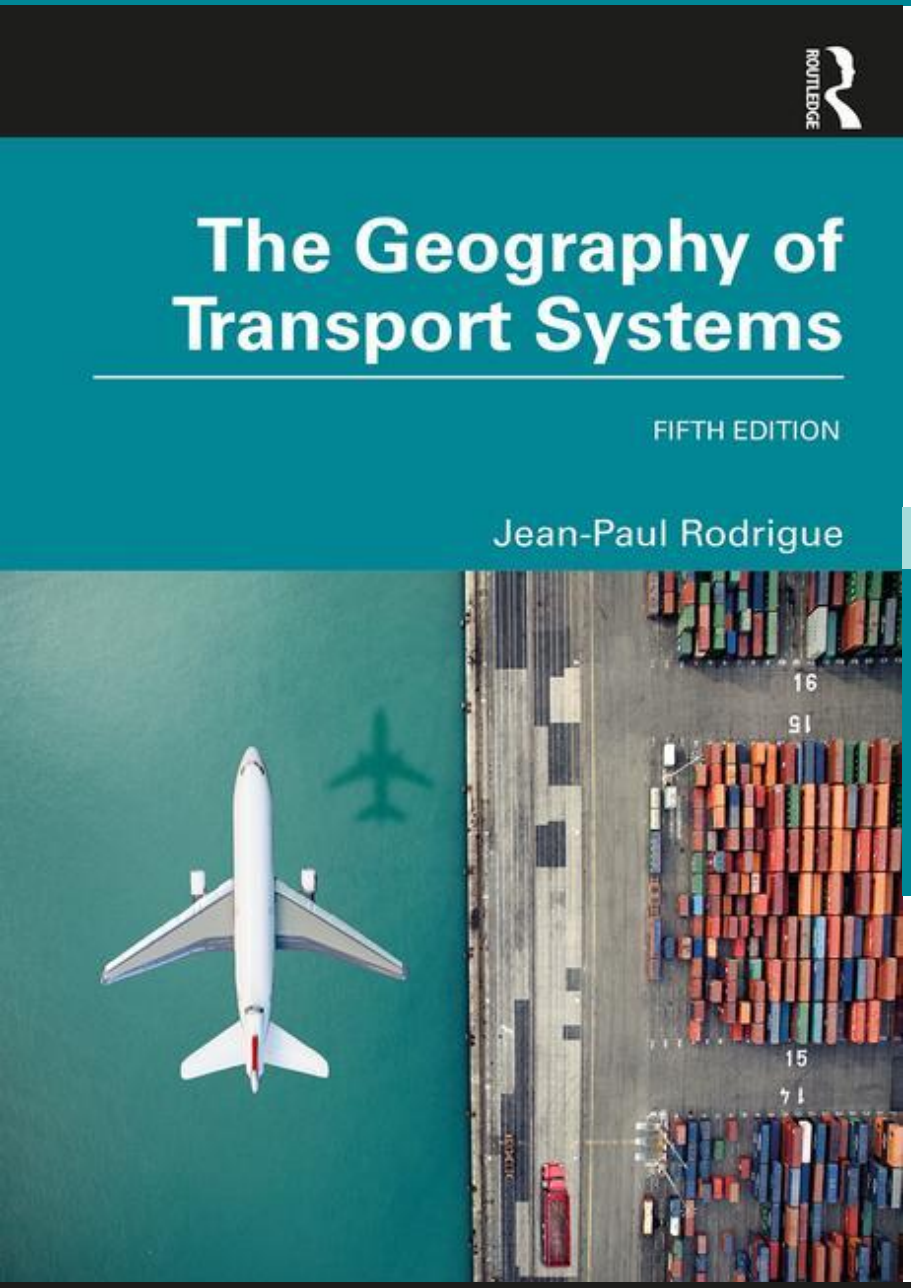

Transportation Modes (Part I)

CHAPTER 5

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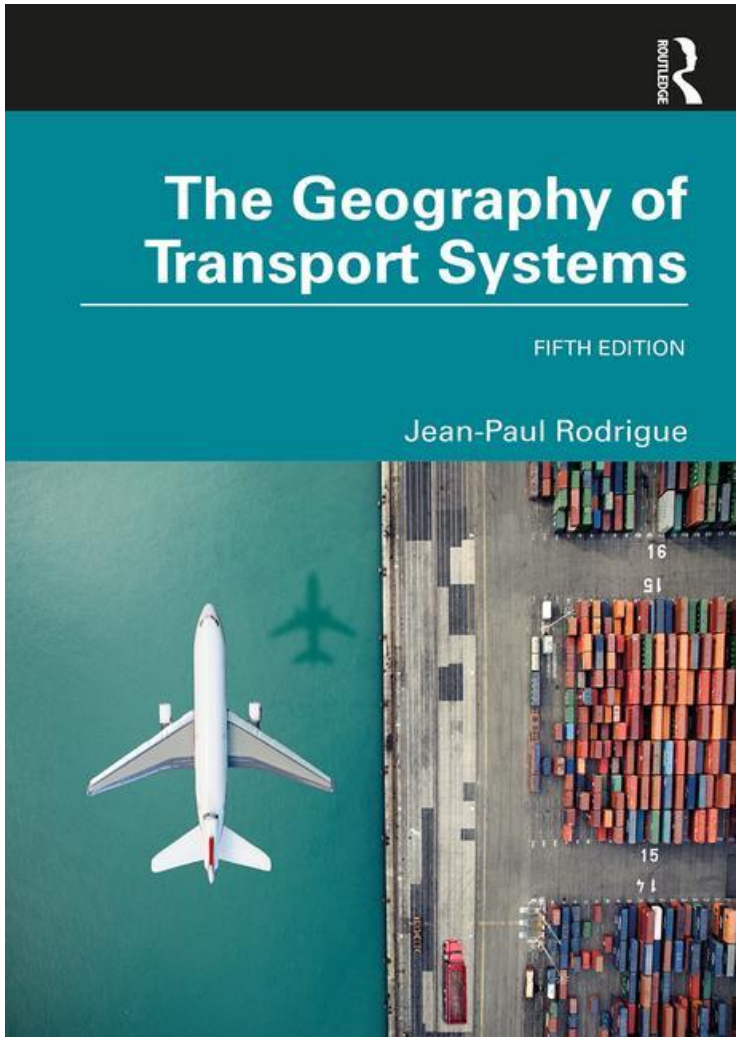
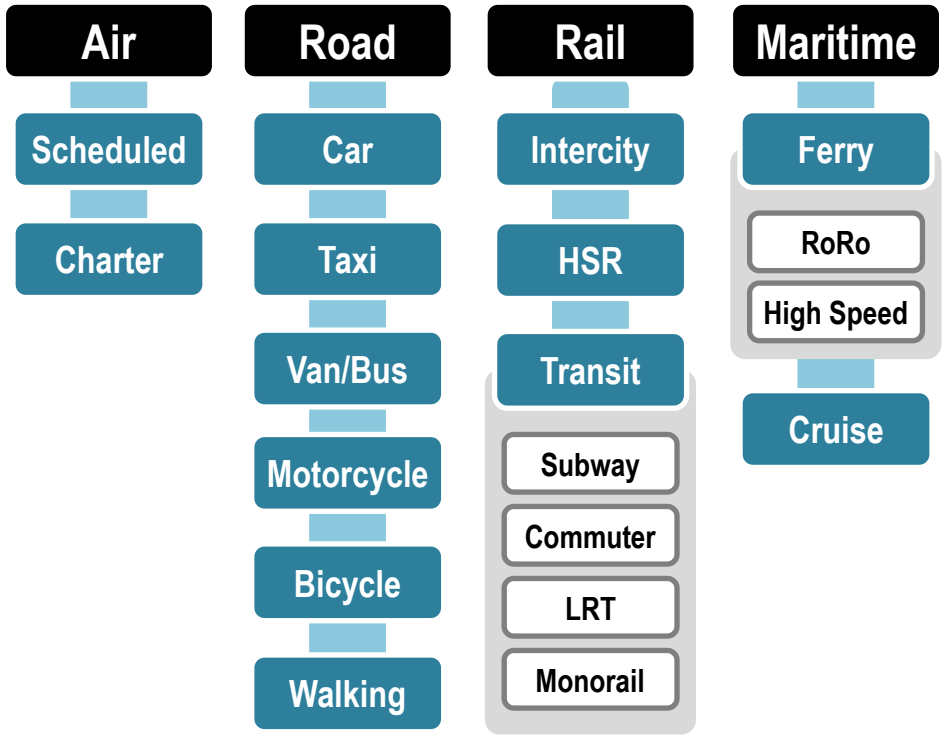
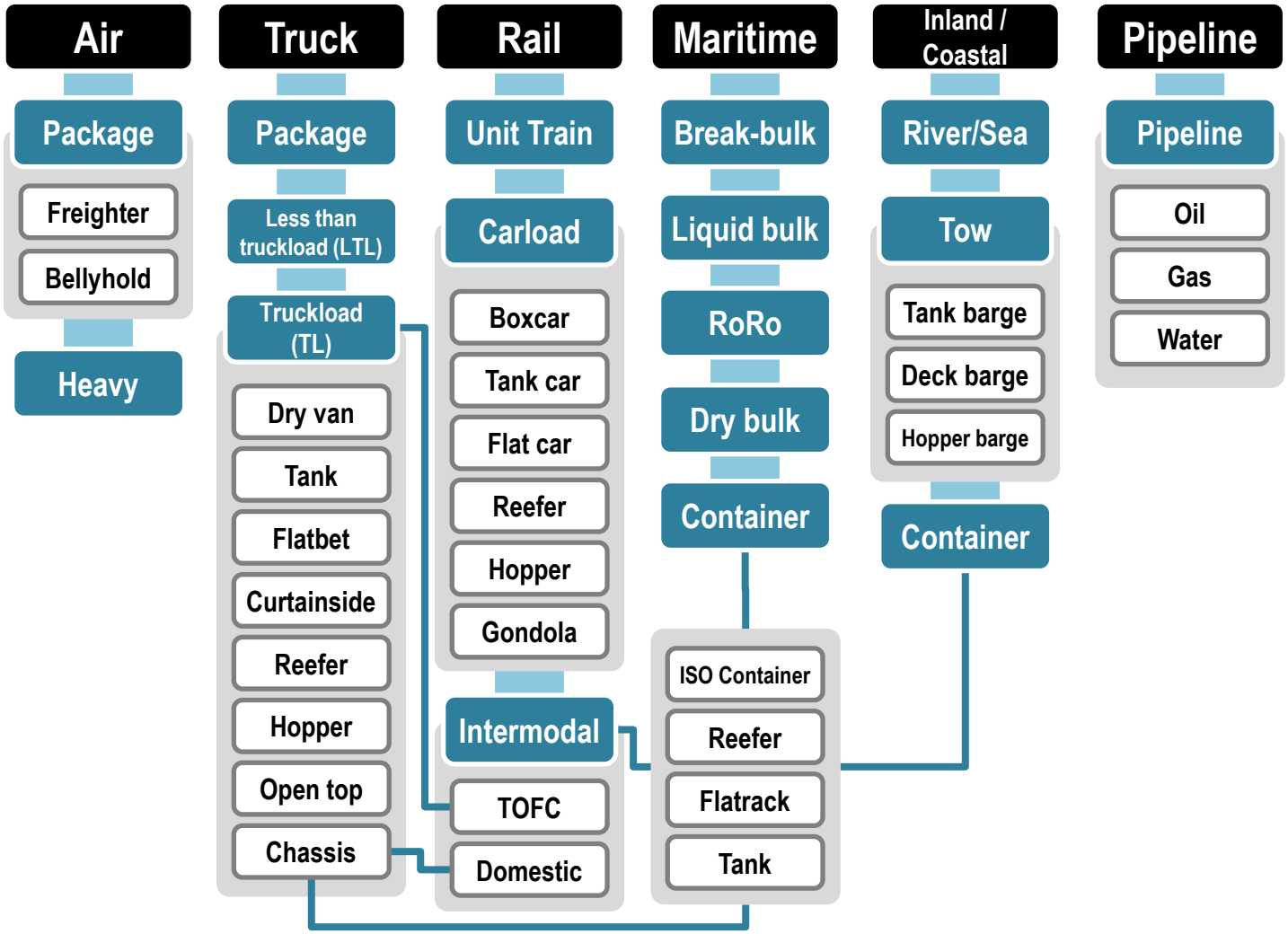


Transportation Modes, Modal Competition and Modal Shift

Main Passenger Modal Options



Main Freight Modal Options



Load of the Global Transport System by Mode

	Tons	Tons-km	Revenue (2004)
Road	?	6,000 to 8,500 billion tons-km	$796 billion
Rail	8,930 million tons	7,773 billion tons-km	$330 billion
Maritime	6,758 million tons (loaded) 6,787 million tons (unloaded)	44,474 billion tons-km	$484 billion

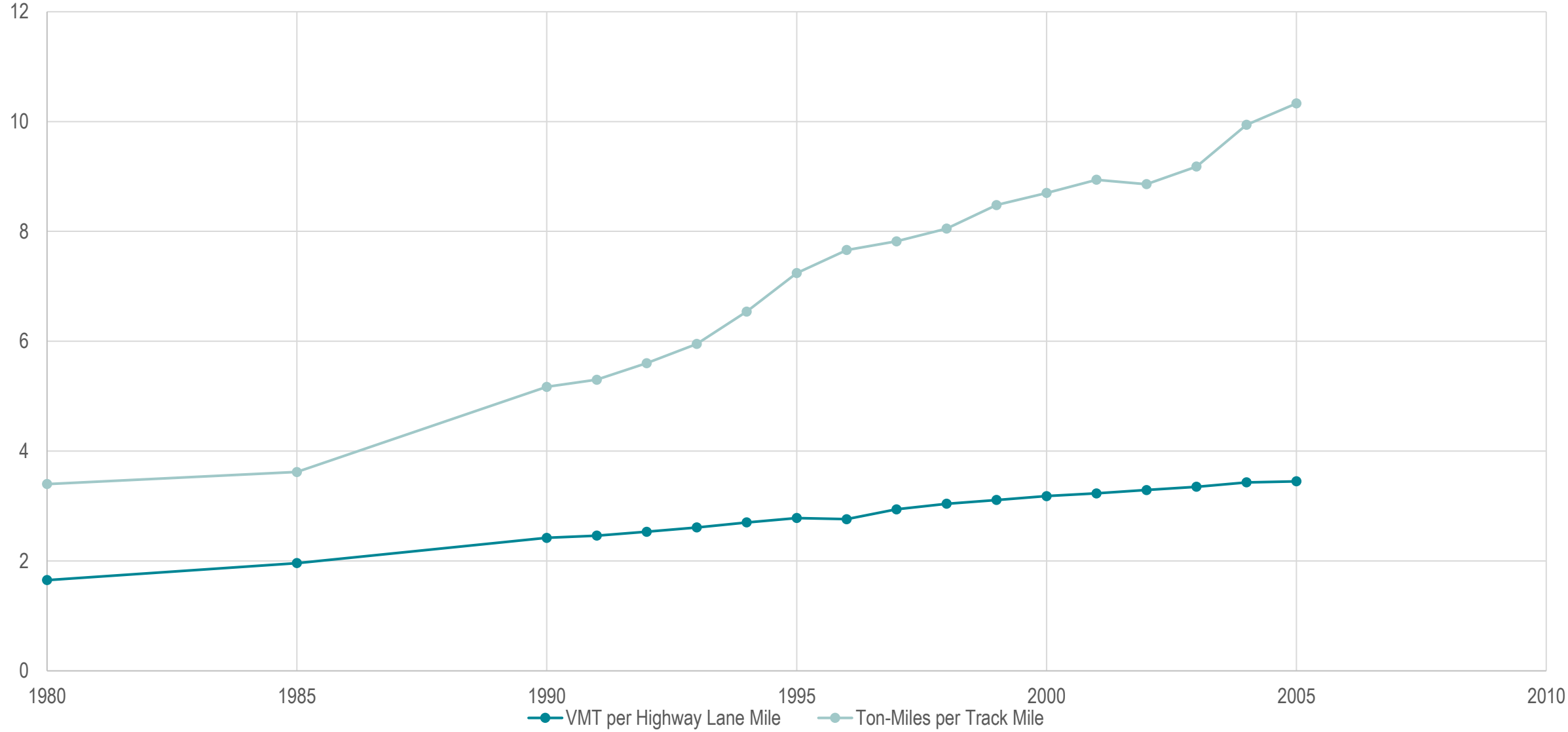
Performance Comparison for Selected Freight Modes

Vehicle	Infrastructure	Capacity	Truck Equivalency
 Barge	Navigation channels, canals, terminals	1500 Tons / 50-100 TEU 52,500 Bushels 453,600 Gallons	57.7 (865 for 15 barges in tow) 18 to 40 (intermodal)
 Hopper car  Doublestack rail car	Tracks, yards and terminals	100 Tons / 4 to 5.3 TEU 3,500 Bushels 30,240 Gallons	2.0 (intermodal) to 3.8
 100 car train unit 100 car intermodal train		10,000 Tons / 400 to 530 TEU 350,000 Bushels 3,024,000 Gallons	385
 Semi-trailer truck	Roads, parking lots and docking bays	26 Tons / 2.65 TEU 910 Bushels 7,865 Gallons 9,000 for a tanker truck	1
 Panamax containership	Navigation channels, canals, terminals	5,000 TEU	2,116
 VLCC		300,000 tons 2 million barrels of oil	9,330
 747-400F	Air corridors, airfields	100-125 tons (Depending on freight density and range)	5

Table 1. Comparing Six Modes of Transport

Transport Mode	US$ Cost per ton-mile	Average Speed	Infrastructure Needs		Efficient scale	Project cargo	Carbon footprint	Market share
			En route	Origin, destination				
Airplanes	>$1	100s of mph	None	Landing strips	<100 tons	Limited	Very large	<10%
Trucks	15-25¢	40-60 mph	Roads	Loading docks	20 - 40 tons	Limited	Large	>50% overland
Rail	3-5¢	>26 mph	Tracks	Stations	>10,000 tons	Yes	Moderate	~20-40% overland
Ships and Barges	<1¢	~12-15 mph	None	Ports and terminals	25,000 - 100,000+ tons	Yes	Small	<5% overland 90%+ over water
Pipelines (fluids only)	~1¢	3-6 mph	Pipe- line	Staging areas, storage tanks	1,000s of tons per day	No	Slight	Dominant for petroleum
Giant Airships	<25¢, possibly as low as 10¢	~90 mph	None	Mooring and transloading sites	30-200+ tons	Yes	Small to none	???

Evolution of American Road and Rail Traffic Density, 1980-2005 (in millions)



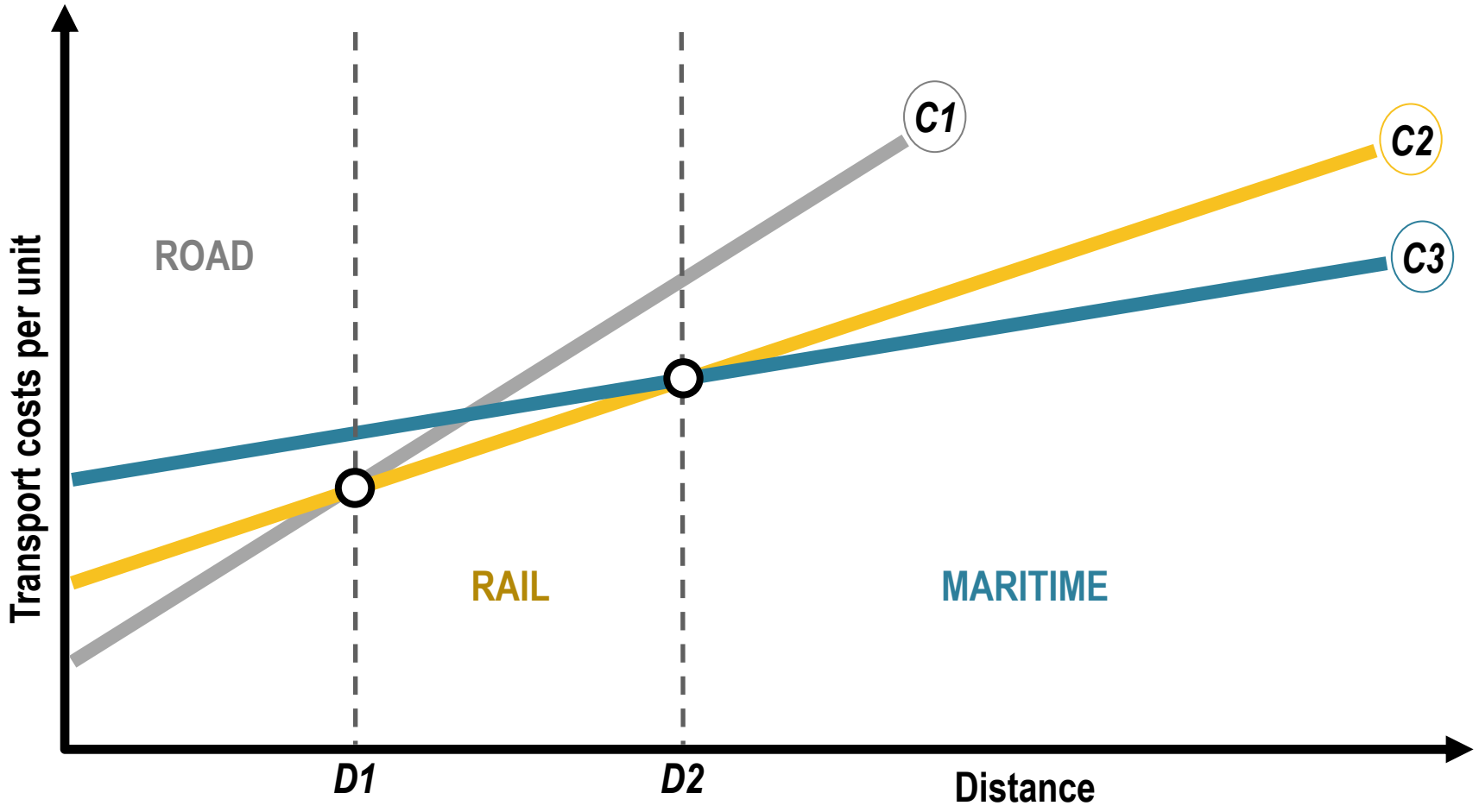
Comparison of the Relative Efficiencies of Rail and Trucking in the United States

Mode	Fuel Consumption	Infrastructure Capacity	Costs	Safety
Railroad	455 ton-miles per gallon	216 million tons per mainline per year	2.7 cents per ton-mile	0.61 fatalities per billion ton-miles; 12.4 incidents per billion ton-miles
Trucking	105 ton-miles per gallon	37.8 million tons per lane per year	5.0 cents per ton-mile	1.45 fatalities per billion ton-miles; 36.4 incidents per billion ton-miles

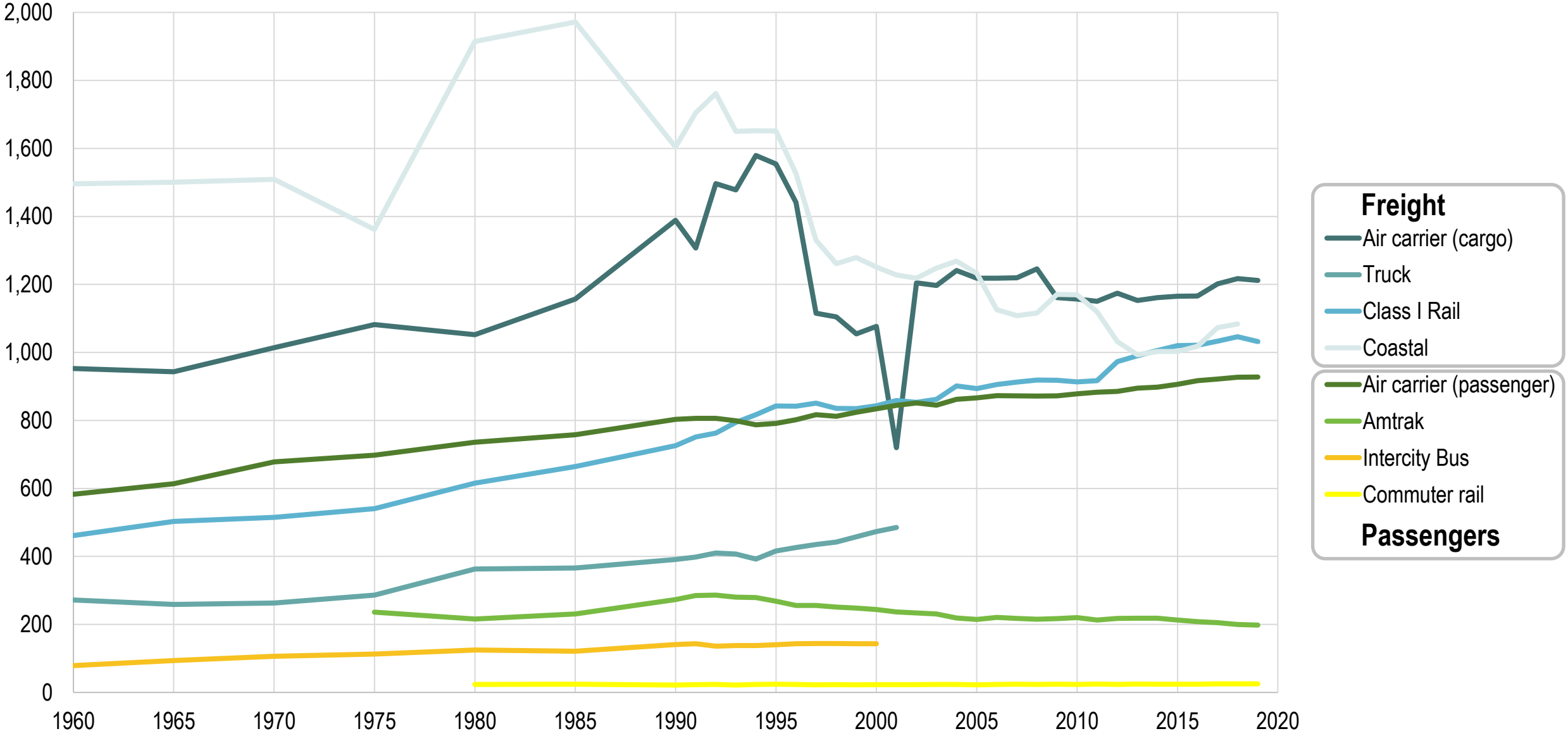
Modal Profile of Freight Transportation, United States

Mode	Value	Volume	Service	Distance
Truck	Moderate to high	Loads of less than 50,000 lbs.	On-time performance above 90%.	Driver can go 500 miles per day. 2/3 of tonnage carried over less than 100 miles.
Rail	Moderate to low	Multiple car loads. No weight restrictions.	4 to 7 days delivery time. 60 to 85% on-time performance.	Average haul length between 600 and 800 miles.
Intermodal	Moderate to high	No weight restrictions.	3 days for cross country. On-time performance between truck and rail.	Average haul between 700 and 1,500 miles.
Air	High	Small. Most loads less than 100 lbs.	Normally overnight or second day.	More than 1,300 miles.
Inland Water	Moderate to low	Bulk shipments.	Varies according to segment. Competitive with rail.	Between 250 and 1,600 miles.
Coastal Water	Moderate to low	Containers, general freight and bulk shipments.	Function of distance. Between 2 to 5 days.	Between 500 and 2,000 miles.
International Water	High to low	Mainly containers and bulk shipments.	7 to 10 days trans-Atlantic and trans-Pacific routes.	More than 2,600 miles.
Pipeline	Low	Bulk shipment of liquids and gazes.	According to demand. 0 to 20 mph.	825 miles average distance for crude oil.

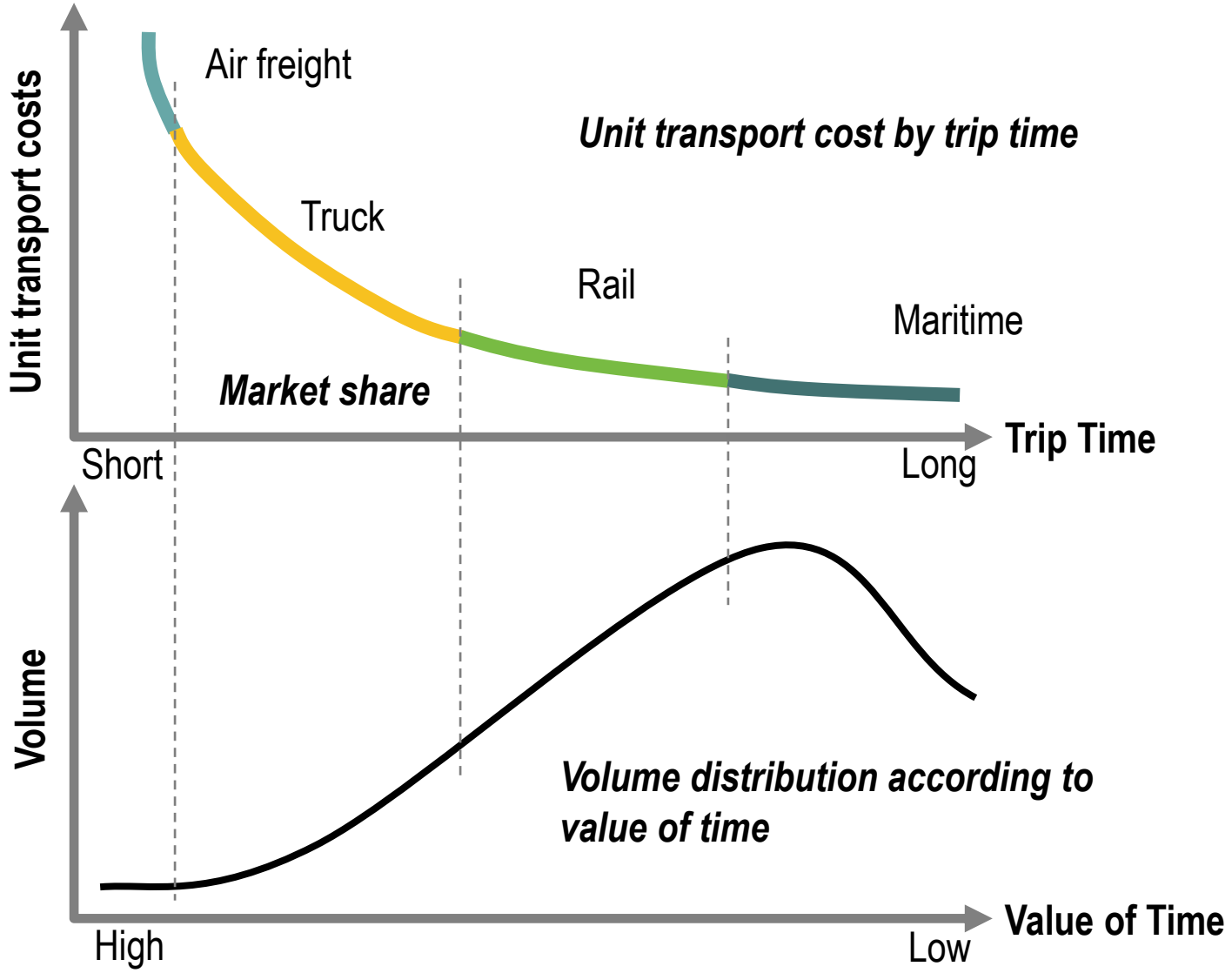
Distance, Modal Choice and Transport Costs



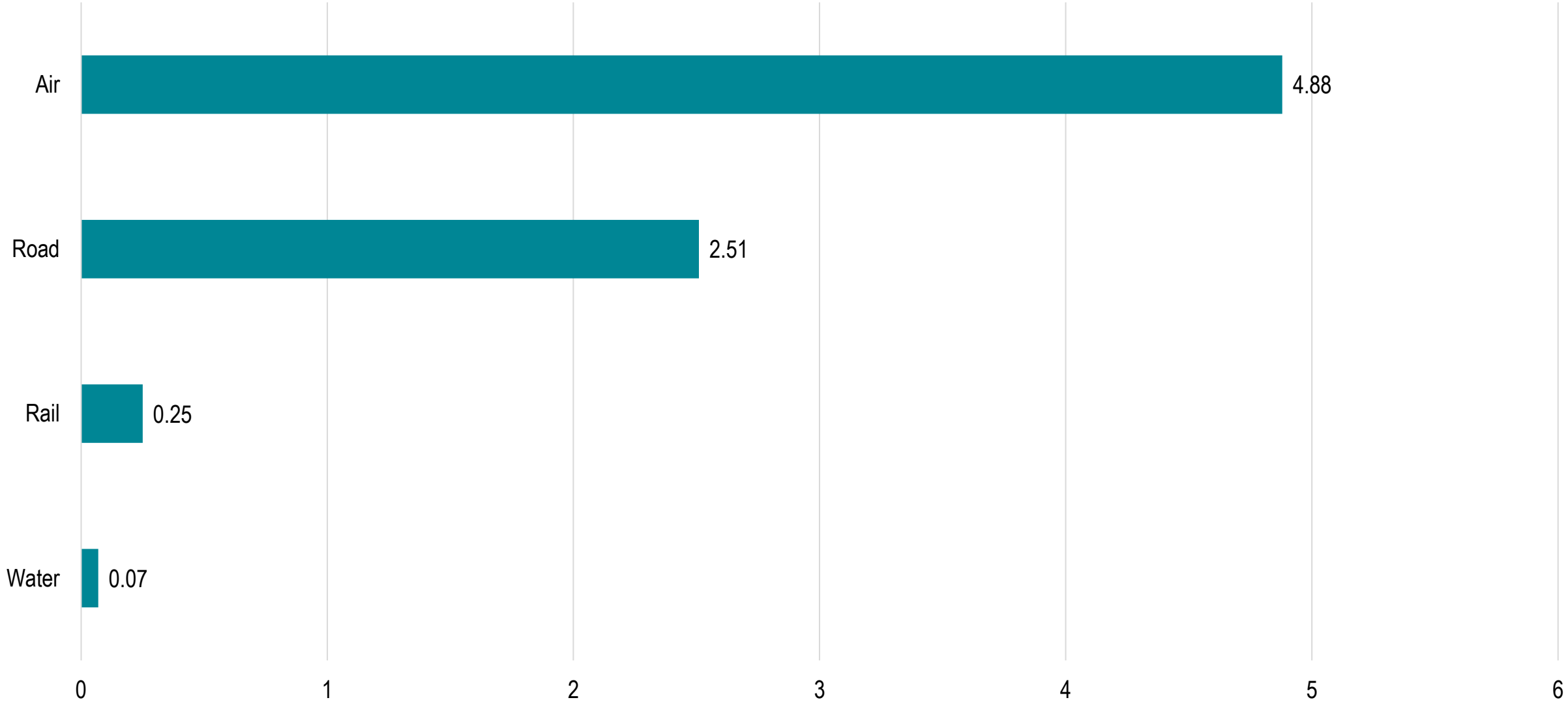
Average Length of Haul, Domestic Passenger and Freight Transport, United States, 1960-2019 (in miles)



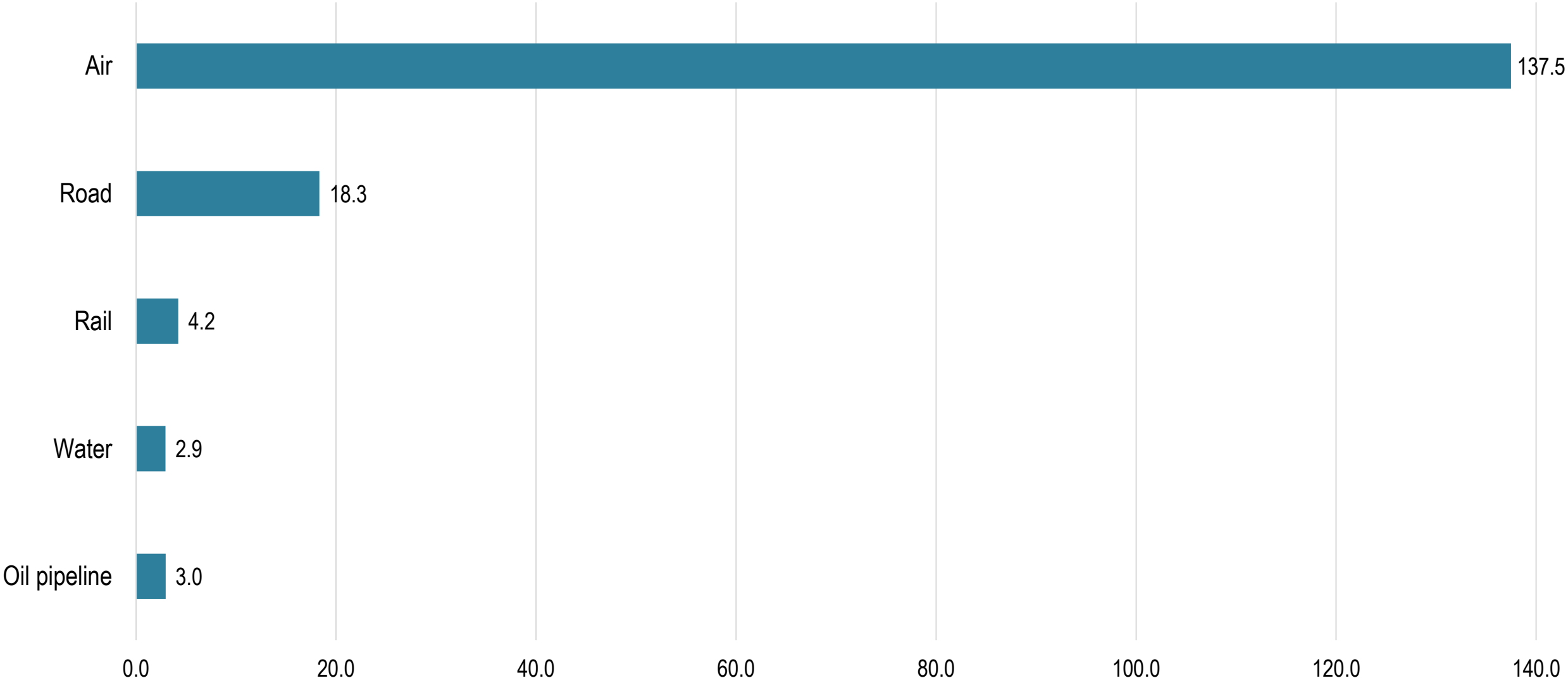
Distribution of Freight Demand by Mode



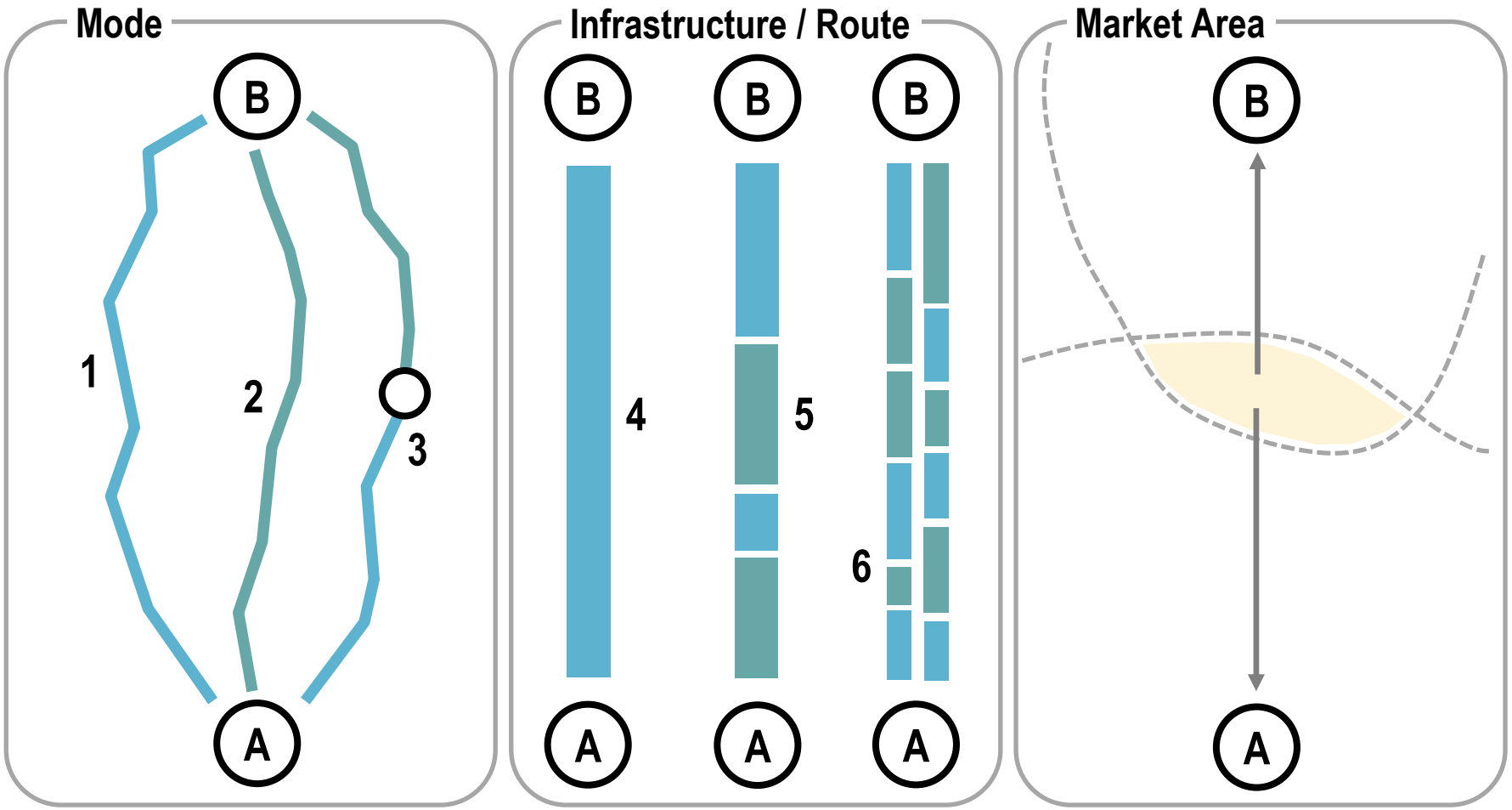
Freight Transport Costs in Cents per Ton-Mile



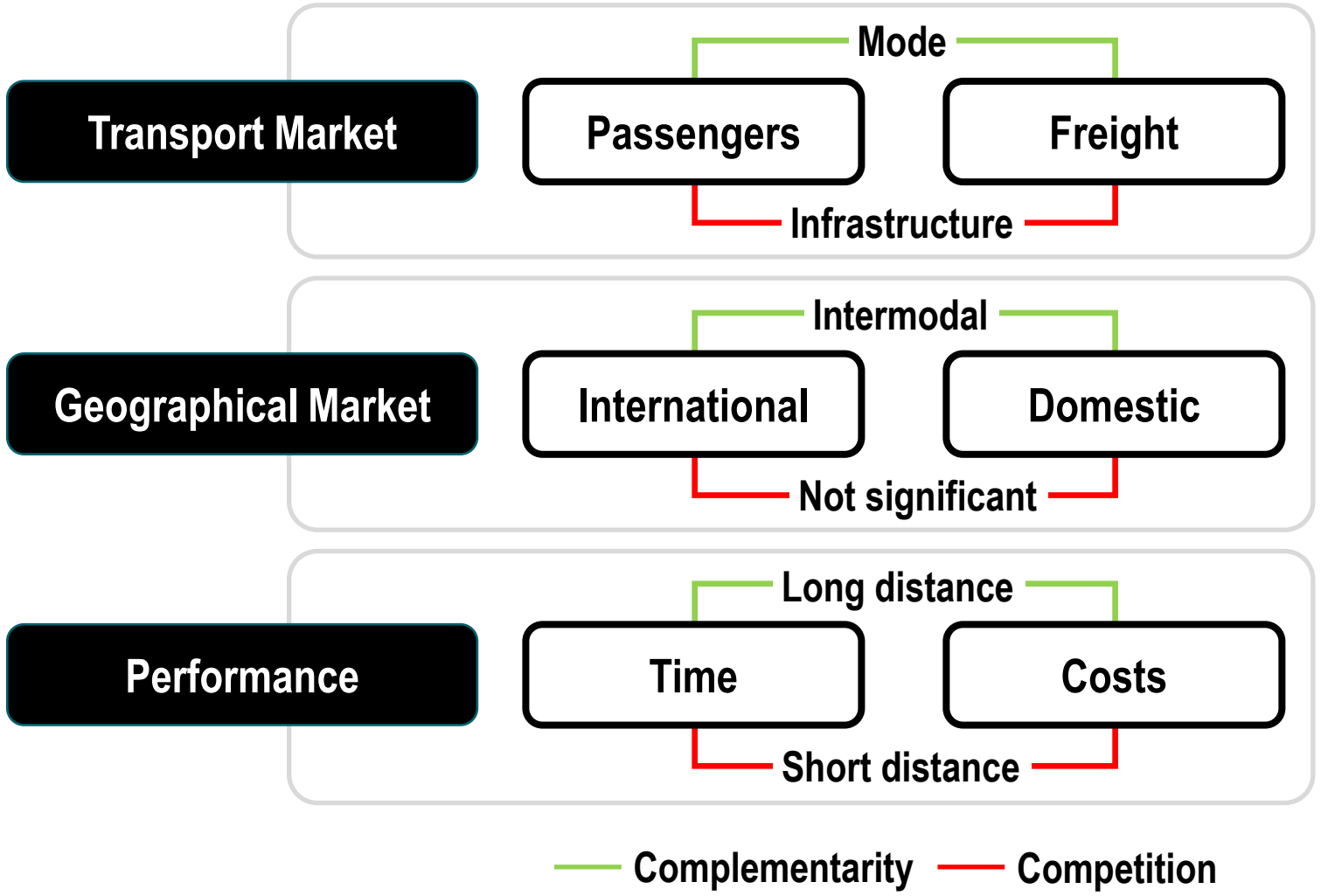
Freight Revenue in Cents per Ton-Mile



Forms of Modal Competition



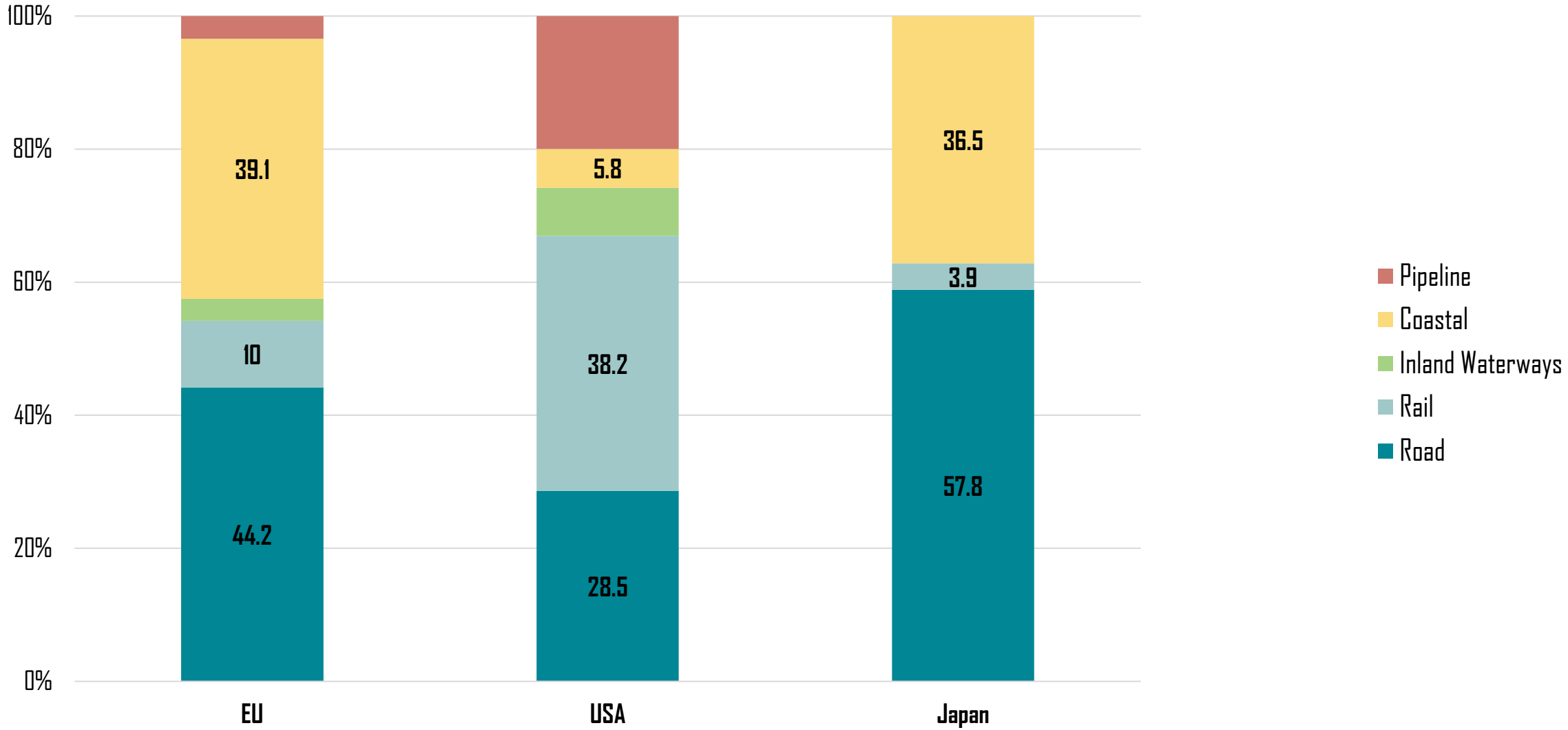
Modal Competition and Complementarity



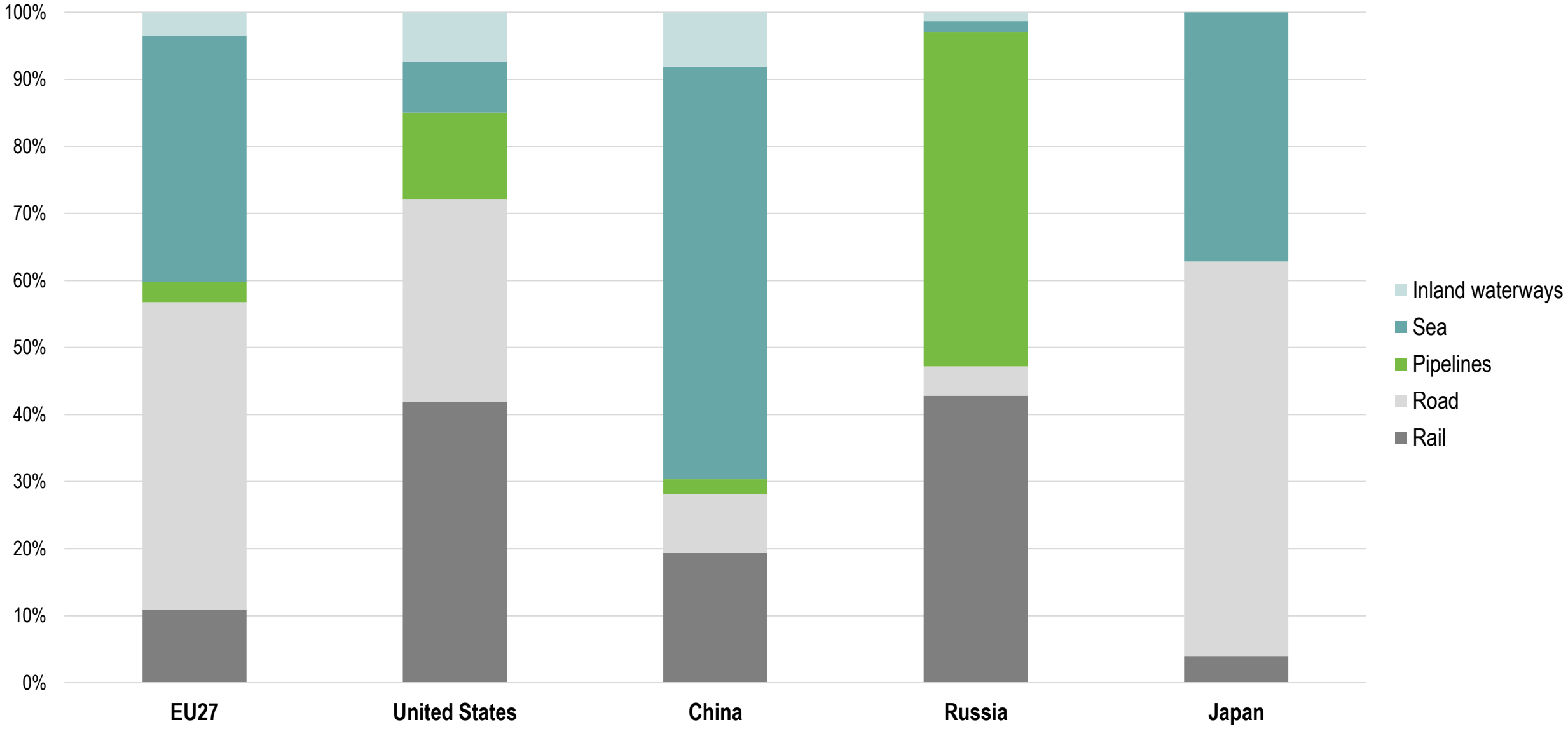
Four Travel Options between New York and Boston, 2004

Mode	Price (one way)	Time
LimoLiner (luxury bus)	$69	4 hours
Acela (Amtrak train)	$99	3 hours
Greyhound bus	$30	4 hours
Air Shuttle	$128	1 hour (plus check in)

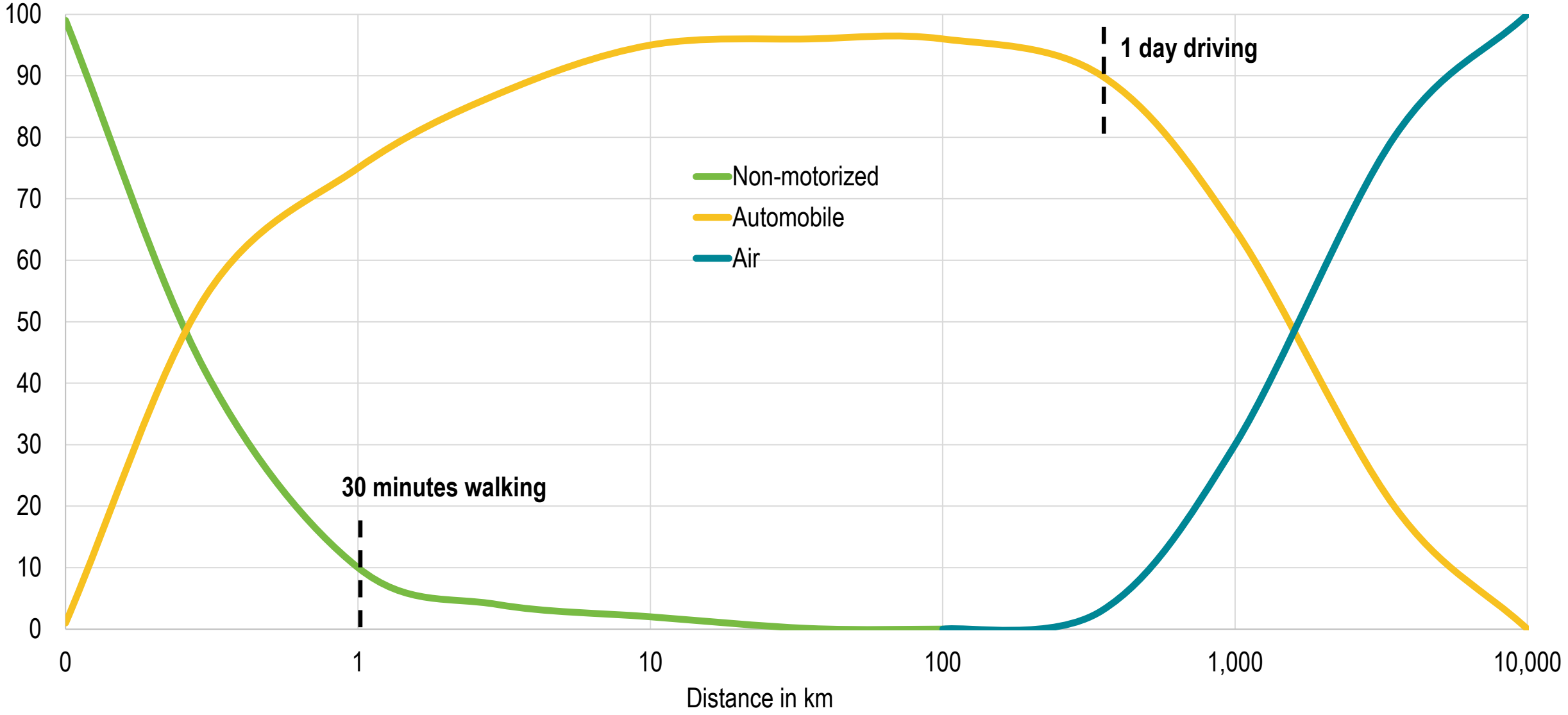
Modal Split in the EU, United States and Japan, 2005 (in % of ton-km)



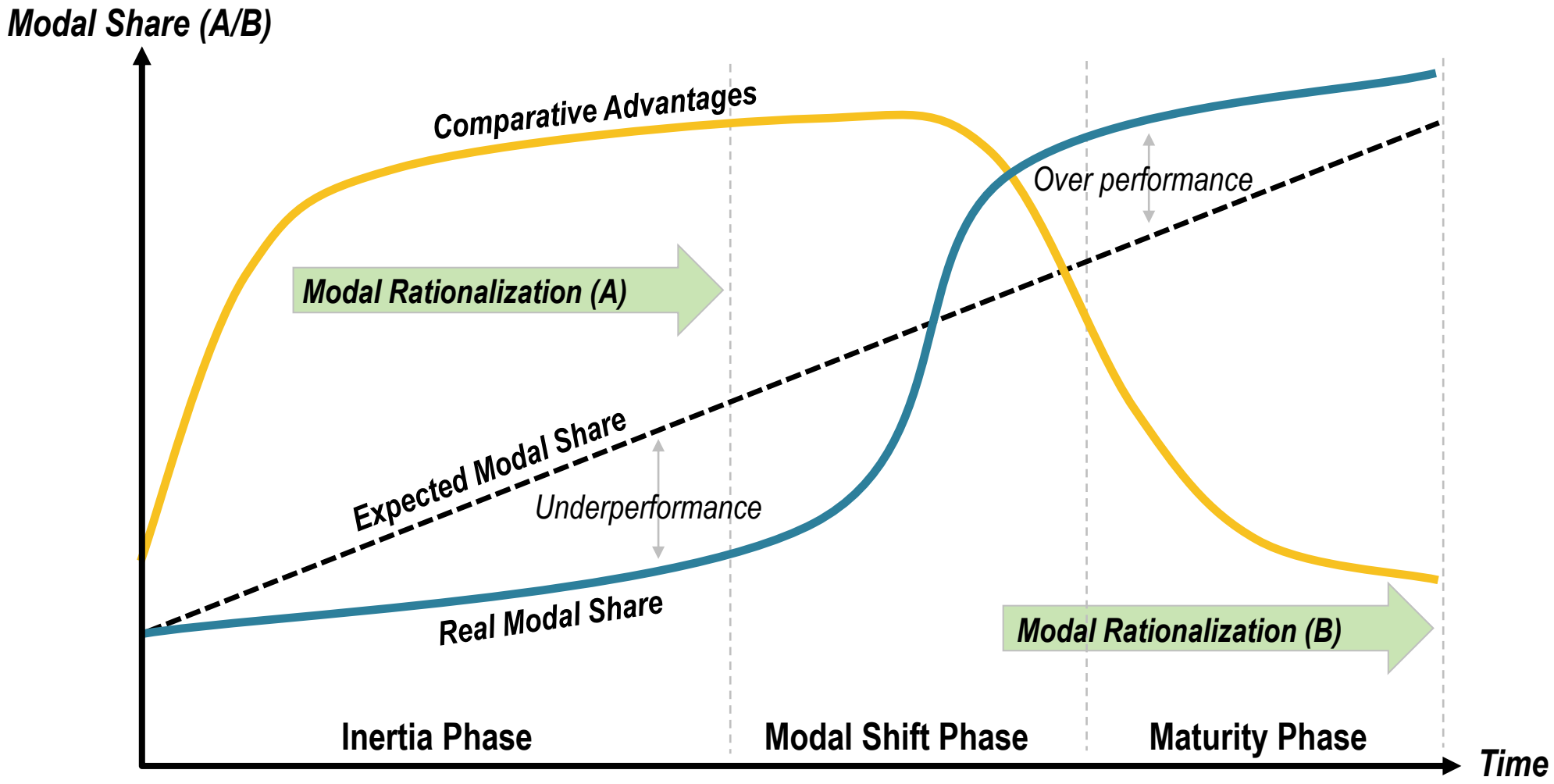
Modal Share of Freight Transportation, Selected Countries, 2008 (in % of ton-kms)



