ENVISION FREIGHT

A ROADMAP TO FREIGHT COMPATIBILITY

THE ROLE OF TRANSPORTATION IN COMMODITY SUPPLY CHAINS – SOME EXAMPLES

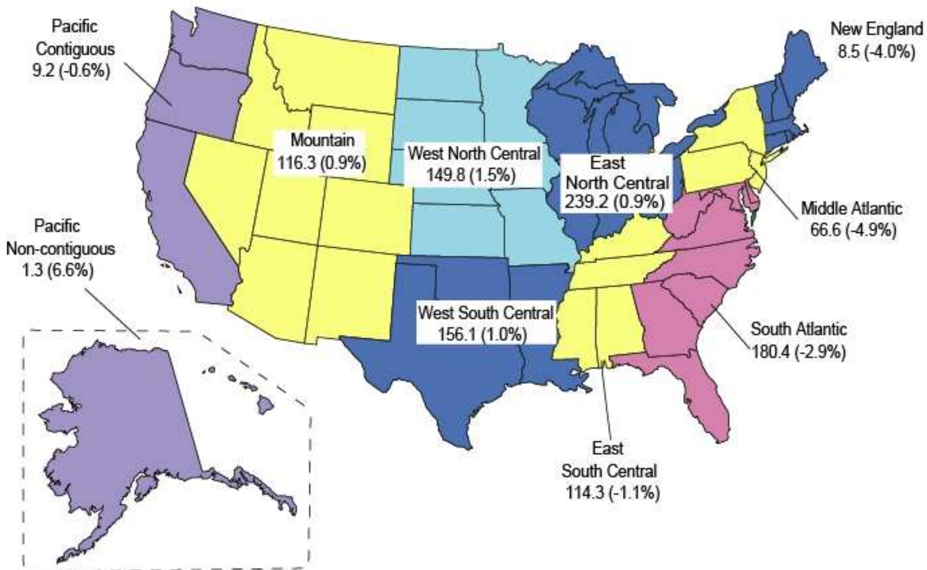
The following short case studies illustrate the importance of transportation in commodity supply chains. A diverse set of commodities was chosen to cover various modes of transportation, and consider factors such as variations in geographic locations, and supply chain complexity. The commodities are coal, containerized imported goods, grains, lumber and wood products, parcels, plastics, and transportation equipment. Some of the data reported in these studies are from special studies that are done on an infrequent basis. However, regardless of the time period for which it is cited, the data series cited here provide a consistent qualitative picture transportation of these various commodities in the United States.

Coal

The U.S. demand for coal is primarily derived from coal's use as a fuel for electricity generation. In 2009 electricity generation accounted for 94% of the total coal consumed domestically. While coal accounted for 49% of 2008 total U.S. electricity generation, its share of generation has been trending down over the past twenty years.[1] Coal-burning electric utilities are generally spread across the United States—only the New England and the Pacific Census regions do not rely extensively on coal for electric generation (see Figure 1). Most other U.S. coal consumption is by coke plants and other industrial users. The U.S. imports coal in small quantities, but is a net coal exporter.

[1] Association of American Railroads, *Railroads and Coal*, AAR Policy and Economics Department, August 2010, p. 2.

FIGURE 1
ELECTRIC POWER SECTOR CONSUMPTION OF COAL BY CENSUS REGION, 2009[2]

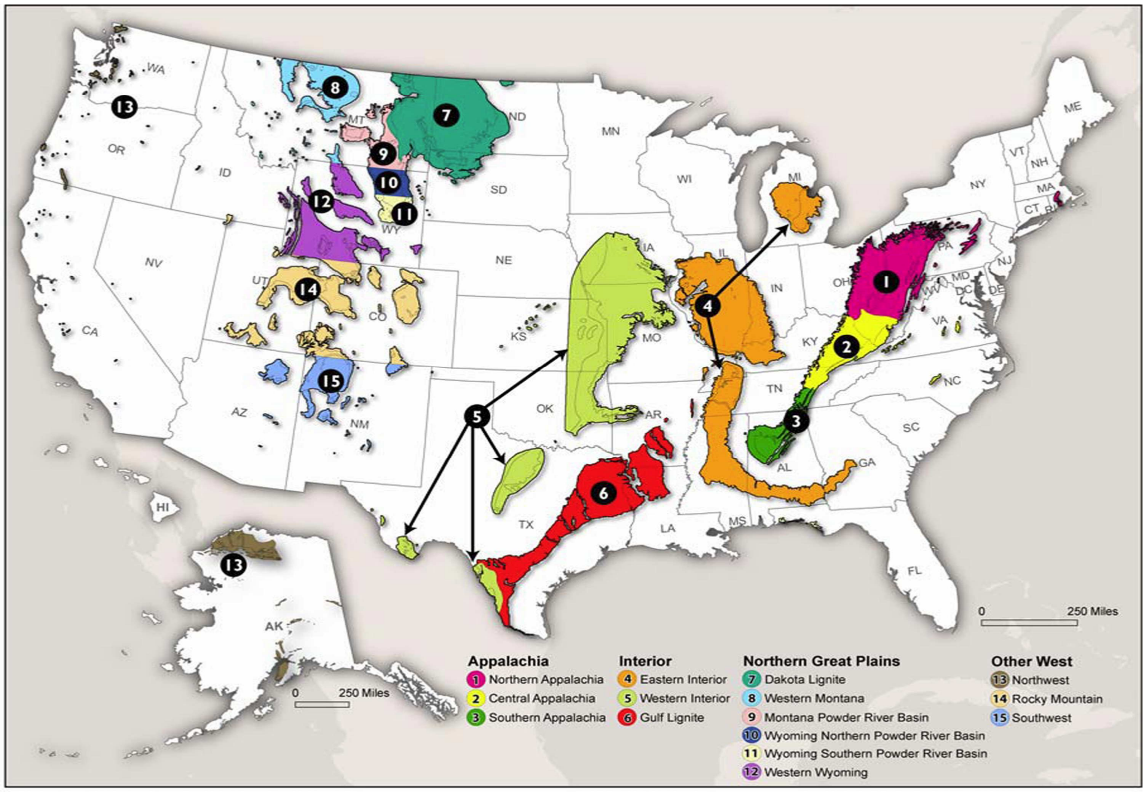


Overall, domestic transportation of coal accounted for about 96% of 2009 movements, and transportation to ports for sea export account for only about 4% of transportation movements.[3] Thus, coal usage and transportation are largely derived from domestic electricity demands and vary with factors that influence electricity demand, such as weather and general economic conditions. In the longer run, government policies that encourage or discourage particular types of fuel for electricity generation are also a factor influencing coal usage and its derived transportation demands.

As illustrated in Figure 2, U.S. coal production is concentrated in three areas. The Western Region (Northern Great Plains) accounts for over half of total U.S. coal production, with the state of Wyoming accounting for approximately 40% of total U.S. production. The largest source of coal in this region is the Powder River Basin (PRB). The Appalachian region accounts for 32% of U.S. coal production, with West Virginia, Eastern Kentucky, and Pennsylvania the largest sources of coal in this region. Finally the Interior Region—including Illinois, Indiana, Western Kentucky, and Texas—accounts for 14% of U.S. Production.[4]

[2] Fred Freme, "U.S. Coal Supply and Demand: 2009 Review," U.S. Energy Information Administration, Figure 3, p. 7
[3] 2009 Provisional Freight Analysis Framework, http://cta-gis.ornl.gov/faf/Extraction4.aspx.
[4] "U.S. Coal Supply and Demand: 2009 Review," Fred Freme, U.S. Energy Information Administration, Table 1, page 2.

