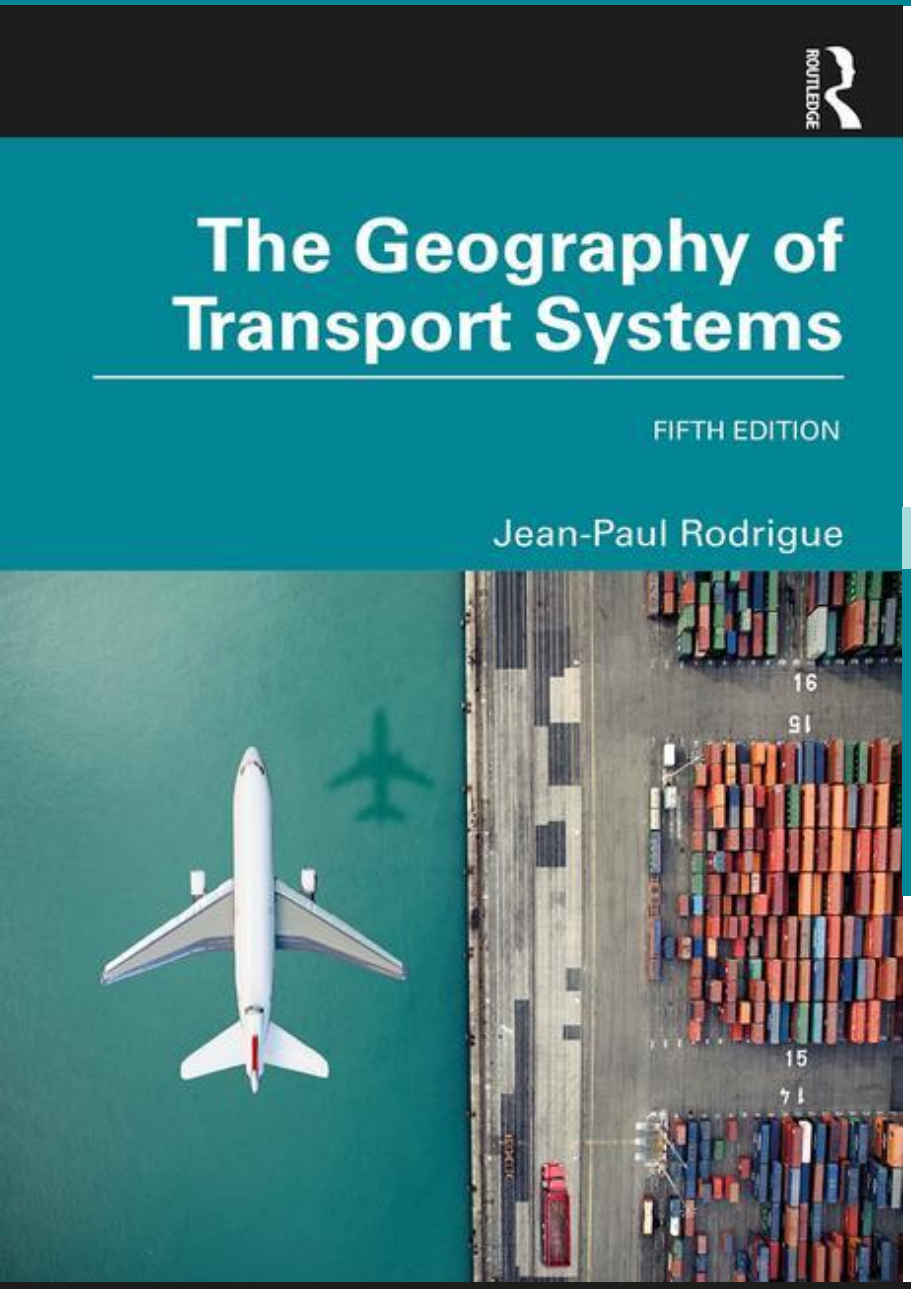

Transportation Modes (Part II)

CHAPTER 5

Jean-Paul.Rodrigue@hofstra.edu

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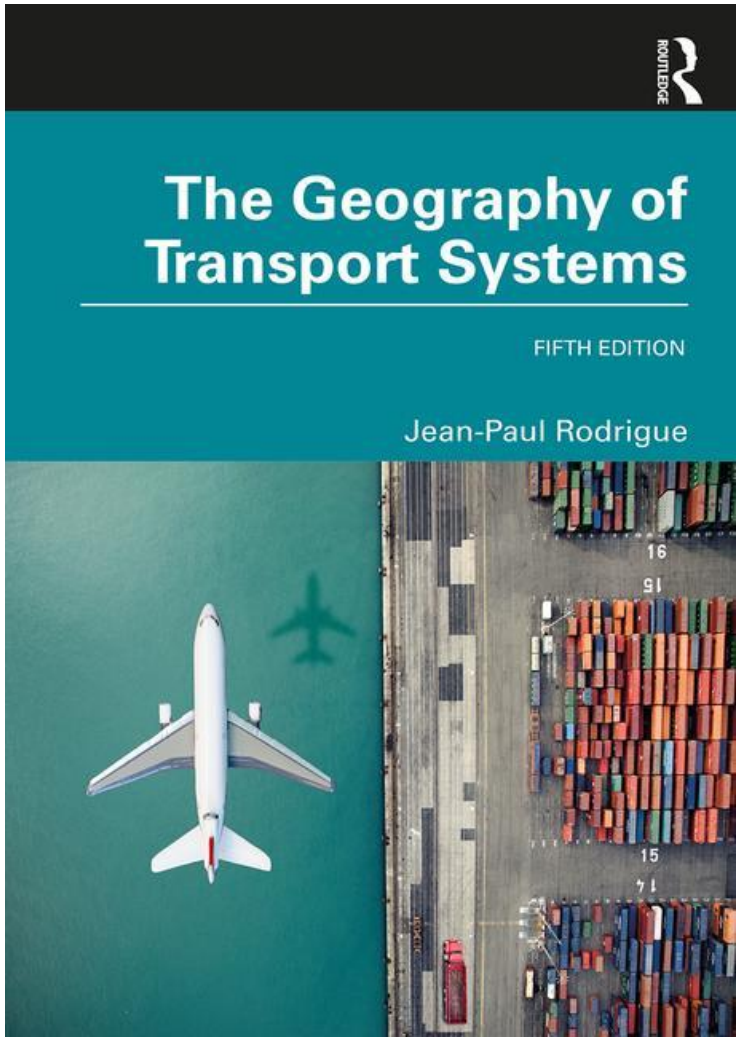
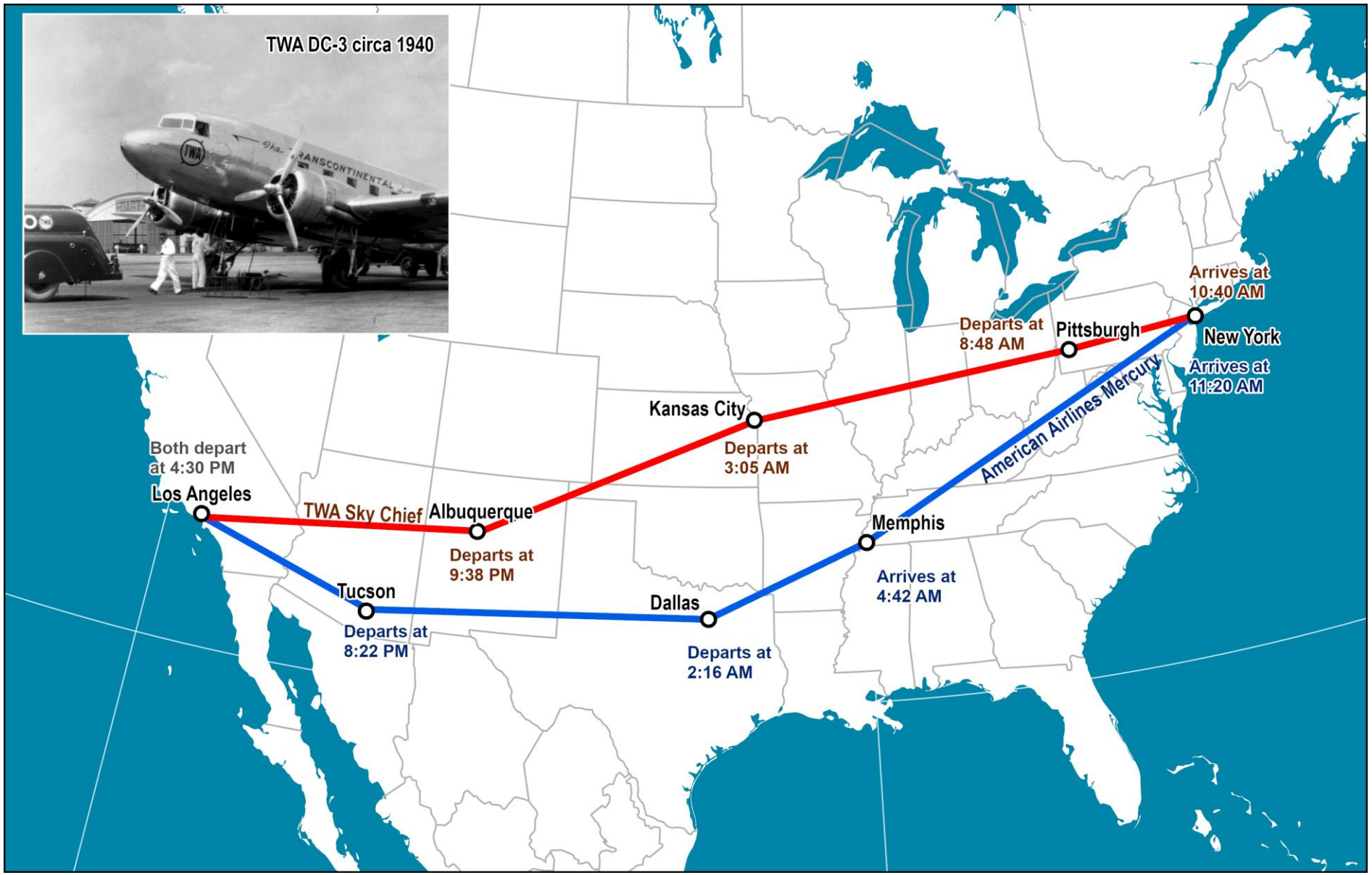


Air Transport

Chapter 5.5

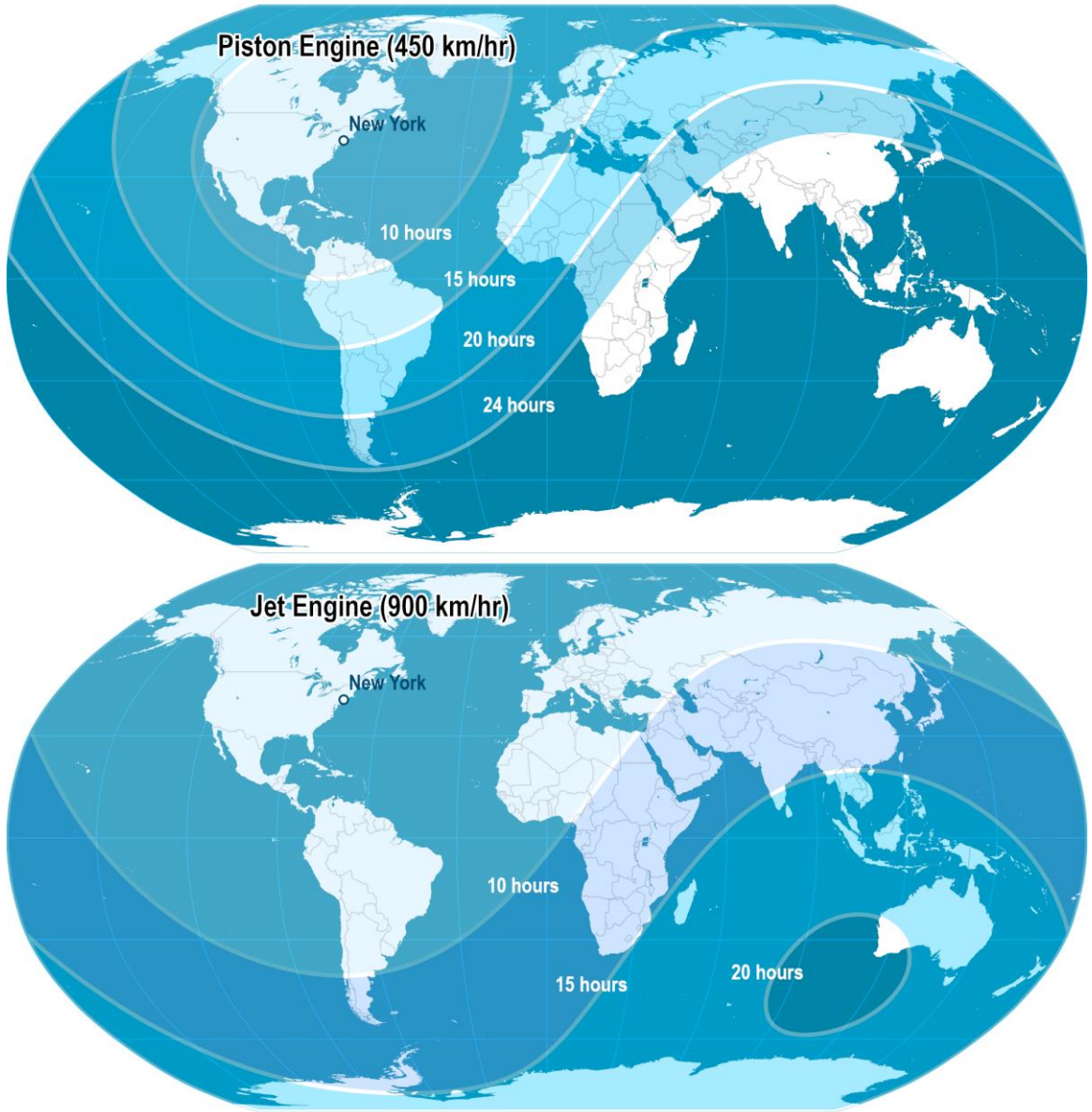
US Post Office Airmail Routes, 1921-26

Selected Transcontinental DC-3 Routes, Late 1930s

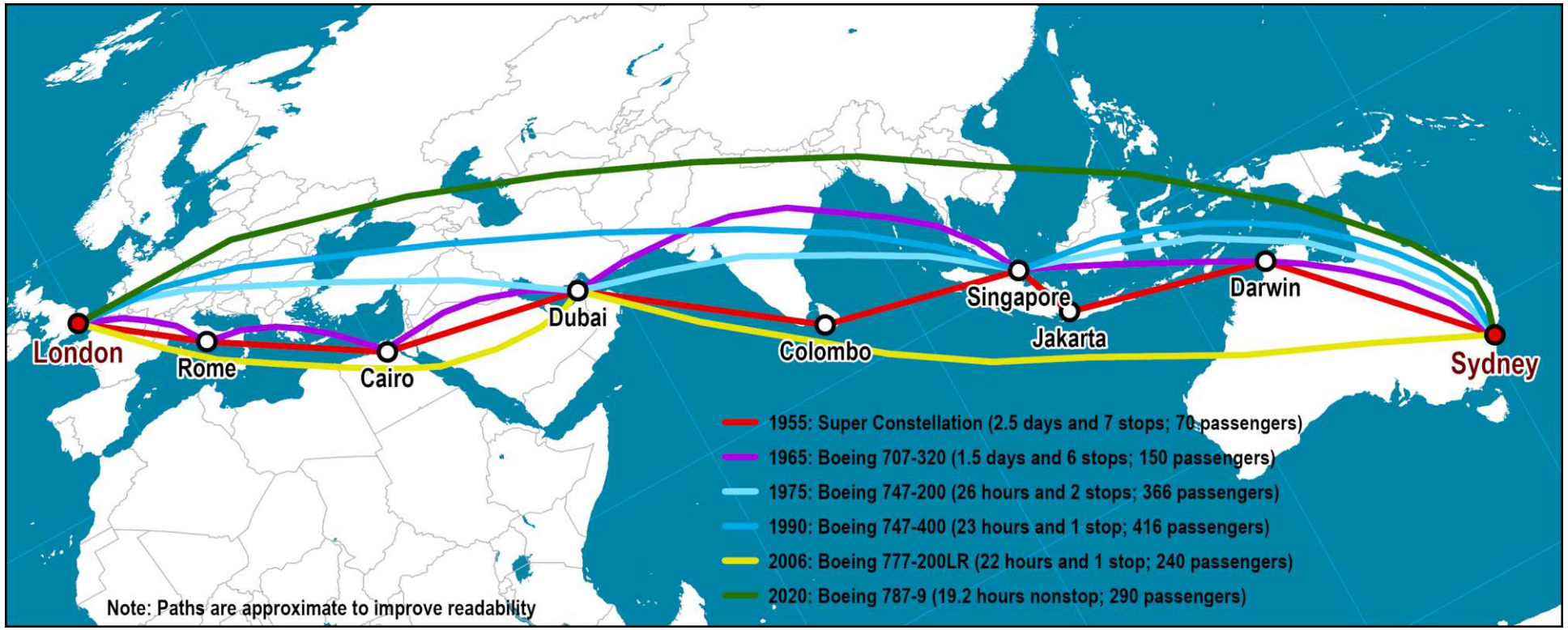


Early Intercontinental Air Routes, 1930s

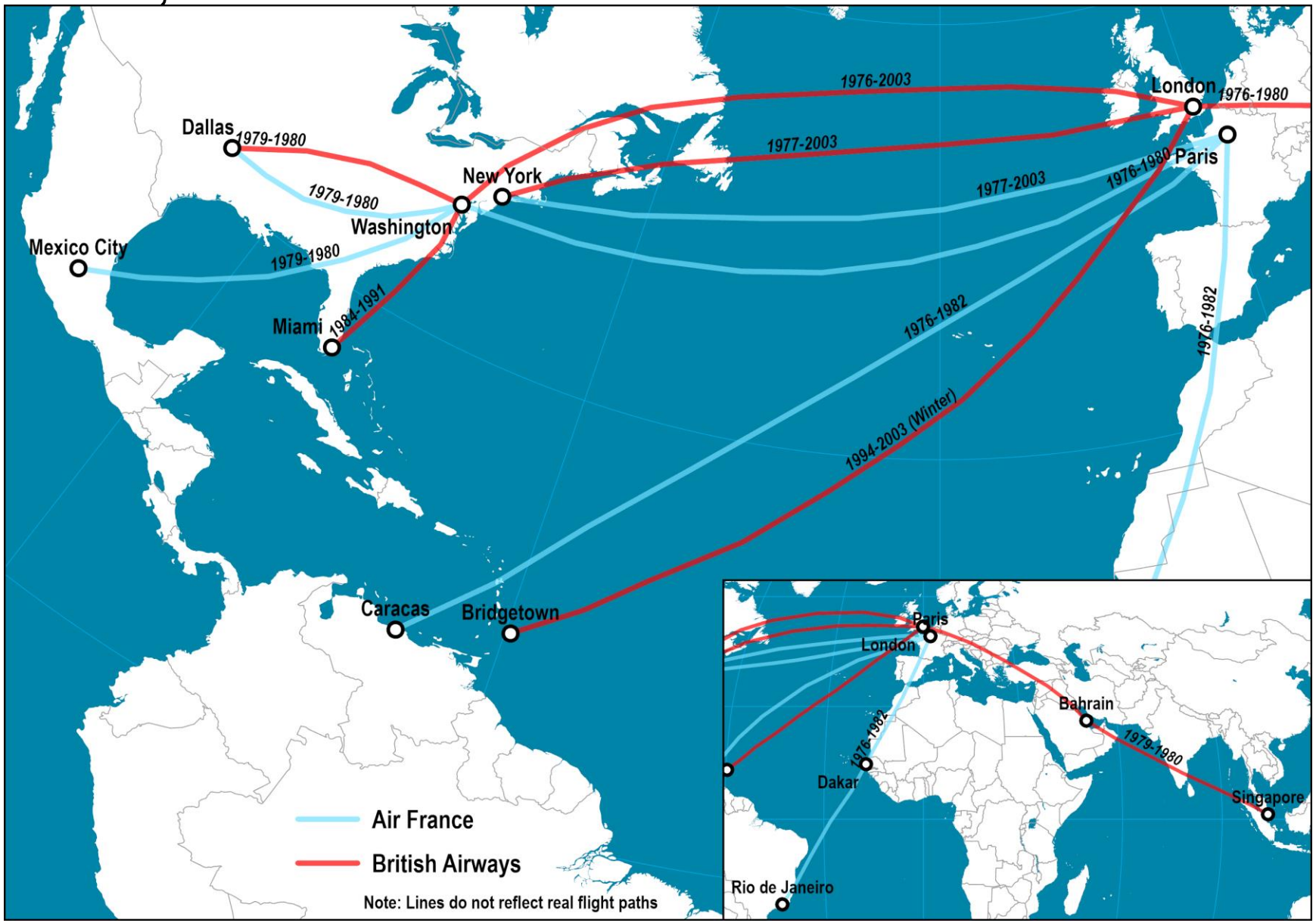
Flight Times by Piston and Jet Engines from New York



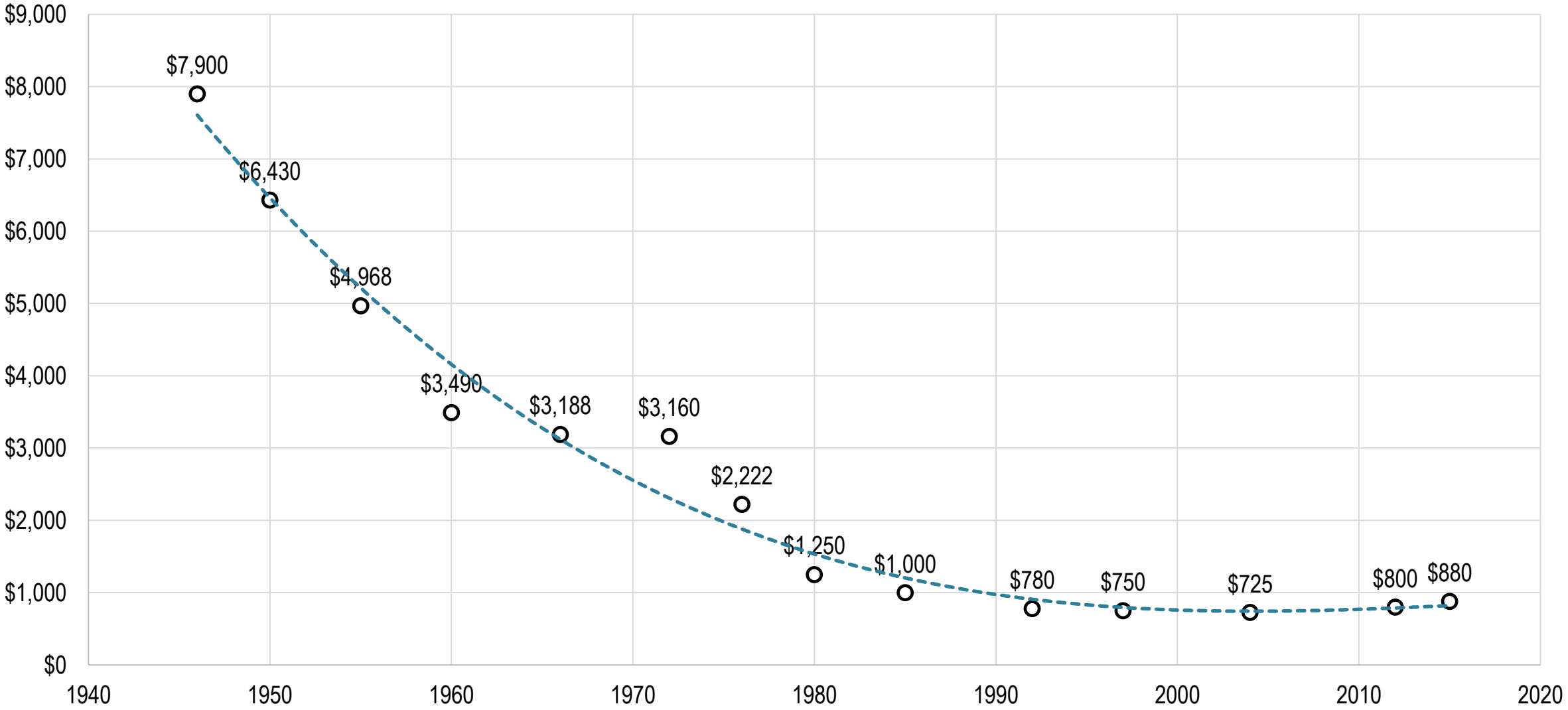
Shortest Air Route between London and Sydney, 1955 - 2020



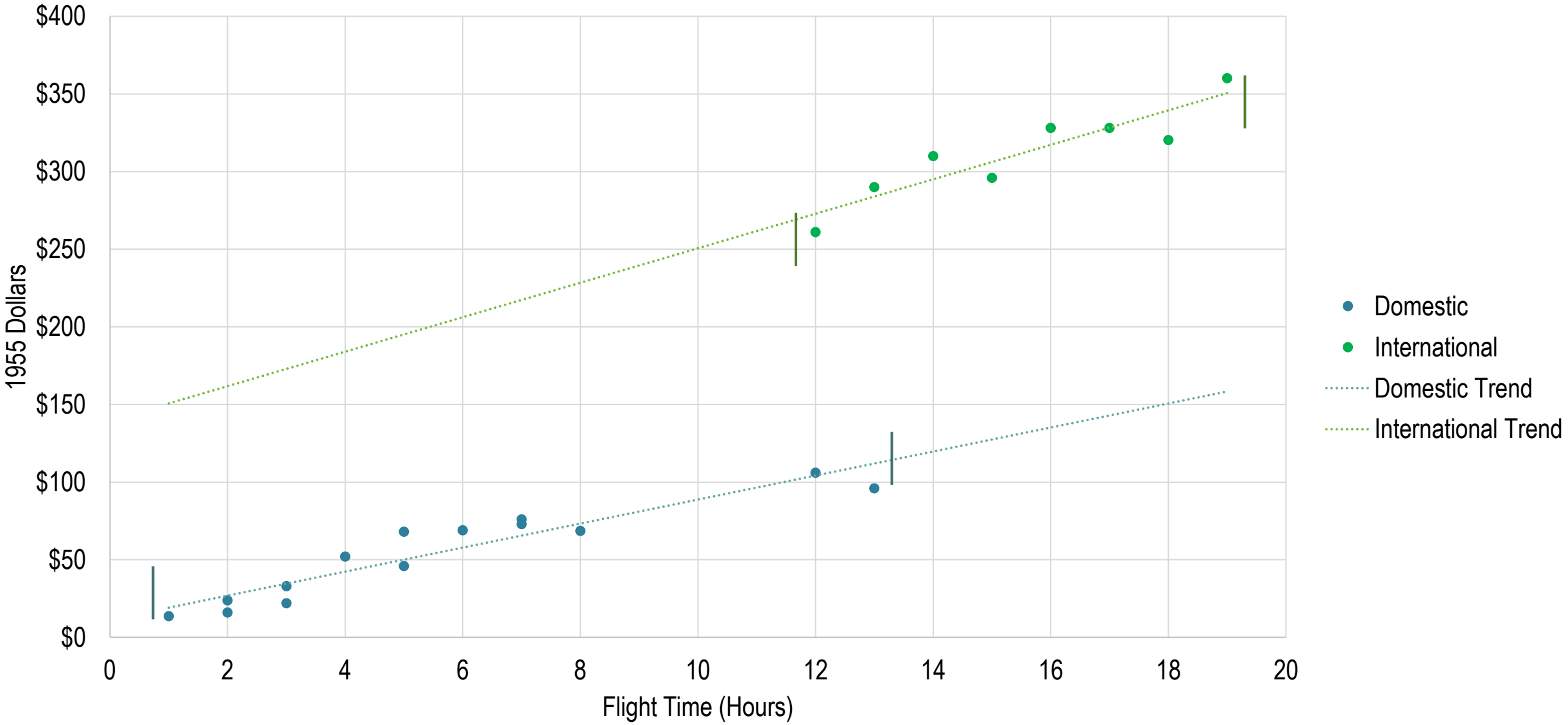
Concorde Services, 1976-2003



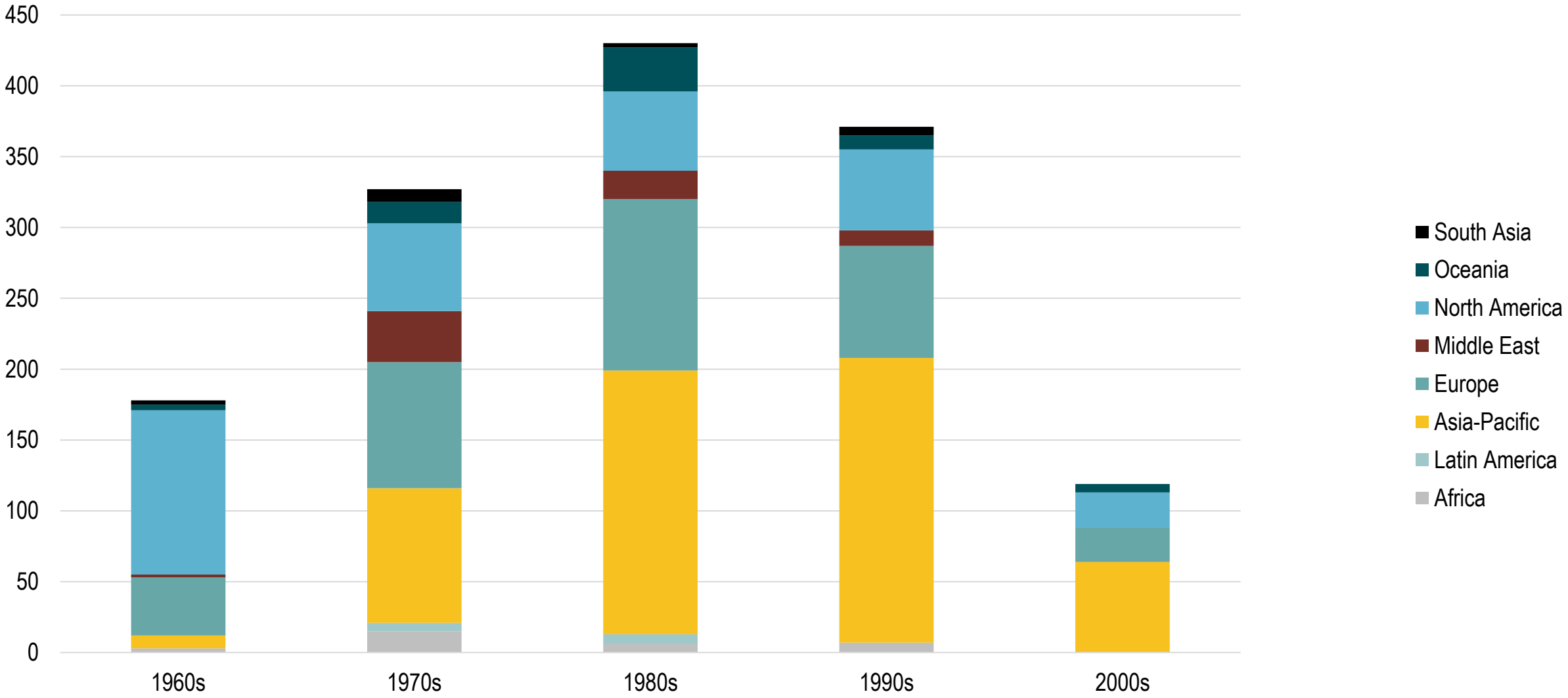
Average Airfare (roundtrip) between New York and London, 1946-2015 (in 2012 dollars)



