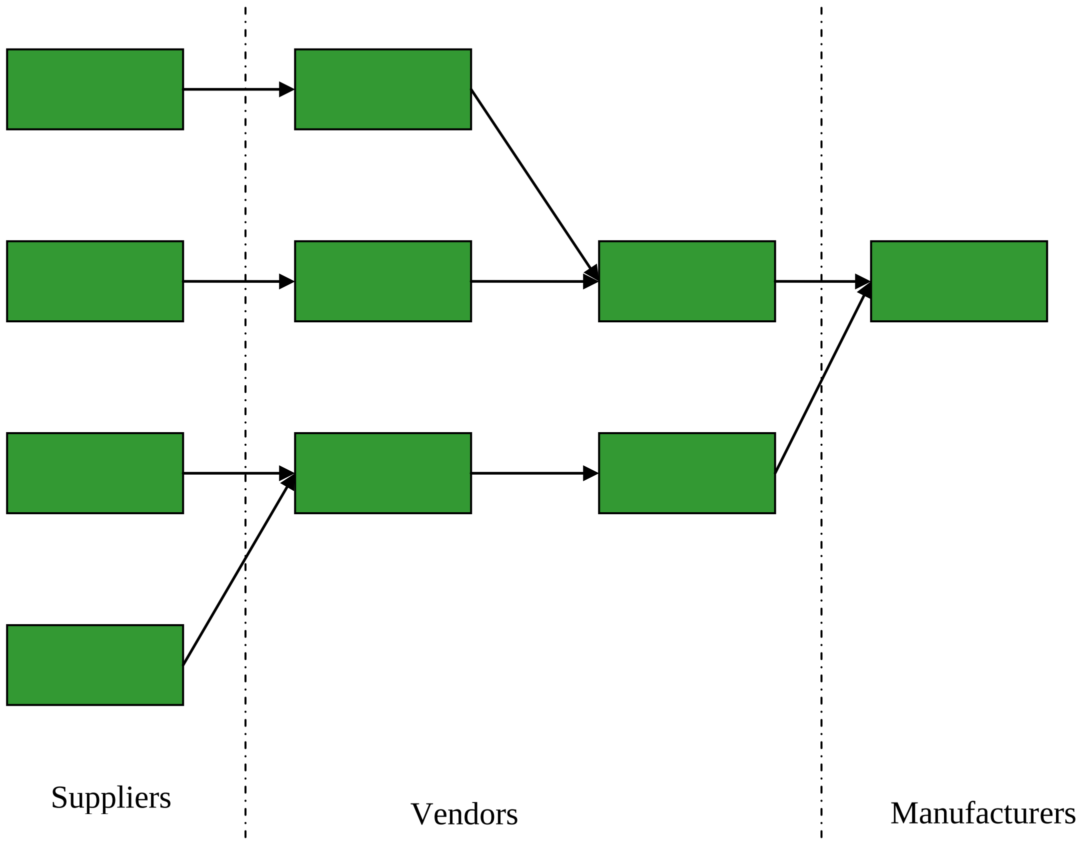


Figure 2.4: Multi-echelon system of assembly

The multi-echelon system point of view towards supply chain management represents a systems approach. It mainly deals with supply chain integration and smooth flow of inventory for system efficiency. Here, if we extend the echelon system of assembly to beyond the final product, we will have an echelon system of distribution. By extending the graph in this way, we will be able to find that the supply chains are in fact intertwined. One might want to consider links between echelons as shipping lines and nodes as major freight terminals to be simple. The links and nodes at different levels of echelon have different significance in terms of its network effect. For example, the links from East Asia to the West Coast prove more important than those to the final retailers.

Delay/cost during ocean transport or at the West Coast ports have an impact on product distribution in the entire national market of the US. To freight planners, it is clear that achieving reliable and efficient performance on trunk freight lines has strategic value to the efficiency of the distribution network. This is an intuitive justification to the special focus on arterial network or arterial freight corridors and major freight terminals.

Supply Chain Integration

Supply chain integration is a broad concept dealing with strategies that bring vendors and suppliers closer together (by risk sharing or binding contracts) in order to make the production/distribution responsive to market changes. The pull system we introduced before represents an integration strategy. Here, we introduce two additional types of integration strategies, distributional and centralized/decentralized control based on different perspectives to the logistics and supply chain systems (Simchi-Levi et al. 2003).

Distributional Strategies

Typically three distinct outbound distributional strategies are used: direct shipping, warehousing and cross-docking.

- **Direct shipping** means shipping directly from manufacturers to retailers bypassing DCs. It is common when retail store requires fully loaded trucks. It is most often mandated where lead time is critical. Sometimes, the manufacturer is reluctant to be involved in direct shipping but may have no choice in order to keep the business. Direct shipping is also prevalent in the grocery industry, where lead time is of greatest importance because of perishable goods. (Simchi-Levi et al., 2003).

- **Warehousing** is the classic strategy in which warehouses keep stock and provide customers with items as required. Typical functions of warehousing are sorting and storage. Value added activities include labeling, packaging and sometimes assembling.

- **Crossing docking** is a strategy that Wal-Mart made famous. In this strategy, warehouses function as inventory coordination points rather than as inventory storage points. In typical cross-docking systems, goods arrive at warehouses from the manufacturer, are transferred to vehicles serving the retailers as rapidly as possible. Goods spend very little time in storage at the warehouse – often less than 12 hours. This system limits inventory costs and decreases lead time by decreasing storage time. The down side of cross-docking is its difficulty to manage. It requires the transportation, dock operations and information sharing all to be efficient.

Centralized vs. Decentralized Control

This represents another unique way of looking at the logistics system.

In a centralized system, decisions are made at a central location for the entire supply network. Typically the objective is to minimize the total cost of the system subject to satisfying some service level requirements. This is true when the network is owned by a single entity. It may also be true in situations that involve multiple organizations provided that savings or profit is distributed among the interest parties with some contractual mechanism. Some typical strategies include buy-back strategy, VMI, etc.

Summary

In recent years, many supply chain strategies have been developed. These strategies largely focus on the system efficiency by information sharing, centralizing decision making, profit/risk sharing, bypassing distribution centers wherever possible, manufacturing postponement (assemble to order system/demand driven distribution, etc.)

The freight system plays an important role in supply chain integration. It may be deemed as a connector of these inventory holding points. Inherent connection of these points in terms of distance, time, cost, and (reliable) responsiveness to each other depends on transportation system performance to a great degree. As examples, an efficient and reliable freight system helps make strategies such as cross-docking and assemble-to-order possible. In addition to the direct savings in freight, the supply chain benefit includes a significant reduction in inventory cost.

According to some statistics, in year 2000 the supply chain in the US remained comparable or better than its global competitors. According to Financial Times (December, 2000), the logistics cost accounts for over 10% of the US national GDP and a slightly higher percentage for other countries. Table 2.1 shows logistics cost as a percentage of national GDP for some countries.

Country	GDP %
USA	10.5
Canada	12
UK	10.63
Denmark	12.88
Ireland	14.26
Spain	11.52
Hong Kong	13.71
Japan	11.37

Table 2.7 Logistics cost as a percentage of national GDP.

The figures above remain true in terms of the general percentage of GDP. We do not have statistics in the most recent years for all countries. However, according to some sources, the logistics cost in percentage of GDP for the States has been below 10% for years, and that this percentage has been rising towards 10% due to the increasing energy cost. For example, the 9.4% of US GDP in 2005 changed to 9.9% in 2006.

However, the logistics cost across sectors varies, as explained in this chapter. The difference in logistics costs are accompanied by different logistics strategies developed in their corresponding sectors. Note that Table 2.7 represents the overall performance only. It does not mean that every sector of the US economy remains equally competitive. In addition, logistics cost in international trade might be different in some particular sectors.

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Logistics Network Design and Facility Location

By now, we have introduced inventory management as a key area in logistics management. However, inventory management is generally on the tactical level. At the strategic level, logistics network design lays the ground for the entire system efficiency and determines the general cost structure. Logistics network design is about where to put the production plants, warehouses and distribution centers, and how to coordinate their activities to make an efficient and natural supply network.

Logistics network planning in the private sector influences freight traffic on the transportation system such as at the major freight terminals and on the freight corridors. The location of a distribution center could give rise to serious congestions on the local street network. For instance, it may be interesting to know how much freight traffic on major interstate corridors is originated at Wal-Mart distribution centers.

In the following, we introduce the location decisions in the private sector. A basic decision is warehouse location.

Warehouse Location

There are several major factors in the warehouse decisions: the number of warehouses, the locations, and their sizes. These decisions are interrelated. As the number of warehouses increases, their sizes decrease. There is always an optimal operational plan for each decided number and locations of warehouses and DCs. The major costs are inventory, warehousing, and transportation.

Figure 2.5 shows an illustrative relationship between the number of warehouses and the total logistical cost. This is an example showing how private firms depend on their logistics network design to control the total cost. The overall system wide inventory cost increases with the number of warehouses. This is due to the lack of pooling effect for having more warehouses.

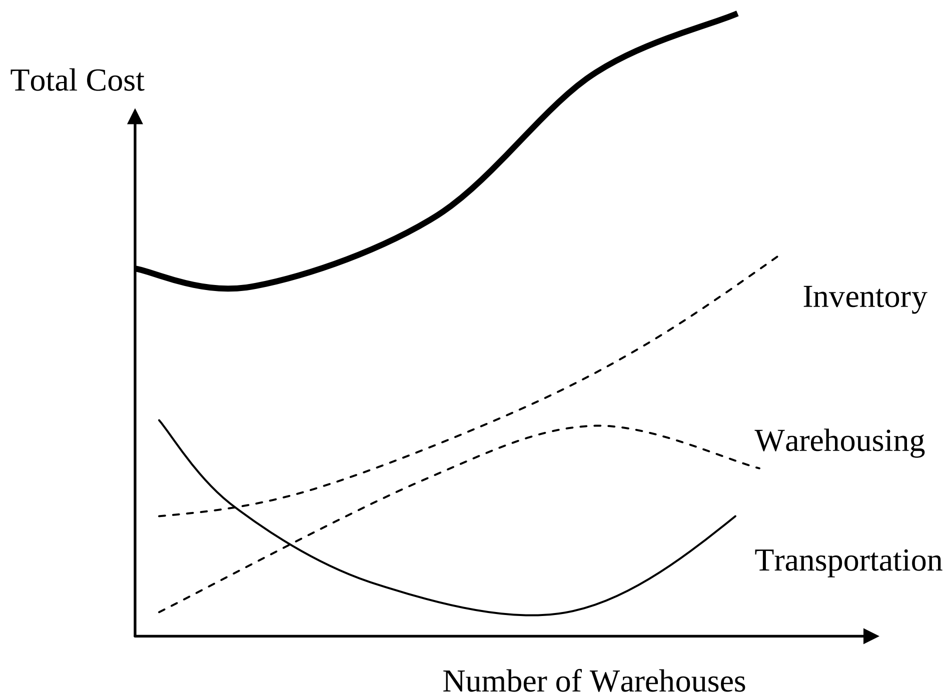

Figure 2.5. Total logistics cost vs. the number of warehouses.