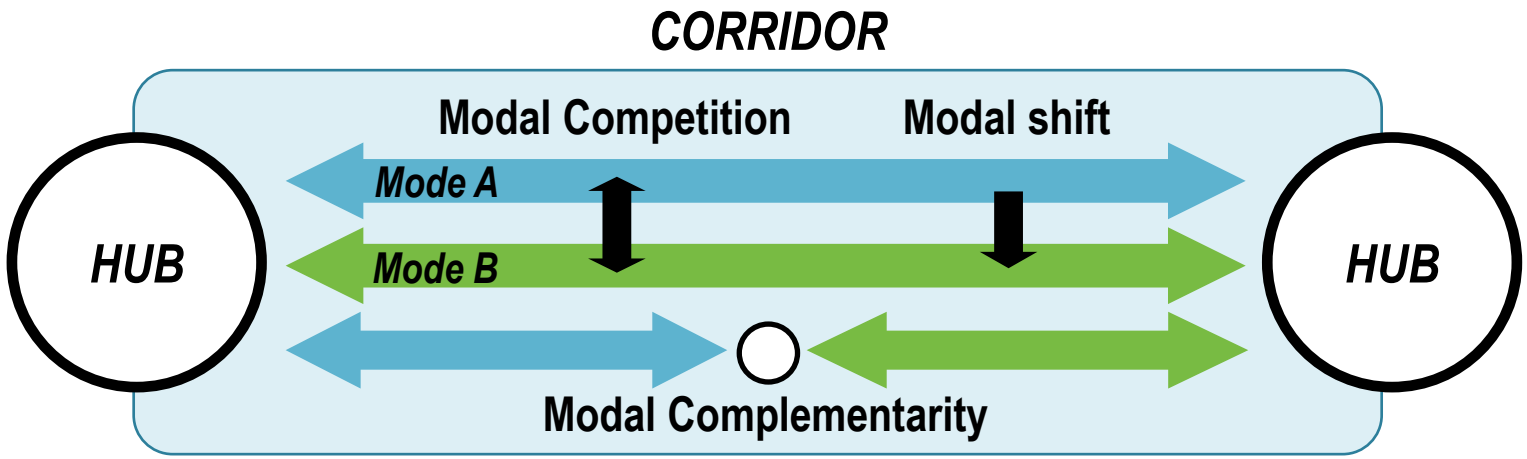
Modal Split in the United States by Passenger Travel Distance, 1995



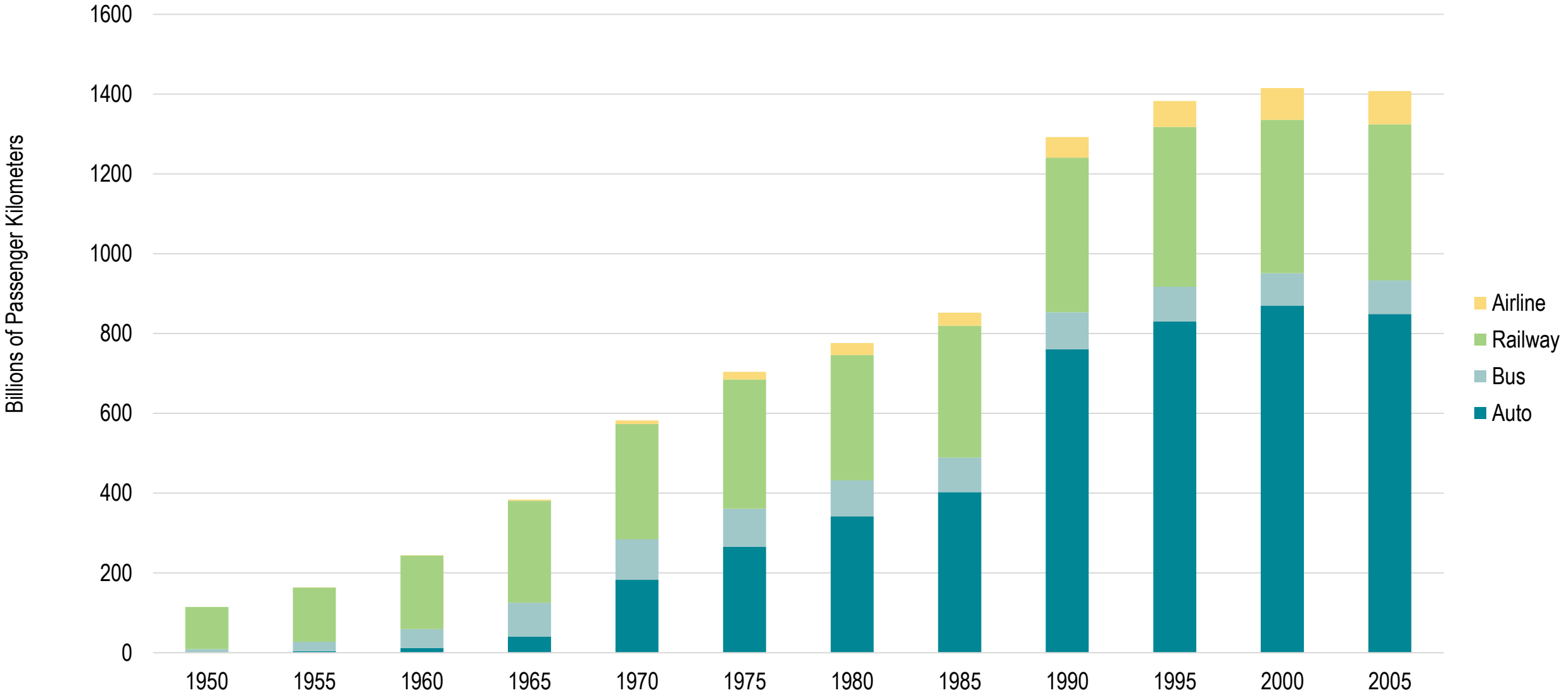
Principles of Modal Shift



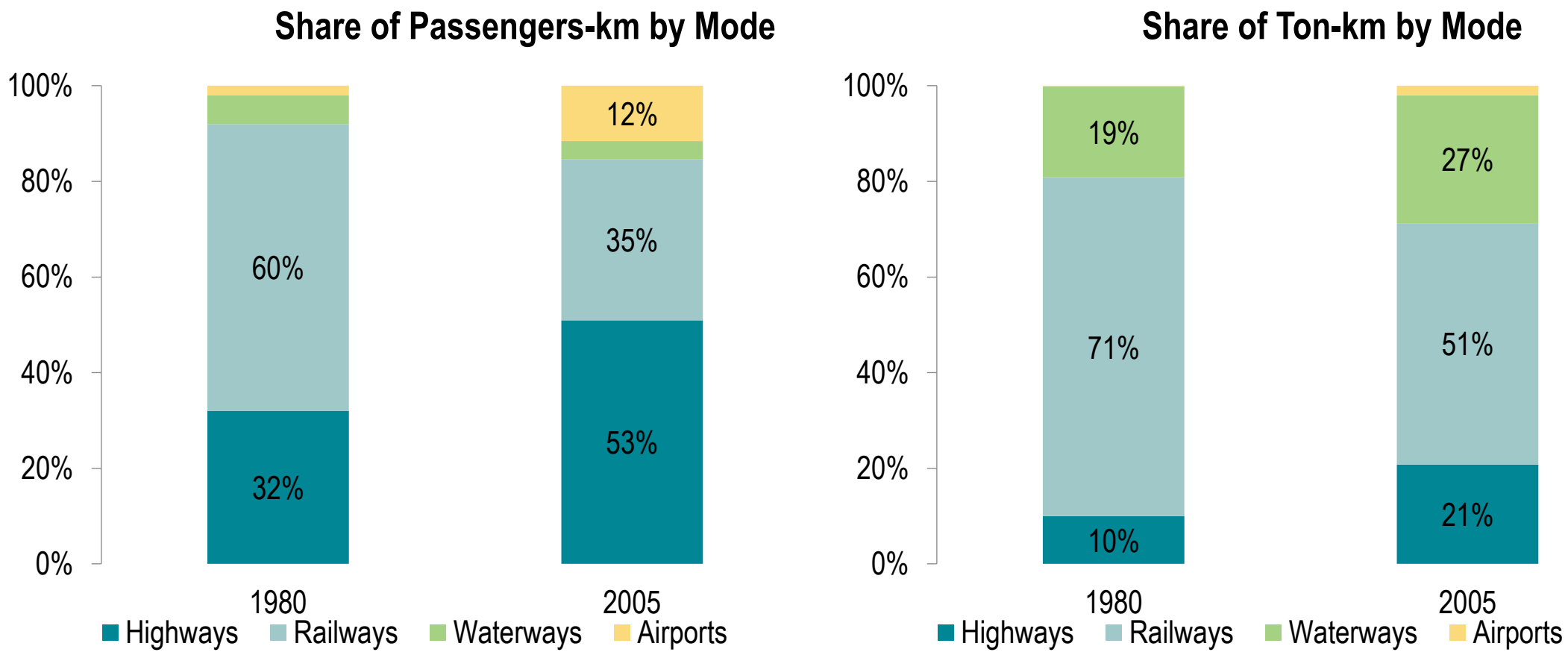
Modal Competition, Complementarity and Shift along a Corridor

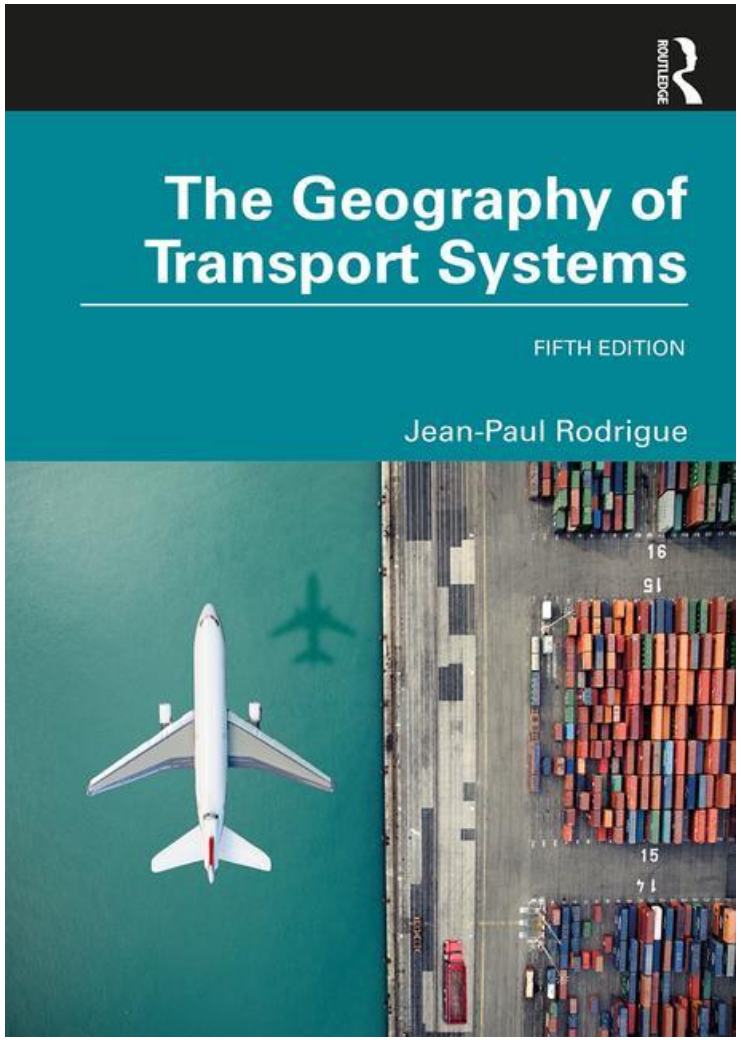


Passenger Transport by Mode, Japan, 1950-2005



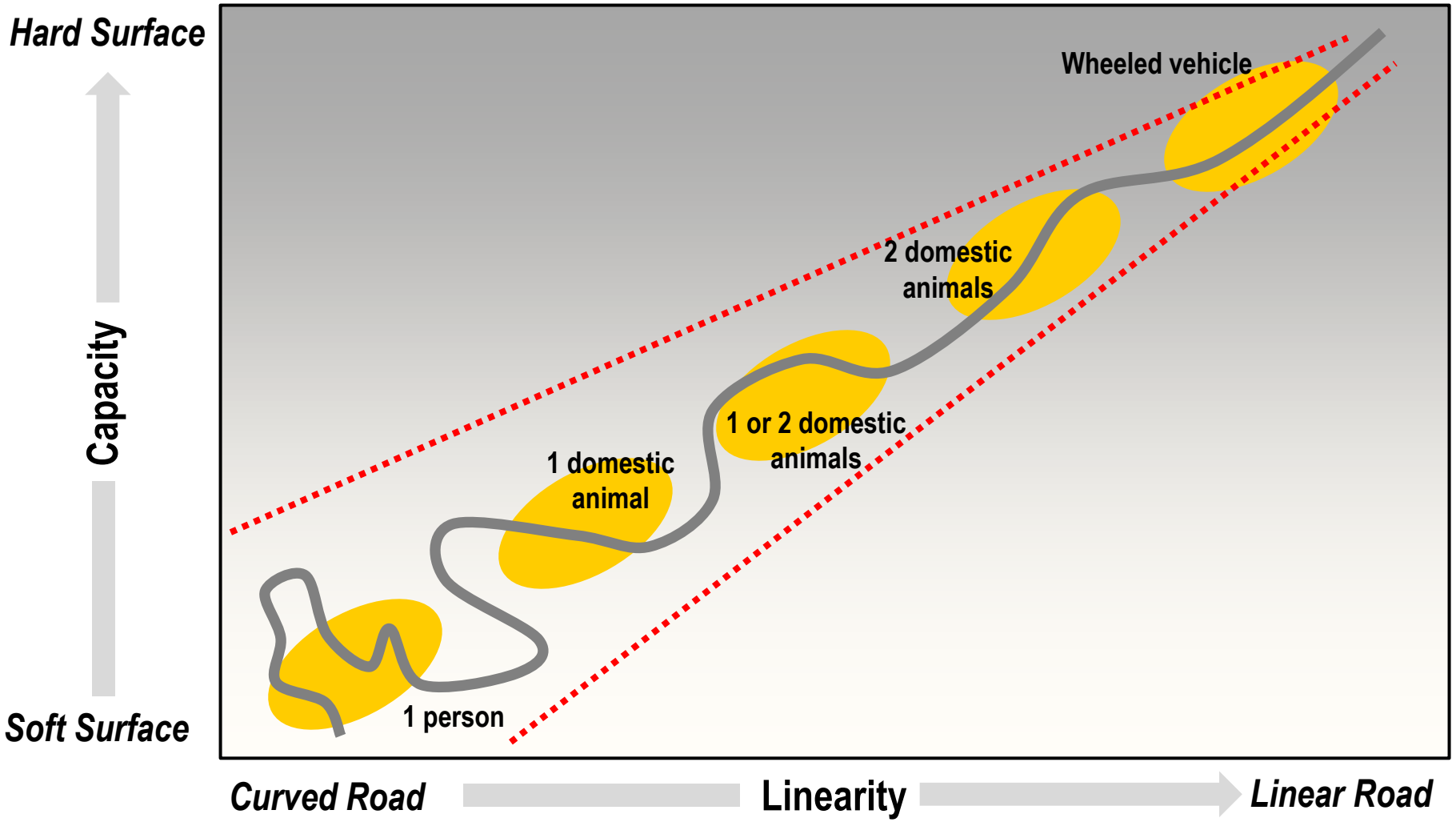
Modal Shift in China, 1980-2005





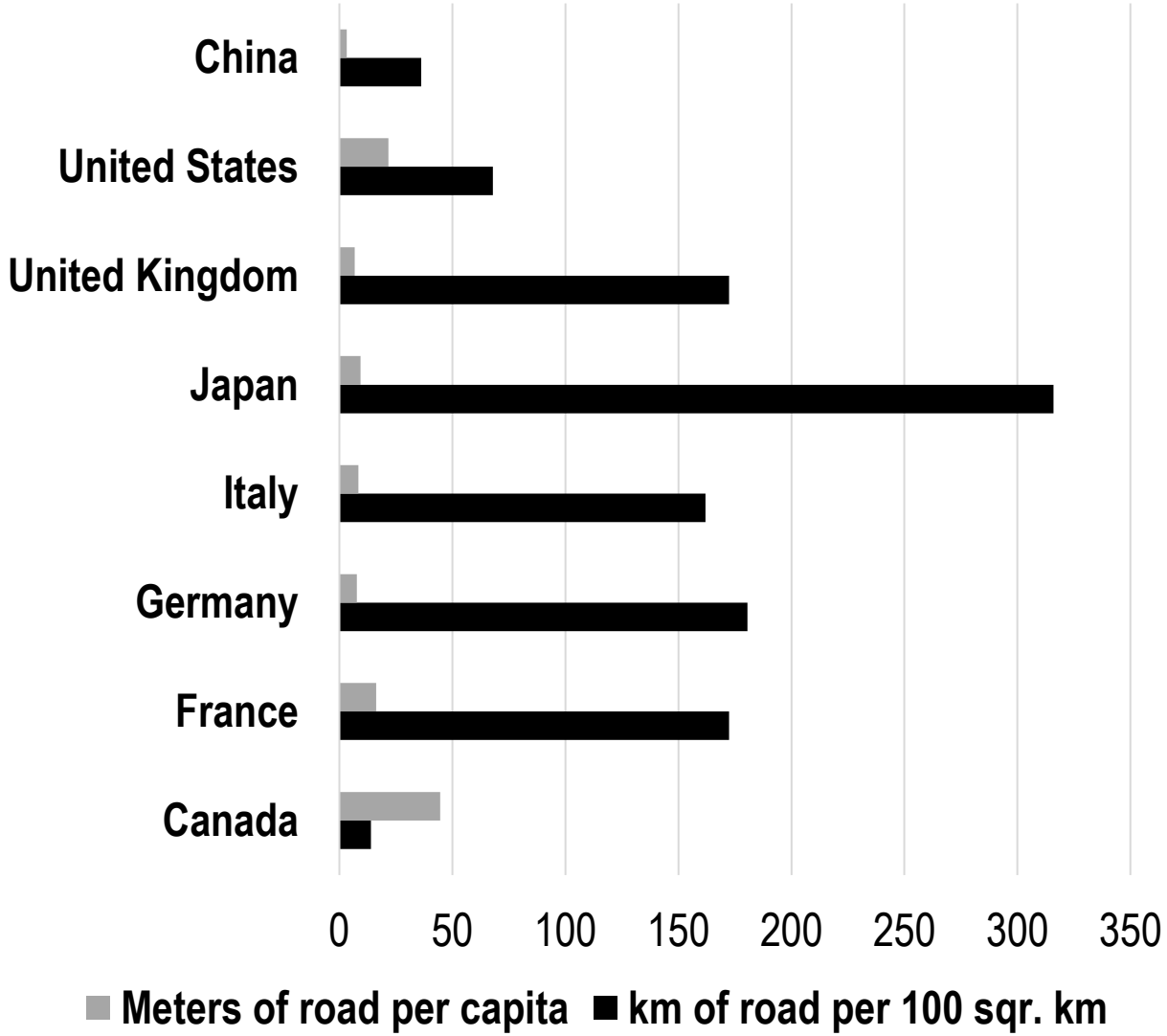
Road Transportation

Linearity, Capacity and Surface of Roads



World Road Network

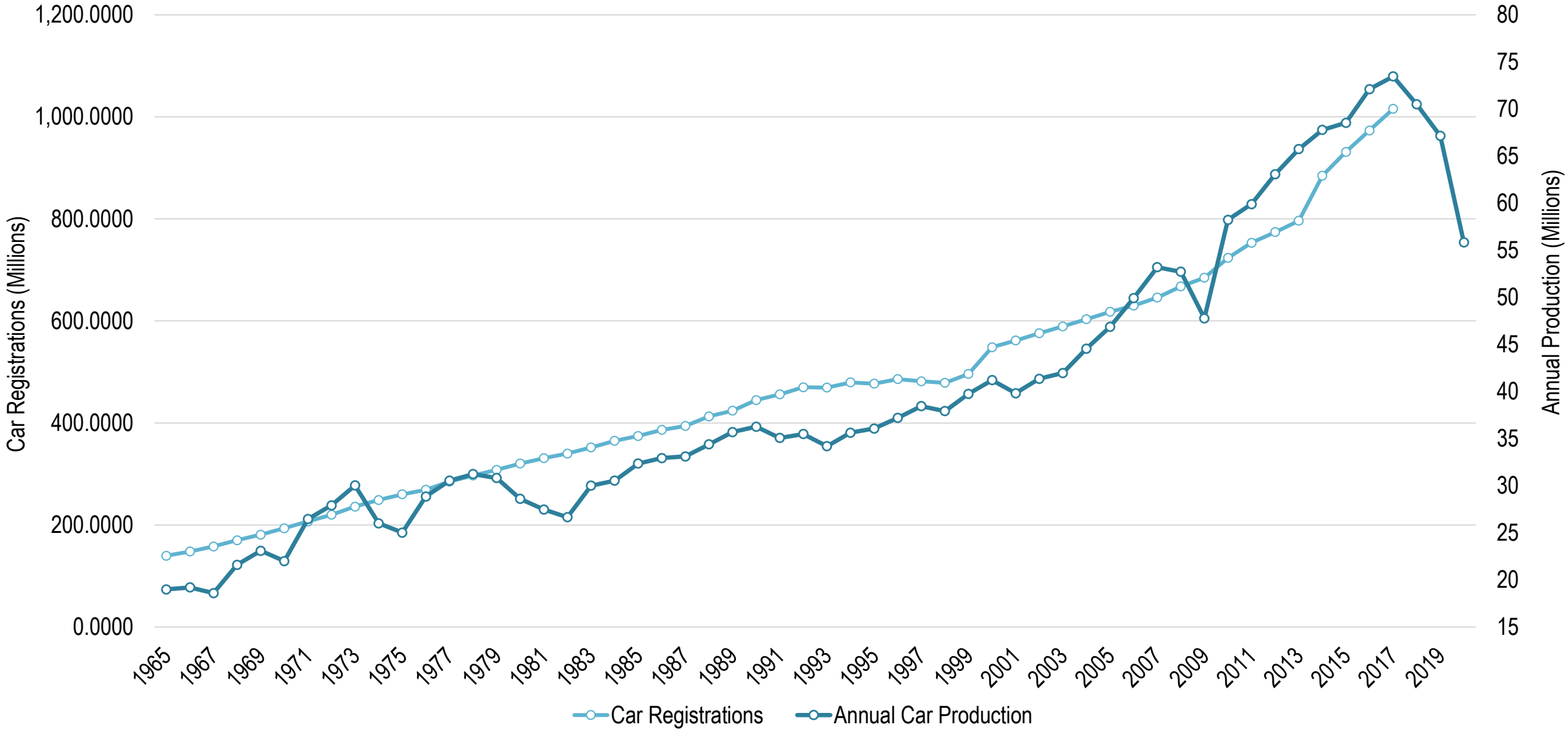
Road Transport Density Measures, 2000s



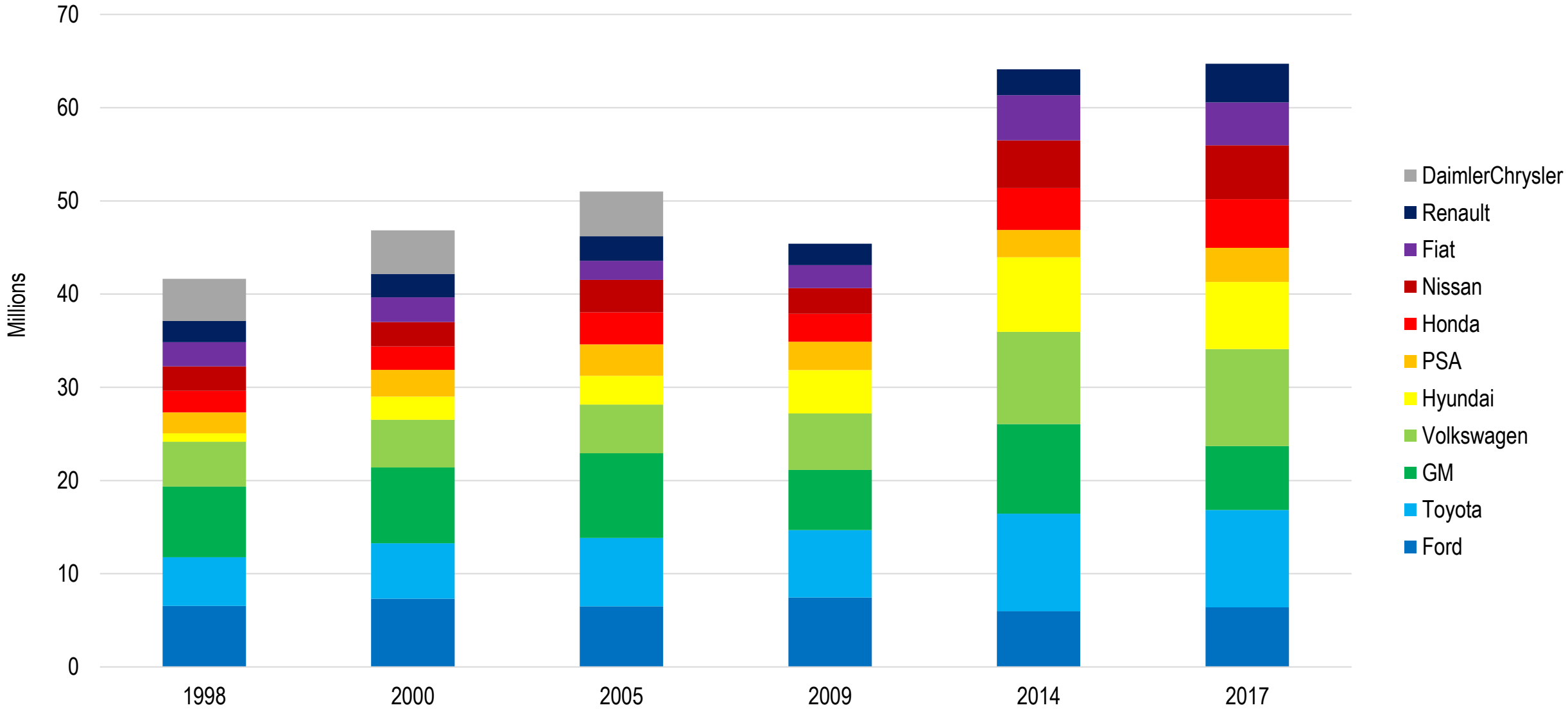
European and North American Crossborder Road Networks

	Trans-European Networks (TEN)	North American Corridors
Governance	Assigned by treaty to national governments.	Assumed by promoters; national governments not directly involved
Management	Second level Nomenclature of territorial units for statistics (NUTS-2)	State Departments of Transportation (DOT)
Financing	European Commission. National governments.	Federal governments
Purpose	Pan-European connectivity. Improving flows.	Competitiveness. Trade.
Border	Attention/improvements not always crossborder; could be internal to a country	Borders (international or interstate) are important elements
External links	Reaching Central and Eastern Europe	Canada-U.S.-Mexico only

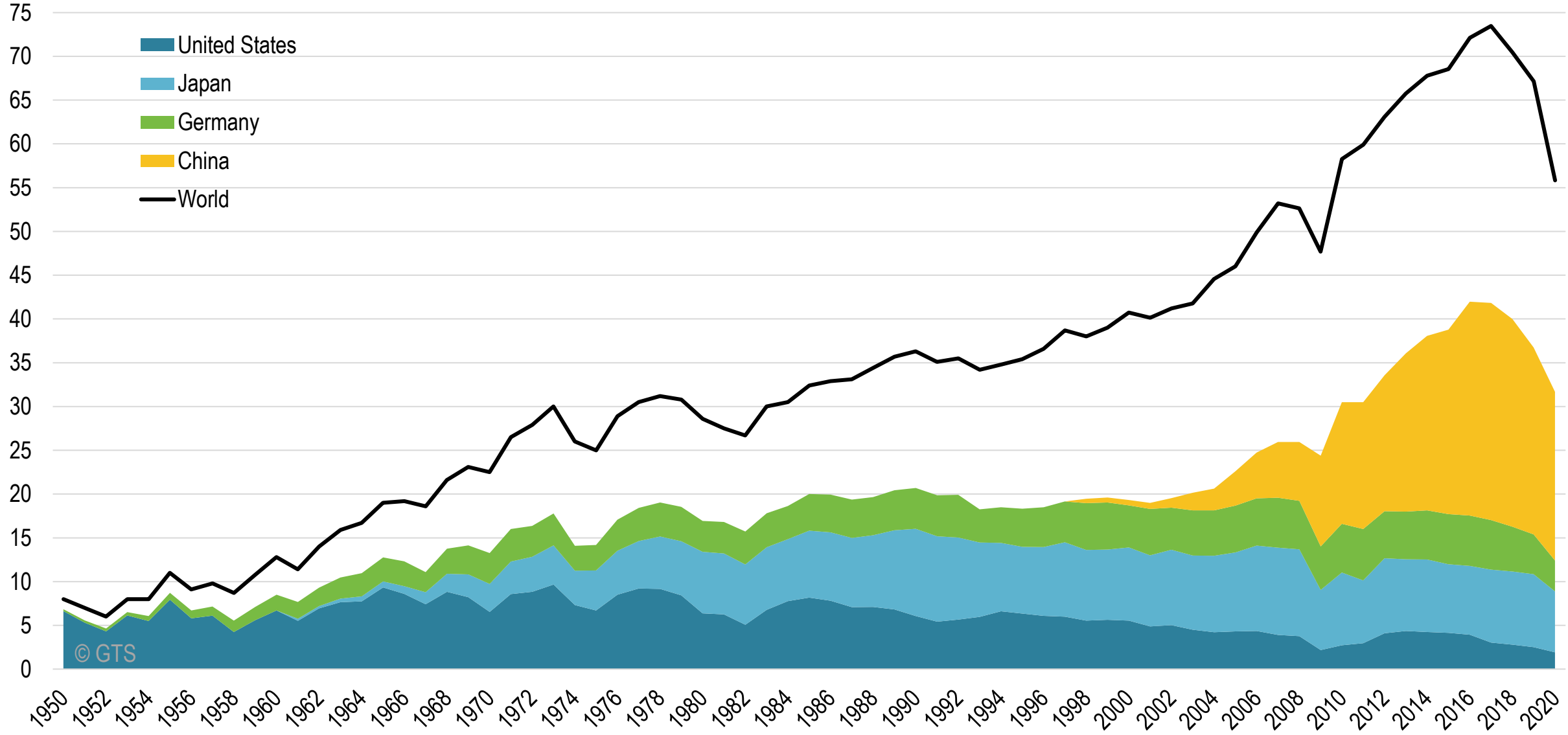
World Automobile Production and Fleet, 1965-2020



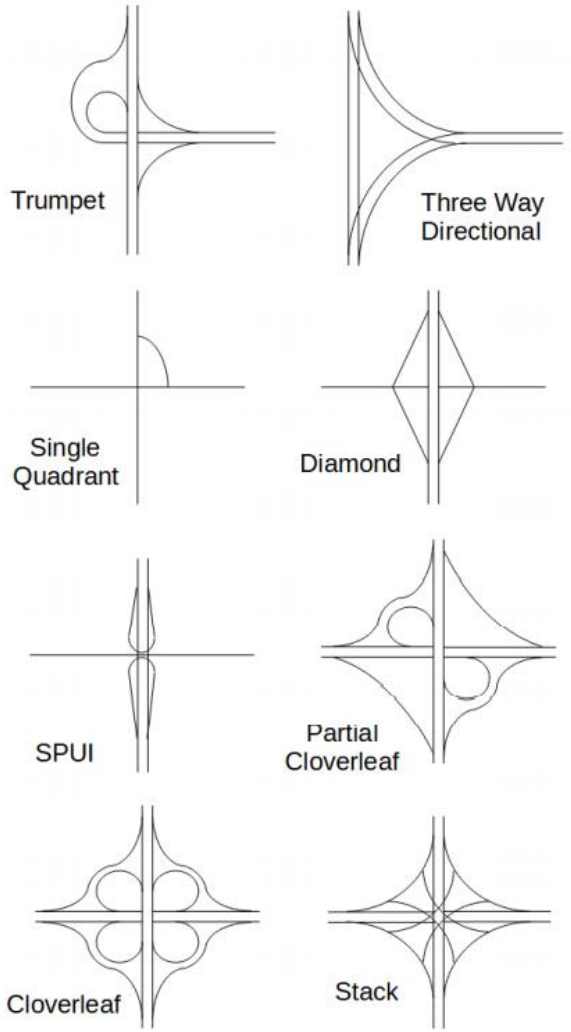
Global Motor Vehicle Production per Manufacturer, 1998-2017

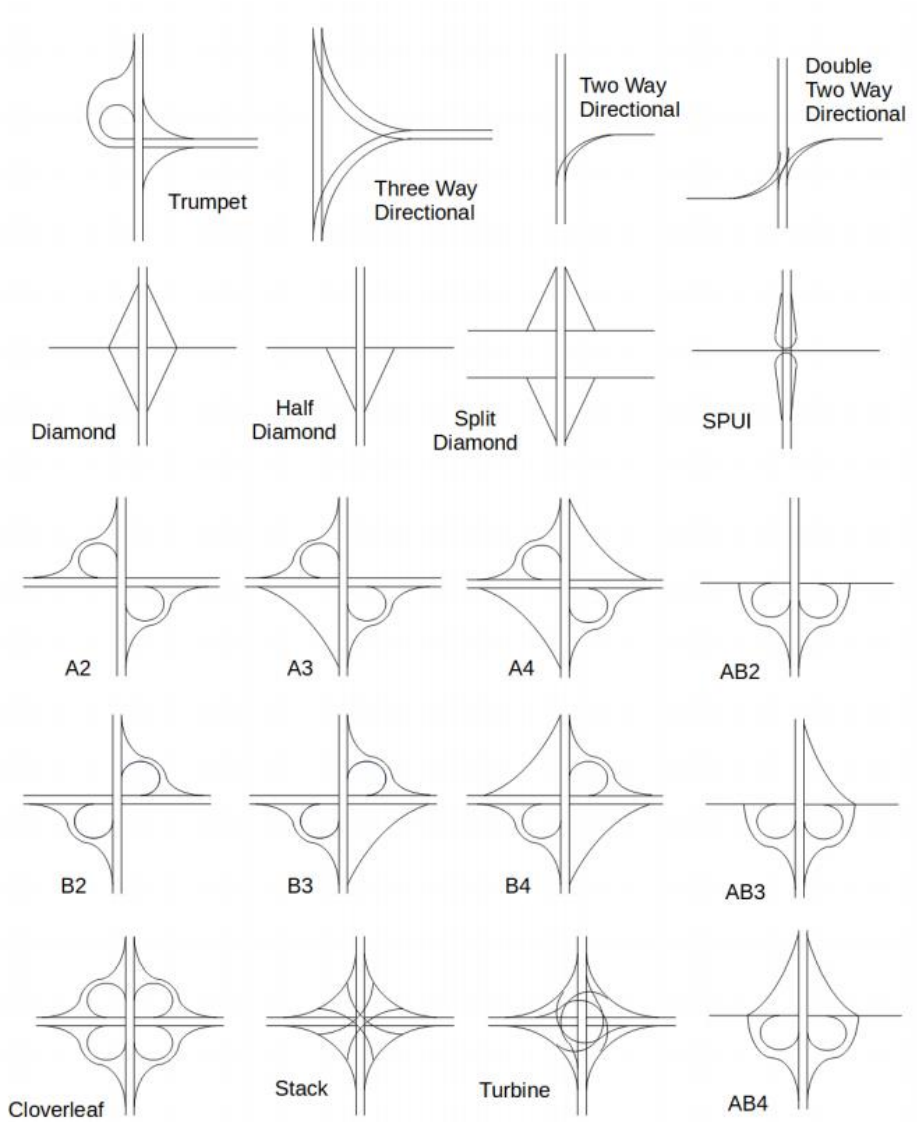


Automobile Production, Selected Countries,1950-2020 (in millions)

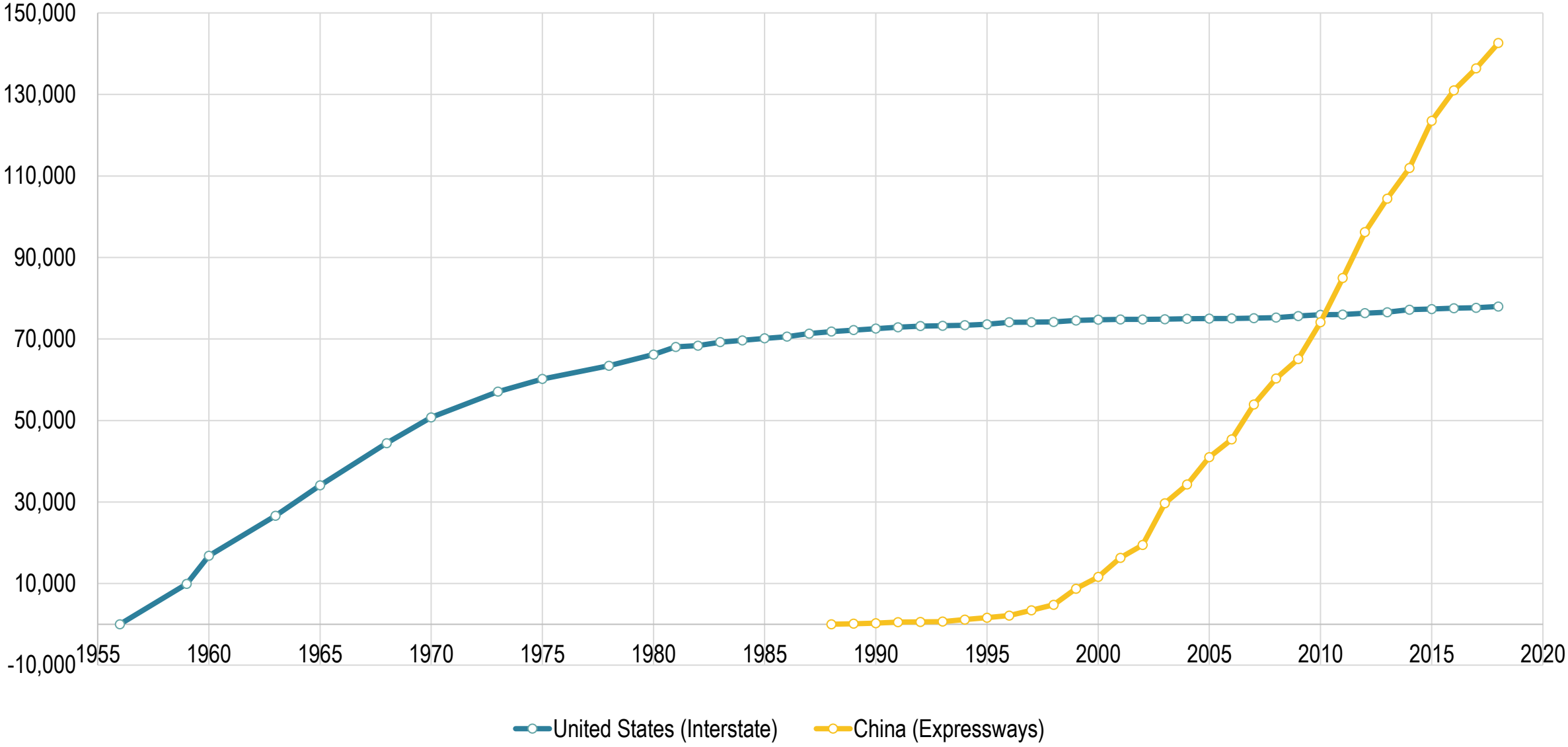


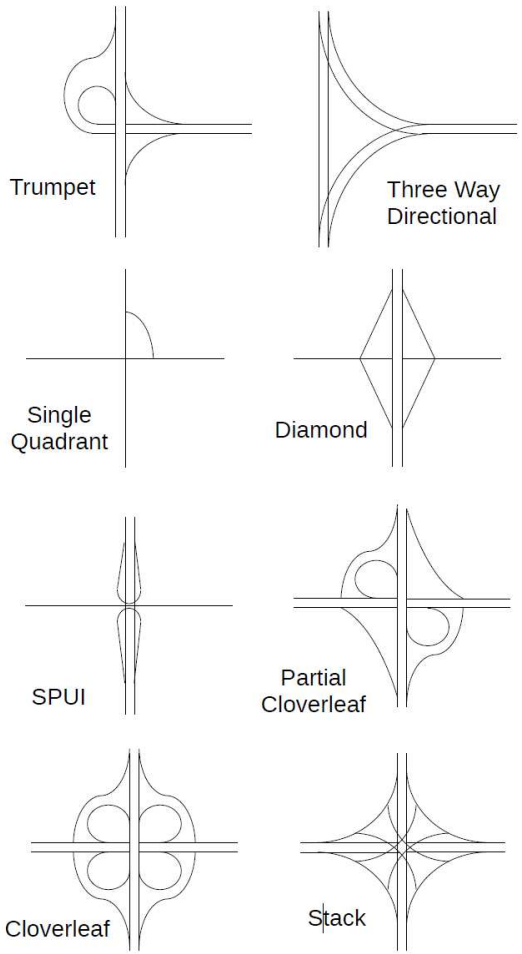
The Interstate Highway System

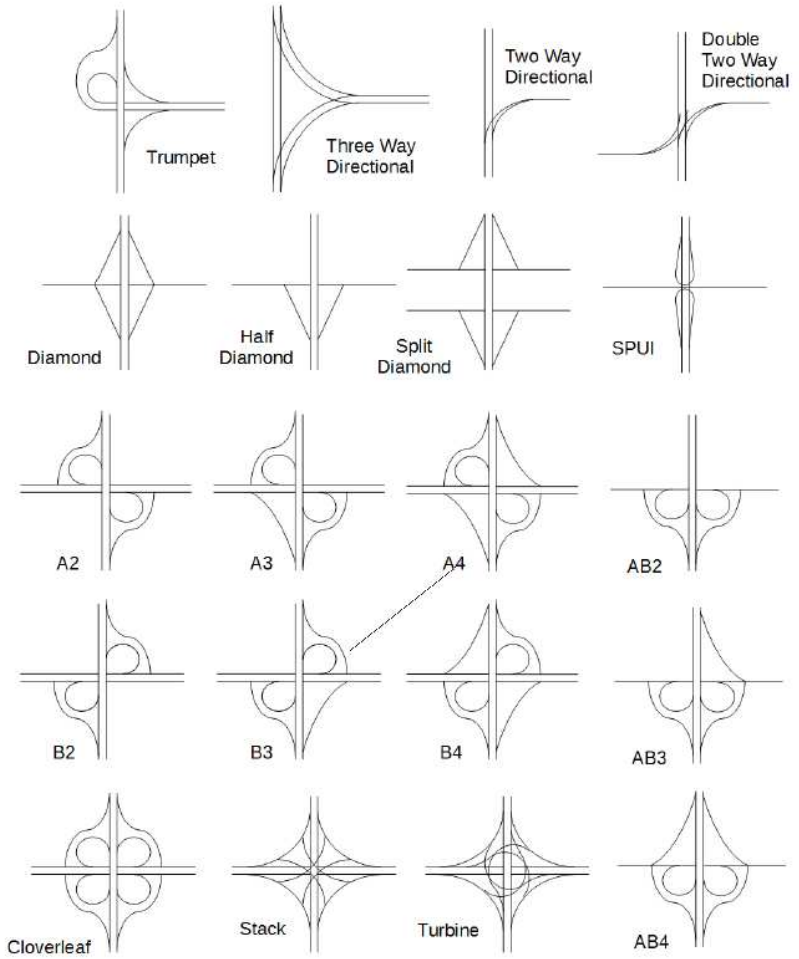




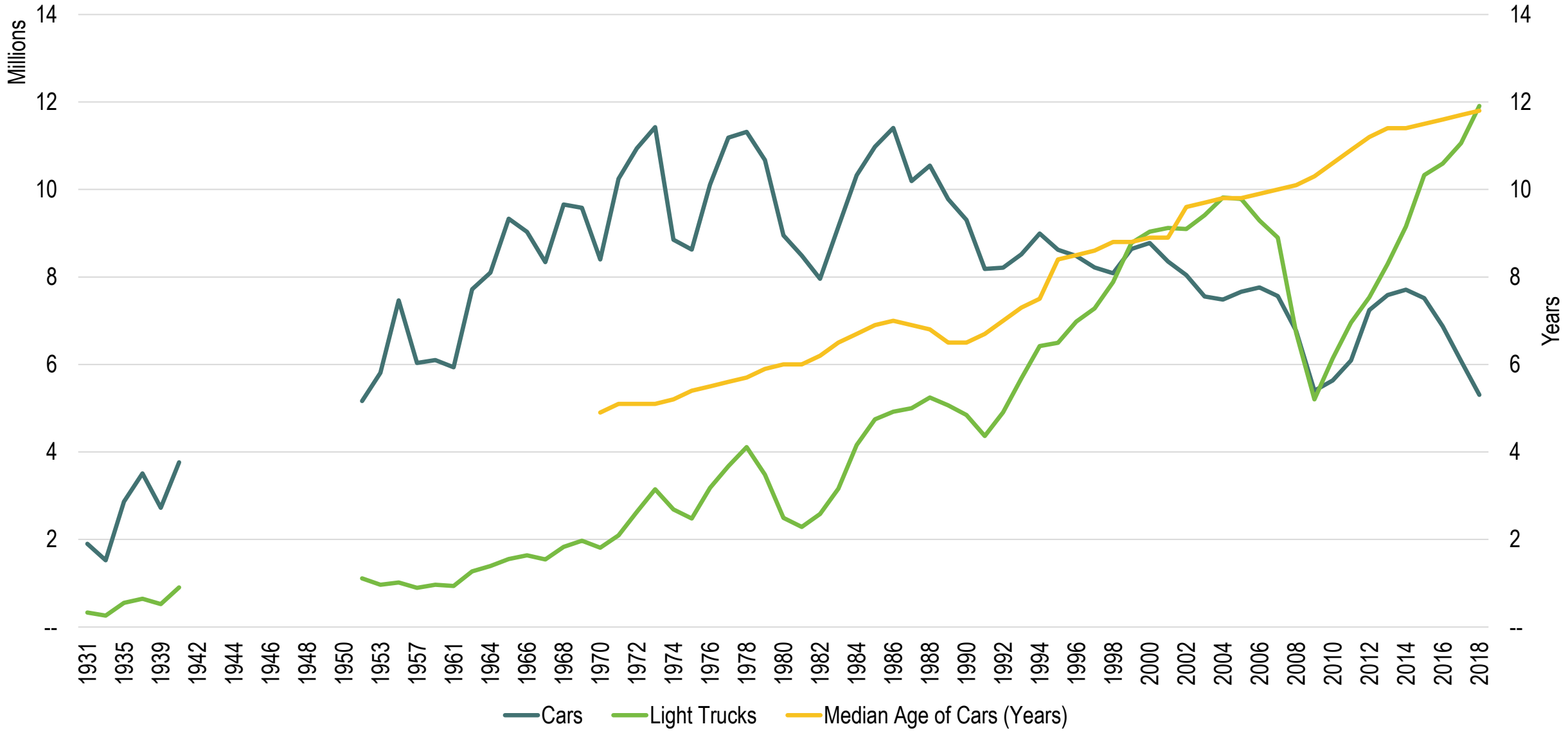
Length of the Interstate Highway System and of the Chinese Expressway System, 1959-2018 (in km)



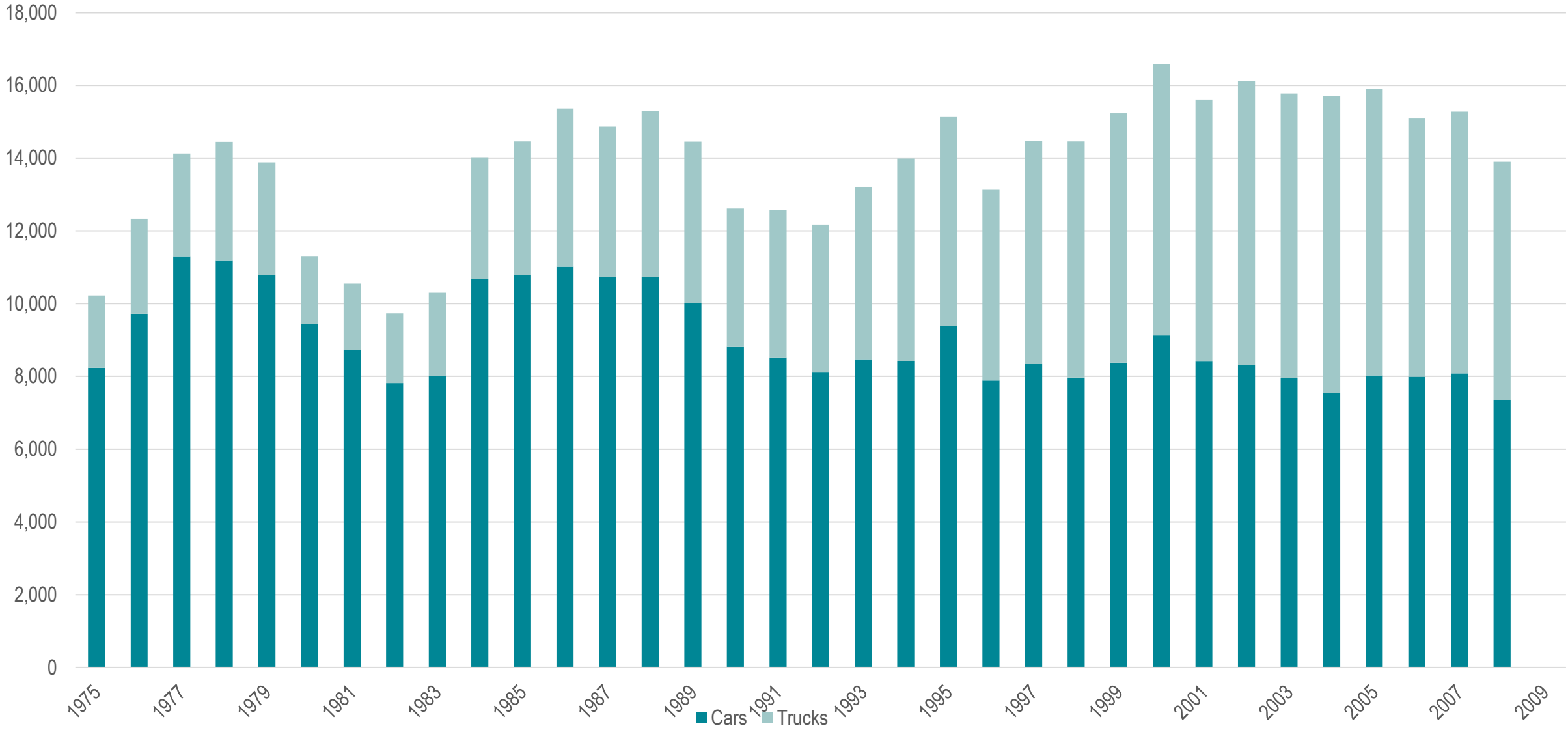




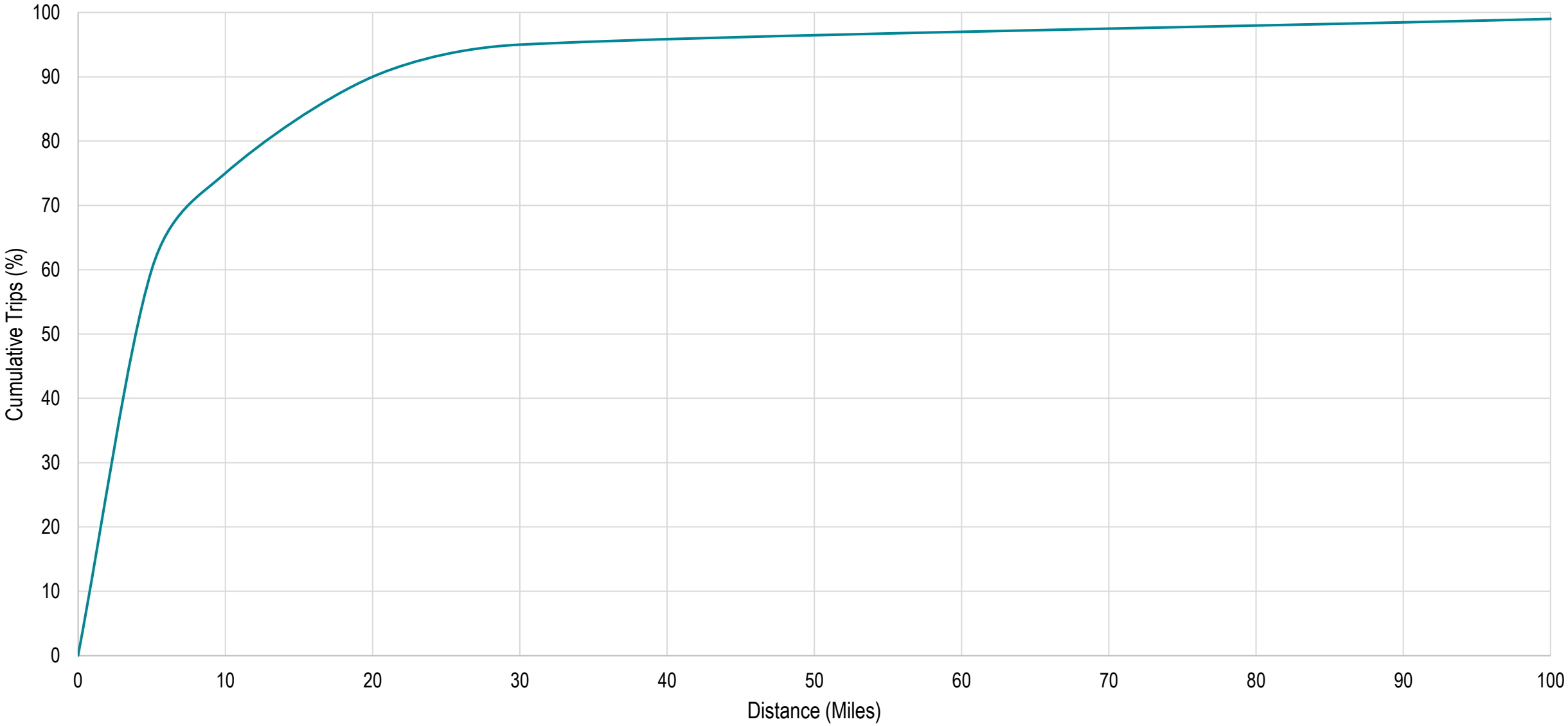
Vehicle Sales, United States, 1931-2018



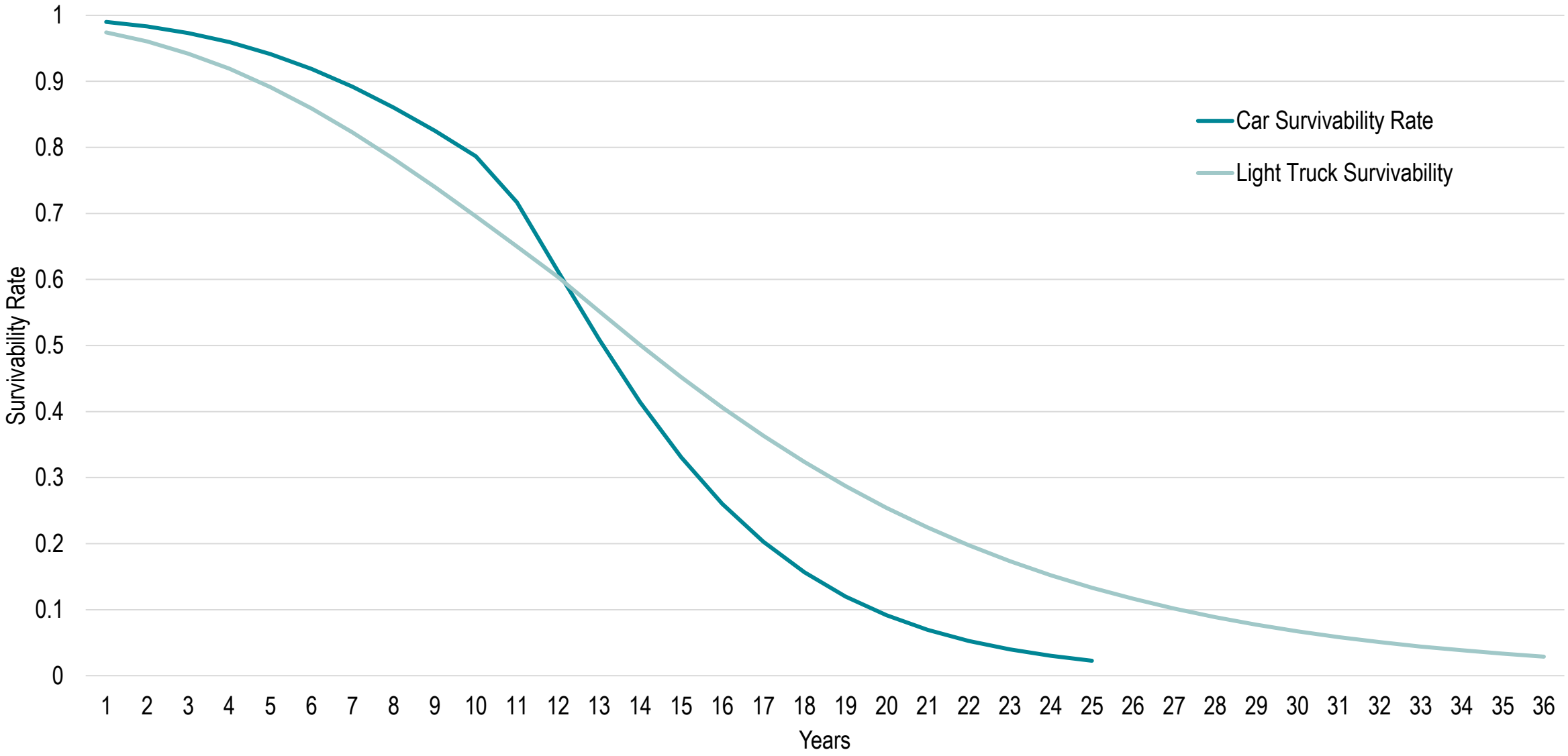
Light-Duty Vehicles Sales in the United States, 1975-2008 (in 1,000s)



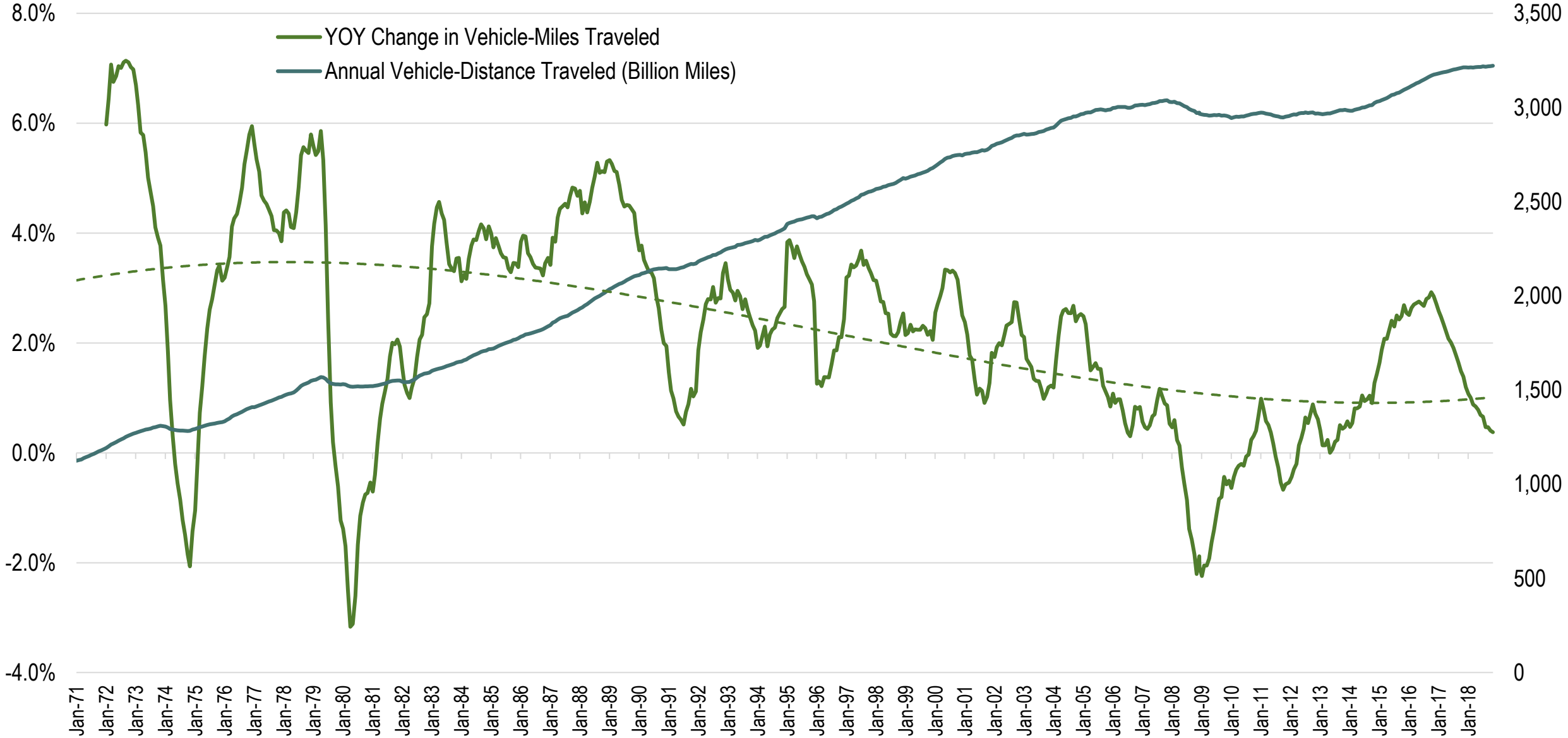
Distribution of Car Trips by Travelled Distance, United States