Flight Time and One-Way Airfare, 1955



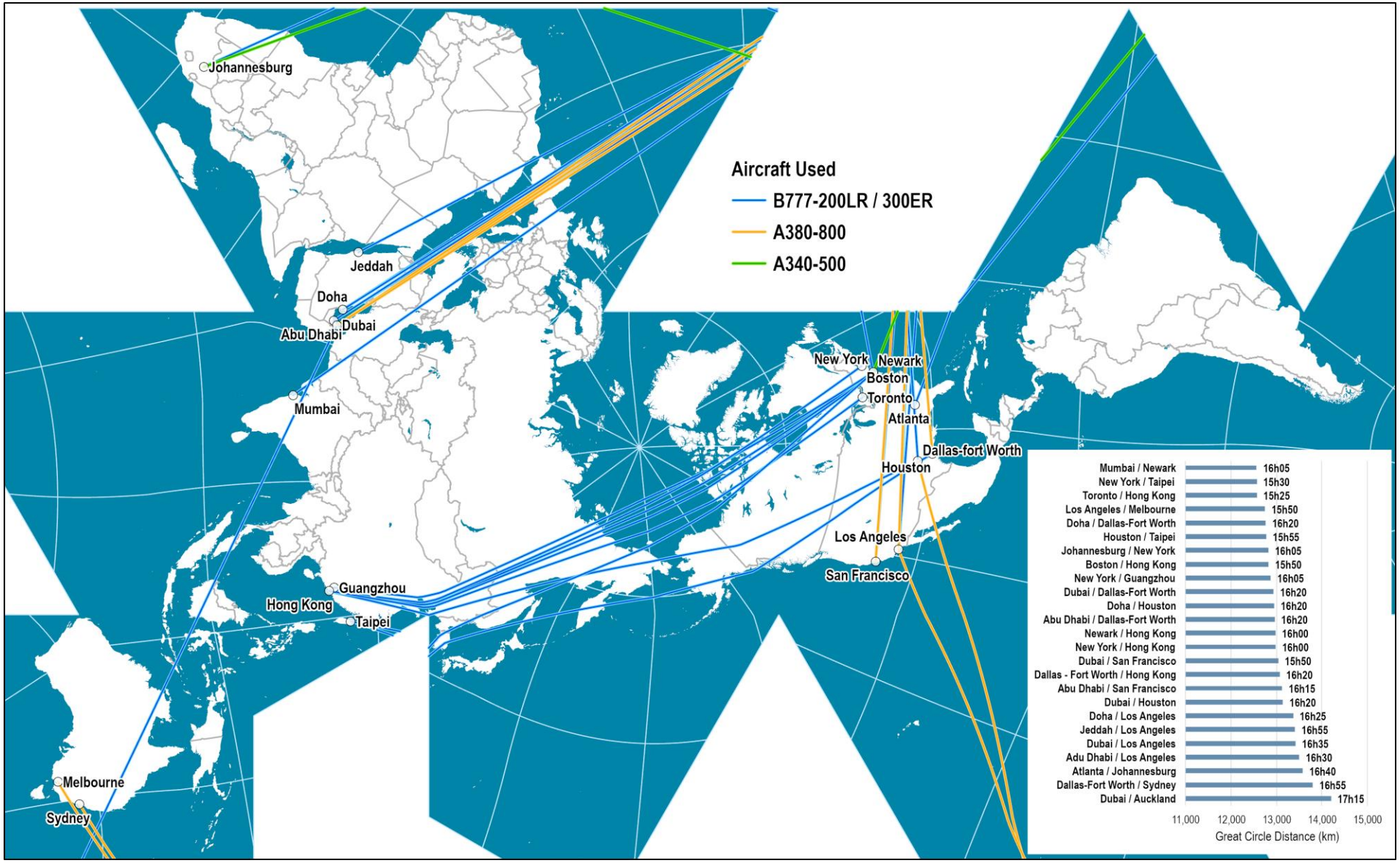
Regional Sales of Boeing 747s, 1960s-2000s



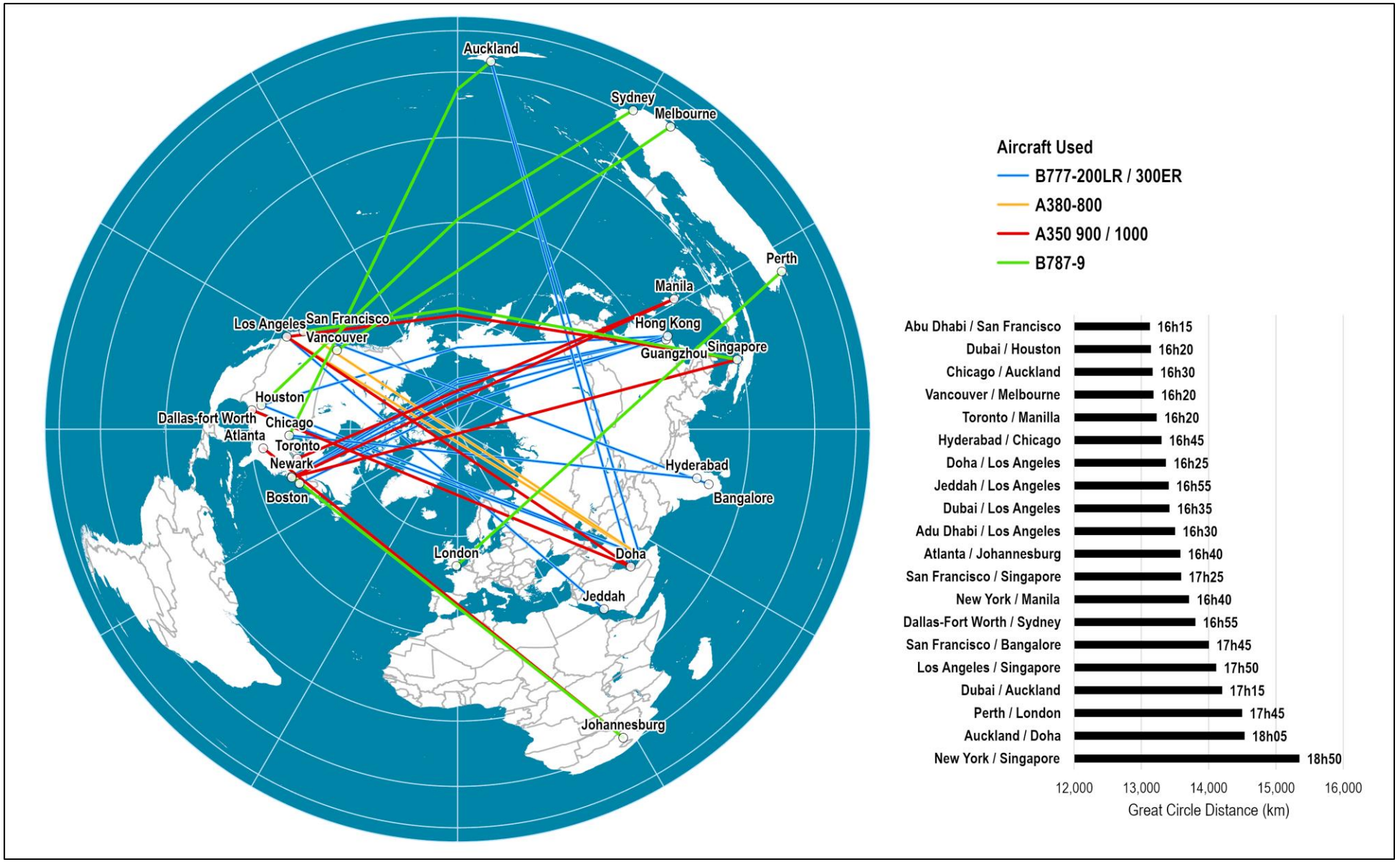
Main Commercial Passenger Aircraft, 1935-2015

Aircraft	Year of First Commercial Service	Speed (km/hr)	Maximum Range at Full Payload (km)	Seating Capacity
Douglas DC-3	1935	346	563	30
Lockheed L-649 Constellation	1943	560	8,200	95
Douglas DC-7	1953	555	7,500	105
Boeing 707-100	1958	897	6,820	110
Boeing 727-100	1964	870	4,300	134
Boeing 737-200	1967	780	3,500	97
Boeing 747-100	1970	907	9,045	385
McDonnell Douglas DC-10	1971	908	7,415	260
Airbus A300	1974	847	3,420	269
Boeing 767-200	1982	954	5,855	216
Boeing 747-400	1989	939	13,444	416
Boeing 777-200ER	1995	1030	14,300	300
Airbus A340-500	2003	886	15,800	313
Airbus A380	2007	1050	14,800	544
Boeing 787-8	2012	902	15,700	250
Airbus A350	2015	902	15,200	280

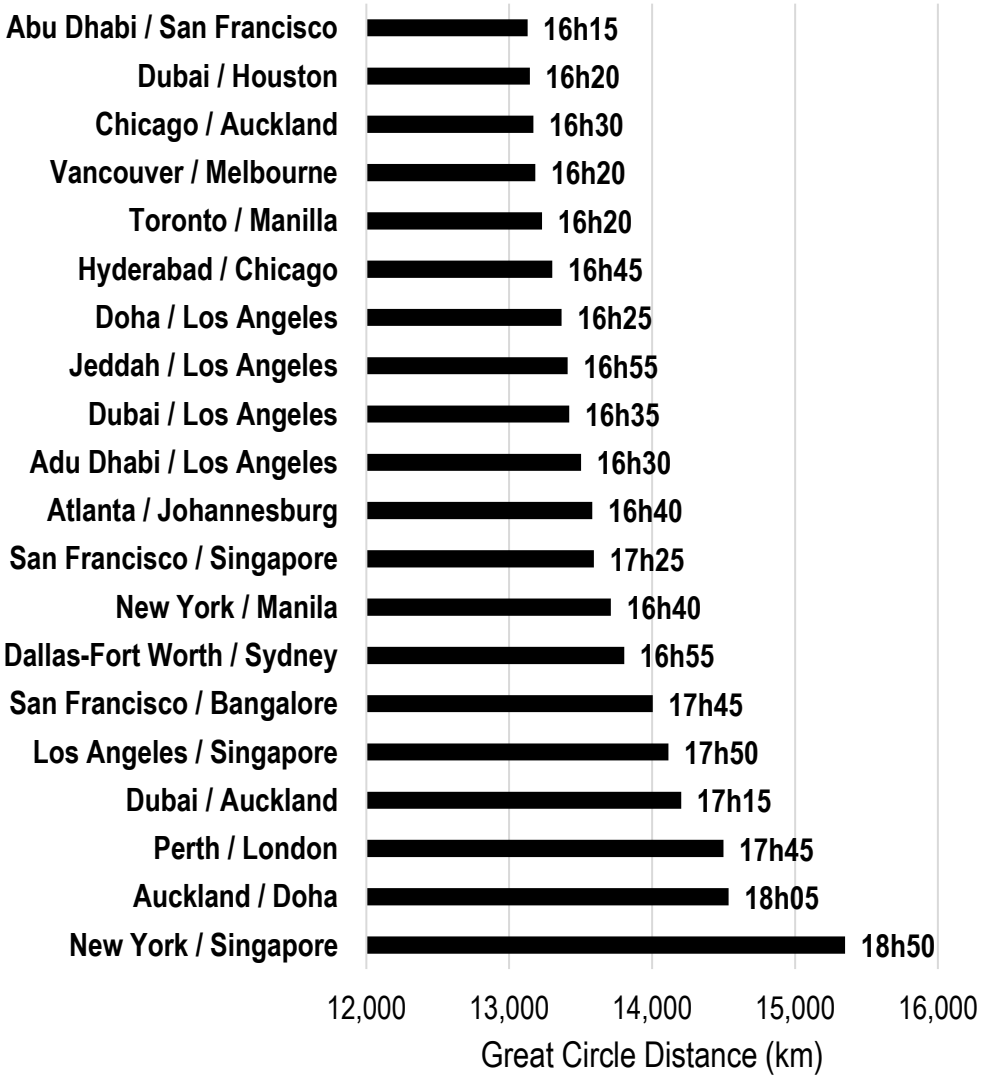
The World's Longest Nonstop Air Transport Routes, 2016



The World's Longest Nonstop Air Transport Routes, 2021



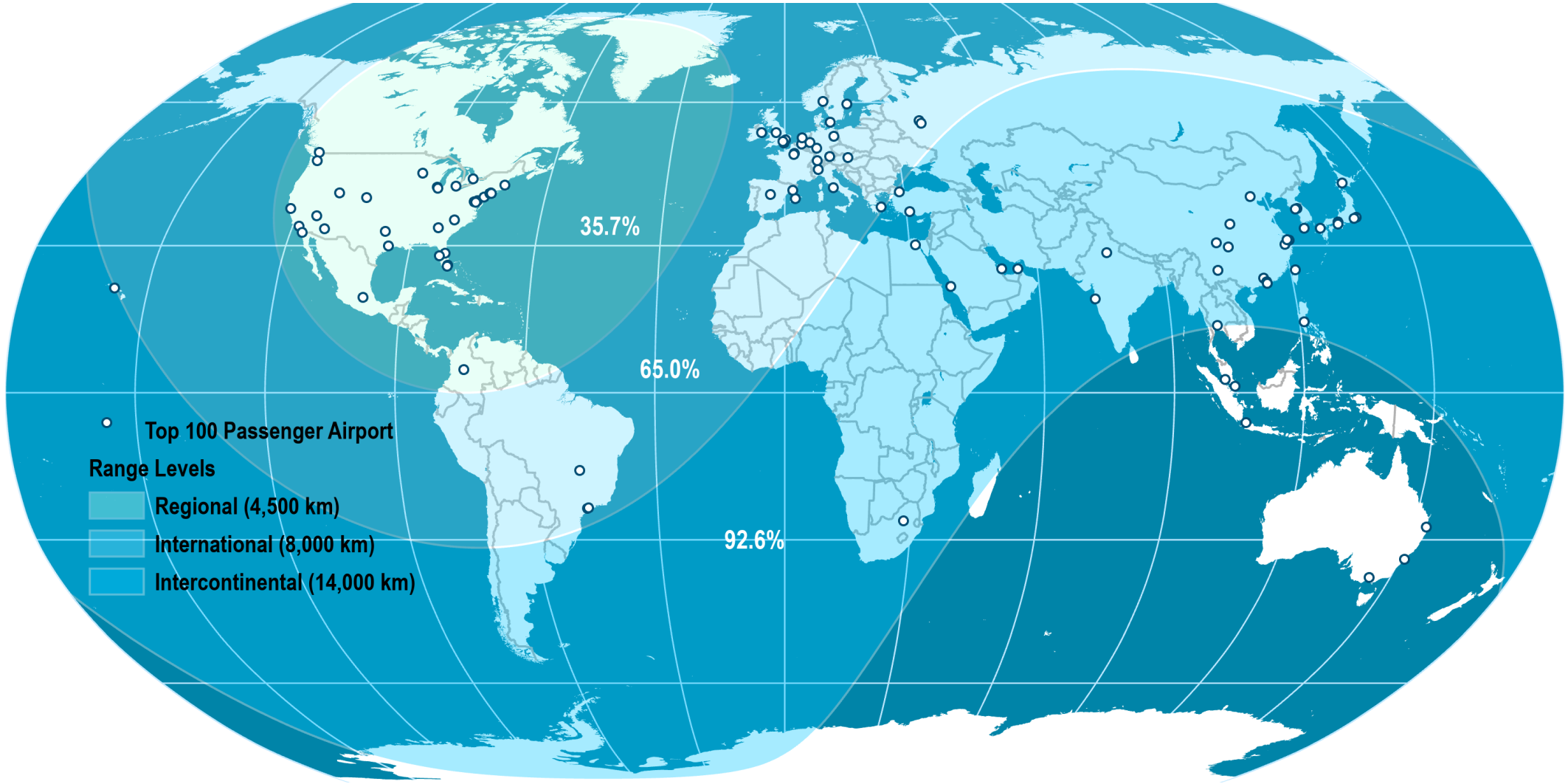
The World's Longest Nonstop Air Transport Routes, 2021



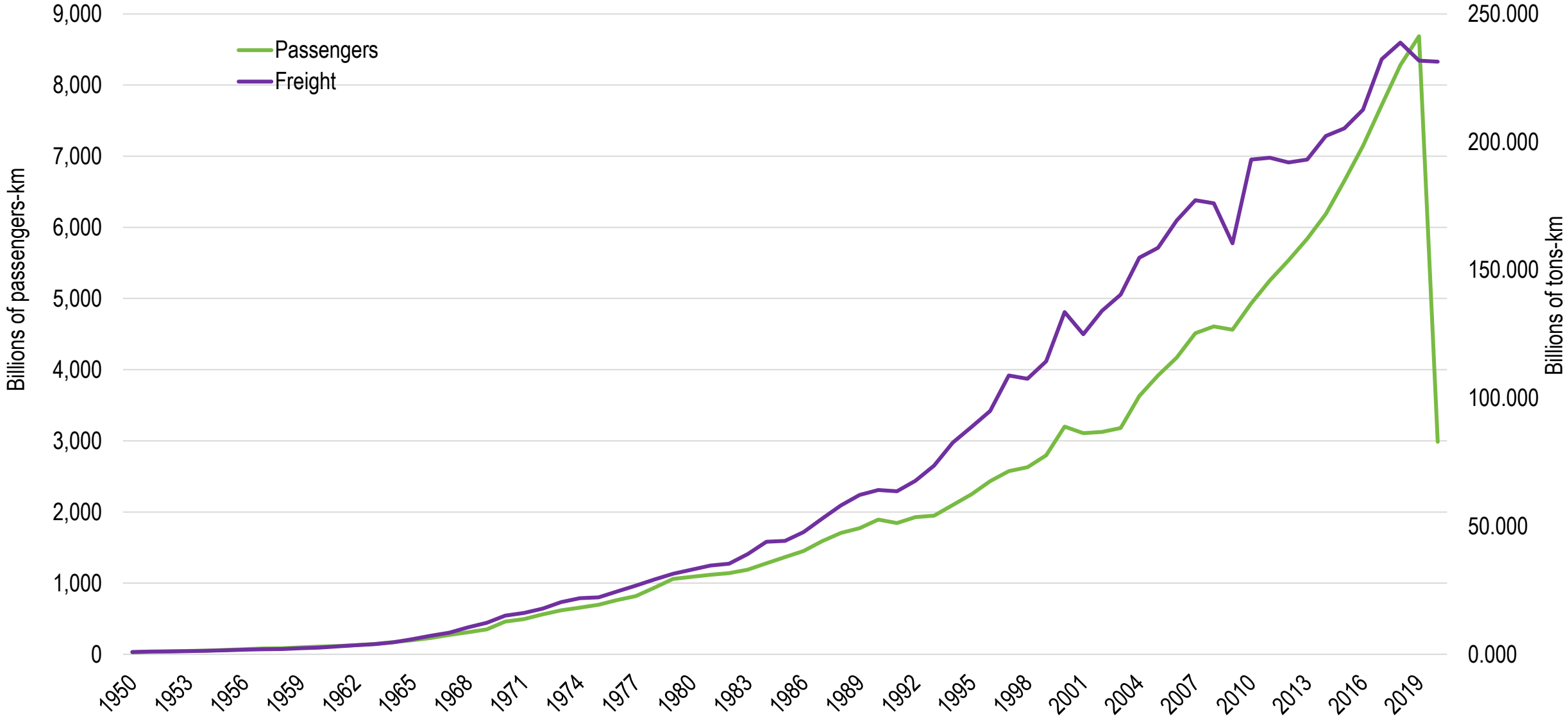
Selected Ultra-Long-Range Nonstop Airline Routes

From	To	Airline	Aircraft	Flying Time	Distance (km)
Singapore	Newark	Singapore	Airbus A340-500	18:50	15,345
Singapore	Los Angeles	Singapore	Airbus A340-500	18:05	14,114
Sydney	Dallas	Qantas	Boeing 747-400ER	15:25	13,804
Johannesburg	Atlanta	Delta	Boeing 777-200LR	17:05	13,582
Dubai	Los Angeles	Emirates	Boeing 777-200LR	16:30	13,420
Dallas	Brisbane	Qantas	Boeing 747-400ER	16:00	13,363
Los Angeles	Bangkok	Thai Airways	Airbus A340-500	17:20	13,309
Dubai	Houston	Emirates	Boeing 777-200LR	16:20	13,144
Dubai	San Francisco	Emirates	Boeing 777-300ER	16:00	13,041
New York	Hong Kong	Cathay Pacific	Boeing 777-300ER	16:05	12,990
Newark	Hong Kong	United	Boeing 777-200ER	15:55	12,980
Doha	Houston	Qatar Airways	Boeing 777-200LR	16:20	12,951
Johannesburg	New York	South African Airways	Airbus A340-600	16:05	12,825
Melbourne	Los Angeles	Qantas	Airbus A380	15:50	12,748
Detroit	Hong Kong	Delta	Boeing 777-200LR	15:45	12,645
Chicago	Hong Kong	United	Boeing 747-400	15:55	12,517
Toronto	Hong Kong	Air Canada	Airbus A340-500	15:20	12,569

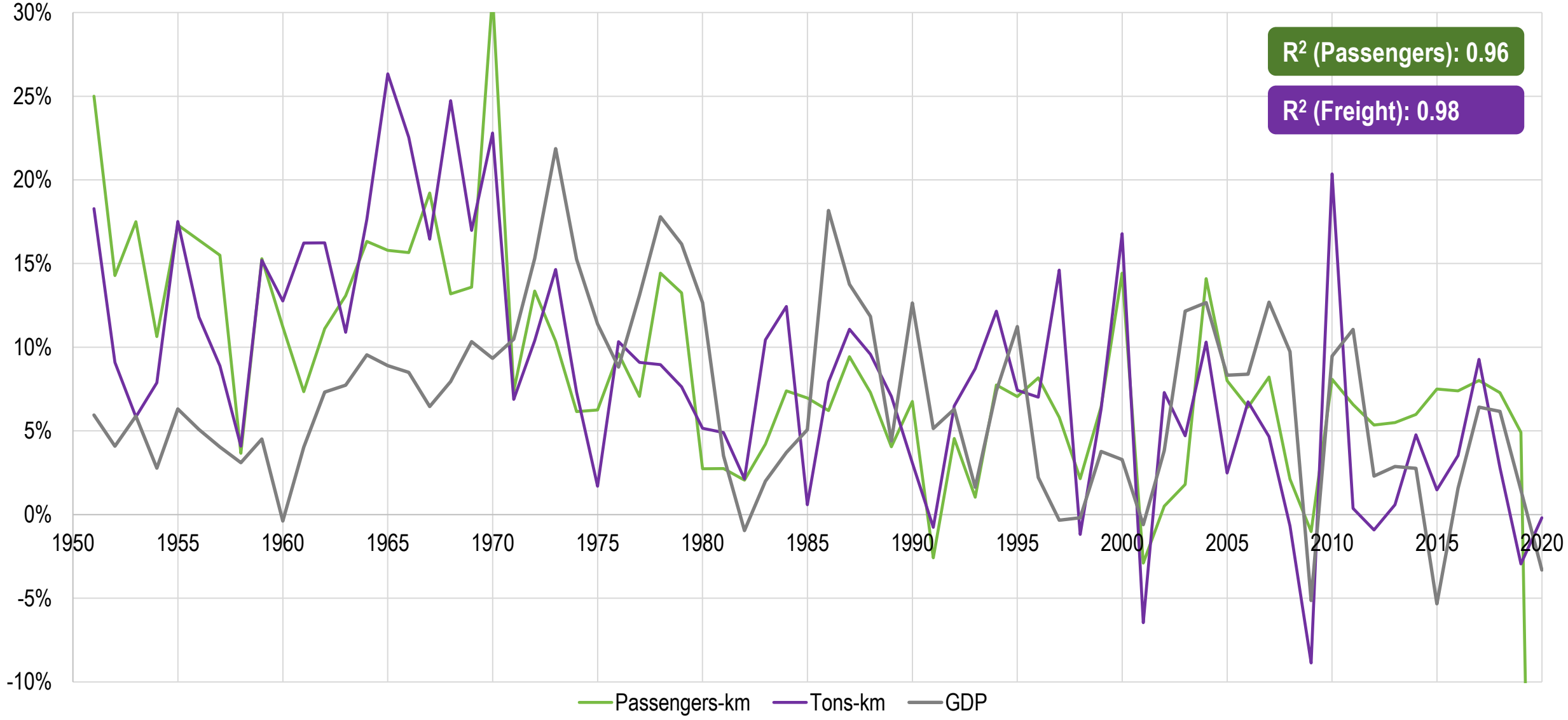
Main Air Transport Service Ranges (From New York)