(Source: Strategic Logistics Management. Stock and Lambert, 2001)

The state of art in network design for facility number and locations often dictates large scale, complex mathematical modeling that considers various operational strategies in different scenarios to balance the trade-offs between factors. The advancing computational power proves to be of great help to put millions of constraints into consideration in order to balance the nuances between different considerations. However, oftentimes, mathematical modeling is not feasible due to the scale of the problem, where computer simulation is adopted to see effects of the what-if scenarios.

To freight planners, it would be helpful to have a big picture about the facility locations in relation to markets. The following gravity model hopefully would serve this purpose.

__Center-of-Gravity Model (COG)__

Here we introduce a simple model developed early on warehouse location. It is called the center-of-gravity approach, or gravity model for short.

In this approach, assume there are a set of customers on a grid system, each having an annual demand. The location of each customer is represented by an *x* and *y* coordinate. This method decides the approximate location of a warehouse to serve those customers, assuming a single warehouse is needed. Briefly, the center-of-gravity approach allows the warehouse to locate closer to larger customers.

The following formula is used to calculate the location (x, y) of the warehouse.

$$x = \frac{\sum x_i d_i}{\sum w_i}; \quad y = \frac{\sum y_i d_i}{\sum w_i}$$

Where x_i and y_i are the coordinates of the i^{th} customer, and d_i is annual demand of the i^{th} customer.

Example: The XYZ company would like to set up a distribution center to serve several key supply chain customers in the area. The annual demand and location of these customers are shown in the table. Use COG model to determine the approximate location of the DC.

Customer	x-y-coordinate(of location)	Annual Demand (units)
A	(5,12)	2,000
B	(7,8)	10,000
C	(12,10)	4,000
D	(3,9)	15,000
E	(15,4)	6,000
F	(7,15)	8,000

Table 8. Demand information

Solution

The warehouse location is calculated as follows.

$$\overline{X} = \frac{\sum_{i=1}^{n} d_i x_i}{\sum_{i=1}^{n} d_i} = \frac{5\times 2000 + 7\times 10000 + 12\times 4000 + 3\times 15000 + 15\times 6000 + 7\times 8000}{2000 + 10000 + 4000 + 15000 + 6000 + 8000} = 7.09$$

$$\overline{Y} = \frac{\sum_{i=1}^{n} d_i y_i}{\sum_{i=1}^{n} d_i} = \frac{12\times 2000 + 8\times 10000 + 10\times 4000 + 9\times 15000 + 4\times 6000 + 15\times 8000}{2000 + 10000 + 4000 + 15000 + 6000 + 8000} = 9.34$$

Note that the location site calculated here is approximate. The final decision is subject to examination of zoning requirements, warehouse taxes, labor availability and other factors. However, what is indicated by the above equation is interesting. It shows that the warehouse location is drawn largely by market demand. The reasoning might be that volume shipping is used from the suppliers to the warehouse, whose cost does not change much with the minor shift of warehouse location in a region. And a large number of shipping in smaller packages is done on the route from the warehouse to the vendors, which has a higher freight rate and is more related to the regional warehouse location.

Exercise

DryIce is a manufacturer of air conditioners that has seen its demand grow significantly. They anticipate nation wide demand for the year 2011 of 180,000 units in the South, 120,000 units in the Midwest, 110,000 units in the East and 100,000 units in the West. Managers at DryIce are designing the production and distribution network and have selected four potential sites – New York, Atlanta, Chicago and San Diego—for production of air conditioners. Plants could have a capacity of either 200,000 or 400,000 units. The annual fixed costs at the four locations are known, along with the cost of producing and shipping the air conditioners to each of the four markets. Where should DryIce build its facilities and how large shall they be?

Distribution Network

From the logistics and supply chain point of view, it is usually a distribution network instead of a single warehouse that is considered in a location design problem. Regarding the distribution network, an example structure is shown below.

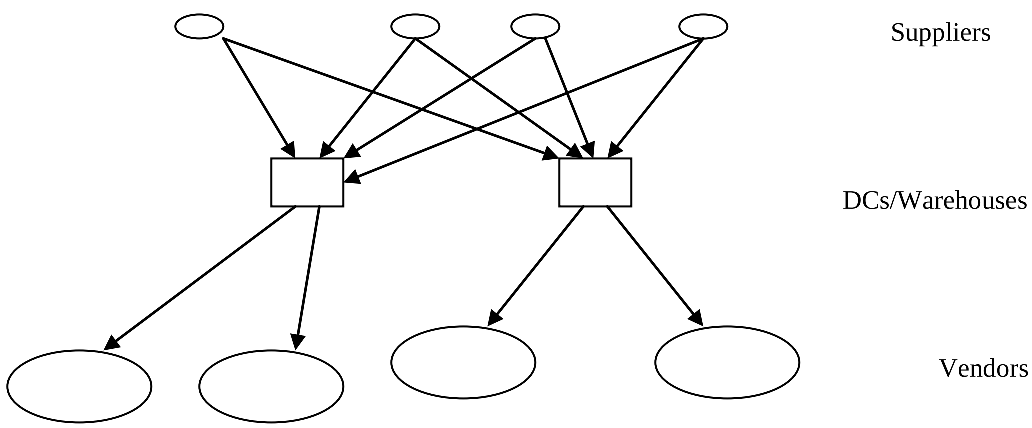

Figure 2.5 An Illustrative Structure of a Distribution Network

Note that from suppliers to DCs, the volume could be high. Each DC could have up to thousands of suppliers. Shipping from suppliers to the DCs might have to go through a consolidation process. For example, purchases in China by Wal-Mart may be consolidated before being shipped to the DCs in the States.

In a distribution network, there are typically multiple suppliers and distributors (warehouses). It is rarely the case that the network is designed from scratch. Instead, it is often re-designed based on the current distribution network in operation. The decisions are about how to efficiently use the existing DCs, which ones to close, and where to add new DCs onto the network if necessary. In this way, the problem is much simpler compared to a complete network design. As is often the case, the network is examined and reengineered frequently. According to a recent report, Wal-Mart re-engineers its distribution network every six months to adapt to the changing market and minimize its shipping costs. Note that such re-engineering does not necessarily have to do with warehouse re-location. It might just be an adjustment to market division among the DCs as well as adjustment to the dispatching strategies at each DC due to market area changes.

The following table shows the best locations given the number of warehouses needed to cover the market in the United States.

Number of Warehouses in the Network	**Shortest Average Distance to US Population**	**Best Warehouse Locations**	**Number of Warehouses in the Network**	**Shortest Average Distance to US Population**	**Best Warehouse Locations**
1	797	Bloomington, IN	**8**	203	Madison, NJ
2	486	Chillicothe, OH			Pasadena, CA
		Mojave, CA			Chicago, IL
3	376	Allentown, PA			Palestine, TX
		Mojave, CA			Gainesville, GA
		McKenzie, TN			Tacoma, WA
4	315	Hilltown, PA			Lakeland, FL
		Mojave, CA			Denvor, CO
		Chicago, IL	**9**	188	Newark, NJ
		Meridian, MS			Pasadena, CA
5	265	Madison, NJ			Rockford, IL
		Mojave, CA			Palestine, TX
		Chicago, IL			Gainesville, GA
		Dallas, TX			Tacoma, WA
		Macon, GA			Lakeland, FL
6	237	Madison, NJ			Denvor, CO
		Pasadena, CA			Mansfield, OH
		Chicago, IL	**10**	174	Newark, NJ
		Dallas, TX			Alhambra, CA

		Macon, GA			Rockford, IL
		Tacoma, WA			Palestine, TX
7	218	Madison, NJ			Gainesville, GA
		Pasadena, CA			Tacoma, WA
		Chicago, IL			Lakeland, FL
		Dallas, TX			Denvor, CO
		Gainesville, GA			Mansfield, OH
		Tacoma, WA			Oakland, CA
		Lakeland, FL			

Table 2.9 Best locations vs. the number of warehouses.

(Source: Strategic logistics management by Stock and Lambert, 2001)

Table 9 shows the locations of warehouses in order to cover the national market with designs of different warehouses.

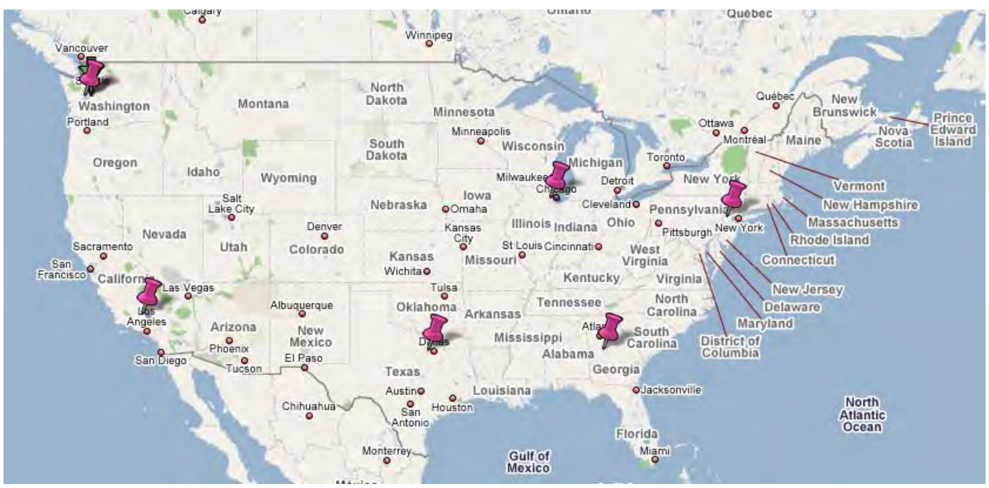

Figure 2.6. Example of six warehouse locations in the States

The above map shows six best locations if six regional warehouses are decided necessary. By comparing the six locations with the transportation network distribution in rail, highway, air, and waterway, one can easily find the coincidence between DC locations and accessibility of the transportation system.