FIGURE 2
COAL FIELDS AND REGIONS OF THE UNITED STATES[5]



Source: Coal Fields of the Conterminous United States, Originator: USGS; Eastern Energy Team; John Tully compiler. Publication Date: May 3, 1996, http://pubs.usgs.gov/of/1996/of96-092/
Region boundaries and names are adapted from those used by the Energy Information Administration's National Energy Modeling System. Map: Congressional Cartography, Library of Congress, 2007

Although truck transportation can be used for short shipments of coal, the dominant mode of coal transportation is rail. In 2008, railroads hauled 70 percent of U.S. total coal tonnage, followed by trucks with 16 percent and river barges with 9 percent.[6] Water transport, where available, tends to be the low-cost transportation mode. The rail share of coal tonnage increased 5 percentage points from 2001 to 2006, with reductions in modal shares for river barges and other modes (excluding trucking).[7] The shift of coal production to the West has aided railroads' modal share for coal shipments. Campbell County, Wyoming, the highest-tonnage PRB origin county, is remote from both the nearest waterway facilities handling coal and from most PRB coal users. As a result, rail is the only feasible mode. In the Eastern part of the United States, some mines are close enough to major waterways so that coal can be trucked or taken by rail to nearby points where it is transferred to barge. Although truck transportation can be used for short shipments of

[5] "Rail Transportation of Coal to Power Plants: Reliability Issues," Stan Mark Kaplan, Congressional Research Service, September 26, 2007, Figure 1, p. 9.
[6] Association of American Railroads, *Railroads and Coal*, AAR Policy and Economics Department, August 2010, p. 3.
[7] U.S. Department of Energy, Energy Information Administration, Domestic Distribution of U.S. Coal by Origin State, Consumer, Destination and Method of Transportation, at http://www.eia.doe.gov/cneaf/coal/page/coaldistrib/coal_distributions.html (Accessed October 3, 2008).

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There have been major changes in the composition of coal shipments over the 20 years prior to 2006. In large part, these changes reflect the predominance of large unit trains for long-distance coal shipments, which is in turn an adaptation to the growth of PRB coal production. Average distance (weighted by tonnage) increased more than 50 percent, and tons per carload increased moderately. The fraction of annual ton-miles in shipments of more than 100 carloads increased from 60 percent to 89 percent.[9]

Availability and reliability of transportation is a critical element in the coal supply chain. Although electric utilities maintain inventories of coal to handle fluctuations in electricity production, there are factors in addition to cost that make maintaining large inventories unattractive. For example, coal can degrade in quality as it sits in inventory, making it more difficult to burn. Another important factor in the supply chain decisions of electric utilities (e.g., inventory levels, transportation mode) is that barge transportation may be limited to certain months of the year, which means that the utilities must store larger inventories during the months when barge transportation is unavailable, or they must rely exclusively on rail transportation during those months.

Originating PRB coal rail traffic is highly concentrated on the BNSF-Union Pacific Joint Line in Wyoming. In 2004 and especially 2005, the coal industry faced major disruptions in both rail and water transportation.[10] Coal train derailments on the PRB joint line in May 2005 led to a major track maintenance and improvement project that disrupted PRB coal shipments for much of 2005. As a result, spot prices for PRB coal increased considerably, and a number of users drew down their coal stocks to unusually low levels. In 2006, according to the Department of Energy's *Annual Coal Report*, the coal transportation system had largely returned to normal functioning.

Appalachian coal routings are relatively diverse, so modest increases or decreases in aggregate shipment tonnage may not tend to create or relieve major bottlenecks. Nevertheless, much of the region is served by single-track lines, and so could be subject to capacity constraints should

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[8] U.S. Department of Energy, Energy Information Administration, Domestic Distribution of U.S. Coal by Origin State, Consumer, Destination and Method of Transportation, at http://www.eia.doe.gov/cneaf/coal/page/coaldistrib/coal_distributions.html (Accessed October 3, 2008).
[9] Christensen Associates, *A Study of Competition in the U.S. Freight Railroad Industry and Analysis of Proposals that Might Enhance Competition*, report to the Surface Transportation Board, November 2008.
[10] U.S. Department of Energy, Energy Information Administration, Annual Coal Report 2005 (Report No.: DOE/EIA-0584 [2005]).

production shift away from existing multiple-track main lines, notably within southwestern West Virginia. Interior region coal shipments have a relatively short average length of haul, and a lower modal share for rail, so substituting Interior coal for Appalachian or Western coal would tend to reduce overall rail tonnage and ton-miles.[11] This owes to the region's proximity to navigable waterways and local use of the resource.[12] Nevertheless, current rail traffic for Interior coal appears to be served in part by relatively low-density, single-track lines that may require upgrades to carry significant additional coal traffic.

As mentioned above, approximately 45% of coal transportation movements are to ports for overseas transit. The majority of these exports are from East coast ports with about 70% of 2009 export volume going through ports in Virginia and Maryland.[13]

Timber and Wood Products

Domestic movements of wood products, including both timber and finished lumber, are performed overwhelmingly by truck. Rail and intermodal modes play a very minor role in the movement of unfinished timber and only a modest role in the movement of sawn lumber products. For domestic movements, FAF data for 2008 show that truck transportation carries approximately 90% of total tonnage of wood shipments and virtually all of movement of logs.[14] Table 1 shows the kilotons of wood products shipped by different modes of transportation, while Table 2 shows the kilotons of logs shipped by mode.

TABLE1
TRANSPORT MODES FOR WOOD PRODUCTS IN 2009[15]

Mode	Kilotons	Percent
Truck	233,975	90.1%
Rail	11,050	4.3%
Intermodal	12,401	4.8%
Other and Unknown Modes	2,383	0.9%
Total	259,089	100.0%

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[11] Christensen Associates, *Supplemental Report to the U.S. Surface Transportation Board on Capacity and Infrastructure Investment*, report the to Surface Transportation Board, March 2009.
[12] For example, the Illinois "Clean Coal Portfolio Standard Law" of January 2009, is intended to "put Illinois coal to work to produce electricity and substitute natural gas." See Illinois Attorney General, *AG Madigan Thanks Coalition That Worked Together on Clean Energy Law*, Press Release, January 12, 2009, at http://www.illinoisattorneygeneral.gov/pressroom/2009_01/20090112C.html.
[13] 2009 Provisional Freight Analysis Framework, http://cta-gis.ornl.gov/faf/Extraction4.aspx.
[14] There are a few markets around the country in which barge transportation is sufficiently concentrated to constitute a measurable share of the total modal split including unfinished logs within Washington State as well as the movement of wood products between Washington and Oregon and between Maine and Massachusetts.
[15] 2009 Provisional Freight Analysis Framework, http://cta-gis.ornl.gov/faf/Extraction4.aspx