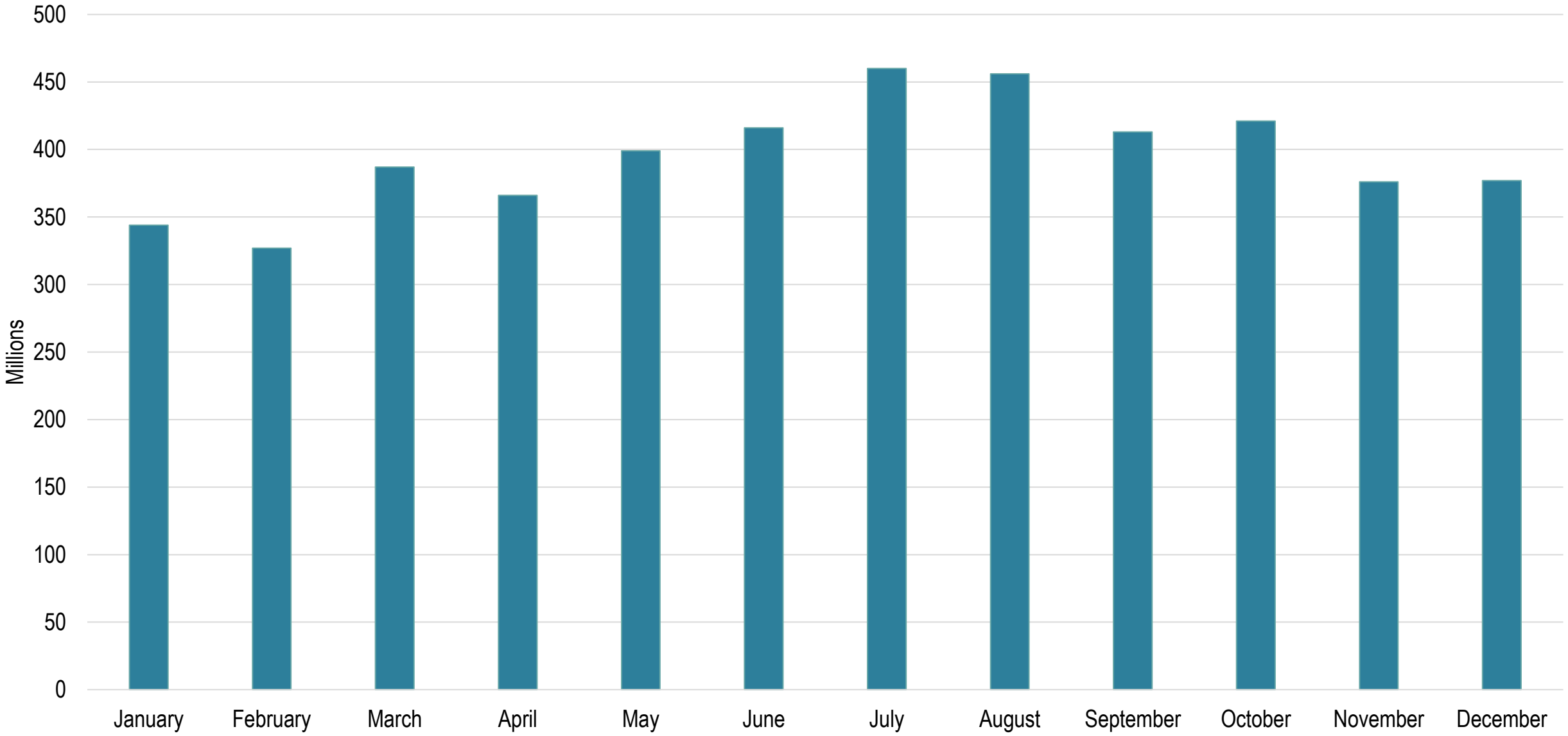
World Air Travel and World Air Freight Carried, 1950-2020



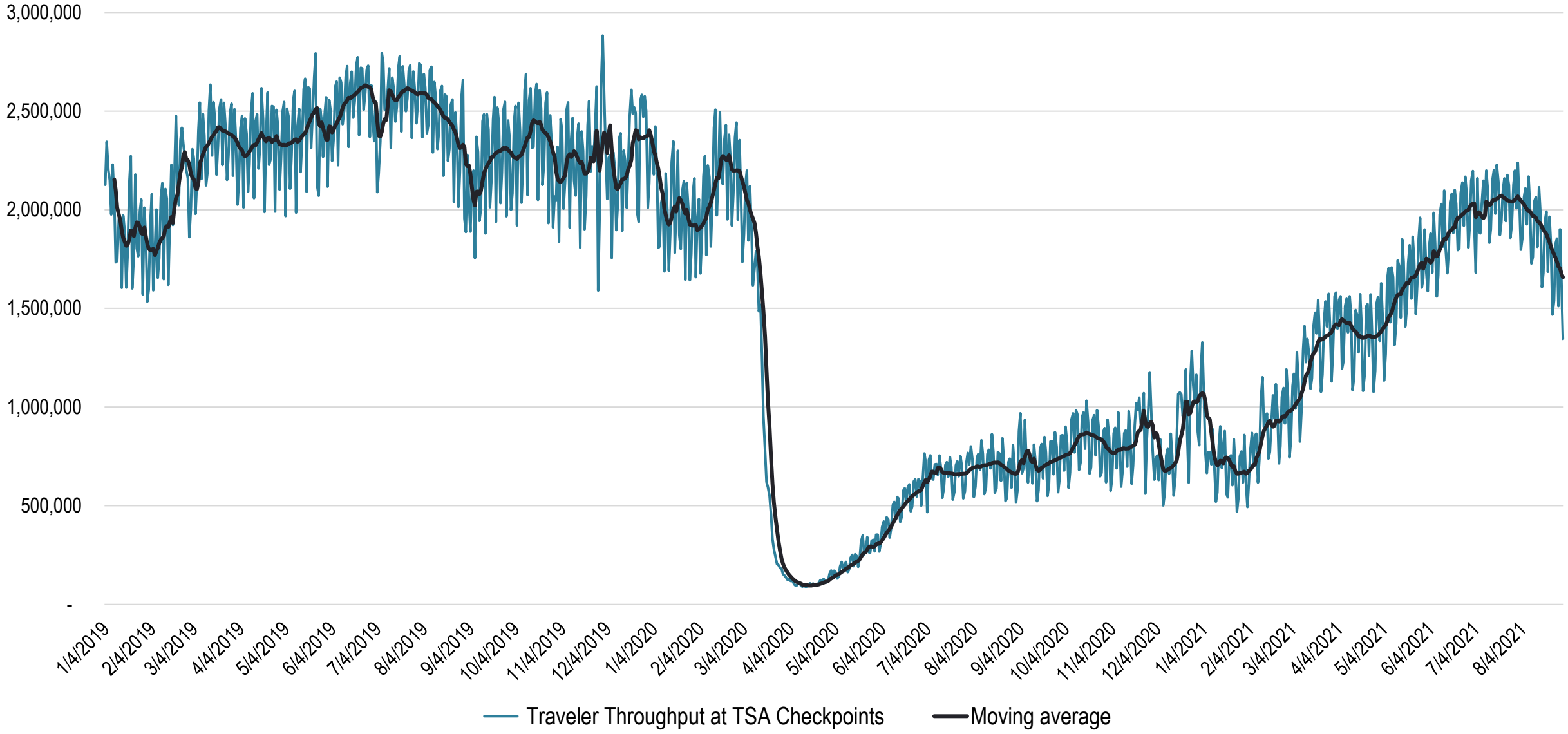
Annual Air Transportation Growth (Passengers and Freight) and Economic Growth, 1950-2020



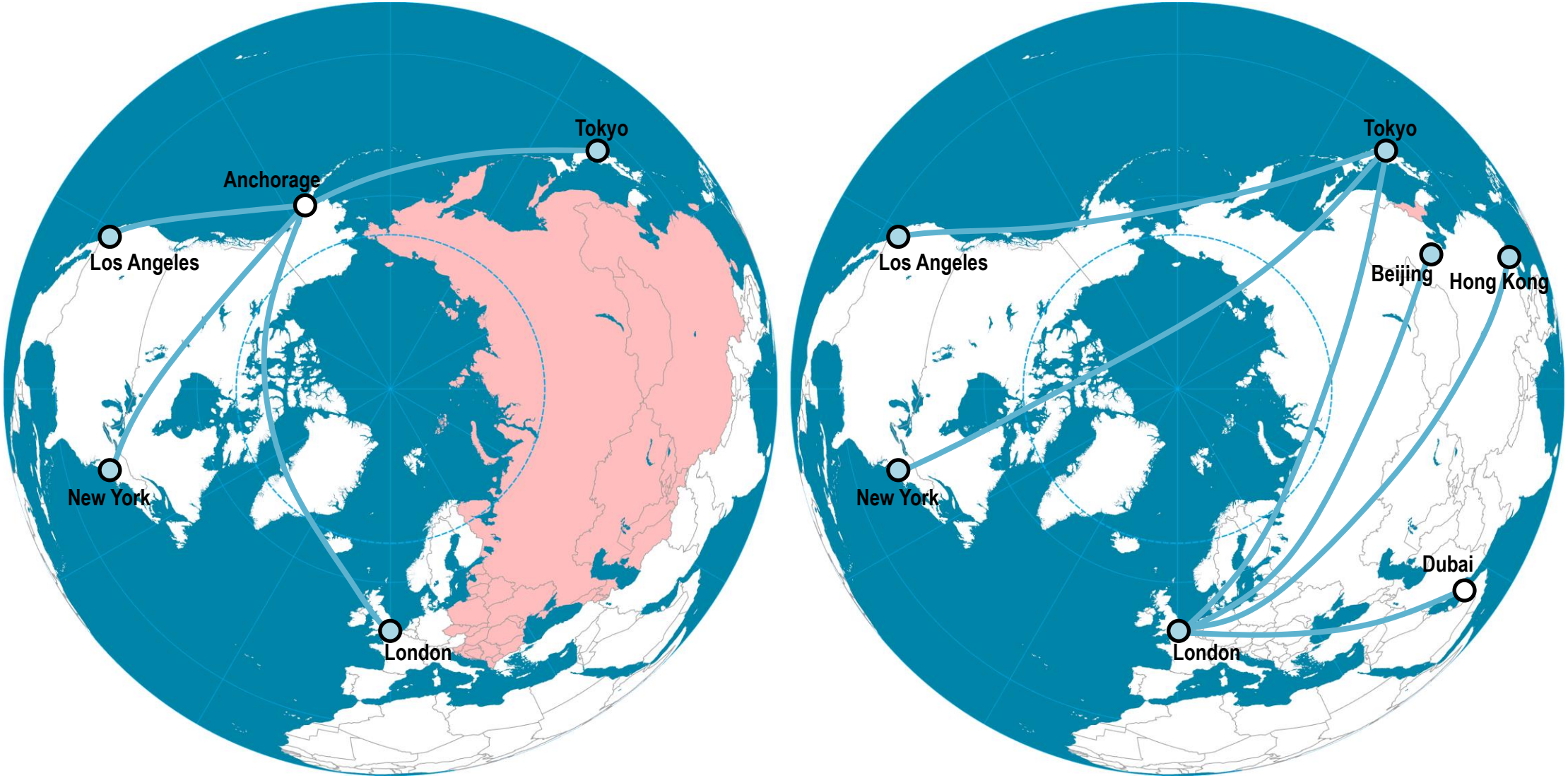
Monthly Global Air Passenger Traffic, 2010



Daily Air Travelers in the United States, 2019-2021



The Development of Polar Air Routes

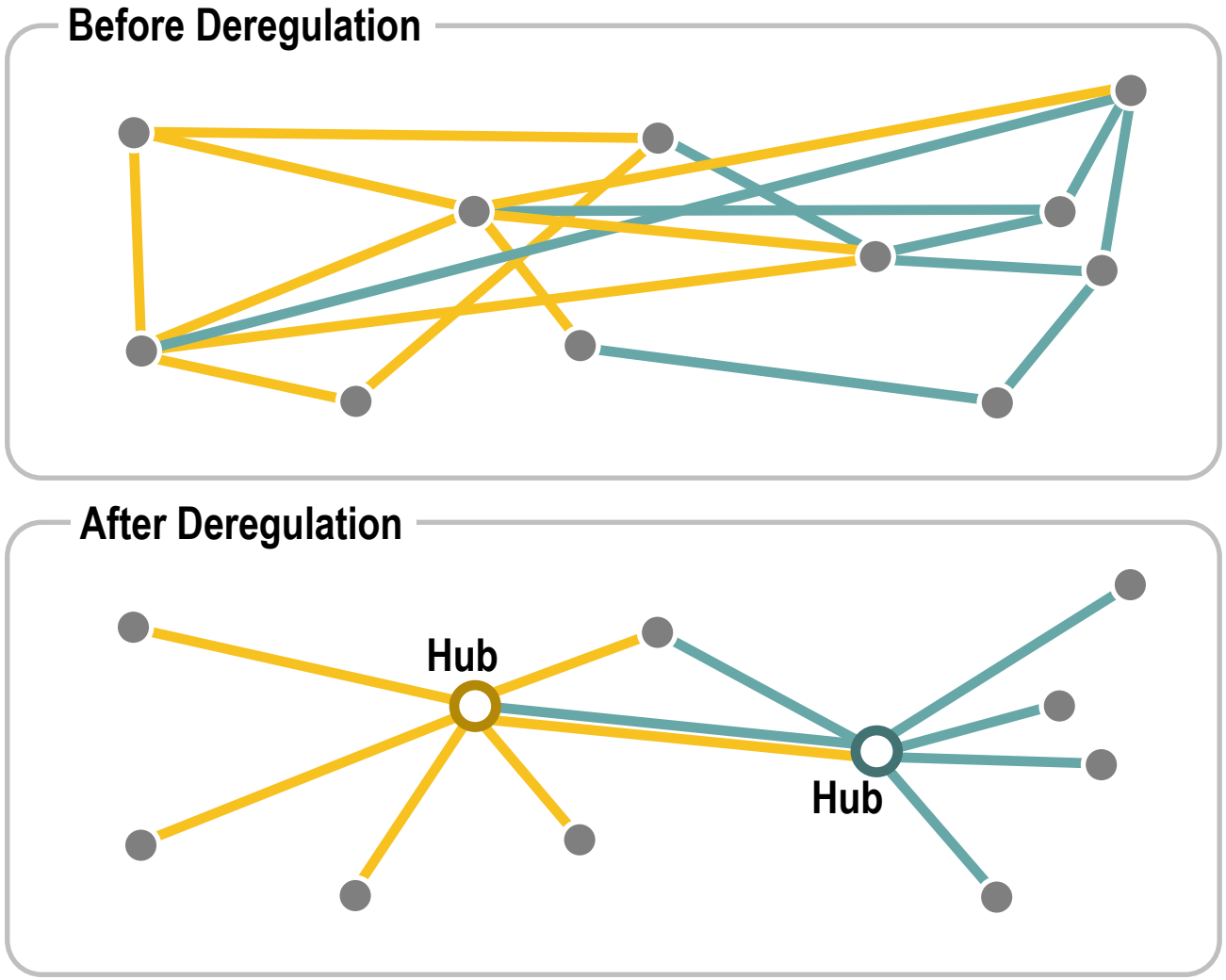


New York / Hong Kong Air Routes: Conventional and Polar

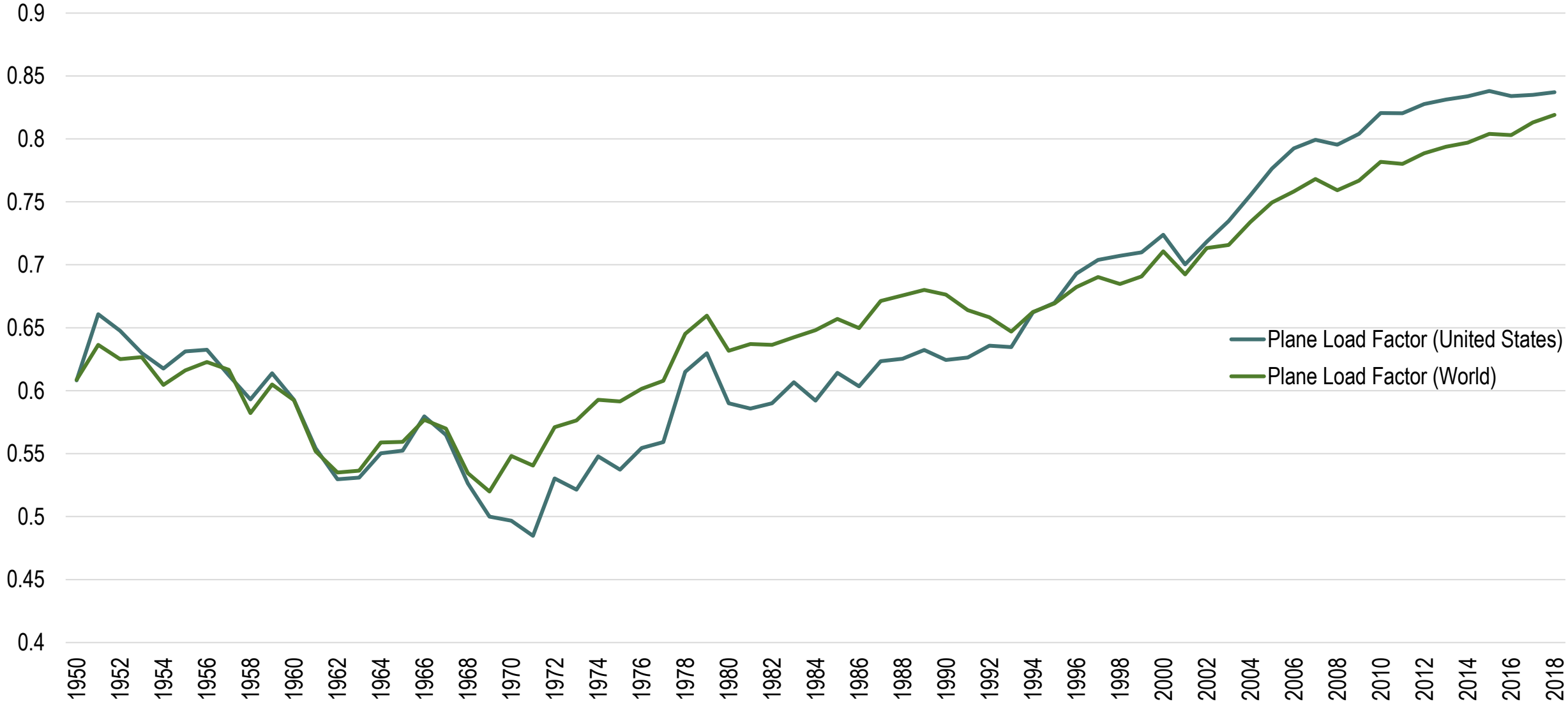
Characteristics of Major Air Travel Markets

United States	Europe	Pacific Asia
Deregulation started in 1978	Deregulation started in 1997	Regulated markets with government ownership
Low population density and dispersed urban centers	High population density and concentrated urban centers	Dispersion of urban centers but high regional concentrations
Relatively open air spaces and airports	Congested air spaces and airports	Congested gateway airports and underutilized regional airports
Rail minor competitor; Car compete for short distances	High speed rail is a direct competitor; Rail is a minor competitor; Car compete for short distances	Except for Japan, less competition from other transportation modes; In China HSR becoming a competitor
No loyalty to carriers (pricing and frequent flyers)	Some lingering loyalty to carriers	Strong “imposed” loyalty to carriers
Price transparency	Price becoming transparent	Price becoming transparent
Limited income growth and limited leisure	Limited income growth and more leisure time	Growing income levels and more leisure time

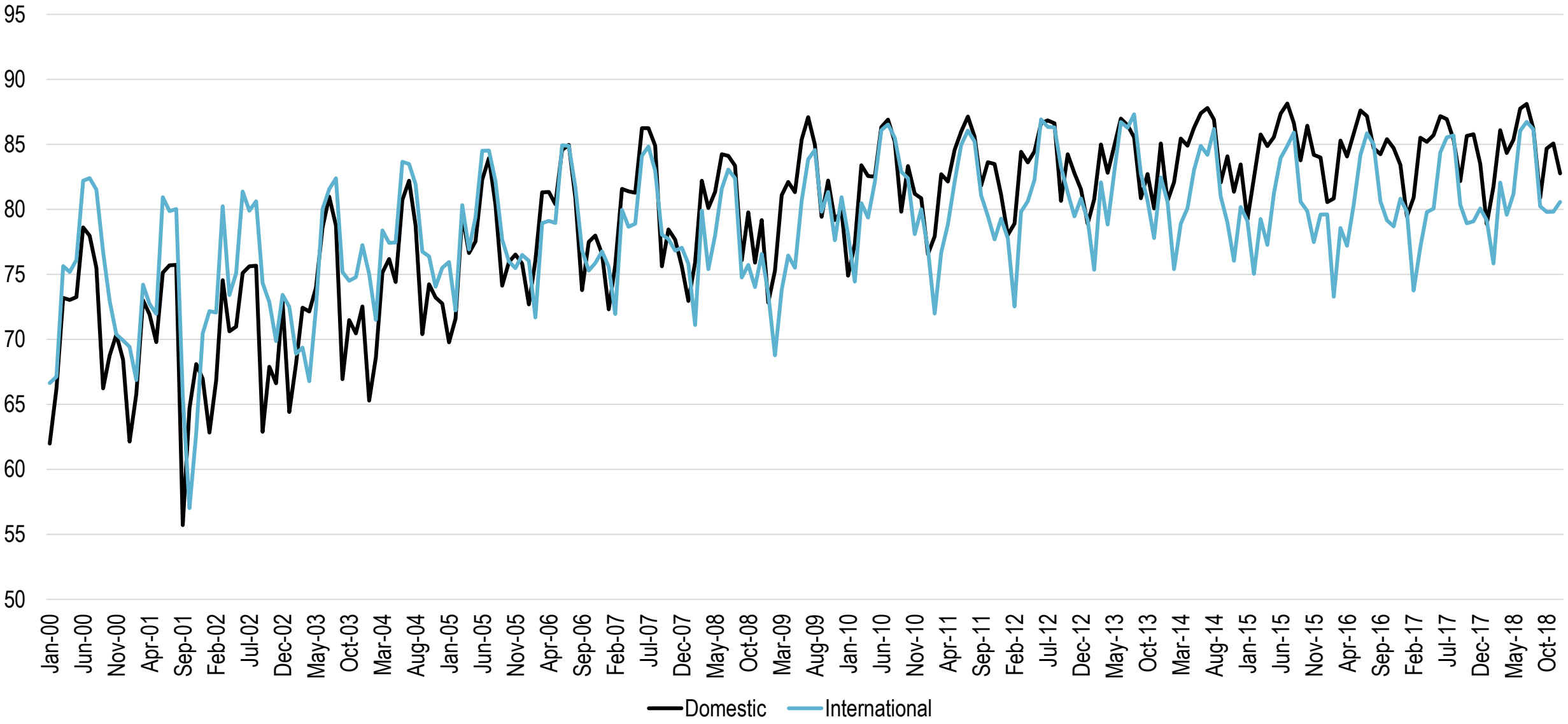
Airline Deregulation and Hub-and-Spoke Networks



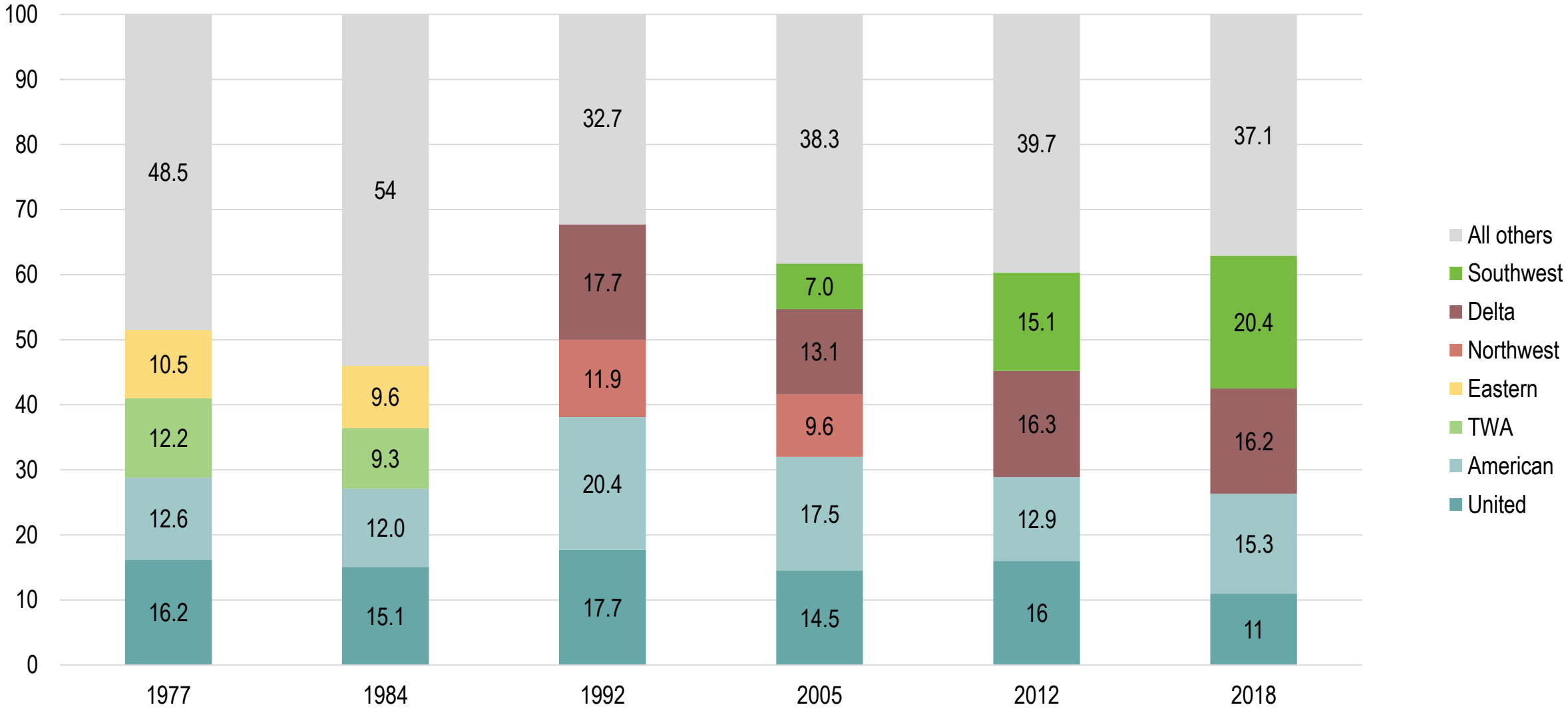
Annual Passenger Plane Load Factor, World and United States, 1950-2018 (in %)



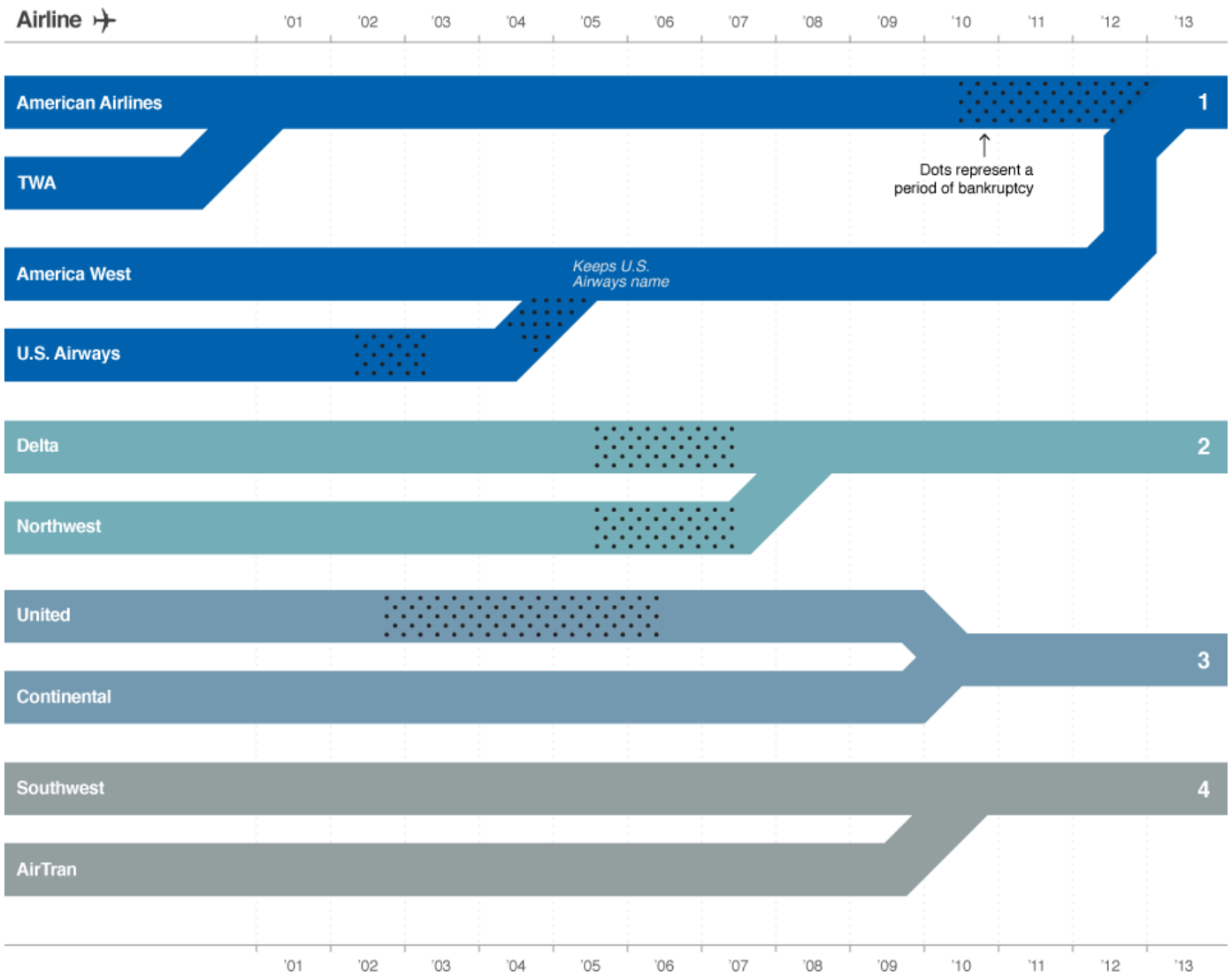
Monthly Passenger Plane Load Factor, United States, 2000-2018 (in %)