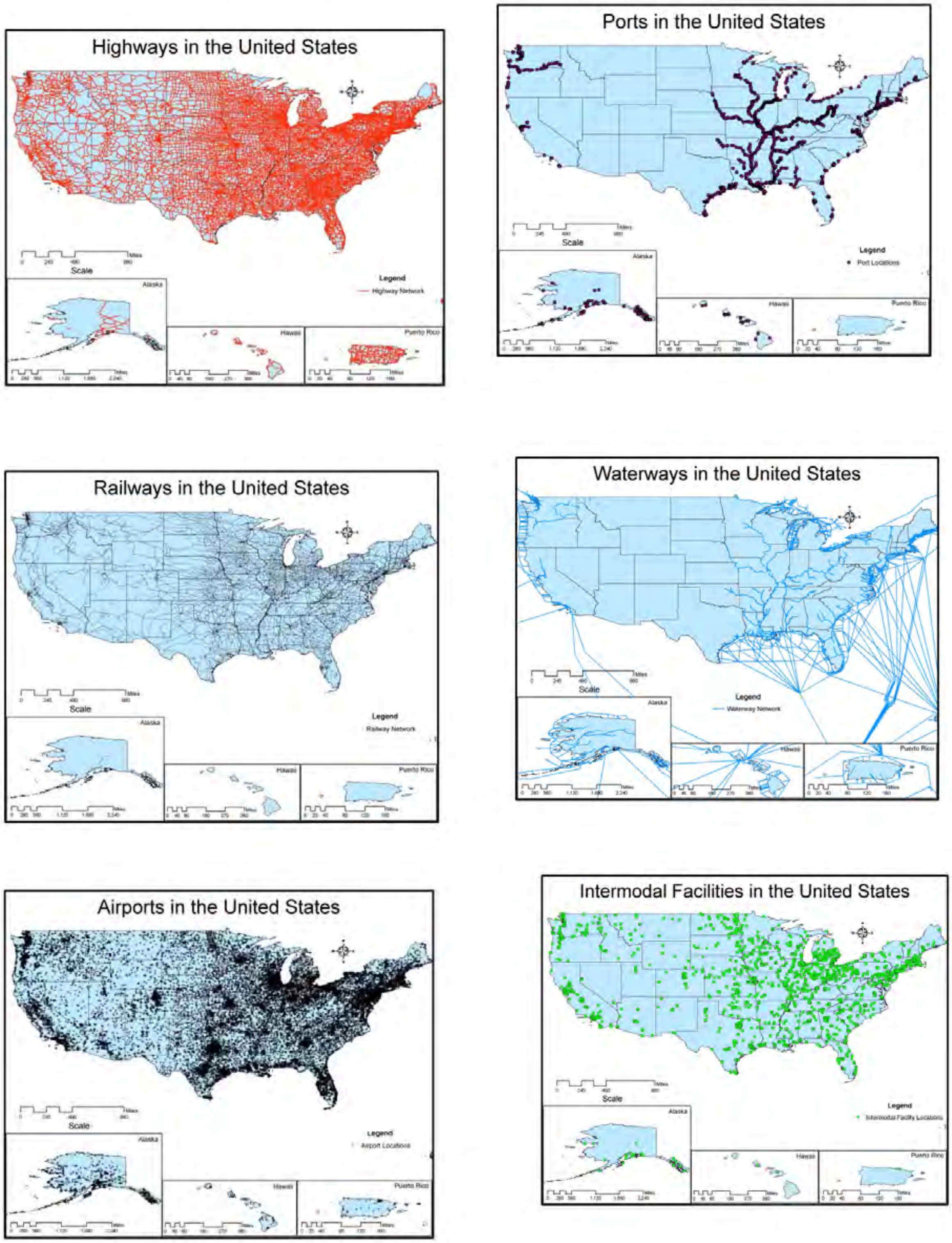

Figure 2.7. Transportation network distribution in the States

The distribution network in the case of six distribution centers coincides with the concentration of the most highway, rail, waterway, airports and intermodal terminals by just an empirical examination of the above distribution maps.

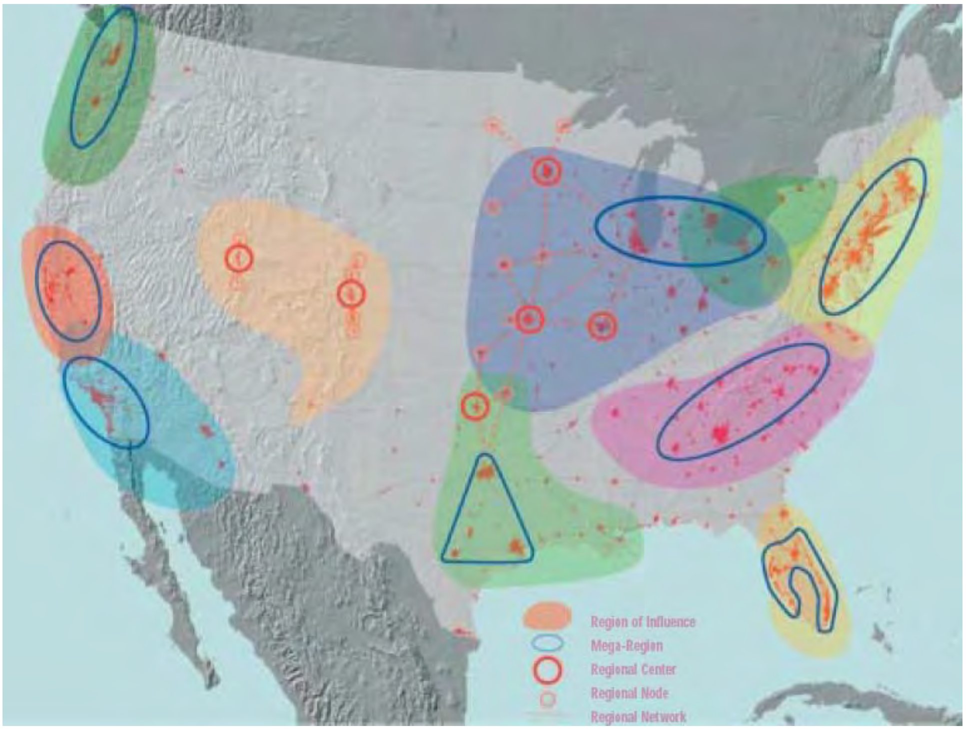

Figure 2.8. Large metro areas in the States

Source: Carbonell et al, Global Gateway Regions, The United States of America's Third Century Strategy, Southern California Association of Governments, Los Angeles, CA, Sept. 2005; based on "Toward an American Spatial Development Perspective," University of Pennsylvania, Department of Planning, Spring 2004.

If we further take a look at the population distribution, we may find this coincidence between locations of distribution centers and the major concentrations of population in the United States. The importance of population distribution to the logistics distribution network is obvious. Therefore, it is important for freight planners to be conscious about potential demographic and geographic shifts of population in the Unites States in order to do a good job that anticipates changes.

Factors Influencing Network Design Decisions

In deciding a warehouse location, there are many factors to consider. These include strategic factors, technological factors, microeconomic factors, exchange rate and demand risk, political factors, infrastructure factors, competitive factors, customer response time and local presence, logistics and facility costs, etc.

We explain these factors in the following.

- Strategic factors

A firm's strategy has a significant impact on its logistics network design. Cost reduction is generally the primary factor. It is suggested to use the following strategic roles for facility classification in a global supply chain.

  - Offshore facility: low cost facility for export production. It serves the role of being a low cost supply source for markets located outside the country.
  - Source facility: low cost facility for global production. It is often a primary source of product for the entire global market.
  - Server facility: regional production facility. Its objective is to supply the market where it is located. A server facility is built because of tax incentives, local content requirement, tariff barriers, and a high logistical cost to supply the region from elsewhere.
  - Contributor facility: regional production facility with development skills. It serves the market where it is located, but also assumes the responsibility for product customization, process improvements, product modifications, or product development.

- Technological factors

Characteristics of available technologies have a significant impact on network design decisions. If the production technology displays significant economies of scale, then a few large production sites may suffice to supply the market. Otherwise, a larger number of production sites are preferred.

- Macroeconomic factors

These include taxes, tariffs, exchange rates and other economic factors that are external to an individual firm. There are risks associated with exchange rates and market changes due to the changes in global economy.

- Political factors

These are related to political stability.

- Infrastructure factors

Availability of good infrastructure for transportation such as water and power is an important prerequisite to locating a facility in a given area. Poor infrastructure adds to the cost of doing business from a given location.

- Competitive factors

Companies must consider their competitors' strategy, size, and location when designing their supply chain networks.

- Customer response time and local presence

Firms that target customers who value a short response time must locate close to them.

- Logistics and facility cost

Logistics and facility costs incurred within a supply chain change as the number of facilities, their location, and capacity allocation are changed. Companies must consider inventory, transportation, and facility costs when designing their supply chain network.

A Framework for Network Design

The goal of the network design decision is to design a network that maximizes the firm's profits while satisfying customer needs in terms of demand, service responsiveness and reliability. Global network design decisions are usually made in four phases. Phase I specifies what capacity a firm's supply chain network must have in order to support the firm's competitive strategy. Phase II defines regions in which facilities must be located, their potential roles and approximate capacity. Phase III determines the particular locations of the facilities. Phase IV finalizes the location decision.

The following graph demonstrates this process. (source: Supply Chain Management: Strategy, Planning and Operations. By Chopra and Meindl, 2001.)

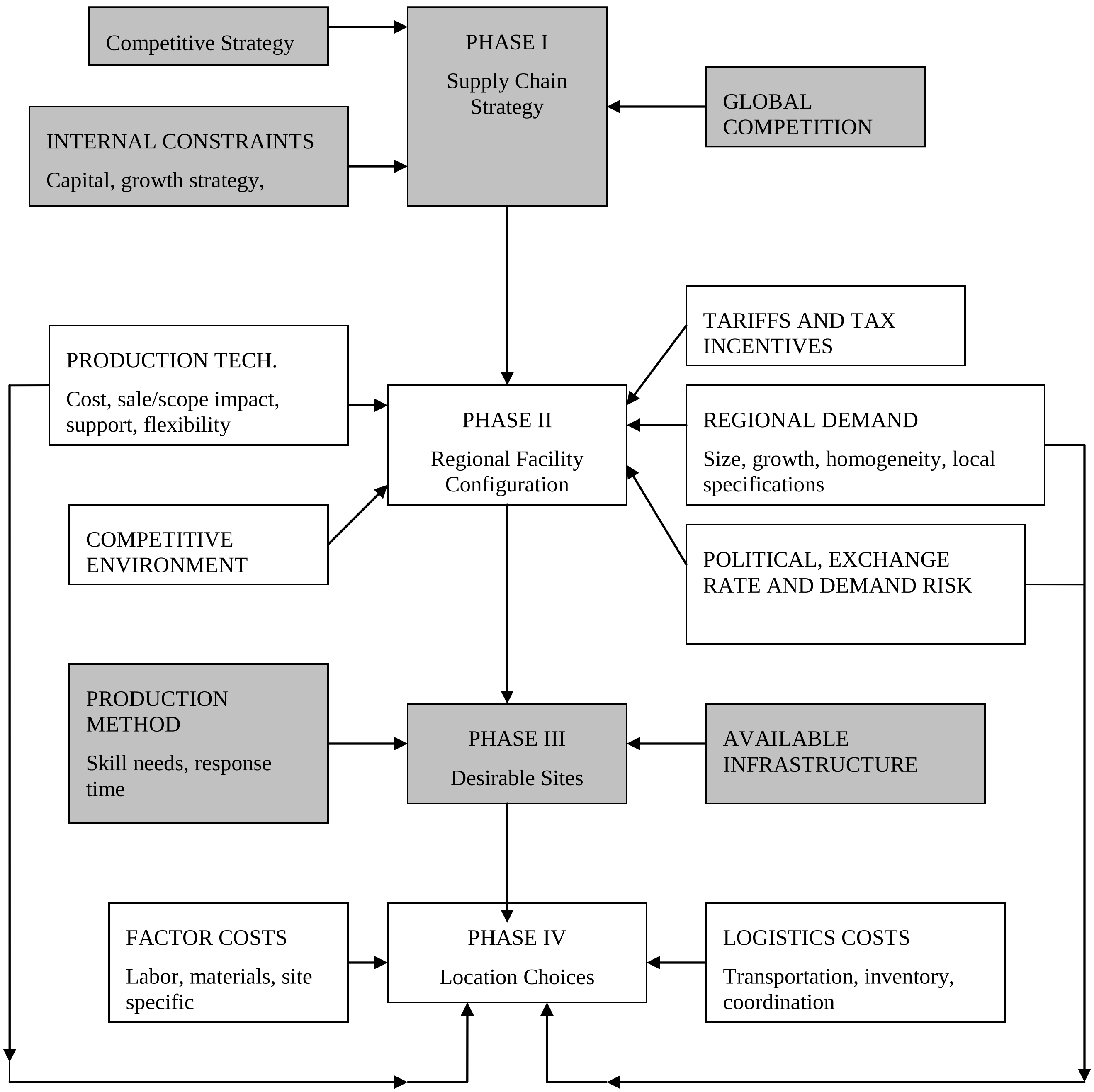

Figure 2.9. A Framework for Network Design.