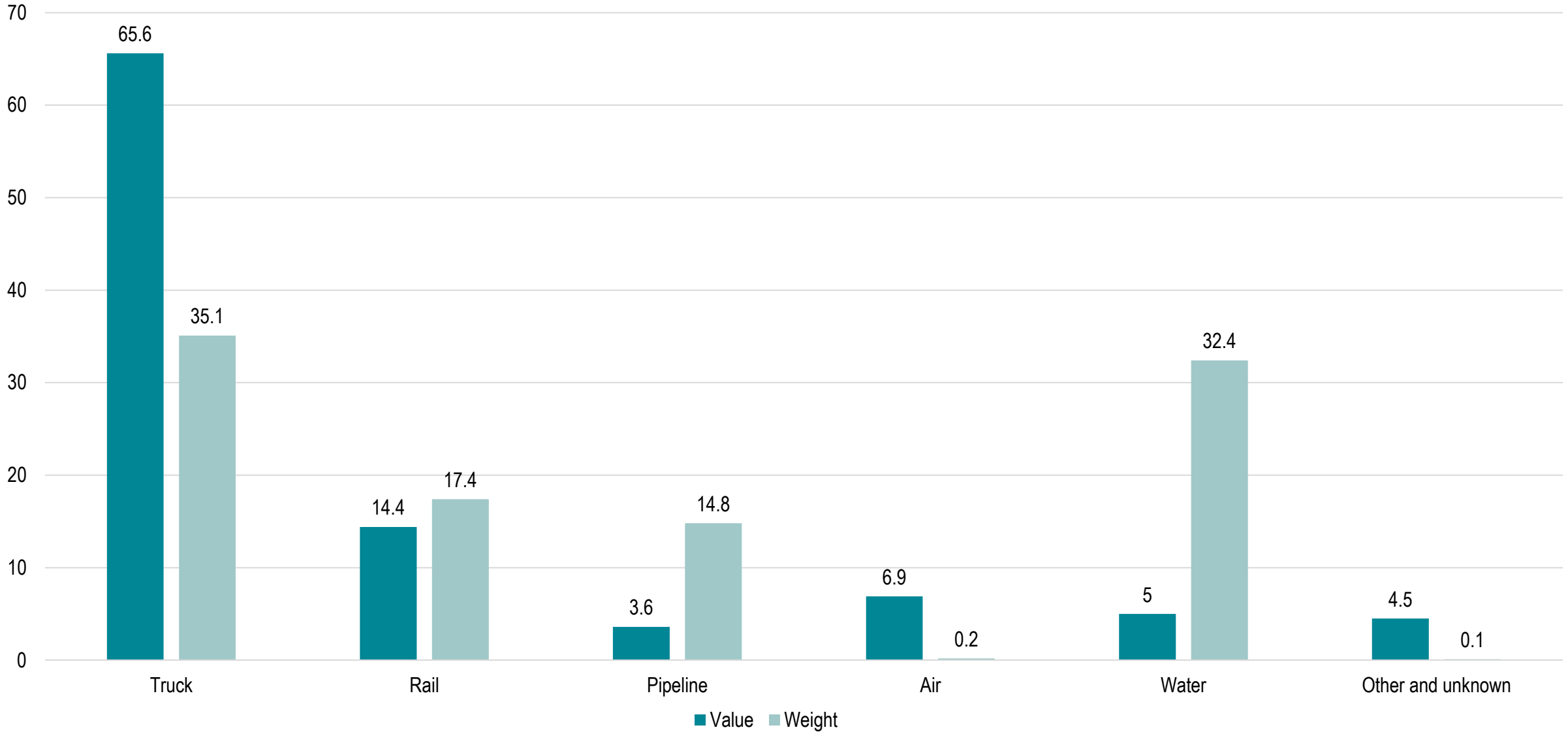
Car and Light Truck Survivability Rates



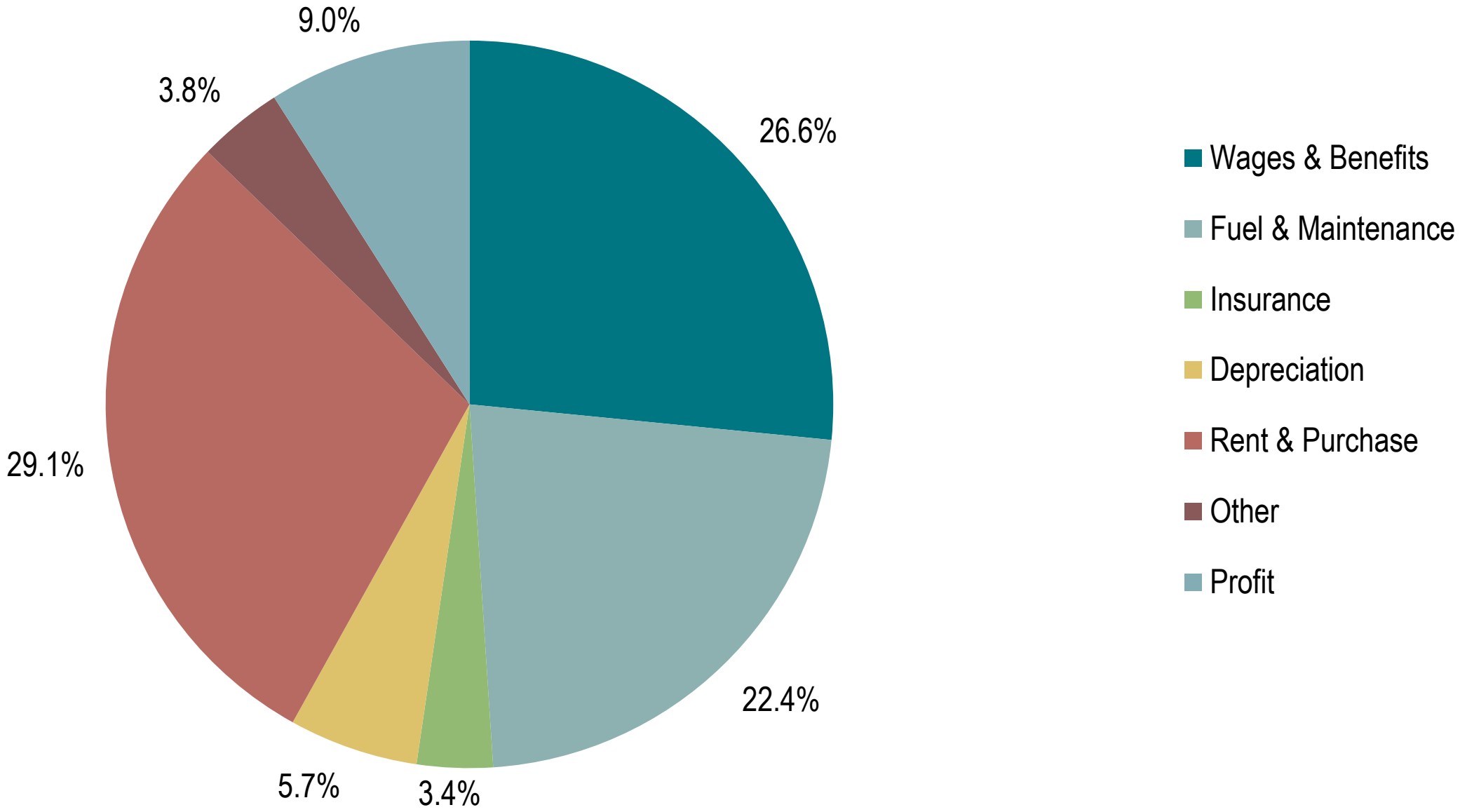
Annual Vehicle-Miles Traveled in the United States and Year-over-Year Changes, 1971-2019



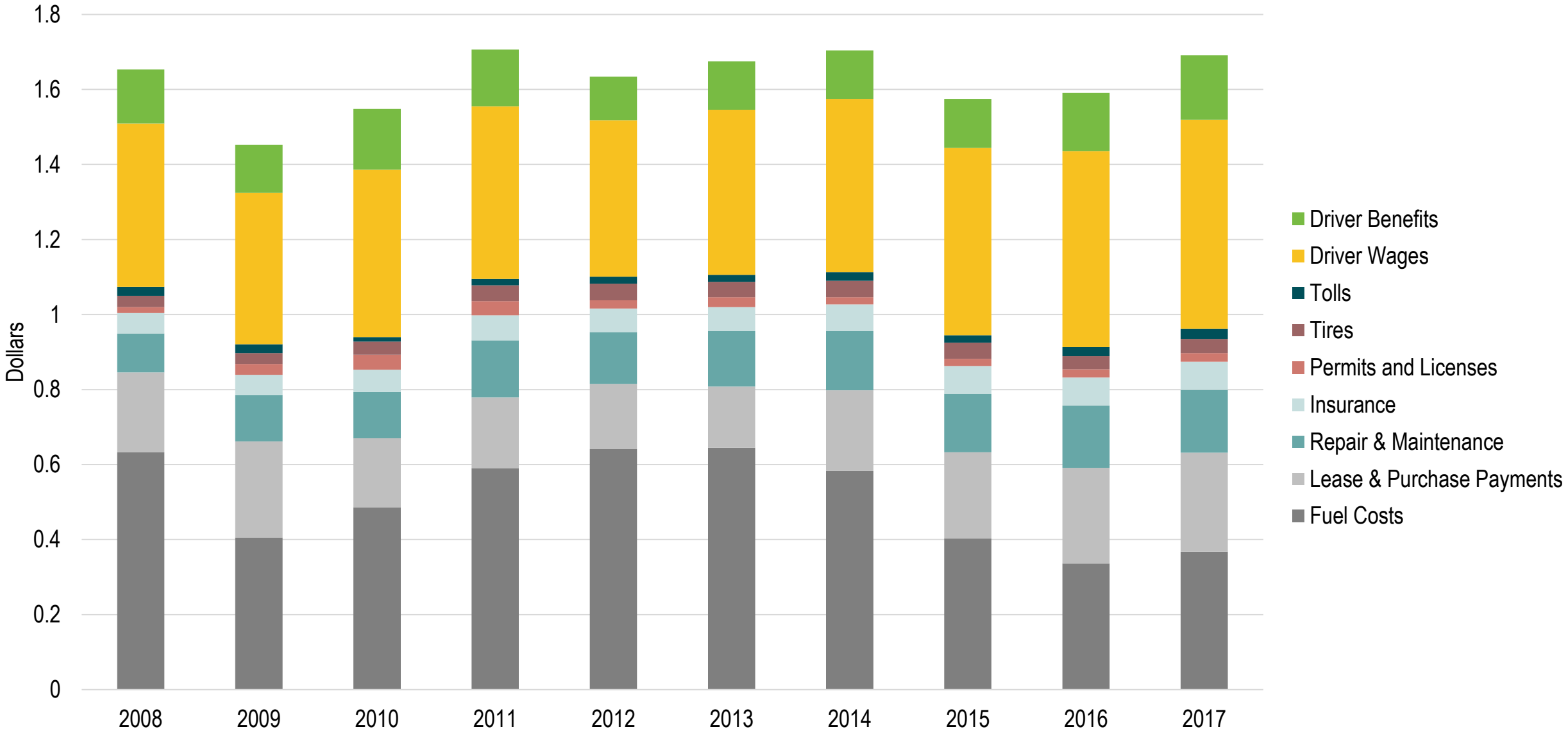
Modal Shares of U.S.-NAFTA-Partner Merchandise Trade by Value and Weight, 2000



Cost Structure of Trucking, United States, 2006



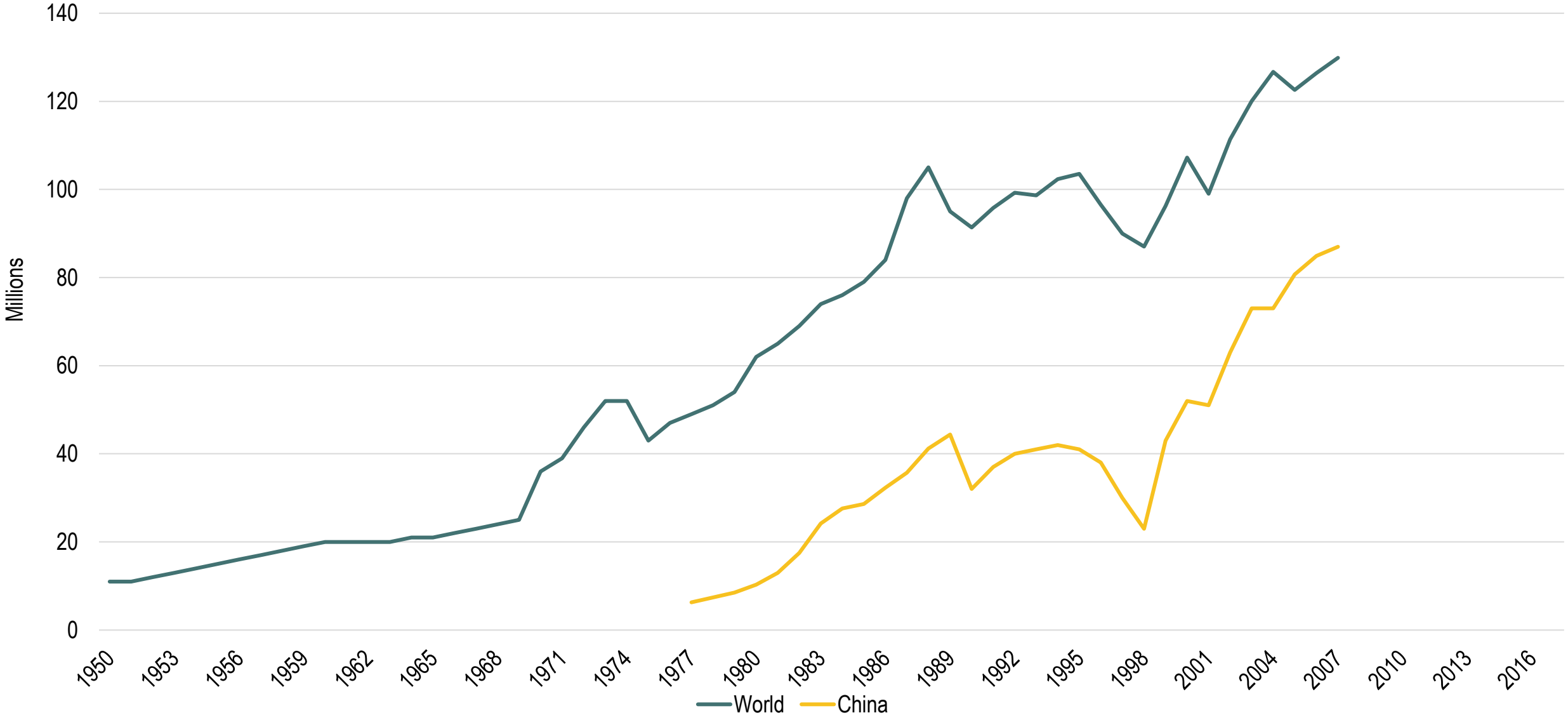
Average Marginal Trucking Costs per Mile, United States, 2008-2017



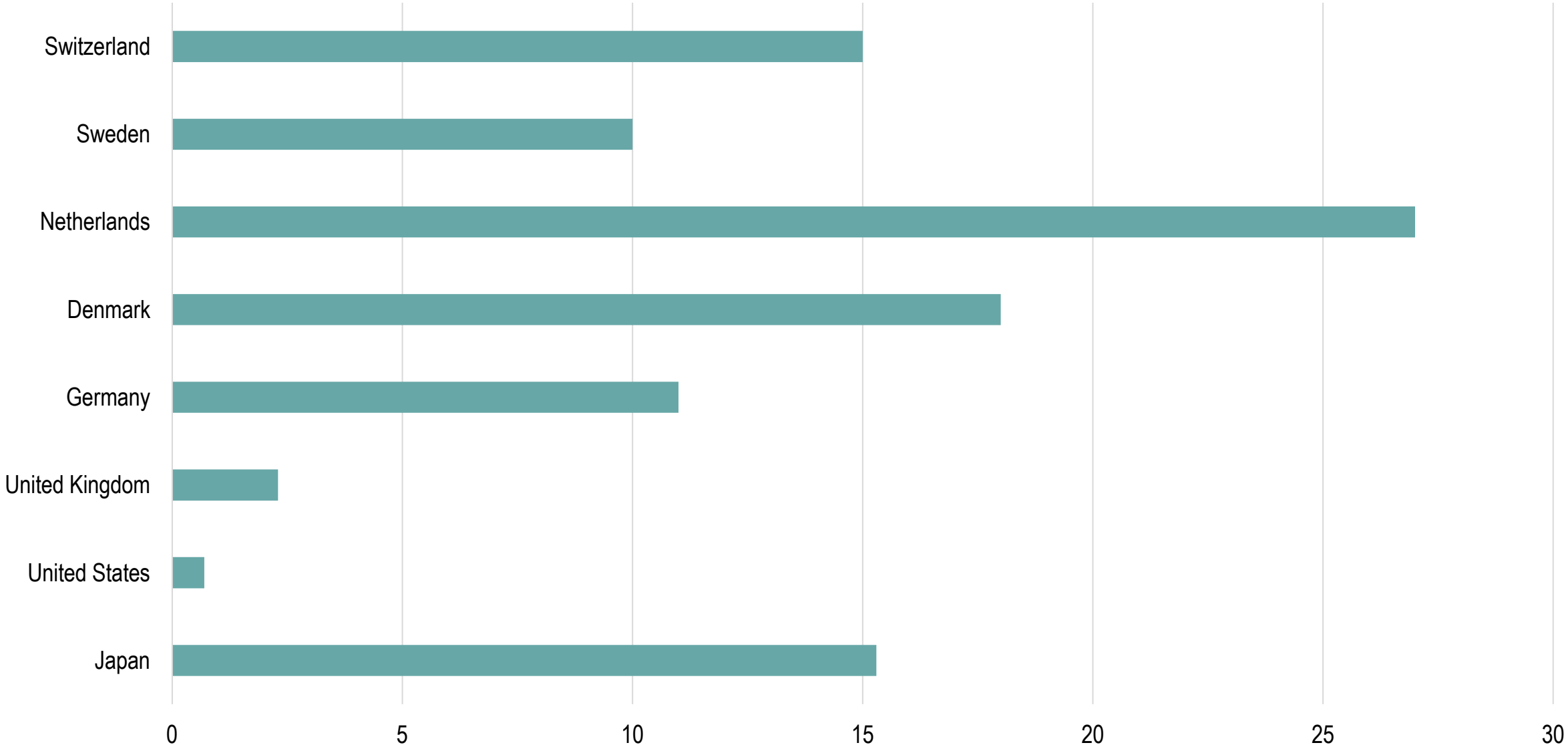
US Domestic Trucking Market, 2006

Company	Market Share
CH Robinson Worldwide	1.6%
Schneider National	1.4%
J.B. Hunt	1.2%
Swift Transportation	1.2%
Landstar Systems	0.9%
Werner Enterprises	0.8%
Pacer International	0.6%
Hub Group	0.5%
US Xpress Enterprises	0.5%

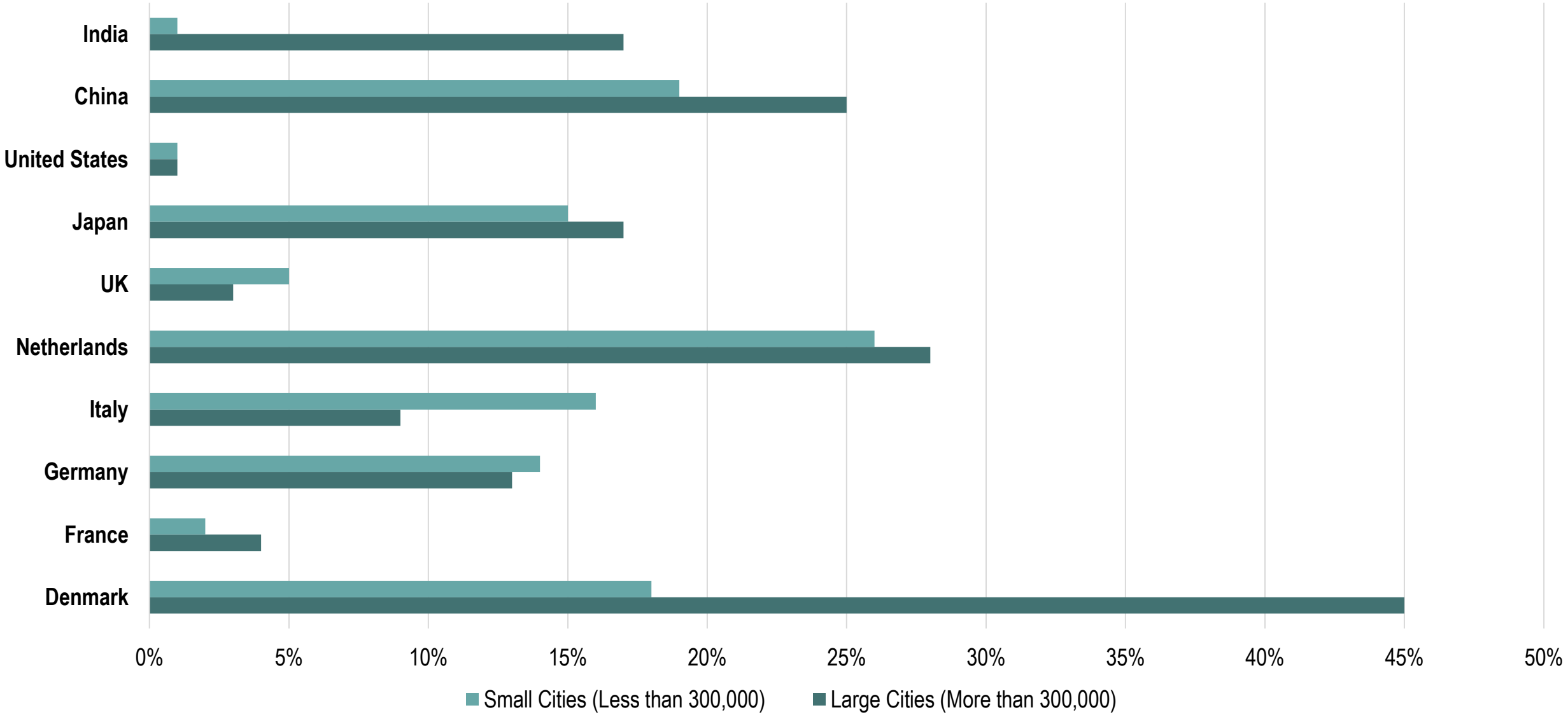
World Bicycle Production, 1950-2007



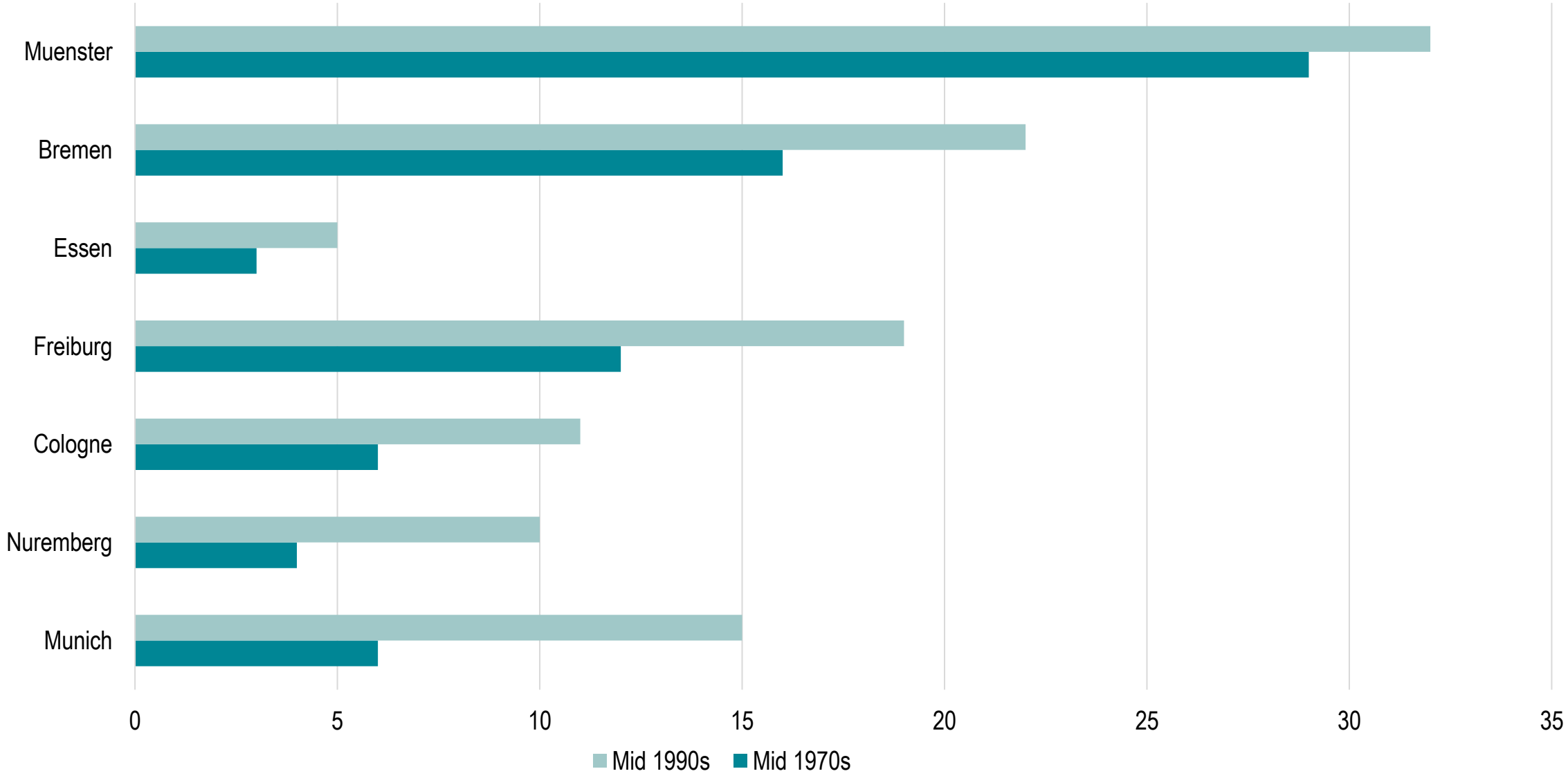
Share of Cycling over the Total Amount of Trips, mid 1990s

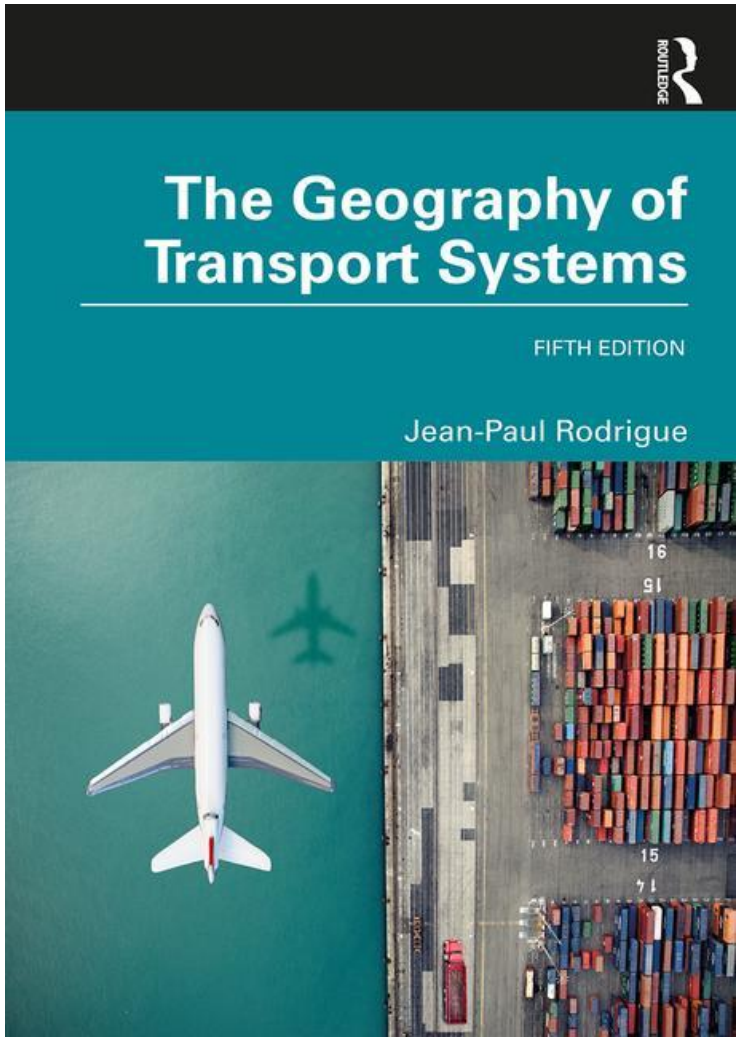


Share of Cycling over the Total Amount of Trips, Selected Countries, 2015



Trips Made by Bicycle in Selected German Cities (in %)

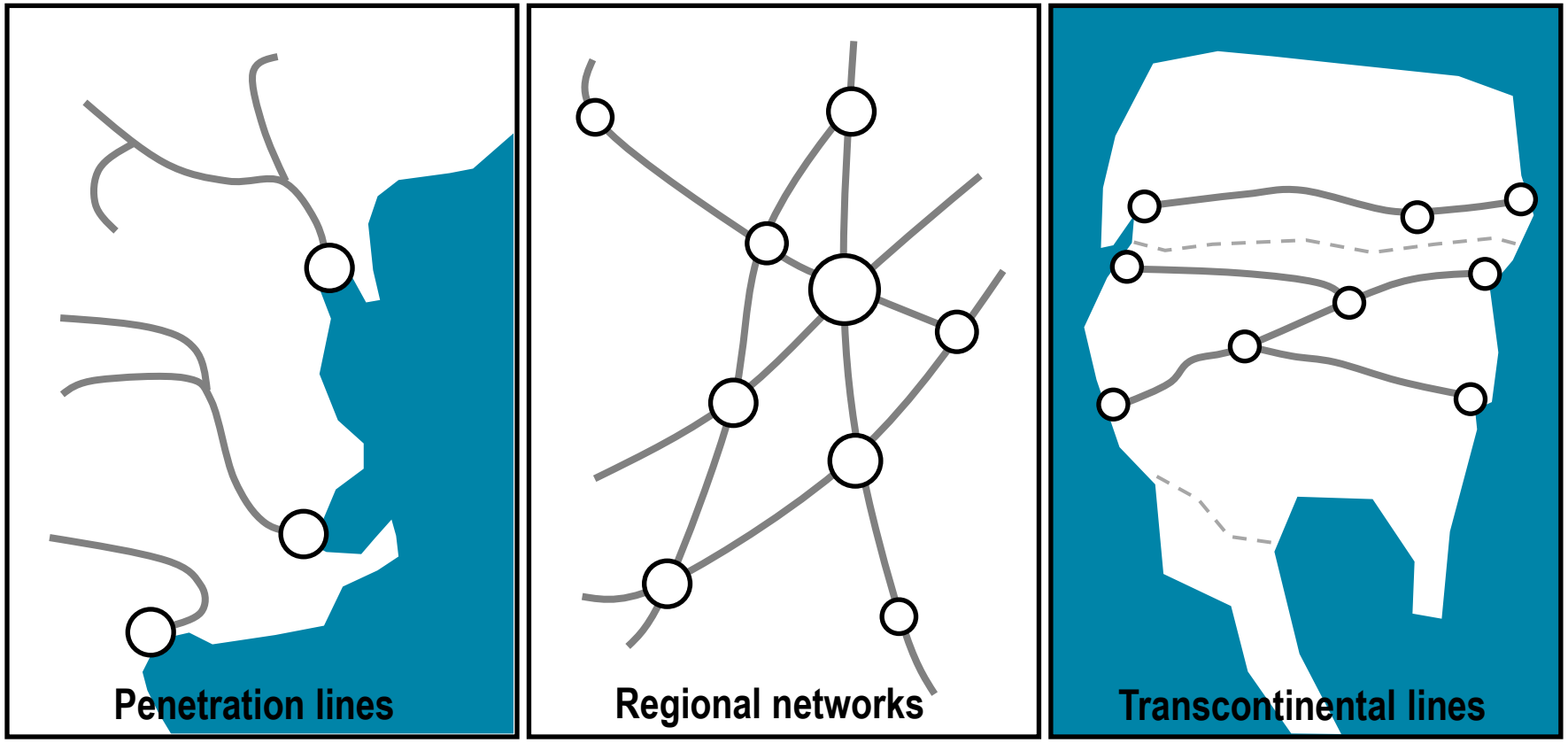




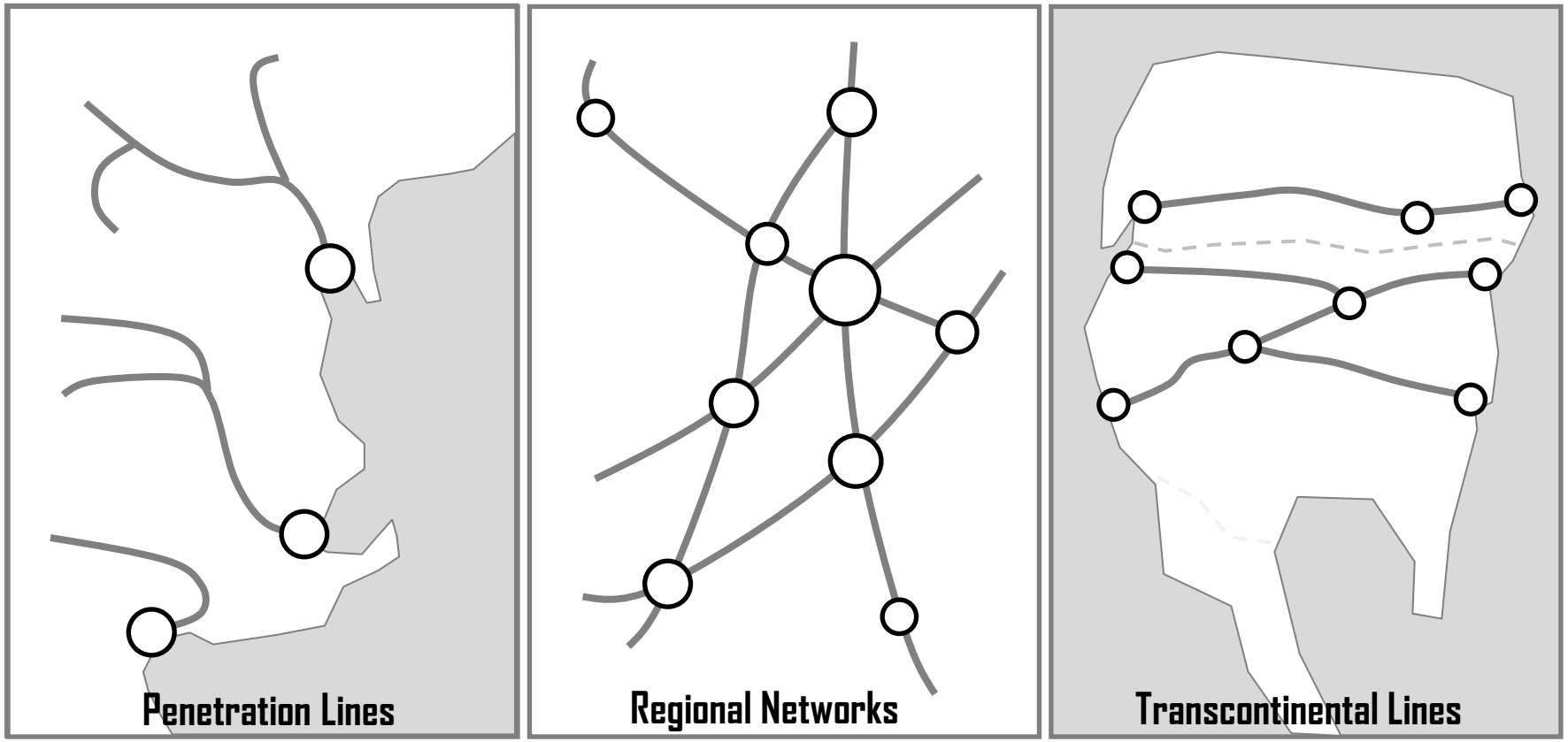
Rail Transportation

World Rail Network and Rail Systems

Geographical Settings of Rail Lines



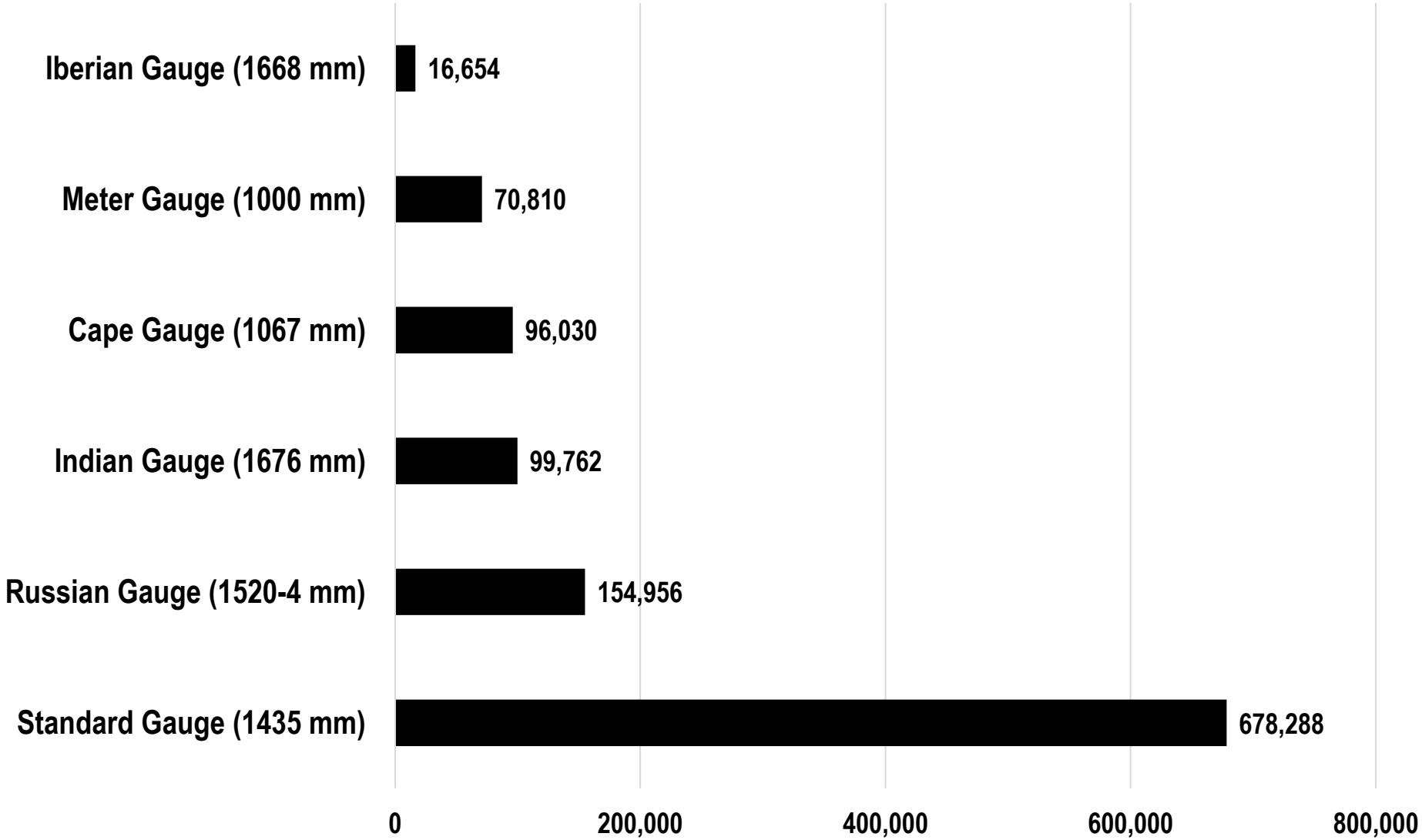
Geographical Settings of Rail Lines (Greyscale)



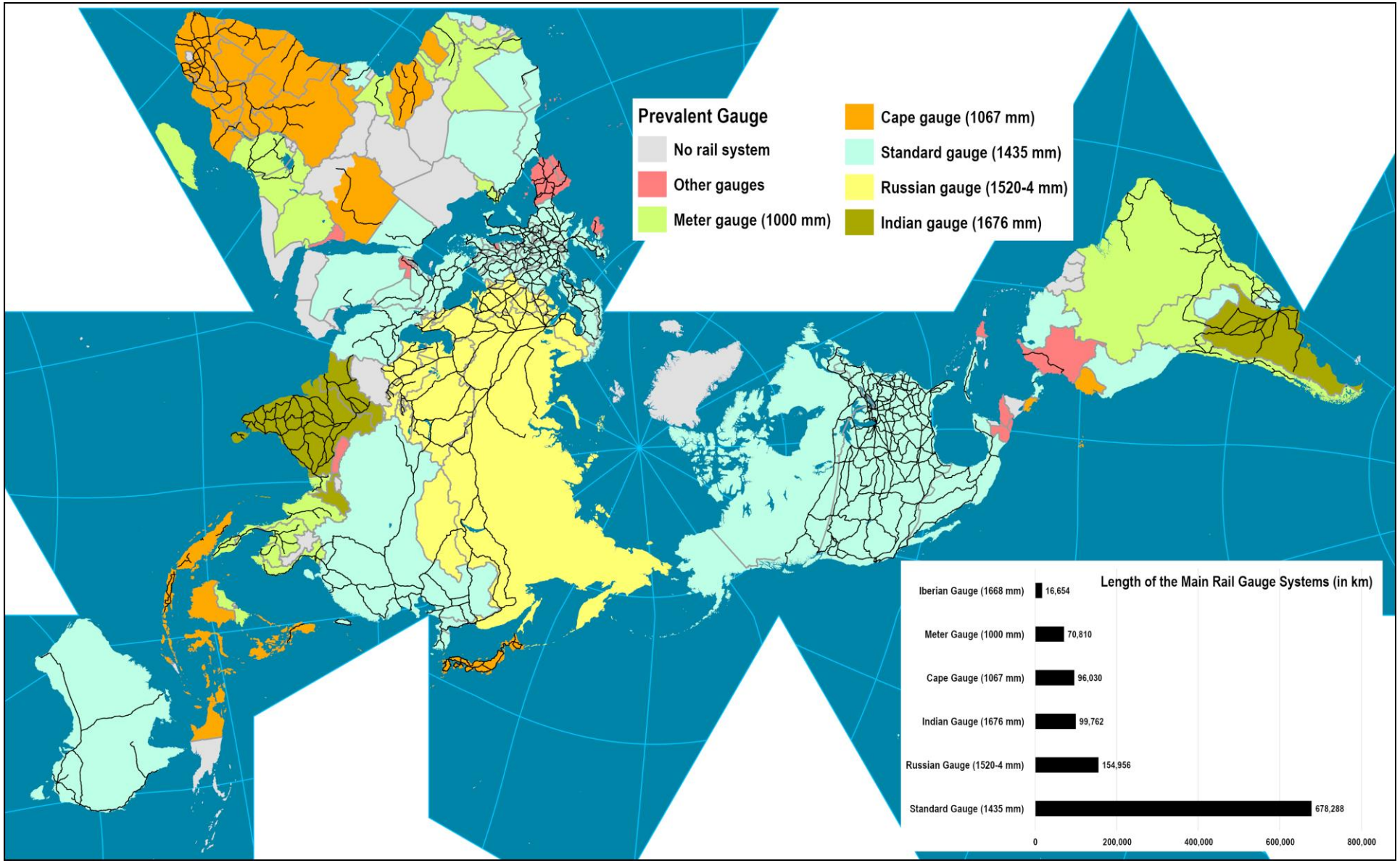
Economic Rationale of Rail Transportation

Market Area	Longest service area for inland transport (average length of 1,300 km). Service both the passengers and freight markets. Intermodal integration favored market segmentation and specialization.
Capacity	A wagon can carry 50 to 100 tons of freight. Economies of scale (unit trains and doublestacking).
Costs	High construction and maintenance costs. High operating costs: labor (60%), locomotives (16%) and fuel & equipment (24%). Shipping costs decrease with distance and load. Transshipments and train assembly increase costs.
Benefits	Accelerated industrialization. Support agricultural and energy supply systems. Intermodal connecting with international trade.
Regulation	Conventionally highly dependent from government subsidies. Government financing, mainly for the sake of national economic imperatives. From regulation to deregulation. Private ownership and operations.

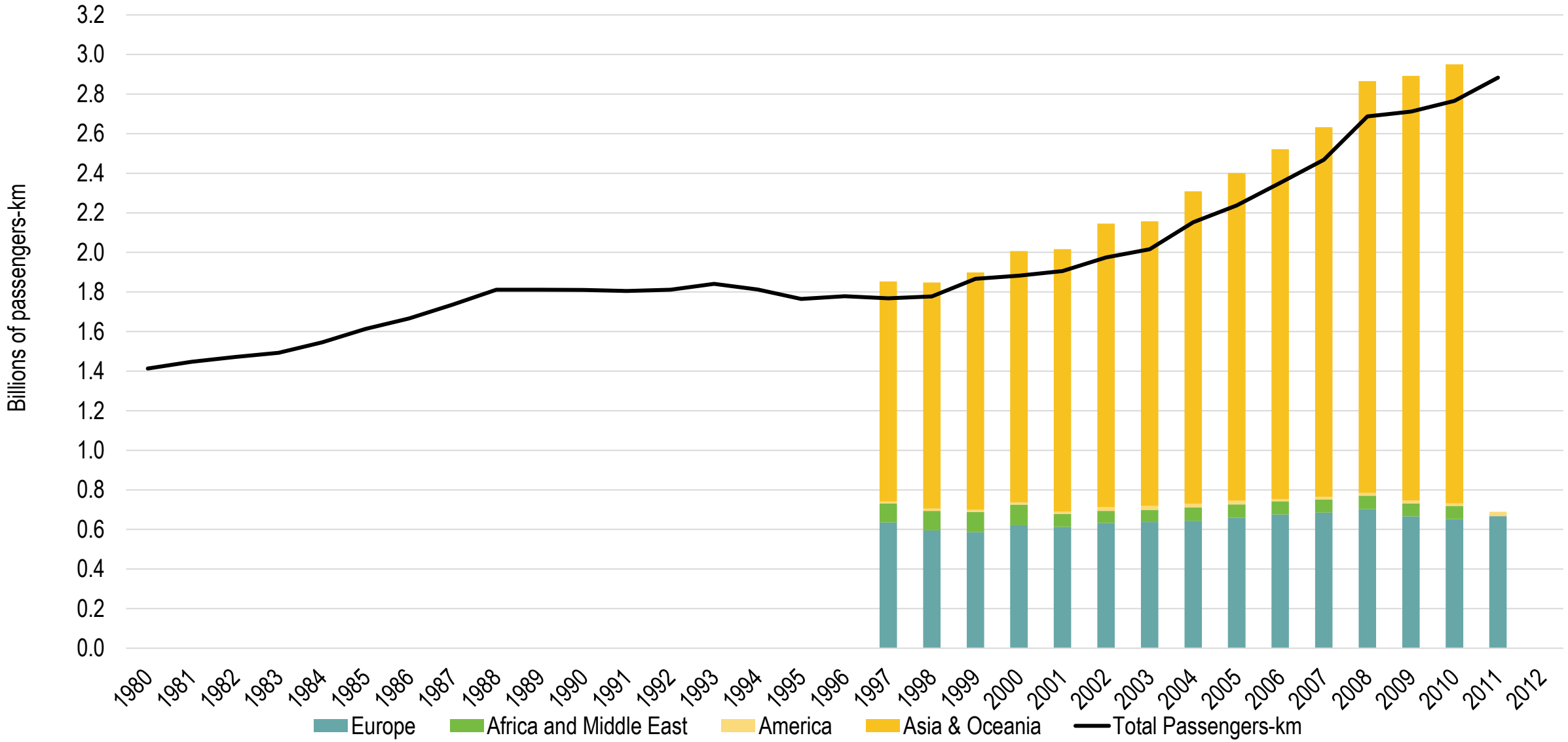
Length of the Main Rail Gauge Systems, 2008 (in km)



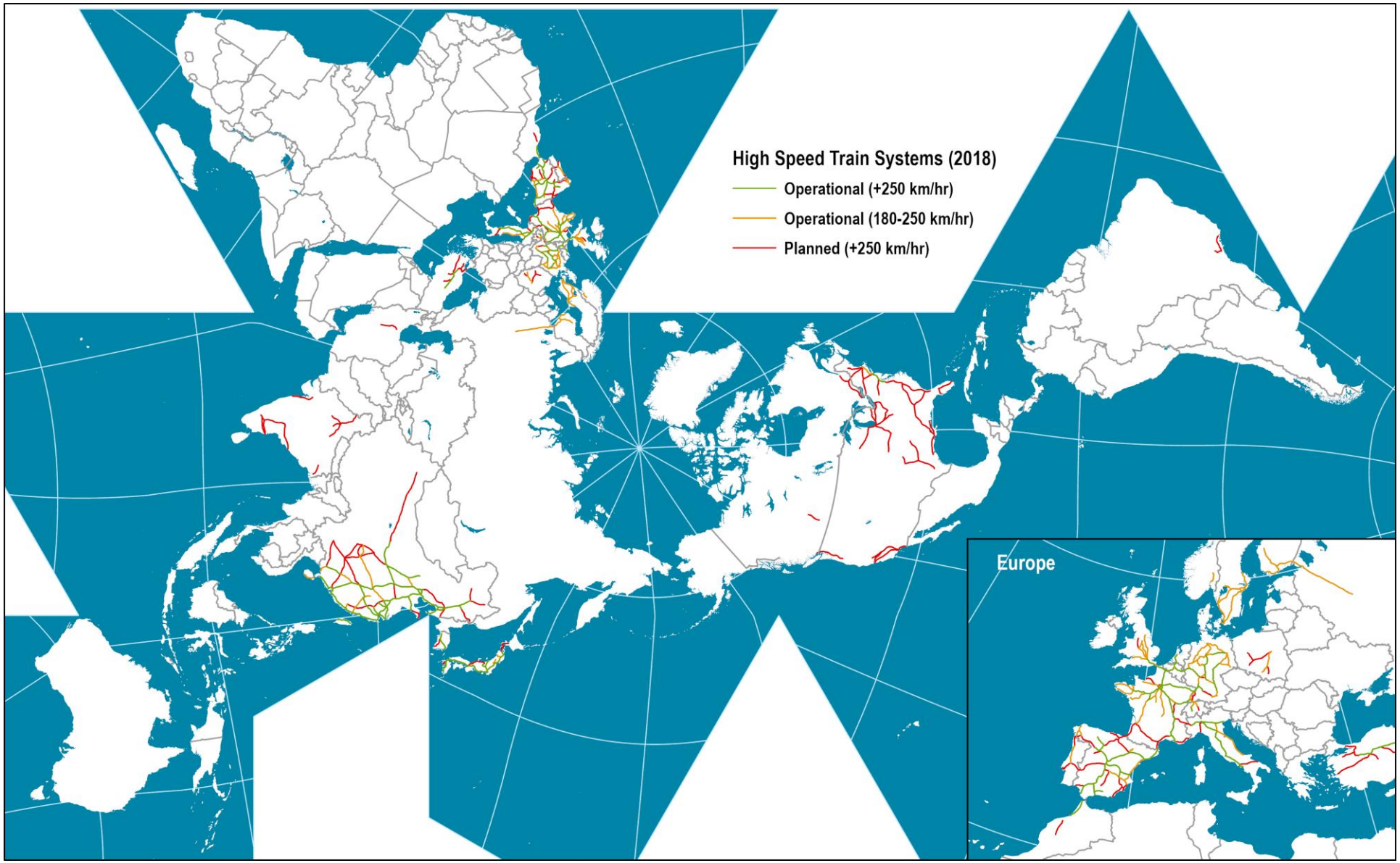
Major Gauges of the Global Rail Systems



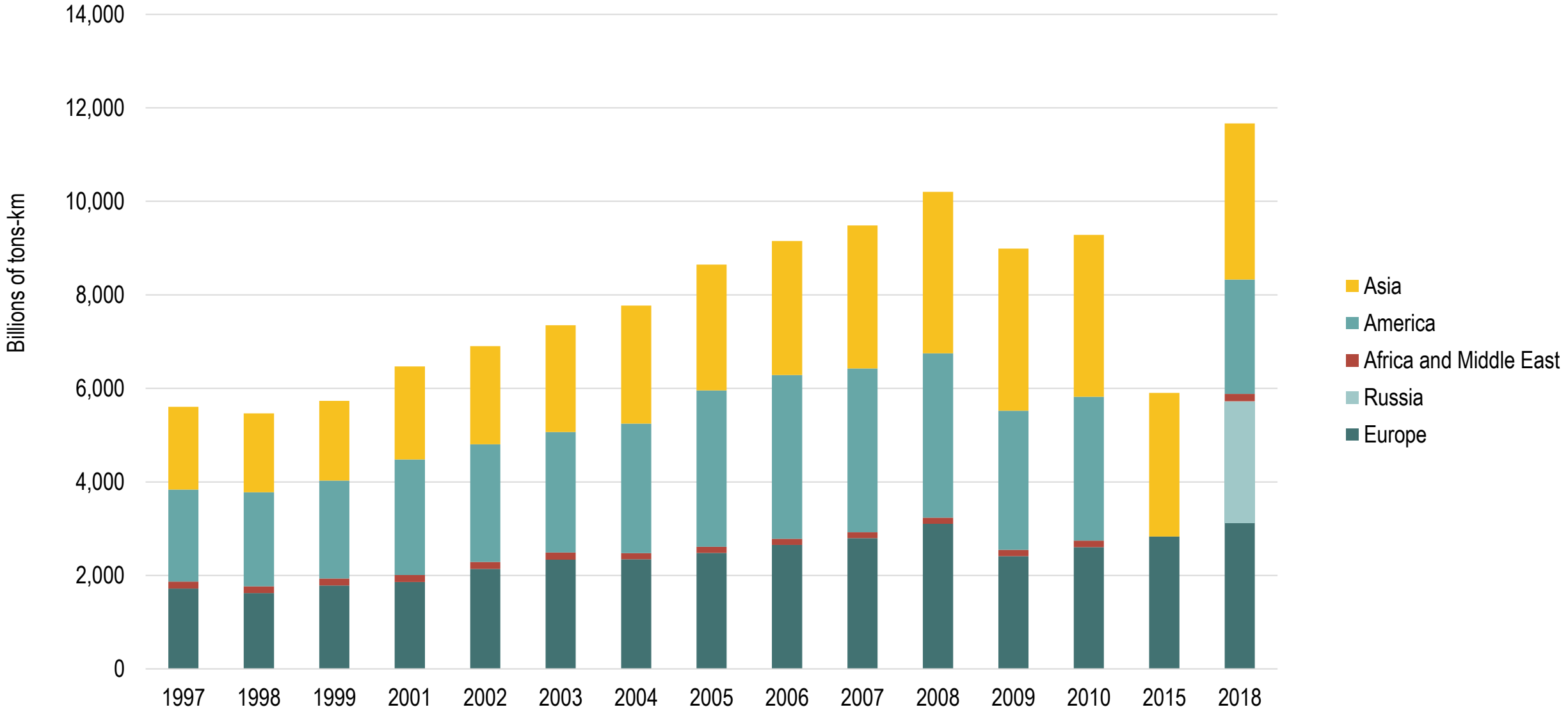
World Rail Passenger Traffic, 1980-2010



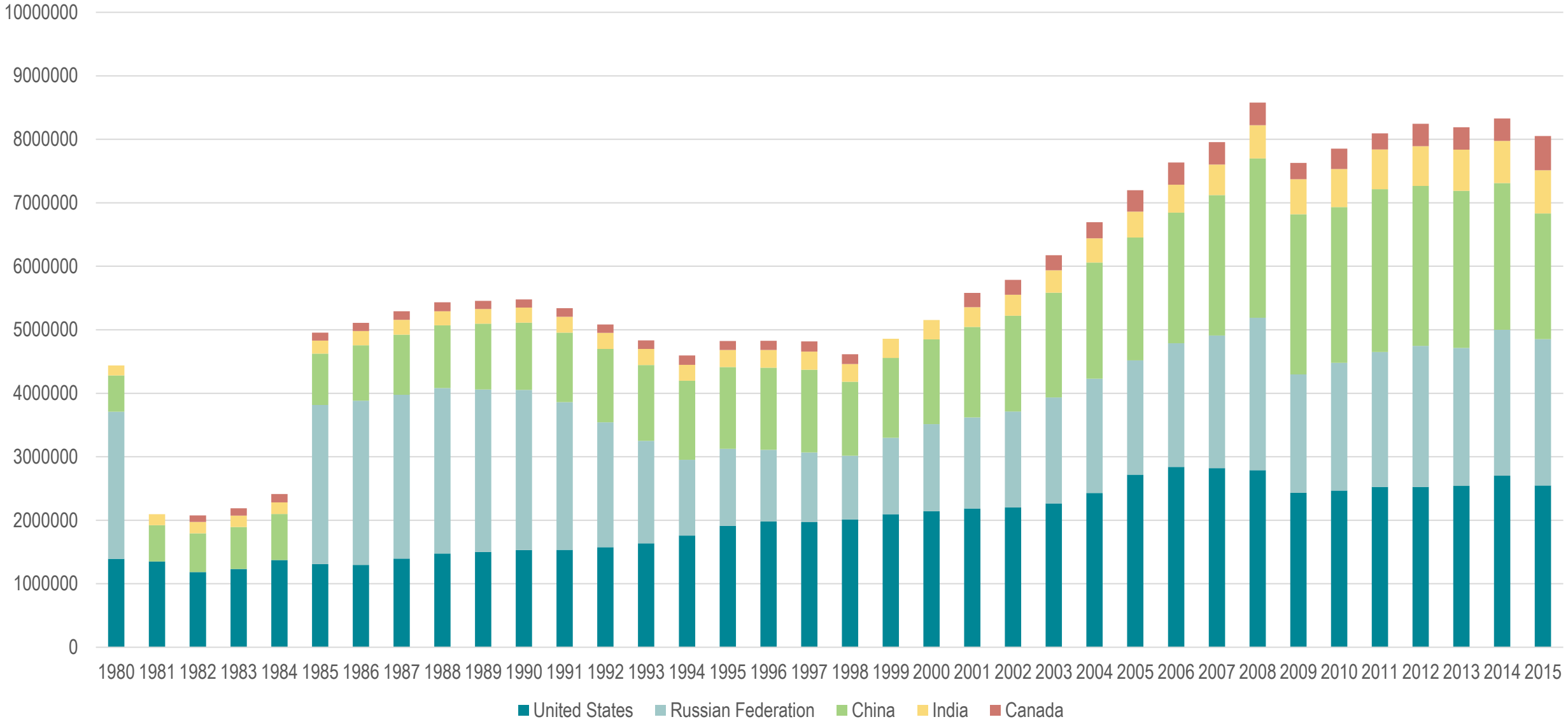
World High Speed Rail Systems, 2018



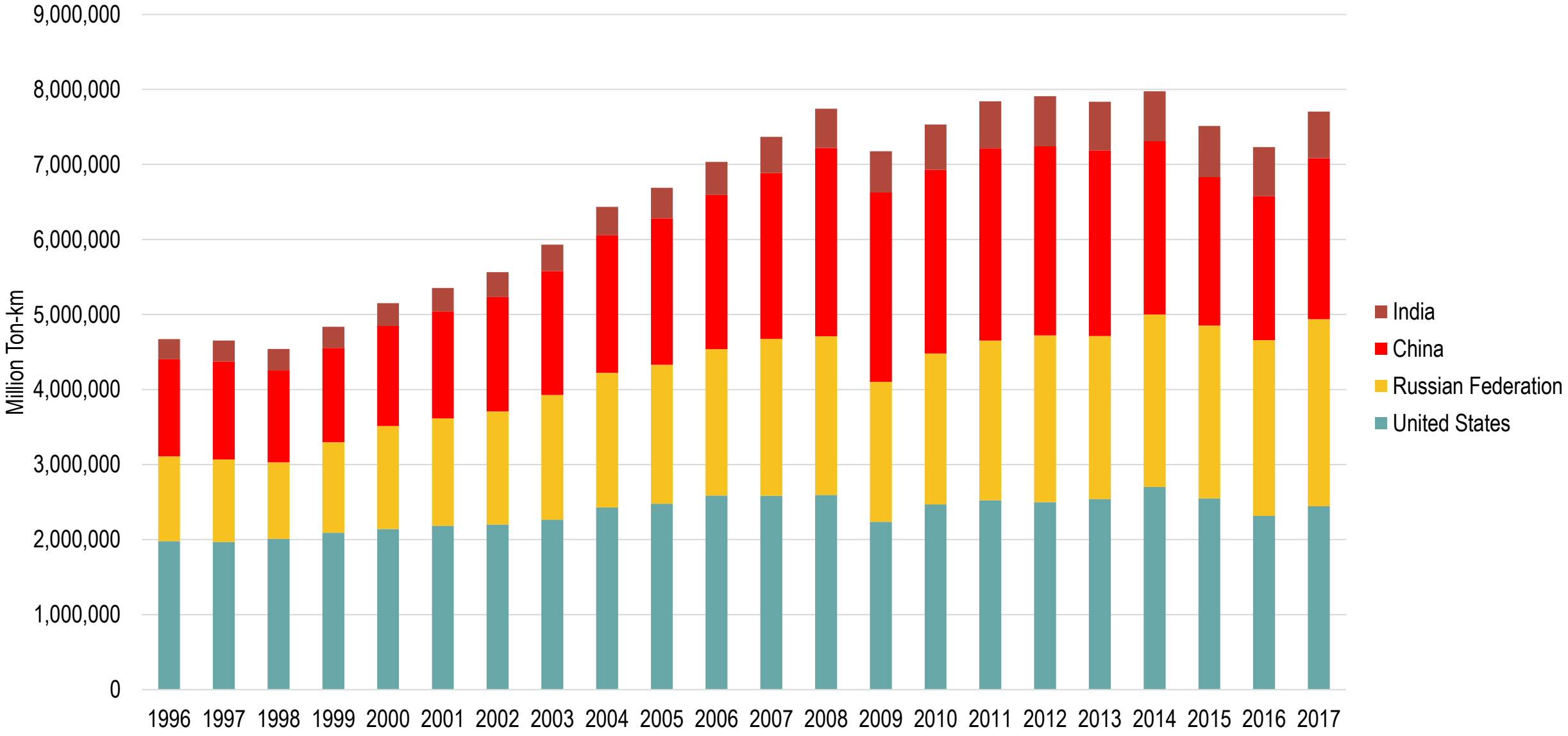
World Rail Freight Traffic, 1997-2010



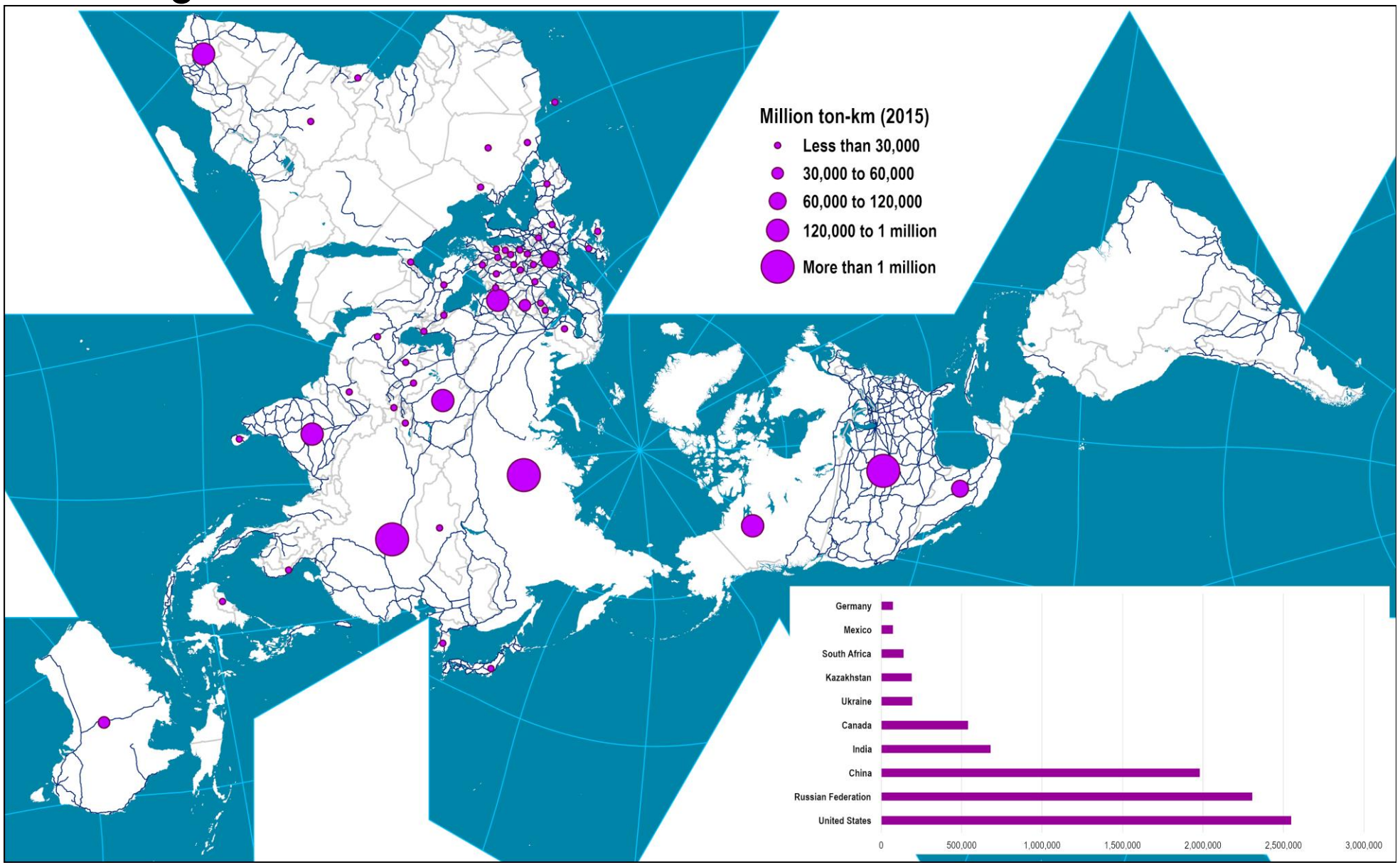
World Rail Freight Traffic, 1980-2018



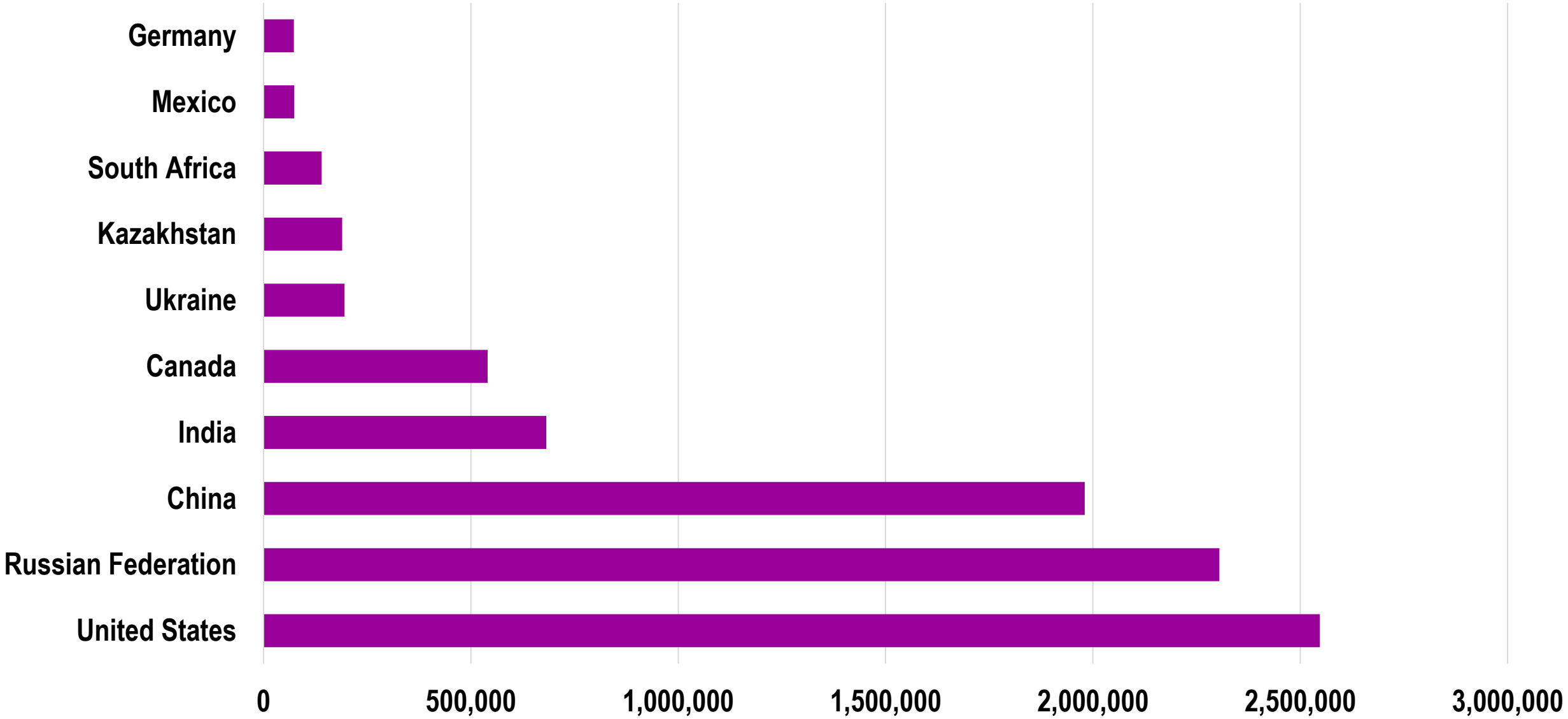
Rail Freight Traffic, Selected Countries, 1996-2017