Domestic Market Share of the top American Airlines, 1977-2018

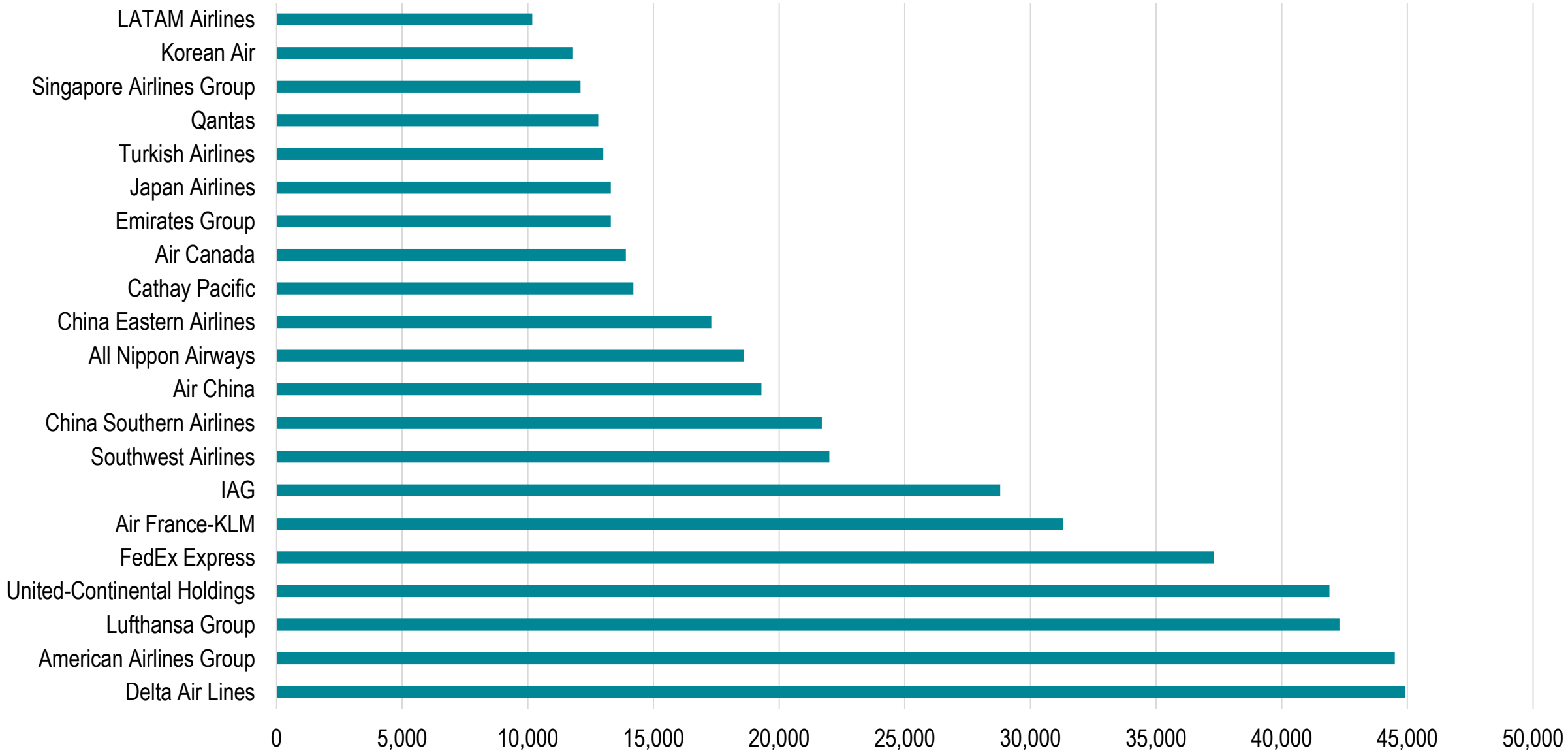


Major Mergers in the American Air Industry since the 2000s



2016
Alaska Airlines / Virgin America

Largest Airlines by Revenue, 2019 (in $millions)



Strategies of Low-Cost Carriers

On-board operations	Optimum use of seating space. Minimal crew. Limited and paying cabin service.
Aircraft operations	Few (often one) types of aircraft used to minimize maintenance costs. Stair boarding instead of air bridges. Maximal usage of runway length (take-off thrust and braking on landing). Fast turn around to maximize aircraft use. No freight carried in bellyhold.
Service network	Point-to-point services. Destinations commonly of less than two hours apart. Usage of secondary airports (lower gate rates).
Booking	Yield management. Online booking to minimize transaction costs (become the norm). No travel agent commissions.

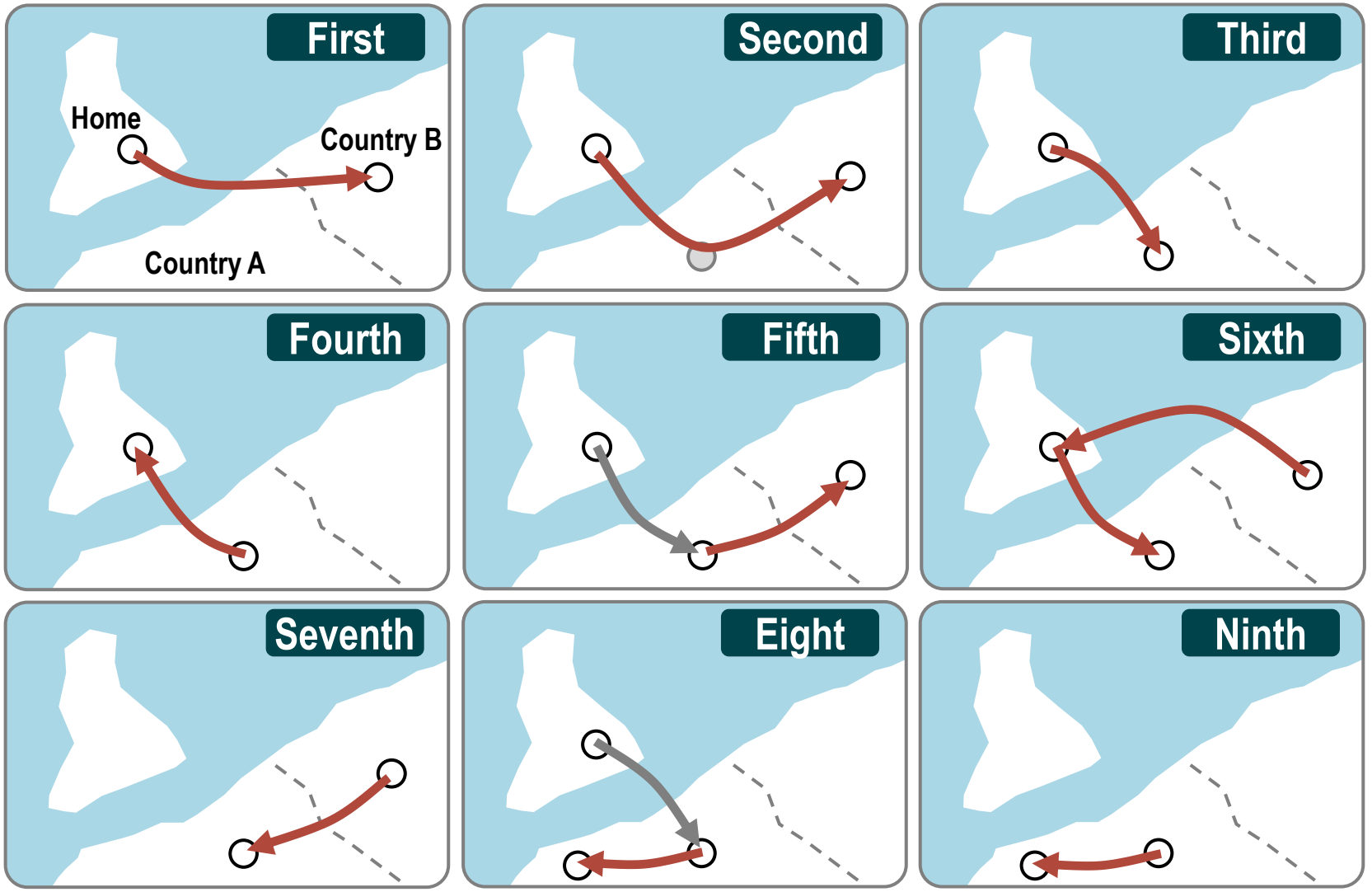
Strategies Used by Airlines to Save Fuel

Dimension	Strategy
Fleet	Retiring less fuel efficient aircrafts (e.g. DC-9, DC10, MD-80). Switching to more fuel efficient aircrafts (e.g. A330, A319).
Operations	Less engine idle at gates (electrical systems). Lower flying speed (-5%). More frequent plane and engine washing.
On board	Lighter seats. Removal of seat-pocket documents (e.g. magazines). Less water in bathrooms. Lighter service carts.
Passengers	Weight restrictions for luggage. Surcharges for first or second check-in luggage. Passengers weight surcharges (?)

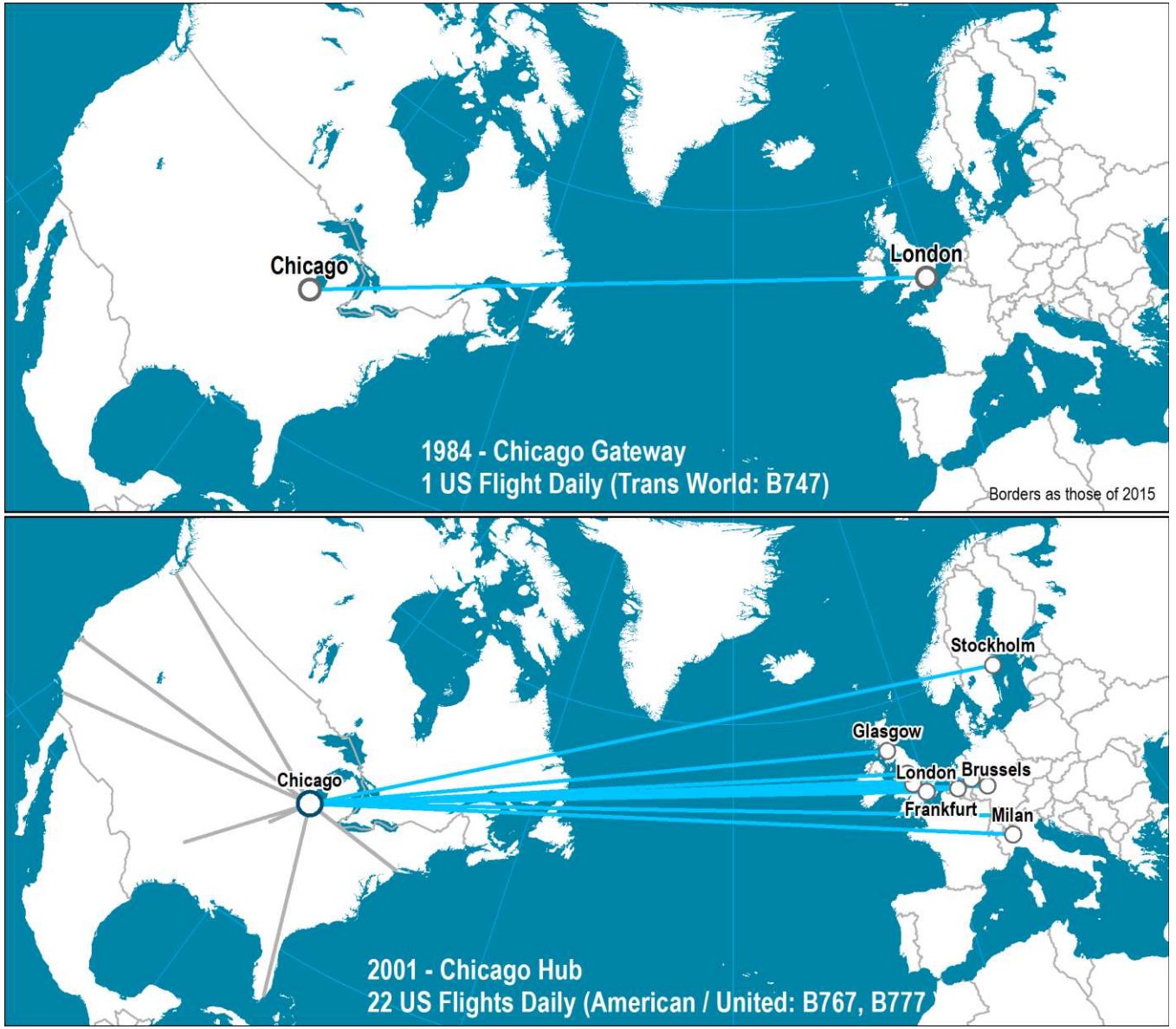
Selected Low-Cost Carriers

Airline	Country	2005 Fleet	2005 Revenue (USD Millions)
Southwest	USA	454 B737s	7,584
EasyJet	UK	62 A319s; 43 B737s	2,365
Ryanair	Ireland	107 B737s	2,044
jetBlue	USA	89 A320s; 19 ERJs	1,701
Air Berlin	Germany	8 A319s/A320; 40 737s; 3 Other	1,457
Virgin Blue	Australia	47 B737s	1,335
WestJet	Canada	56 B737s	1,197
Gol	Brazil	47 B737s	1,140
Frontier	USA	51 A318s/A319s/A320s	944
AirAsia	Malaysia	6 A320s; 21 B737s	174

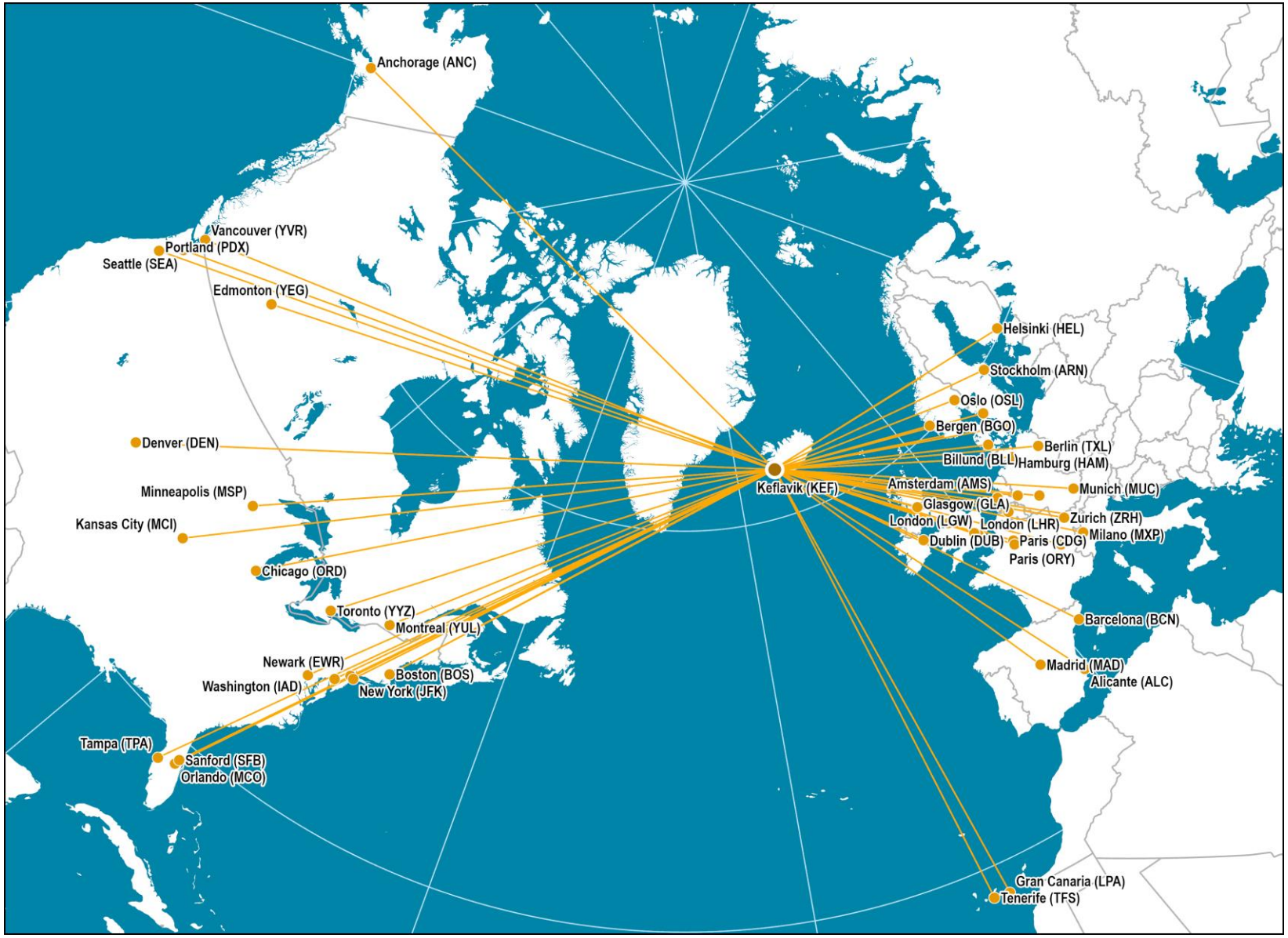
Air Freedom Rights



Air Hubs and Market Fragmentation: The Case of Chicago



Longitudinal Intermediacy: Icelandair

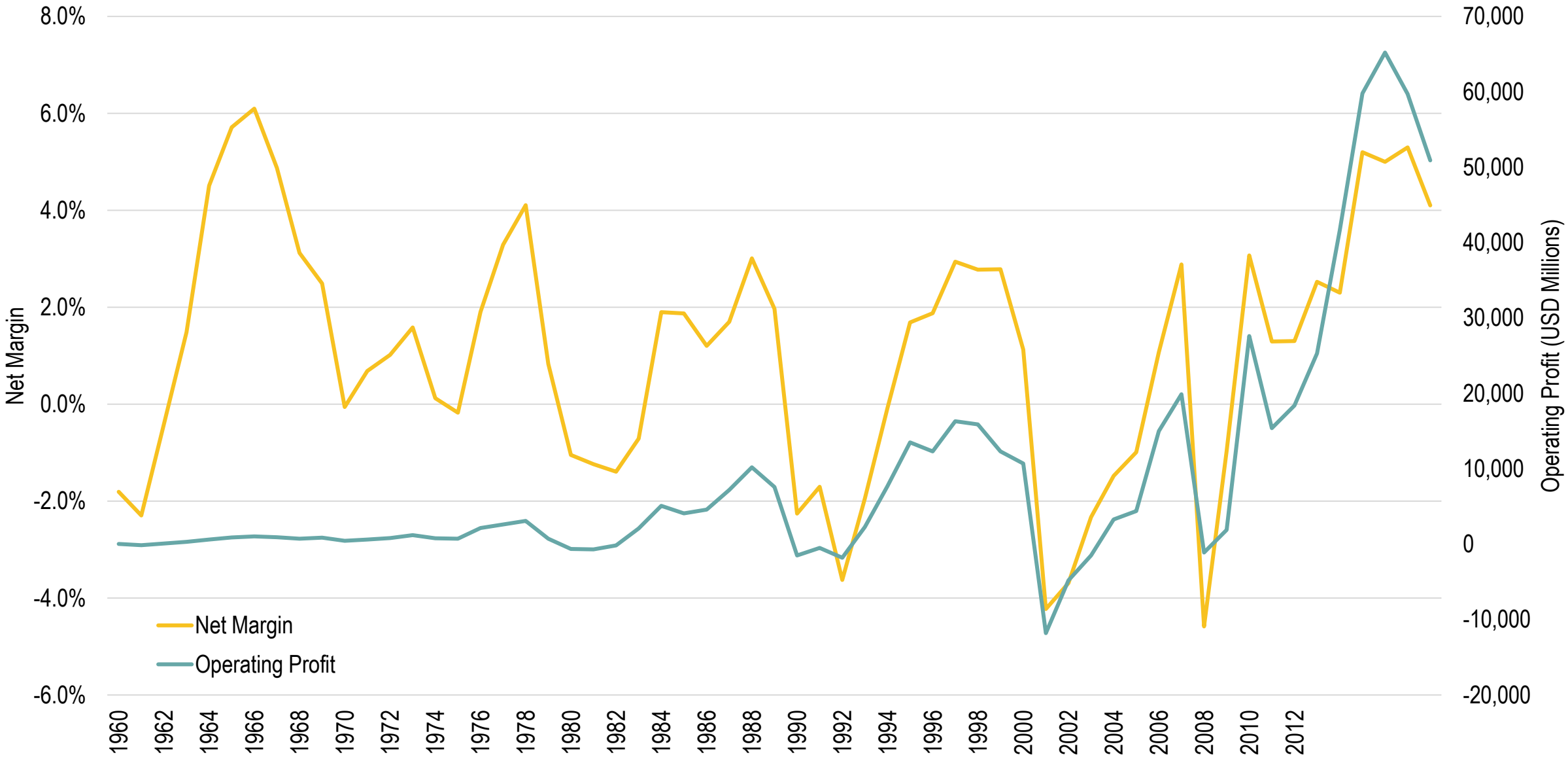


Latitudinal Intermediacy: COPA Airlines

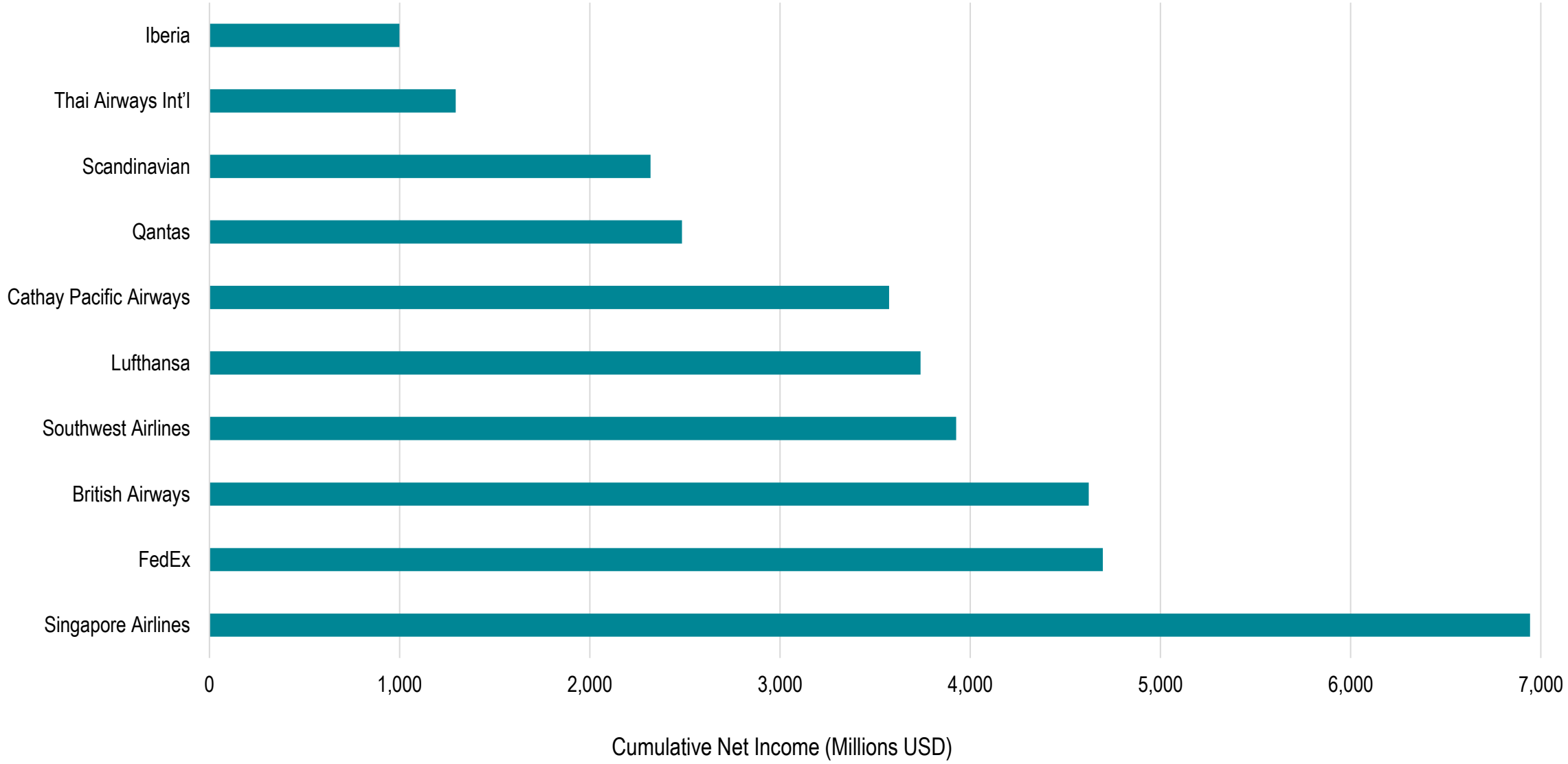
Development Costs for Selected Aircraft

Aircraft	Year of First Service	Development Costs (2004 Dollars)
Douglas DC-3	1936	4,300,000
Douglas DC-6	1946	144,000,000
Boeing 707	1958	1,300,000,000
Boeing 747	1970	3,700,000,000
Boeing 777	1995	7,000,000,000
Airbus A380	2007	14,400,000,000
Boeing 787	2012	13,400,000,000

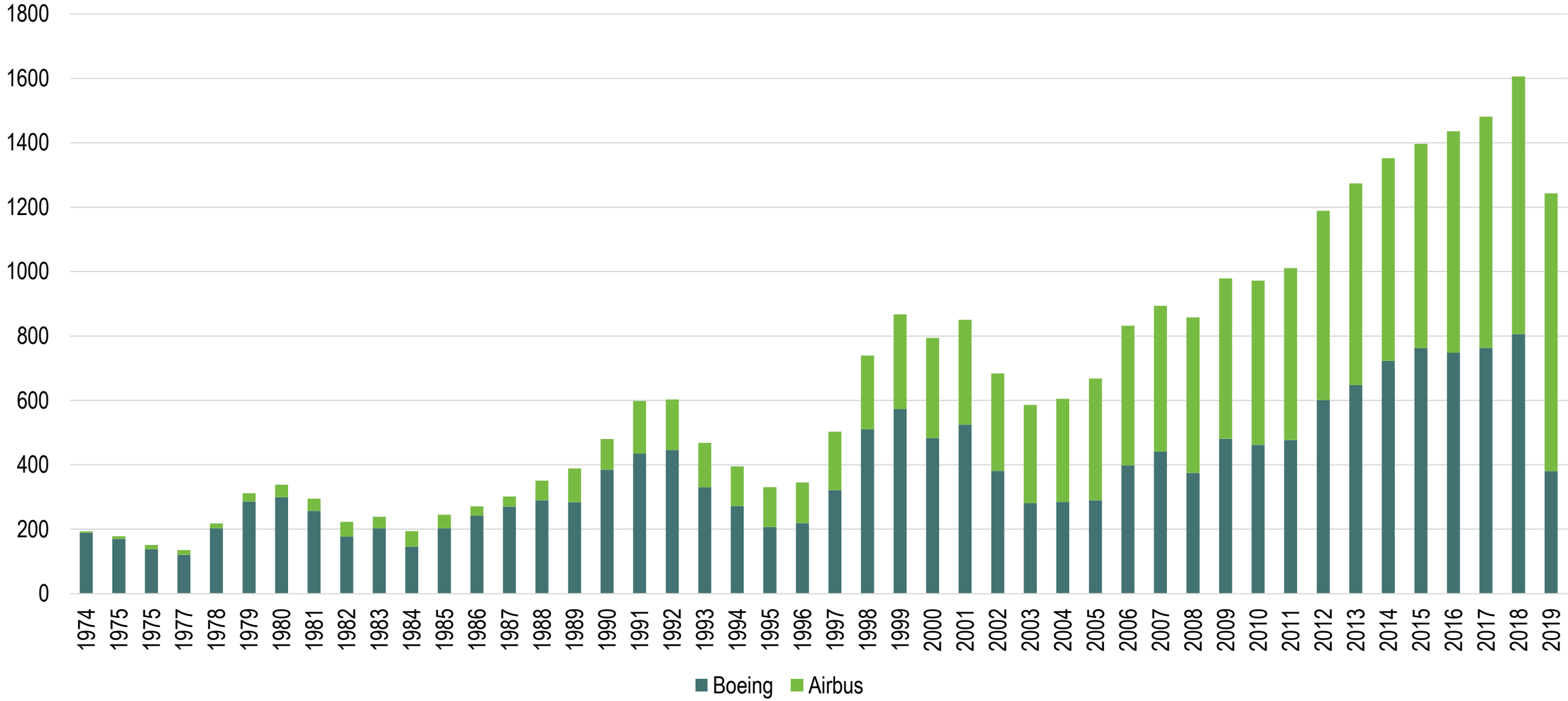
Operating Profit in the Global Airline Industry, 1960-2018