Remarks

Facility location for a supply chain network is a complex decision process. A large portion of the cost of the system is on freight, inventory and warehousing. Design of a network also resolves division of markets among distribution centers, and largely defines modal shipping from the suppliers, distribution centers to retailers. Decision support systems employing optimization models are widely adopted to capture the cost tradeoffs between alternative plans.

In practice, the network design problem has more factors to consider than discussed here. For example, the life-cycle cost of facilities, quality of life for employees, and the focus on tariffs and tax incentives when locating facilities are all important to a firm.

Due to economies of scale in distribution, many networks follow a hub-n-spoke pattern. For example, FedEx has large freight terminals for package consolidation. Airlines have their hub airports for passenger transfer. Between hub locations or terminals, volume shipping takes place.

The figure below shows an example distribution network with its market division among the distribution centers.

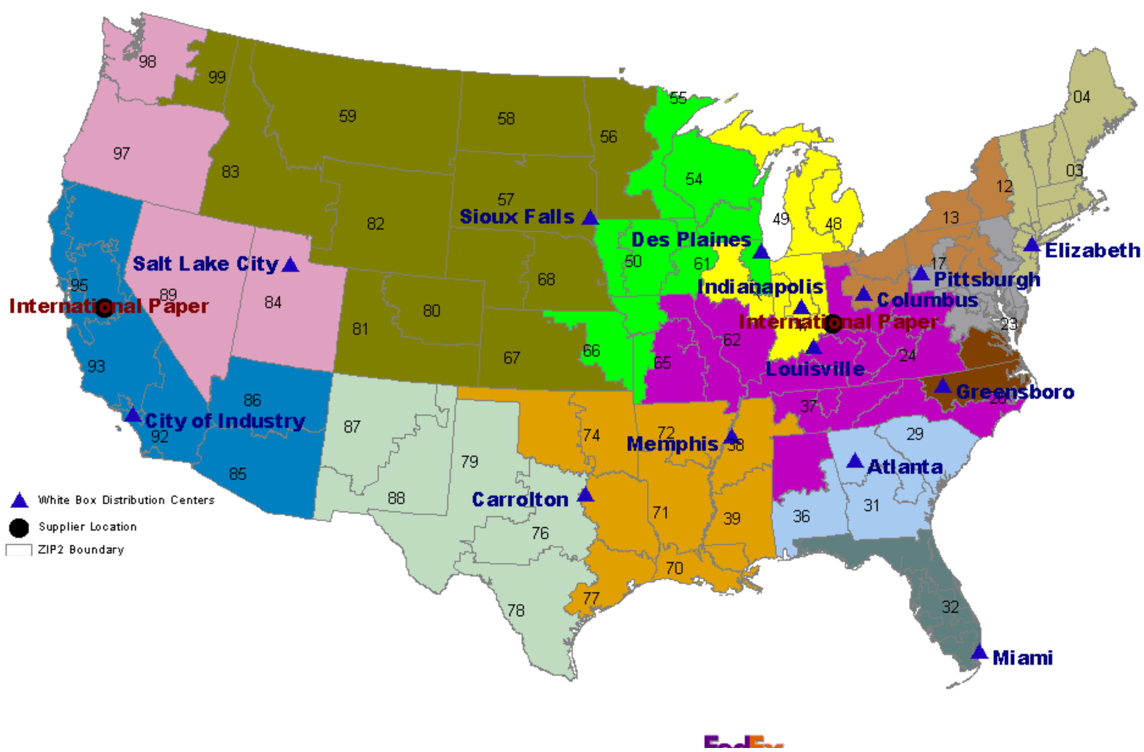

Figure 2.10. International Paper Distribution Network of a Global Carrier

At hub locations or major freight terminals, a significant amount of traffic is expected. The hub locations require heavy capital investment from the carriers. Therefore, they are relatively stable and cannot be easily changed. These hub locations often cause serious traffic delays that challenge freight planners. From the private sector's network point of view, delays in and around these hub locations have a profound effect on distribution system efficiency.

Literature

32. James R. Stock and Douglas M. Lambert. 2001. Strategic Logistics and Management. 4th Edition. McGraw Hill Publishing. [Chapter 10: Warehousing. Page 405 contains facility development, useful]
33. S. Chopra and P. Meindl. 2004. Supply Chain Management: Strategy, Planning and Operations. 2nd Edition. Pearson Prentice Hall (Page 101-).

Procurement and Outsourcing

Example: Strategic purchasing at Medical Solutions

Siemens, founded in 1847 and headquartered in the Federal Republic of Germany, is an electronics and electrical engineering company employing more than 450,000 employees in 190 countries. Their annual sales for fiscal year 2001 was €87 billion (€ is the symbol for euro). Approximately 22% of the sales were from Germany, whereas 30% each came from the United States and the rest of Europe. Siemens spent about 47% of the sales for the year, about €41 billion, on purchases of production materials, system components, software, and services. Its diverse business portfolio is segmented into the following areas: information and communications, automation and control, power, transportation, medical, lighting, and financial and real estate. The medical segment, Medical Solutions (Med), provides broad spectrum of products, solutions, and services for the healthcare industry.

Prior to 1997, buyers at Medical Solutions' decentralized purchasing system bought components and materials for the individual plants without communicating and considering the needs of other segments or divisions within the same segment. Purchasers and suppliers were rarely involved in new product design and development. Purchasing was considered strictly a tactical supporting function, and there were no synergies with the design and manufacturing facilities. Purchasing's responsibility was simply to ensure that the right materials were available at the right place, at the right time, and at the right price. The decentralized purchasing system missed out on opportunities to leverage purchases of common items among the various business units. It has no long term contracts with strategic suppliers or control over prices.

When Dietmar Dresp, vice president of strategic purchasing, was hired in 1997, he transformed medical solutions purchasing function into a strategic purchasing organization. The goals of the organization were to leverage Medical Solution's material purchases with suppliers, exploit the technical expertise of suppliers, and form long term mutually beneficial relationship with suppliers. Purchasing engineers were hired to work with design engineers and suppliers in product design and development. Eight materials groups, each headed by a manager, were formed to handle strategic sourcing of production materials.

The new centralized strategic purchasing structure reduced medical solutions' materials cost by 25% and cut its supplier base by 50% to 2500 over a three year period. Keys to the strategic efforts included outsourcing, supplier base reduction, strategic alliances, supplier performance evaluation, and supplier *involvement in new product design and development. With its new strategic purchasing organization, Medical Solutions drastically reduced its product development and manufacturing cycle times. For example, Medical Solutions newest ultrasound product, the SONOLINE Antares, is built in hours, whereas previous generations of the equipment took days to manufacture. [Source: Wisner, leong and Tan, 2005]*

Procurement is an important function for firms especially those in manufacturing and retail sectors. The procurement function manages the purchase of raw materials, components, (semi) products, related services and other resources from suppliers. Purchasing can be broadly classified into two categories: merchants and industrial buyers. The former refers to wholesalers and retailers who purchase their merchandise in volume to take advantage of volume discounts and other incentives such as transportation economy and storage efficiency. They create value by consolidating merchandise, breaking bulk, and providing the essential logistics services. The industrial buyers purchase primarily for production. They purchase services, capital equipment, maintenance, and repair, and operating supplies.

The primary goal of purchasing is to ensure uninterrupted flow of raw materials at the lowest total cost, Purchasing is the crucial link between the sources of supply and the organization itself. It is considered by many to be essential to involve purchasing and strategic suppliers in concurrent engineering activities in order to collapse the design-to-production cycle time.

The details of purchasing process such as identification of needs, request for quotation and proposal and final selection are skipped here for the interest of time. Worthy of a special mention is sourcing, a popular concept in supply chain management in the recent years. Sourcing is the entire set of business processes required to purchase goods and services, including selection of suppliers, design of supplier contracts, product design collaboration, procurement of materials, and evaluation of supplier performance.

The benefits from effective sourcing can be partially listed as follows.

- Better economies of scale can be achieved if orders within a firm are aggregated.
- Efficient procurement transactions significantly reduce the overall cost of purchasing. This is most important for items which have a large number of low-value transactions.

- Good procurement processes can facilitate coordination with suppliers and improve forecasting and planning. Better coordination lowers inventories and service levels.
- An appropriate supplier contract can allow for the sharing of risks, resulting in higher profits for both the supplier and the buyer.
- Firms can achieve a lower purchase price by increasing competition through the use of auctions (bidding for businesses).

It is important for a firm to be clear on the factors that have the greatest influence on performance and make improvement in those areas. For example, if most of the spending for a firm is on materials with only a few high-value transactions, improving the efficiency of procurement transactions will provide little value whereas improving design collaboration and coordination with the supplier will provide significant value. In contrast, when sourcing items with many low –value transactions, increasing the efficiency of procurement transactions will be very valuable.

Supplier Scoring and Assessment

Procurement often needs to decide among a number of competing suppliers the ones that best meet their needs. Supplier scoring is an effective means to choose the right suppliers. The primary factor is usually the quote price. However, there are also other factors that play a significant role in the decision. These factors include

- Replenish lead time
- On-time delivery performance
- Supply flexibility
- Delivery frequency (minimum lot size)
- Supply quality
- Inbound transportation cost
- Pricing terms
- Information coordination capability
- Design collaboration capability
- Exchange rates, taxes, and duties
- Supplier viability

Detailed explanation of the above factors is seen in Chapter 13 of Chopra and Meindl (2007).

The following example illustrates how lead time and on time performance affect the overall cost of a company.

Example

Green Thumb, a manufacturer of lawn mowers and snow blowers, has historically purchased a thousand bearings per week from a local supplier who charges $1.00 per bearing. The purchasing manager has identified another potential source willing to supply the bearings at $0.97 per bearing. Before making his decision, the purchasing manager evaluates the performance of the two suppliers. The local supplier has an average lead time of two weeks and has agreed to deliver the bearings in batches of 2000 units. Based on past on-time performance, the purchasing manager estimates that the lead time has a standard deviation of one week. The new source has an average lead time of six weeks and a standard deviation of four weeks. The new source requires a minimum batch size of 8,000 bearings. Which supplier should the purchasing manager go with? Green Thumb has a holding cost of 25 cents per bearing. They currently use a continuous review policy for managing inventory and aim for a cycle service level of 95 percent. (Note: a continuous review policy monitors the inventory continuously and places a replenishment order whenever the inventory falls below a threshold.)

Solution

A supplier's performance on lead time (including its variability) affects the safety stock level, and the minimum batch size affects the cycle inventory held. Thus, the purchasing manager should evaluate the total cost of using each supplier.

First, consider the cost of using the local supplier.

Annual material cost = (annual demand in units) x unit cost = 1000 x 52 x 1 = \$52,000

Average cycle inventory = (order quantity)/(cycle length) = 2,000 / 2 = 1000 (unit)

Annual cost of holding cycle inventory = (average inventory value) x 25%

= 1000 x 1 x 0.25 = 250 (UDS)

Safety inventory required with new supplier = $z\sqrt{AVGL \times STD^2 + AVG^2 \times STDL^2}$

=1.65*1086=1792 (units)[2]

Annual cost of holding safety inventory = 1792 x 1 x 0.25 = 448 (\$)

The total annual cost of using current supplier =material cost + safety inventory cost + cycle inventory cost= 52,000+250+448 = **52,698.00 (**\$)

Correspondingly the annual cost for the new supplier is calculated as follows.