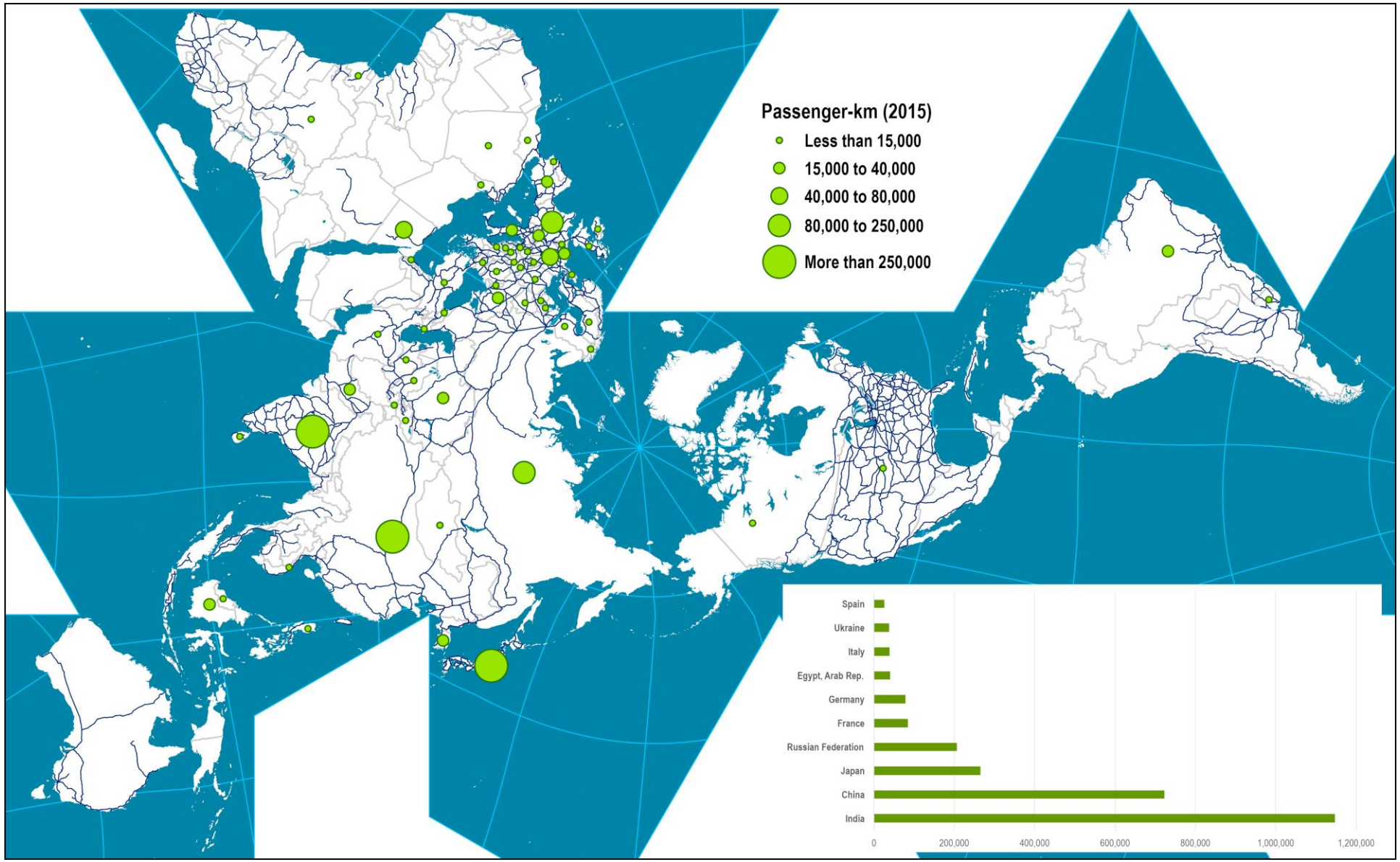
World Rail Freight Traffic, 2015



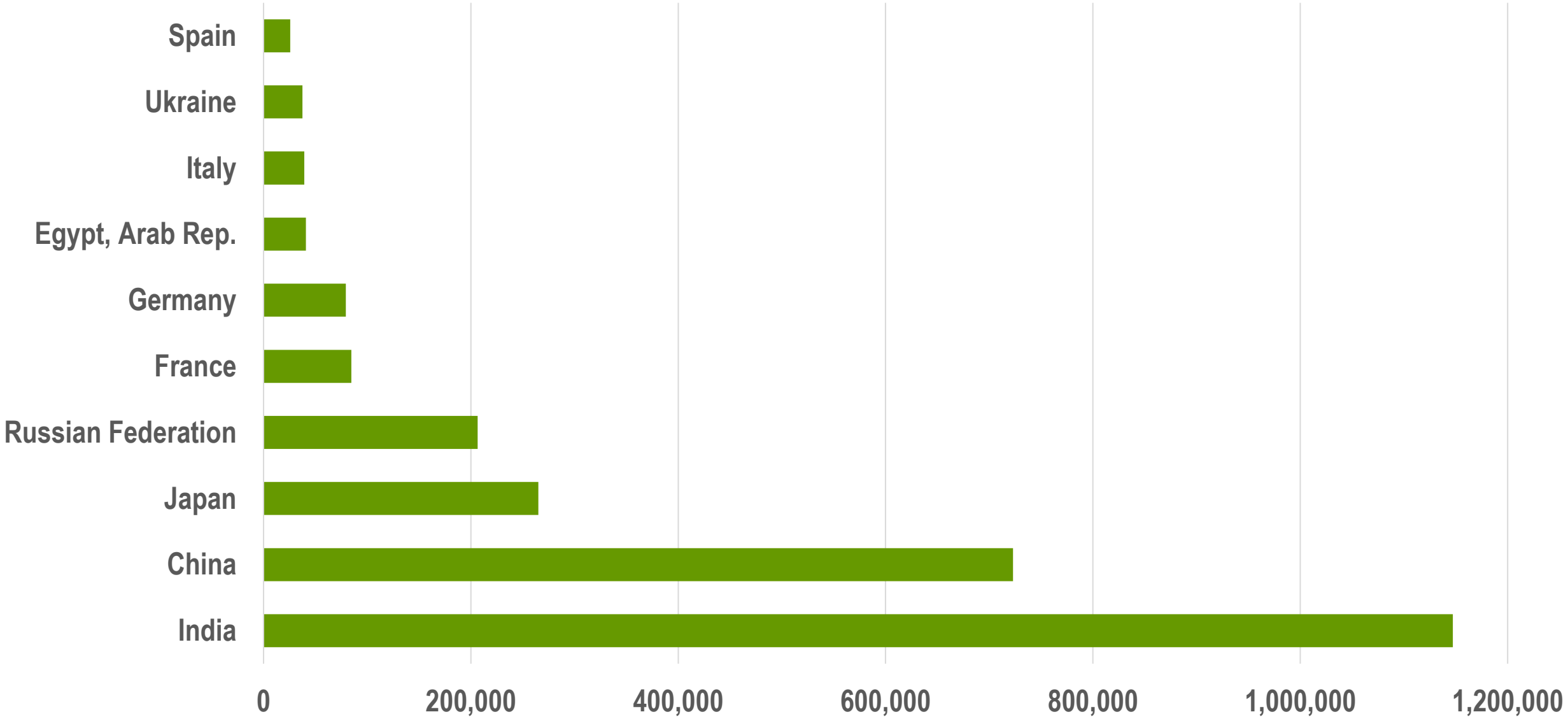
Rail Freight Traffic, Selected Countries, 2015



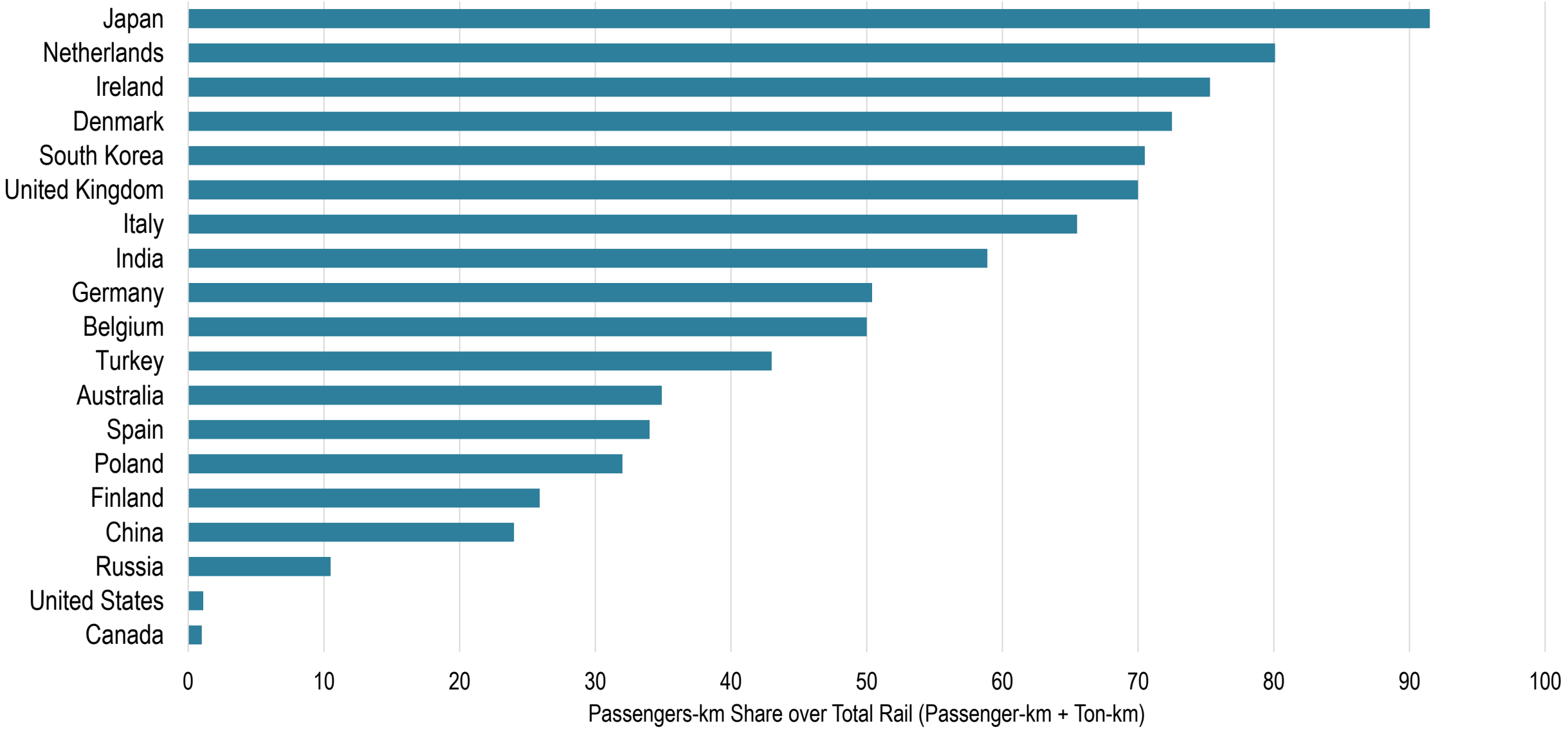
World Rail Passenger Traffic, 2015



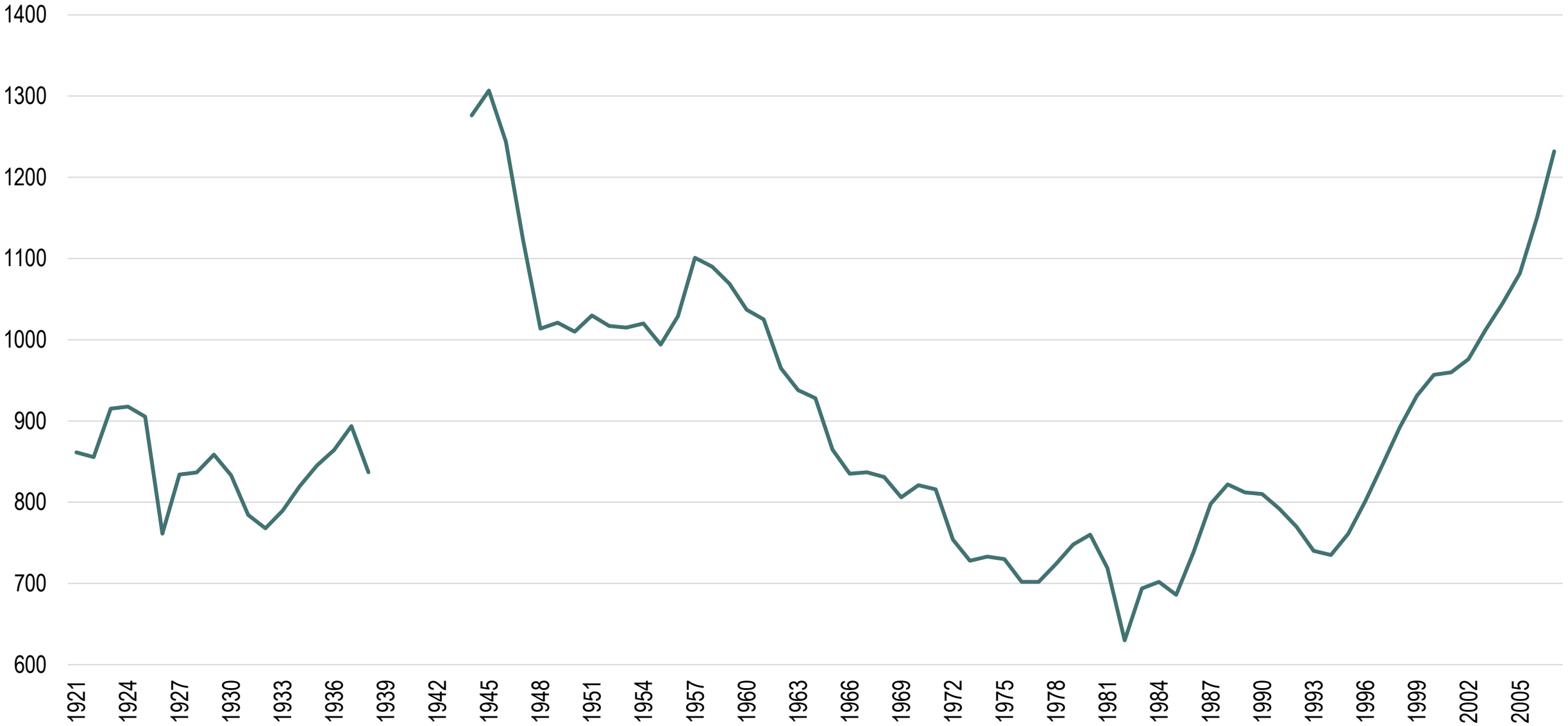
Rail Passenger Traffic, Selected Countries, 2015



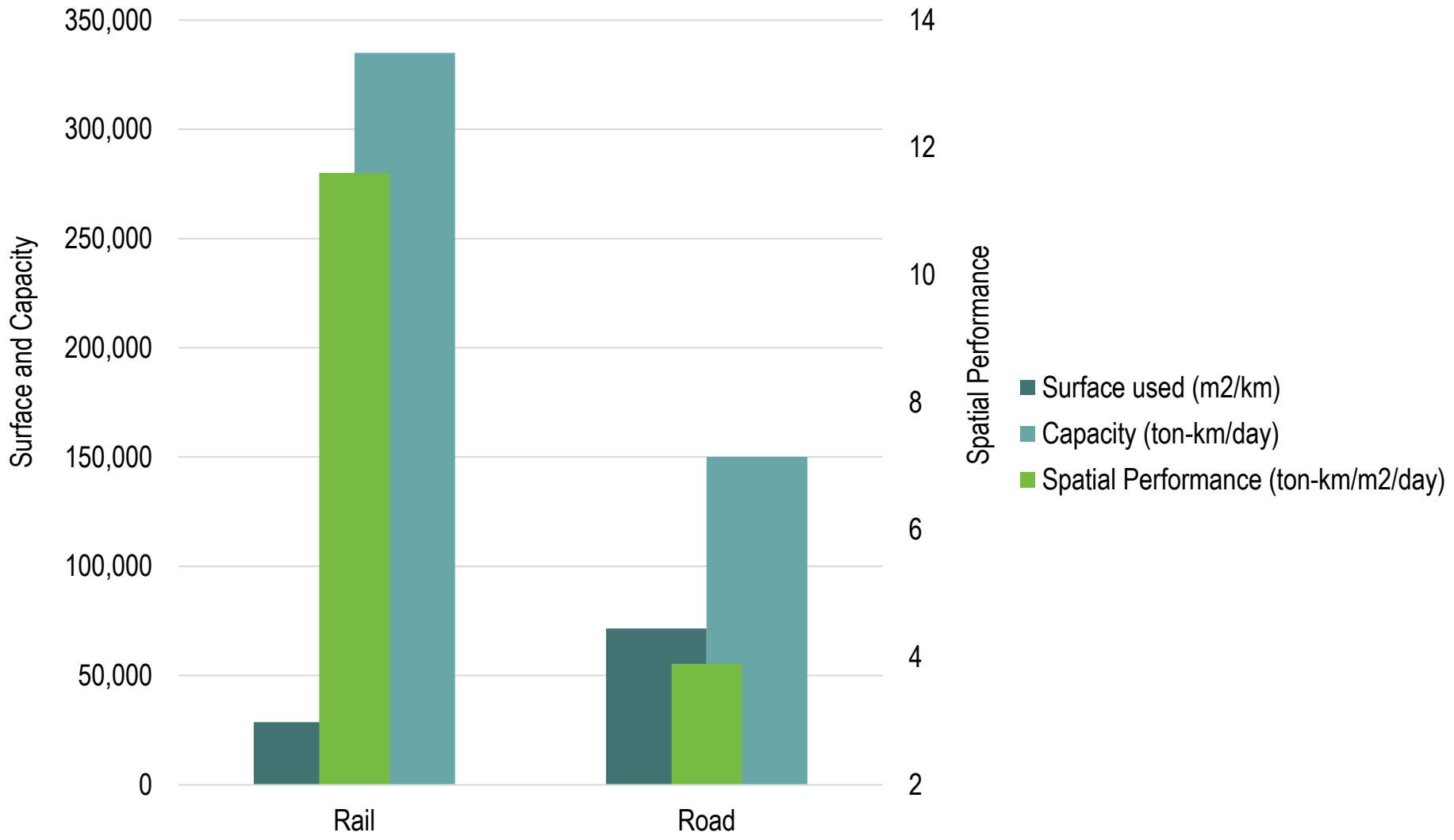
Percent of Rail Passenger Traffic to Total Rail Traffic



Passenger Journeys on the British Rail Network, 1921-2007 (millions)



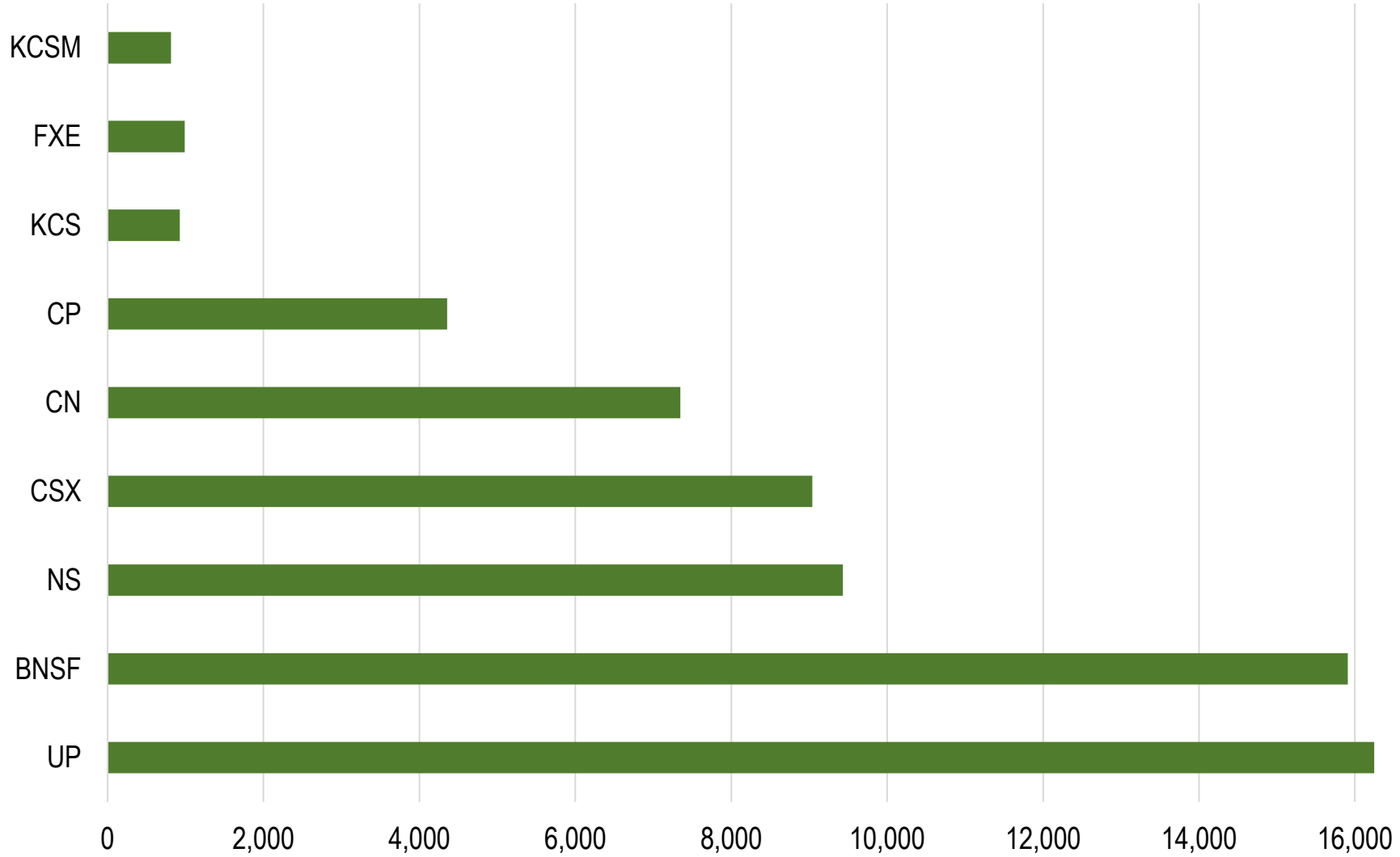
Spatial Performance of Rail and Road Transportation



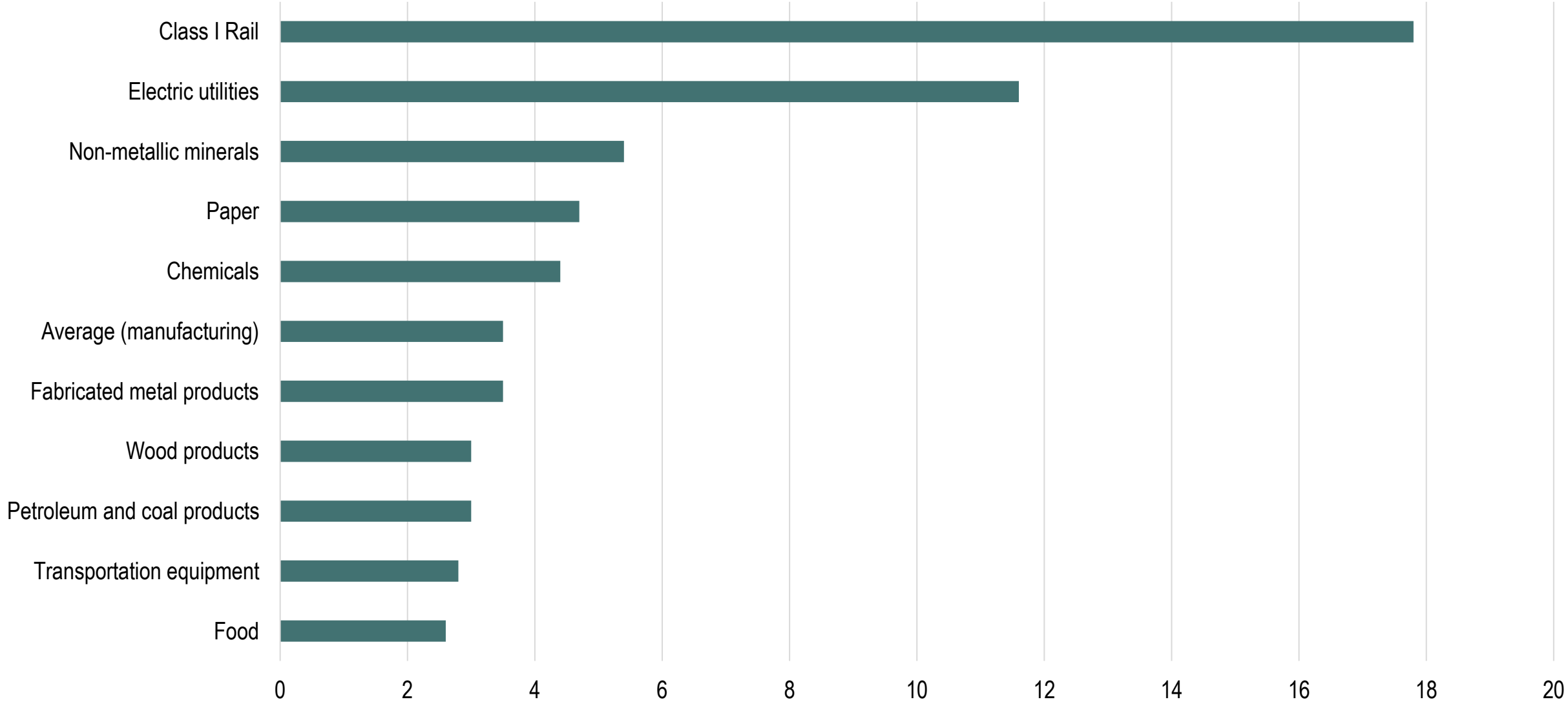
Major Segments of the Rail Freight Market

Segment	Description	Commodities	Share of volume
Single Wagon	Customer using a few wagons	Chemicals, Vehicles and Machinery	50 %
Full / Block Train	Customer has enough goods to fill a train	Coal and Steel, Construction materials	35 %
Intermodal	Transportation by container: the container or trailer is lifted on the wagon	Finished goods, Containerized goods	15 %

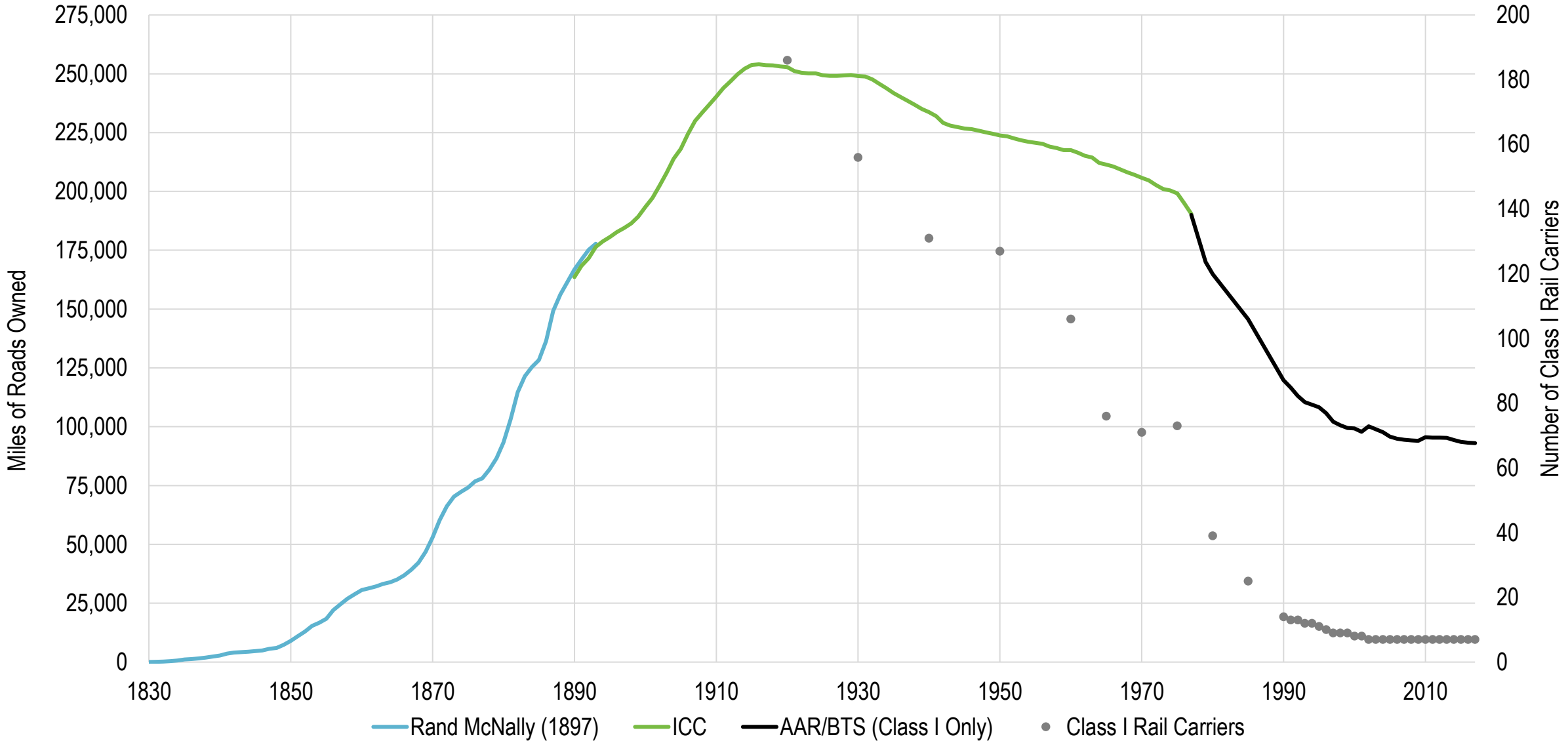
Operating Revenue of Major North American Railroads, 2007 (million U.S. dollars)



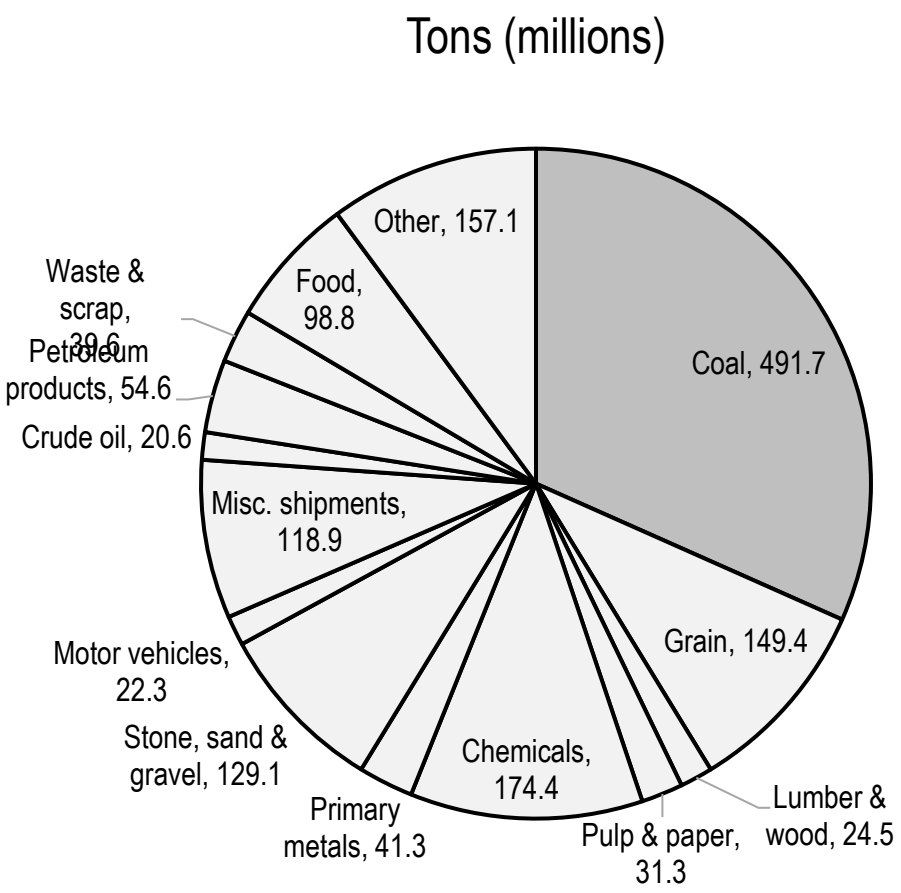
Capital Expenditures as % of Revenue

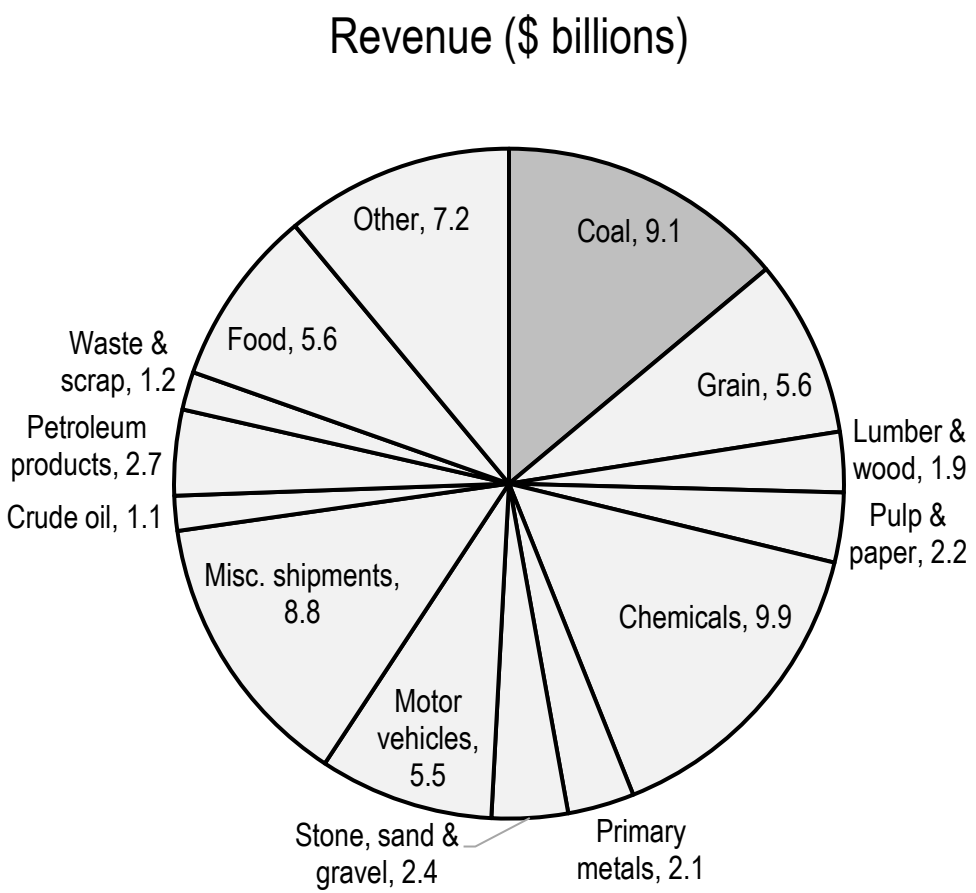


Rail Track Mileage and Number of Class I Rail Carriers, United States, 1830-2017

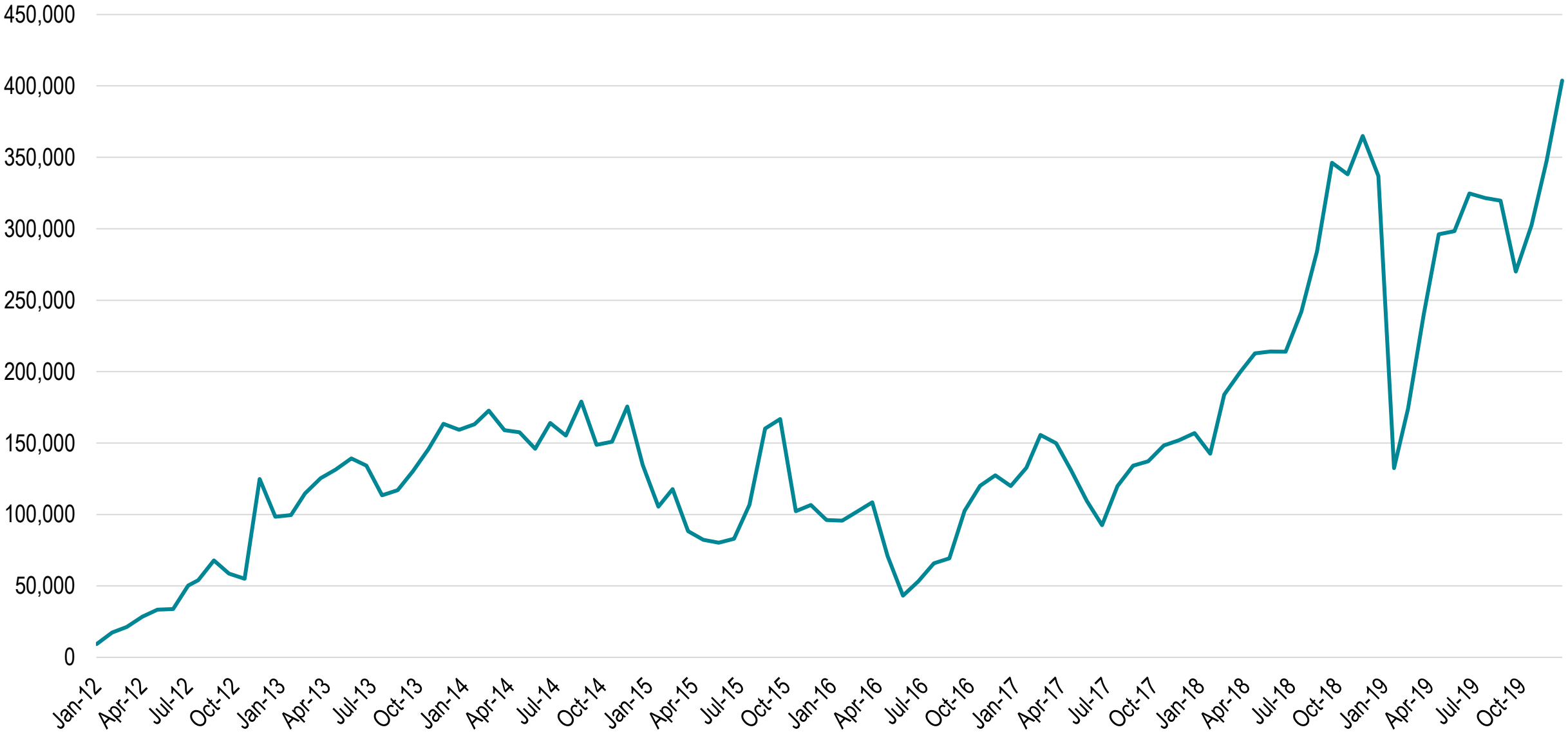


Commodity Carried by Class I American Railways, 2016

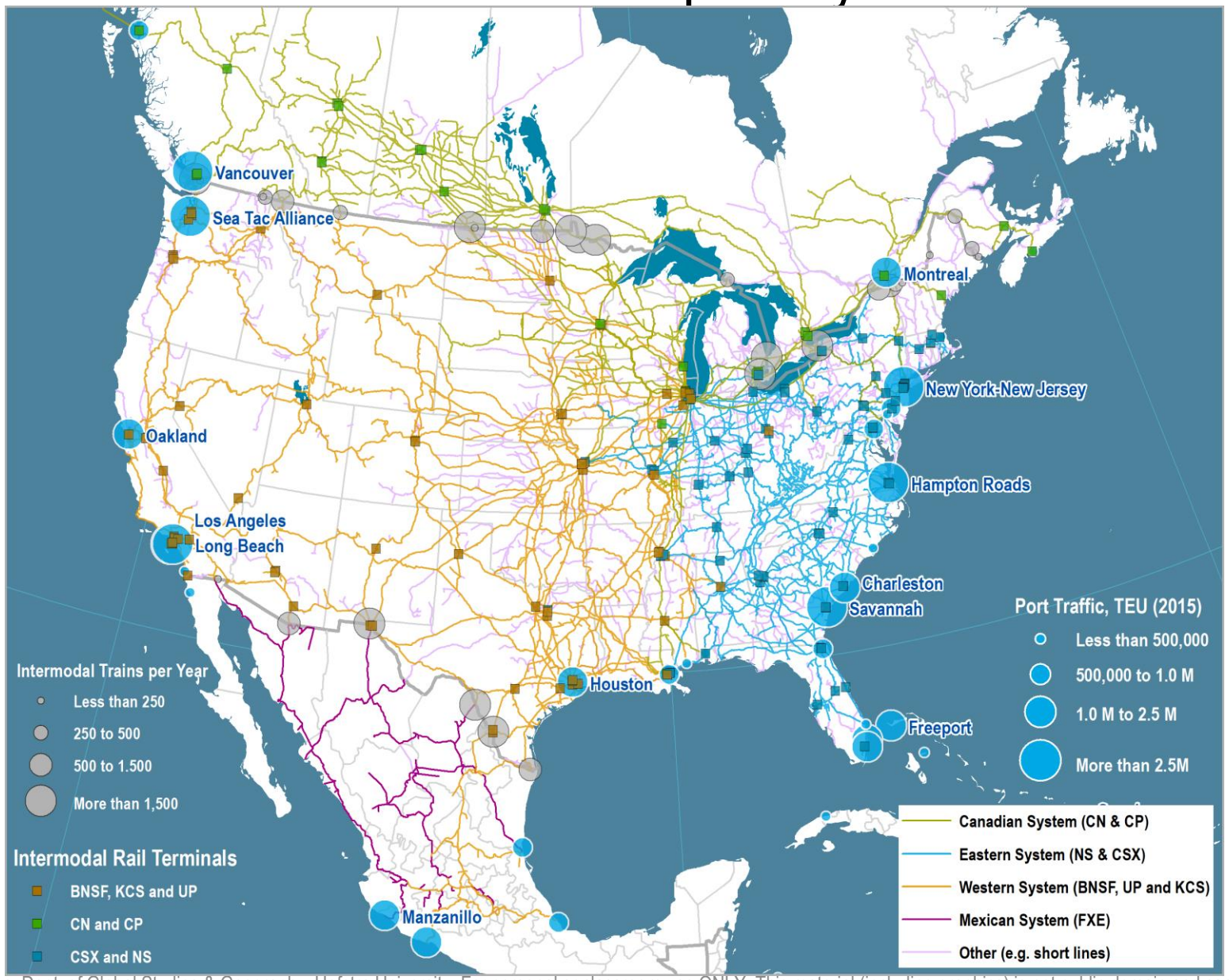




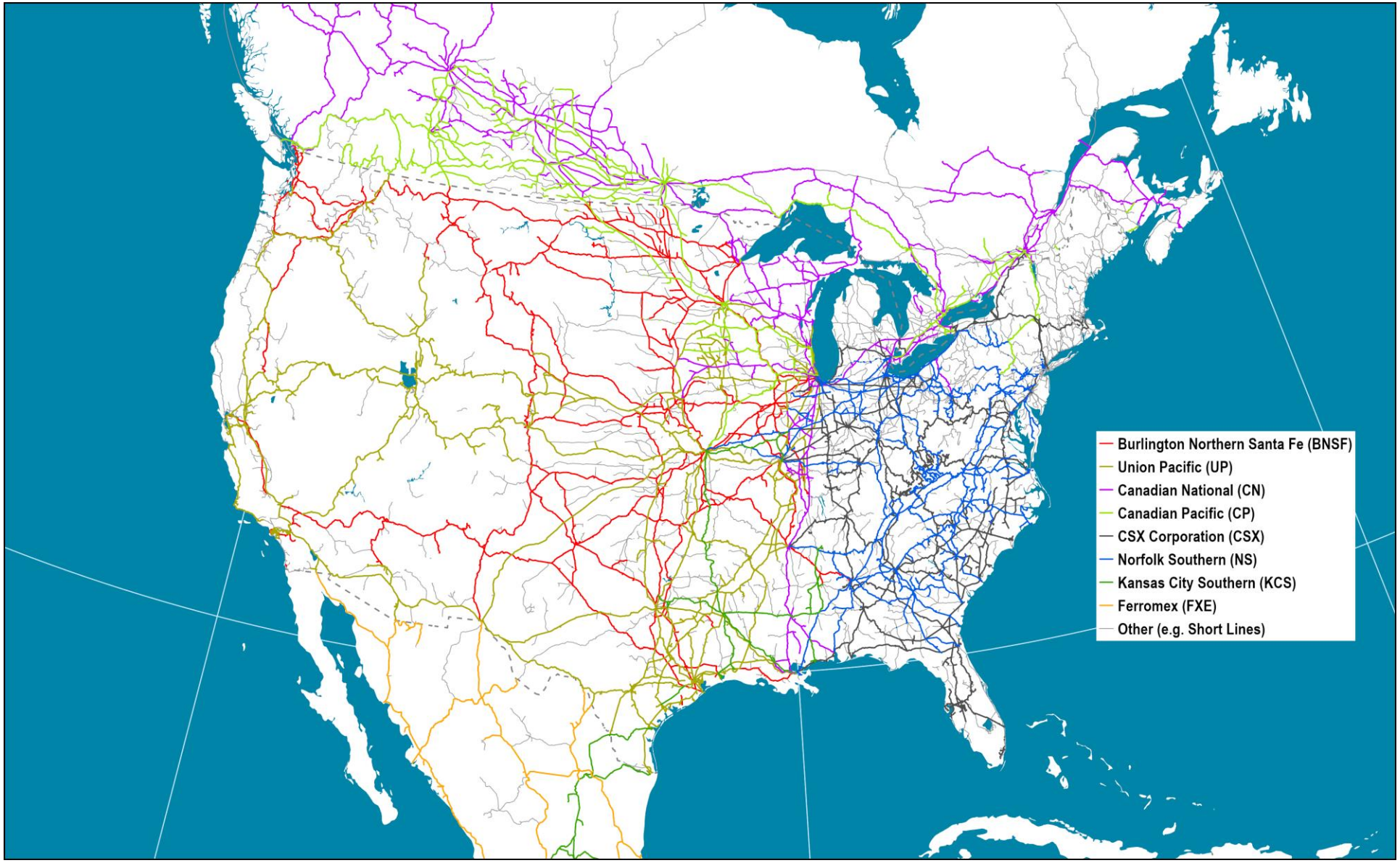
Canadian Crude Oil Exports by Rail, 2012-2020 (in barrels per day)



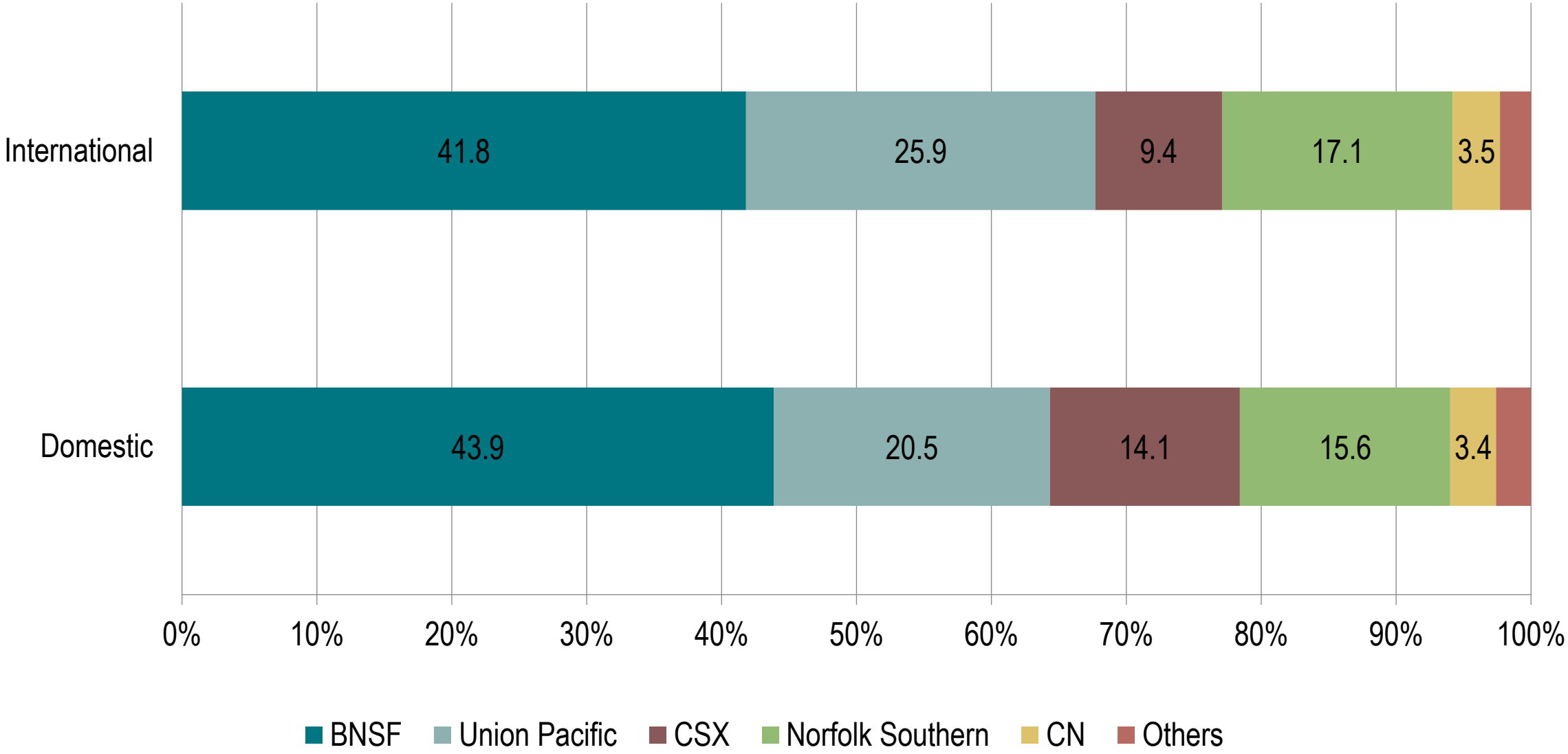
The North American Intermodal Rail Transport System