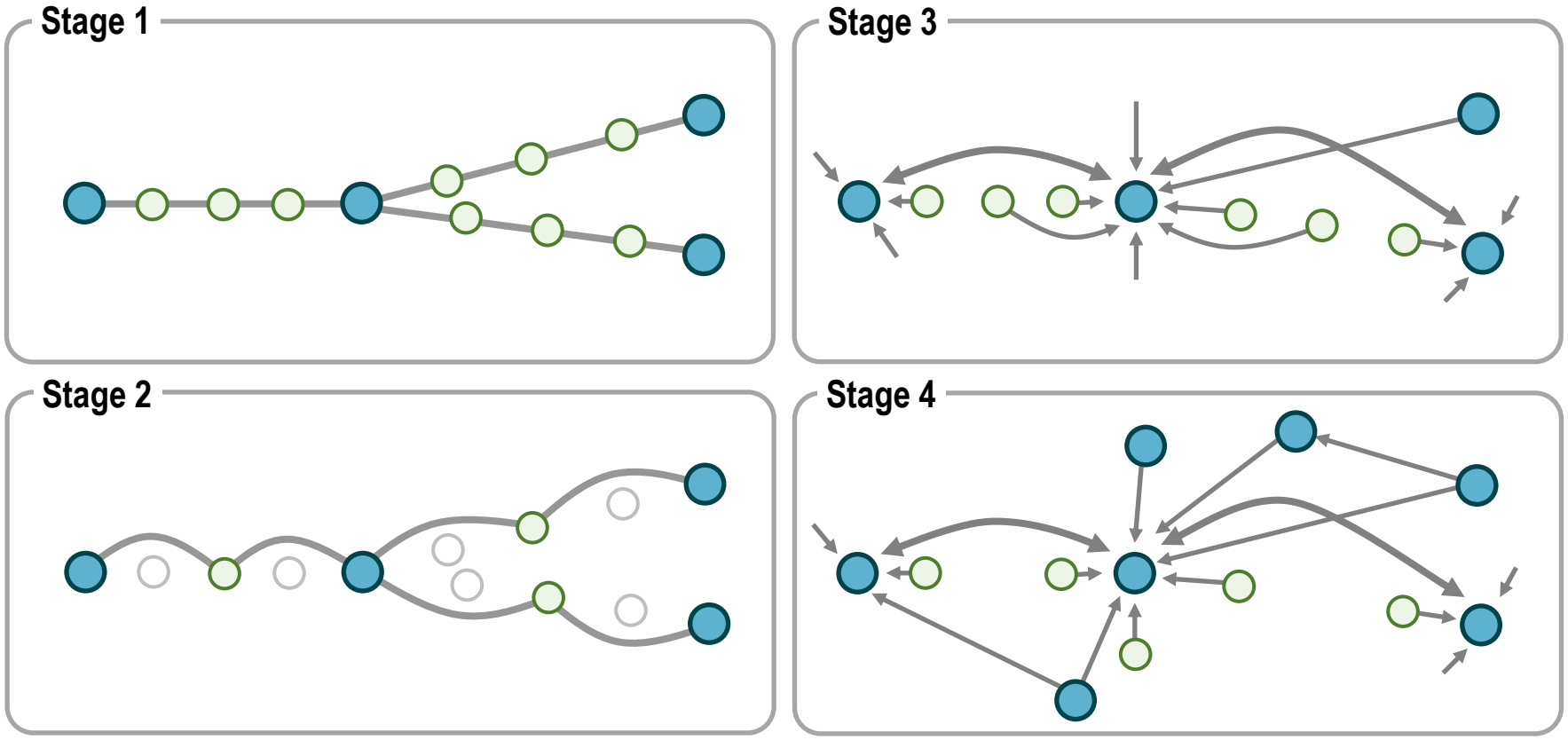
The World's Most Profitable Airlines, 1994-2004



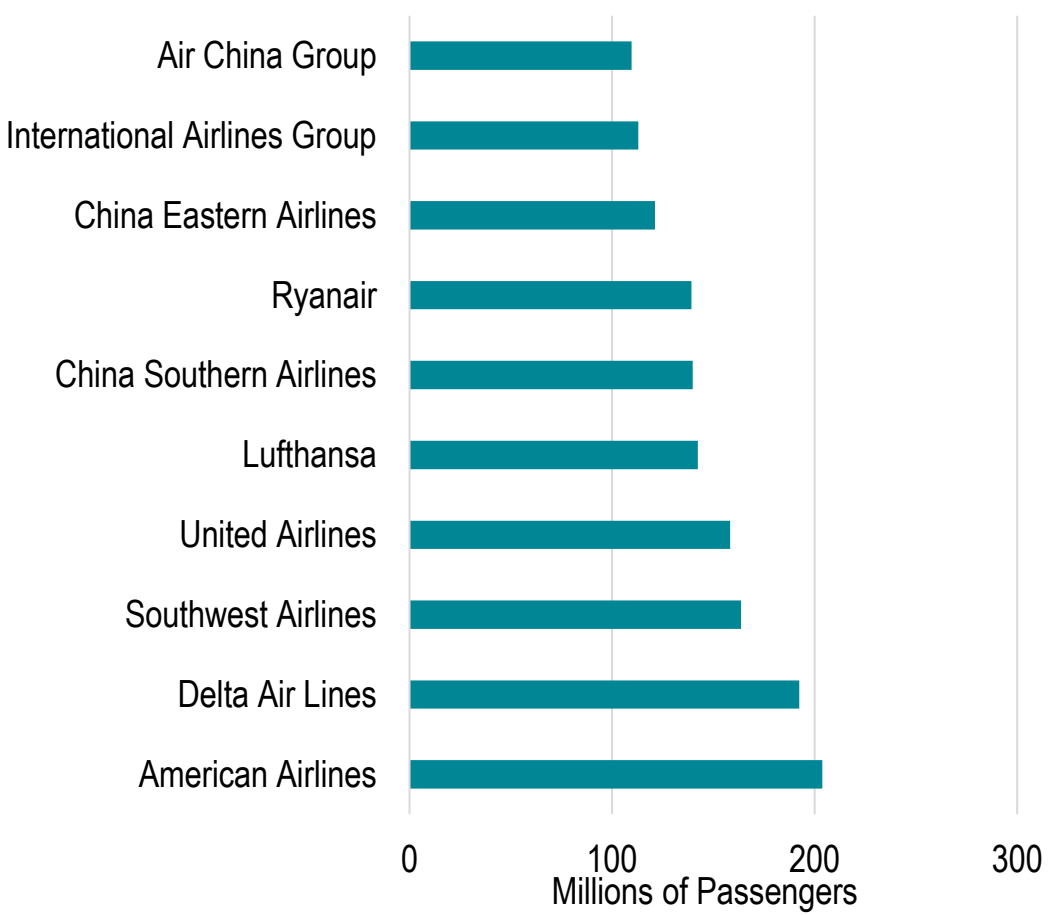
Jetliners Deliveries from Boeing and Airbus, 1974-2019

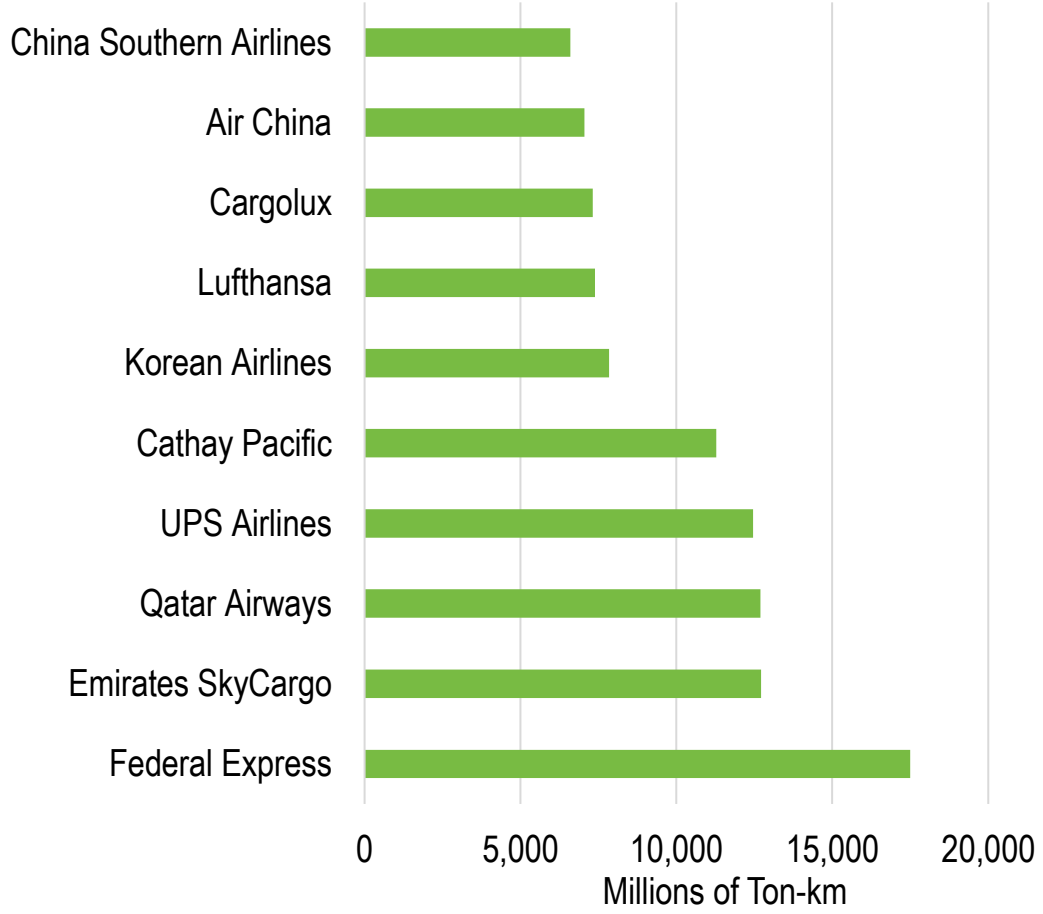


Stages in Air Network Development



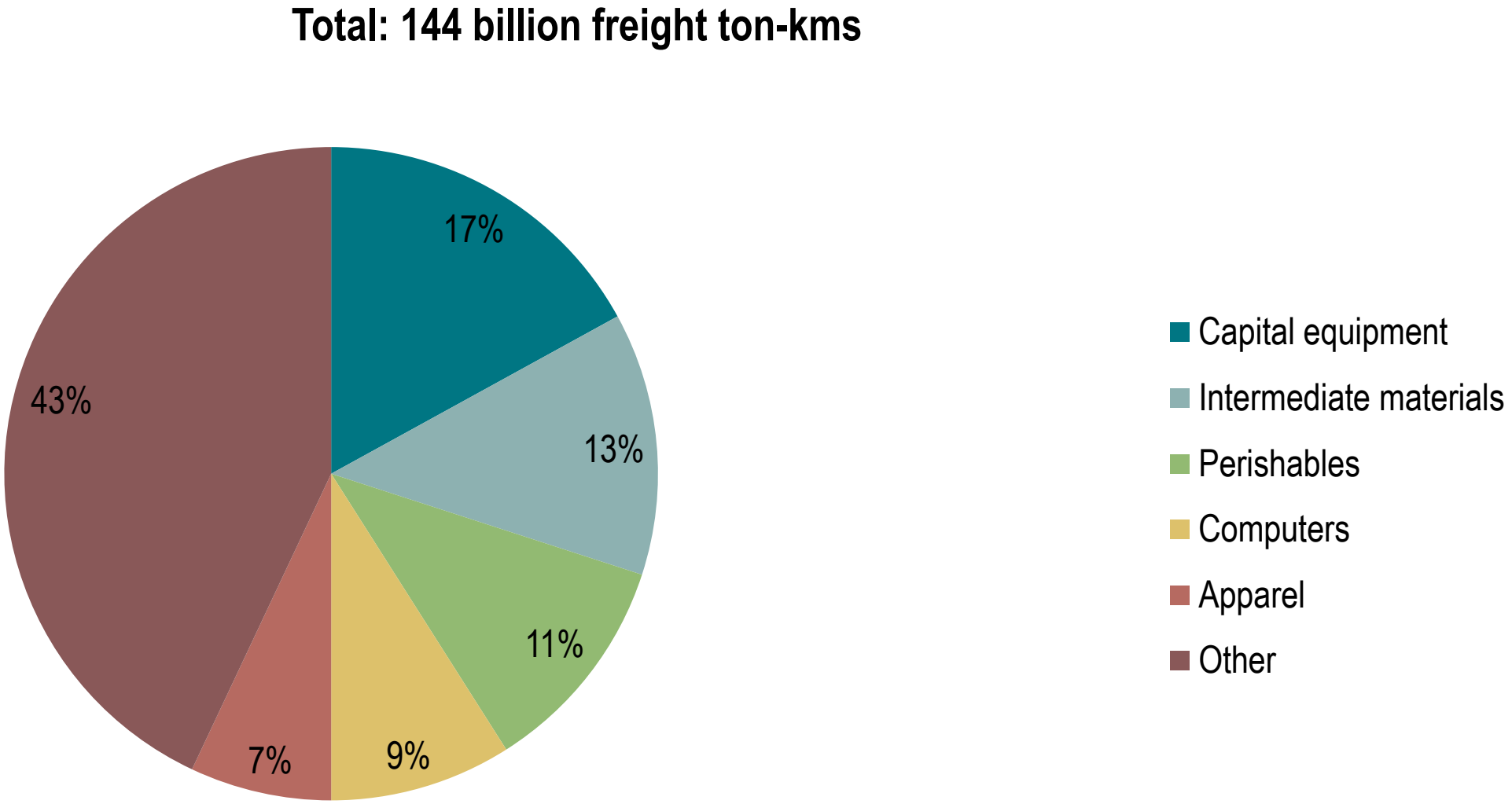
World's 10 Largest Passengers and Freight Airlines, 2018





Passenger and Cargo Share of Operating Revenues, Selected Airlines, 2013

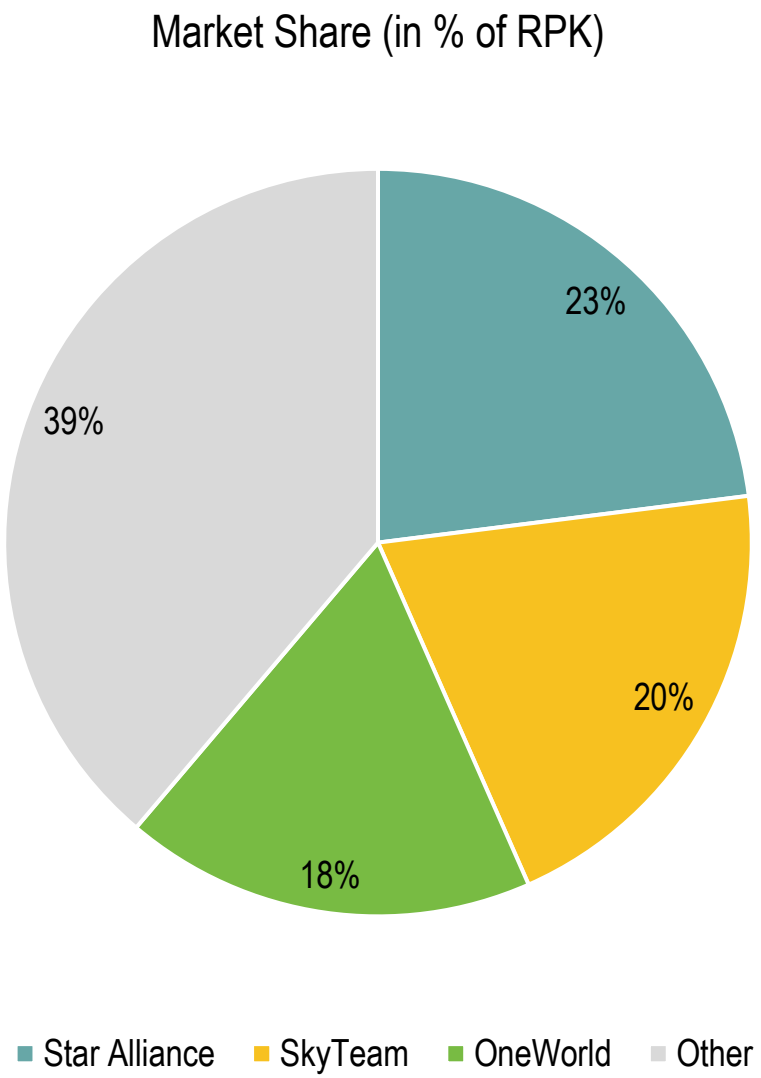
Commodities Shipped by Air Freight, 2003



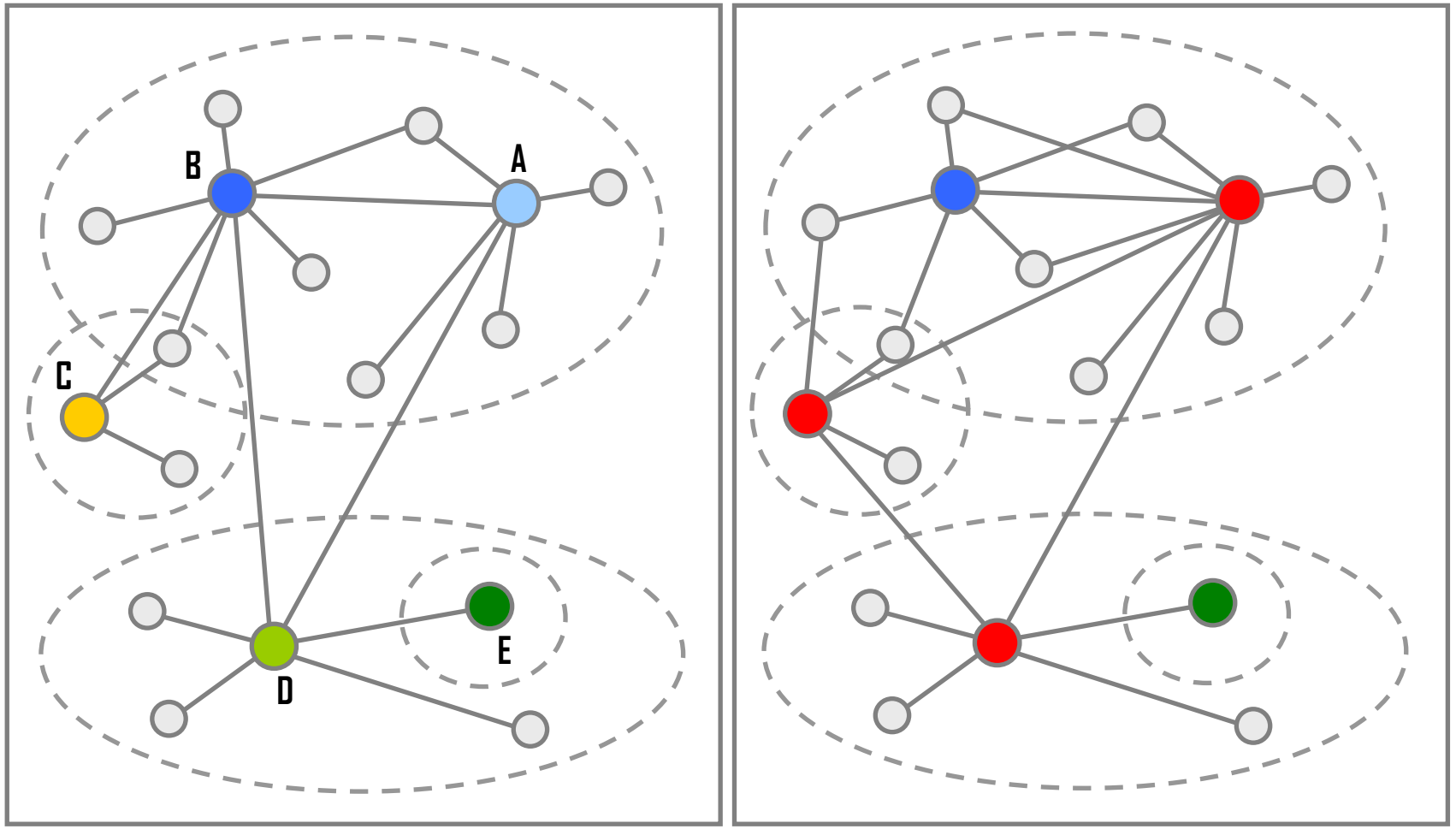
(JP) Adria Airways (2004), (A3) Aegean Airlines (2010), (AC) Air Canada (founder), (CA) Air China (2007), (AI) Air India (2014), (NZ) Air New Zealand (1999), (NH) All Nippon Airways (1999), (OZ) Asiana Airlines (2003), (OS) Austrian Airlines (2000), (AV) Avianca (2012), (SN) Brussels Airlines (2009), (CM) Copa Airlines (2012), (OU) Croatia Airlines (2004), (MS) EgyptAir (2008), (ET) Ethiopian Airlines (2011), (BR) EVA Air (2013), (LO) LOT Polish Airlines (2003), (LH) Lufthansa (founder), (SK) Scandinavian Airlines (founder), (ZH) Shenzhen Airlines (2012), (SQ) Singapore Airlines (2000), (SA) South African Airways (2006), (LX) Swiss International Air Lines (2006), (TP) TAP Portugal (2005), (TG) Thai Airways International (founder), (TK) Turkish Airlines (2008), (UA) United Airlines (founder)

(AA) American Airlines (founder), (BA) British Airways (founder), (CX) Cathay Pacific (founder), (AY) Finnair (1999), (IB) Iberia Airlines (1999), (JL) Japan Airlines (2007), (LA/JJ) LATAM Chile (2000) / LATAM Brasil (2014), (MH) Malaysia Airlines (2013), (QF) Qantas (founder), (QR) Qatar Airways (2013), (RJ) Royal Jordanian (2007), (UL) SriLankan Airlines (2014)

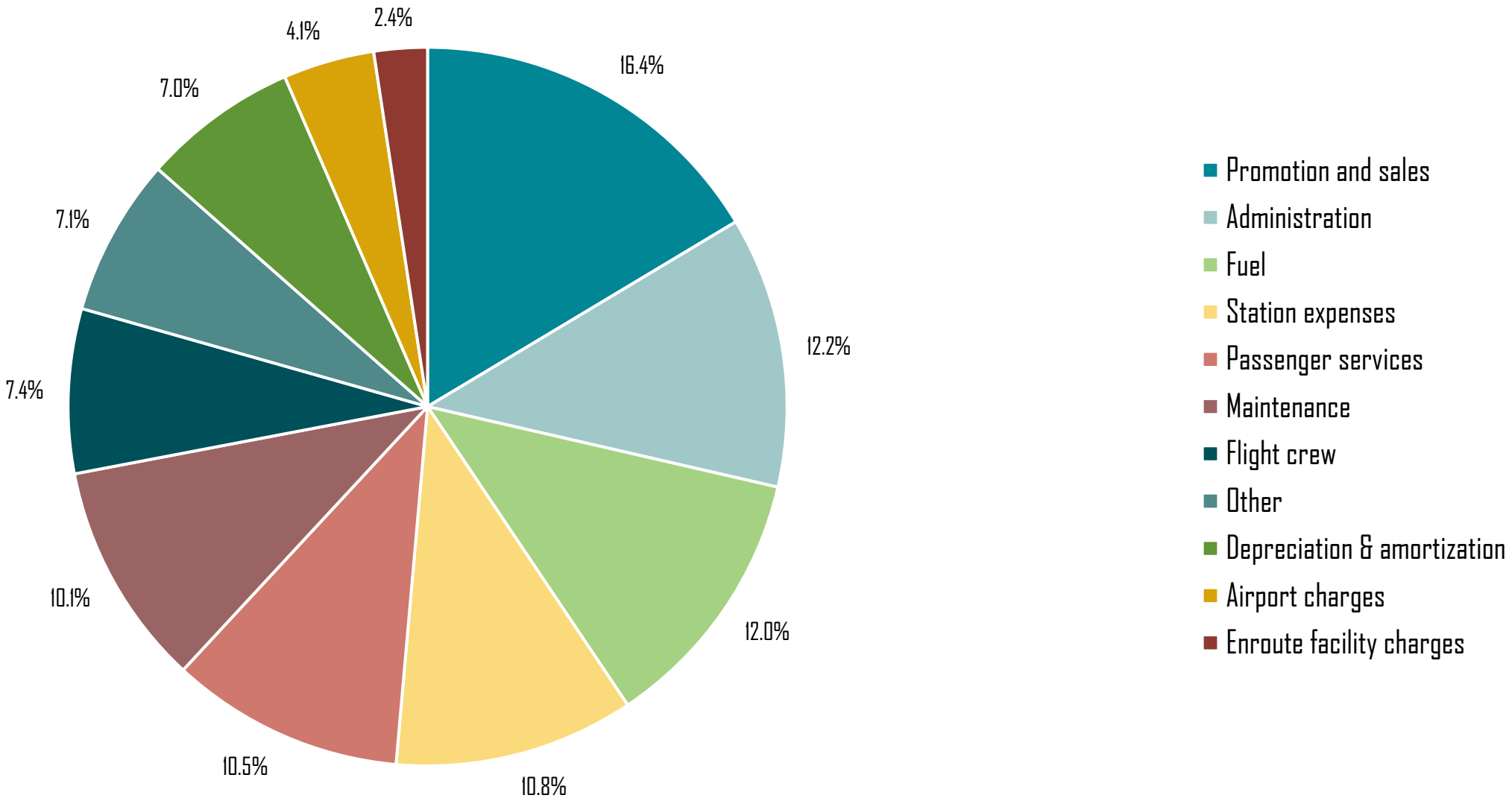
(SU) Aeroflot (2006), (AR) Aerolíneas Argentinas (2012, (AM) Aeroméxico (founder), (UX) Air Europa (2007), (AF) Air France (founder), (AZ) Alitalia (2009), (CI) China Airlines (2011), (MU) China Eastern Airlines (2011), (CZ) China Southern Airlines (2007), (OK) Czech Airlines (2001), (DL) Delta Air Lines (founder), (GA) Garuda Indonesia (2014), (KQ) Kenya Airways (2007), (KL) KLM (2004), (KE) Korean Air (founder), (ME) Middle East Airlines (2012), (SV) Saudia (2012), (RO) TAROM (2010), (VN) Vietnam Airlines (2011), (MF) Xiamen Airlines (2012)