Annual material cost = 0.97x1000x52=\$50440

Average cycle inventory = 8,000 / 2 = 4000 (units)

Annual cost of holding cycle inventory = 4000 x 0.97 x 0.25 = \$970

Safety inventory required with new supplier = $z\sqrt{AVGL \times STD^2 + AVG^2 \times STDL^2}$

=1.65*4066.94 units (for 95% service level)

=6710 (units)

Annual cost of holding safety inventory = 6710 x 0.97 x 0.25 = \$1627

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[2] Here we assume that the standard deviation of demand during the lead time is 30% of the average demand. Therefore STD=300 units.

The total annual cost of using the new supplier = $53037.00

The conclusion is to use the local supplier since the new supplier incurs a higher overall cost although the latter has a lower purchasing cost. Price advantage can be easily offset by lead time (part of which is shipping time) and inventory cost.

Supplier Selection and Contract

Once the aforementioned scoring analysis has been completed, a list of promising suppliers will emerge. The firm can then select desired suppliers using a variety of mechanisms such as off-line competitive bids, reverse auctions, or direct negotiations. No matter what mechanism is used, supplier selection should be based on total cost of using a supplier and not just the purchase price, as demonstrated in the example above.

The relationship with suppliers may be better appreciated if one realizes the risk associated with the purchasing decision. As an example, when demand changes quickly, the retailer has a significant risk in volume purchasing. The purchasing contract is a binding document between the parties. However, properly set up, it may also help mitigate the purchasing risks involved. There are several alternative contracts worth mentioning.

- ***Buyback*** contracts have been popular in recent years. The supplier buys back the remaining inventory at a discount price within a certain time period of purchase. This provides incentives to the buyer to purchase a larger variety and at a larger quantity of products to solicit demand. It is suitable for products with a low variable cost. But it can lead to surplus inventory.
- ***Revenue-Sharing*** contracts apply in the retail sector. It allows the buyer to pay a minimal amount for each unit purchased, but shares a fraction of the revenue for each unit sold. In this way, there are no product returns.
- ***Quantity flexible*** contracts allow the buyer to modify the order (within limits agreed to by the supplier) as demand becomes clearer when closer to sales.
- ***Contracts to coordinate supply chain costs*** apply to supply chain parties with strategic relationship. It aims at reducing the total supply chain cost including manufacturing, distribution, and inventory.
- ***Contracts to induce performance improvement*** contain the flexibility of rewarding the supplier based on performance such as percentage of on-time delivery and percentage of damage.

Outsourcing

Outsourcing is similar to purchasing. It emphasizes on the choice between keeping in-house and subcontracting. Purchasing as mentioned above is not just about materials but also services such as transportation. Typically, when a firm purchases transportation services, this process is called transportation services outsourcing. Transportation services outsourcing is an important and complex process for large manufacturing firms such as GM and large retail stores.

The outsourcing decision is centered at the company's core competency. The products and services are outsourced to those firms with superior competency in providing related services and products. Related to the concept of outsourcing are 3rd and 4th party logistics service providers. The 3rd party logistics service providers provide services such as transportation, distribution, warehousing, as well as IT services. If the functions outsourced are too complex, they could be outsourced to a 4th party service provider. And the 4th party service provider then serves as the primary contractor to multiple additional 3rd party logistics providers.

Case Study

A critical decision of outsourcing is first about make-or-buy. Should a manufacturing firm make the component by itself, or purchase from outside providers? A break-even analysis is a handy tool for computing the cost effectiveness of sourcing decisions when cost is the most important criterion. The following example is for illustrative purposes. More sophisticated models are needed in practice (Source: Wisner, Leong and Tan, 2005).

Consider a hypothetical situation in which a company has the option to make or buy a component part. Its annual requirement is 15,000 units. A supplier is able to supply it at $7 per unit. The firm estimates that it costs $500 to prepare the contract with the supplier. To make the part in house, the firm must invest $25,000 in equipment and it estimates a unit cost of $5 to manufacture.

Costs	make option	buy option
Fixed cost	$25000	$500
Variable cost (per unit)	5	7

Annual requirement = 15,000 units.

Solution

The break-even quantity, Q*, is found by setting the two options equal to each other and solving for Q* (see in figure below). If the quantity Q>Q*, the make option is more desirable. Otherwise, the buy option gives a lower cost.

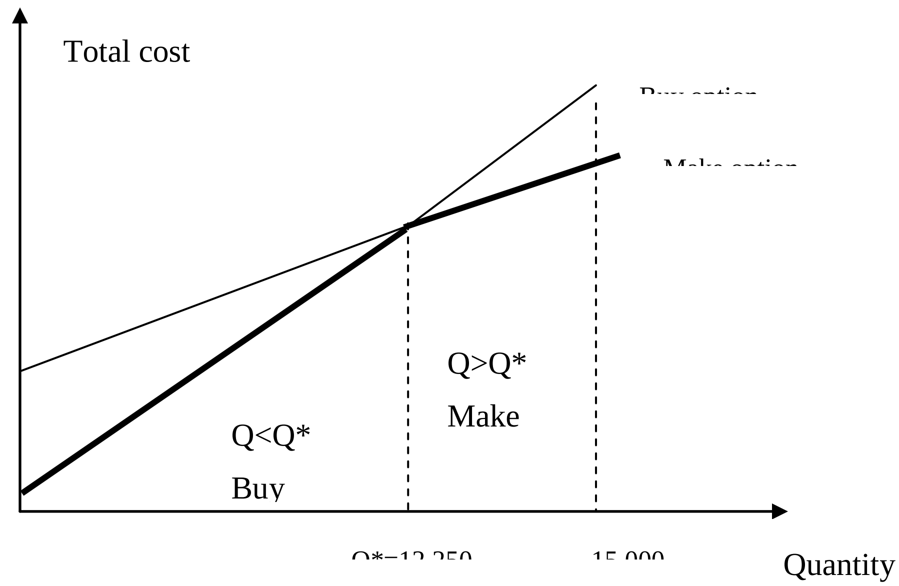

Figure 2.11 Cost curve of a product component

Total cost to make = total cost to buy

$25000+$5Q* = $500+$7Q* → Break-even quantity Q* = 12,250 units

Total cost at break even point TC_{BE}=$25000+$5x12250=$86,250

As to the actual demand quantity, we compare the two options below.

Total cost for make option TC_M = $25000+$5x15000=$87250

Total cost for buy option TC_B = $500+$7x15000=$105,500

The conclusion is to make the part in-house.

This example is a highly simplified case. In reality, a firm needs to consider whether the in-house production option is within the firm's core competency. To maintain its market competitiveness, the firm would prefer to develop in areas within its own core competency and to outsource functions in other areas.

Remarks

Procurement and outsourcing are expedited with the development of regionalization and globalization. For example, the North American Trade Agreement significantly enhances the business relationship between Canada, US and Mexico. Many manufacturing functions are outsourced or shifted to border areas with Mexico. Significant cross-border traffic is seen at crossings with Canada that go to the greater Detroit and New York areas. Procurement and outsourcing is largely driven by the complementarities of businesses, resources and technology.

It would not be surprising to see increasing traffic between regions and countries in the years to come. Great pressure will continue to build on the major freight terminals, harbors and ports. Therefore, it is safe to say that procurement is one of the drivers of logistic activities that impact the transportation system. For example, Wal-Mart heavily relies on its global purchasing. A large volume of low cost products are purchased from developing countries, and shipped to its distribution centers through the major West Coast ports and on the major freight (rail and highway) corridors within the continent US.

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Information Technology in Logistics

Information is valuable in logistics and supply chain management. It enables the supply chain processes to execute transactions and managers make decisions. Without information, managers would not know what customers want, how much inventory is in stock, when additional products should be produced and shipped. In short, without information, managers would have to make decisions blindly.

Using IT systems to capture and analyze information can have a significant impact on a firm's performance. For example, a major manufacturer of computer work-stations and servers found that much of the information on customer demand was not being used to set production schedules and inventory levels. The manufacturing group lacked this demand information, which forced them to make inventory and manufacturing decisions blindly. By installing a supply chain software system, the company was able to gather and analyze data to produce recommended stocking levels. Using the IT system enabled the company to cut its inventory in half because managers could now make decisions based on information rather than educated guesses. Large impacts like this underscore the importance of IT as a driver for better supply chain performance.

Information must be *accurate, accessible in a timely manner, and of the right kind* in order to be useful. Accurate information often exists. But by the time it becomes available, it is either inaccessible or out of date. Information particularly useful is about resource availability (e.g. inventory, equipments, space.) and system performance such as shipping time and reliability.

The following graph shows flows of information and goods in the supply chain.

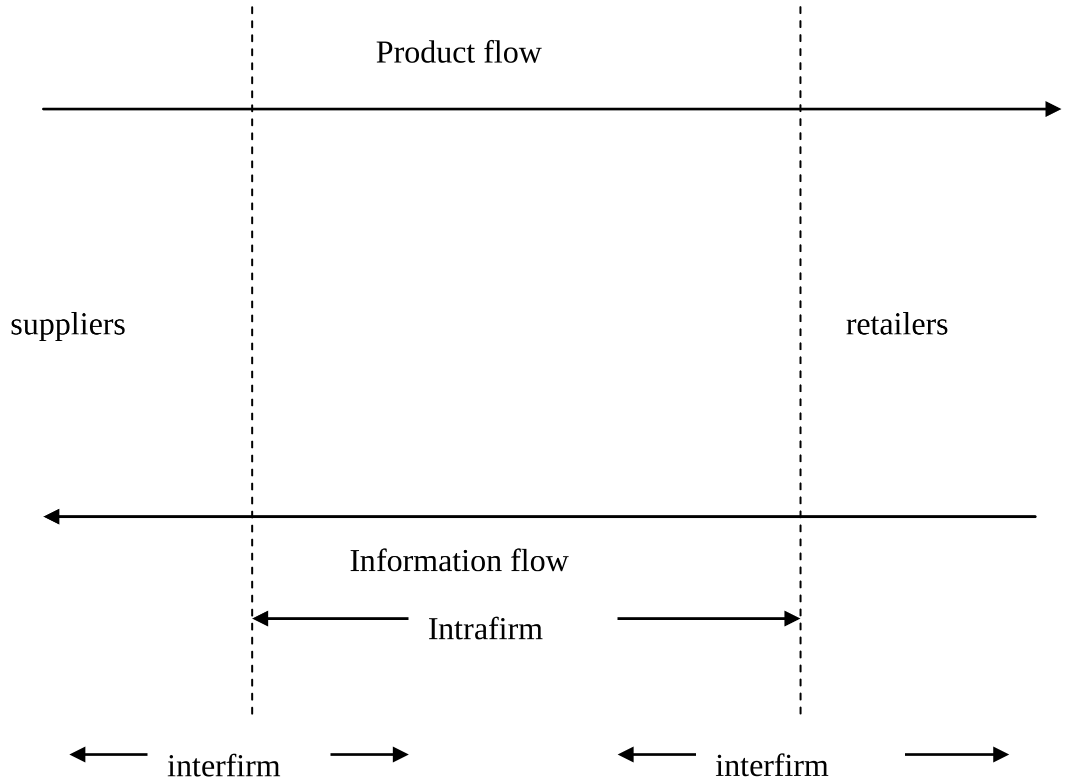

Figure 2.12. Flow of information and goods in the supply chain[3]
(*Source: Simchi-levi et al. 2003*)

The above figure shows two types of flows along the supply chain: commodity and information. The flow of information is critical to timing of the commodity flow. The retail information is eventually the deciding factor in making manufacturing, distribution, and marketing decisions. Smooth flow of this retail information all the way to the supplier is critical. Along with the demand information is information about system performance such as transit time duration and reliability. Transportation system performance evidently affects the distribution decisions, at both the strategic and tactical levels.