Ownership of Major North American Rail Lines, 2017

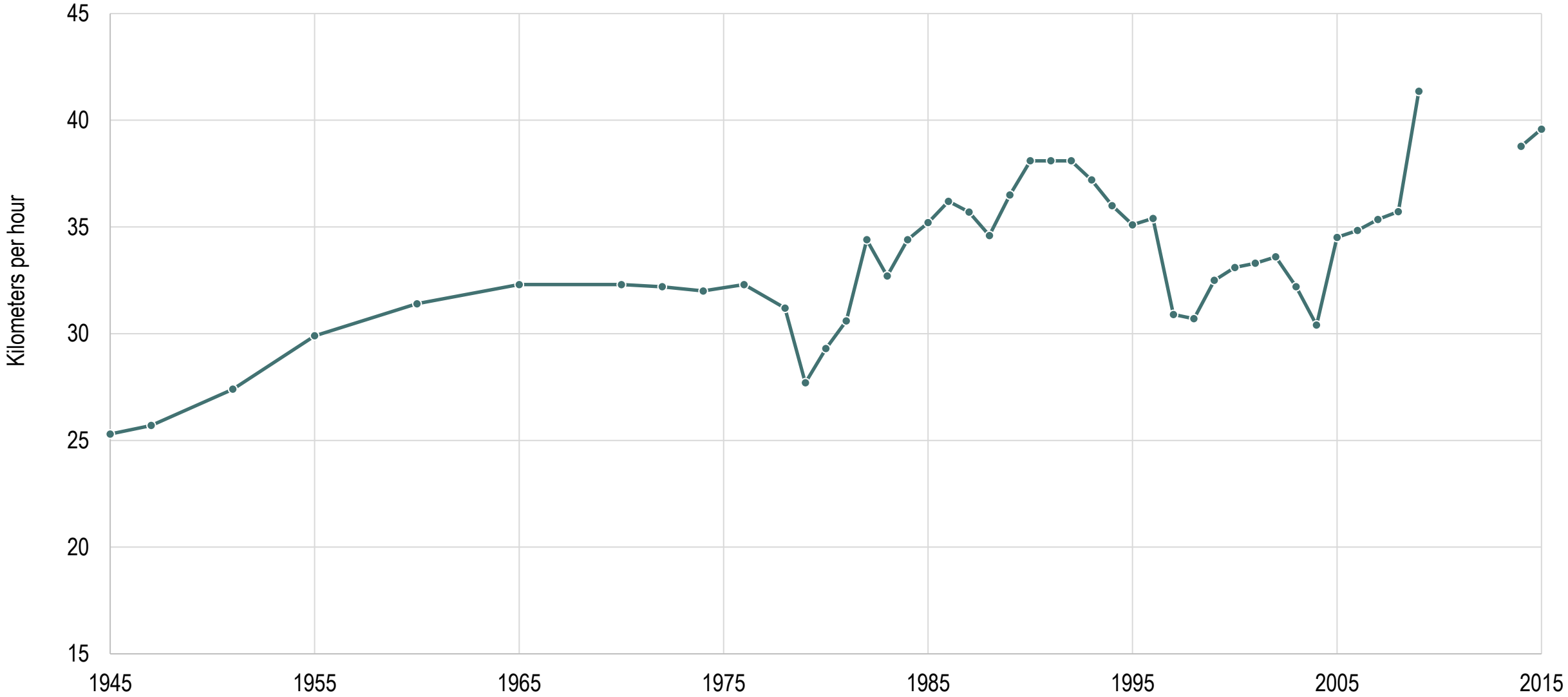


Market Share of US Intermodal Rail, 2006

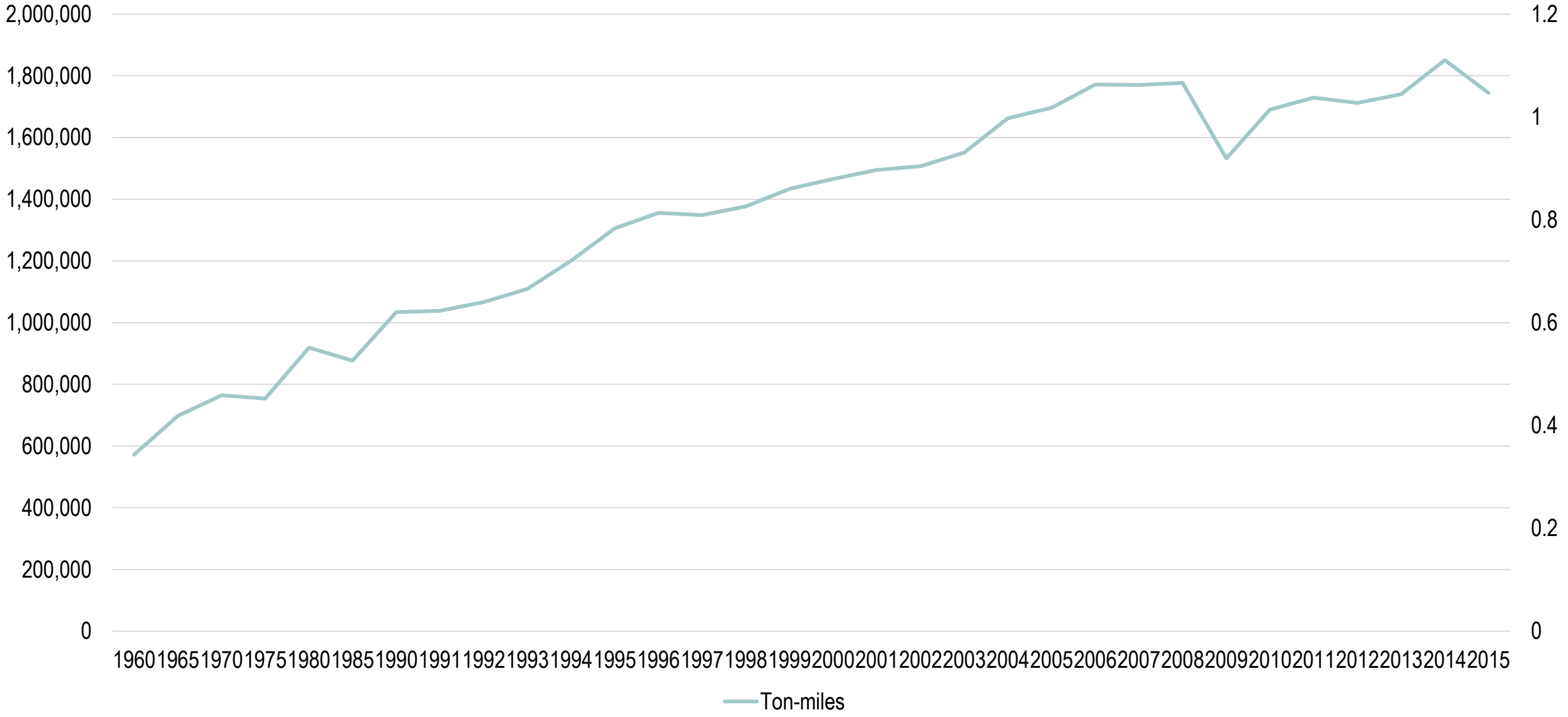


Major North American Rail Corridors Improved since 2000

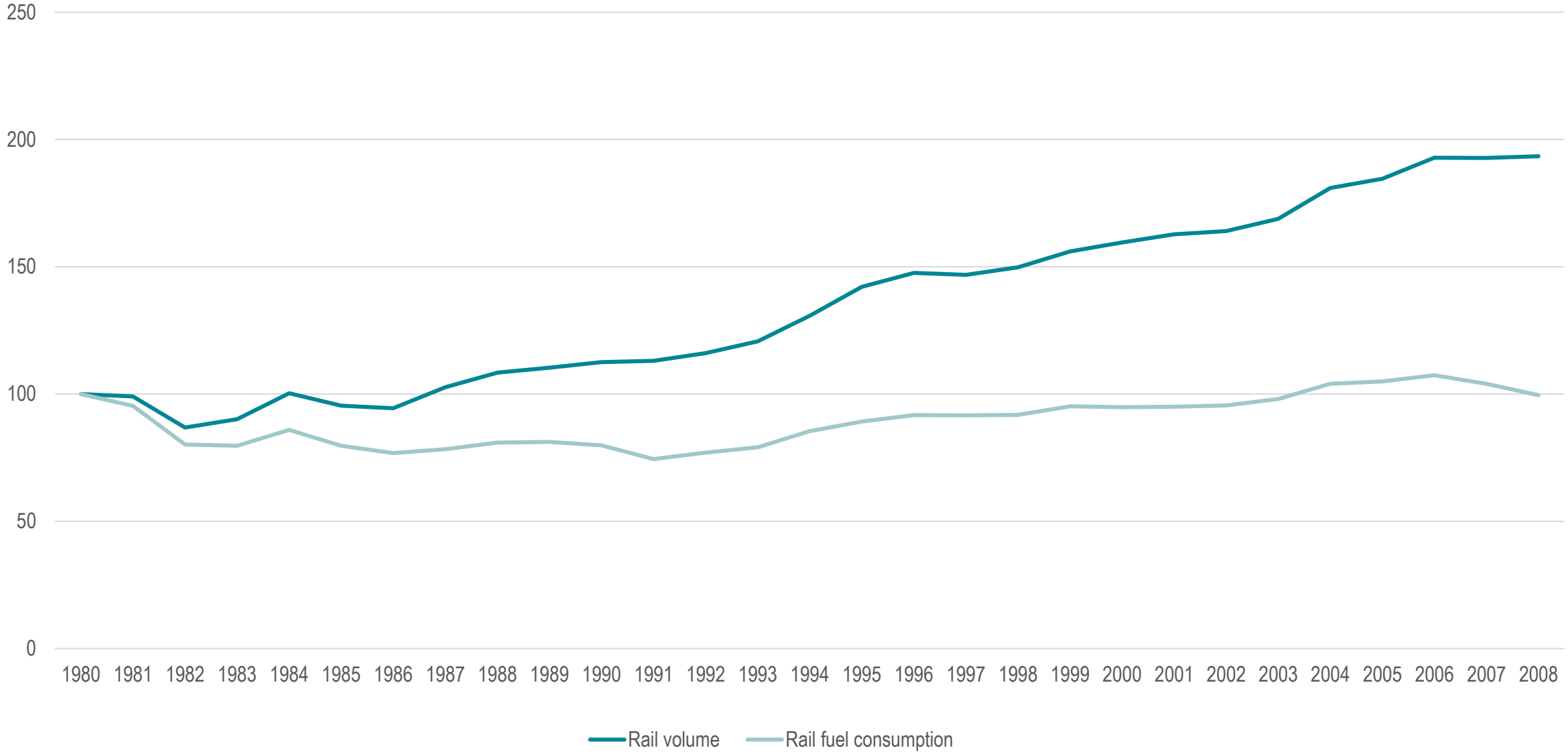
Average Speed of Class I Railroads, 1945-2015



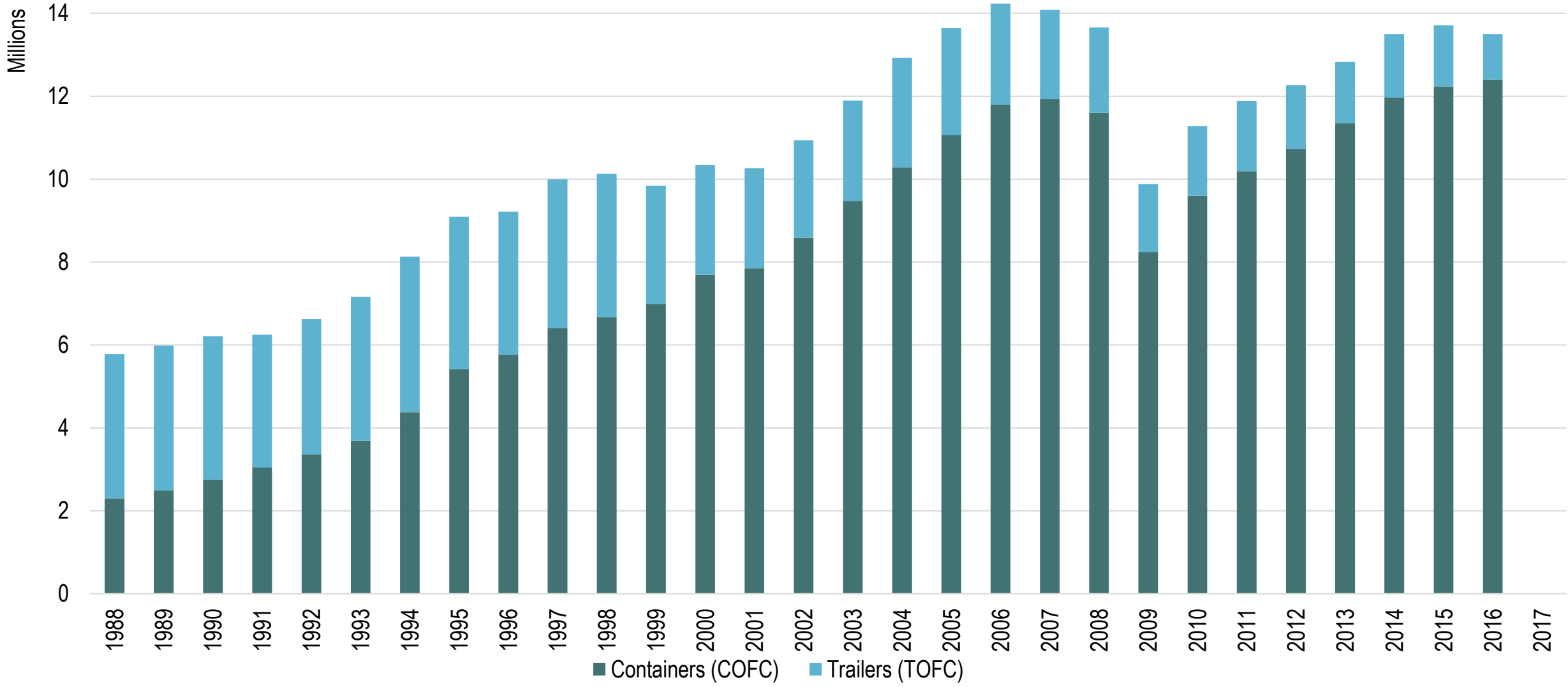
Rail Freight Volumes Transported in the United States, 1960-2015



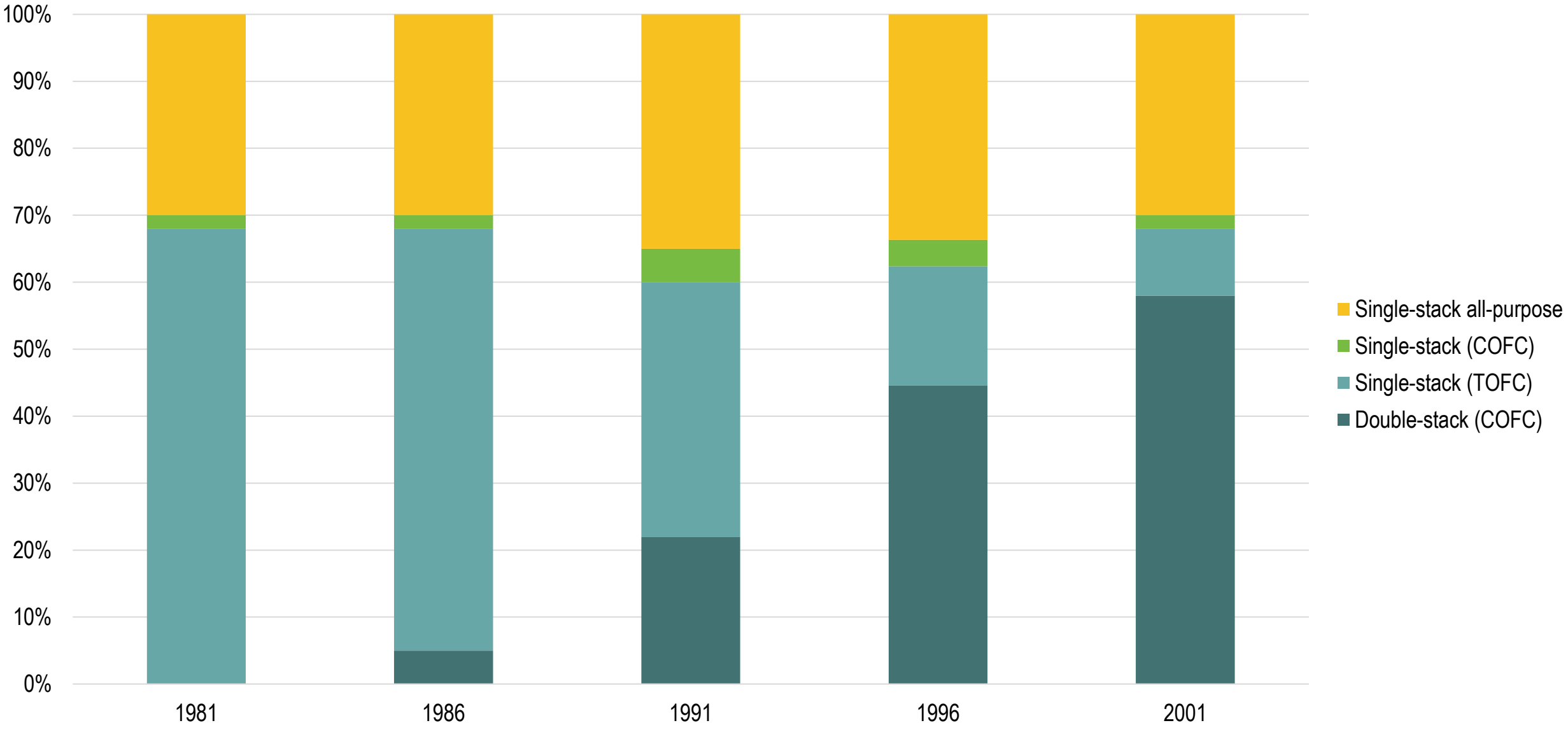
Rail Volume and Fuel Consumption, United States, 1980-2008 (1980=100)



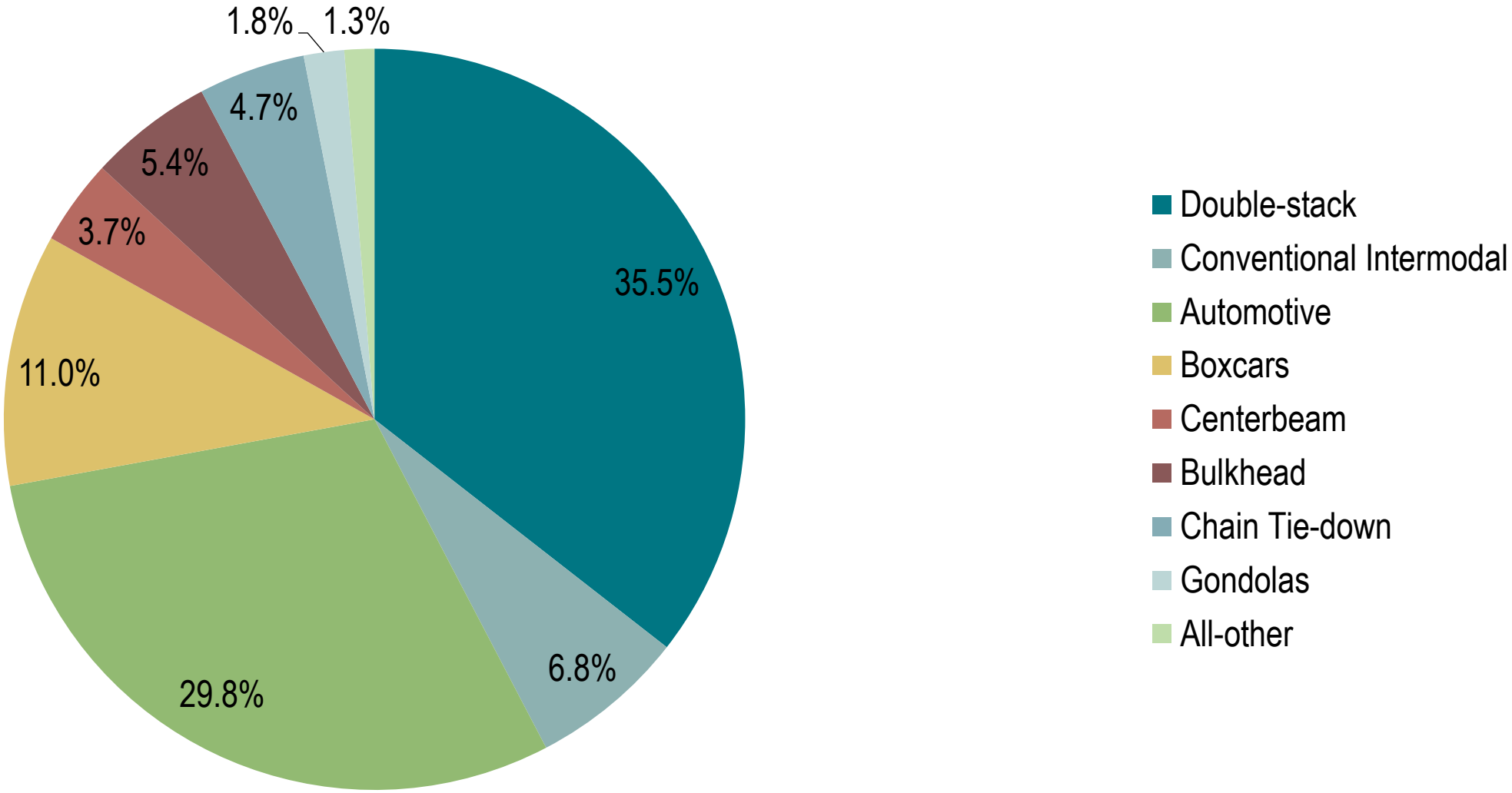
American Intermodal Rail Traffic, 1988-2016



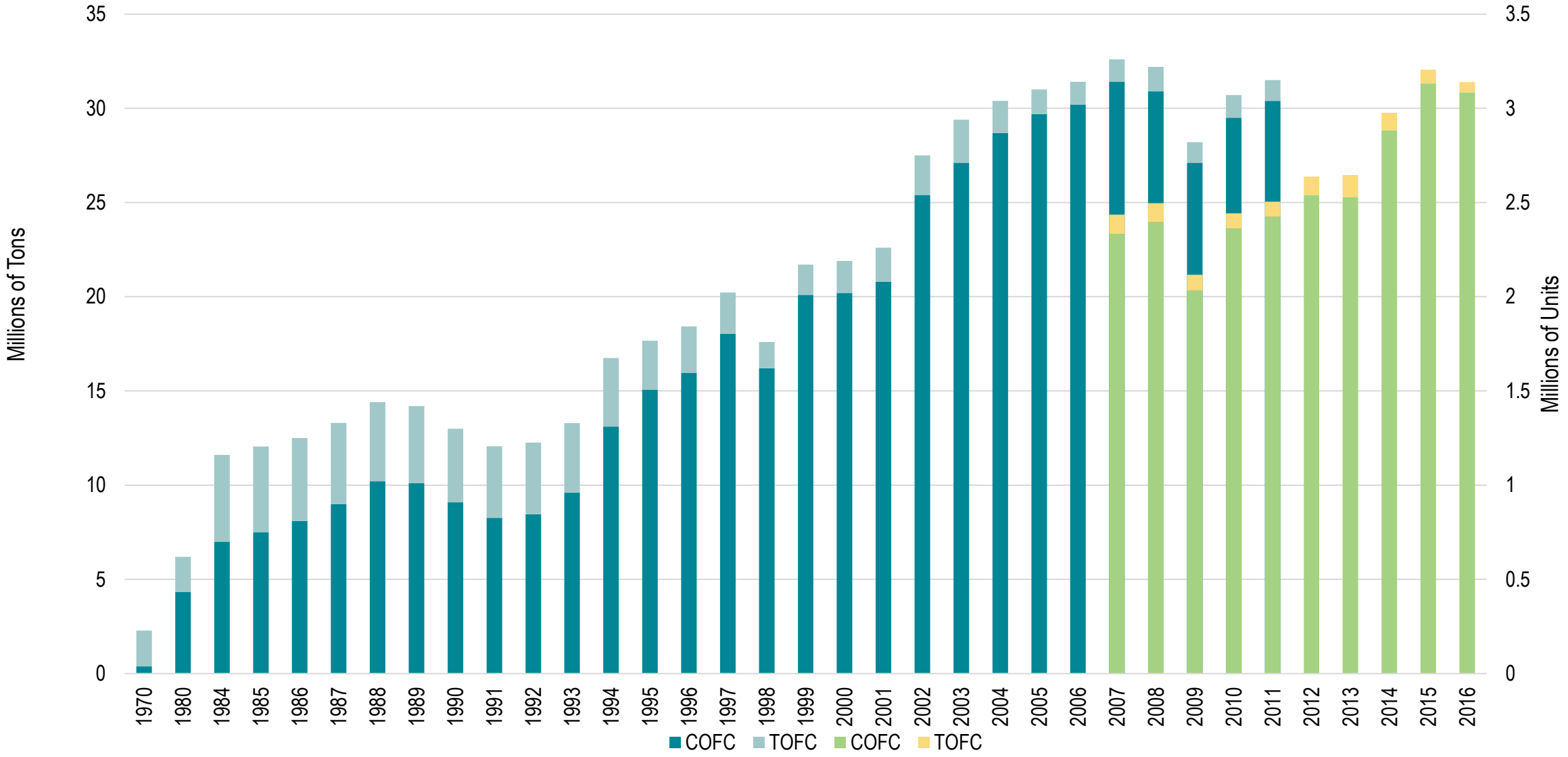
Composition of the North American Intermodal Rail Fleet



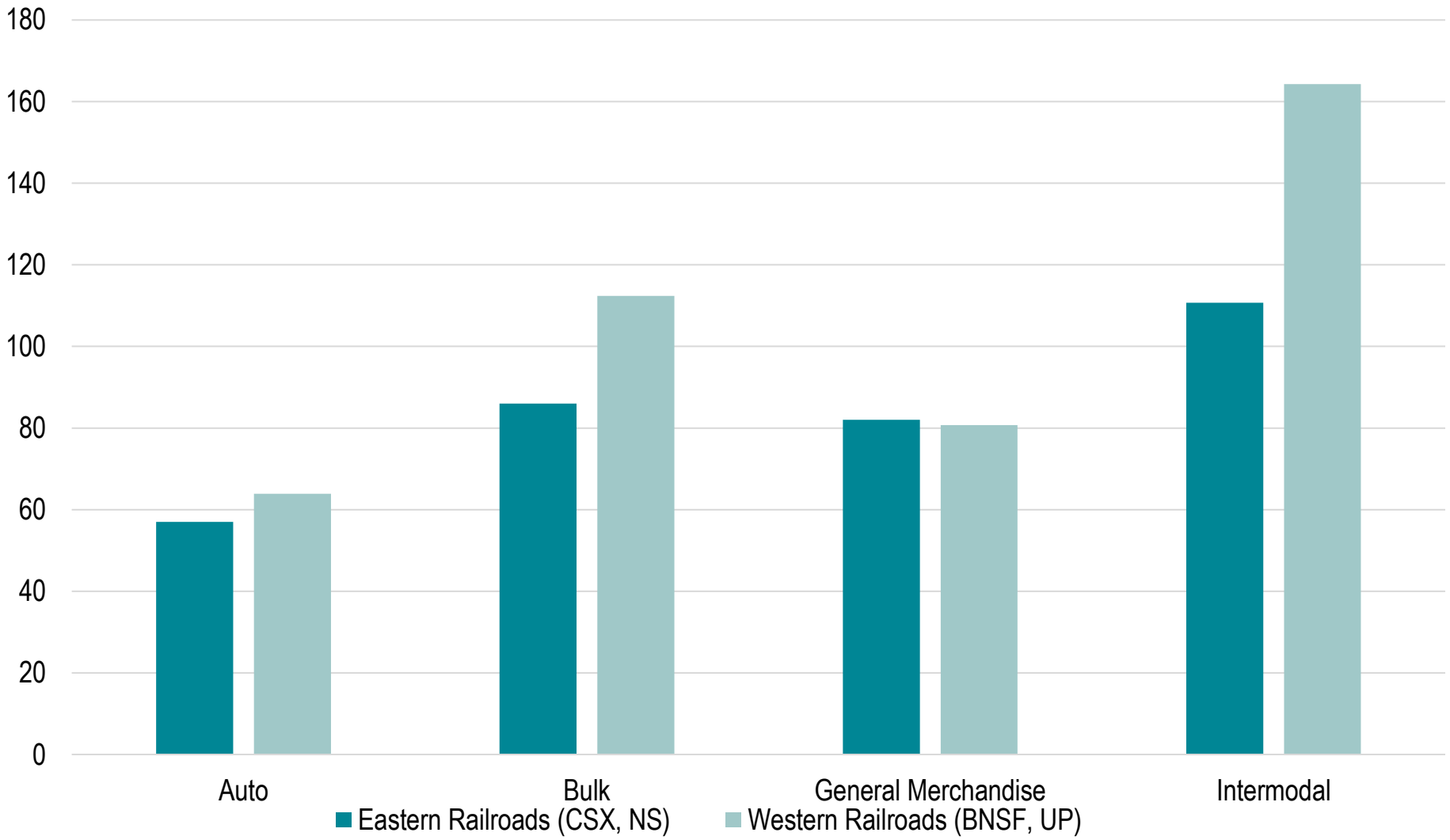
Composition of the TTX Railcar Fleet, 2013



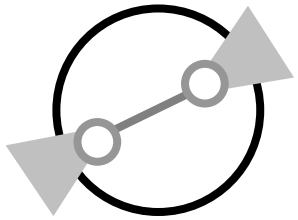
Canadian Intermodal Rail Traffic, 1970-2016

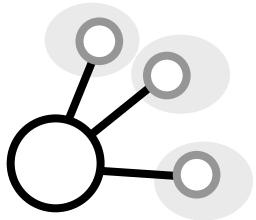


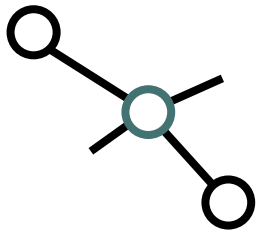
Average Freight Train Length, United States

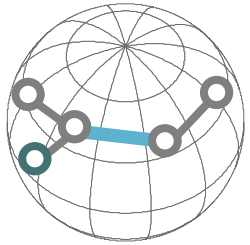


Types and Functions of Rail Freight Corridors



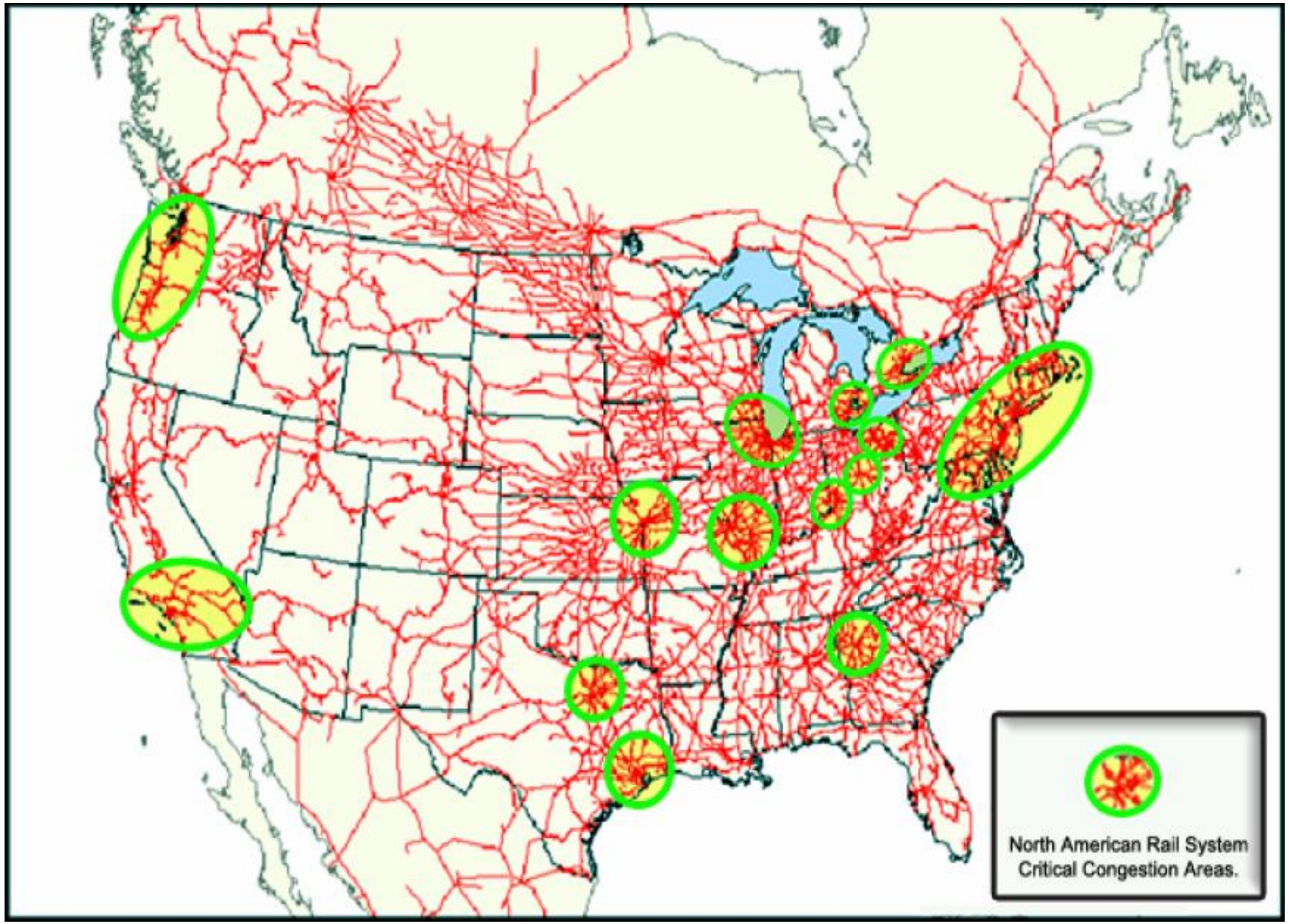




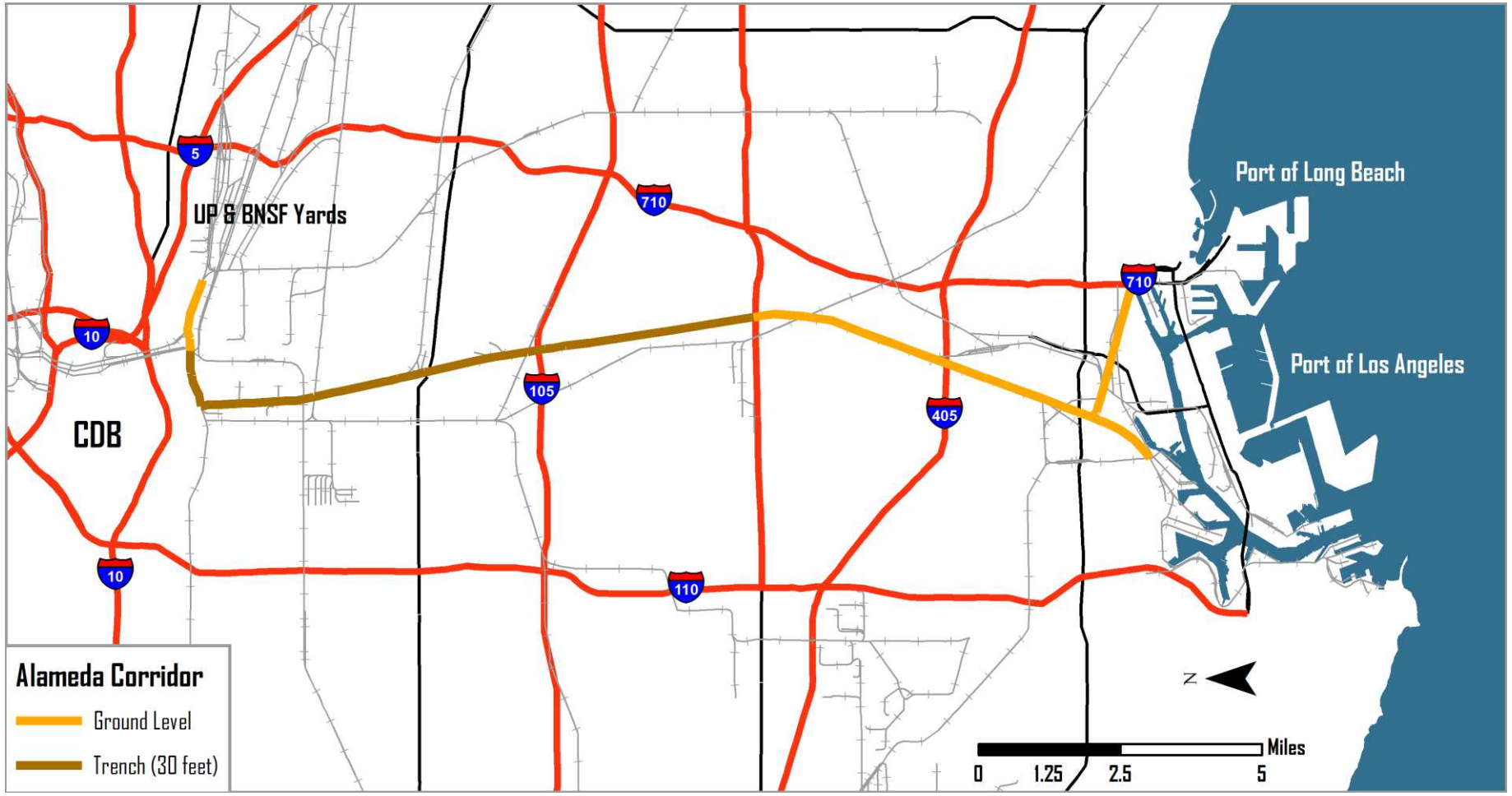


Type	Function	Example
Short distance (within a gateway / hub)	Modal shift, improved capacity and throughput	Switch carrying; Alameda Corridor; Panama Canal Railway
Hinterland access (between a gateway and its market area)	Expand market area, reduce distribution costs & congestion	Rail shuttles; Satellite terminals; Inland ports
Landbridge (between gateways)	Long distance container flows, continuity of global commodity chains	North American landbridge; Eurasian landbridge
Circum-hemispheric (between gateways with a maritime segment)	Integrated global transport chains	“Belt and Road Initiative”

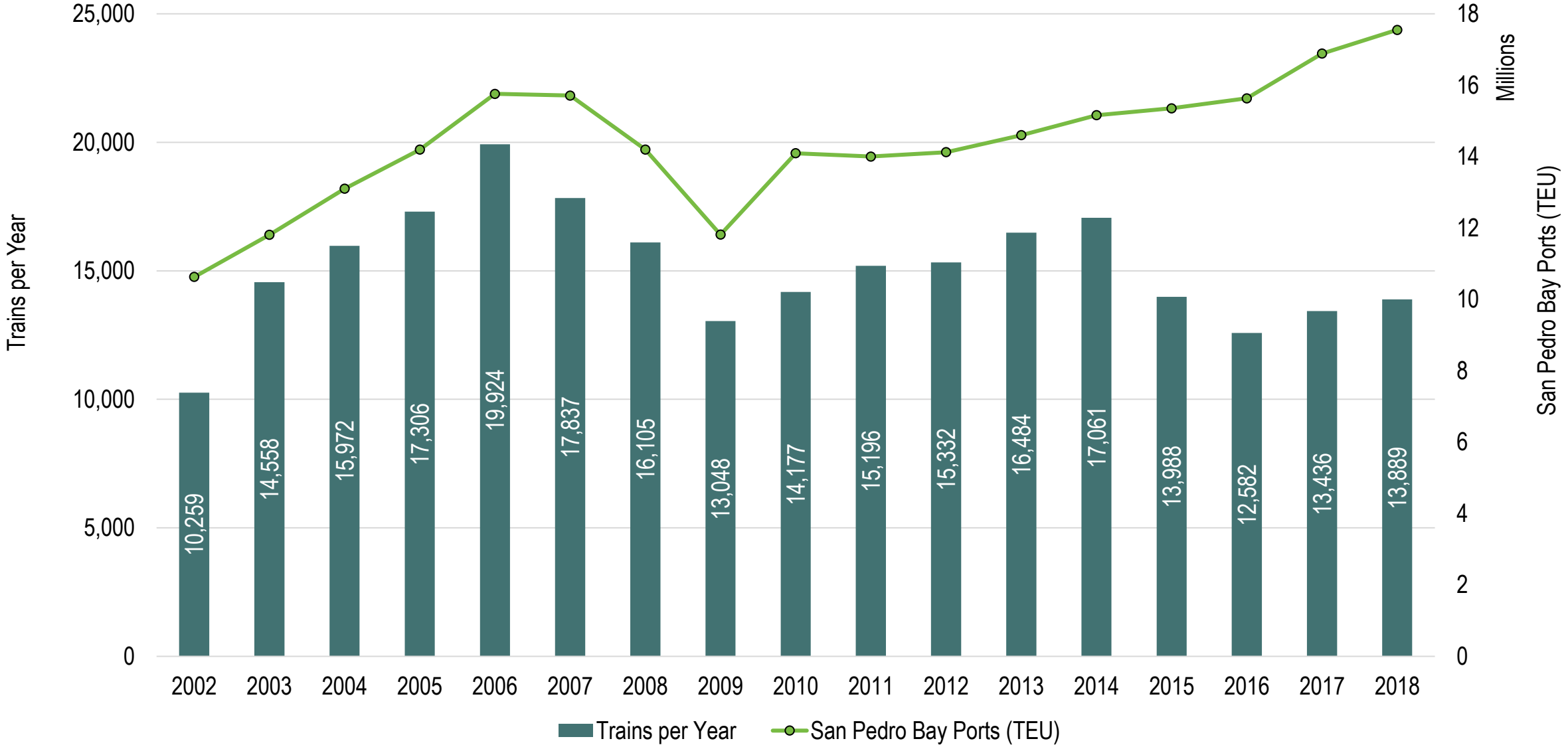
Under Construction



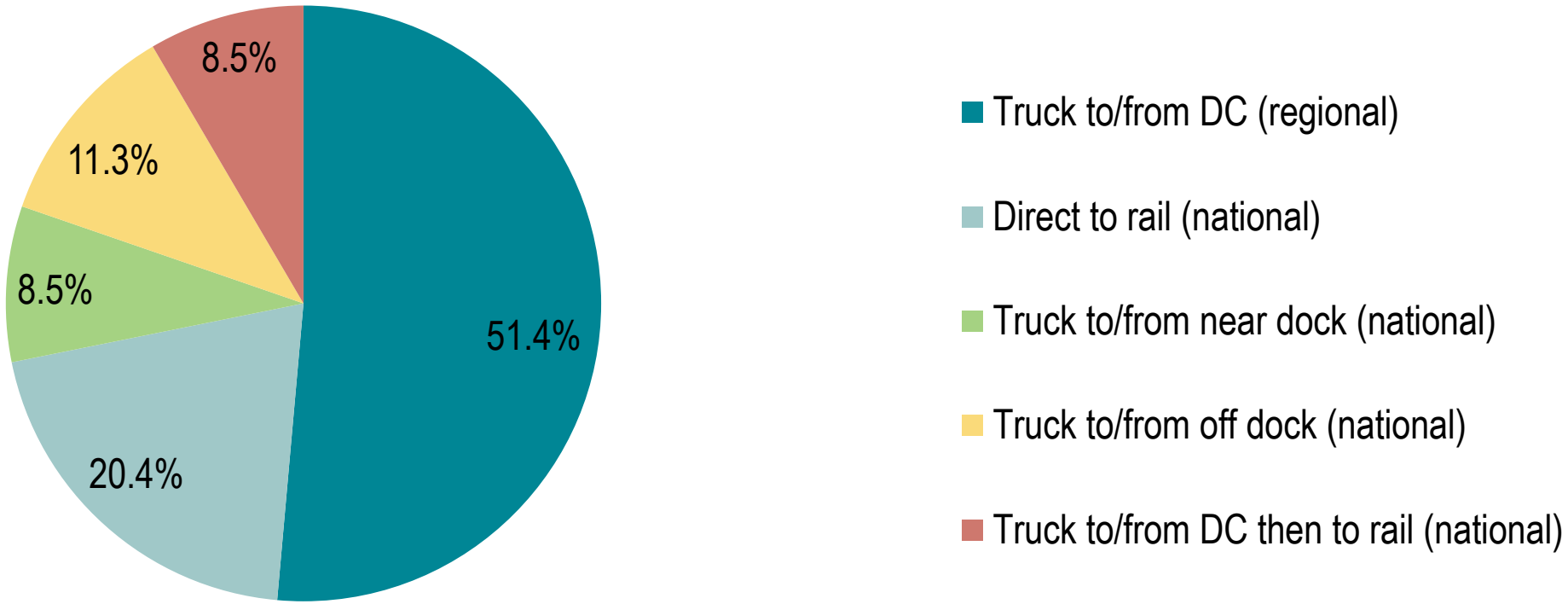
The Alameda Rail Corridor



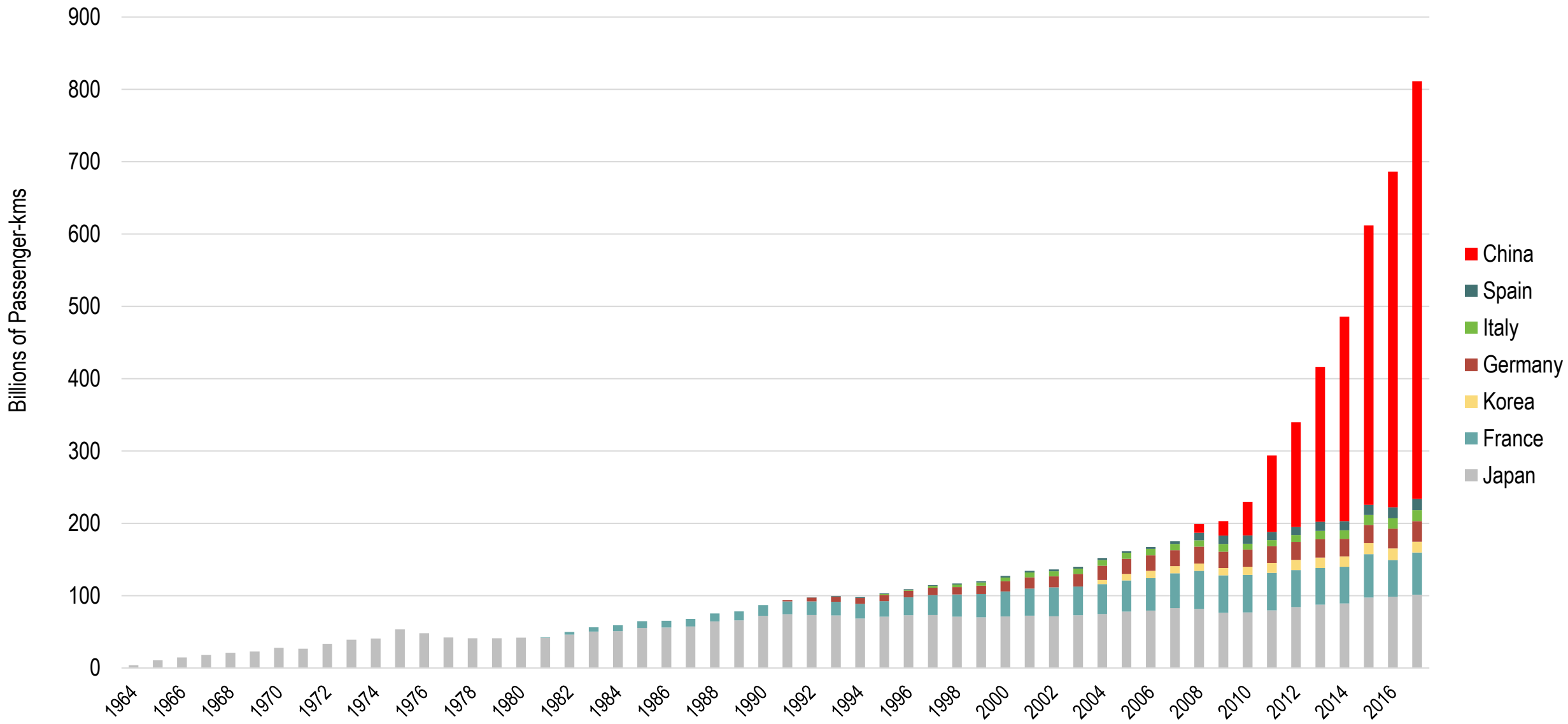
Number of Trains Running Through the Alameda Corridor per Year and Containers Handled by the San Pedro Bay Port Cluster, 2002-2018



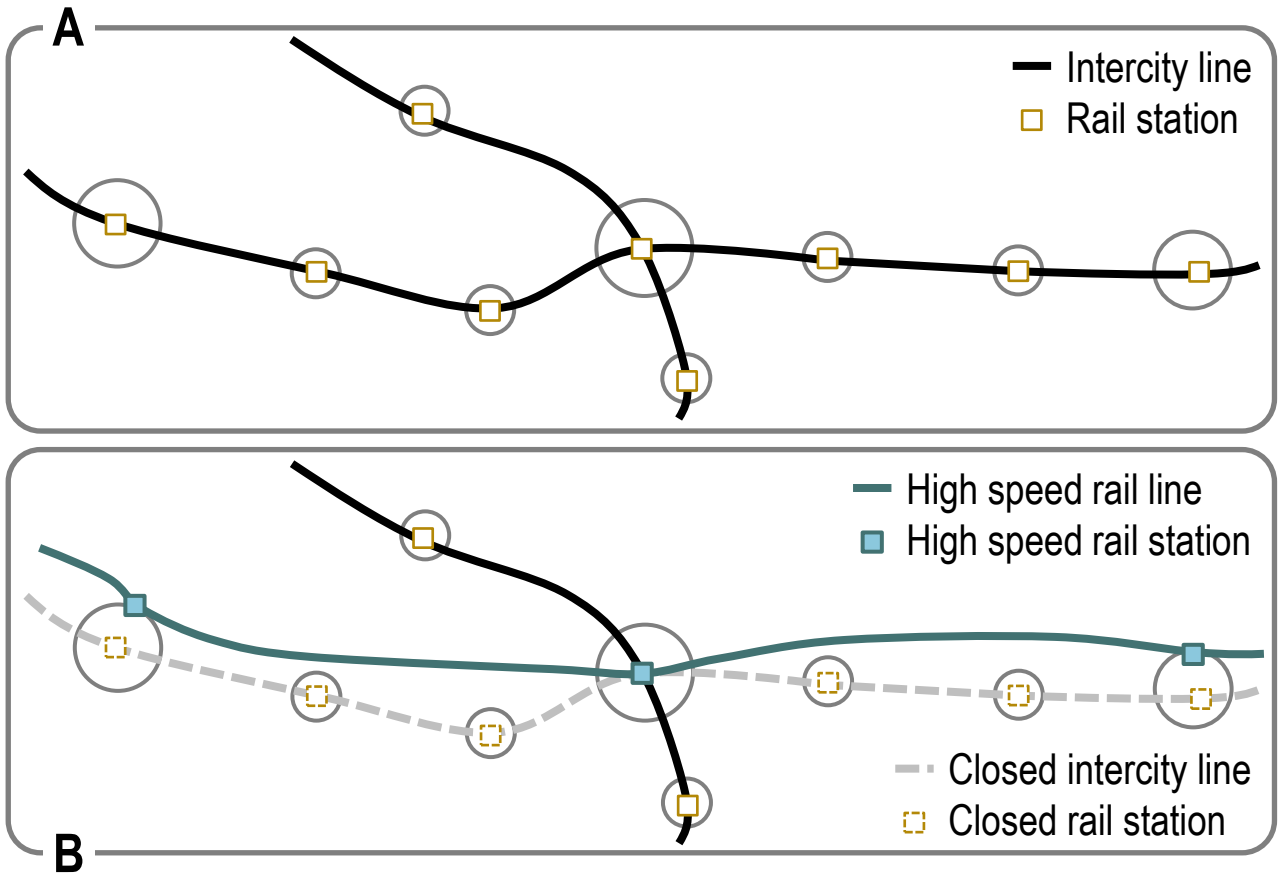
San Pedro Bay Port Container Distribution



Development of High-Speed Train Traffic, Largest Markets,1964-2017



Restructuring Effects of High-Speed Rail



Comparison Between European, North American and Pacific Asian Railways

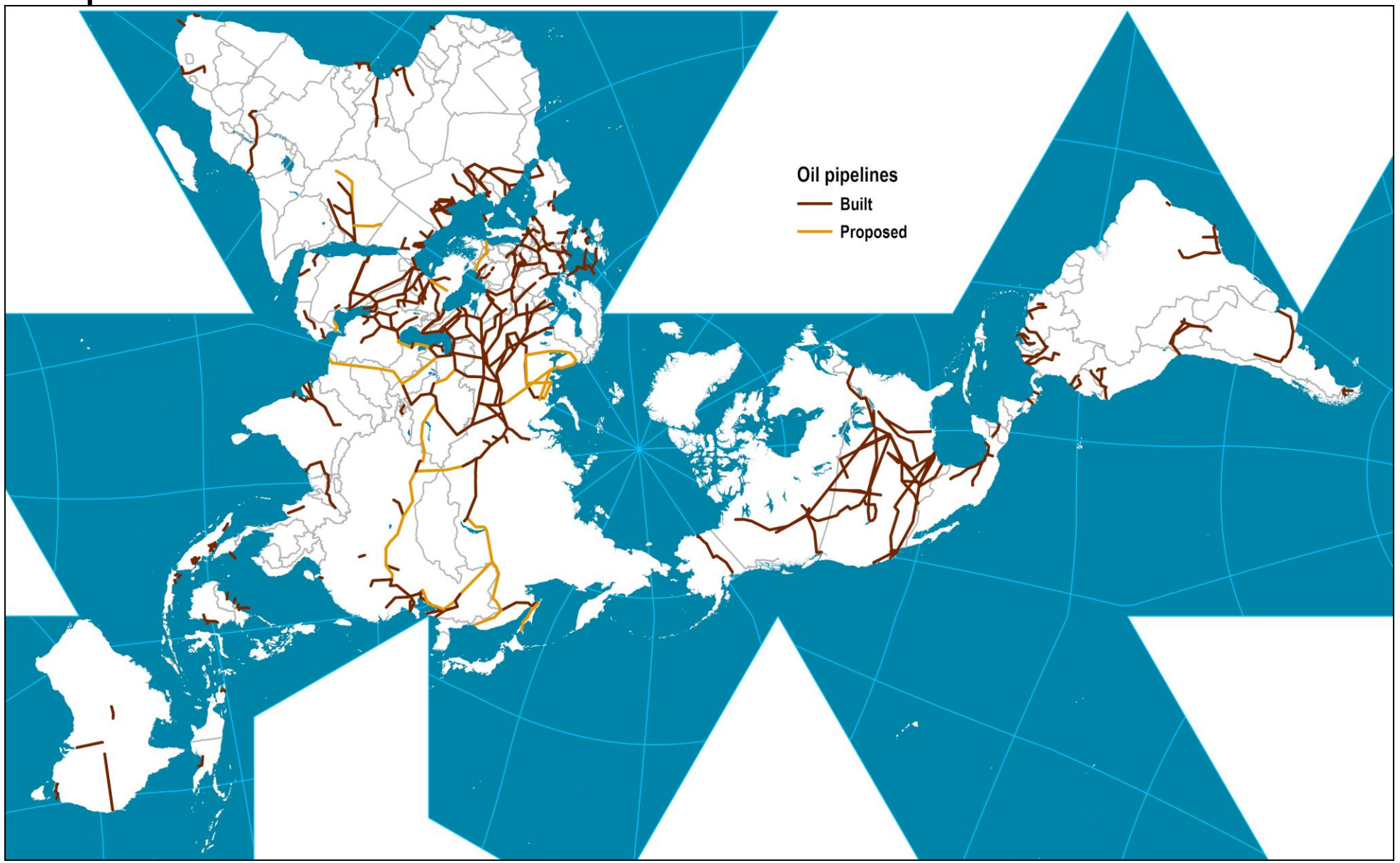
Issue	Europe	North America	Pacific Asia
Organisation	Separation of infrastructure from operations (for accountancy purposes)	Separation by region (markets) (private companies and concessions of vertically integrated companies)	Infrastructure and operations publicly owned
Market focus	Passenger oriented	Freight oriented	Passenger oriented
Ownership	Infrastructure mainly publicly owned with a few exceptions (e.g. UK). Freight equipment and terminals increasingly privately owned and operated.	Private	Public
Distances	Short to medium	Medium to long	Short to long

	European Union	United States
Ownership of rail infrastructure	Close to 90% state owned	Entirely private
Technical characteristics	Low axle load (standard 22,5t), electric traction limiting height of loads, differences among EU countries (loading gauge, track gauge, power supply standards)	High axle load (standard 36t), no electric traction, max. axle weight 31,8t, national railroad infrastructure standards (USA and Canada)
Capacity	400-750 meter in length, single stack, 80-120 TEU or 40-60 semitrailers	1300-3000m in length, double-stack, 250-600 TEU or 120-280 semitrailers
Operators	10 large operators	6 large class I operators
Competition	Strong competition limited by informal national and political regulations	Semi oligopolistic competition according to regions
Operations	Dense network with numerous long and short-distance corridors. Average intermodal train distance ca. 500km. Sea containers and short-sea containers distribution in rail shuttle.	Large network with main long-distance corridors from gateway ports. Average intermodal train distance 1000-1200km (US West) and 2500-3500km (US East). Sea containers distribution in port-hinterland trains. After transloading to domestic containers and semitrailers distribution in port-hinterland trains. Domestic containers and semitrailers in mostly in West- East directions.

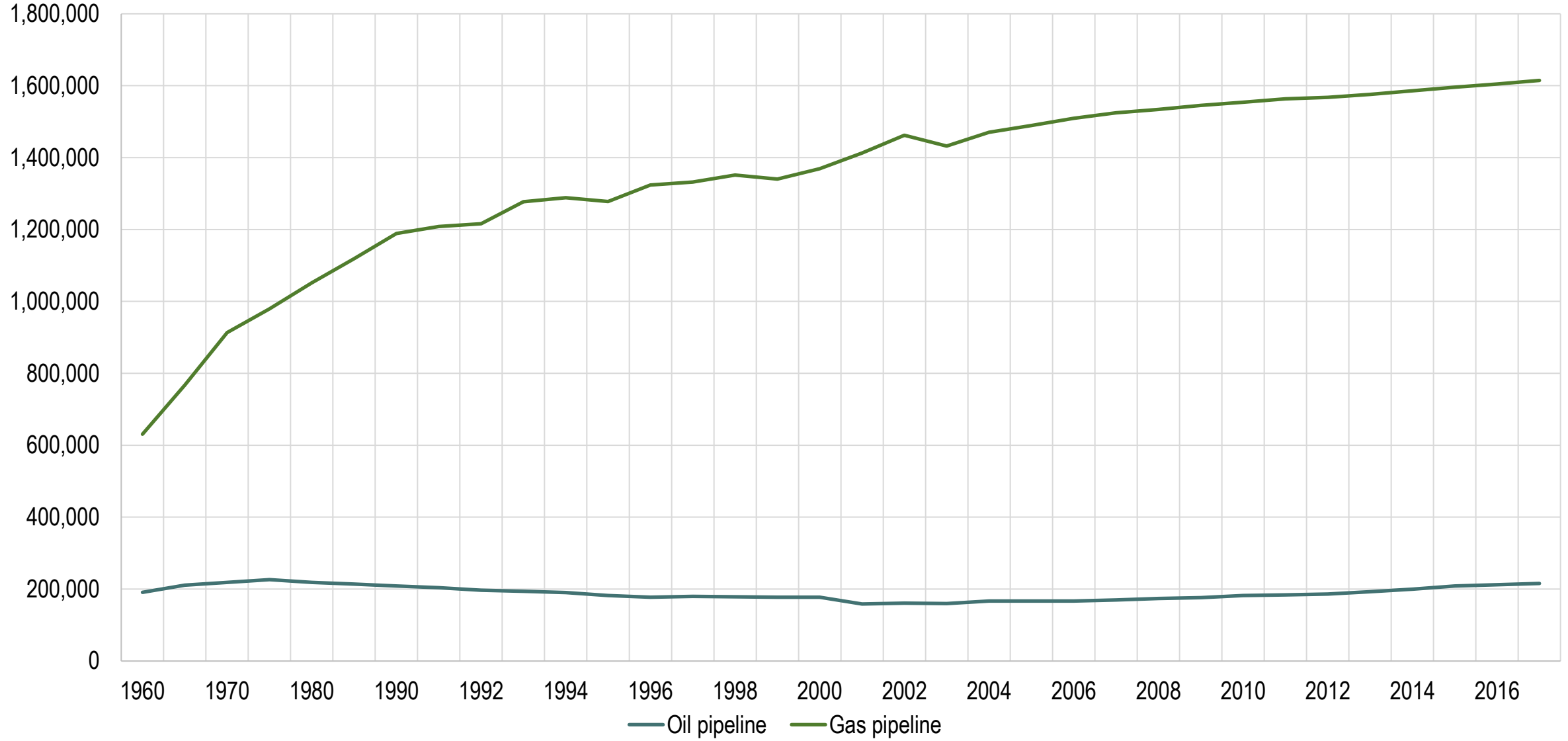
Main Advantages of Railway Infrastructure Investment

Group	Benefit	Description
Public sector	Lower highway congestion and maintenance	Potential substitution effect. Each intermodal train can take 280 trucks off the roadways, while each bulk and merchandise train can remove up to 500 trucks. Every passenger train displaces hundreds of automobiles.
	Improved safety and security	Freight railroads are safer than trucks. Railroads have one-fourth the rate of fatalities of trucks for intercity transportation, on a per ton-mile basis.
	Economic growth	Economies of scale provide long distance transport services at a lower cost.
	Environment	On average, railroads are three or more times more fuel efficient than trucks.
Shippers	Lower transit times	Reduced transit times lower shippers' costs by lowering the inventory carrying costs of the transported goods.
	Lower logistics costs	Due to economies of scale, freight rail can provide long-haul transportation services at a lower rate than trucks.
	Improved reliability	Expanded rail capacity lowers the variability in transit time by reducing the uncertainty created from delays. Improved transportation on-time performance lowers manufacturing costs, both from reducing stock-outs and shut-downs, and from the ability to safely maintain lower inventory levels.
Rail operators	Increased ridership or traffic	Expanding freight capacity can increase the revenue of the freight railroads through increased business opportunities.
	Improved reliability	Expanded rail capacity lowers the variability in transit time by reducing the uncertainty created from delays.