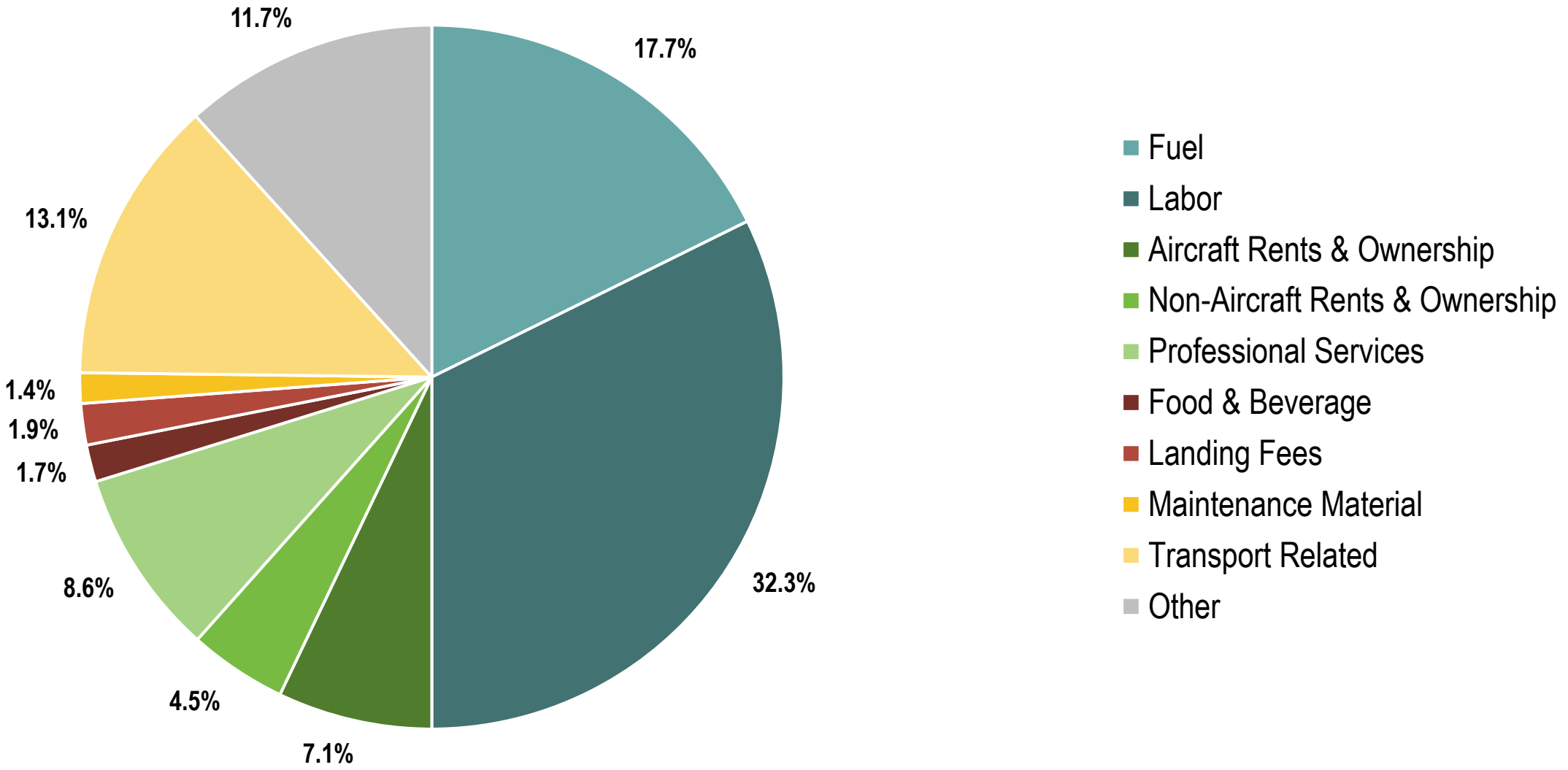
Network Effect of Strategic Alliances



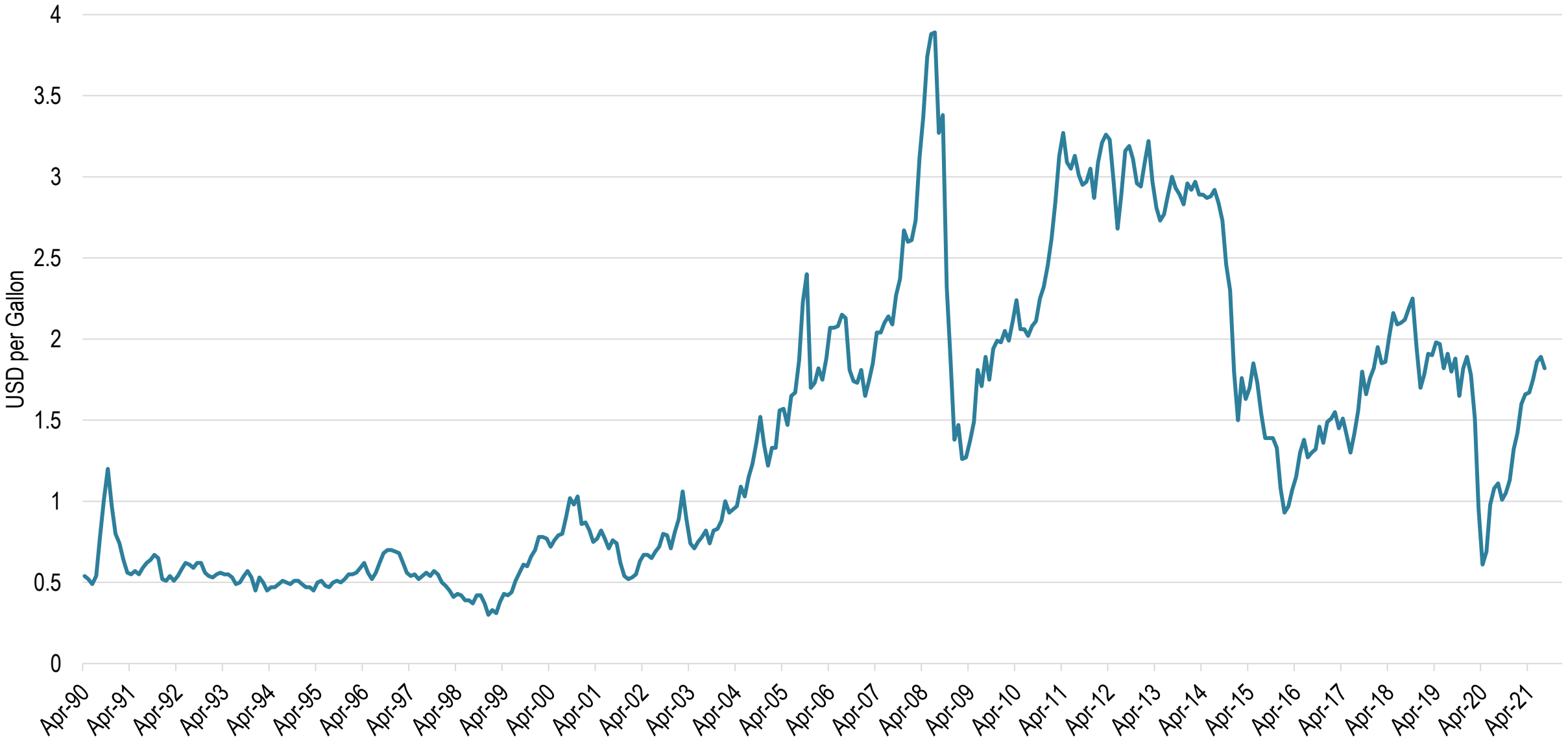
Operating Expenses of the Global Airline Industry, 2005



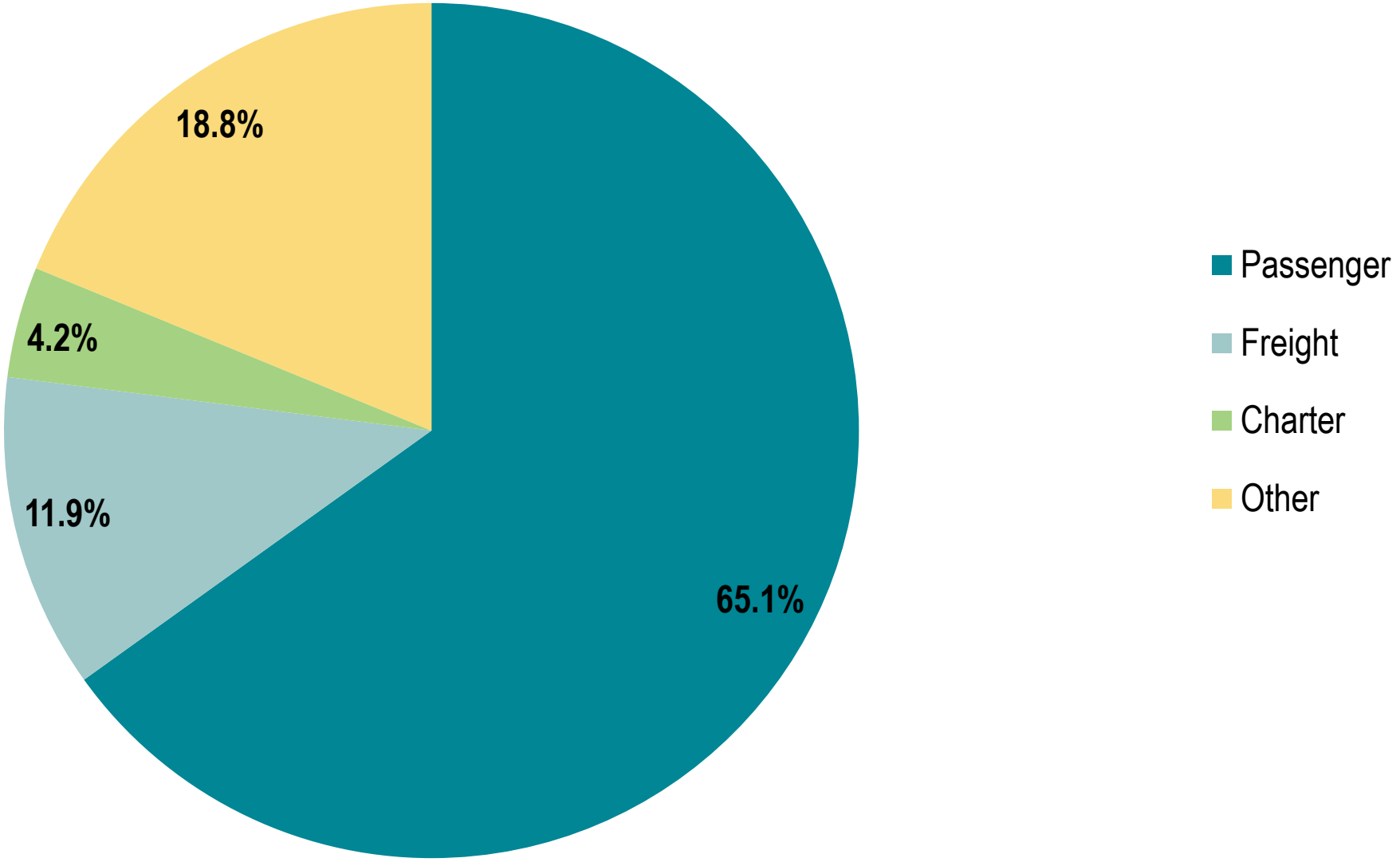
Passenger Airlines Operating Costs, United States, 2019



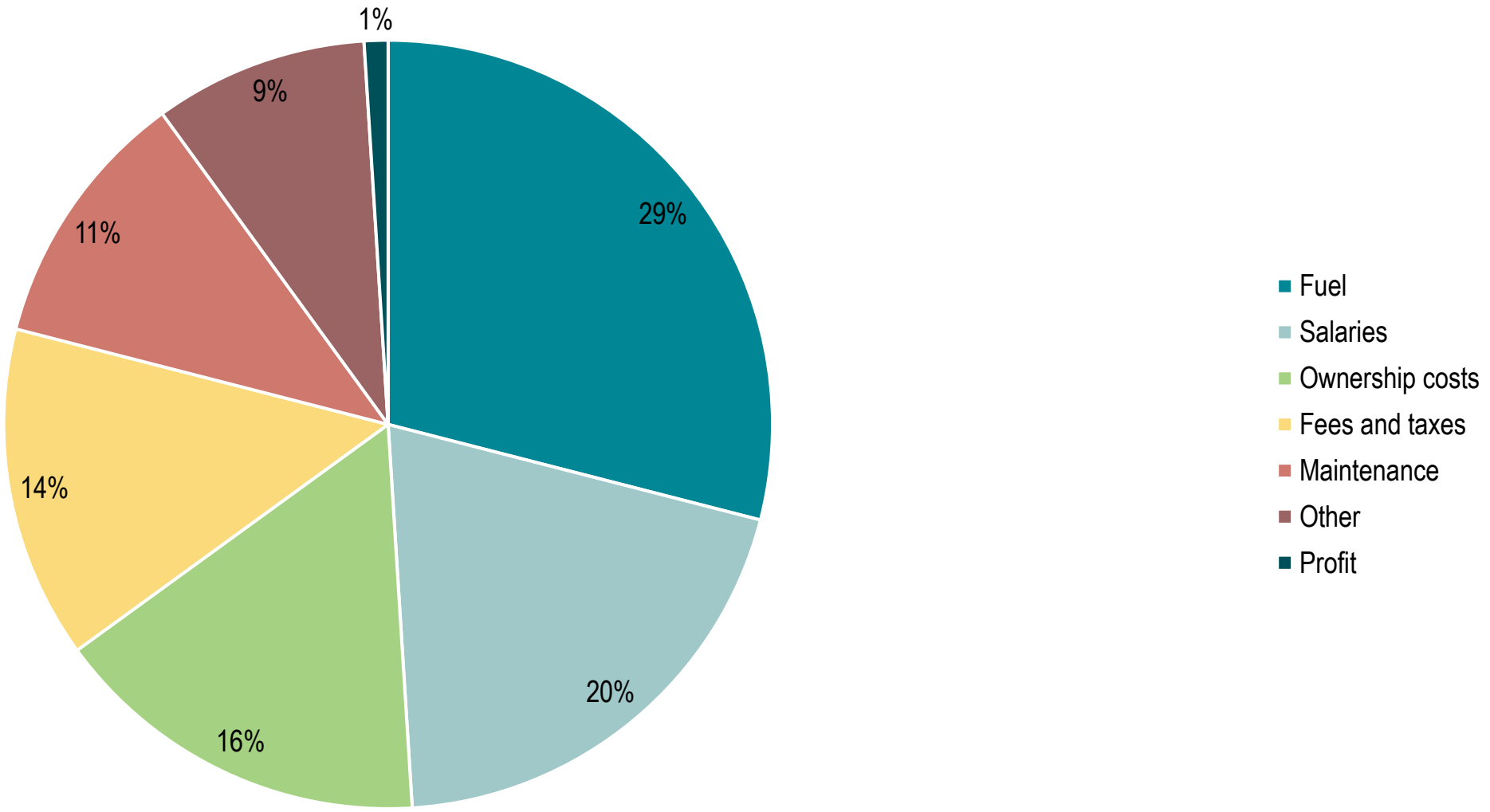
Jet Fuel Prices, 1990-2021



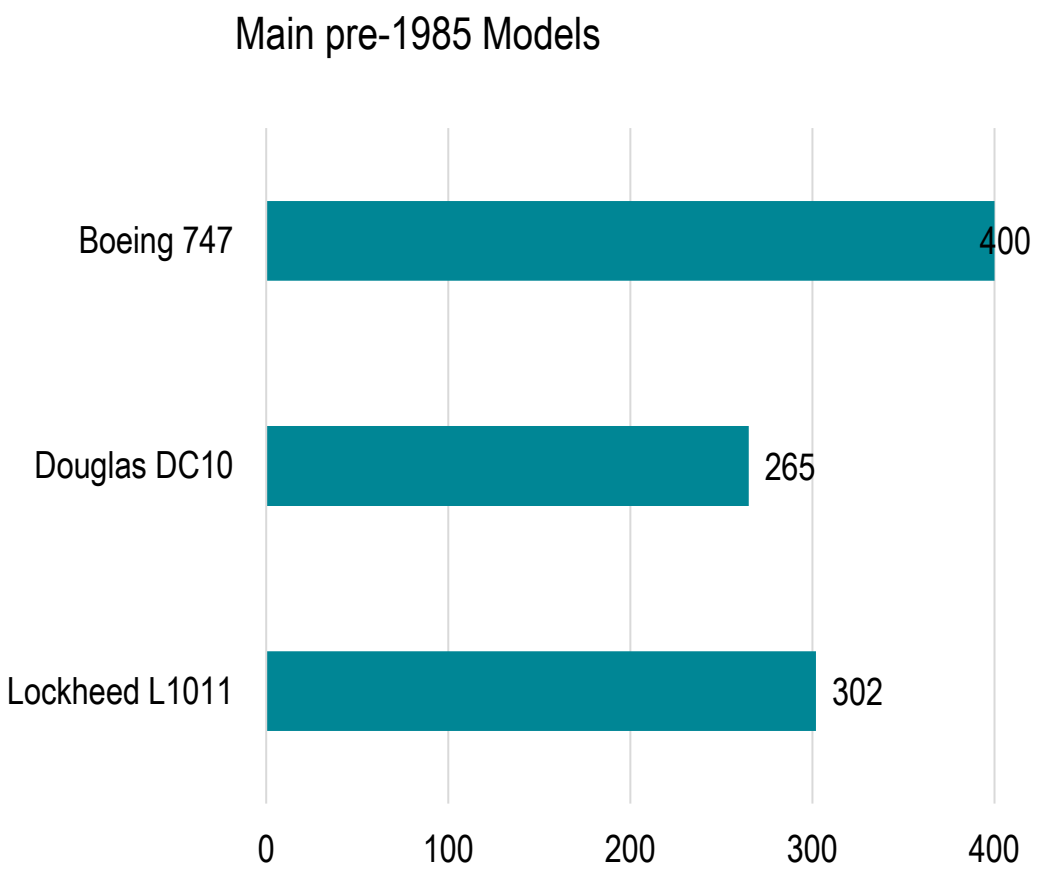
Operating Revenues of the Airline Industry

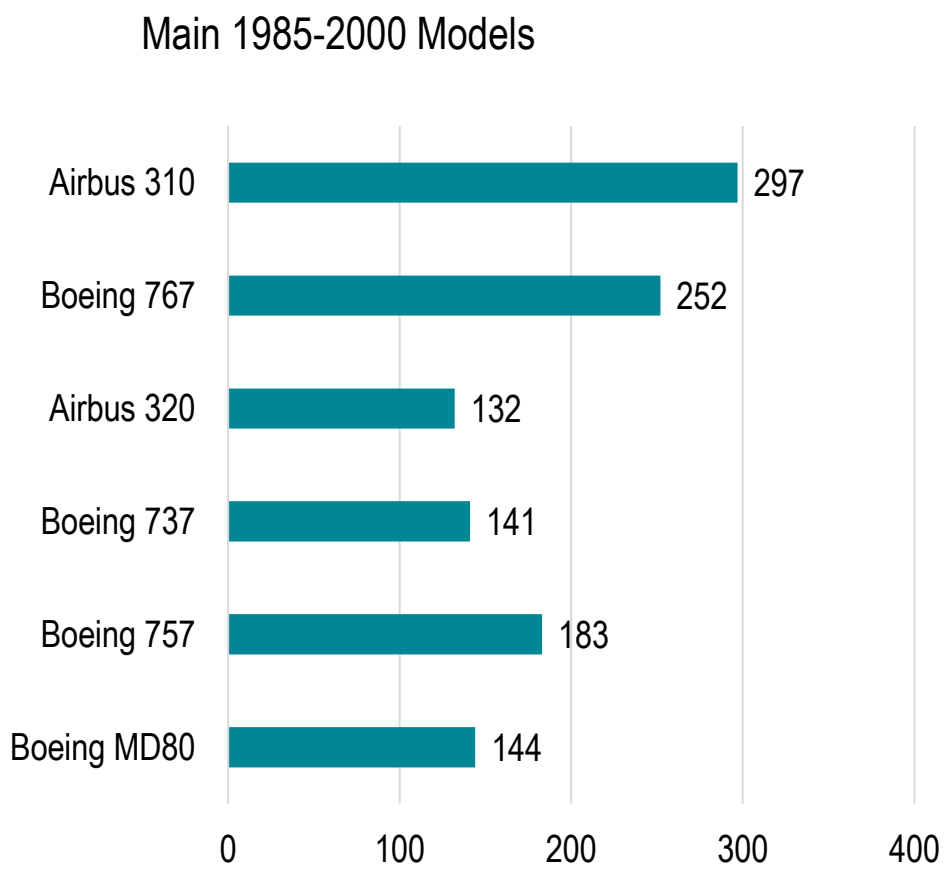


Cost Structure of a Typical 100 Passengers Domestic Flight, c2012

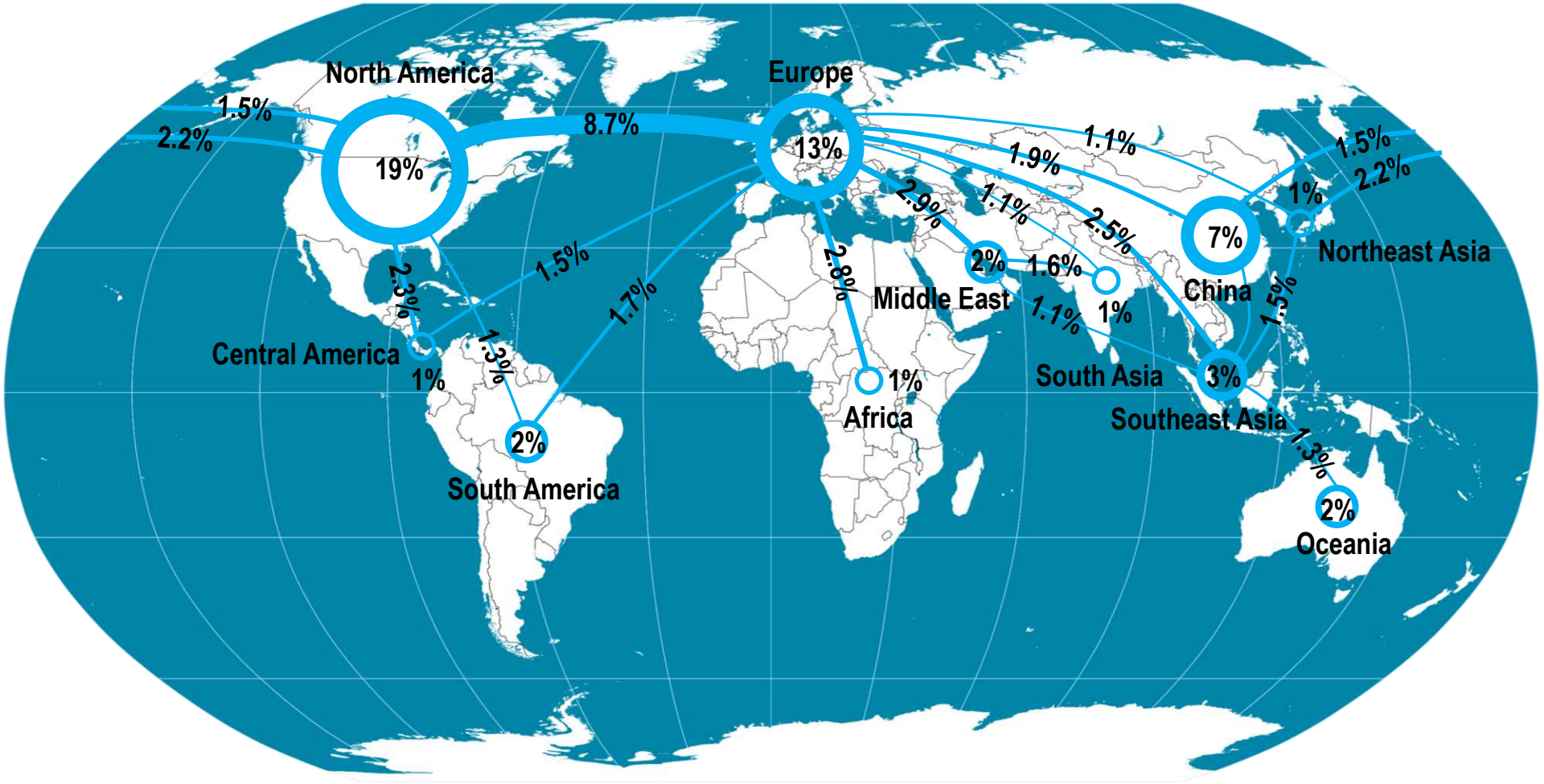


Seat Capacity of Selected Aircrafts, pre-1985 and 1985-2000

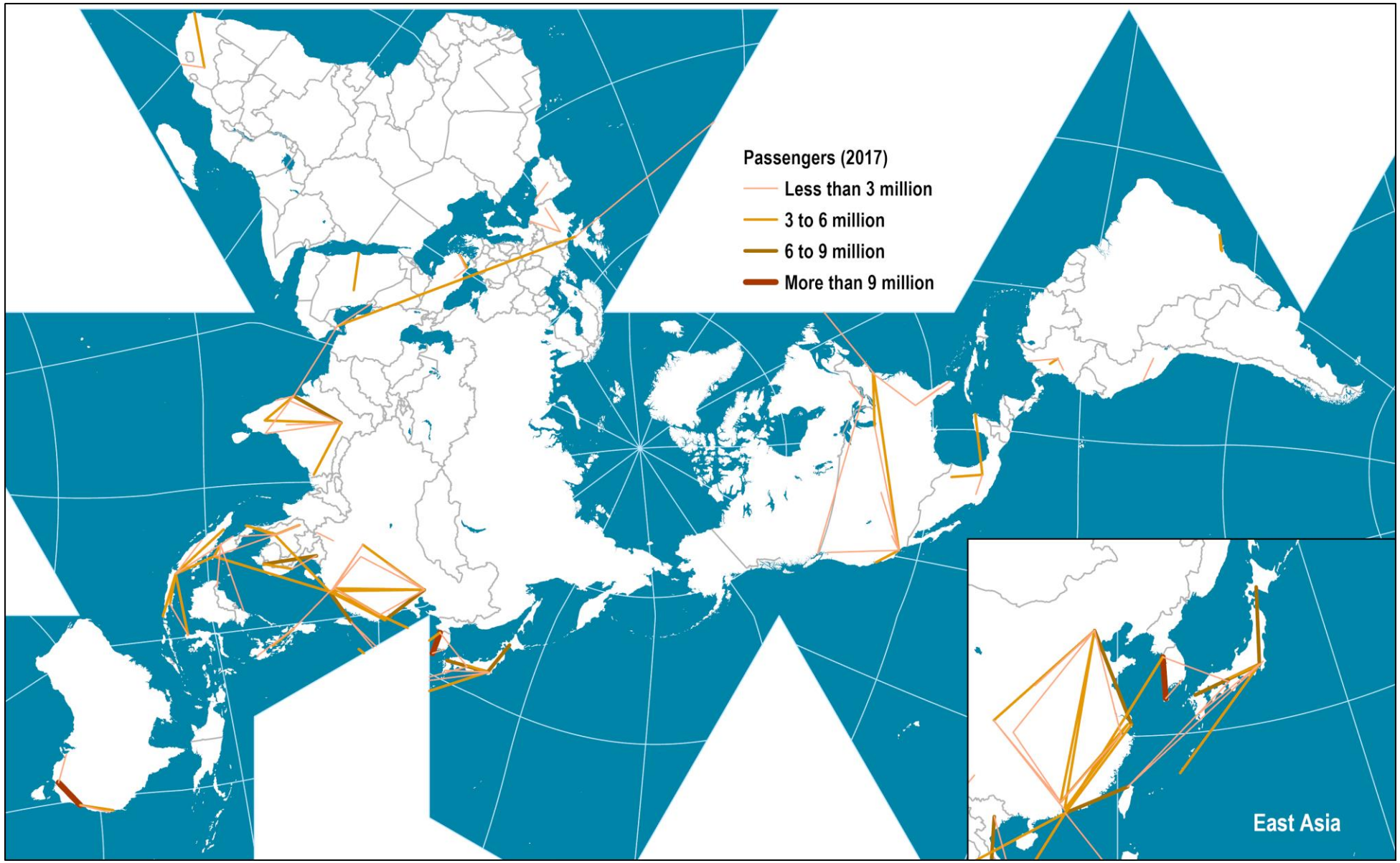




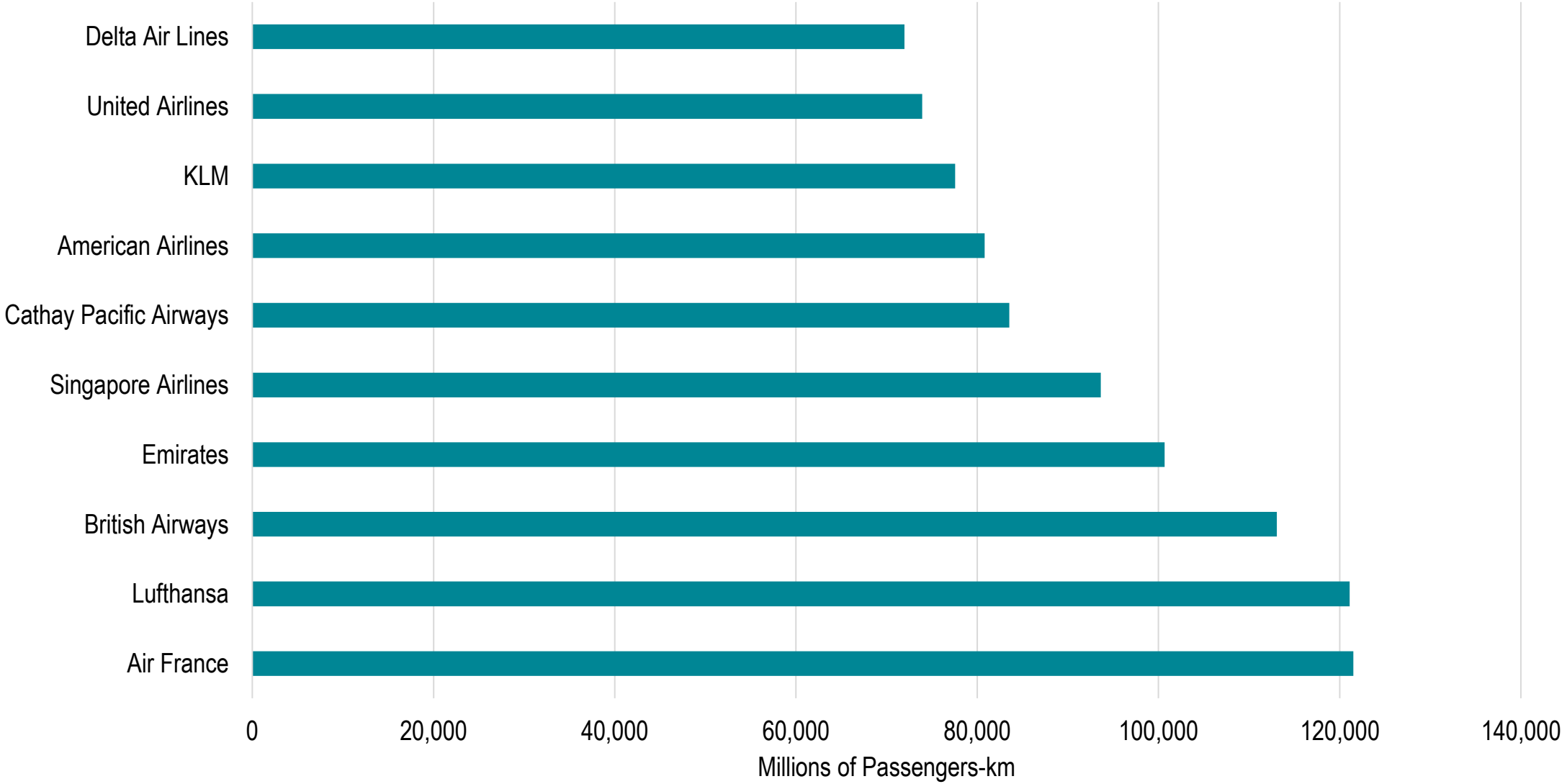
Major Air Traffic Flows Between Regions, 2010