Simchi-levi *et al*. (2003) present an illustrative graph of the relationship between the goals and means of supply chain management.

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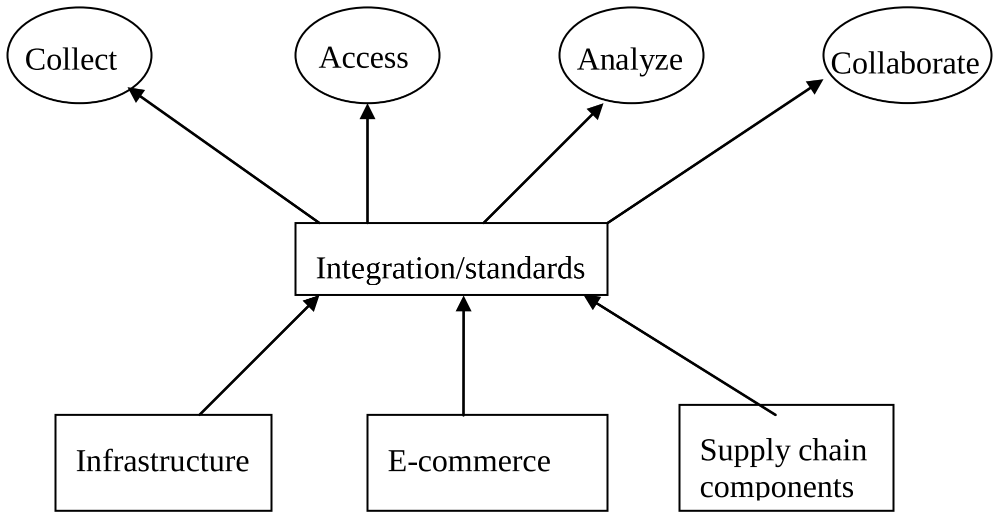


Figure2.13. Goals and means of supply chain management

(*Source: Simchi-Levi, et al. 2003*)

The major means to make an efficient IT system are explained below.

- *Standardization* is critical to cost and feasibility of implementation. There are many issues to be considered in this process such as market forces, interconnectivity, new software models and economies of scale.
- *Information technology infrastructure* is critical in the success or failure of any system implementation. It includes interface devices such as PCs, voice mail, terminals, Internet devices, barcode scanners, RFID, etc., communications (e.g. EDI, LAN, mainframe, intranet, etc.), databases (legacy databases, relational databases, object databases, data warehouses, groupware databases, etc.), systems architecture (e.g. client/server computing system) and electronic commerce.

\`                    \`

It might be of interest to provide a more detailed introduction to the electronic commerce (e-commerce). E-commerce refers to the replacement of physical processes with electronic ones and the creation of new models for collaboration with customers and suppliers. It facilitates transactions between businesses, and also between business and consumers. Worth mentioning for the use of internet is the portal, a role based entry into a company's systems. A portal aggregates all the applications and sources of information employees need in order to perform their jobs into a single desktop environment, typically through the web browser. Portals typically require integration technology such as databases, java classes, web services and XML. E-commerce, according to Simchi-Levi *et al.* (2003) typically has four levels: one way communication, database access, data exchange and process sharing.

IT technology has a profound impact on the logistics and supply chain management. Its capabilities can be classified into four layers.

- Strategic network design

  This layer decides the optimal number of facilities (manufacturing plants, warehouses, distribution centers, etc.), their locations, outsourcing strategies and best distribution channels, etc. These decisions lay the ground for the general cost structure.
- Supply chain master planning

  This layer of decision-making is made on a weekly to monthly schedule in order to coordinate production, distribution strategies, and storage requirements by efficiently allocating supply chain resources to maximize profit or minimize system cost.
- Operational planning

  These systems enable efficiencies in production, distribution, inventory and transportation for short term planning. The planning horizon is typically from daily to weekly. This layer includes typically four factors: demand planning, production scheduling, inventory management, and transportation planning.
- Operational execution

  This system generally provides the data, transaction processing, user access, and infrastructure for running a company. It includes five factors: enterprise resource planning (ERP), customer relationship management, supplier relationship management, supply chain management and transportation management.

The upper layers are mainly about strategic decision making through decision support systems while the lower ones are more about information system management. Most of the information management systems in the layer of *Operational Execution* are the ones that we often hear and see. ERP system is an example of the IT systems that transverses the several layers. ERP system spans manufacturing, human resources, and financials, is now the backbone of most companies' IT infrastructure. It includes the most up-to-date information about resources available, demand updates, and short term planning. These systems are expanding to include new functionalities.

The decision support system deserves a special attention. Taking advantage of the increasingly powerful computer technology, more and more decisions regarding the complicated system are made with computers using large scale optimization technologies in such areas as the distribution network design, production scheduling, real time demand forecast, warehousing and inventory management, etc. It generally uses operations research techniques, simulation and artificial intelligence methodologies. The decision support system needs basic data input such as shipping time and reliability, freight rate, market demand, fleet capacity, and so on.

Wide application of IT technologies in industry results in a close relationship between manufacturers and vendors. The suppliers and vendors become more responsive to demand changes as information is becoming more transparent across the supply chain. Inventory management becomes more efficient, and redundant inventory is eliminated. All of these mean a shorter response time from the manufacturers to market and freight infrastructure changes. The reason is that it is easier to accommodate the changes in its decision processes and to take advantages of these changes with the IT system. To put it differently, the suppliers are held closer to the market in terms of responsive distribution and production.

In the following, we introduce a few IT technologies that have had wide applications in practices.

RFID

Radio Frequency Identification (RFID) is a rapidly emerging identification and logging technology.

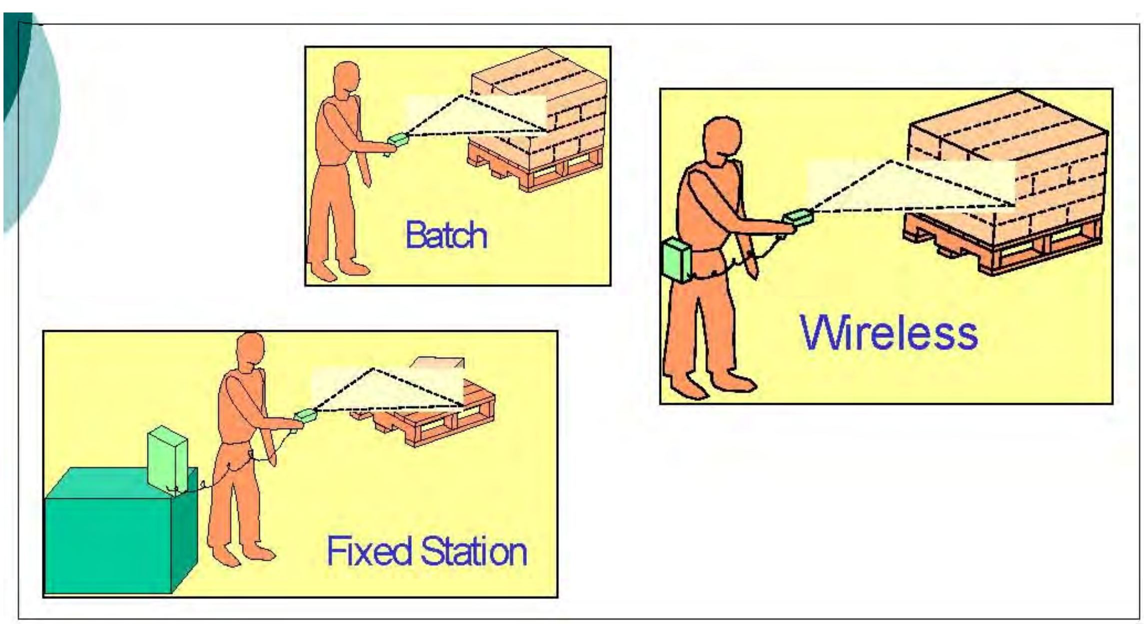


Figure 2.14. RFID used in warehouse management

(Source: http://events.fcw.com/events/2006/wireless/downloads/WRFID06_T-3_Wyld.pdf. Accessed on may 20, 2007)

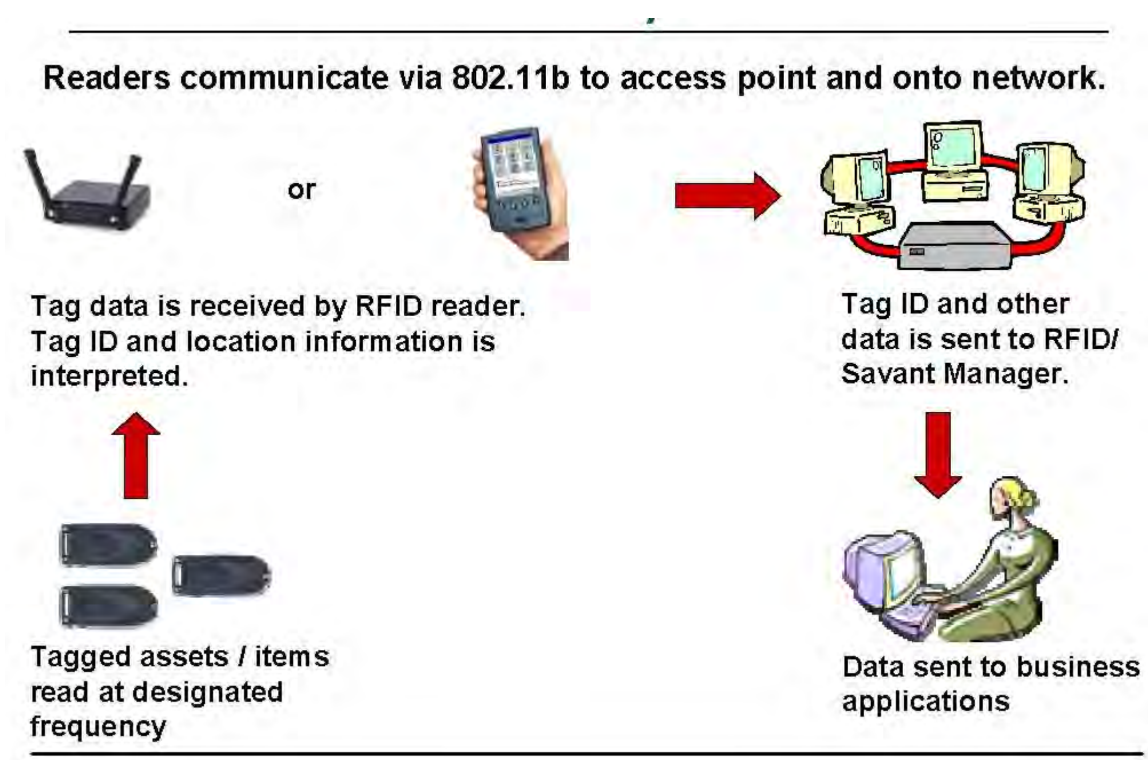


Figure 2.15. Illustrative graph of how RFID is integrated into the system

An RFID tag is used to store the information. RFID tags consist of an integrated circuit (IC) attached to an antenna—typically a small coil of wires—plus some protective packaging (like a plastic card) as determined by the application requirements. Tags also sometimes are called "transponders". RFID tags can come in many forms and sizes. Some can be as small as a grain of rice. Data is stored in the IC and transmitted through the antenna to a reader. An RFID chip can typically store 2000 bytes of information.