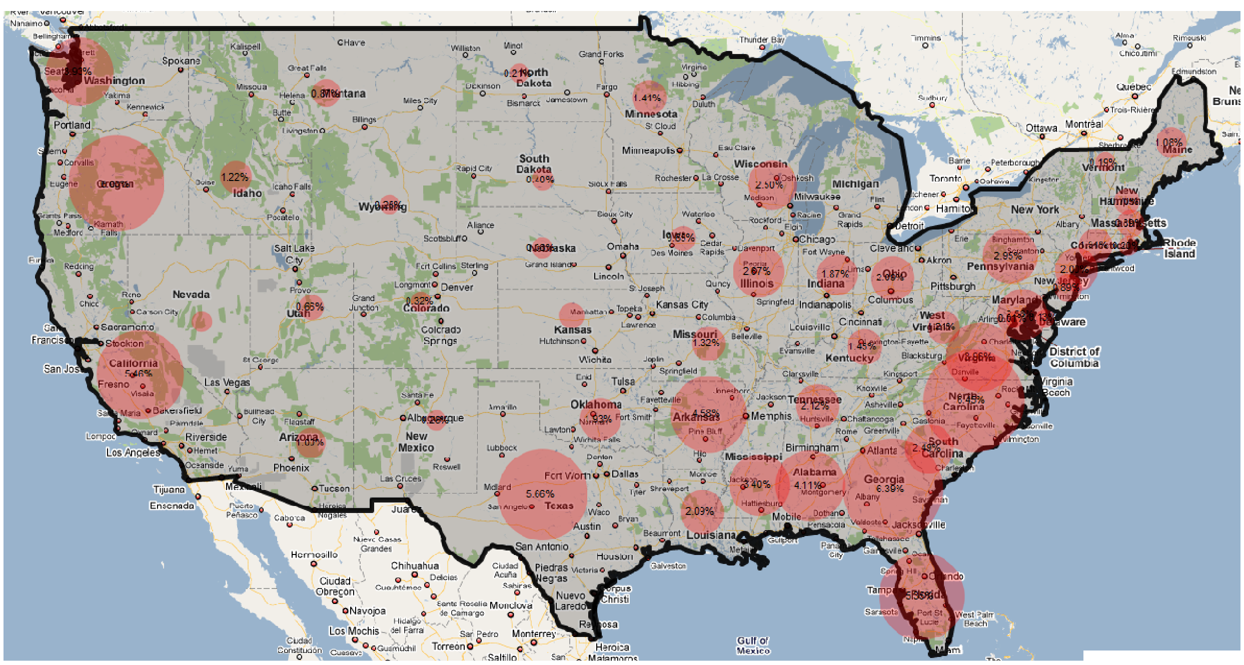
TABLE 2
TRANSPORT MODES FOR LOGS IN 2009[16]

Mode	Kilotons	Percent
Truck	413,593	98.3%
Rail	1,982	0.5%
Intermodal	3,682	0.9%
Other and Unknown Modes	1,523	0.4%
Total	455,419	100.0%

Origins and Destinations

Figures 3 and 4 show the origins and destinations of wood products by tonnage. It can be seen that while there are multiple states on the Mid-Atlantic and Pacific Northwest where production far outstrips local demand, there are many other centers of wood production within the country that are dedicated to fulfilling regional demand. While there were 891 mills across the U.S. and Canada in 2005, the total number of mills has been decreasing over time as larger, more productive mills have displaced smaller mills. In general, total production increased while the total number of production facilities has decreased and become more centralized. As this process has evolved some historical lumber-producing states, such as Maine, have seen mill capacity fall without new capacity coming on line.[17]

FIGURE 3
ORIGIN STATES FOR WOOD SHIPMENTS, ALL STATES[18]



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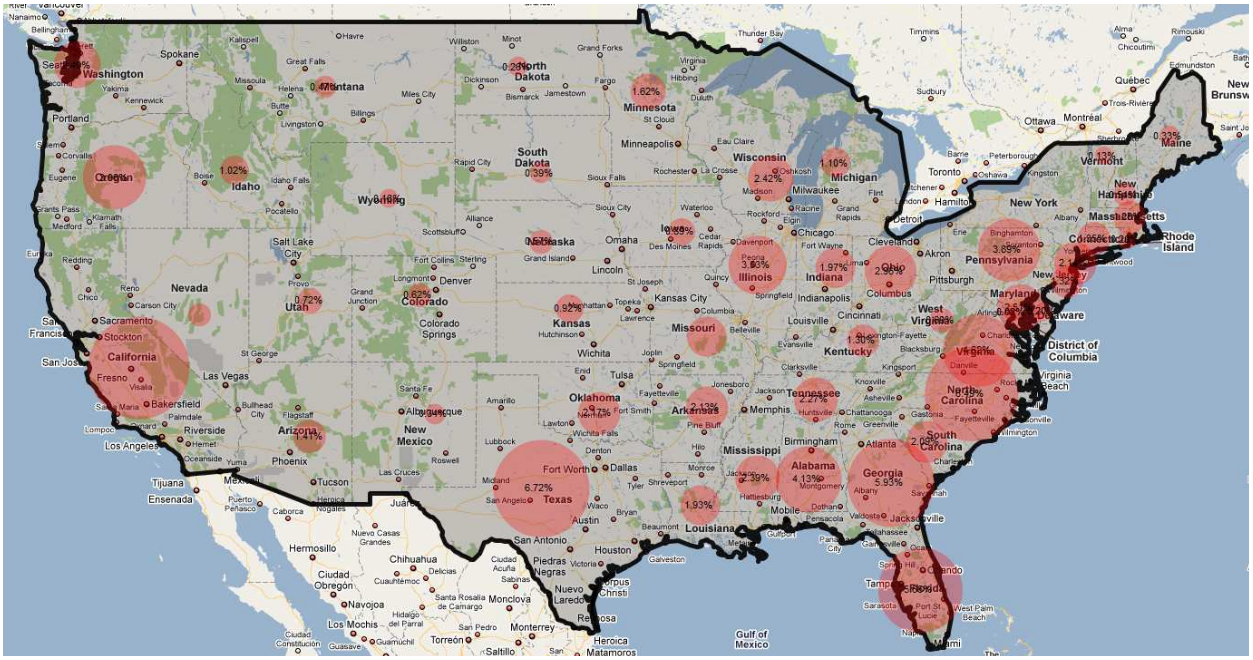
16 2008 Provisional Freight Analysis Framework, ops.fhwa.dot.gov/freight/freight_analysis/faf/faf2_pro.htm.
17 Profile 2005: Softwood Sawmills in the United States and Canada http://www.fpl.fs.fed.us/documnts/fplrp/fpl_rp630.pdf.
18 2008 Provisional Freight Analysis Framework, ops.fhwa.dot.gov/freight/freight_analysis/faf/faf2_pro.htm

FIGURE 4
DESTINATION STATES FOR WOOD PRODUCTS, ALL MODES[19]



Starting in 2007 and continuing into 2009, total capacity across the U.S. and Canada began to fall along with the total number of mills. The falloff in the number of production facilities, which had been a slow but steady attrition from 1995 to 2006 has become more dramatic since 2006. Even with the drop in available capacity, capacity utilization rates have been declining, which may indicate that the contraction process will continue. The latest USDA estimates are that the total capacity reduction will bottom out in 2012 with an effective drop in capacity of 22% below the peak achieved in 2006.[20]

The United States exports a substantial amount of wood products. Most production of exported product is harvested and sawn near the port of export. Thus, rail is utilized principally to service domestic demand. Marine ports involved in the timber trade include Seattle/Tacoma, Portland, Savannah, Charleston, and Wilmington, North Carolina—for which wood products constitute the single largest export commodity by tonnage.[21] While the U.S. is projected to require additional imports in coming years, the role of imports as a percentage of total demand is not expected to change markedly as efficiency improvements in forest management should produce increased wood yields.