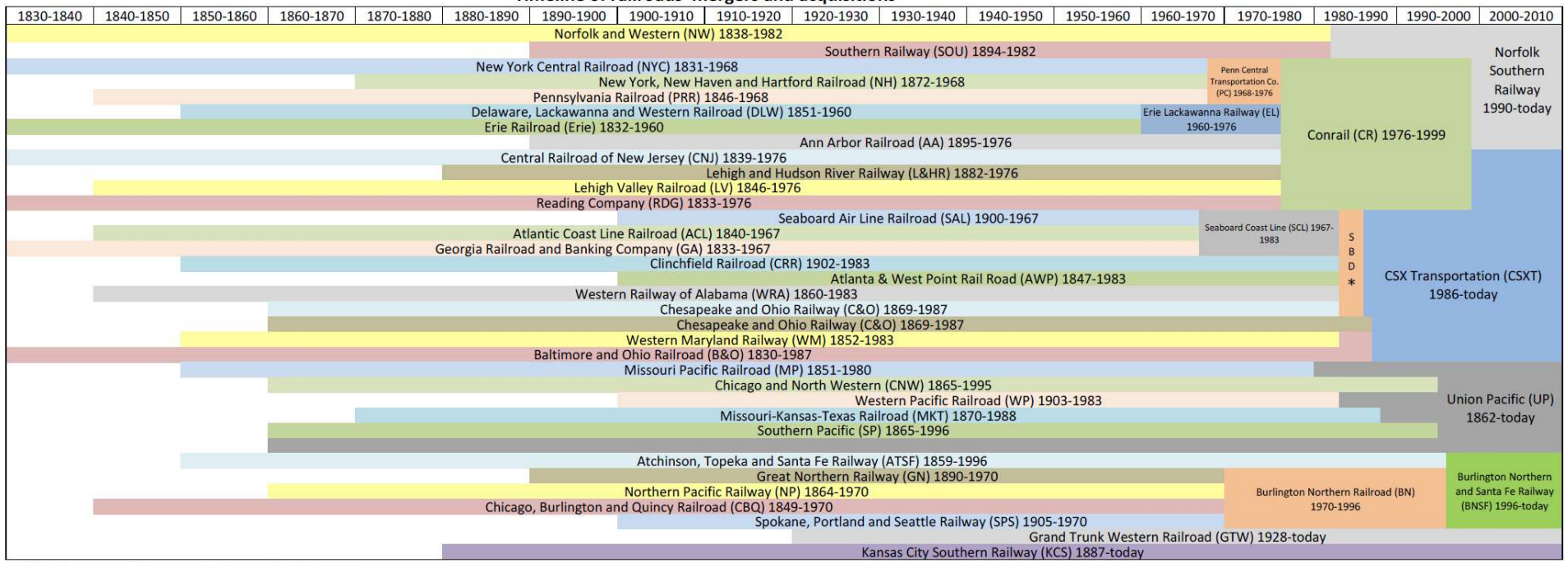
Major Oil Pipelines



Oil and Gas Pipelines Mileage in the United States, 1960-2017

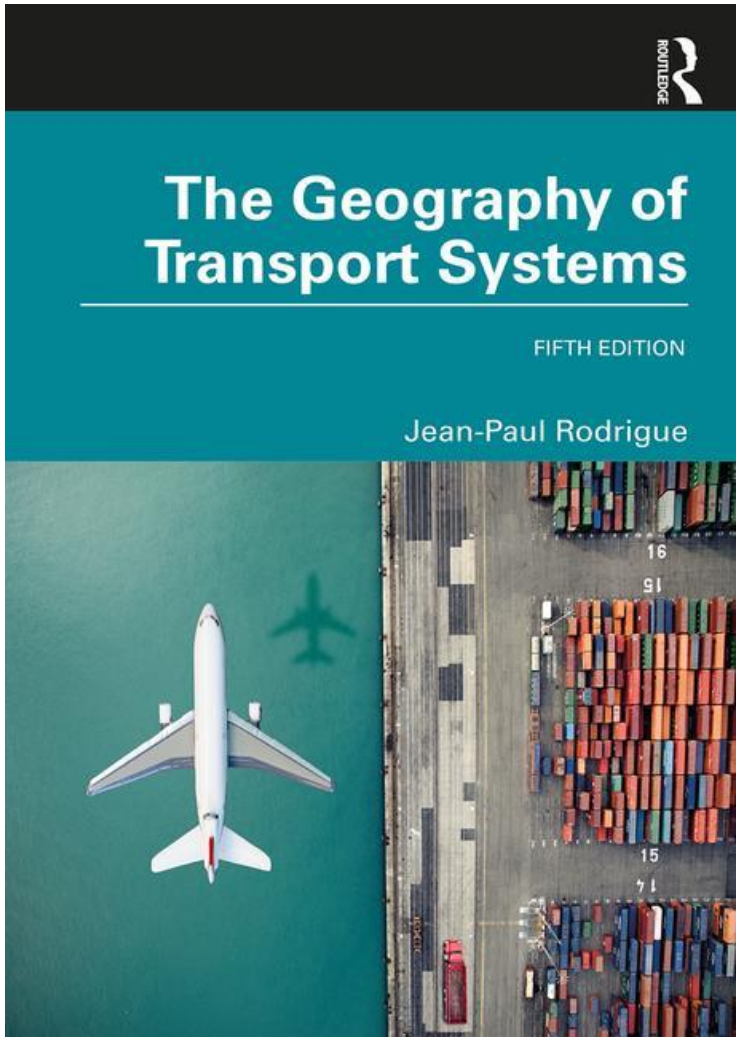


Timeline of railroads' mergers and acquisitions



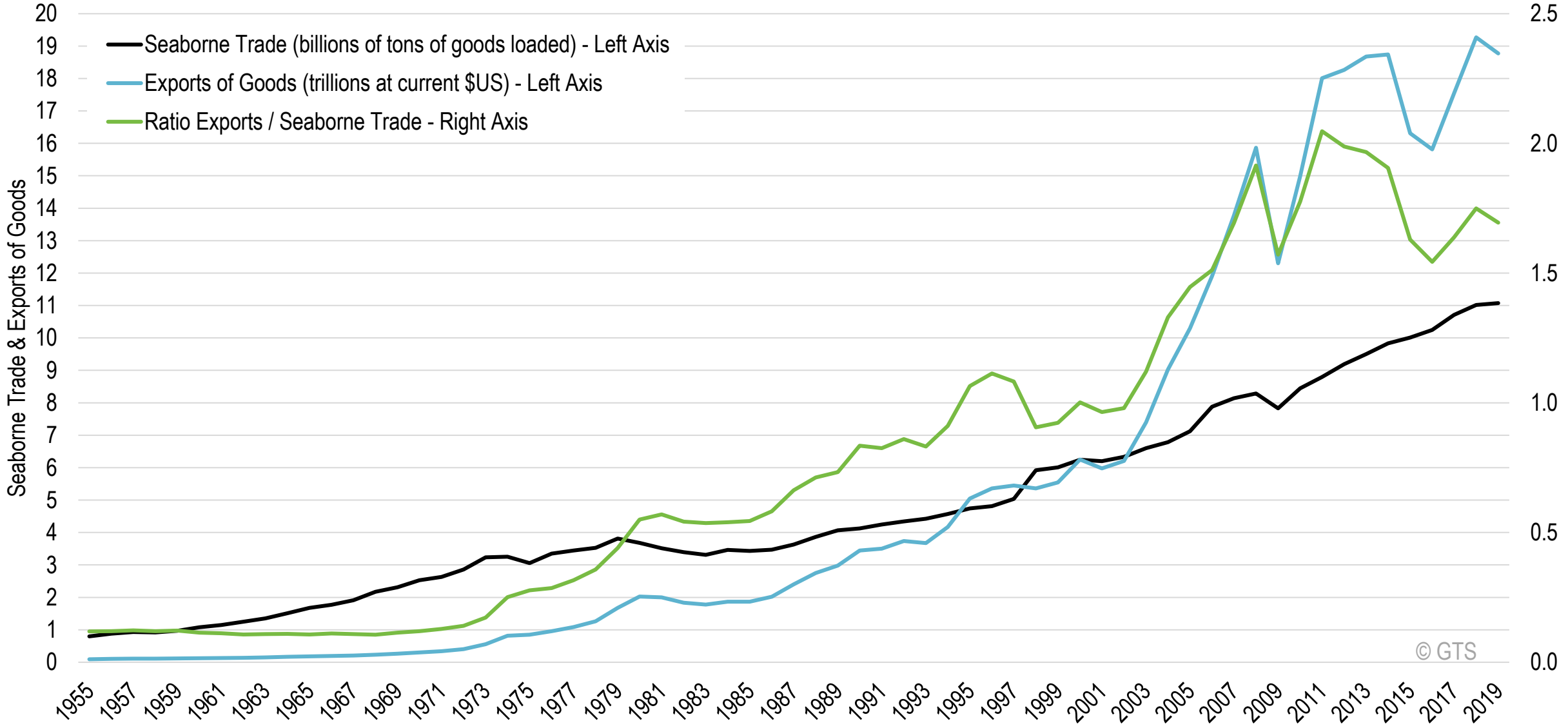
*SBD: Seaboard System Railroad 1983-1986

Source: Railroads' websites, backward historical analysis based on public data available online

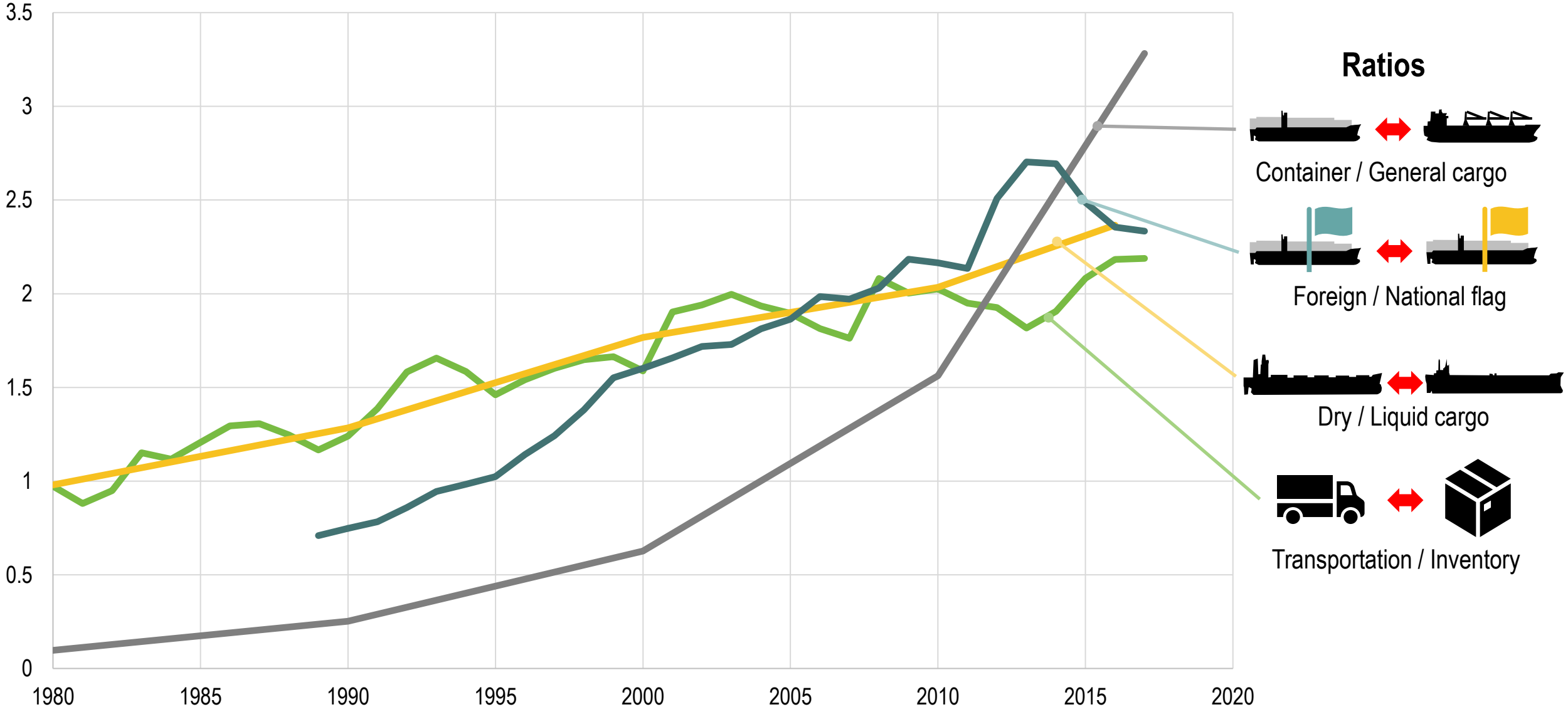


Maritime Transport

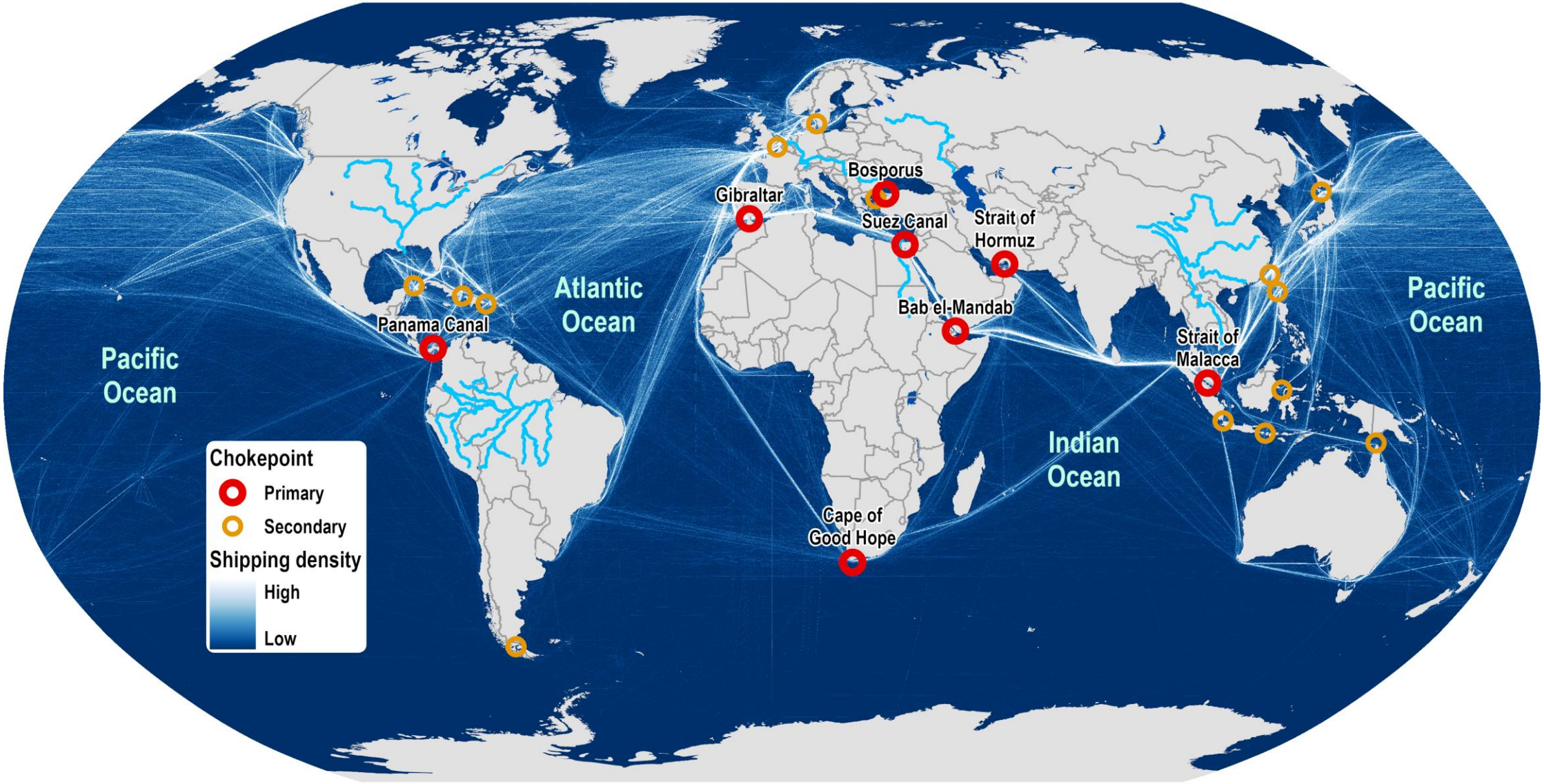
International Seaborne Trade and Exports of Goods, 1955-2019



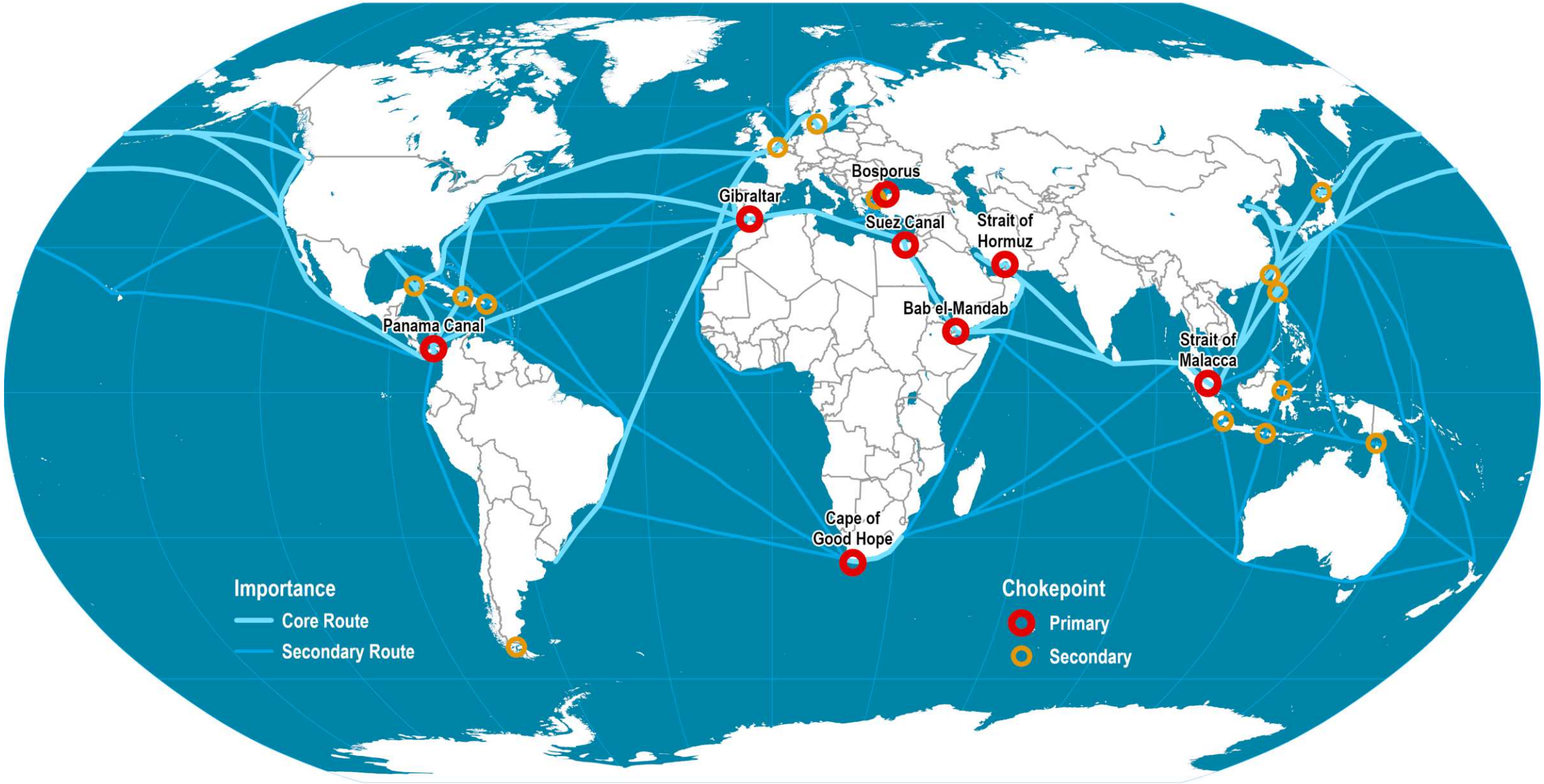
Selected Changes in Maritime Shipping, 1980-2017



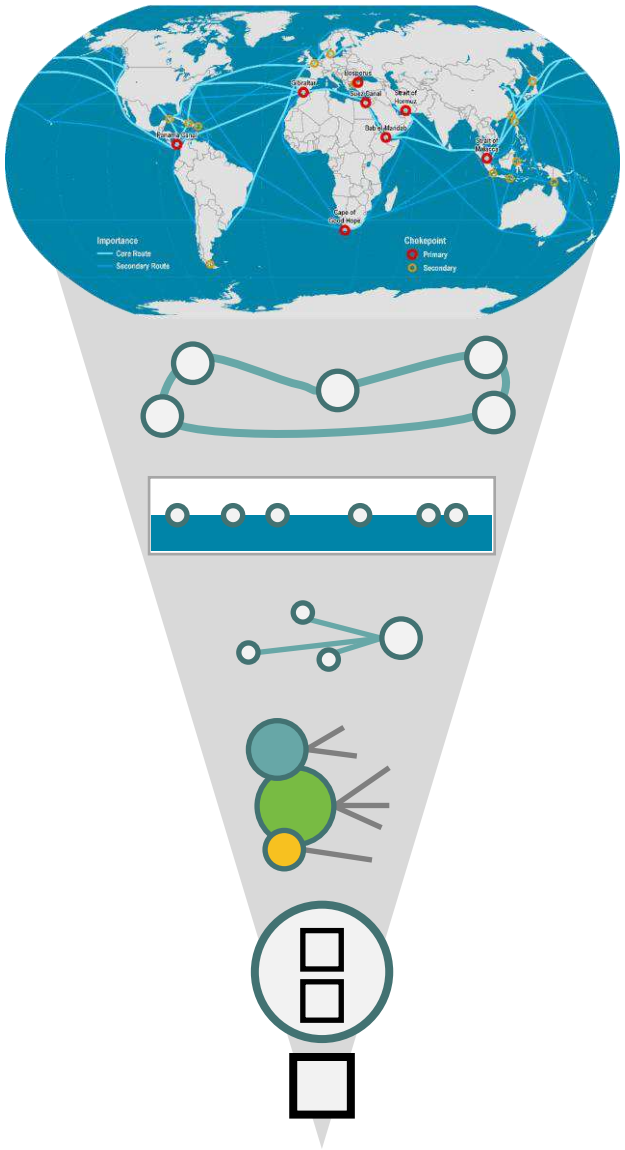
Domains of Maritime Circulation



Main Maritime Shipping Routes and Chokepoints

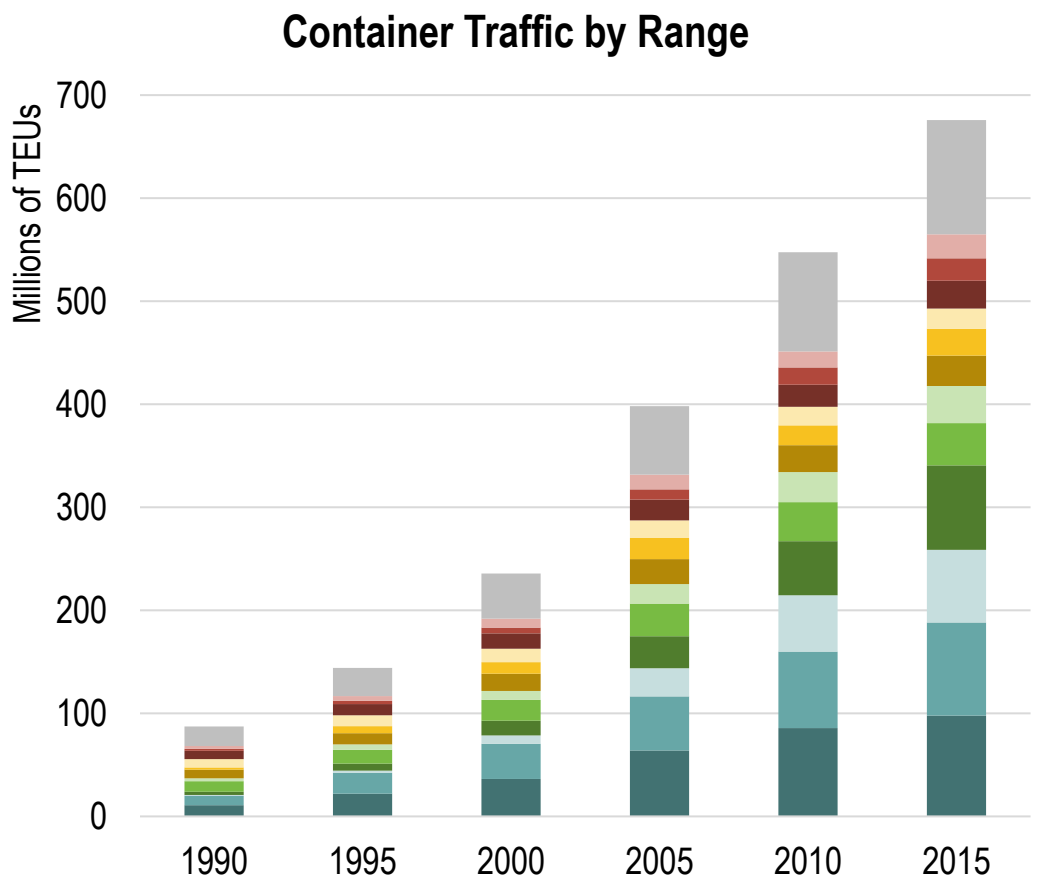


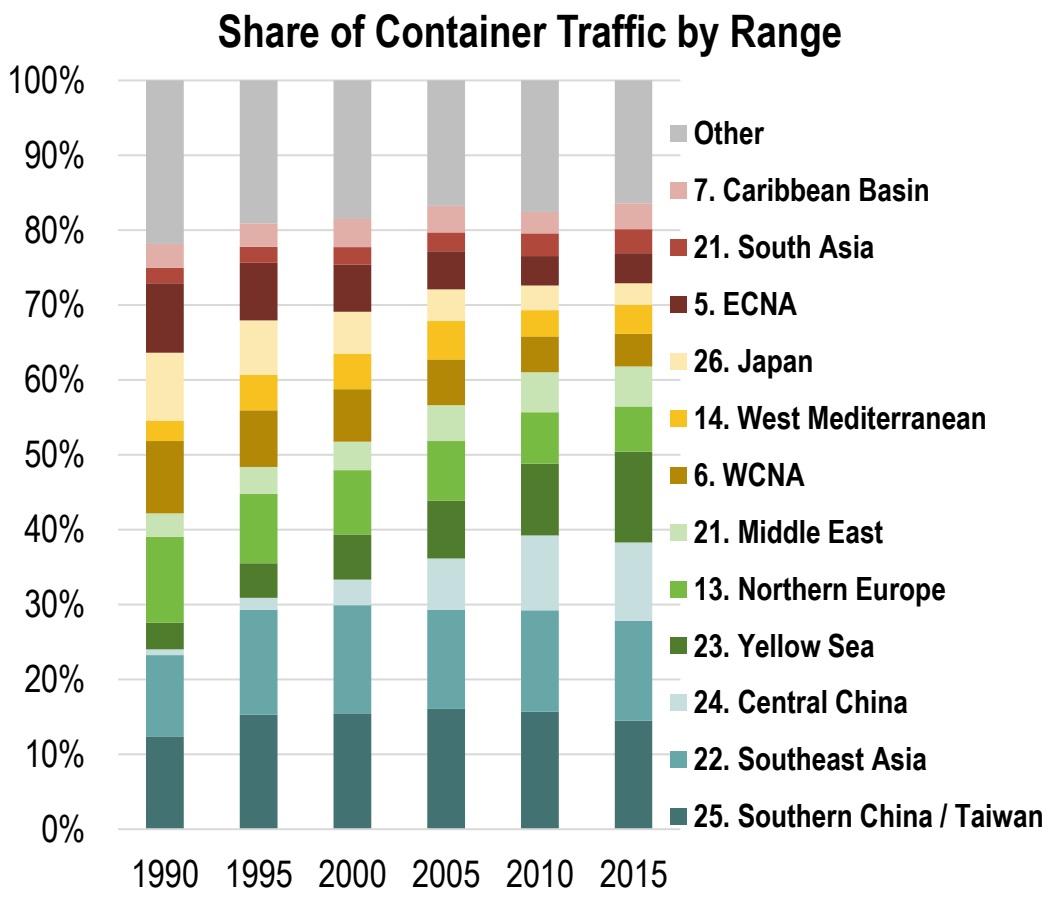
The Scales of Analysis of Maritime Transportation



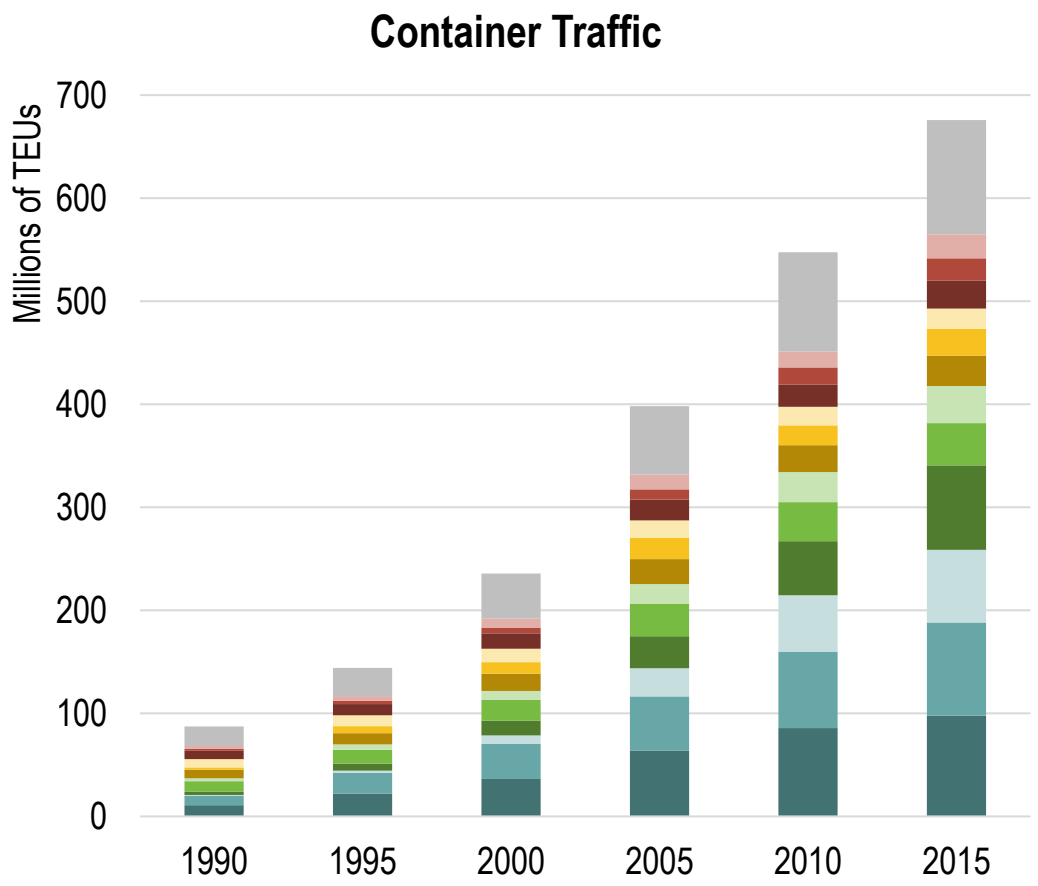
- **Global**
  - Global Maritime Transport System
  - Deep Sea Services
  - Maritime Range
- **Regional**
  - Short Sea / Feeder Services
  - Port Cluster / Region / Hinterland
- **Local**
  - Port
  - Terminal

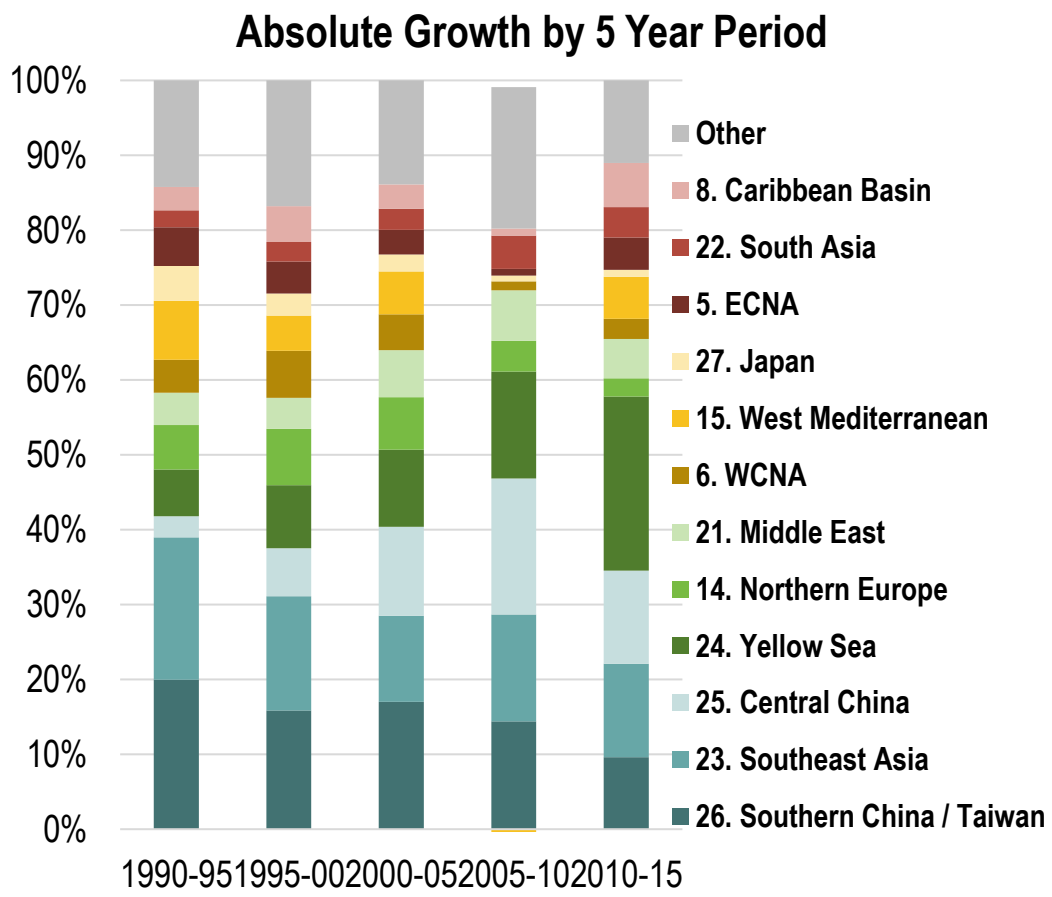
Container Traffic per Maritime Range, 1980-2015



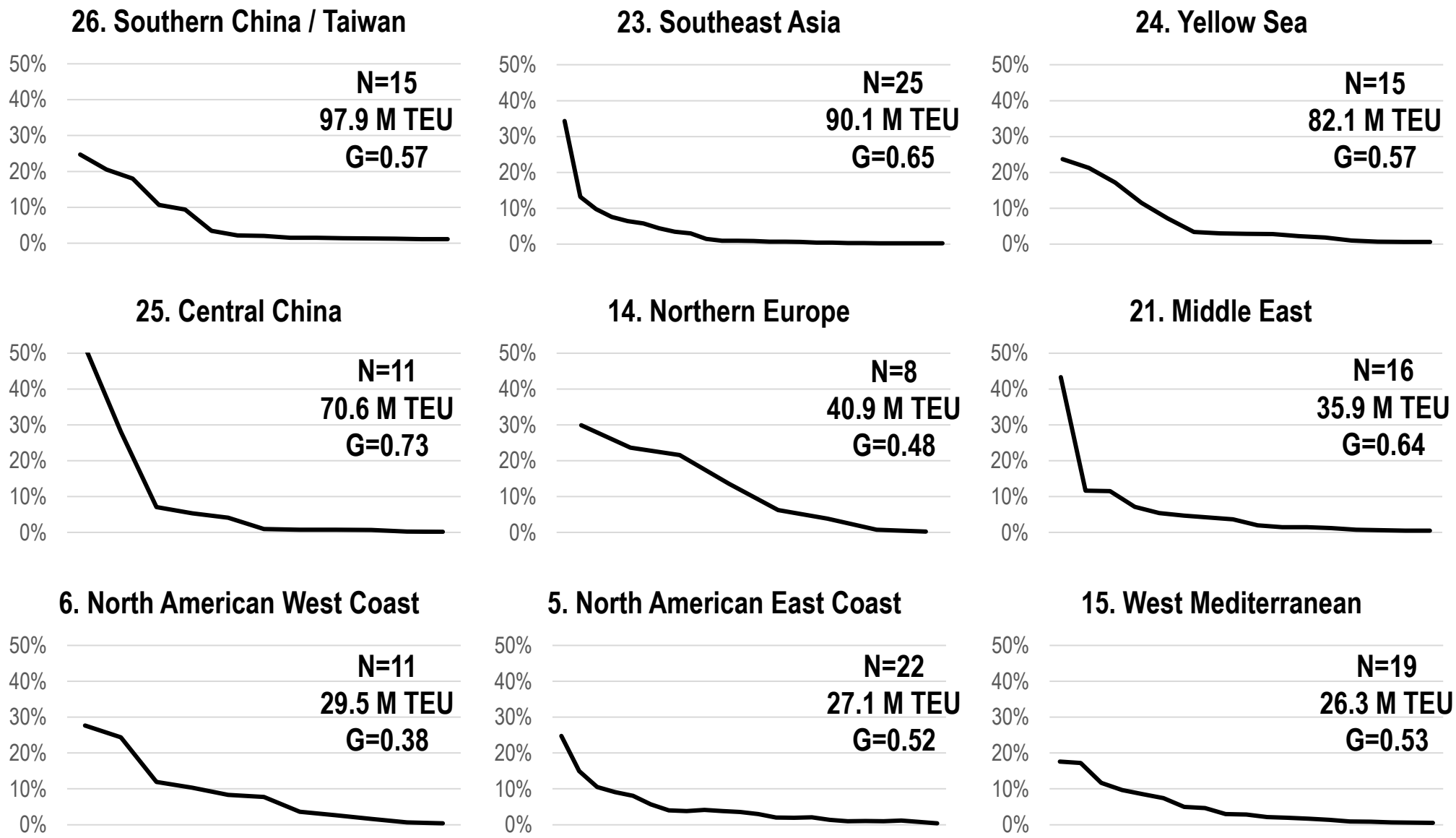


Container Traffic per Maritime Range, 1980-2015

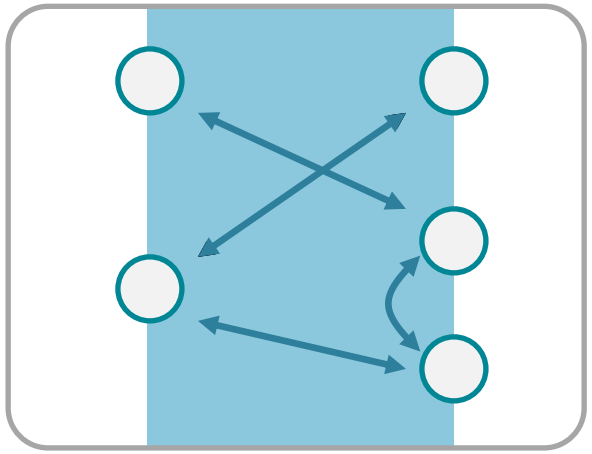




Container Port Rank / Size Distribution by Major Maritime Range, 2015

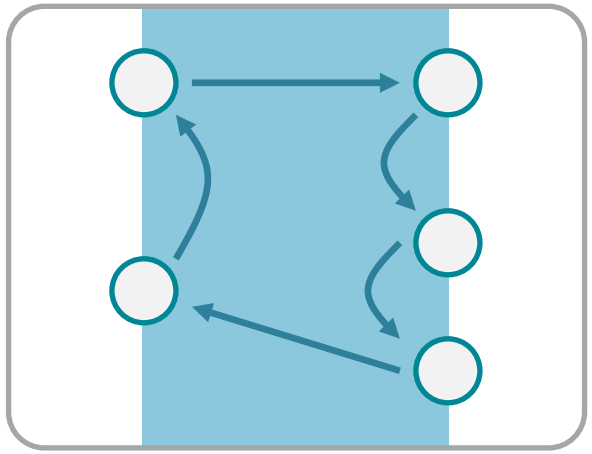


Types of Maritime Routes



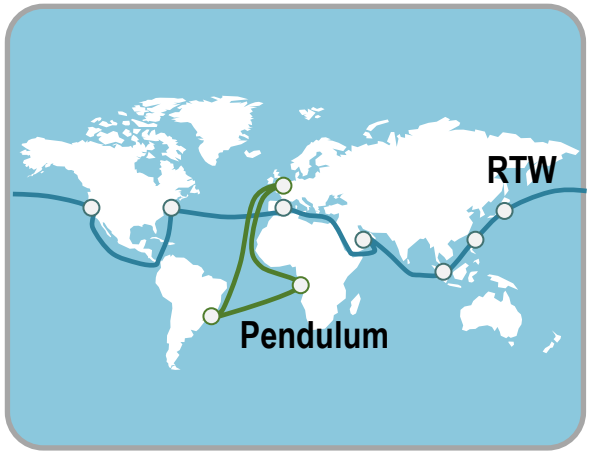
Port-to-Port

- Point to point services.
- Empty backhauls.
- Common for bulk freight shipping.



Inter-Range

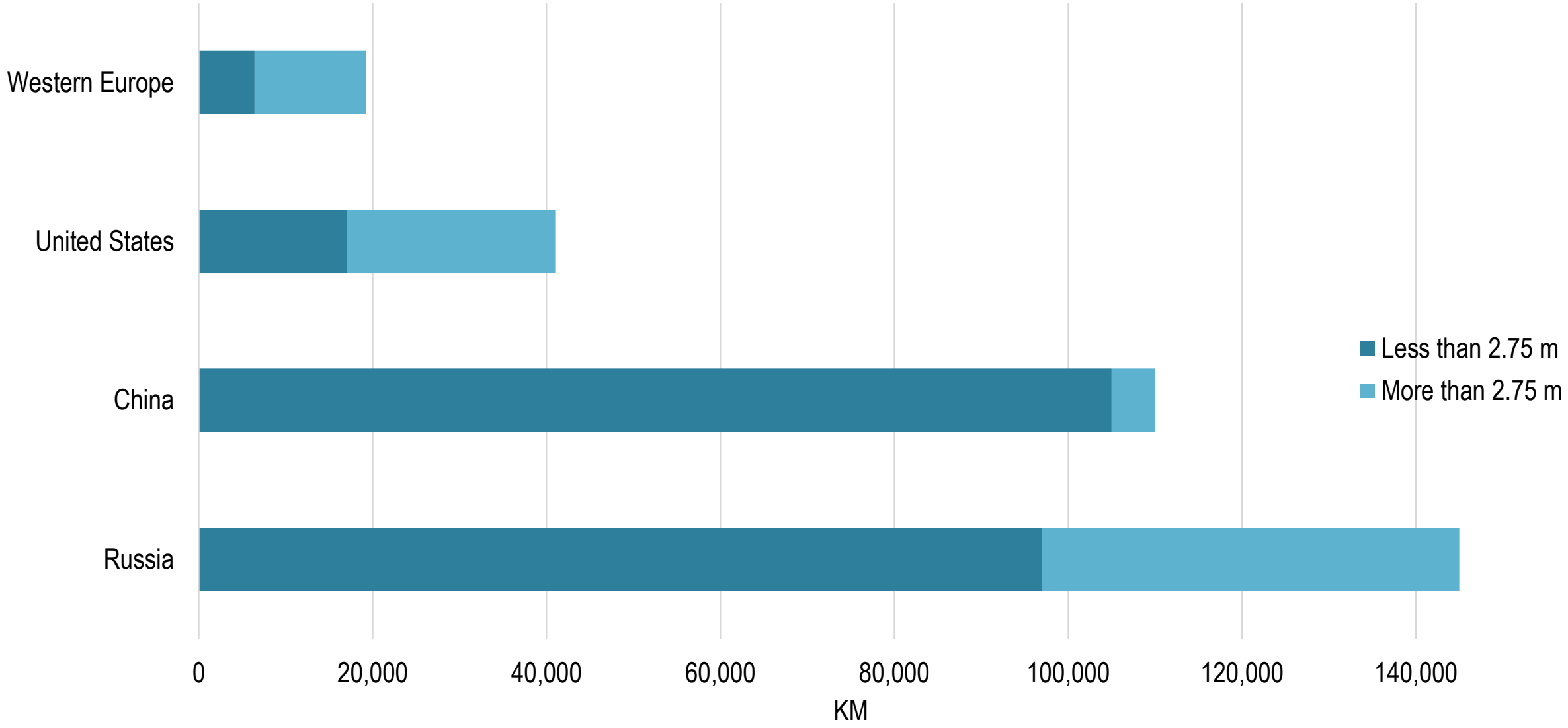
- Sequential shipping services between two maritime ranges (seaboards).
- Balancing the number of port calls and the frequency of services.
- Can rely on transshipment hubs between ranges.



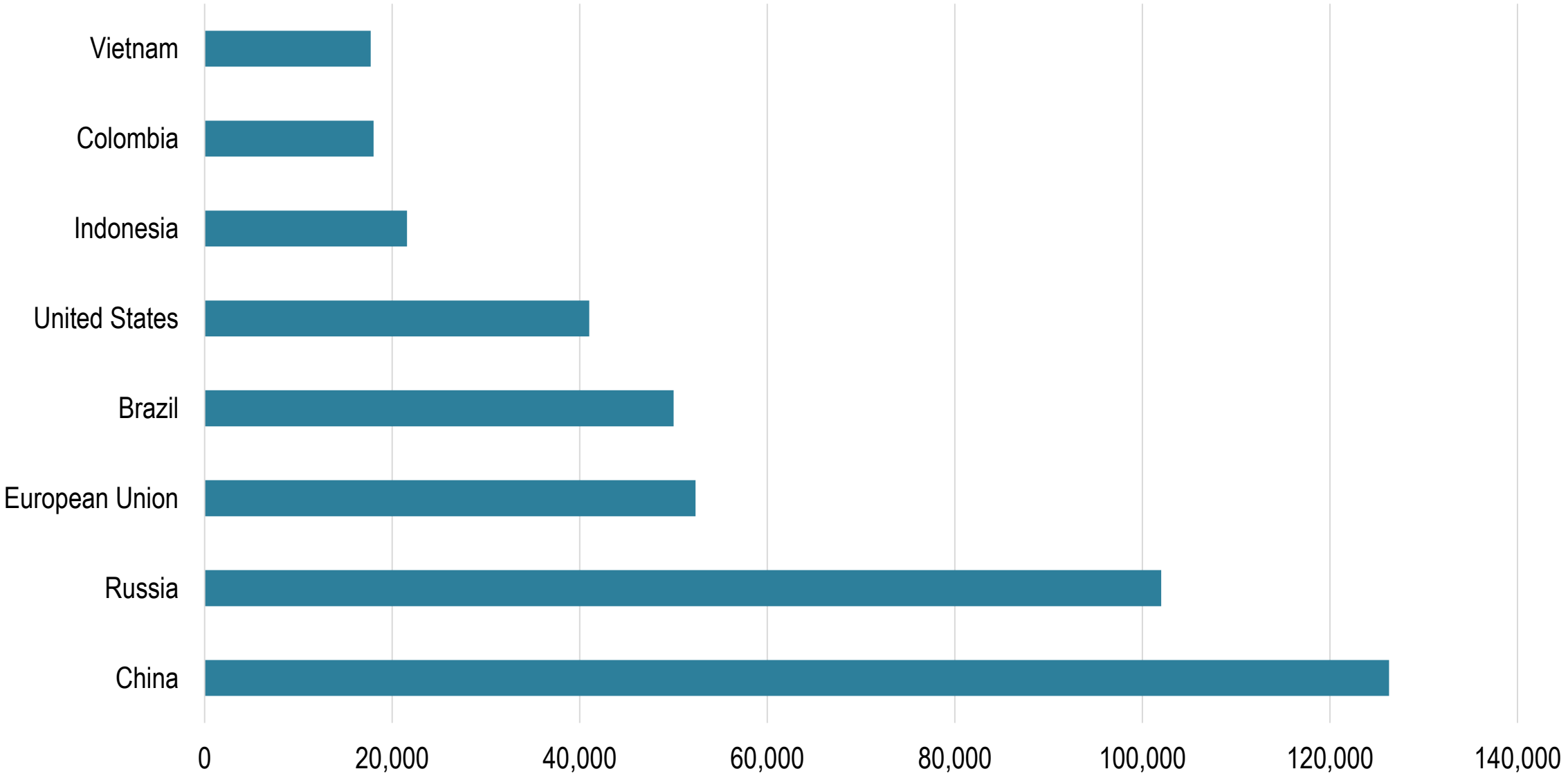
Multi-Ranges

- Servicing a sequence of ports along several ranges.
- Pendulum services.
- Round-the-world services.
- Small number of ports per range are serviced.
- Transshipment hubs connecting with regional services.

Length of the Major Inland Waterway Systems, 2000



Length of the Major Inland Waterway Systems



Largest Ships by Category

Containership

MSC Oscar (2015)

LOA: 394 m
Beam: 59 m
Draft: 16 m
TEU: 19,224

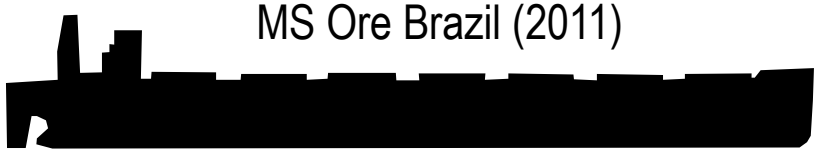
Ultra Large Crude Carrier

TI Europe (2003)

LOA: 380 m
Beam: 68 m
Draft: 24.5 m
DWT: 442,000 t

Bulk Carrier

MS Ore Brazil (2011)



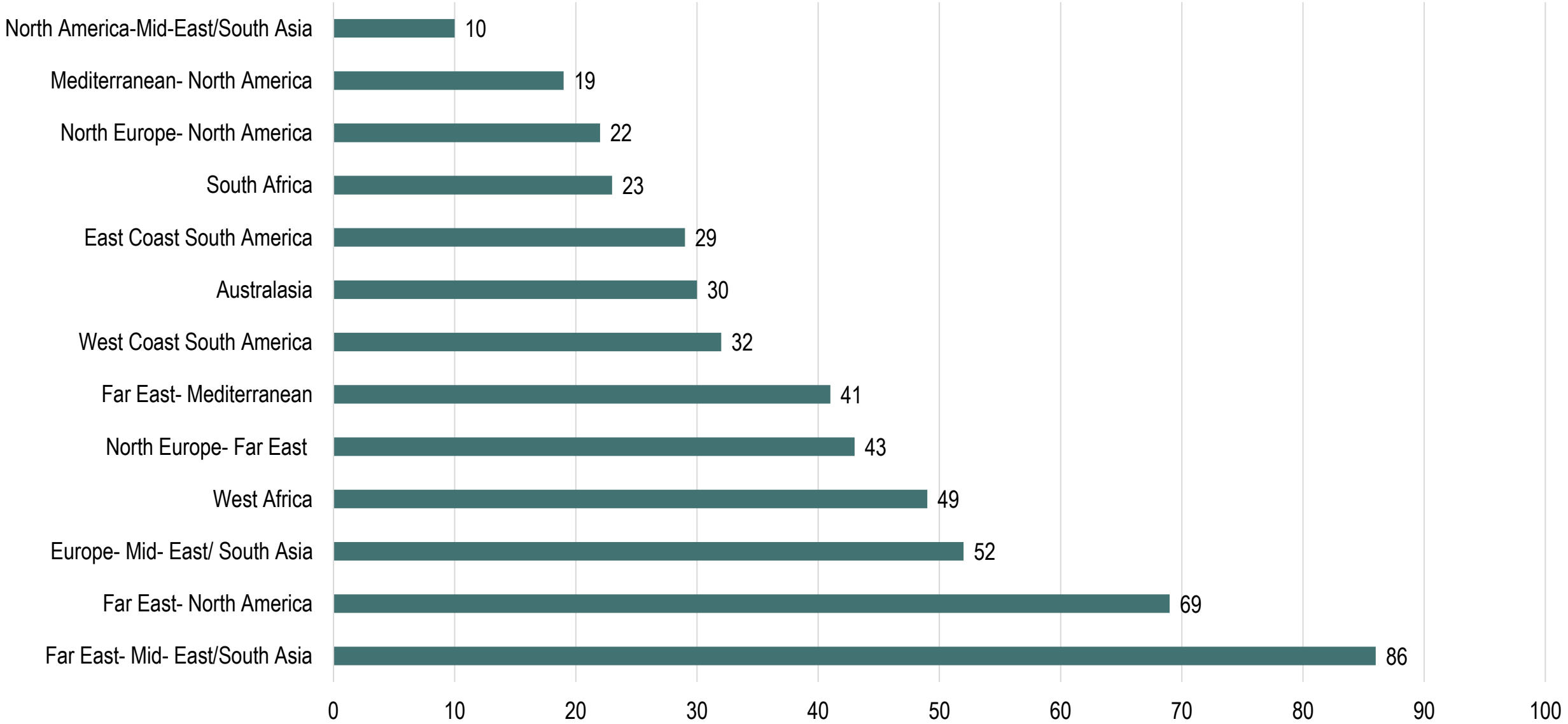
LOA: 362 m
Beam: 65 m
Draft: 23 m
DWT: 402,000 t

Cruise Ship

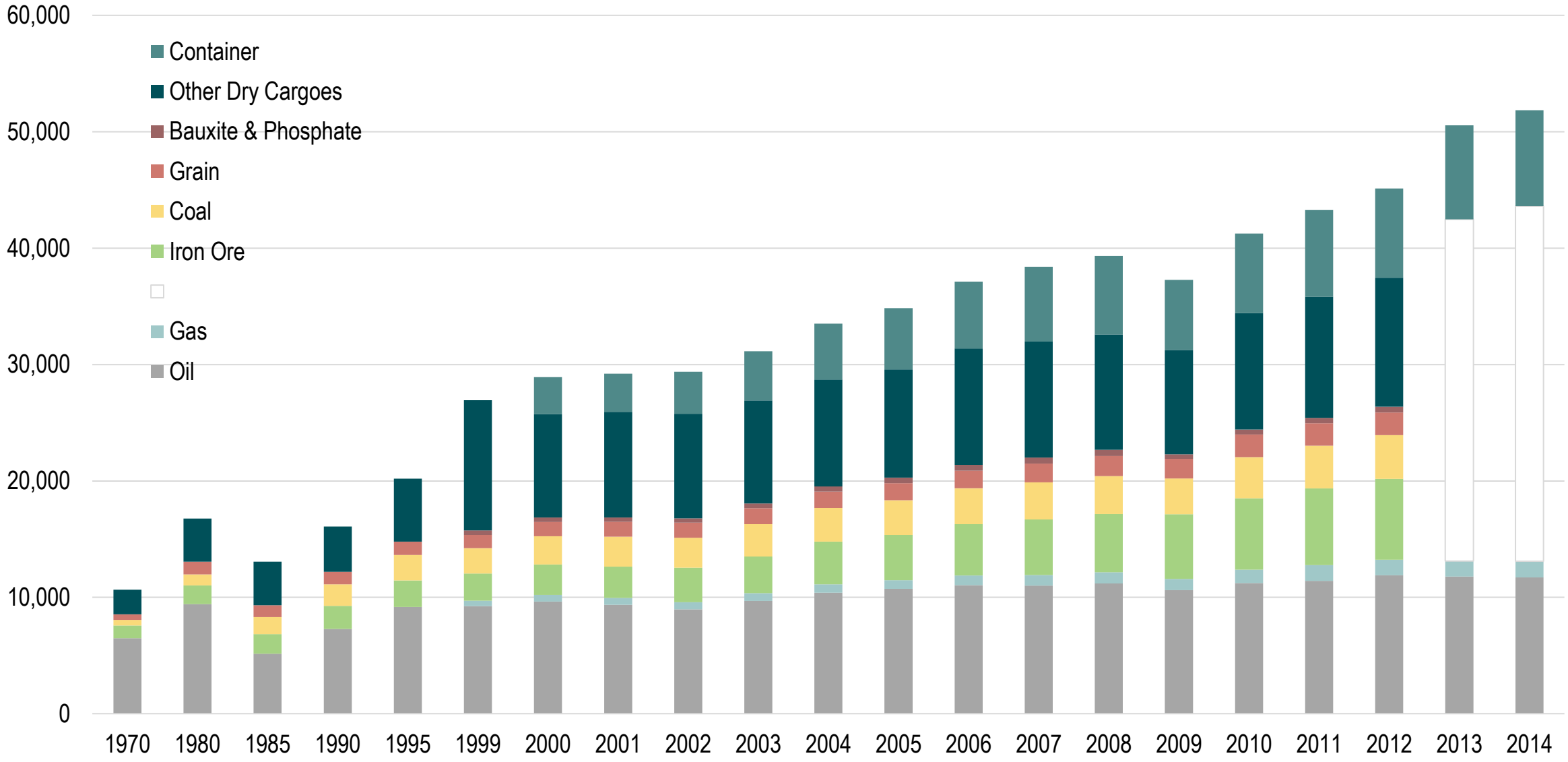
Oasis of the Seas (2009)

LOA: 362 m
Beam: 60.5 m
Draft: 9.3 m
Passengers: 5,400

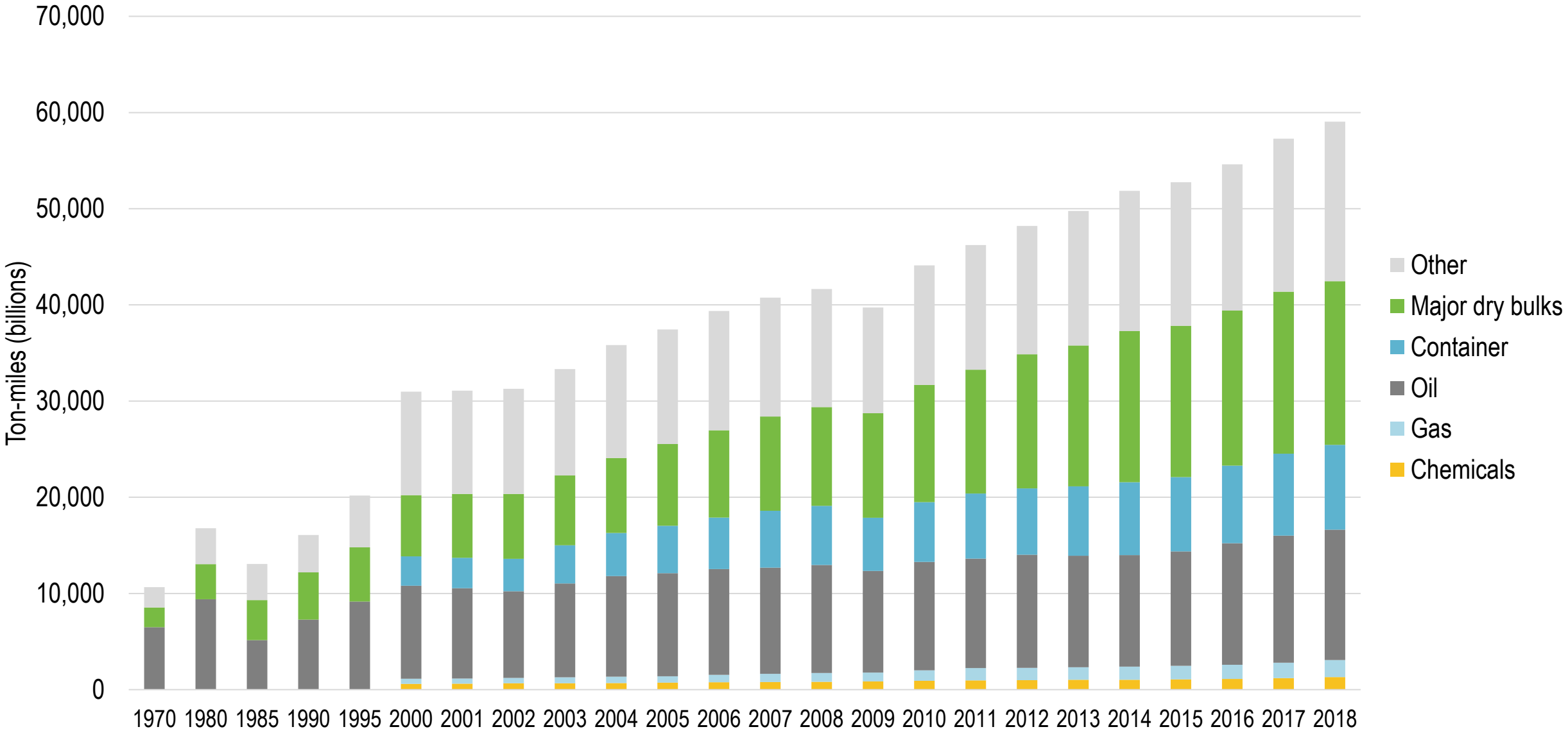
Liner Shipping Services by Trade Route, 2012



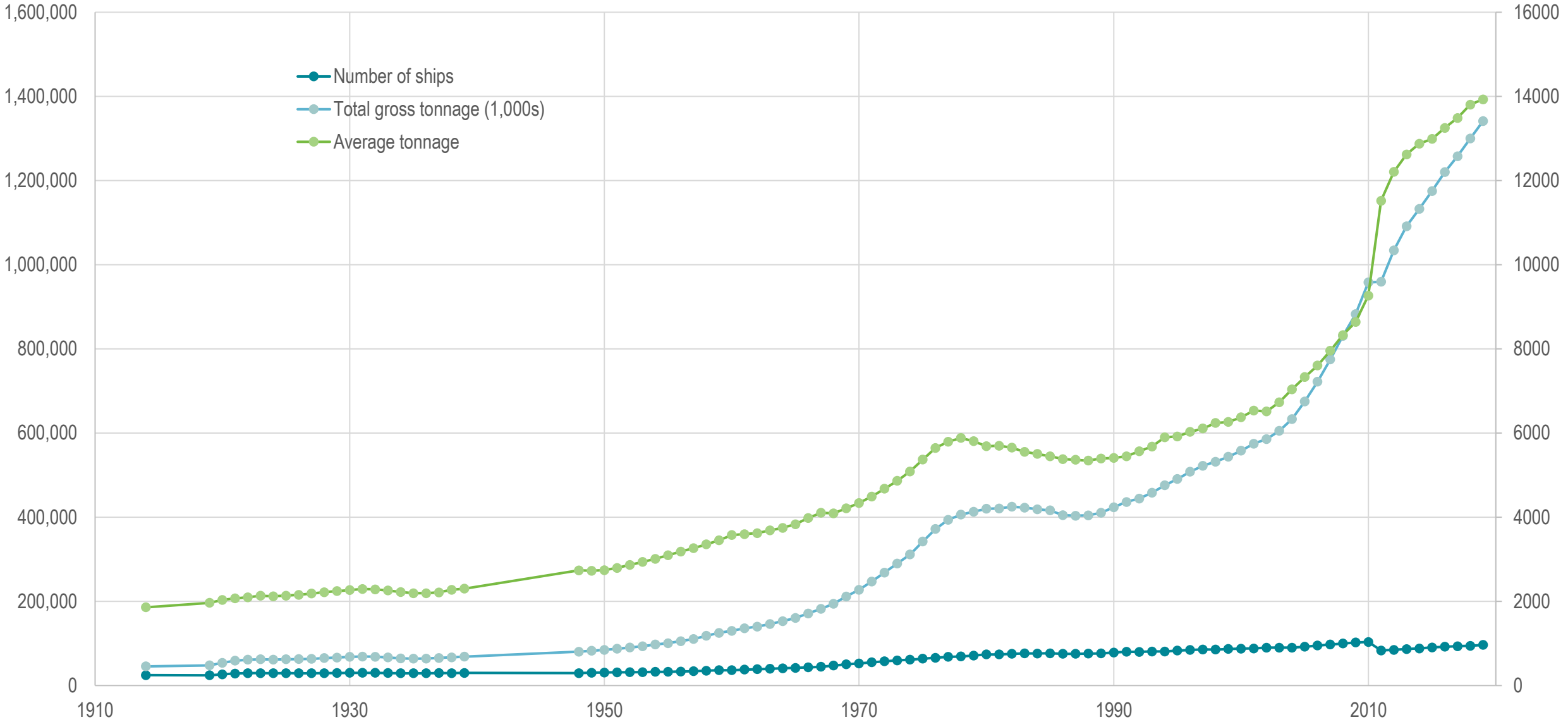
Ton-miles Shipped by Maritime Transportation, 1970-2014 (in billions)