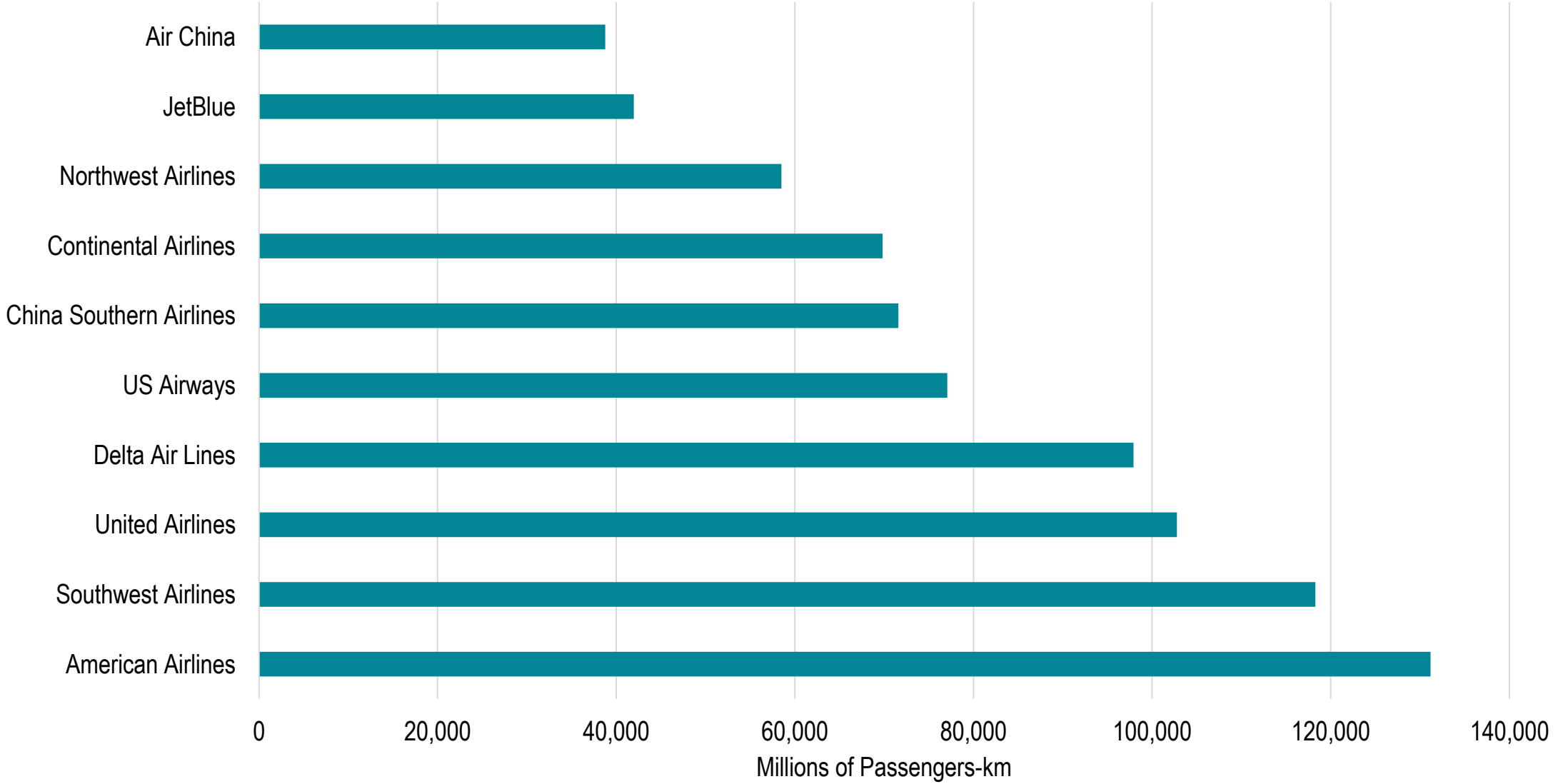
The World's Busiest Air Transport Routes, 2017



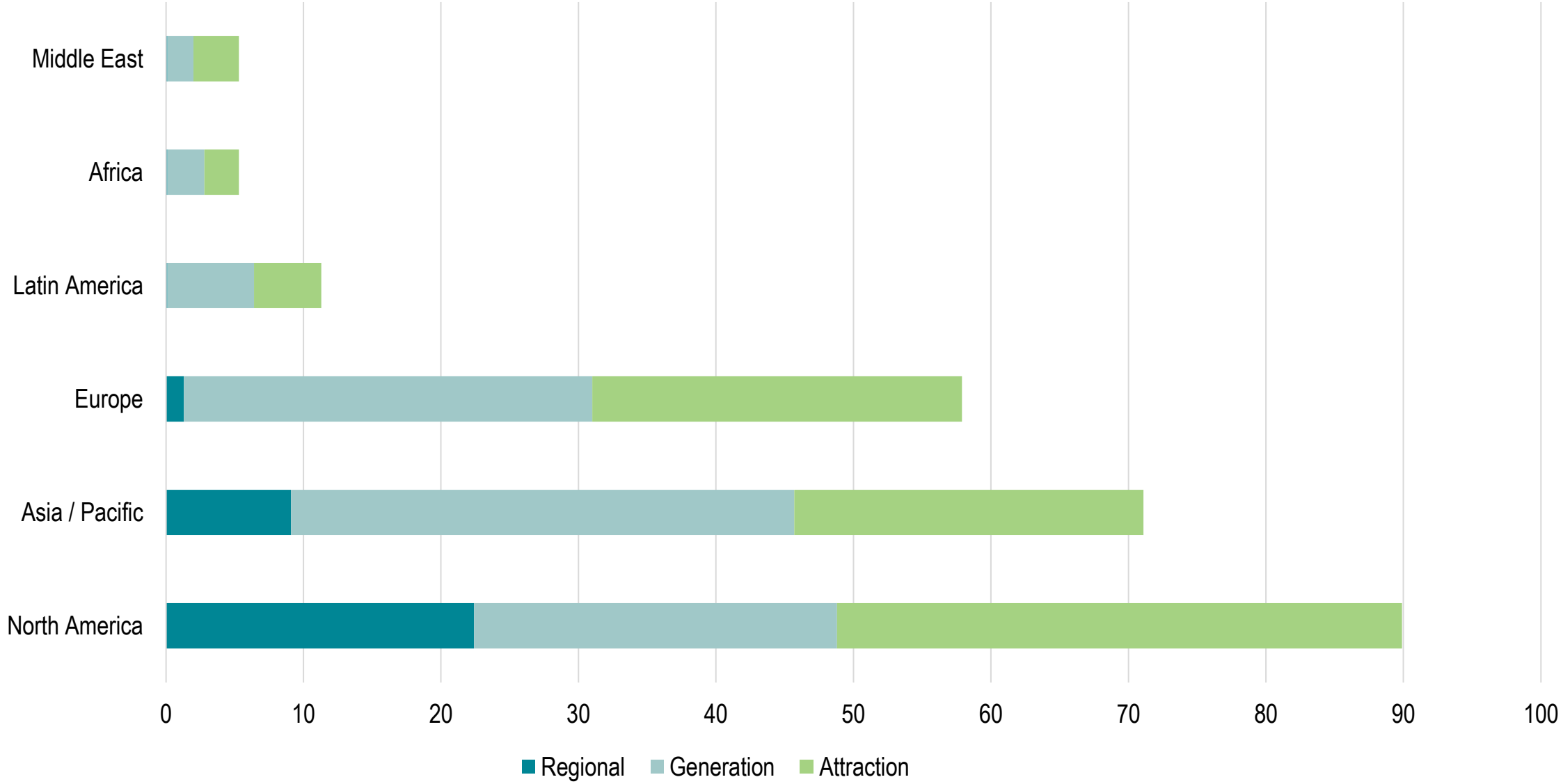
World's 10 Largest International Air Carriers, 2008



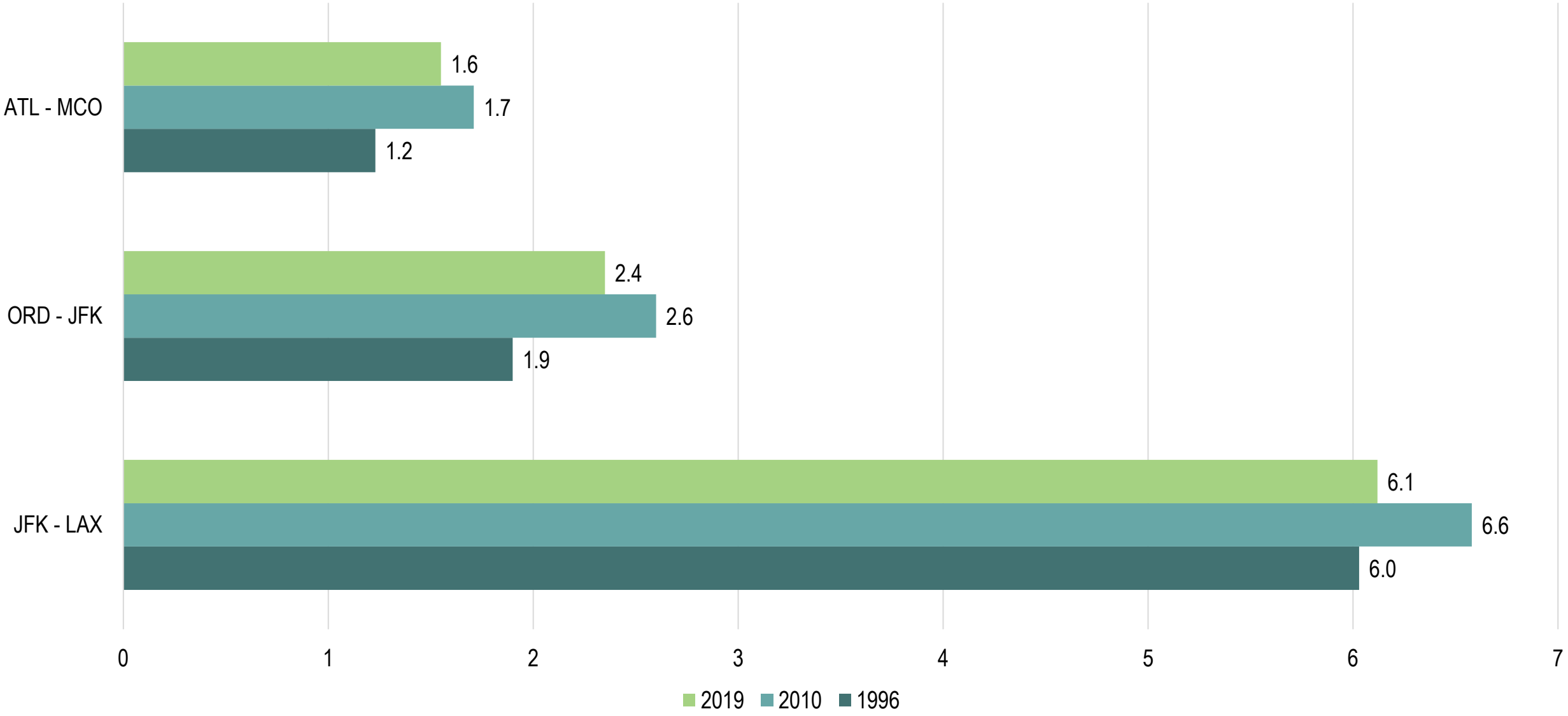
World's 10 Largest Domestic Airlines, 2008



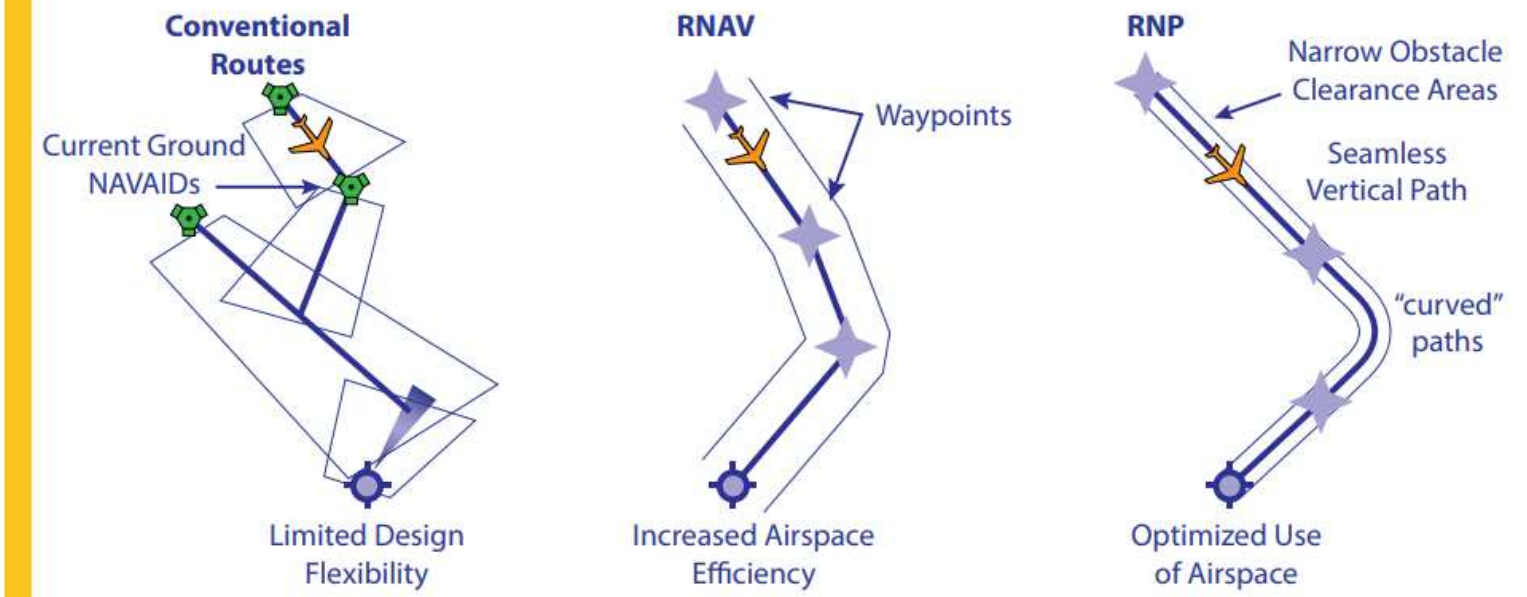
Generation and Attraction of Global Air Freight Flows, 2003 (in billions of ton-km)



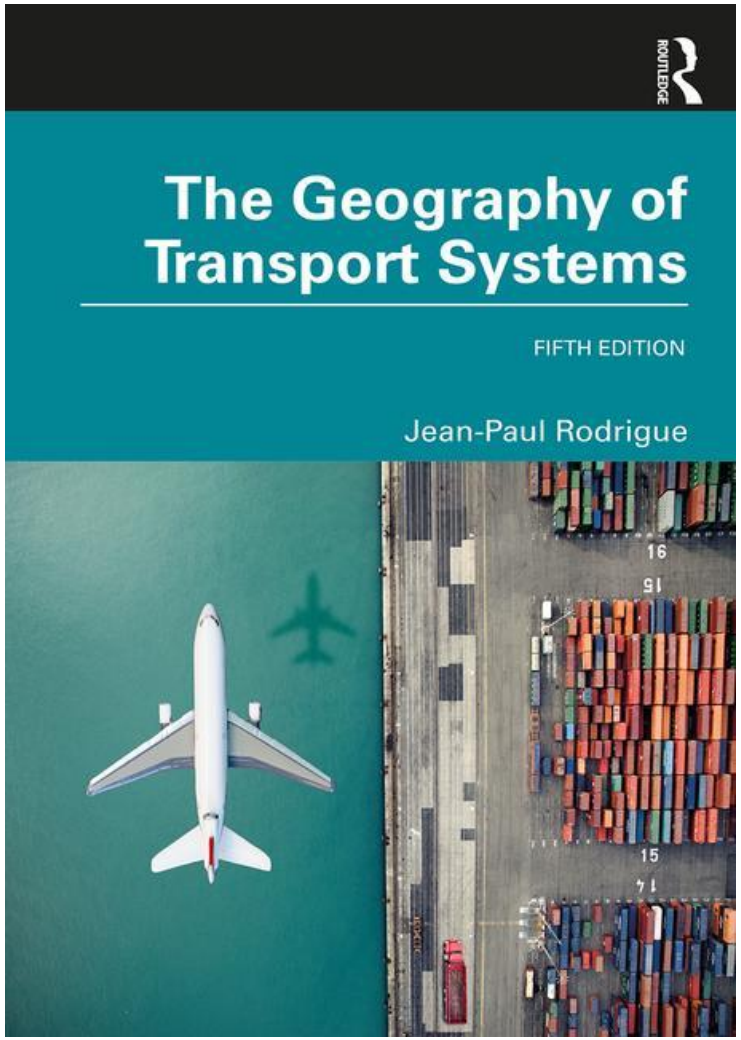
Changes in the Duration of Selected Scheduled Flights, 1996-2019 (hours)



Evolution to Performance-Based Navigation

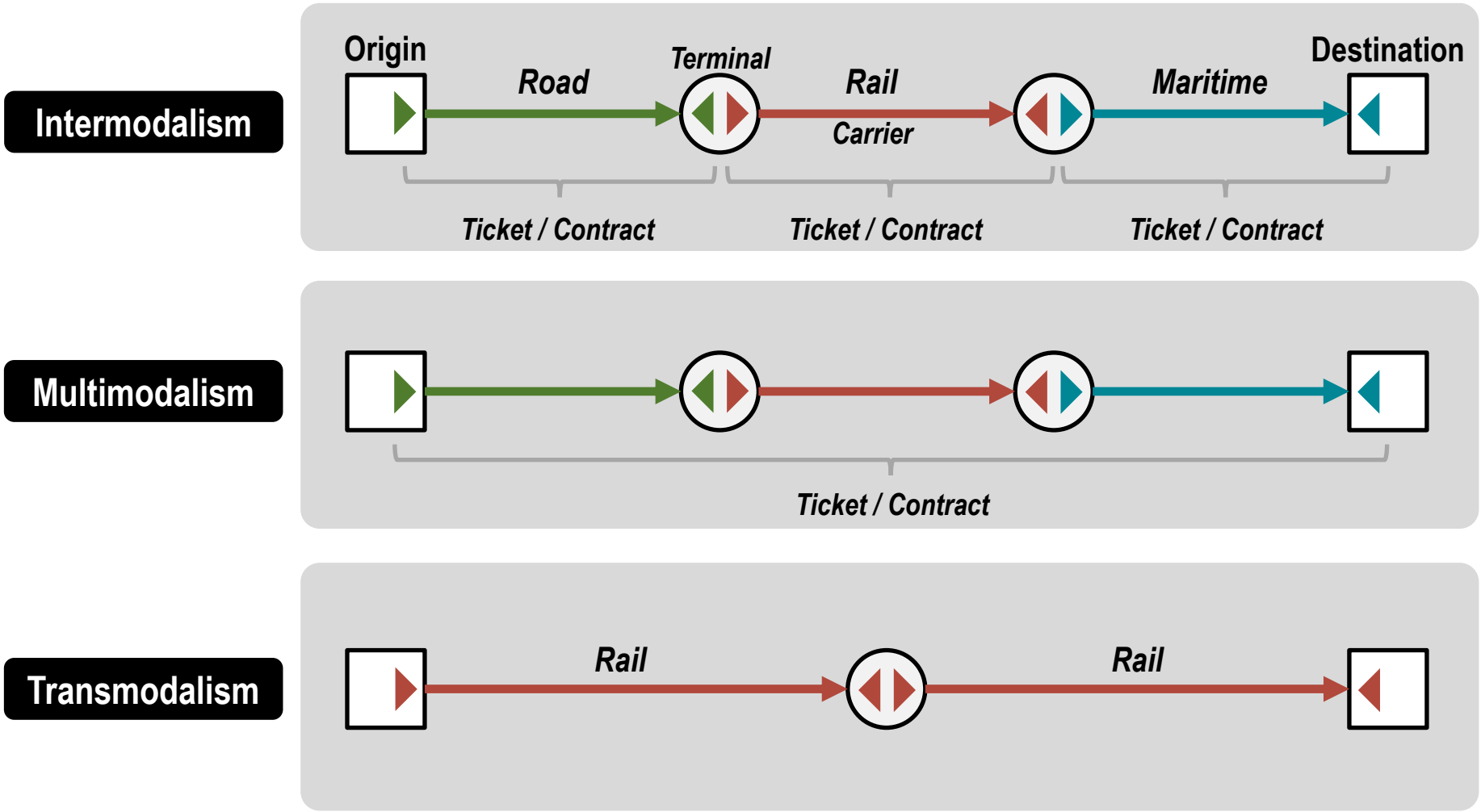


Connected to Recommendations: 1, 2, 3, 10

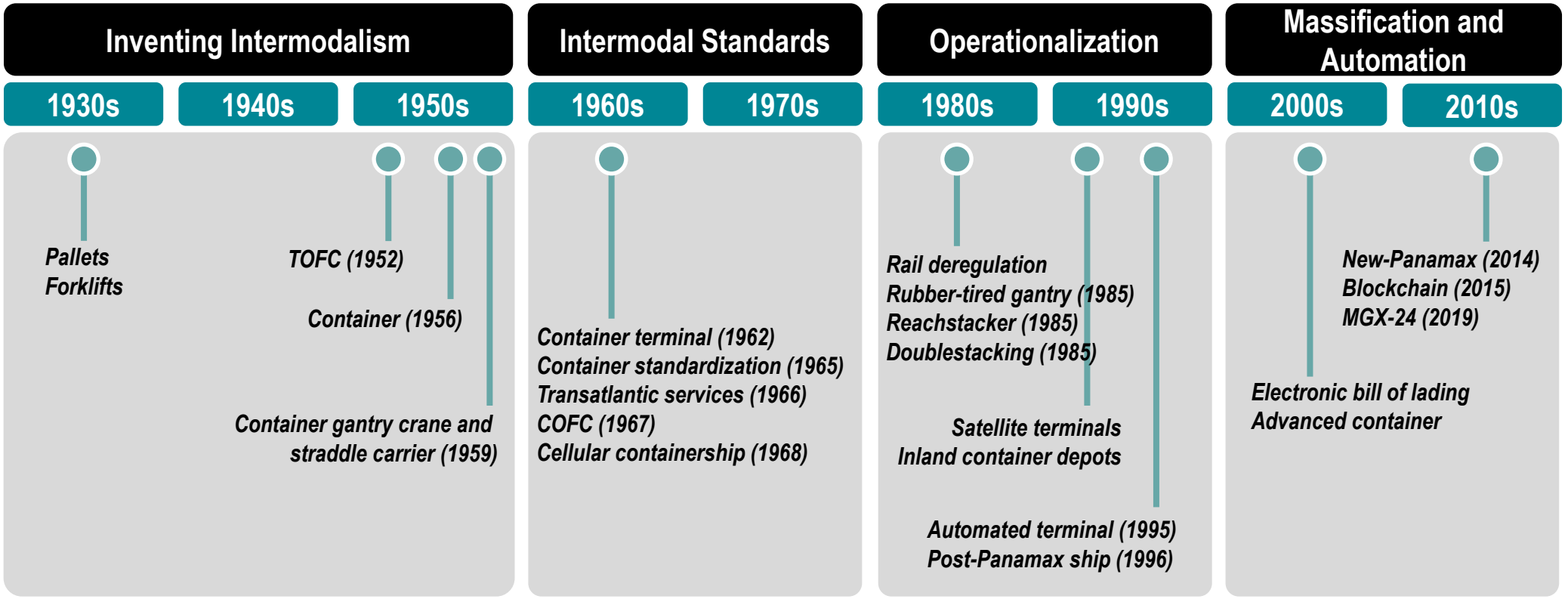


Intermodal Transportation

Intermodalism, Multimodalism and Transmodalism



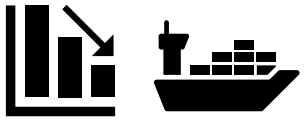
Major Steps in Intermodal Integration



Integrated Transport Systems: From Fragmentation to Coordination

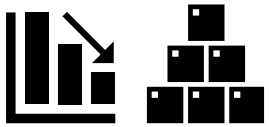
	Cause	Consequence
Technology	Containerization & IT	Modal and intermodal innovations; Tracking shipments and managing fleets
Capital Investments	Returns on investments	High costs and long amortization; Improve utilization to lessen capital costs
Alliances and M&A	Deregulation	Easier contractual agreements; Joint ownership
Value Chains	Globalization	Coordination of transportation and production (integrated demand)
Networks	Consolidation and interconnection	Economies of scale, efficiency and control

The Benefits of Containerization



Transportation Costs

- Lower freight rates.
- Lower insurance rates.
- Minimal load unit.



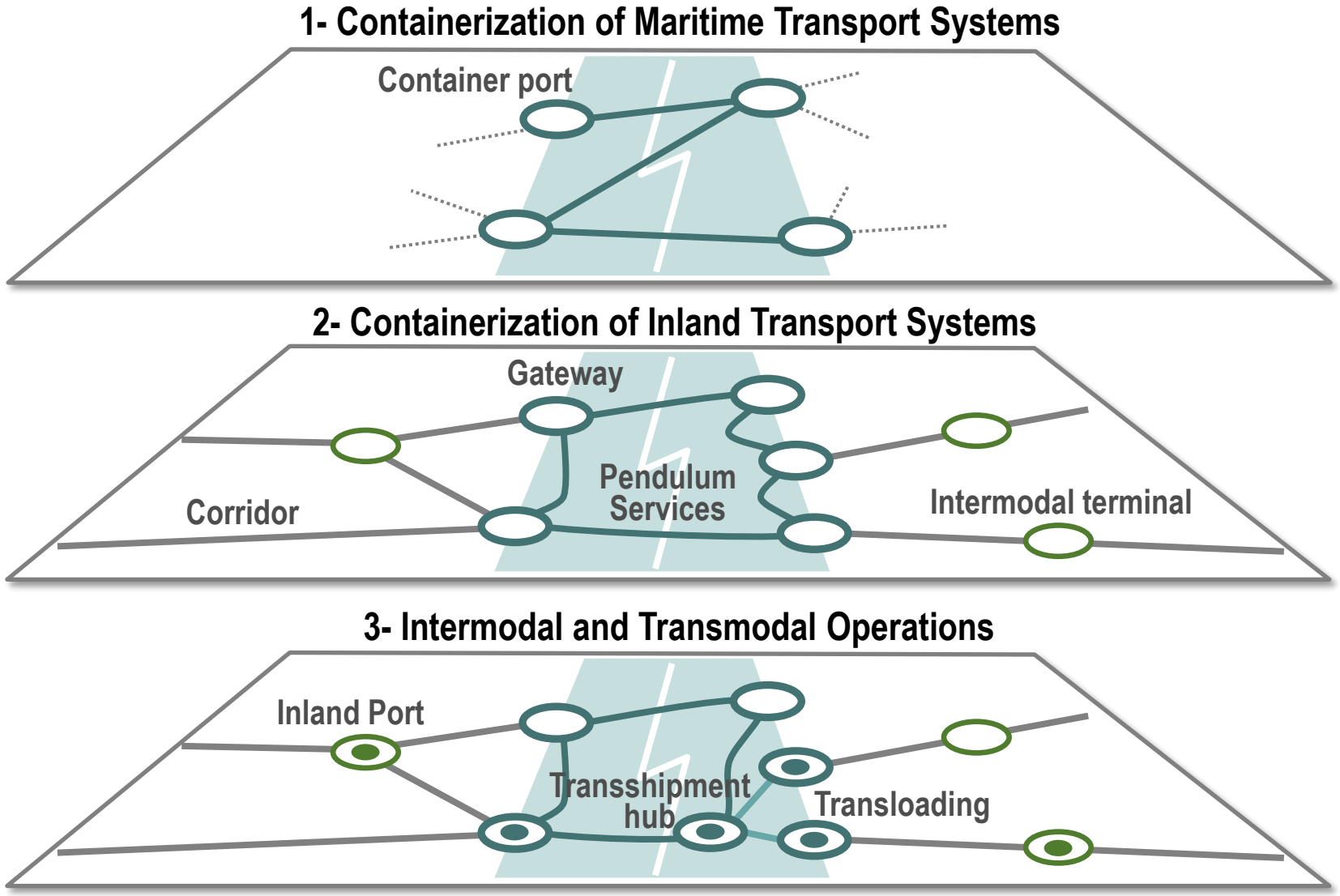
Inventory Costs

- Lower storage costs.
- Lower packing and packaging costs.
- Faster inventory turnover.