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[19] 2008 Provisional Freight Analysis Framework, ops.fhwa.dot.gov/freight/freight_analysis/faf/faf2_pro.htm.
[20] Profile 2009: Softwood Sawmills in the United States and Canada http://www.fpl.fs.fed.us/documnts/fplrp/fpl_rp659.pdf.
[21] "Port of Wilmington 2010 Statistics" http://www.ncports.com/_Port_Statistics.htm

Demand for wood products is driven overwhelmingly by the housing market which was, until recently, concentrated in Sun Belt states that do not have very extensive rail access. Furthermore, when rail access in these destination states does exist, it is usually in the downtown area, far from the suburbs where most new home construction is occurring. Longer truck delivery at destination has the effect of pushing out the inflexion point where rail can be competitive with truck. The BNSF, which handles a significant share of wood product deliveries due to its market presence in the Pacific Northwest, estimated that wood product deliveries by Class I rail only become competitive with trucking at distances of around 2000 miles. This eliminates all but a small minority of wood product shipments that occur within the United States. Virtually all of the wood that is shipped by Class I rail has been sawn prior to loading. The transport of logs to the mill is performed by truck except within a few niche markets. Shortline railroads play a significant role in the movement of product from sawmills to the main lines. On the origin side, the principal issue is not encroachment per se but rather the continued financial viability of some short lines that feed sawmills in the Pacific Northwest. In Oregon, for example, approximately half of the total rail miles are owned by short lines and most of these lines are used for carrying timber.[22] The Port of Tillamook Bay Railroad in Oregon was mentioned by a Class I railroad as an asset which is important to the Class I's wood products market yet has experienced financial difficulty. There have also been some successes in recent years shifting cargo flows that had been trucked to rail for accessing sawmills. For example, the development of a log shipping program between the Portland & Western and the Central Oregon & Pacific has allowed timber from forests in the northwest corner of the state to sawmills in the southern part of the state.[23]

There have been cases in which the service level on short lines has declined to the extent that it is no longer reliable, thus forcing shippers to truck from the sawmills to load points on the Class I's. Railroads have also seen a decline in market share for long distance shipments that had previously been considered safe such as the Pacific Northwest to Texas or Chicago. A final factor in the decline of rail fortunes for wood movements is the increasing adaptability of sawmills which allows for the manufacture of synthetic wood based product using local forest species lessening the need for long haul shipments. The 2007 Commodity Flow Survey shows that while the total value of wood product shipments has increased marginally between 2002 and 2007, total tonnage and ton miles has fallen for wood products since 2002. Furthermore, these estimates were produced prior to the collapse of the housing market which has further depressed total ton miles.

[22] "The Role of Shortline Railroads in Oregon", Zereck Jones, Portland State University http://web.cecs.pdx.edu/~monserec/courses/freight/classprojects/CE453_Winter07_ShortLines1.pdf.
[23] "The Role of Shortline Railroads in Oregon", Zereck Jones, Portland State University http://web.cecs.pdx.edu/~monserec/courses/freight/classprojects/CE453_Winter07_ShortLines1.pdf.

TABLE 3
CHARACTERISTICS OF WOOD PRODUCT SHIPMENTS, COMPARISON OF 2002 AND 2007[24]

SCTG code (1)	Commodity description (2-digit)	2007 Value (million $)	2002 (million $)	Change from 2002	2007 Tons (thousands)	2002 thousands	Change from 2002	2007 Ton-miles (2) (millions)	2002 (millions)	Change from 2002	2007 Average miles per shipment	2002 Average Miles Per shipment	Change from 2002
26	Wood products	183,868	158,586	25,282	323,773	345,940	-22,167	100,787	120,151	-19,364	328	242	86

It should be noted that the average total length of haul increased from 242 to 328 miles. Nevertheless, given the railroads estimate that wood product shipment must be in the neighborhood of 2000 miles to be rail competitive, it is clear that most wood shipments will continue to be truck based.

Commodity Type and Trade

While the United States has a substantial timber industry to satisfy a significant percentage of its total wood products need, Canada is a major supplier of wood products to United States and other countries. Despite Canada's vast forest reserves, it is also the chief importer of U.S. wood products. Japan, Mexico, and China are also key recipients. Trading relationships for wood products are in constant flux tied to factors such as construction activity within the trading partner economies, the frequent alternations in tariffs and non-tariff barriers including new policies in forest management alter the short run and long run productive capacity of harvested forests, or new policies such as the recent policy decision in Japan to shift away from Douglas-fir for residential construction.[25] Hardwood lumber was, as of 2006, the U.S.'s top export commodity followed by softwood logs, hardwood logs, softwood lumber, and hardwood veneers. Policies that may favor the additional use of wood in construction in both Asia and Europe include efforts to reduce greenhouse gas emissions from traditional building materials such as cement. Russia's vast forest resources have been poorly managed and underproductive, yet the U.S. Foreign Agricultural Service estimates that Russia will play a far more substantial role in fulfilling global demand for wood products in the future—supplying both European and Asian markets that currently import substantial volumes of timber from the United States and Canada.

Parcel and Air Cargo Delivery

The necessity and importance of a well-integrated transportation network for the smooth functioning of supply chains is best illustrated with parcel and air cargo delivery services. A significant portion of parcel and air cargo delivery commodity flows require use of multiple transportation modes for time-sensitive delivery of parcels that are of high-value. In discussing parcel and air cargo delivery, we use the distinction employed by the Bureau of the Census in the Commodity Flow Survey. The Commodity Flow Survey categorizes the shipment of parcels and

[24] Commodity Flow Survey, 2007.
[25] Tony Halstead, "Wood Market Update" USDA Office of Global Analysis, March 2007 http://www.fas.usda.gov/ffpd/Newsroom/Wood%20Market%20Update.pdf.

packages that are less than 100 pounds as being transported via the parcel delivery, courier, and U.S. Parcel Post transportation mode. Packages that are more than 100 pounds and shipped either by air or by a combination of air and truck are categorized as being transported by the air transportation mode.[26]

Table 4 shows the value of shipments for various commodities shipped by parcel delivery, courier, and U.S. Parcel Post.[27]

TABLE 4
2007 VALUE OF SHIPMENTS FOR COMMODITIES TRANSPORTED BY PARCEL DELIVERY, COURIER, AND U.S. PARCEL POST

STCC Commodity Code	Commodity	Value ($million)	Percent of Total Value
35	Electronic and other electrical equipment, components, and office equipment	382,922	25%
21	Pharmaceutical products	240,974	15%
40	Miscellaneous manufactured products	179,058	11%
38	Precision instruments and apparatus	157,222	10%
30	Textiles, leather, and articles of textiles or leather	116,240	7%
34	Machinery	97,390	6%
29	Printed products	58,286	4%
	Other Commodities	329,782	21%

In terms of the value of the shipments, the commodity class electronic and other electrical equipment, components, and office equipment accounts for 25% of the shipments. However one can see from the table that the commodities shipped via this transportation mode are very diverse.

Table 5 shows the distribution of commodities when measured in terms of ton-miles.

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[26] 2007 Commodity Flow Survey, Definition of Key CFS Terms, http://www.bts.gov/publications/commodity_flow_survey/def_terms/index.html.
[27] The tables on the shipment of commodities come from the 2007 Commodity Flow Survey interactive tables at http://www.bts.gov/programs/commodity_flow_survey/.