The RFID device serves the same purpose as a bar code or a magnetic strip on the back of a credit card or ATM card; it provides a unique identifier for that object. And, just as a bar code or magnetic strip must be scanned to get the information, the RFID device must be read to retrieve the identifying information. A significant advantage of RFID devices over the others just mentioned is that the RFID device does not need to be positioned precisely relative to the scanner.

RFID has a couple of basic types of tags. Passive tags have no power source of their own, while active tags are self powered, usually by some type of battery. Passive tags generally operate at a maximum distance of 3 meters or less, and have power only when in communication with an RFID reader.

In an RFID system, RFID tags are "interrogated" by an RFID reader. The tag reader generates a radio frequency "interrogation" signal that communicates with the tags. The reader also has a receiver that captures a reply signal from the tags, and decodes that signal. The reply signal from the tags reflects the tag's data content.

RFID provides an excellent means to synchronize freight flow or physical movements of goods with information flow. With RFID applications, planners and managers are able to better visualize the flow of materials and products along the supply chain. The first two most pronounced examples of RFID applications are at Wal-Mart and the US Department of Defense.

GPS

The global positioning system (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. Largely for its affordability and availability, this system has been used in transportation, mainly for tracking movement of commercial vehicles in the private sector for efficient dispatching operations. In the recent years, it's seen in some applications in vehicle telematics in the area of intelligent transportation systems (ITS).

Figure 2.16. GPS technology

The most essential function of a GPS receiver is to pick up the transmissions of at least four satellites and combine the information from those transmissions with information in an electronic almanac, all in order to figure out the receiver's position on Earth.

Once the receiver makes this calculation, it can tell you the latitude, longitude and altitude (or some similar measurement) of its current position. To make the navigation more user-friendly, most receivers plug this raw data into map files stored in memory.

The GPS not only makes drivers (freight and passengers alike) conscious of where they are, but also is capable of integrating into a GIS system that relates their routing decisions to road conditions (speed limit, distance, congestion, meal/lodge available, gas stations, etc). It also leads to better informed decisions with changing road traffic conditions.

EDI

Electronic Data Interchange (EDI) is a set of standards for structuring information to be electronically exchanged between and within businesses, organizations, government entities and other groups. The standards describe structures that emulate documents, for example purchase orders to automate purchasing. The term EDI is also used to refer to the implementation and operation of systems and processes for creating, transmitting, and receiving EDI documents.

EDI documents generally contain the same information that would normally be found in a paper document used for the same organizational function. For example an EDI 940 ship-from-warehouse order is used by a manufacturer to tell a warehouse to ship product to a retailer. It typically has a ship-to address, bill-to address, a list of product numbers (usually a UPC code) and quantities. It may have other information if the parties agree to include. However, EDI is not confined to just business data related to trade but encompasses all fields such as medicine (e.g., patient records and laboratory results), transport (e.g., container and modal information), engineering and construction, etc. In some cases, EDI will be used to create a new business information flow (that was not a paper flow before).

EDI enables integration of information systems across the supply chain. It basically helps business partners 'talk' with each other based on a common IT language. There are different standards developed and recommended by different organizations.

EDI is used very intensively in transportation. Some additional information is available at http://www.mima.gov.my/mima/htmls/papers/pdf/apandi/edi-transport.pdf.

Other information management systems for logistics management exist such as the Enterprise Resource Planning (ERP) system, which are skipped here.

Remarks

All these types of devices and systems lay a general information platform on which private firms operate. It is worth mentioning that information technology in general, and decision support systems in particular, have become more and more important in both daily operations and long term planning. Those decision support systems are built upon the rich data available. Nuances in freight shipping cost, traffic congestion, parking availability, regulatory restrictions and other factors can be more and more easily taken into consideration by these intelligent decision support systems with data from RFID, GPS and other sources. One may conclude that the private sectors are using better and better information about our freight infrastructure and road network to make their business decisions, often in real time.

Network performance and traffic information sharing between the public and private sector will be a niche area where public and private sectors work in a partnership. A potential benefit to the public sector is its increased capability of responding to the changes in the private sector operations in terms of early symptoms of system disruption and shift of freight demand.

Literature

1. http://www.lavalink.com/fileadmin/newsletters/link_06.04.pdf (online materials introducing how RFID works. Accessed May 25, 2007)
2. http://www.technovelgy.com/ct/Technology-Article.asp?ArtNum=2 (online materials introducing how RFID works. Accessed May 25, 2007)
3. http://events.fcw.com/events/2006/wireless/downloads/WRFID06_T-3_Wyld.pdf

   (An RFID Power point presentation online. Accessed on May 15.)

Comparison of Private and Public Sector Planning & Implementation

It is important for transportation planners to understand the logistics system planning and operation in the private sector. It is desirable for freight planners to incorporate the potential logistical benefits in their planning projects and operational controls. However, freight planners should be conscientious about the differences between the private and public planning.

Public sector planning provides the infrastructure, laying ground for private sector planning. The infrastructure, once constructed, cannot be removed and usually lasts for a very long time. In turn, the private sector relies on the infrastructure to establish its production and distribution network. After its facilities have been established, they are intended to be used for at least 10 years. After the market has changed, these facilities may have to be converted, sold, or abandoned.

The fundamental differences between public and private sector planning exist in a number of domains. In the private sector, all the cost has to be covered by revenue in order to sustain the production and operation. Timeframe is a critical issue in the private sector. A private firm cannot sustain a lack of profit. The private sector planning is for-profit. Its goal is to make a profit through optimizing the use of its resources and location decisions. Its decisions have to be quick and its operational system has to be responsive to market changes.

In contrast, the public sector planning is for the general public good. For example, corridor congestion relief through the use of ITS and an addition of new capacity or bypasses only takes the government budget, and seldom returns revenue to the government unless it is a toll road.

Contributing to the differences between public sector planning and private sector planning might also be the performance measure. The measure in private sector is straight forward. If an investment decision does not bring in profit, it is considered a failure. In contrast, the public sector evaluates a project impact based on many factors that are usually 'vague' and hard to quantify such as environmental protection, economic growth or traffic improvement. It is almost impossible to find a benchmark to convincingly evaluate a public project.

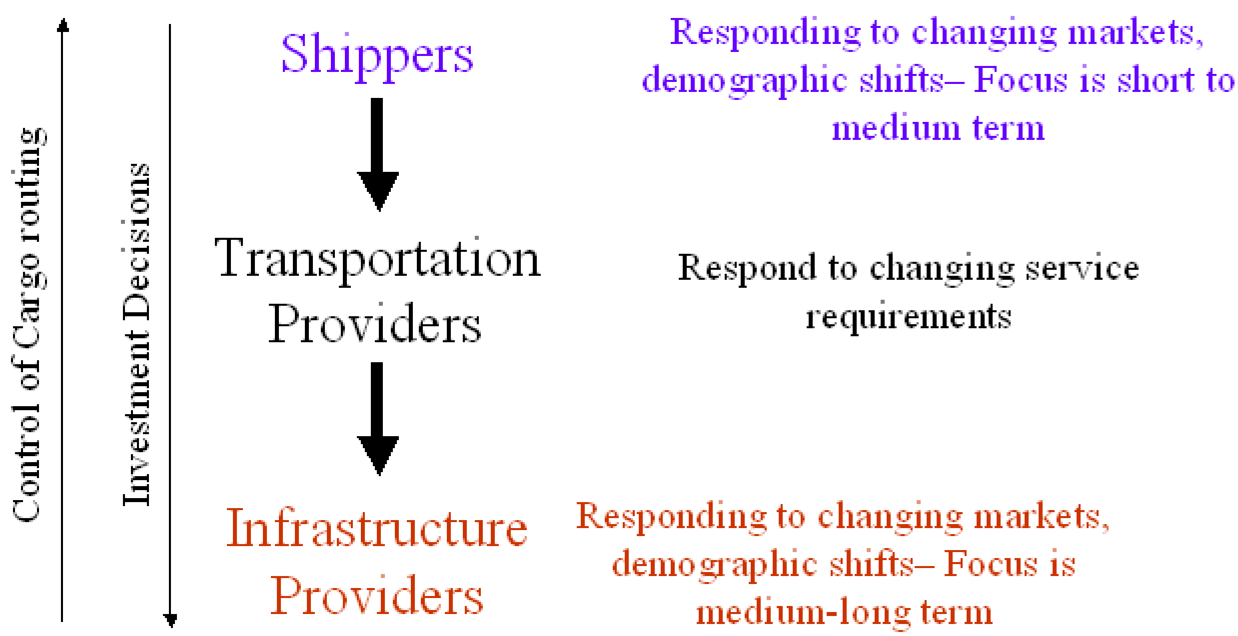
The following are some materials from the Federal Highway Administration (FHWA) (http://www.fhwa.dot.gov, accessed May 15, 2007) detailing the differences between public and private sectors.