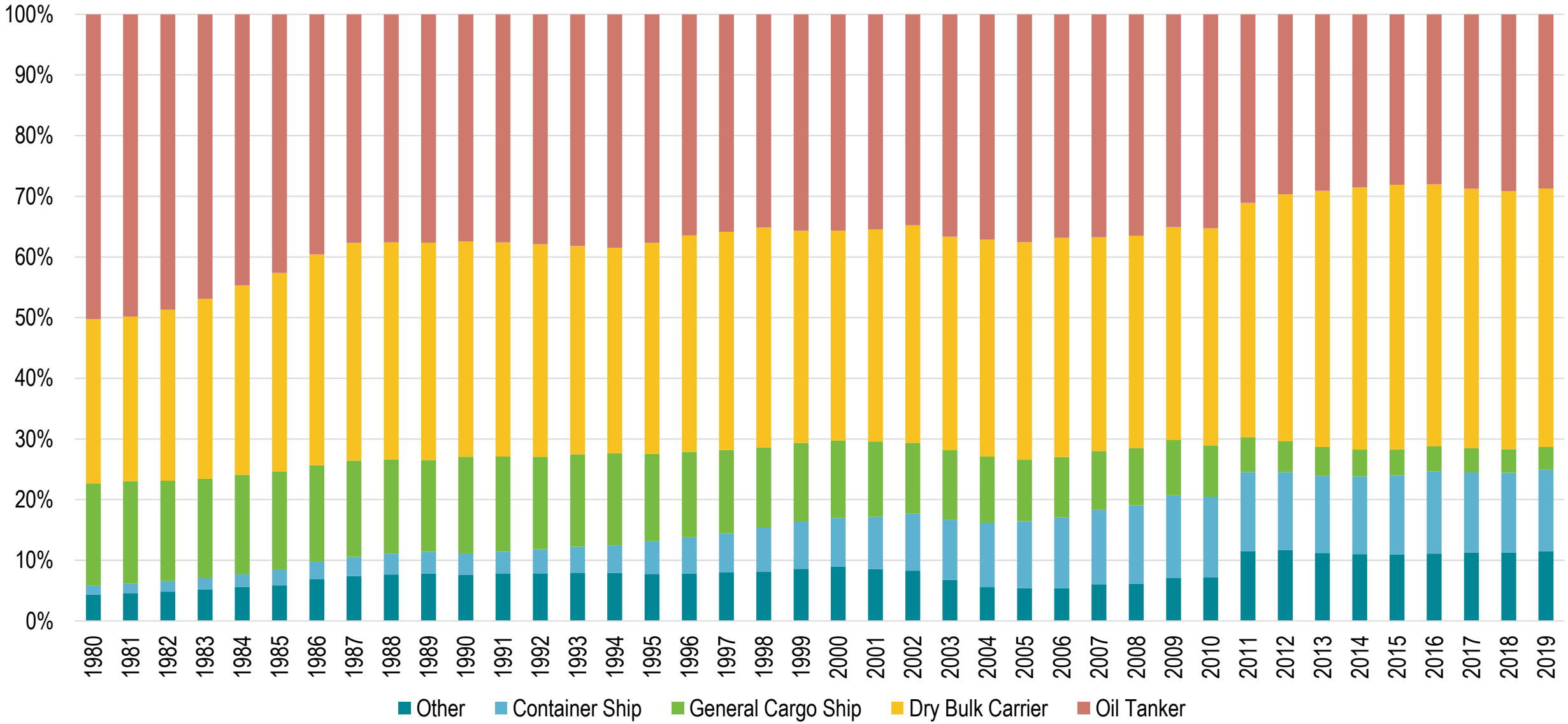
World Seaborne Trade by Cargo Type, 1970-2018



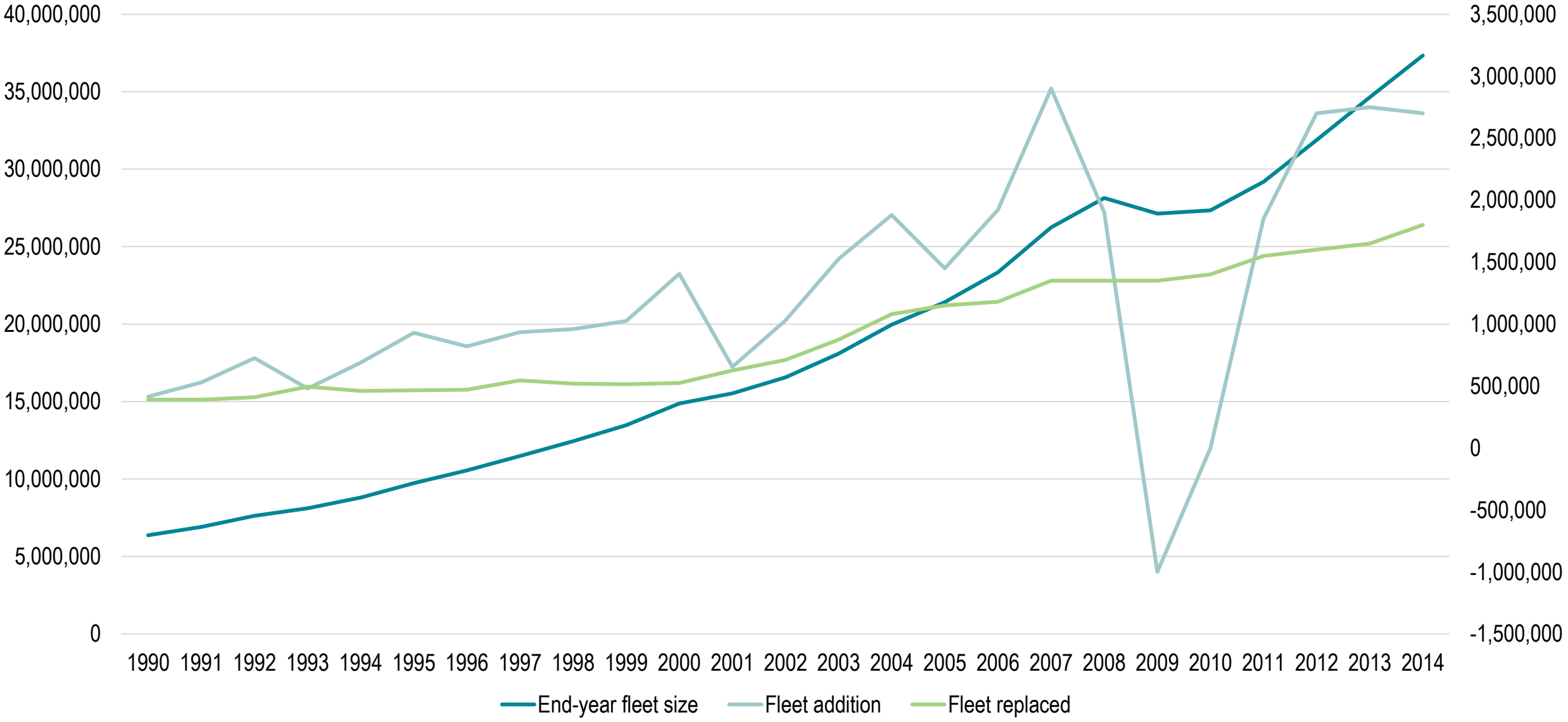
Registered World Fleet, 1914-2019



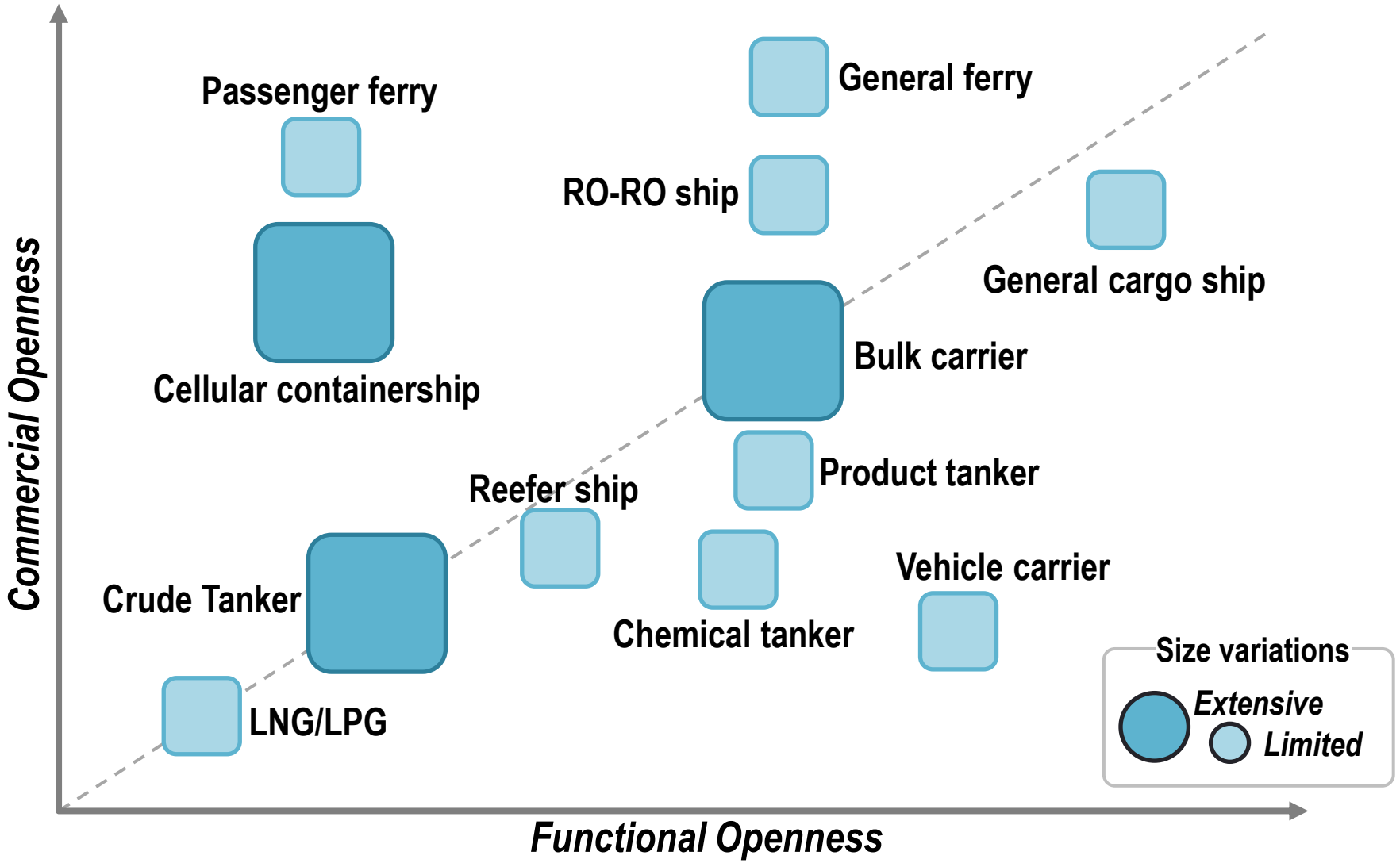
Composition of the Global Fleet, 1980-2019 (Share of deadweight tons)



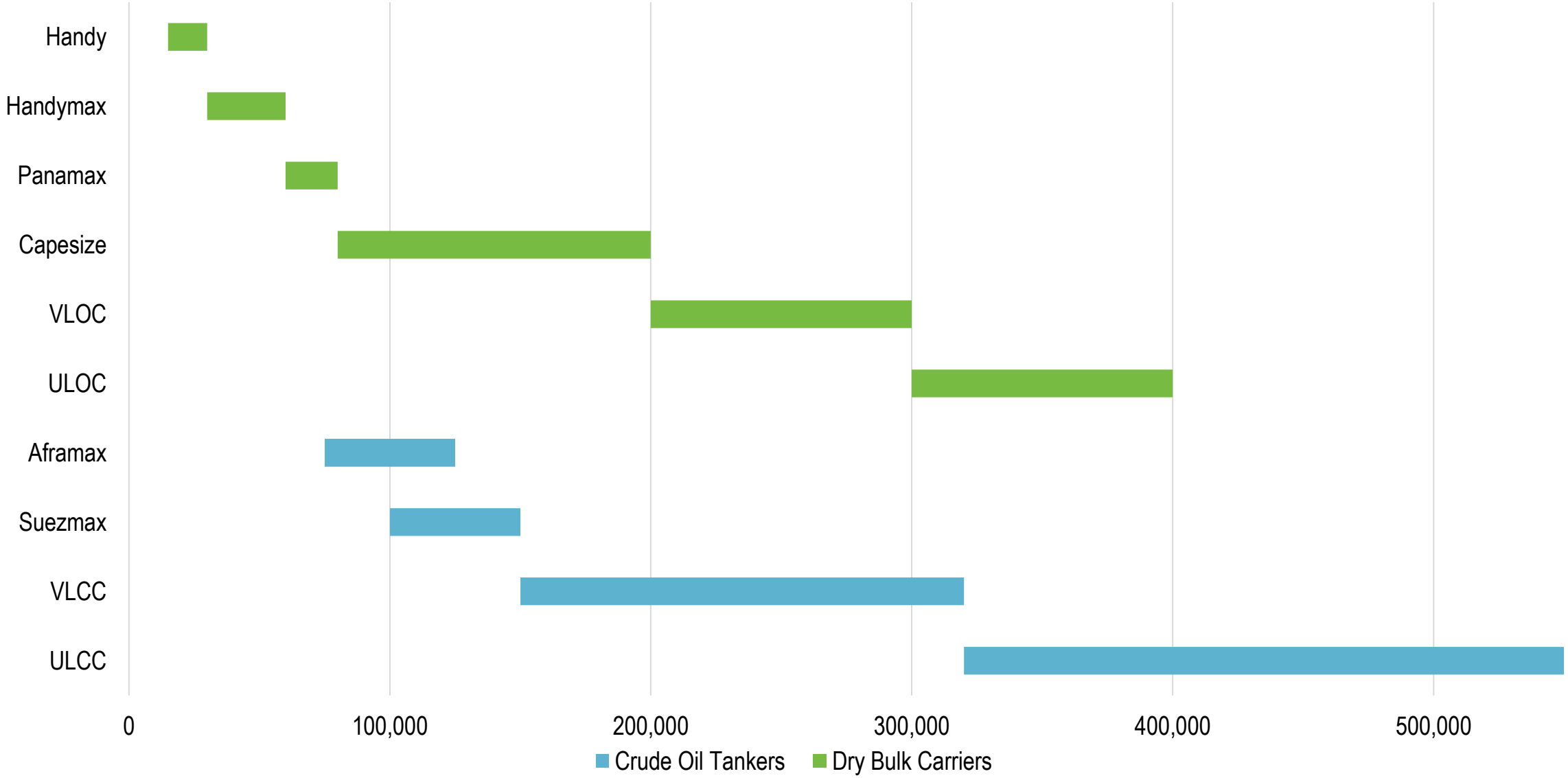
Changes in the World Container Fleet, 1990-2014



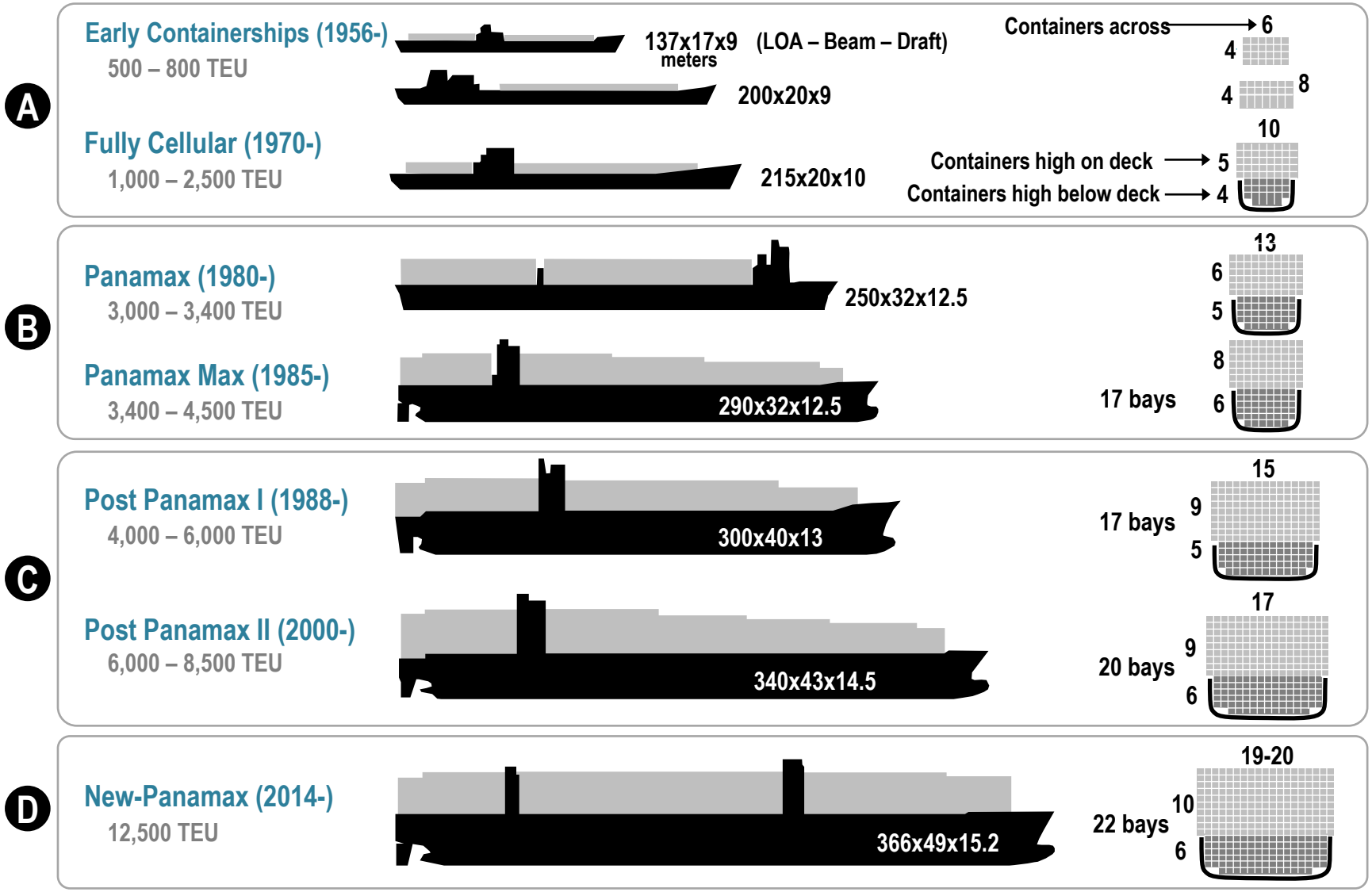
Flexibility and Specialization of Major Ship Designs



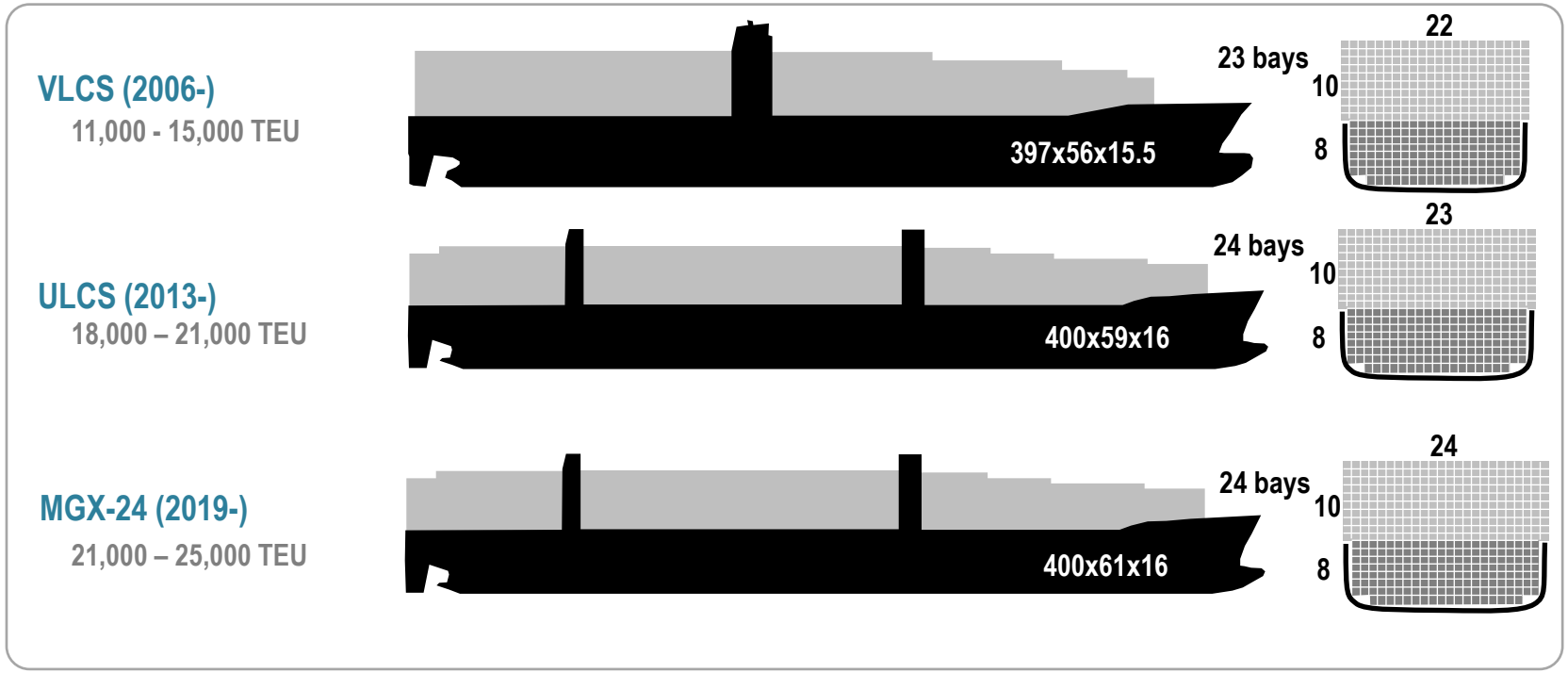
Vessel Size Groups (in dead weight tons)



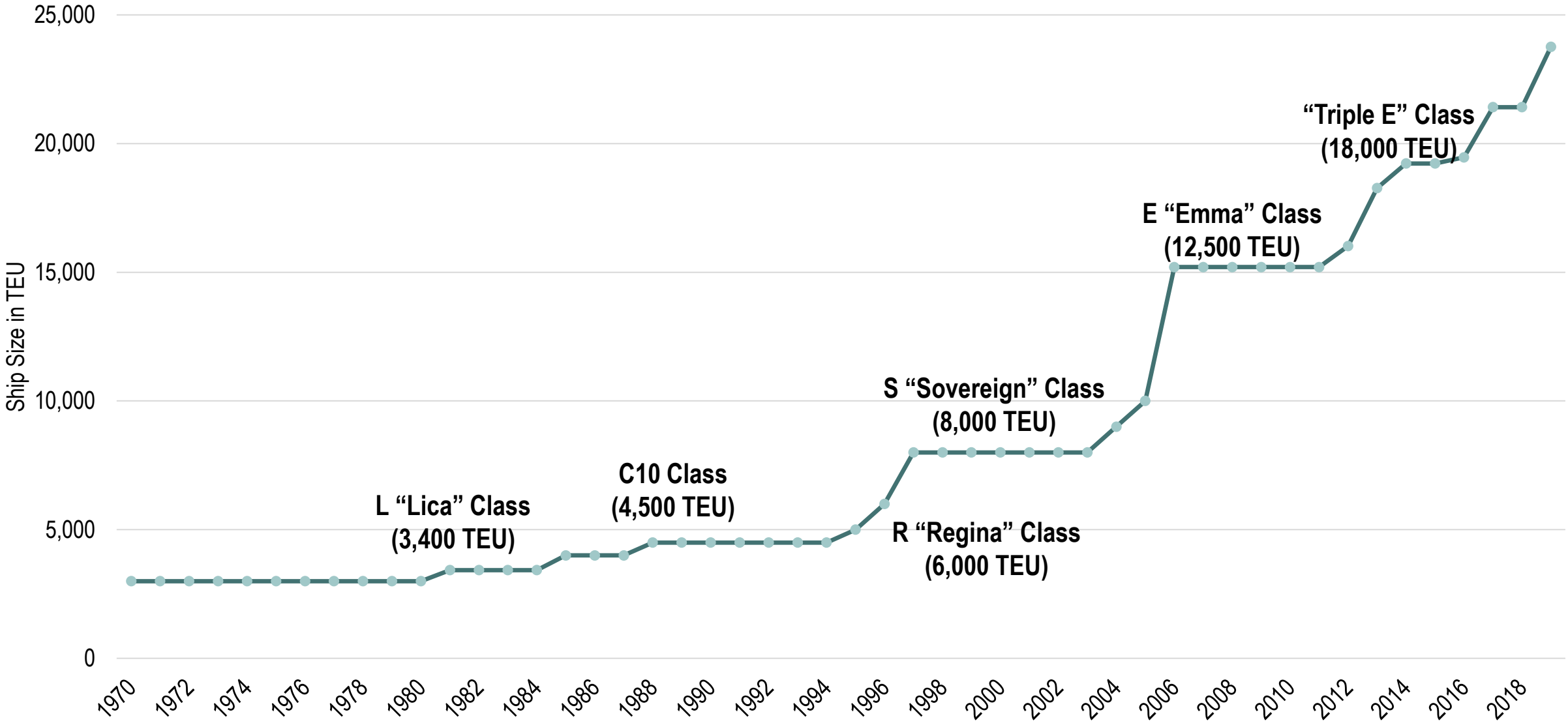
Evolution of Containerships



Evolution of Containerships



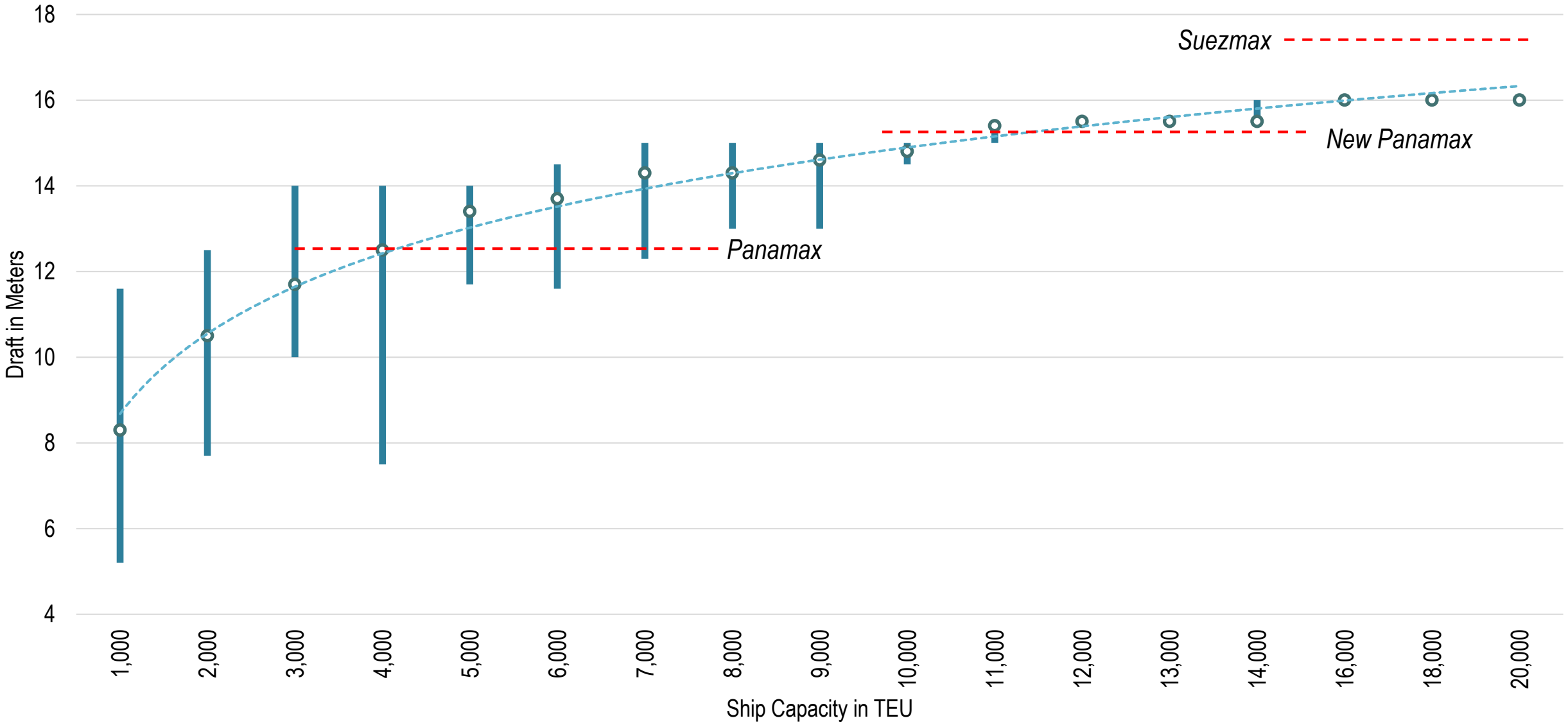
The Largest Available Containership, 1970-2019 (in TEUs)



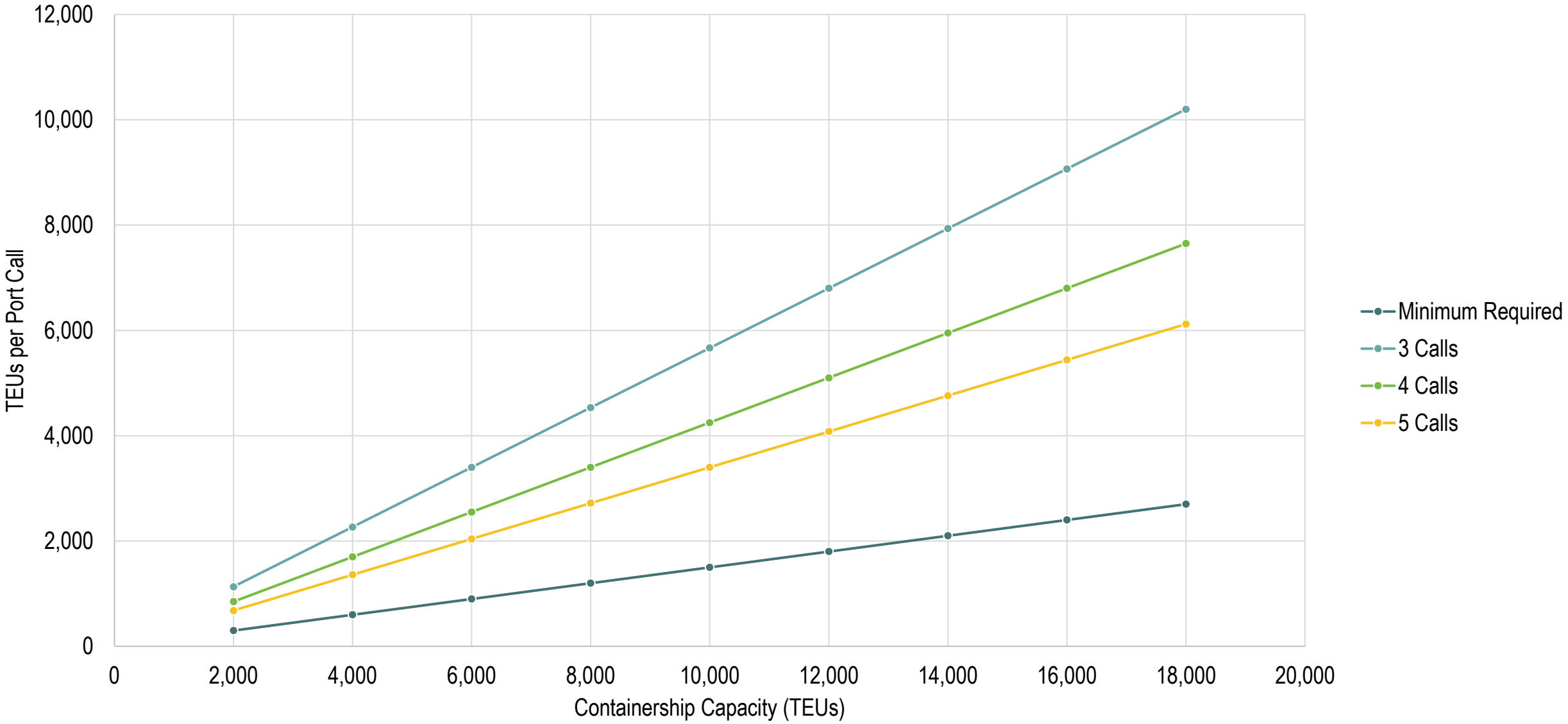
Characteristics of Some Historical Containerships

Year	Name	Capacity (TEU)	Yard	Length (m)	Width (m)	Draft (m)	Speed (knots)
1956	Ideal X	58	US	174.2	23.6	8.0	18.0
1968	Elbe Express	730	B&V	171.0	24.5	7.9	20.0
1970	Sealand Navigator	2,361		247.6	27.5	11.1	
1972	Liverpool Bay	2,961	B&V	248.6	32.3	13.0	23.0
1981	Frankfurt Express	3,430	HDW	271.0	32.3	11.5	23.0
1991	Hanover Express	4,407	Samsung	281.6	32.3	13.5	23.0
1995	APL China	4,832	HDW	262.0	40.0	12.0	24.6
1996	Regina Maersk	6,700	Odense	302.3	42.8	12.2	24.6
1998	Sovereign Maersk	8,200	Odense	332.0	42.8	14.5	24.7
2001	Hamburg Express	7,506	Hyundai	304.0	42.8	14.5	25.0
2003	OOCL Shenzhen	8,063	Samsung	319.0	42.8	14.5	25.2
2005	MSC Pamela	9,200	Samsung	321.0	45.6	15.0	25.0
2006	Emma Maersk	14,700	Odense	397.0	56.0	16.0	24.5
2009	MSC Beatrice	13,798	Samsung	366.1	51.2	15.0	25.2
2012	MSC Marco Polo	16,000	Daewoo	396.0	53.6	16.0	25.1
2013	Maersk Mc-Kinney Møller	18,270	Daewoo	399.0	59	14.5	23.0
2015	MSC Oscar	19.224	Daewoo	395.5	59	16.0	22.8

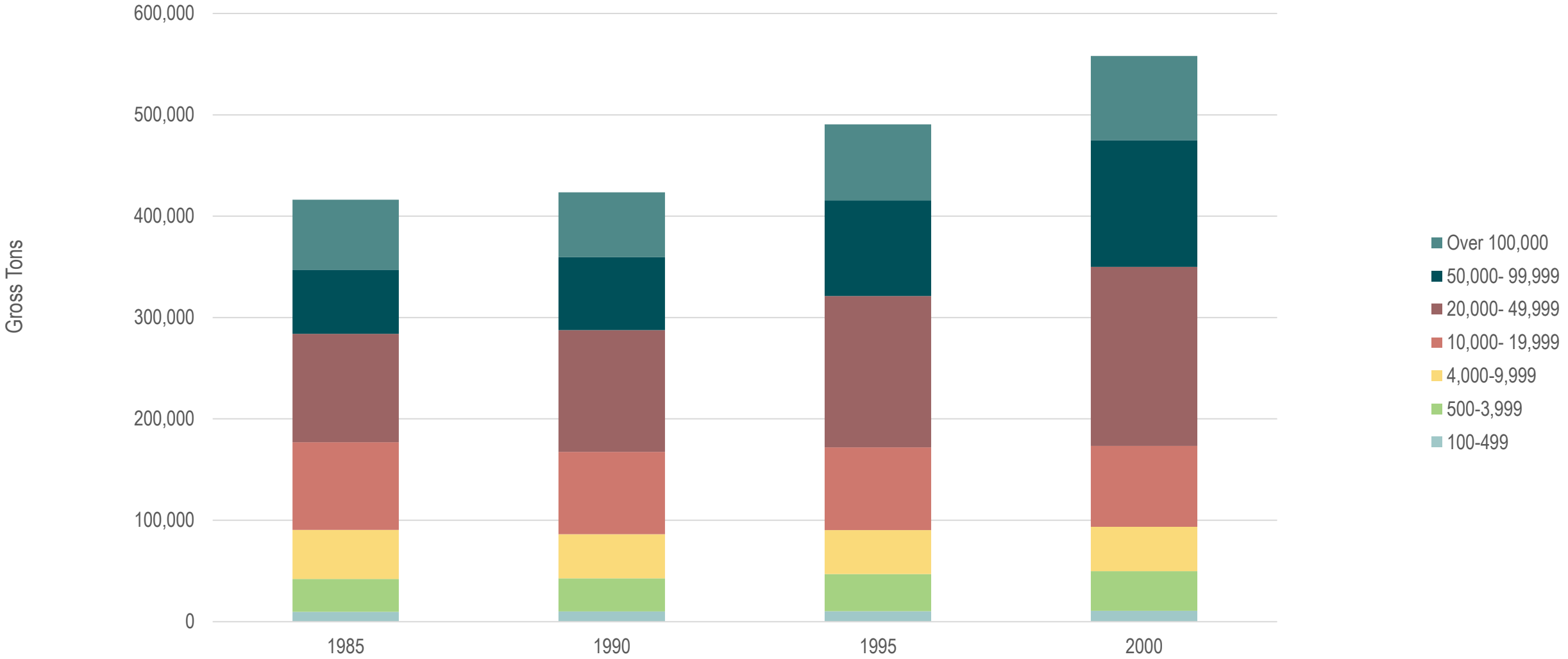
Average Draft by Containership Capacity



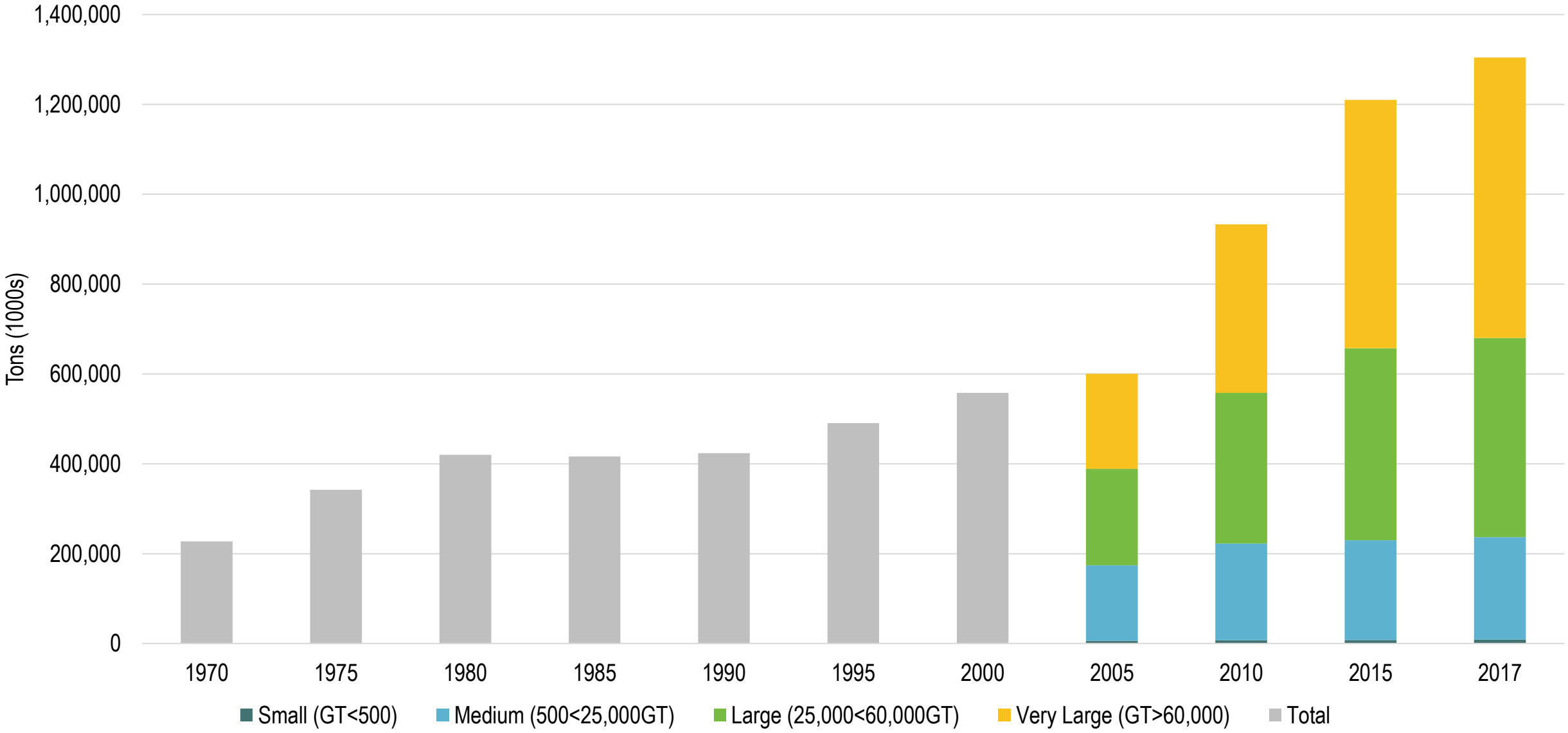
Average TEU per Port Call by Containership Size along a Maritime Range



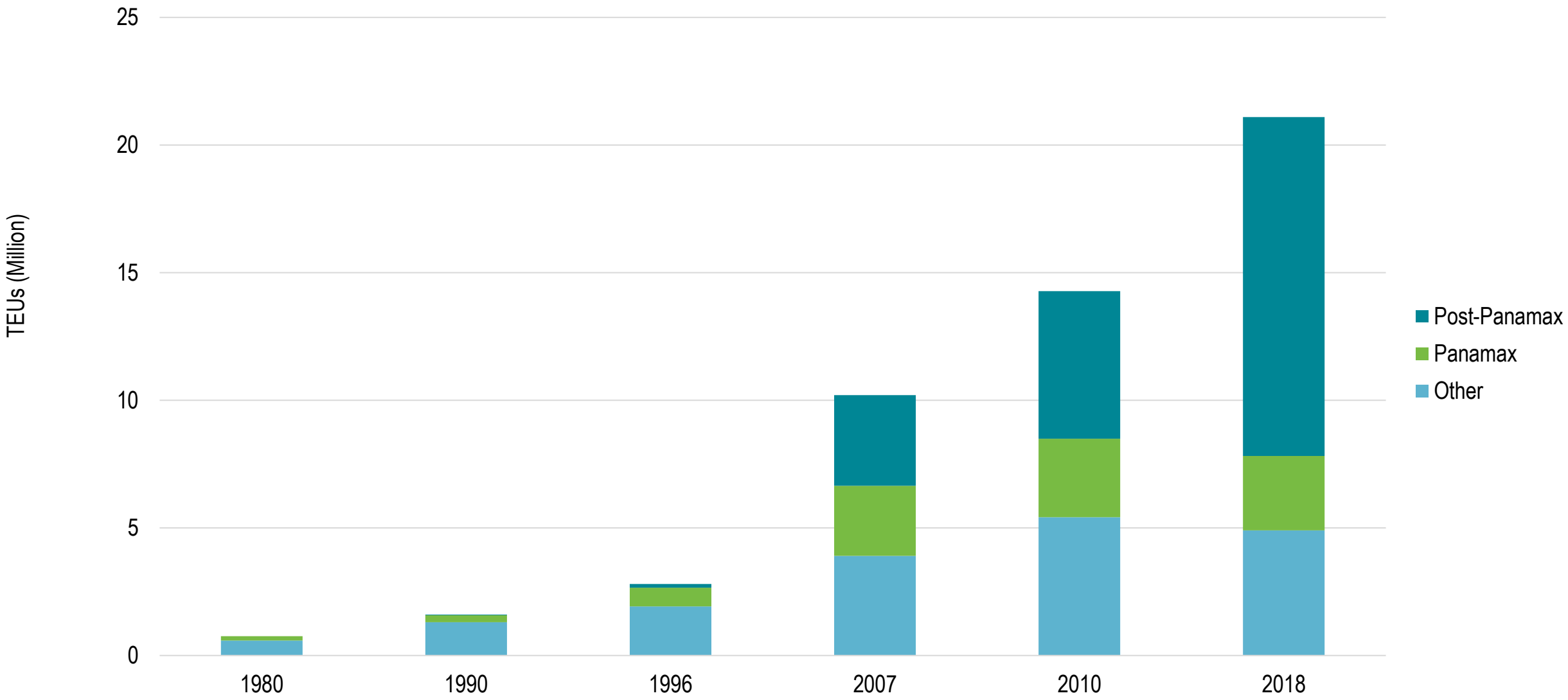
World Merchant Fleet, Tonnage Registered per Ship Size, 1985-2000



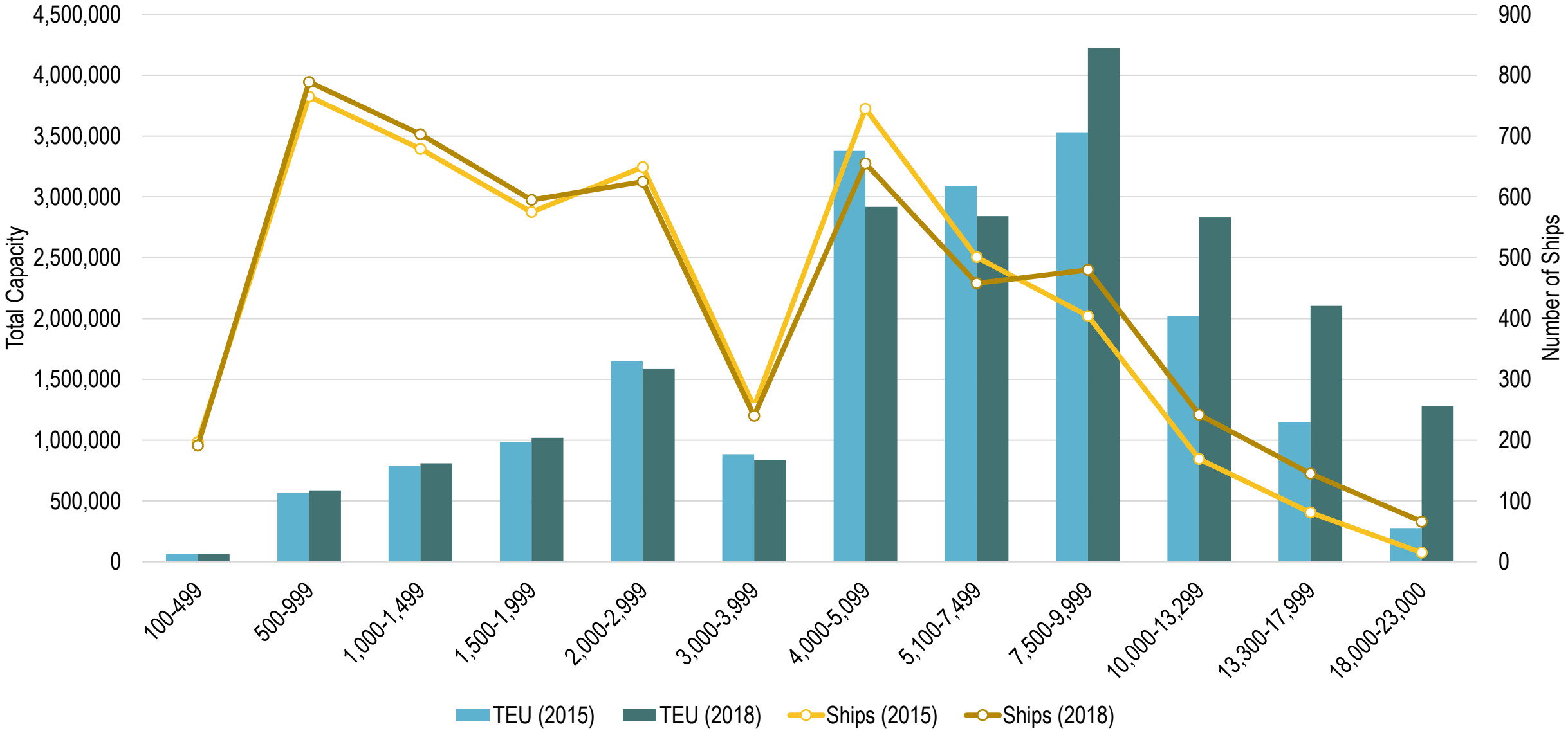
World Merchant Fleet, Tonnage Registered per Ship Size, 1970-2017



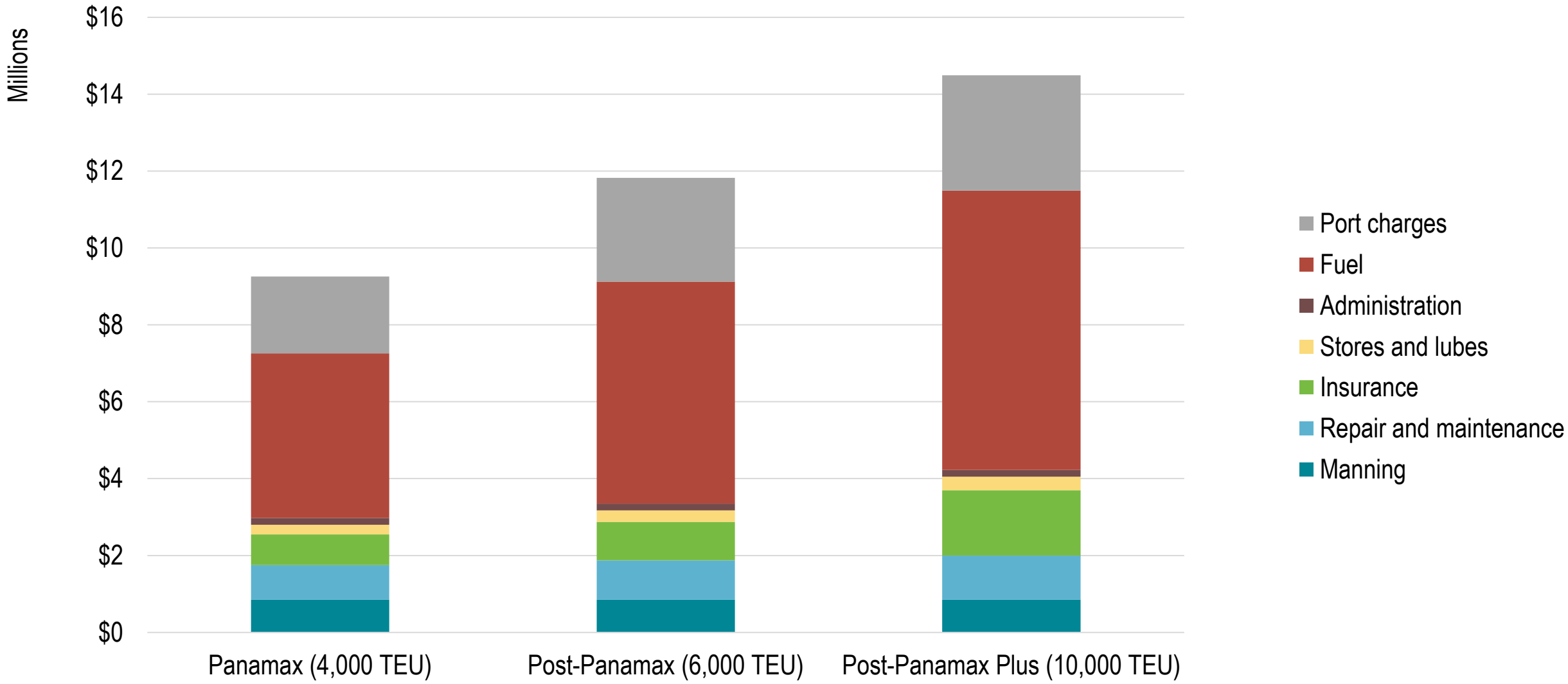
Evolution of the World's Containerized Carrying Capacity, 1980-2018



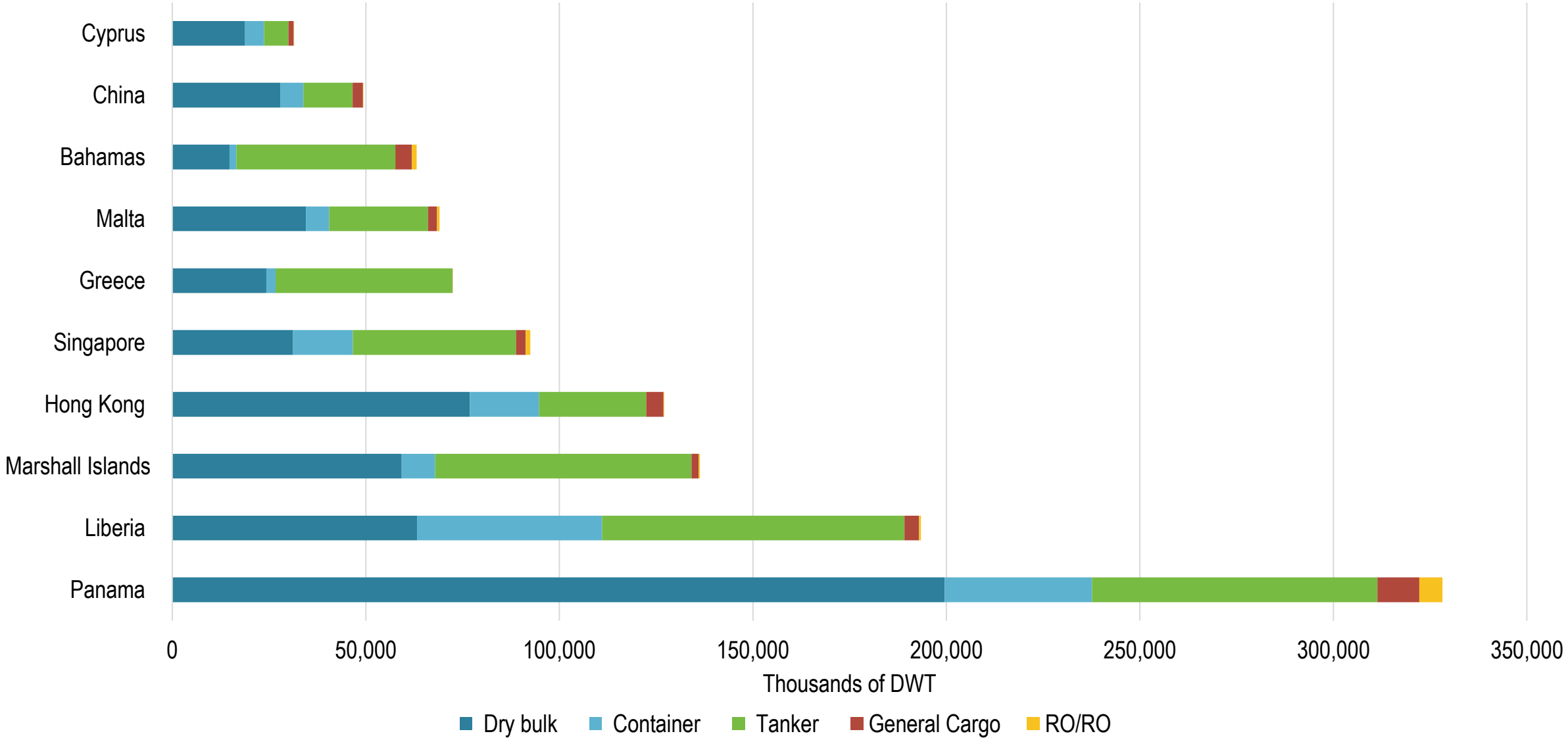
World Cellular Container Fleet, 2015-2018



Operating Costs of Panamax and Post-Panamax Containerships (in USD)

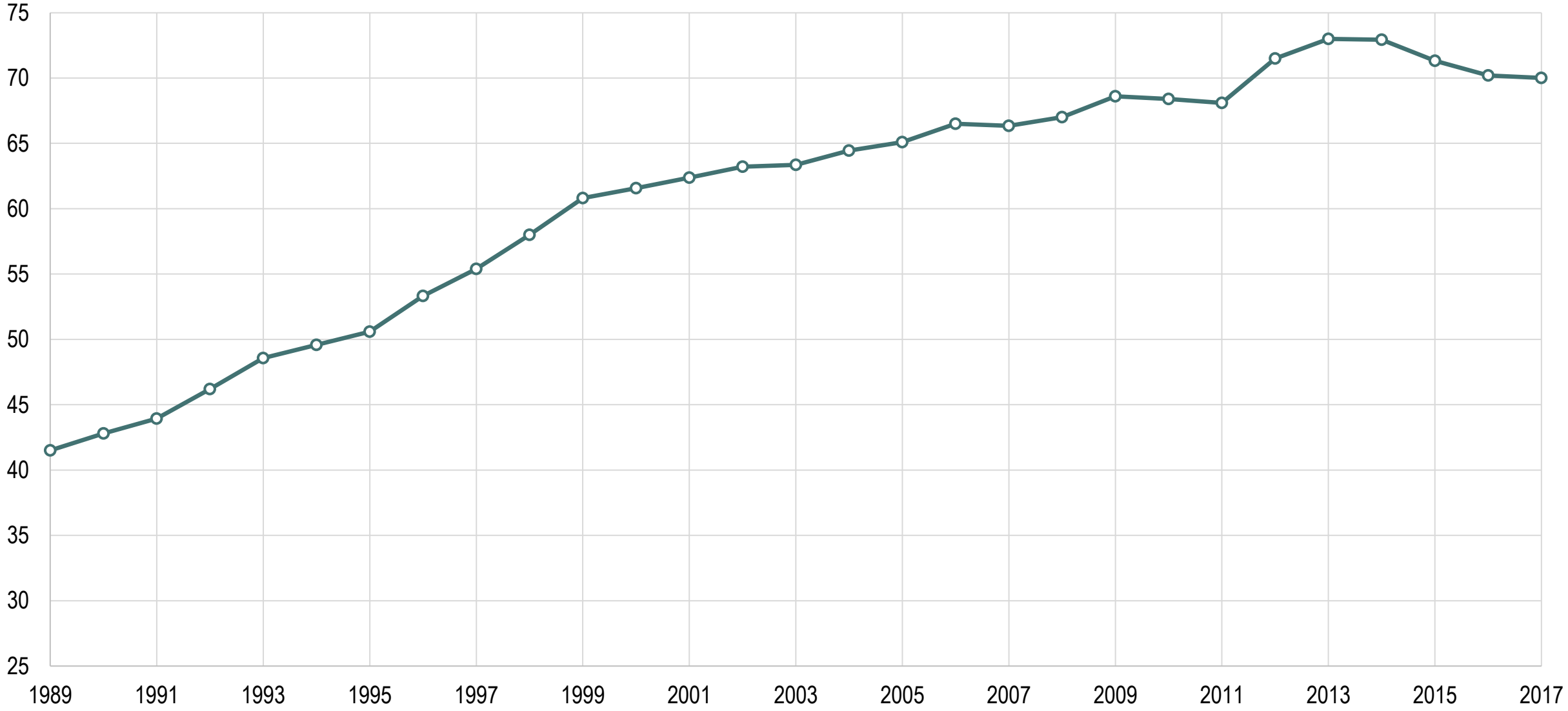


Tonnage by Country of Registry, 2013



Slow Steaming

Share of Foreign-flagged Deadweight Tonnage, 1989-2017



Maritime Shipping Characteristics (to be updated)

	Tramping	Liner Shipping
	Transportation Demand	
Number of shippers	Few	Many
Quantity	Large	Small
Density	High (weight)	Low (volume)
Unit value	Low	High
Regularity	Low	High
	Transportation Supply	
Contract	Vessel	Freight (bill of lading)
Vessels	Liquid and bulk	General cargo
Frequency	Low	High
	Implications	
Freight	Liquid and main bulk commodities	Minor bulk and general cargo (containerized)
Services	Supply / demand regulation	Prior to demand
Freight elasticity	Low	Low
Main markets	Developing / developed countries	Developed / developed countries
	Share in Maritime Transport (2000)	
Tons	70%	30%
Value	20%	80%