TABLE 5
2007 TON-MILES FOR COMMODITIES TRANSPORTED BY PARCEL DELIVERY, COURIER, AND U.S. PARCEL POST

STCC Commodity Code	Commodity	Ton-miles (million)	Percent of Ton-Miles
40	Miscellaneous manufactured products	4,360	16%
35	Electronic and other electrical equipment, components, and office equipment	4,120	15%
30	Textiles, leather, and articles of textiles or leather	3,399	12%
29	Printed products	2,143	8%
43	Mixed freight	1,505	5%
24	Plastics and rubber	1,455	5%
36	Motorized and other vehicles (including parts)	1,393	5%
34	Machinery	1,306	5%
33	Articles of base metal	1,251	4%
38	Precision instruments and apparatus	1,118	4%
39	Furniture, mattresses and mattress supports, lamps, lighting	980	4%
	Other Commodities	4,931	18%

Using this metric, miscellaneous manufactured products is the commodity class most shipped by this transportation mode. Once again, the table shows considerable diversity in the types of commodities shipped.

Table 6 and 7 show the distribution of commodities shipped by air cargo delivery. Table 6 shows the value of shipments for various commodities shipped by air cargo delivery.

TABLE 6
2007 VALUE OF SHIPMENTS FOR COMMODITIES TRANSPORTED BY AIR CARGO

STCC Commodity Code	Commodity	Value ($million)	Percent of Total Value
35	Electronic and other electrical equipment, components, and office equipment	89,321	35%
37	Transportation equipment, nec	56,567	22%
38	Precision instruments and apparatus	32,797	13%
21	Pharmaceutical products	18,060	7%
34	Machinery	14,617	6%
40	Miscellaneous manufactured products	13,074	5%
	Other Commodities	27,840	11%

Once again the commodity category electronic and other electrical equipment, components, and office equipment is the largest category in terms of value of shipment, with it accounting for 35% of the value of shipments. Transportation equipment and precision instruments and apparatus are the next largest categories, accounting for 22% and 13% of value of shipments, respectively.

Table 7 shows the distribution of shipments when measured by ton-miles.

TABLE 7
2007 TON-MILES FOR COMMODITIES TRANSPORTED BY AIR CARGO

STCC Commodity Code	Commodity	Ton-miles (million)	Percent of Ton-Miles
35	Electronic and other electrical equipment, components, and office equipment	626	14%
40	Miscellaneous manufactured products	406	9%
34	Machinery	303	7%
38	Precision instruments and apparatus	248	5%
36	Motorized and other vehicles (including parts)	240	5%
5	Meat, fish, seafood, and their preparations	212	5%
30	Textiles, leather, and articles of textiles or leather	210	5%
21	Pharmaceutical products	201	4%
24	Plastics and rubber	183	4%
37	Transportation equipment, nec	158	4%
	Other Commodities	1,723	38%

This table highlights how diverse the types of commodities shipped are. Once again, the category electronic and other electrical equipment, components, and office equipment is the largest commodity category, but it only accounts for 14% of total ton-miles. Miscellaneous manufactured products and machinery are the next largest commodity classes, accounting for 9% and 7% respectively.

The parcel and air cargo delivery industry is made up of numerous players: commercial air carriers, freight forwarders, airport logistics handlers, and ground handlers among others. The division of tasks between these different parties can lead to cargo being held at airports, there has been increasing integration of these tasks into single companies.[28] UPS and FedEx are two of the largest parcel and air cargo delivery companies in the United States, and they now provide complete and integrated logistics services. Both companies have large networks of facilities that accept parcels, as well as provide parcel pick-up service. Similarly, their delivery networks are widespread with significant international growth over the past 20 years. Both companies have large fleets of aircraft and trucks that are used to transport parcels from point of acceptance to the point of delivery. UPS has 101,900 vehicles and 510 aircraft[29] and FedEx has 49,000 vehicles and 664 aircraft.[30]

While parcel delivery over short distances may be carried out exclusively using trucks, over longer distances, combinations of truck and some other mode (typically air) are required, particularly for time-sensitive or long distance parcels. FedEx has its primary sorting facility in Memphis and accounts for nearly all of the freight movement processed by Memphis

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[28] John D. Kasarda, Stephen J. Appold, and Makoto Mori, "The Impact of the Air Cargo Industry on the Global Economy," prepared for The International Air Cargo Association Air Cargo Forum, September 13, 2006. http://www.tiaca.org/images/TIACA/PDF/The%20Impact%20of%20the%20Air%20Cargo%20Industry%20on%20the%20Global%20Economy.pdf.
[29] United Parcel Service, Inc. Form 10-K, FY 2009, p. 1.
[30] FedEx Corporation Form 10-K, FY 2010, p. 3.

International Airport.[31] FedEx has a second national hub in Indianapolis and a number of regional hubs. FedEx has facilities in Anchorage, Paris, and Guangzhou that serve as sorting facilities for shipments moving to and from Asia and Europe, and Miami serves as the hub for Latin America and the Caribbean.[32] UPS has its primary sorting facility in Louisville and accounts for nearly all freight traffic at Standiford Field in Louisville.[33] It has a number of regional domestic air hubs with international air hubs in Germany, Miami, Canada, Hong Kong, China, and the Philippines.[34]

In the first step of the delivery process, trucks are used to collect parcels. These parcels are then taken to processing facilities (or dropped off by customers), where they are combined and sorted. Parcels that are to be delivered locally are sorted to route and taken to their final destinations, by the same fleet of local trucks that picked them up. Non-local parcels that are going shorter distances or are not time sensitive may be loaded on trailers and transported by truck to destinations or other processing facilities, where they are combined with other destinating parcels and sorted to delivery routes or other destination facilities. Time sensitive or long-distance parcels may be transported from the origin facility by air. They may be placed in containers for easier shipment and flown to one of the airports where the delivery service has its hub operations. At the hub, the containers are sorted to destination and all, except those destinating in the hub service area, will fly back out on the same fleet of planes that brought them. These planes then arrive at airports near their destination, where the containers are broken down, and the parcels sorted to delivery route. Final delivery is by truck.

In the case of time-sensitive deliveries, good intermodal connectivity is essential. For overnight delivery, trucks that have collected parcels must get them to the initial processing facility in time to make the outbound flights to hub airports. Conversely, the inbound flights from the hubs must arrive in time for sortation to delivery route and dispatch.

While the typical multimodal example of parcel and express delivery is truck-air, rail is also used for the long-distance leg of shipments that have some time-sensitivity, but not necessarily of the priority that requires the use of air transportation. In fact, the major parcel couriers have sorting facilities collocated next to railroad intermodal facilities. For example, UPS has a facility located next to BNSF's Willow Springs intermodal terminal in the Chicago area. UPS trailers are placed on specially-designed railroad flatcars and transported by BNSF to Los Angeles on one of its high-priority "Z" trains. Again, good intermodal connectivity is essential for this type of service to be effective. This connectivity not only involves the rail and parcel terminal facilities, but also the road connections that allow for the flow of trucks into and out of the terminals.

[31] *Freight in America: A New National Picture*, U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, January 2006, p. 35.
[32] FedEx Corporation Form 10-K, FY 2010, pp. 6.
[33] *Freight in America: A New National Picture*, U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, January 2006, p. 35.
[34] United Parcel Service, Inc. Form 10-K, FY 2009, p. 1.

Plastics

The manufacture and movement of plastics is tied very closely with the petroleum industry. States and localities that have ready access to raw petroleum, and/or organic chemical production facilities, frequently have plastics production facilities located nearby. Using petroleum and other chemical feedstocks, plastic resins are manufactured through the process of polymerization. Resins are defined as polymers that have been dried and shaped into pellets.[35]

Transportation Requirements

The plastics industry relies on multimodal access for the provision of chemical feedstocks and the delivery of intermediate and final products. While most plastics are relatively inert and non-hazardous to ship, the chemical feedstocks and catalysts required to support plastics production can be hazardous and require special care to transport. Waterways and rail are important in the transport of chemical feedstocks. Care in the transport of plastics inputs in also essential for preserving the purity of the reactants necessary to sustain chemical reactions.