Timeframes

Public project planning and implementation, even for relatively small projects, will take a minimum of 5 to 10 years, depending on the complexity of the project. As a result, the private sector often loses interest in projects that seemingly take "forever" to be built. As one private sector representative commented, *"We know that we have to get engaged with the MPOs to get our projects. When I come to the meetings and ask when we can get some help, they tell me to come back in 7 years. That's not good enough. We can't wait that long. That's why we have a hard time getting engaged with government agencies...we have a different time horizon and they have a hard time dealing with that."*

For extensive projects involving multiple jurisdictions, environmental evaluations, complex financing, and State/Federal project development oversight, the time horizon may be even lengthier. In addition, States and MPOs use multiyear programming of projects as a means of relating the planning process to project development. Typically, programs will be established 3 to 5 years out, with periodic updates to reprioritize projects as needed. Private sector decision making, in contrast, is accelerating to accommodate the demands of competitive international environments for quick response to market pressures. This means that public sector time frames for freight connector improvements are increasingly lagging private sector requirements for decision-making. [http://ops.fhwa.dot.gov/freight/freight_analysis/nhs_intermod_fr_con/chap_4.htm. accessed on May 15, 2007]

Challenges Placed on Infrastructure



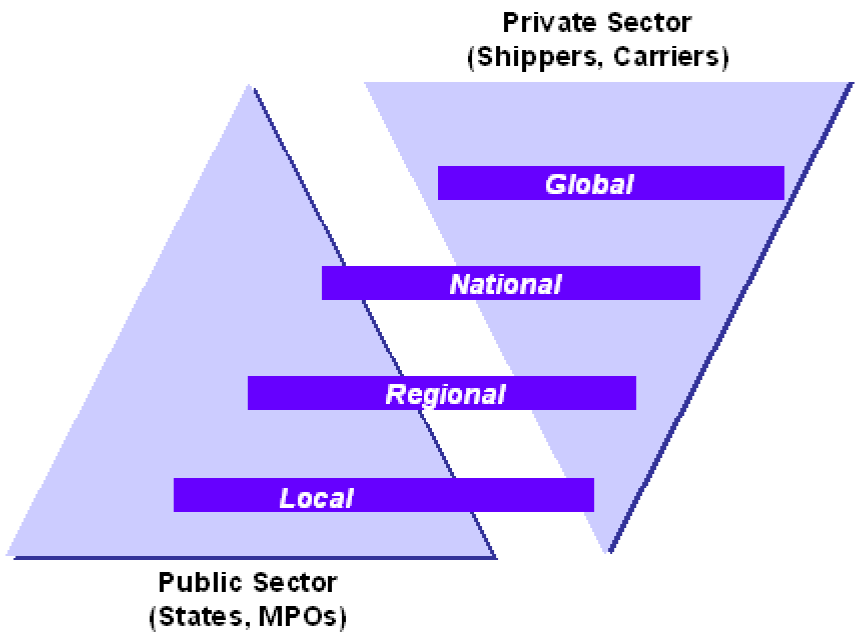
(Source: http://www.fhwa.dot.gov/freightplanning/caldwell.htm)

Introducing new projects, especially freight projects, into the pipeline is a political challenge when legitimate transportation needs invariably exceed anticipated revenues. Several States and MPOs are actively involved in freight planning, including the establishment of freight advisory committees, but it is difficult to maintain a high level of visibility over time. Examination of a better means of institutionalizing freight concerns and addressing the conflicts between public and private sector decision making will be required to address NHS connector and other intermodal freight transportation concerns in a more consistent manner. The designation of the connectors as NHS has increased the awareness of intermodal connectors; however, it is important to ensure that the appropriate public sector agencies and private sector freight stakeholders are involved in planning capital improvements and ensuring efficient operations. Improving awareness of freight and coordination are fundamental to the furtherance of this goal.

Freight projects usually given priority are the high-profile major port, rail terminal, or airport terminal initiatives with the vast majority of connectors unnoticed in the planning process. High profile projects have been funded through the MPOs, states, and High Priority Projects under ISTEA and TEA-21. Approximately 20 percent of all federally funded freight transportation improvements have received funding under the Demonstration or High Priority Project programs (http://ops.fhwa.dot.gov/freight/freight_analysis/nhs_intermod_fr_con/chap_4.htm#note9#note9). These high profile projects (for example: Alameda Corridor in California, Point Mack Terminal in Maine, FAST Corridor in Washington State, New Jersey Portway, Cross Harbor Freight Study in New York City, etc.) have brought to the attention of public officials, the potential for economic growth in the area, State, and Nation as well as community, air quality, and congestion benefits. In contrast, most NHS intermodal freight connector improvements have not necessarily been understood, well defined, or caught the imagination of the decision makers, and as a result, has not been funded. This was evidenced in the field review, which showed that a very large share of the reported investments were on only a handful of connector projects.

Freight Transportation Perspectives

State and MPO focus is regional and local; private sector focus is increasingly national and global.



(Source: http://www.fhwa.dot.gov/freightplanning/caldwell.htm)

A few additional words about the global nature of the private sector planning might be helpful for a better understanding. Large manufacturing firms operate their manufacturing and distributions on a global scale. So do big retail stores such as Wal-Mart. The global network takes advantages of regional complimentarity in terms of labor, natural resources and transportation infrastructure. In contrast, public sector freight planning often focuses on local scales. For example, a freight intermodal terminal planning often targets congestion reduction in and around the terminal, or along an interstate corridor for a limited distance.

The differences between public and private sector planning give rise to frictions when it comes for both to sit together jointly, planning some transportation infrastructure project. It is important that the public freight planners bear in mind the process and characteristics in which the private sector operates. With the use of information technologies and globalization, it is clear that the market follows population, that distribution centers follow market balancing transportation cost, and that if a local or regional freight system does not lead to overall logistical advantages, it be out of the private sector's consideration in designing their logistical network.

Remarks

Public and private sector planning are different, but intimately interact with each other. The public sector planning takes a much longer time than private sectors, but the infrastructure becomes fundamental to private sector planning and operations as well. Due to time horizon differences and differences in planning criteria, it does not appear completely appropriate for the public sectors to cater to the private sector interest for short terms. Public freight planning should be for long term economic interests including long term private sector interest. However, to be able to foresee the private sector shifts in their distribution network definitely will prove to be value in public sector freight planning.

On the other hand, the public freight system has its goals to serve the economic interests of the region. With this, freight system planners should be aware that the freight system becomes most efficient when it reduces the overall logistical cost of the private sector, instead of just freight cost and congestion.

Logistics Vocabulary[4]

Service level: the percentage of customers whose orders are fulfilled at the time of demand.

Freight forwarder: an enterprise that provides services to facilitate the transport of shipments. Services can include documentation preparation, space and equipment reservation, warehousing, consolidation, delivery, clearance, banking and insurance services, and agency services. The forwarder may facilitate transport by land, air, ocean, or may specialize in one mode of transport. Also referred to as forwarder.

Freight alongside ship: The point of embarkment chosen by the buyer, from where a carrier transports goods. Under this designation, a seller is obligated to pay the cost and assumes all risks for transporting goods from the place of businesses to the FAS point.

General Agreement on Tariffs and Trade: GATT for short. A multilateral trade agreement aimed at expanding international trade as a means of raising world welfare.

General-commodities carrier: A common motor carrier that has operating authority to transport general commodities, or all commodities not listed as special ones.

Lead time: the time interval from order placing to order arrival.

Load factor: a measure of operating efficiency used by air carriers to determine a plane's utilized capacity percentage or the number of passengers over the total number of seats.

Log book: a daily record of the hours an interstate driver spends driving, off duty, sleeping in the birth, or on duty but not driving.

Lot size: the quantity of goods a company purchases or produces in anticipation of future use or sale.

Line-haul shipment: a shipment that moves between cities and over distances more than 100 to 150 miles in length.

Inventory in-transit: inventory that has been ordered, but has not arrived at the warehouse yet.

Inventory position: current in-stock inventory plus inventory in-order;

(s, S) policy: an inventory management policy in which a replenishment order is placed whenever the inventory position falls below a threshold level s to make the inventory position back up to S.

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[4] Many of the terms are based on *Speaking the Language of Freight and Logistics* by Wilbur Smith Associates published in 2007.

Re-order point: a threshold inventory point at which a replenishment order is placed.

Marginal cost: the cost of producing one additional unit of product.

Order cycle: The time from an order is received to its actual delivery. Another definition from the order fulfiller's perspective is the time from order received to order assembled.

Order Processing: The activities associated with filling customer orders.

Order Cost: The cost of placing an inventory order with a supplier.

Outsource: Getting a third party to provide a function that was historically performed in house.

Pallet: A platform device used for moving and storing goods. A forklift truck is used to lift and move the loaded pallet. It is an efficient means to handle goods movement.

Safety stock: stock that is constant carried to prevent from stockout due to unexpected spike of demand.

Economic lot size model: Also called EOQ model as introduced in the text. It decides the order quantity for inventory replenishment.

Continuous review policy: An inventory management policy which assumes a capability of continuous review of inventory position.

Peak demand: The demand during a time period in which customers demand the greatest quantity.

Periodic review policy: In contrast to the continuous review policy, this policy assumes that inventory position is reviewed periodically.

Per diem: A payment rate one railroad makes to use another's car.

Physical distribution: The movement and storage of finished goods from manufacturing plants to warehouses to customers; used synonymously with business logistics.

Picking by aisle: A method by which pickers all needed items in an aisle regardless of the items ultimate destination; the items must be sorted later.

Picking by source: A method in which pickers successively pick all items going to a particular destination regardless of the aisle in which each item is located.

Piggyback: A rail truck service. A shipper loads a highway trailer, and a carrier drives it to a rail terminal and loads it on a rail flatcar; the railroad moves the trailer-on-flatcar combination to the destination terminal, where the carrier offloads the trailer and delivers it to the consignee.

Port of entry: A port at which foreign goods are admitted into the receiving country.

Port of discharge: Port where vessel is off loaded.

For hire carrier: A carrier that provides transportation services to the public on a fee basis. It is subject to government regulation regarding service provision.

Private warehousing: The storage of goods in a warehouse owned by the company that has title to the goods.

Public warehousing: The storage of goods by a firm that offers storage service for a fee to the public.

Rail waybill: The bill of lading issued by rail carriers to their customers.

Replenishment: The process of re-stocking inventory, especially at a store level as in "rapid replenishment" programs.

Reverse logistics: The process of collecting, moving, storing used, damaged, outdated, or returned products and packaging from end users. It moves in the opposite direction to the initial distribution process.

RO/RO: Roll-on/Roll-off. A type of cargo designed to permit cargo to be driven on at origin and off at destination; used extensively for the movement of automobiles.

Route: Path of a complete movement of a shipment from its origin to its destination by a carrier.

Shipment: A shipment is a user defined unit containing goods (single or multiple units) and requires transportation from one location to another. A shipment becomes a shipment when it leaves the consignor's location, and is complete when it arrives at the consignee's destination.

Stock keeping unit: also called SKU. The unit in which a product is kept in stock.

Spur track: a railroad track that connects a company's plant or warehouse with a railroad track; the user bears the cost of the spur track and its maintenance.

Stockout: A situation in which the items that a customer orders are currently unavailable.

Tandem: A truck or trailer that has two axles.

Tare weight: The weight of a vehicle when it is completely empty.

F.O.B origin: A special terms of sales. The seller agrees to deliver the goods to the point of origin. The buyer assumes all responsibility and risk thereafter. FOB refers to free on board.

F.O.B destination: The seller agrees to deliver the goods to the destination point after which the buyer assumes all responsibility.

Total cost analysis: A decision making approach that considers total system cost minimization and recognizes the interrelationship among system variables such as transportation, warehousing, inventory, and customer service.

TEU: twenty foot equivalent unit. The basic size used to measure container traffic volume.

Traffic Management: Buying and controlling of transportation services for a shipper or consignee, or both.

Transit privilege: A carrier service that permits the shipper to stop the shipment in transit to perform a function that changes the commodity's physical characteristics, but to still pay the through rate. It was a railroad practice before, and is rarely used now.

Transportation Research Board: A division of the National Academy of Sciences which pertains to transportation research.

Transportation Research Forum: A professional association that provides forum for the discussion of transportation ideas and research techniques.

Transshipment: The shipment of merchandise to a single point of destination on more than one vessel or vehicle. The liability may be passed from one carrier to another, or it may be covered by Through Bills of Lading issued by the first carrier.

Unit train: A train that repeatedly runs between the same pair of origin and destination without car switching or locomotive changes.

Value-of-service pricing: Pricing according to the value of the product that the company is transporting; third degree price discrimination; demand oriented pricing; charging what the traffic will bear.

Variable cost: a cost that fluctuates with the volume of business.

Vendor: A firm or individual that supplies goods or services; the seller.

Wharfage: A charge assessed by a pier or dock owner against the cargo or a steamship company for use of the pier or dock for the handling of incoming or outgoing cargo.