Types of Maritime Cargo

Commodity type	Examples	Maritime Transshipment	Inland distribution
Liquid			
A) Normal pressure and temperature	Crude oil, most oil products, wine, slurried coal	Pump/pipe	Pipeline
B) Other pressure and temperature	Liquefied gases (LNG, LPG), heavy oils, latex, bitumen, vegetable oils	Pumps, temperature controlled pipelines	Temperature controlled pipelines
Dry Bulk			
A) Flowing	Grain, sugar, powders (alumina, cement)	Pneumatic / suction, conveyor, grabs	Pipes, conveyors, barge, rail wagon, lorry
B) Irregular	Coal, iron ores, non-ferrous ores, phosphate rock	Grab, conveyor	Conveyor, barge, rail wagon, lorry
Neo Bulk	Forest products, steel products, baled scrap	Lift-on/lift-off, roll-on/roll-off	Barge, rail wagon, lorry
Wheeled Units	Cars, lorries, rail wagons	Roll-on/roll-off	Rail wagon, lorry
Refrigerated/chilled cargo	Meat, fruit, dairy produce	Lift-on/lift-off	Rail wagon, lorry

Types of Maritime Cargo

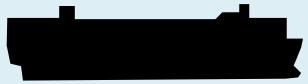
General Cargo

Unitized Cargo

Break Bulk

Drums, bags, pallets, boxes
Lift-on/lift-off (1.0 day average port time)
7% of tonnage

Neo Bulk



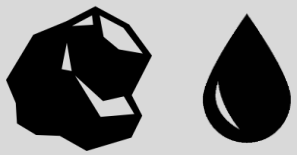
Lumber, paper, steel, vehicles
Lift-on/lift-off, roll-on/roll-off (1.0 day average port time)
5% of tonnage

Containerized

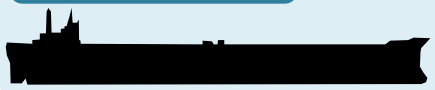
Containers
Lift-on/lift-off (0.9 days average port time)
13% of tonnage

Bulk Cargo

Loose Cargo



Liquid Bulk



Petroleum, LNG, chemicals, vegetal oils
Pumps and pipelines (1.1 to 1.3 days average port time)
35% of tonnage

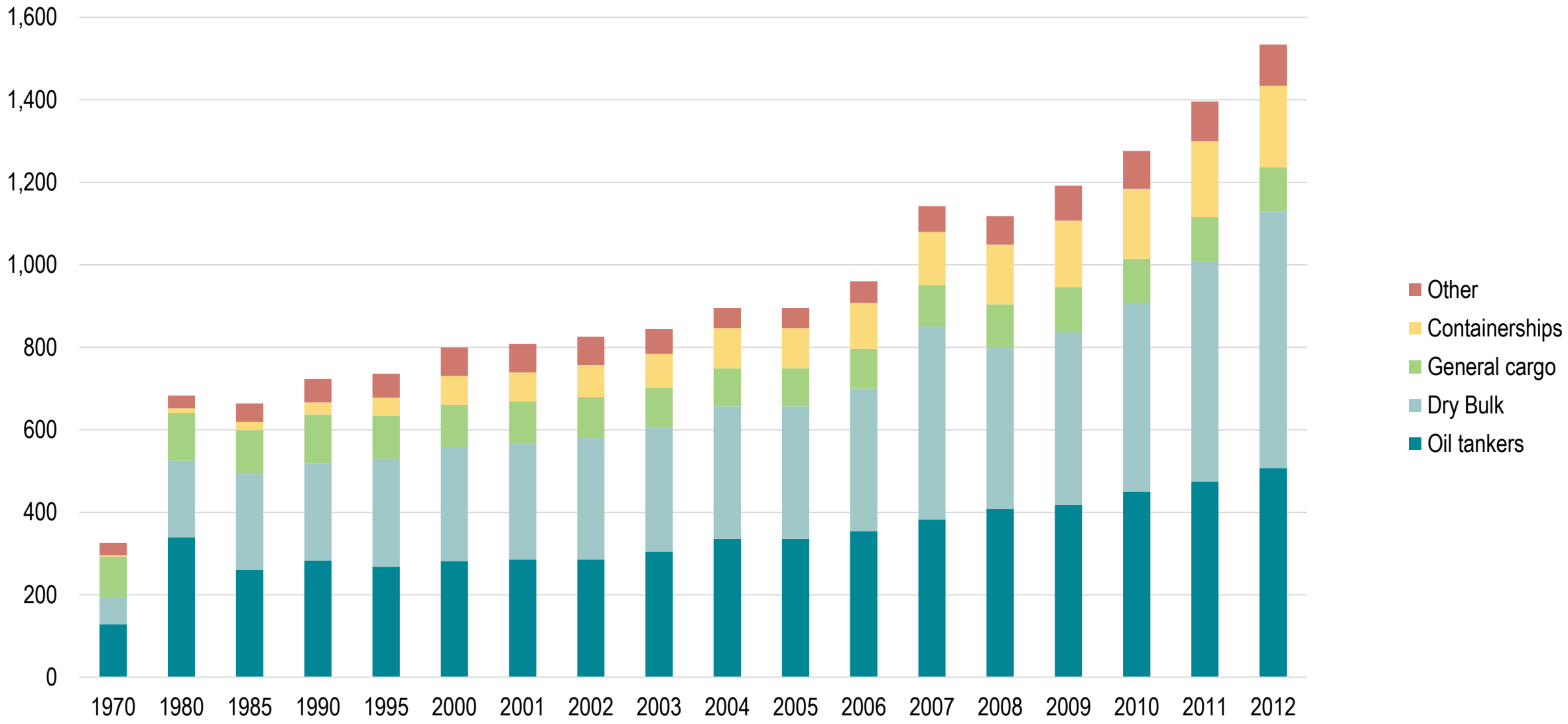
Dry Bulk

Coal, iron ore, grains, bauxite, sand
Grabs / suction and conveyors (2.7 days average port time)
40% of tonnage

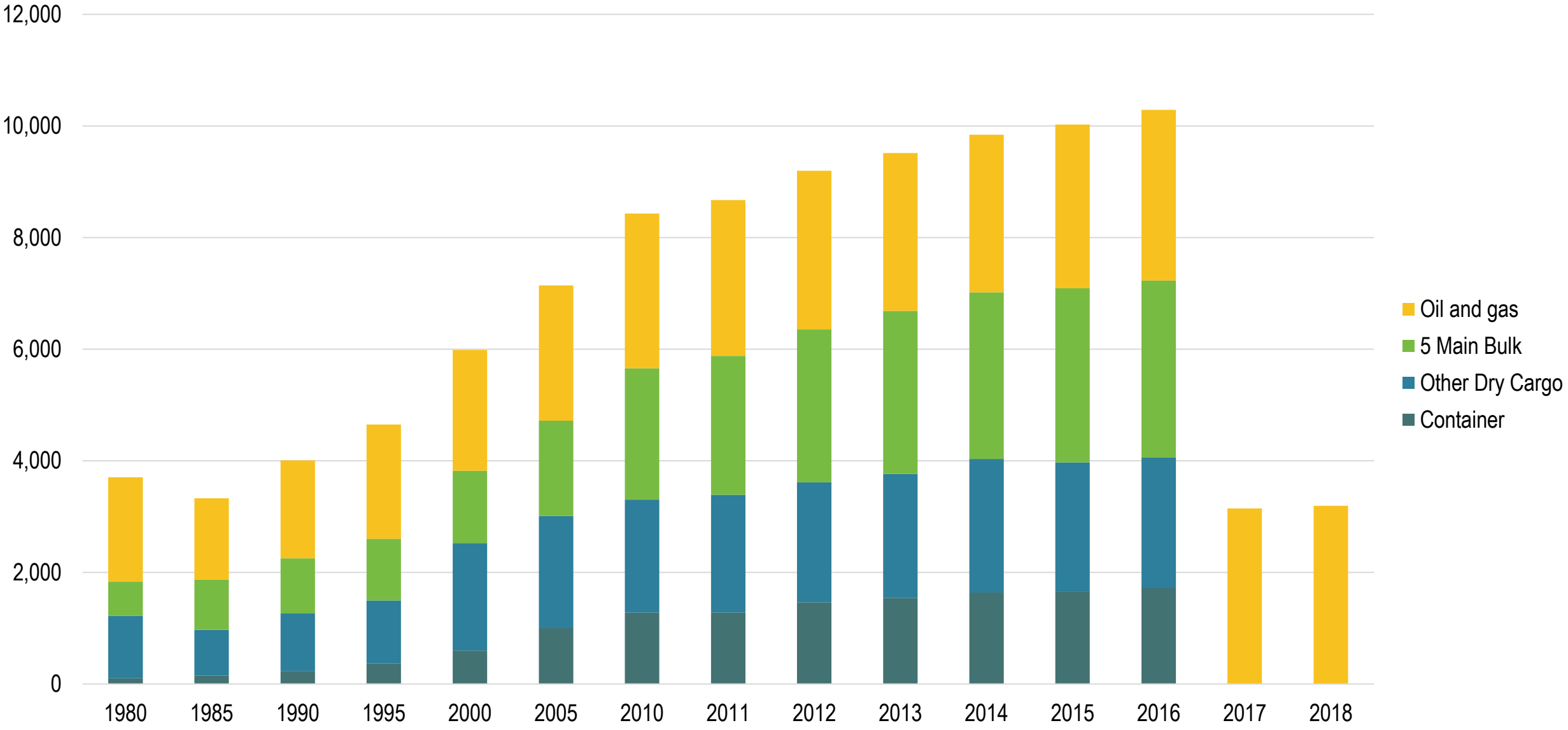
Cargo, Trade and Ship Characteristics

Cargo Type	Trade Characteristics	Vessel Size
General Cargo		
Conventional	Varied small consignments, Numerous consignees, Slow handling rates, Various routes, Numerous ports	Small
Unitized (containers)	More uniform cargo, Rapid handling, Many ports	Medium to large
Dry Bulk		
Grain	Small to medium consignments, Varied handling rates, Many restrictive ports	Small to medium
Ores/coal	Large consignments, Long hauls, Moderate handling rates, Specialized terminals, Few ports	Medium to very large
Liquid		
Crude oil	Very large consignments, Long hauls, Few routes, Specialized terminals, Few ports	Very large to ultra large
Oil products	Small shipments, Numerous consignees, Many ports	Small to medium

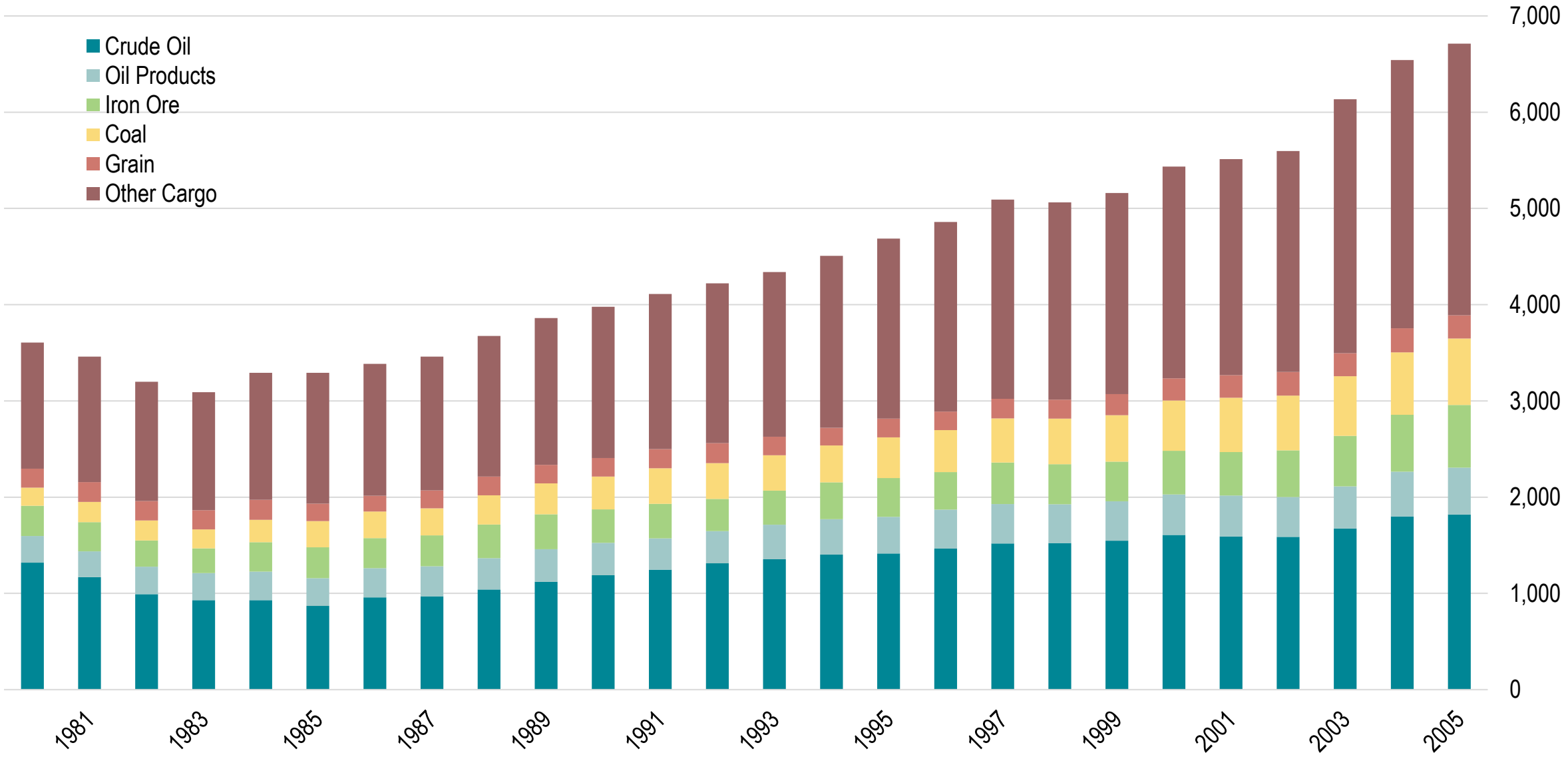
World Tonnage by Cargo Vessel Type, 1970-2012 (in millions dwt)



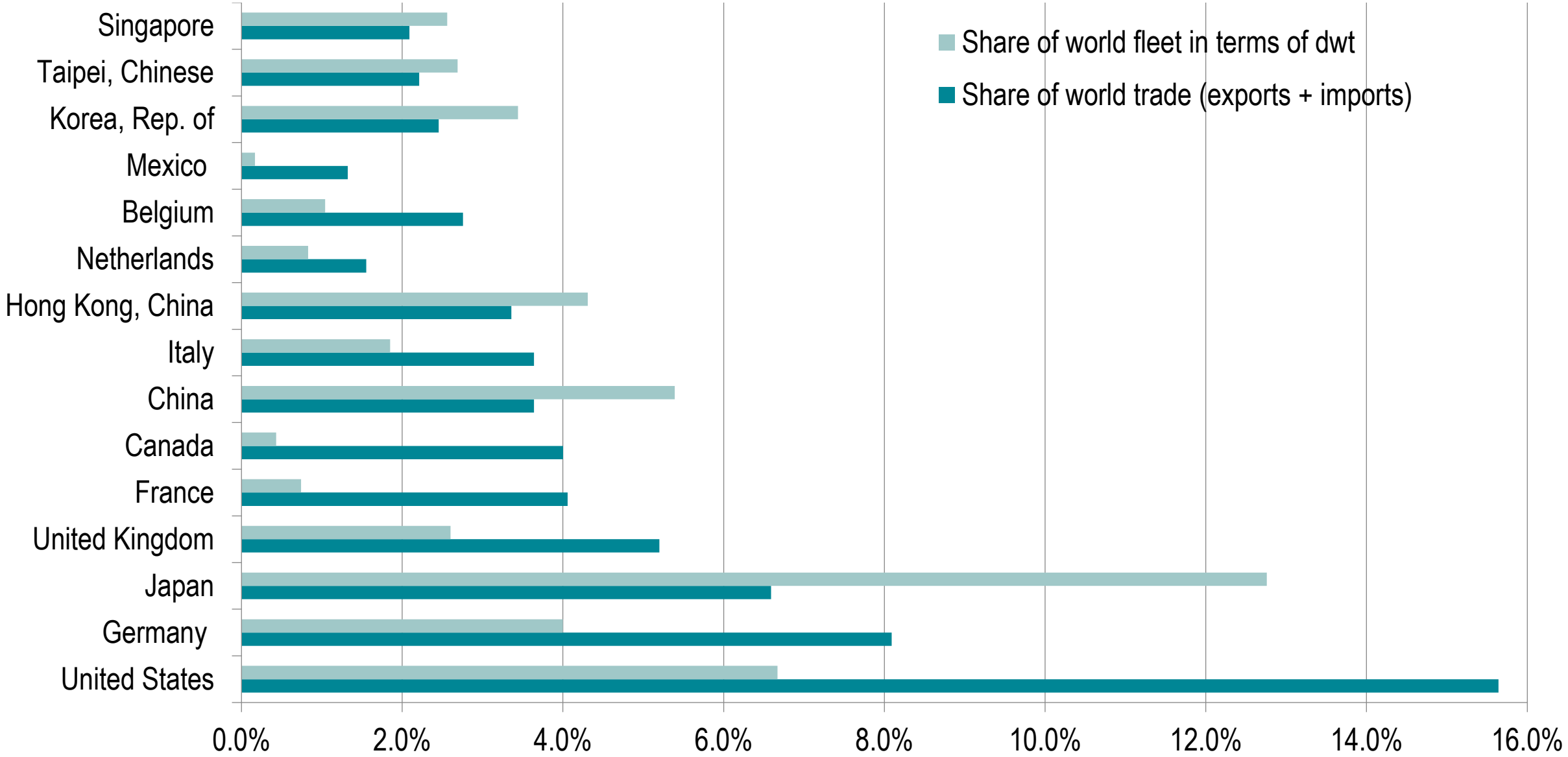
International Seaborne Trade, 1980-2015 (millions of tons loaded)



Tons Shipped by Maritime Transportation, 1980-2005 (in millions metric tons)



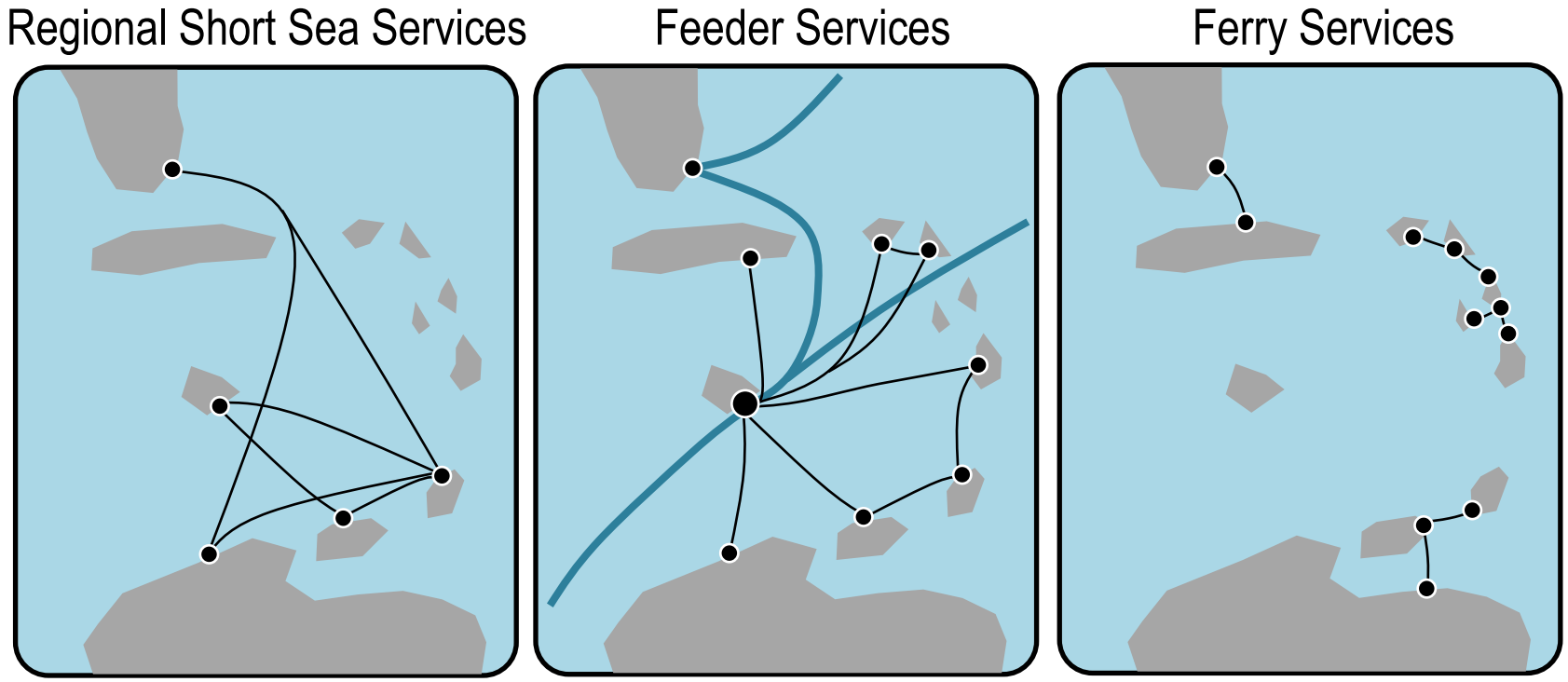
Maritime Engagement of the 15 largest Traders, 2000 (in %)



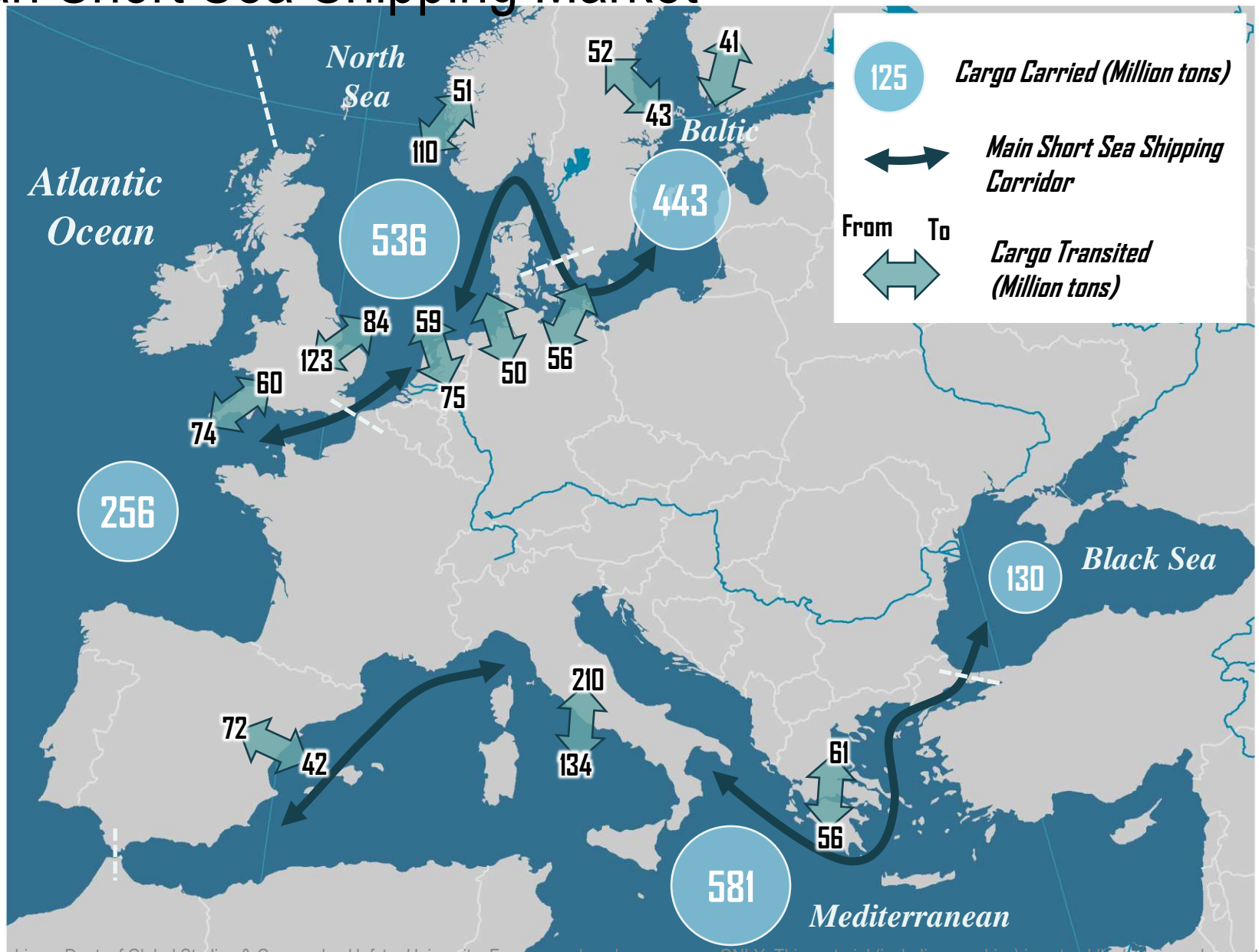
Characteristics of Short Sea Shipping Services

Characteristics	Regional Short Sea Services	Feeder Services	Ferry Services
Market	Regional or intra-corporation cargo	Feeder cargo (from/to deepsea services)	Regional cargo over short distances
Frequency	Fixed schedule with low frequency	Shipping line schedule	Fixed schedule with high frequency
Service orientation	Regional loop	Transshipment hubs	Point to point
Operations	Lift-on/Lift-off (Lo/Lo); Roll-on/Roll-off (Ro/Ro)	Lift-on/Lift-off (Lo/Lo)	Roll-on/Roll-off (Ro/Ro)
Cargo type	Containers, break bulk, Ro/Ro	Containers	Trucks, trailers, passengers
Infrastructure Requirements	Shore-side cranes, warehouses and container storage areas	Shore-side cranes and container storage areas	Minimal (quays), particularly if vessels have self-sustaining ramps
Competition	Road and rail transport (if present)	Direct port calls. Ferry services.	Road and air transport (if present). Feeder services.

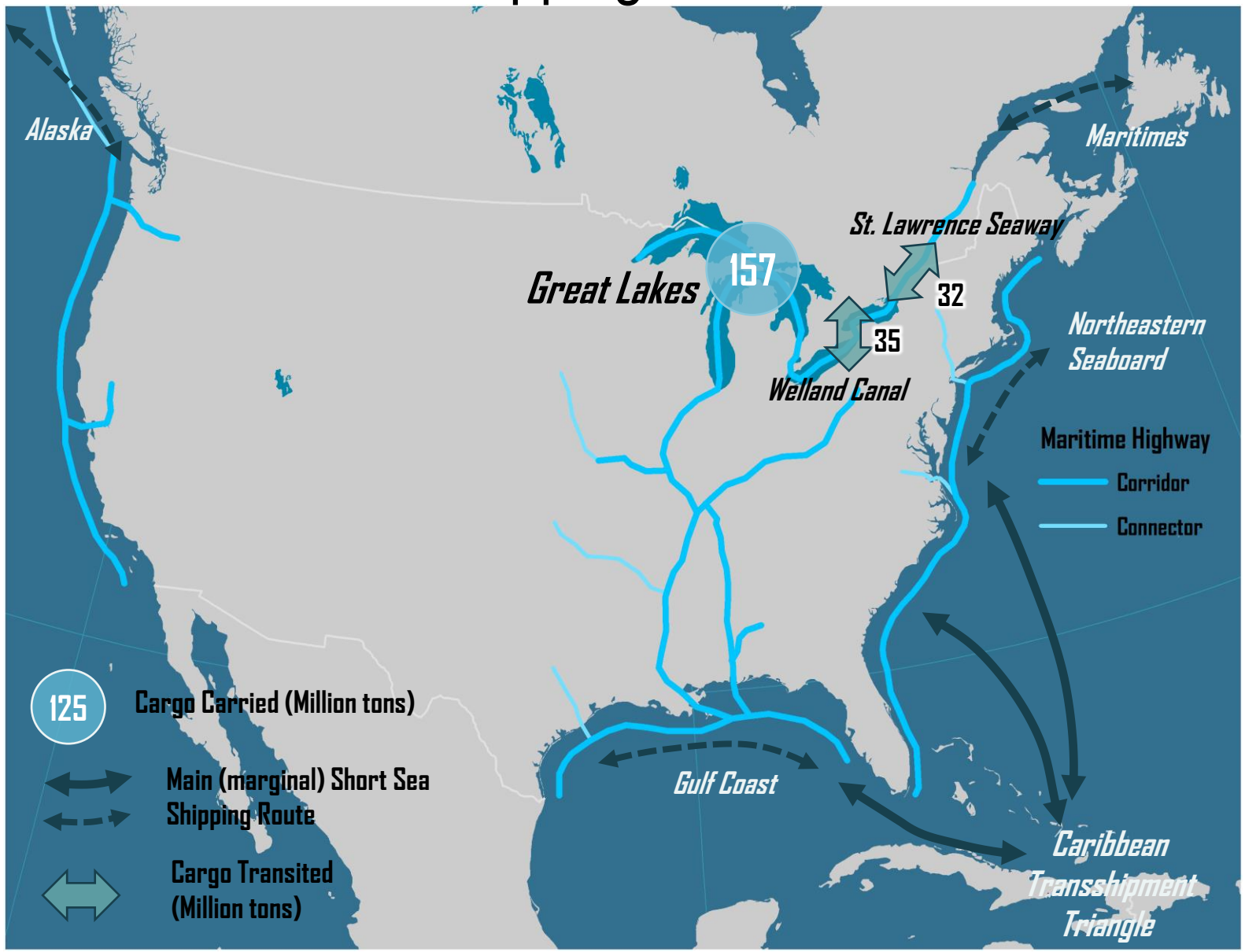
Short Sea Shipping Services Network Configuration



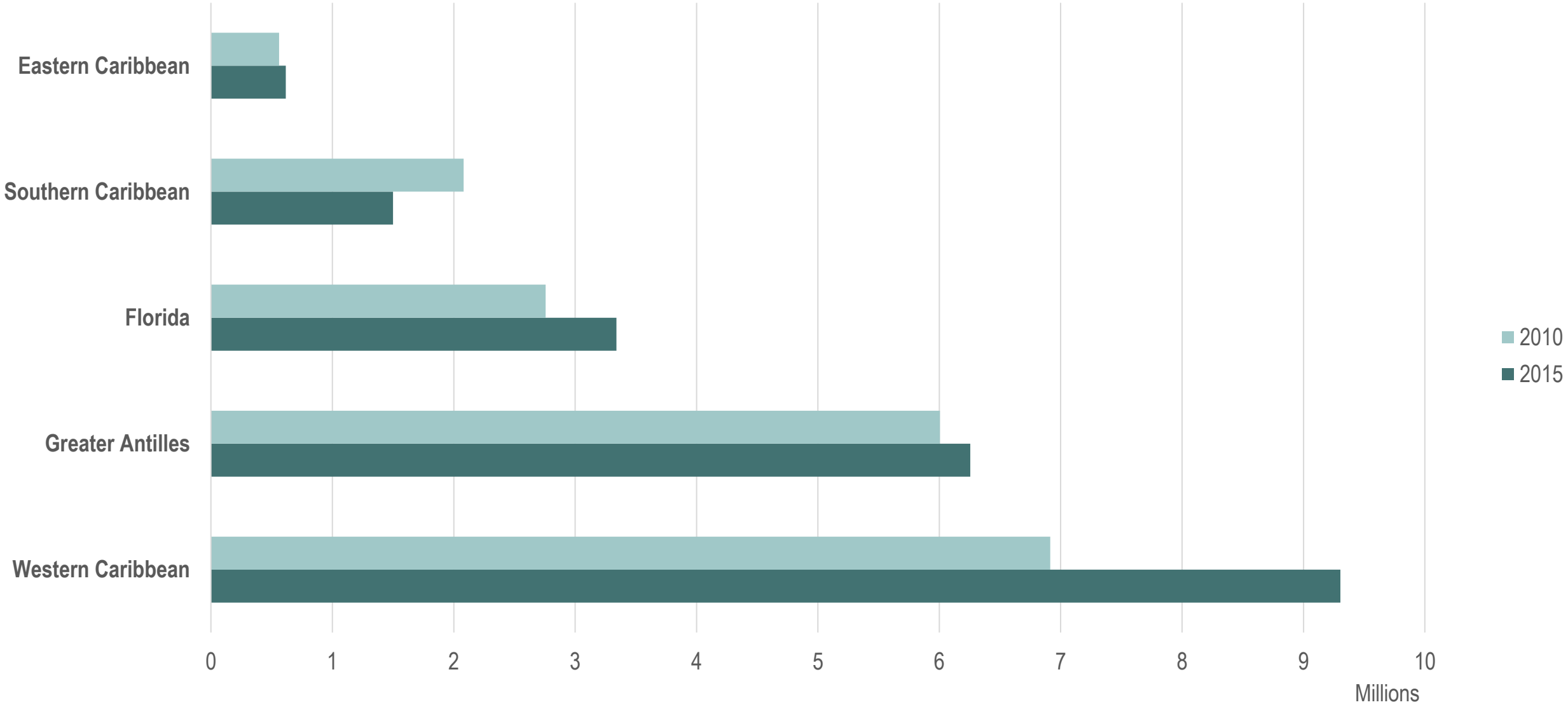
The European Short Sea Shipping Market



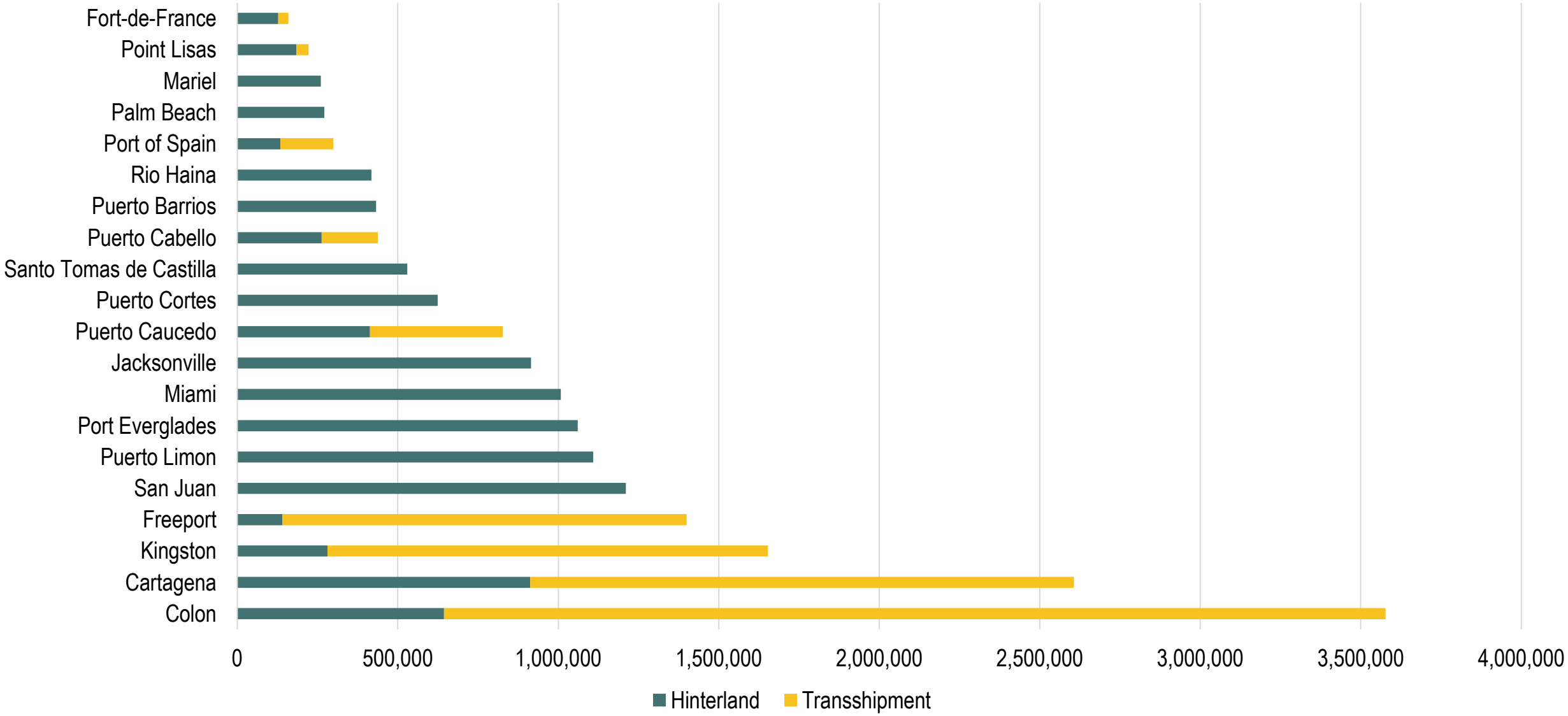
The North American Short Sea Shipping Market



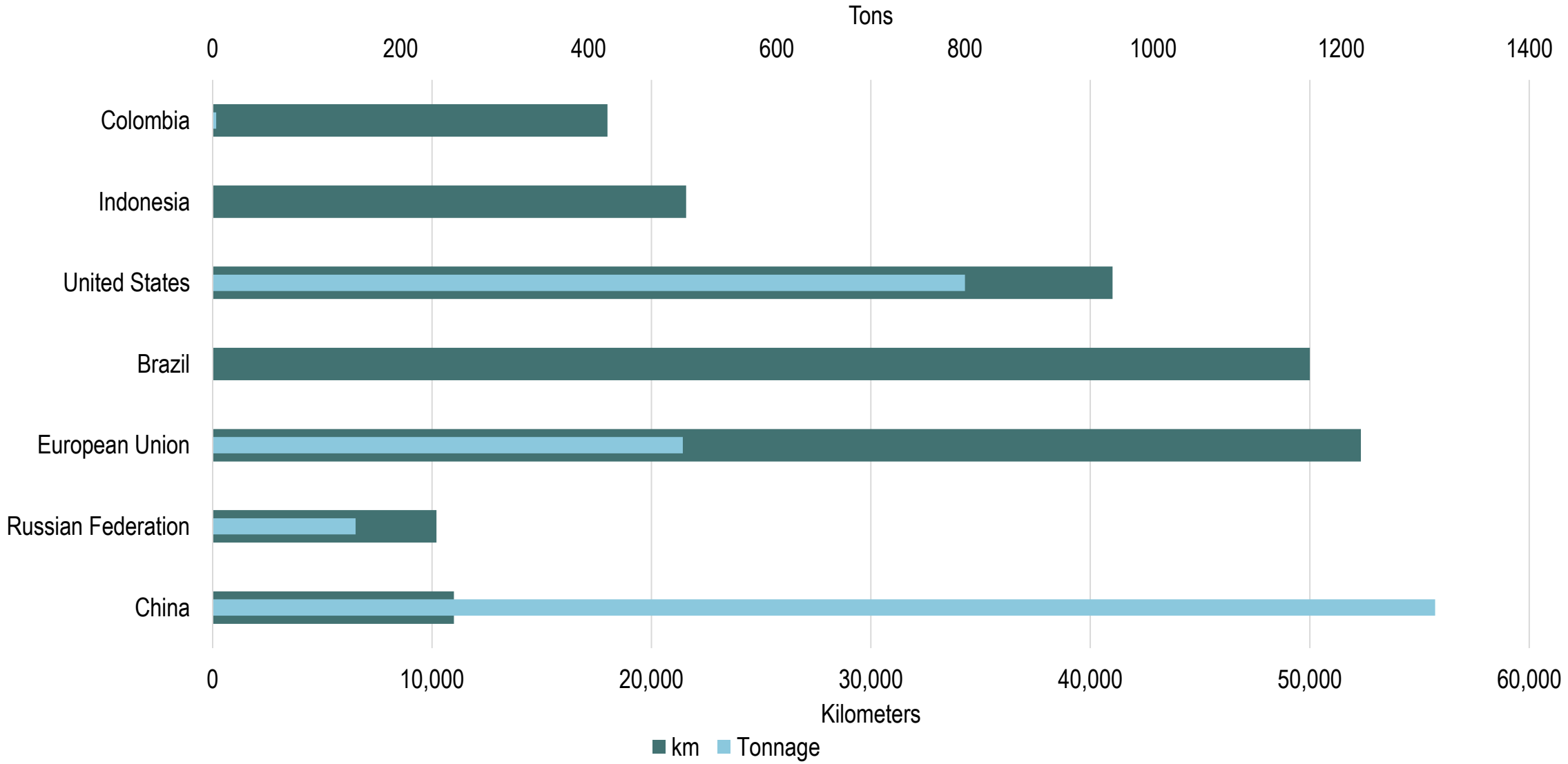
Container Traffic Handled by Main Caribbean Sub Regions



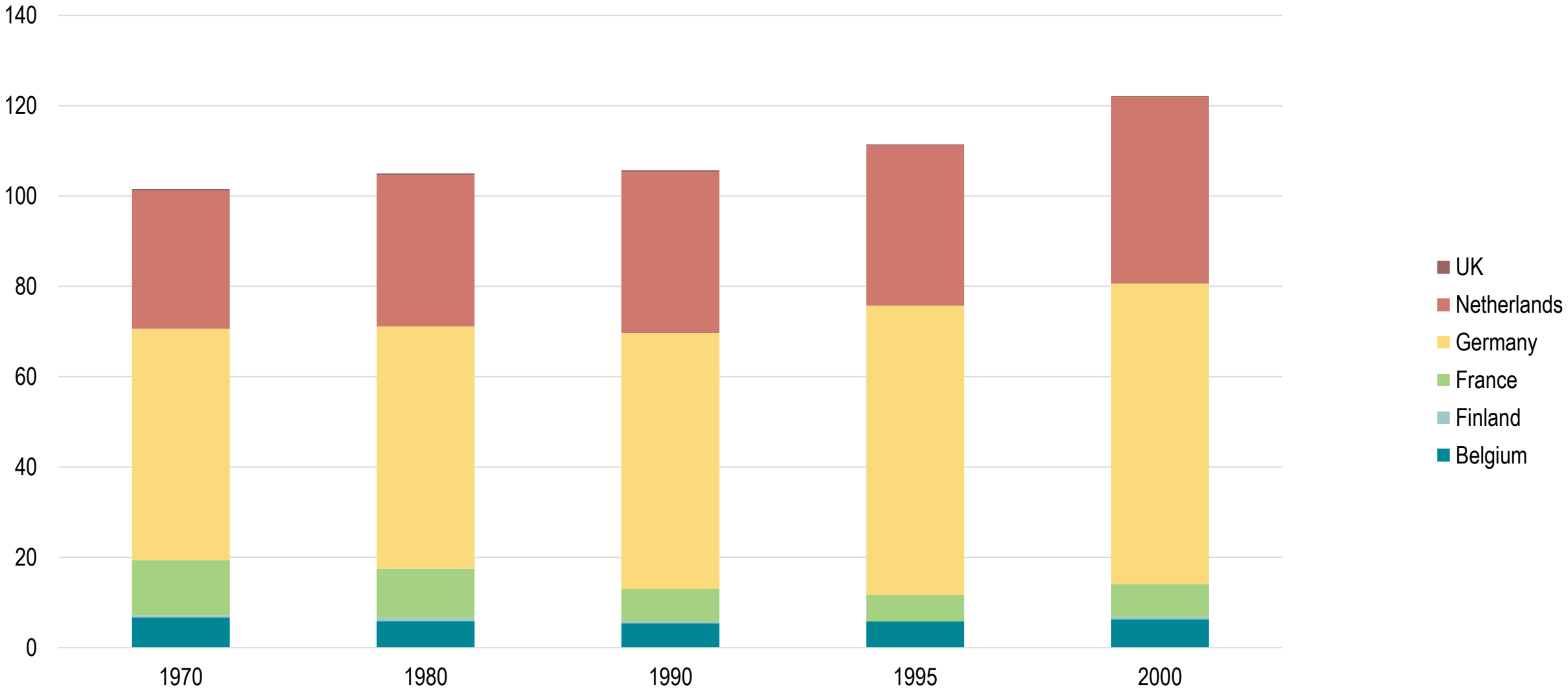
Largest Ports of the Caribbean



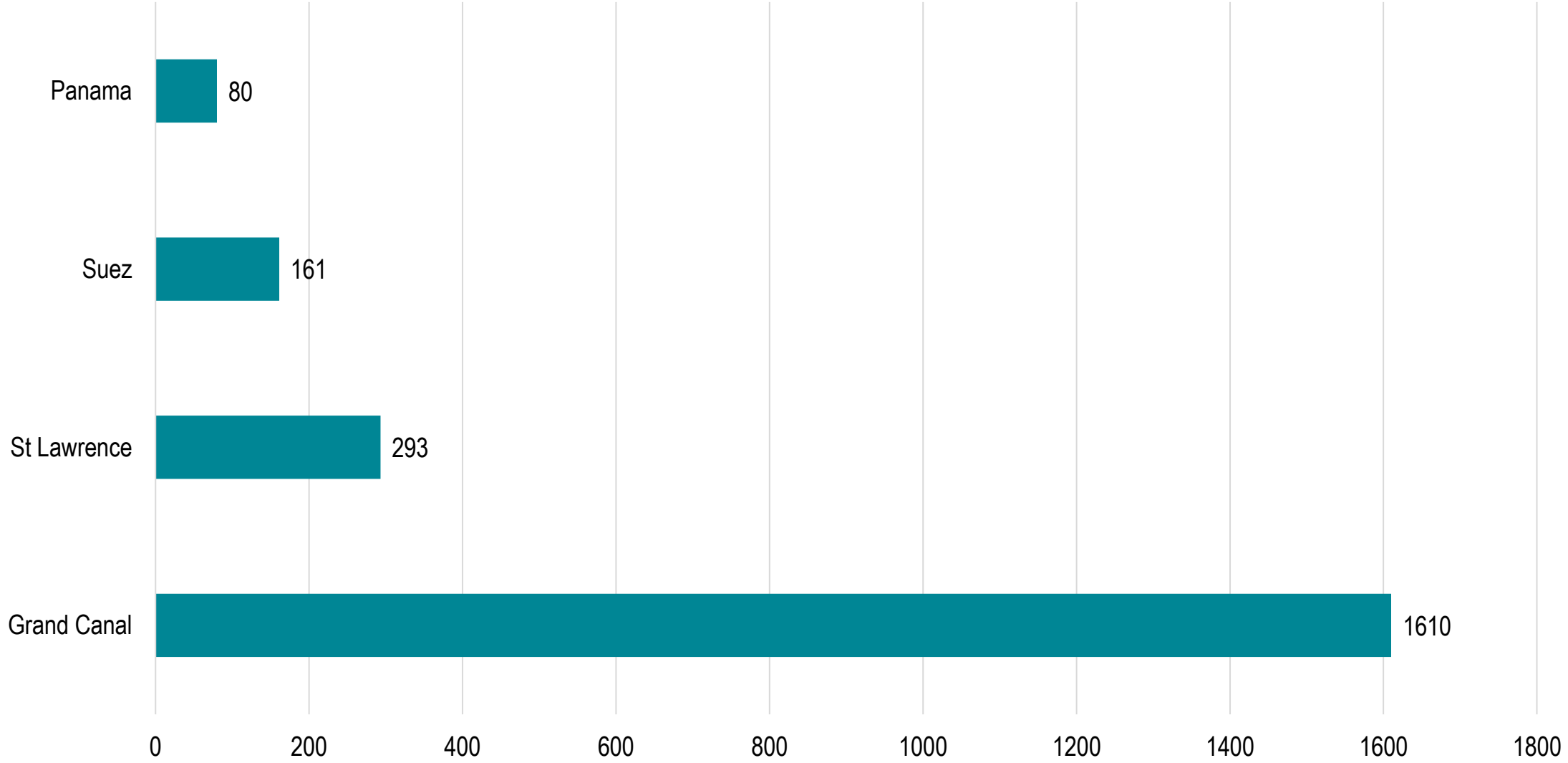
Length of Navigable Waters and Tonnage Carried, 2006-08



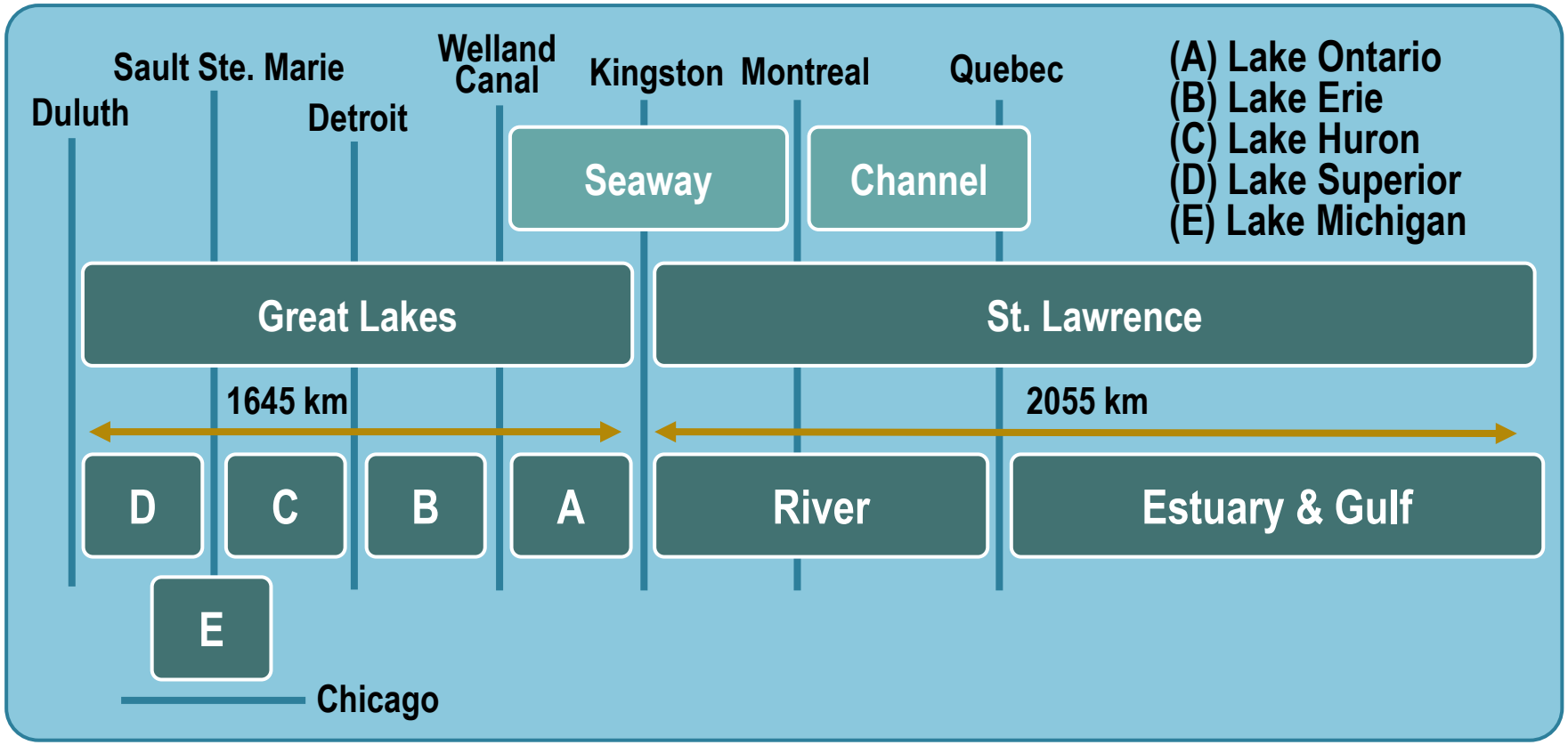
Inland Waterway Traffic, Western Europe, 1970-2000 (in billion ton-kms)



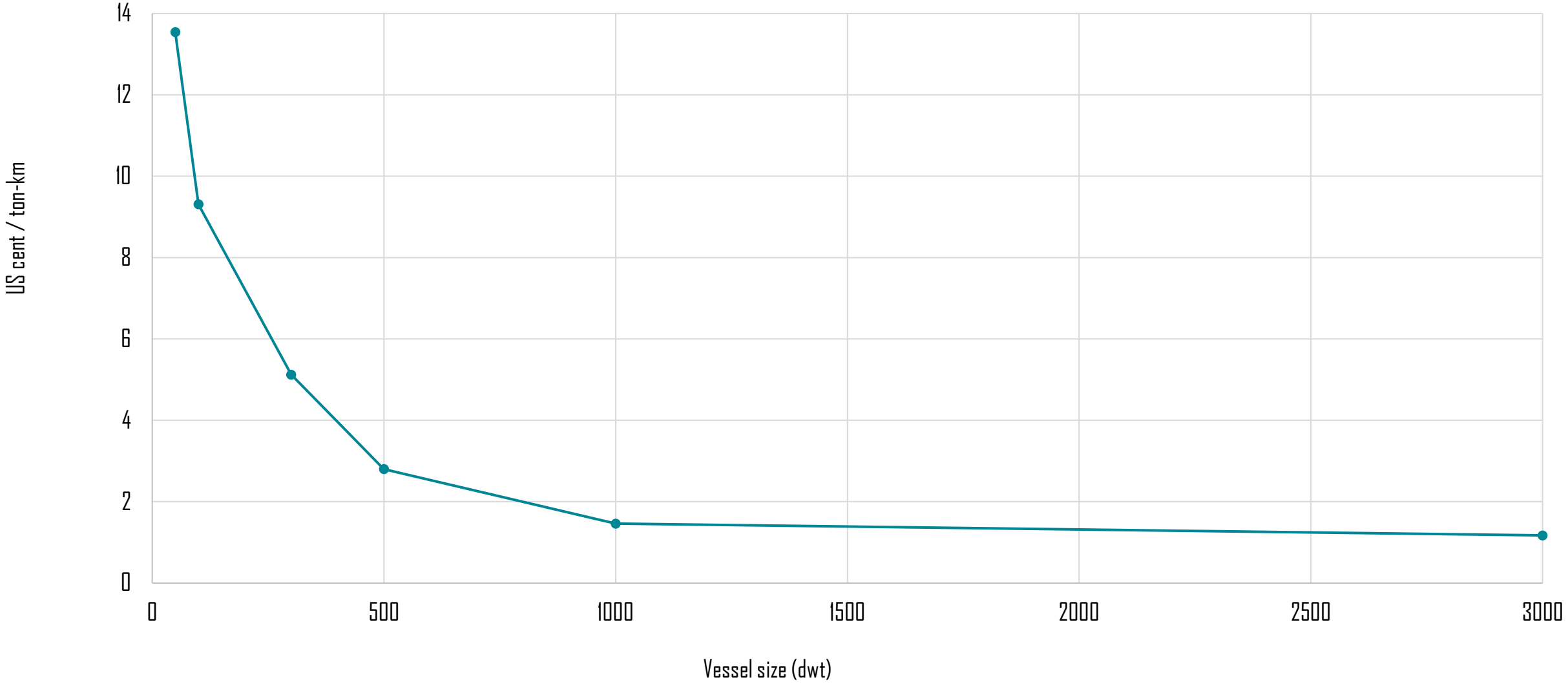
Channel length (in km)



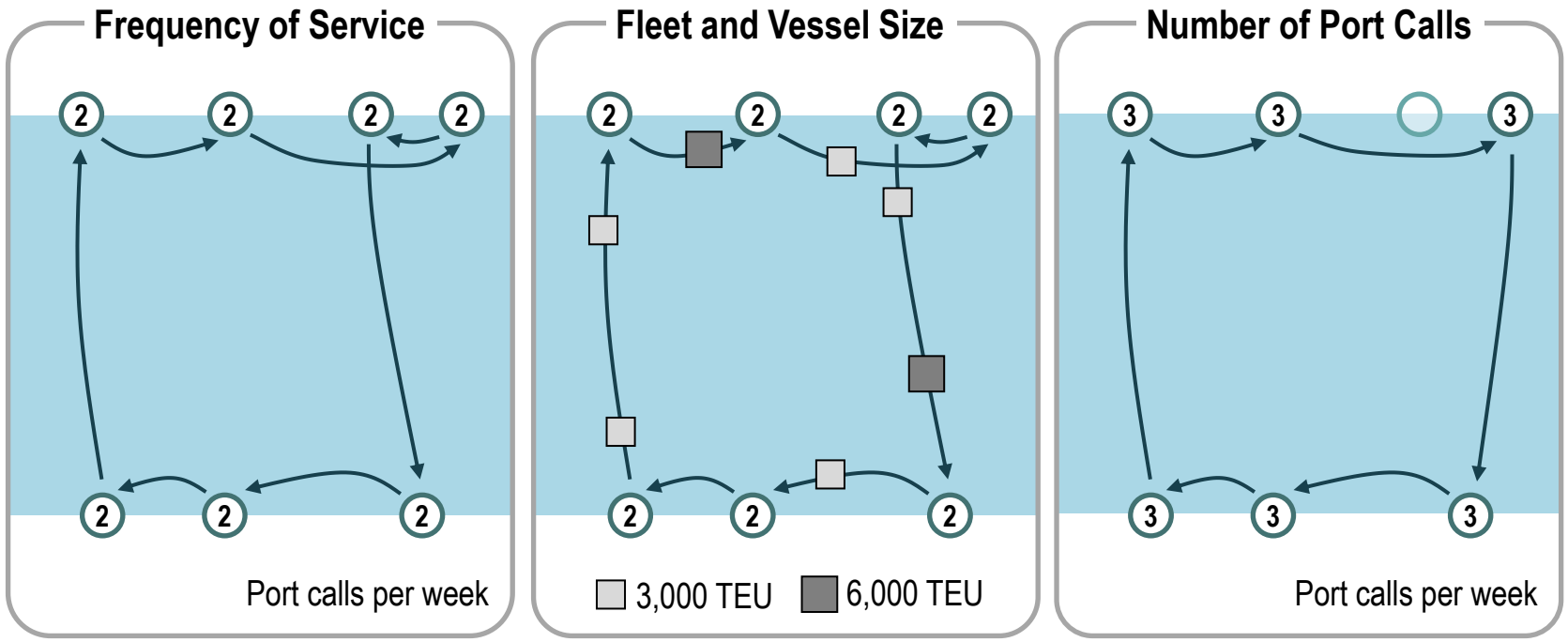
The St. Lawrence / Great Lakes System



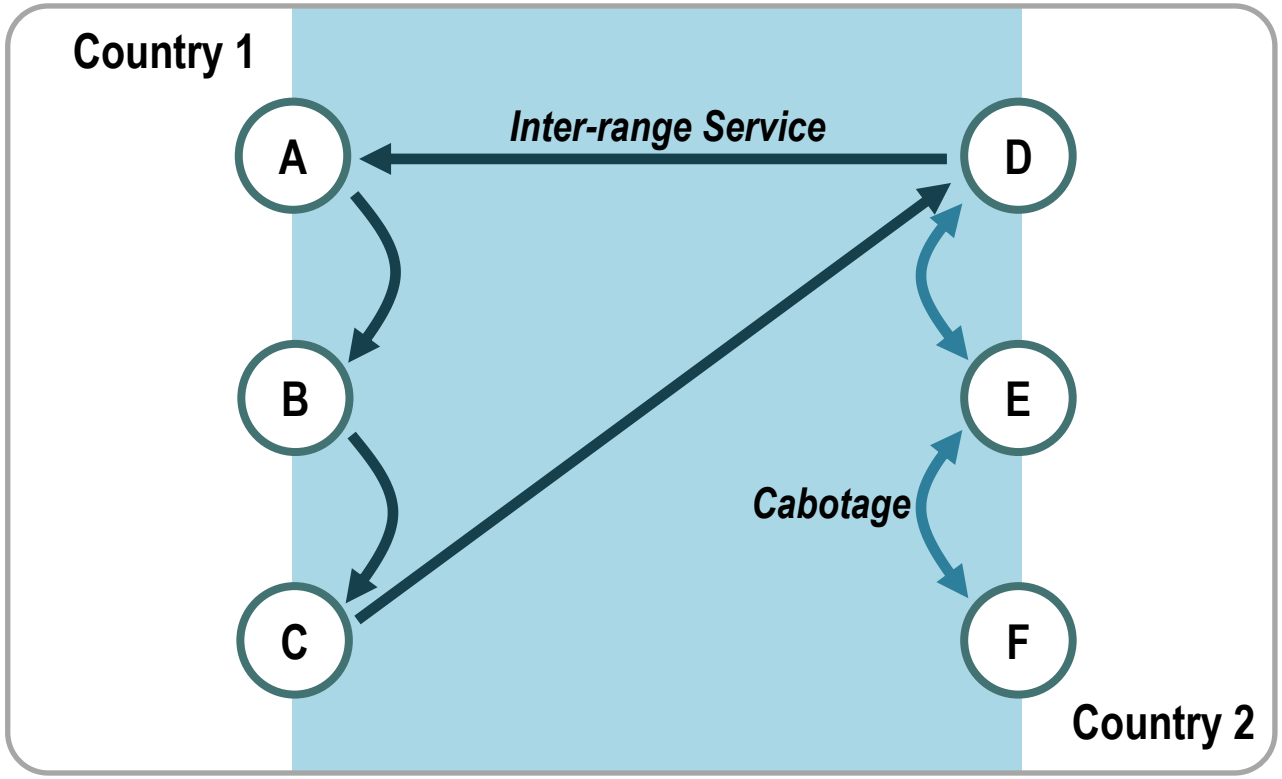
Inland Waterway Vessels Operating Costs, China 1998



Factors Impacting Maritime Shipping Networks



Inter-Range Services and Cabotage



The Maritime Transport Life Cycle and Main National Actors