Rail access is also important for the movement of plastics products both internationally and domestically, particularly for the movement of plastics in primary forms. Water access is critical for the import and export of plastics in primary forms and is becoming more important for the movement of domestic plastics shipments, yet domestic movement of plastics and rubber by water currently account for less than one percent of total tonnage. Due to the reliance on fixed capital assets and connection with the petrochemical industry, the plastics production tends to be concentrated in a few major geographic locations which are served by specific transportation corridors. Movements within the Houston area constitute, by far the largest concentration of plastics movements within the country. Intracity movements on the Houston road and rail network handle approximately 5% of shipments by tonnage for the country. Houston also serves as the single largest gateway for shipments to other parts of the country and trade. Rail is used more frequently to transport resins as opposed to finished product.

While data specific to plastics shipments is difficult to obtain, the FAF provides some useful information on the commodity group "plastics and rubber." Table 8 shows the distribution of plastics and rubber kilotons shipped by mode of transportation. This table shows that truck accounts for the largest share of kilotons shipped, with rail also accounting for a substantial fraction.

TABLE 8
TRANSPORT MODES FOR PLASTICS AND RUBBER SHIPMENTS, FAF 2009

Mode	Kilotons	Percent
Truck	113,576	74.4%
Rail	25,489	16.7%
Intermodal	11,243	7.5%
Other and Unknown Modes	2,162	1.4%
Total	152,650	100.0%

[35] http://www.epa.gov/Compliance/resources/publications/assistance/sectors/notebooks/resfibsn.pdf

Manufacture and Distribution of Plastic and Resin Products

While there are currently over 18,000 plastics manufacturers in the United States, there are far fewer companies involved directly in the manufacture of plastic material and resin with approximately 500 firms with 20 or more employees.[36] In 2002, Texas and California were the states with the top number of manufacturing establishments, but the average amount of product shipped per firm was far higher in Texas. Louisiana, which in 2002 ranked second in terms of total value of shipments, has a pattern of production similar to Texas, with a small number of firms accounting for most of the production. As the plastics industry has evolved, it has become more specialized with different types of plastics manufactured for more specific purposes. As such, while there are many transportation corridors that are used for transporting plastics, each unique type of resin has far fewer manufacturers and associated corridors for distributing product around the world. Chronic overcapacity in the plastics market in the late 1980s and early 1990s drove plastics manufacturers in high labor cost countries to focus on specialization and the servicing of niche markets.[37]

The vast majority of resins produced in the United States are thermoplastics which can be heated and remolded. Major categories of thermoplastics include polyethelene, polyvinyl chloride**,** polypropylene, and polystyrene.[38] Many of the technologically advanced plastics are thermosets which can only be molded once and often have more specific uses. The distribution of thermoset manufacturing is somewhat more evenly distributed by state. While Texas and Louisiana held a 47% marketshare for thermoplastic resins and materials in 2002, these states marketshare for thermosets was only 32%.[39] Within Texas, plastics manufacturing employment is split almost equally between the Houston area and the rest of the state.[40]

Import and Export Supply Chains

Due to the variety of complex polymers that are currently manufactured, the complexity of the feedstock provision process, as well as the high fixed capital costs associated with establishing new manufacturing sites, the global plastics industry currently realizes substantial gains from trade. International trade allows for greater specialization and scale economies than would be possible under autarkic conditions. The growth on containerization around the world has been particularly beneficial to international trade in plastics resins as it allows fixed quantities of product to be moved without fear of contamination. The industry has also benefitted from the ability to use double rail which allows for the shipment of containers that would be too heavy to ship over the road.

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[36] http://www.plasticsindustry.org/AboutPlastics/content.cfm?ItemNumber=787&navItemNumber=1280.
[37] http://www.epa.gov/Compliance/resources/publications/assistance/sectors/notebooks/resfibsn.pdf.
[38] http://www.epa.gov/Compliance/resources/publications/assistance/sectors/notebooks/resfibsn.pdf.
[39] http://www.census.gov/prod/ec02/ec0231i325211t.pdf.
[40] http://www.houston.org/pdf/research/16HW005.pdf.

Export and Import Partners

According to U.S. Census trade statistics, in 2007 Canada was the United State's largest export recipient for plastics, receiving $10.9 billion in shipments. Shipments to Mexico were almost identical in value at $10.5. China was the largest recipient of U.S. plastics exports with $3.6 billion, $3.3 billion of which was transported by marine vessel and $2.9 billion of which was transported in containers. Other top trading partners for export included, Hong Kong, Belgium, Brazil, and the Netherlands.

By value and weight, ethylene polymer resins constituted the single largest export at $6.5 billion and 2.7 billion kilograms. China also receives a substantial amount of waste plastic product for recycling. In fact, this commodity type (HS 3915) constitutes the single largest share of exports to China by weight at 552 million kilograms.

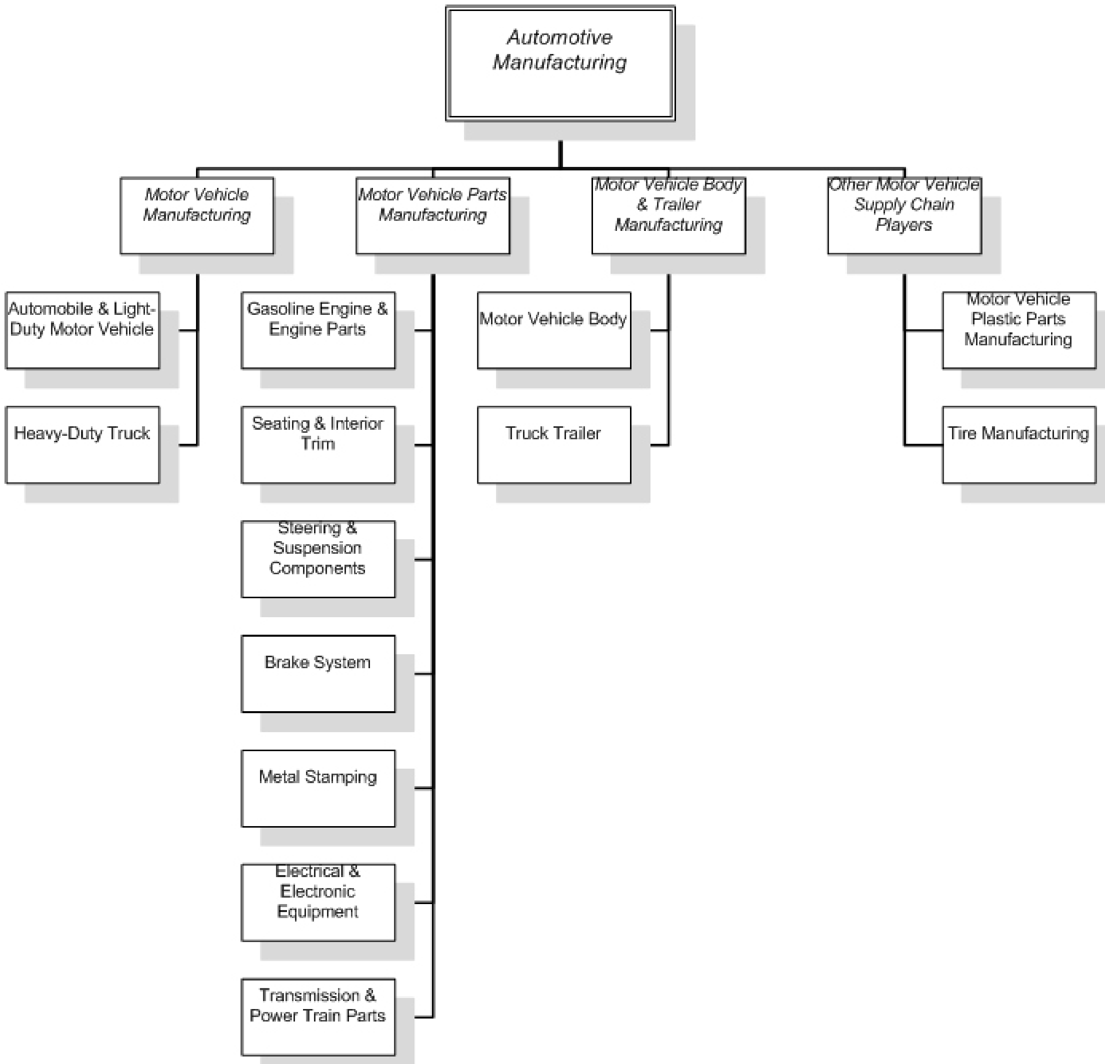
For 2007, Houston was the largest marine exporter of plastics by weight at 3.44 billion kg. Long Beach and Los Angeles exported 1.48 and 1.32 billion kg of plastics respectively. Together these three port facilities exported over half of the total tonnage. Other important exporters include Charleston, New York, Savannah, Norfolk, Freeport, and New Orleans. For Long Beach waste shipments constituted the single commodity type while in Houston, ethylene polymers were the largest export by weight.

Automobile Manufacturing

Although the North American auto industry has experienced unprecedented change in the last few years, it still provides a good illustration of the role of transportation in manufacturing supply chains. It is also an example of the importance of a handful of border gateways in U.S. commerce with its NAFTA partners, Canada and Mexico.

The auto industry was one of the first in this country to adopt "lean manufacturing" and "just-in-time" logistics and supply chain principles. Figure 5 generally illustrates the linkages between a number of different parts and subcomponent suppliers and auto manufacturers.

FIGURE 5
AUTOMOTIVE MANUFACTURING SUPPLY CHAIN[41]



A key to the lean manufacturing approach is to keep inventory levels as low as possible for anticipated levels of production, with suppliers providing their inputs "just in time." A critical component in the success of this approach is efficient and reliable transportation.

Much of the domestic auto industry supply chain crosses borders with Canada and Mexico, who are this country's largest foreign trade partners. U.S. foreign trade stood at a total of $2,575

[41] *Logistics and Supply Chain Management (SCM) Key Performance Indicators (KPI) Analysis: A Canada/United States Automotive Sector Supply Chain Perspective*, Industry Canada, October 2006, p. 12.

billion in 2005. The NAFTA countries of Canada and Mexico were our largest trading partners, with $494 billion and $290 billion, respectively. China was third-largest trading partner of the U.S., and was within $5 billion of Mexico in 2005.[42]

Motor vehicles and parts was leading commodity in NAFTA trade in 2005, accounting for over 18% of the value shipments ($143 billion). Motor vehicles and parts was the leading commodity in U.S.-Canada land mode trade ($104 billion), and third in U.S.-Mexico land mode trade ($38 billion).[43] Reflecting the auto industry supply chain, Michigan had $98 billion in trade with NAFTA partners in 2005, with $73 billion of this being trade with Canada. Michigan NAFTA trade was second to Texas, which had $127 billion in trade with NAFTA partners in 2005 ($102 billion was with Mexico).[44]

The volume of trade with Canada and Mexico highlights the importance of land ports or land gateways—locations where land transportation corridors (primarily highway and rail) traverse borders. Even though there are 75 land ports along the U.S.-Canadian border and over 25 along the U.S.-Mexican border, the land freight transported across these borders is heavily concentrated at a few major gateways. This concentration creates congestion at these gateways and affects traffic flow along connected corridors.[45] Two of the four largest U.S. land ports are in Michigan, at Detroit and Port Huron, which accounted for $198 billion in 2005 trade with Canada. This figure is larger than Michigan's trade with Canada because these ports serve as gateways for a number of states trading with Canada. Detroit and Port Huron accounted for 40% of U.S.-Canada truck crossings in 2005 and about one-third of U.S.-Canada rail container crossings.[46] Texas land ports of Laredo, El Paso and Hidalgo serve as national gateways, and account for a combined $155 billion in trade with Mexico (greater than the total for Texas, alone, at $98 billion).[47]

By transportation mode, motor vehicles and parts is the third leading commodity moved by truck in U.S.-NAFTA trade ($81 billion) and is the leading commodity transported by truck between the U.S. and Canada ($66 billion).[48] The leading U.S.-NAFTA commodity transported by rail

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[42] *North American Freight Transportation: U.S. Trade with Canada and Mexico*, U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, June 2006, p. 4.

[43] *North American Freight Transportation: U.S. Trade with Canada and Mexico*, U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, June 2006, p. 13. Electrical machinery and equipment was the top commodity traded with Mexico ($63b).

[44] *North American Freight Transportation: U.S. Trade with Canada and Mexico*, U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, June 2006, p. 11.

[45] *America's Freight Transportation Gateways: Connecting our Nation to Places and Markets Abroad*, U.S. Department of Transportation, Bureau of Transportation Statistics, 2004, p. 6.

[46] *North American Freight Transportation: U.S. Trade with Canada and Mexico*, U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, June 2006, pp. 19-20, Table A-4.

[47] *North American Freight Transportation: U.S. Trade with Canada and Mexico*, U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, June 2006, p. 11.

[48] *North American Freight Transportation: U.S. Trade with Canada and Mexico*, U.S. Department of

(in terms of value) was motor vehicles and parts ($57 billion), accounting for 49% of total rail freight between the U.S. and its NAFTA partners. Of this, $37 billion was between the U.S. and Canada and $20 billion was between the U.S. and Mexico.[49]

Although trucks haul the majority of U.S. trade by value at the major land ports, many border crossings are important rail gateways. Over half the value of U.S.-NAFTA rail trade passes through just two gateways, Laredo, Texas, and Port Huron, Michigan. These two ports, along with Eagle Pass, Texas, have seen large growth in the value of rail cargo in recent years.[50]

The following figures illustrate major railroad routes the serve the auto industry.

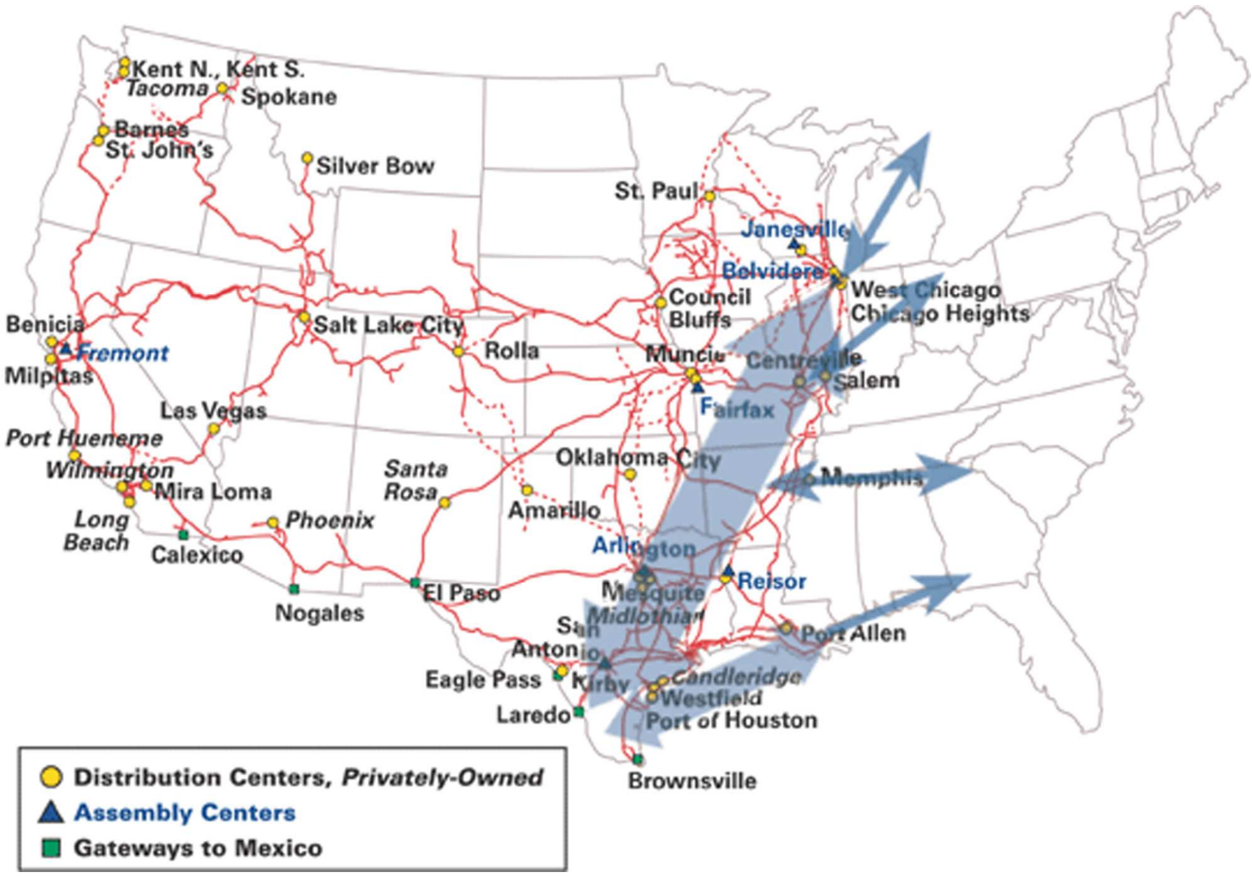
Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, June 2006, p. 14.

[49] *North American Freight Transportation: U.S. Trade with Canada and Mexico*, U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, June 2006, p. 14.

[50] *America's Freight Transportation Gateways: Connecting our Nation to Places and Markets Abroad*, U.S. Department of Transportation, Bureau of Transportation Statistics, 2004, p. 8.

Figure 6 shows the Union Pacific automotive network, which primarily serves the Midwest from Chicago, the Southwest (including the Mexican border), and West Coast ports.

FIGURE 6
UNION PACIFIC AUTOMOTIVE NETWORK[51]



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[51] http://www.uprr.com/customers/autos/svcs/north_american.shtml.

Michigan and much of the U.S. automotive industry located in proximity are served by Eastern railroads, such as Norfolk Southern and CSX. Figure 7 shows the Norfolk Southern network in relation to the auto industry.

FIGURE 7
NORFOLK SOUTHERN SYSTEM AND U.S. AUTO INDUSTRY[52]

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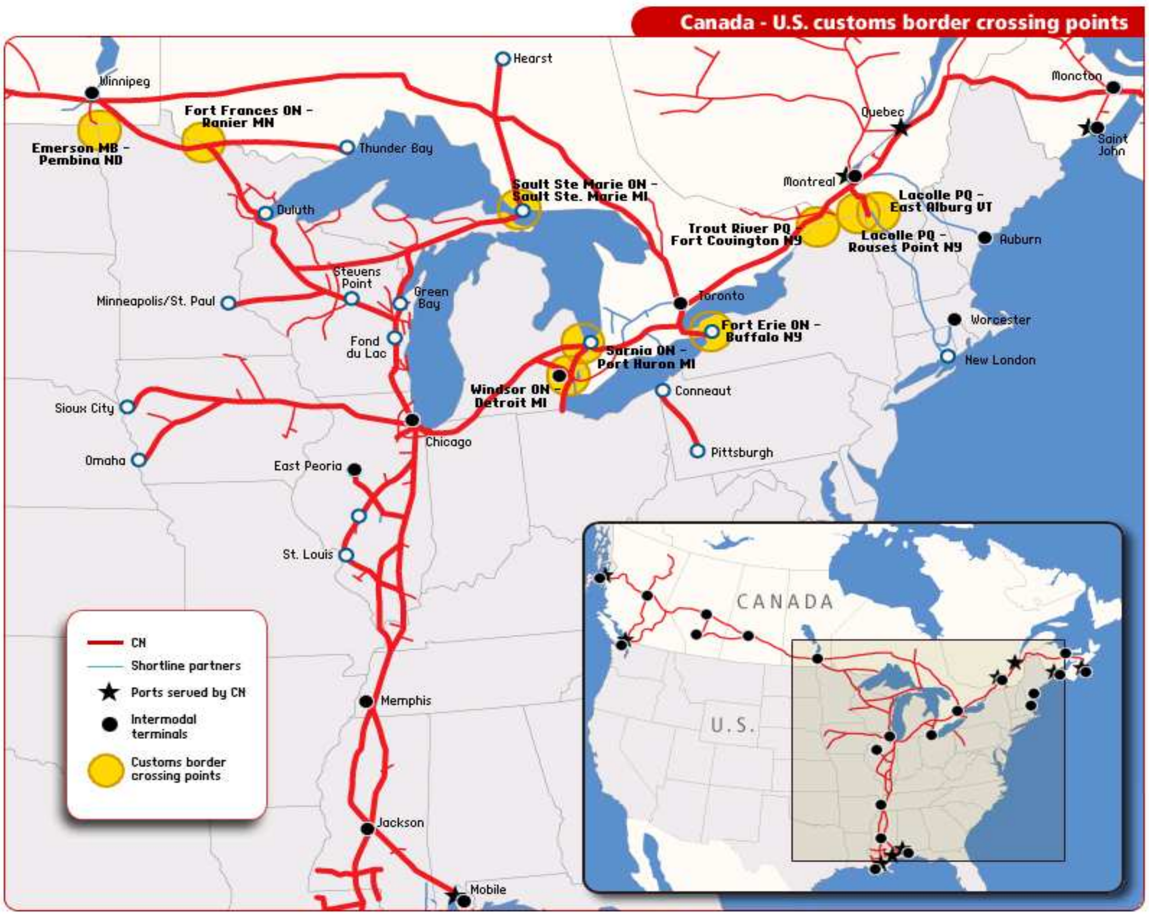
[52] http://www.nscorp.com/nscportal/nscorp/Customers/Automotive/Facilities/pdf/ns_auto_distr.pdf

Figure 8, which shows Canadian National's network and border crossing points, illustrates the transborder operations of Canadian railroads and their importance to the North America auto industry supply chain.

FIGURE 8
CANADIAN NATIONAL NETWORK AND CANADA-U.S. BORDER CROSSINGS[53]



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53 http://www.cn.ca/en/customer-service-border-crossing-map.htm