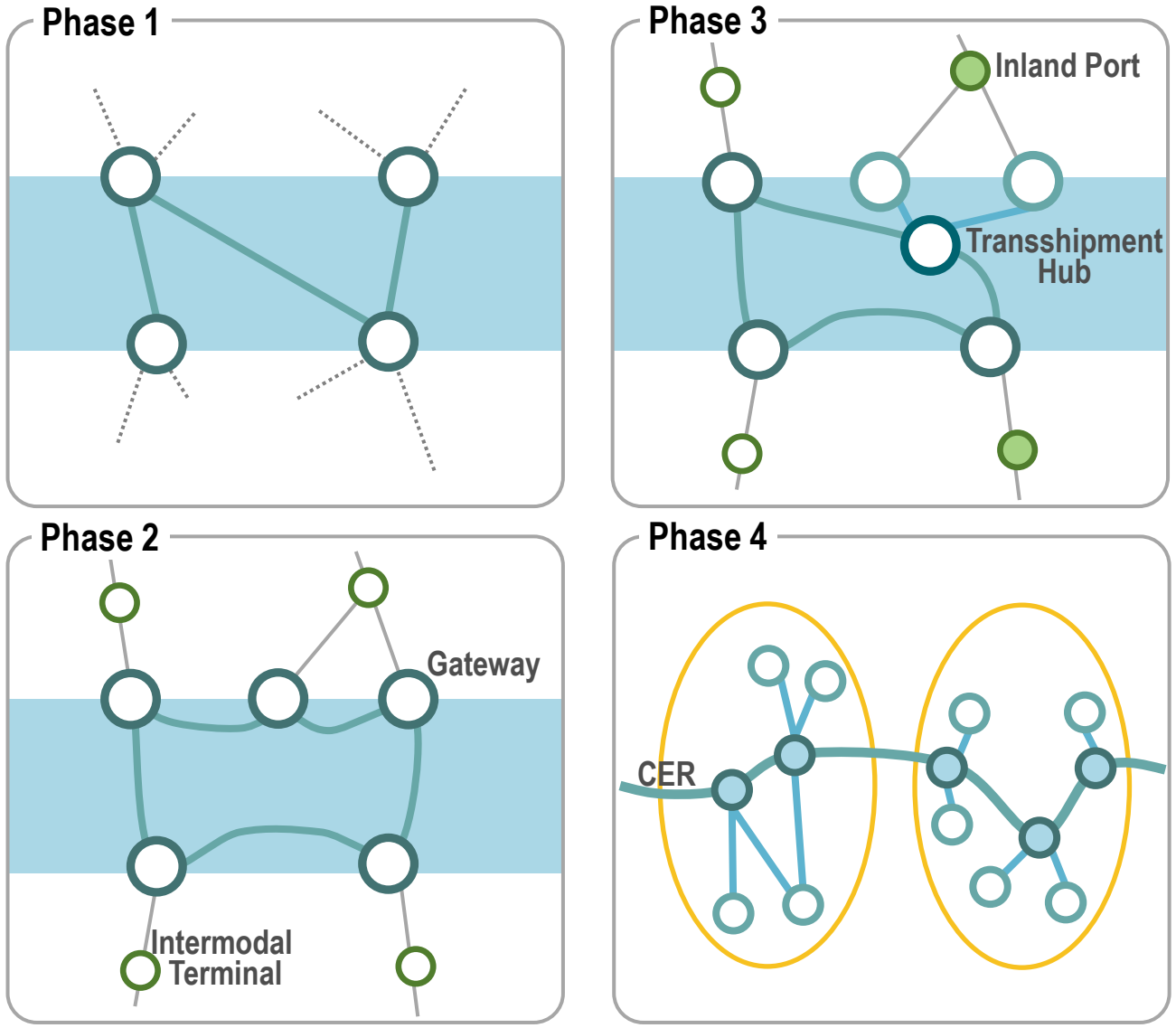
Service Level

- Time reliability.
- Higher frequency.

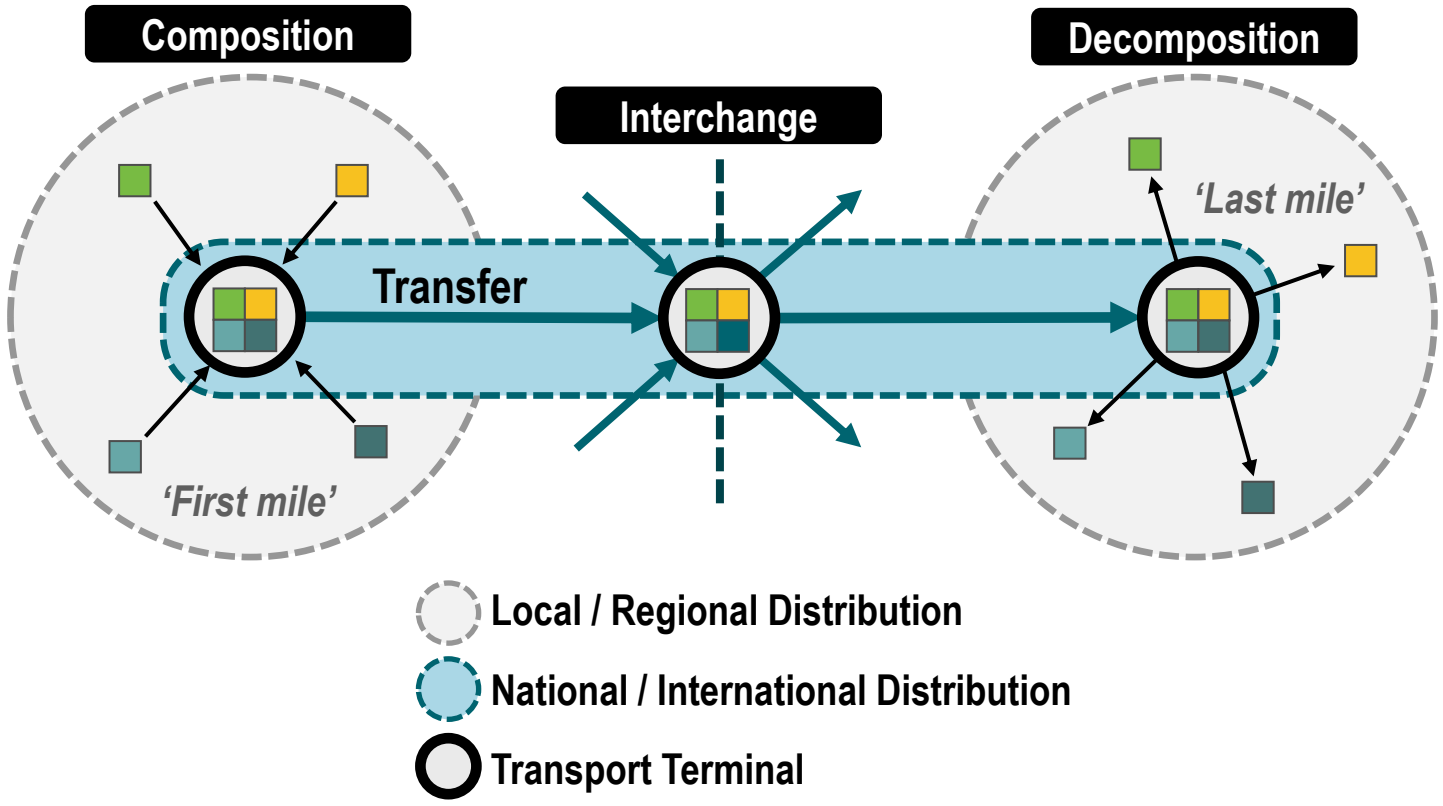
The Four Revolutions of Containerization



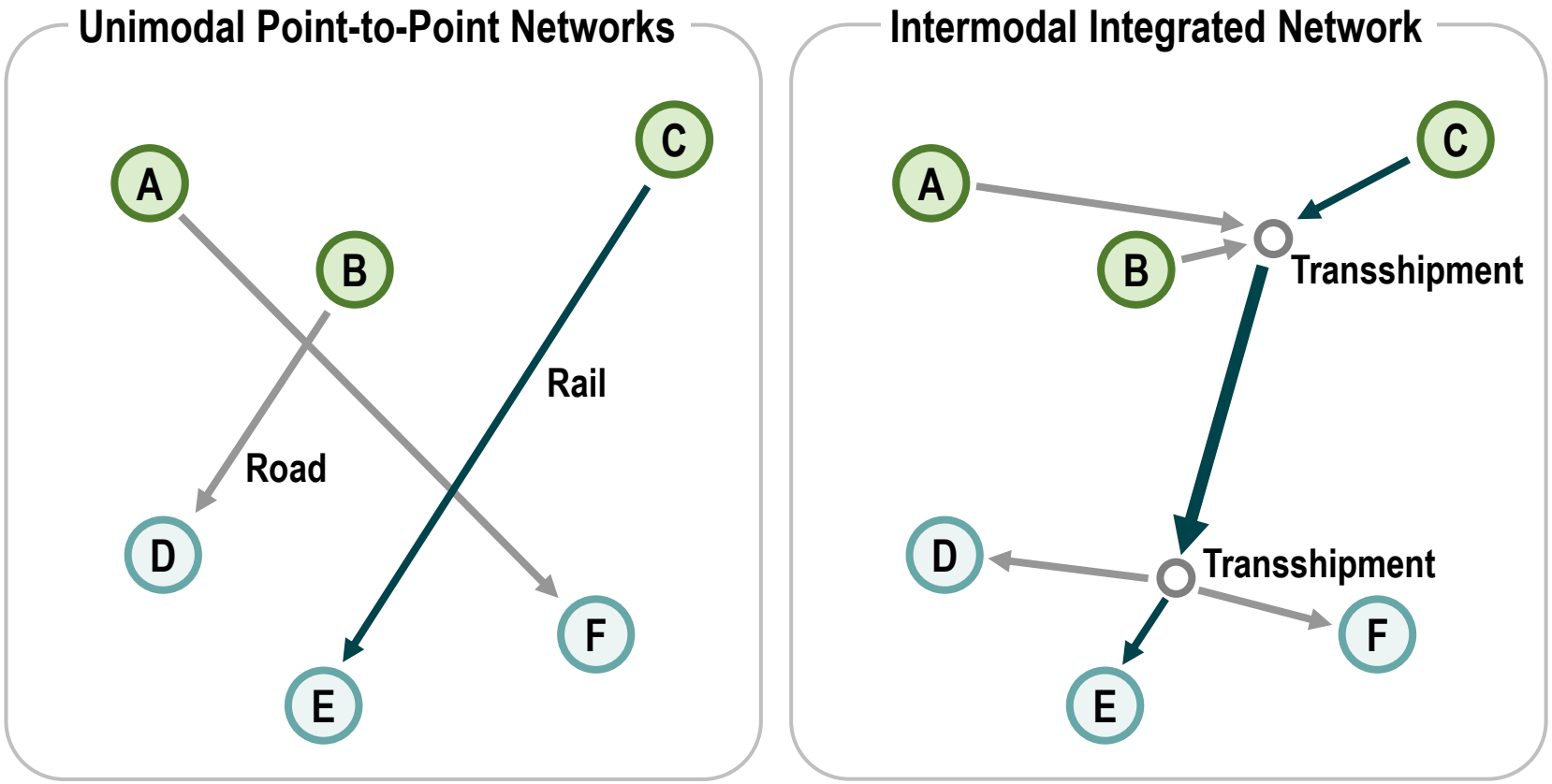
The Four Revolutions of Containerization



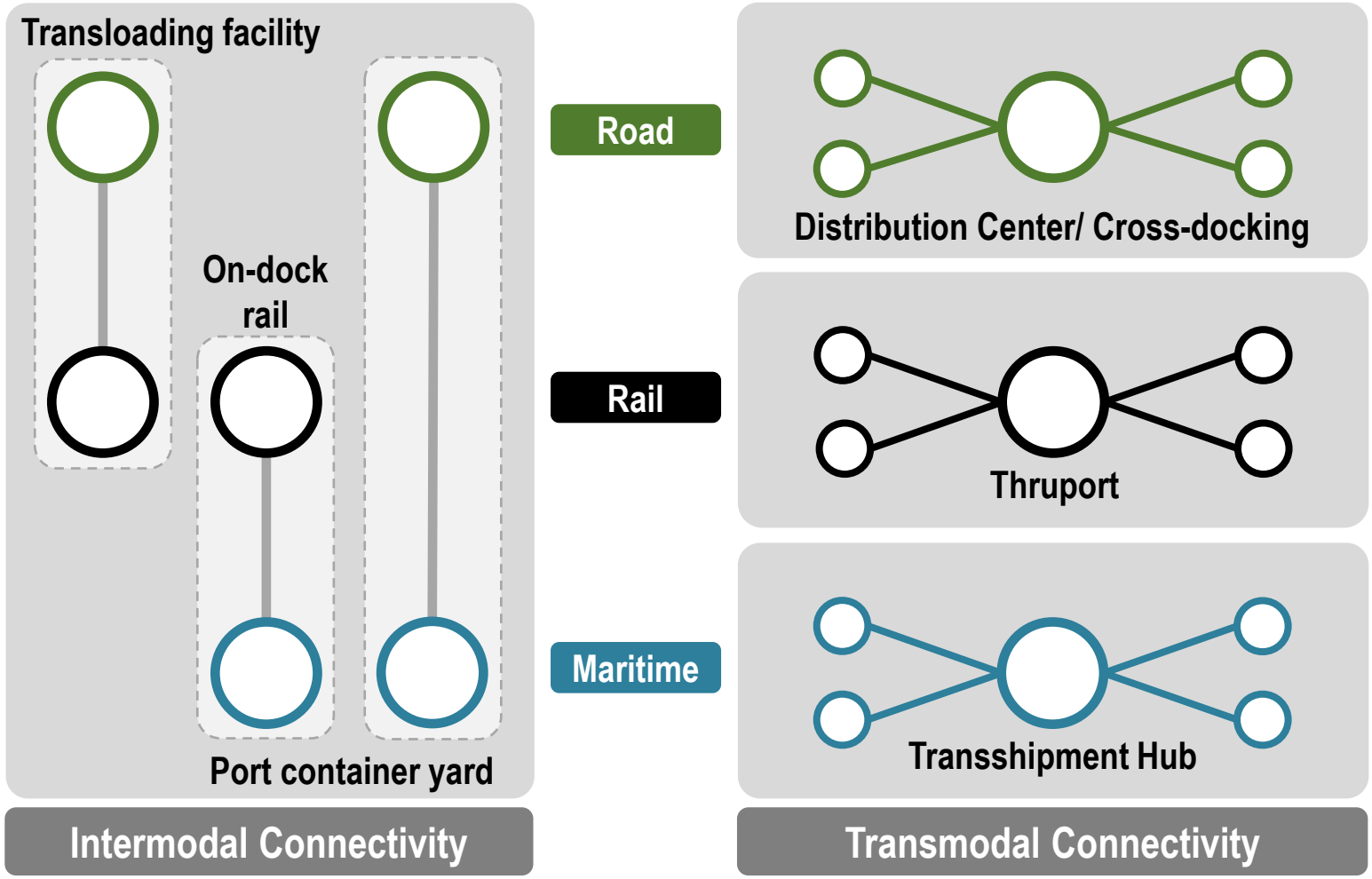
Intermodal Transport Chain



Intermodal Transportation as an Integrative Force



Integrated Freight Transport Systems: Intermodal and Transmodal Connectivity



Conditions and Outcomes of Intermodal Transport

CONDITIONS

Load unit

Intermediate and finished goods in load units of less than 25 tons.

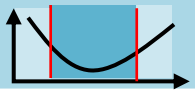
Modal continuity

Sequence of connected infrastructure; an intermodal transport chain.

Transport distance

Distances above 500 km (longer than one day of trucking) usually require intermodal transportation.

Cargo Value



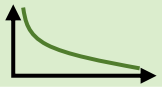
Suitable for intermediate cargo values. Low and high value shipments are usually less suitable.

Frequency of shipments

Cargo flows need to be continuous and in similar quantities.

OUTCOMES

Total transport costs



From economies of scale and the use of more effective modes and intermodal operations.

Modal shift

Each mode according to their respective time and cost advantages.

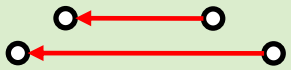
Consolidation

Requirement to consolidate and deconsolidate load units at intermodal terminals.

Higher load factor

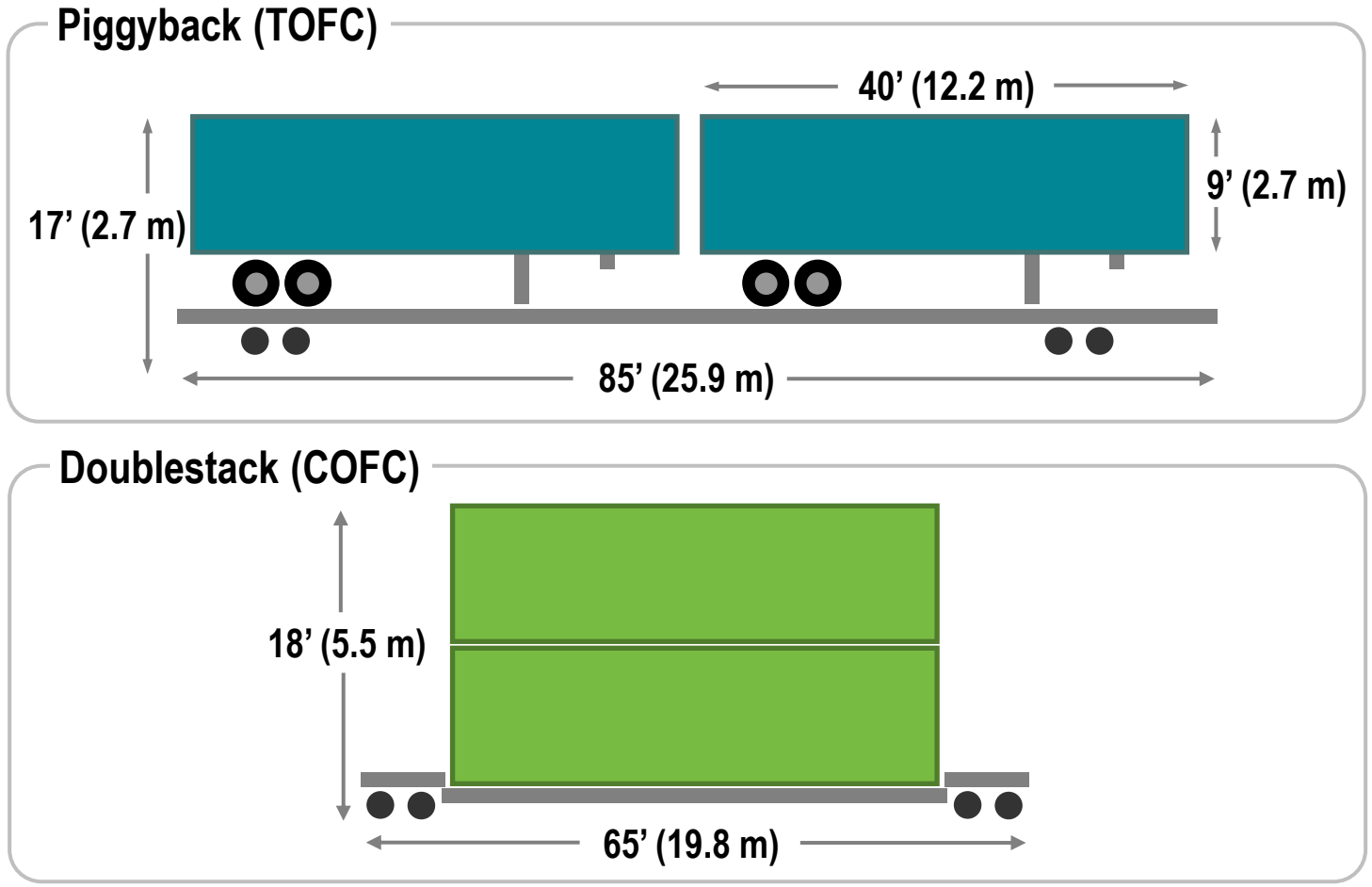
Less LTL and more TL. Better utilization of existing capacity.

Less empty backhauls

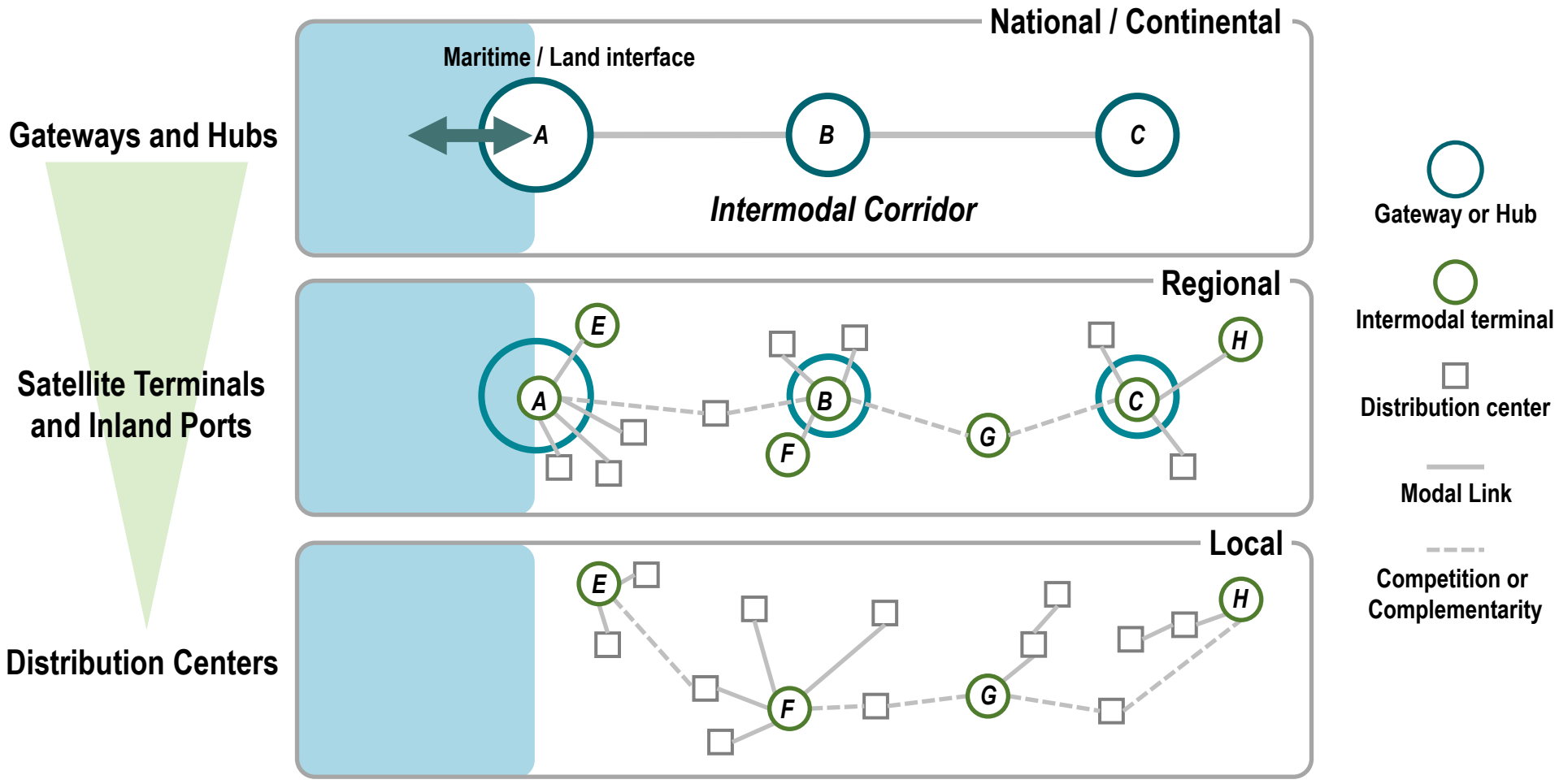


Less vehicle-km of empty backhauls due to modal shift, higher load factor and consolidation.

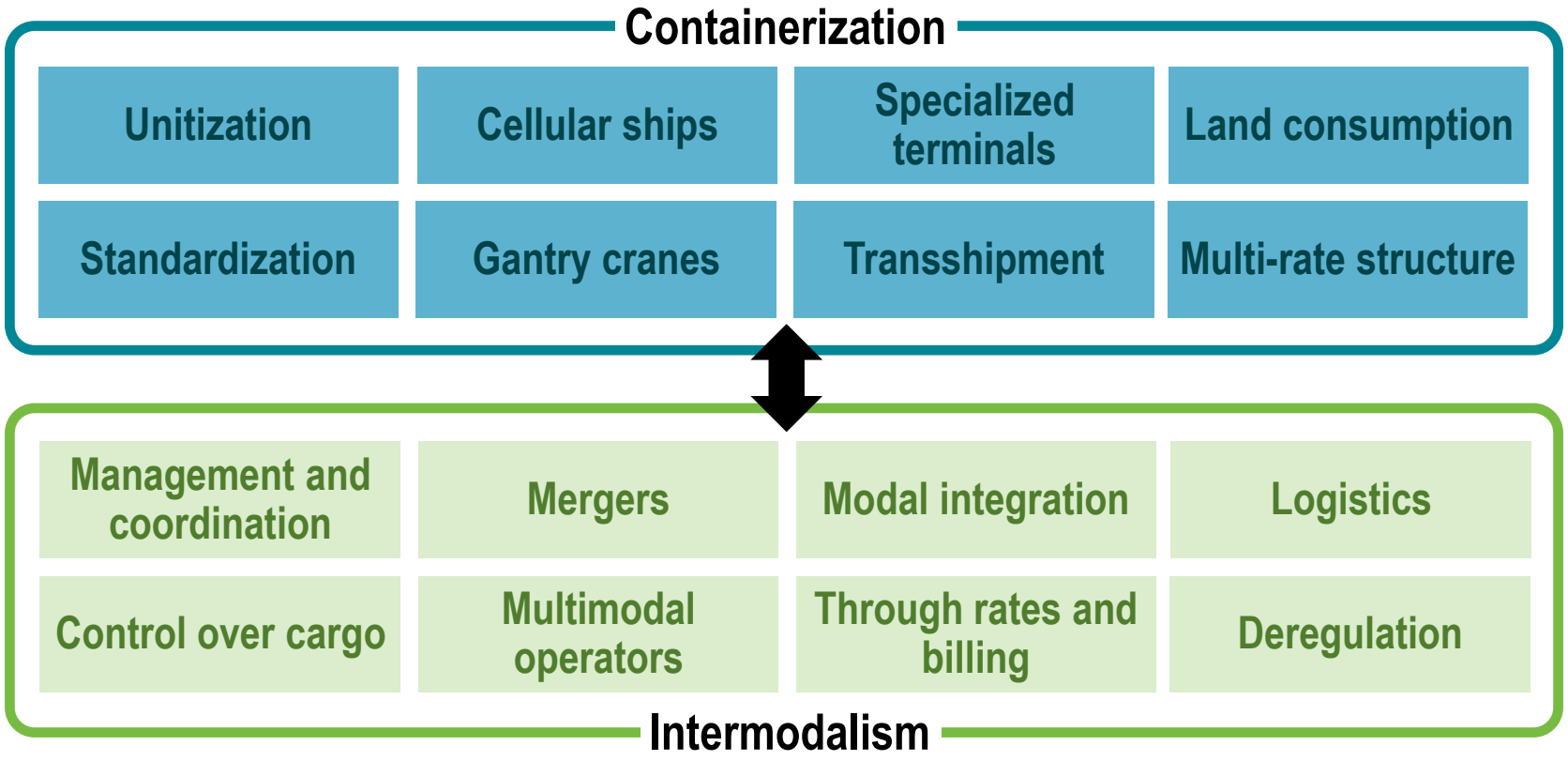
Piggyback and Doublestack Train Cars



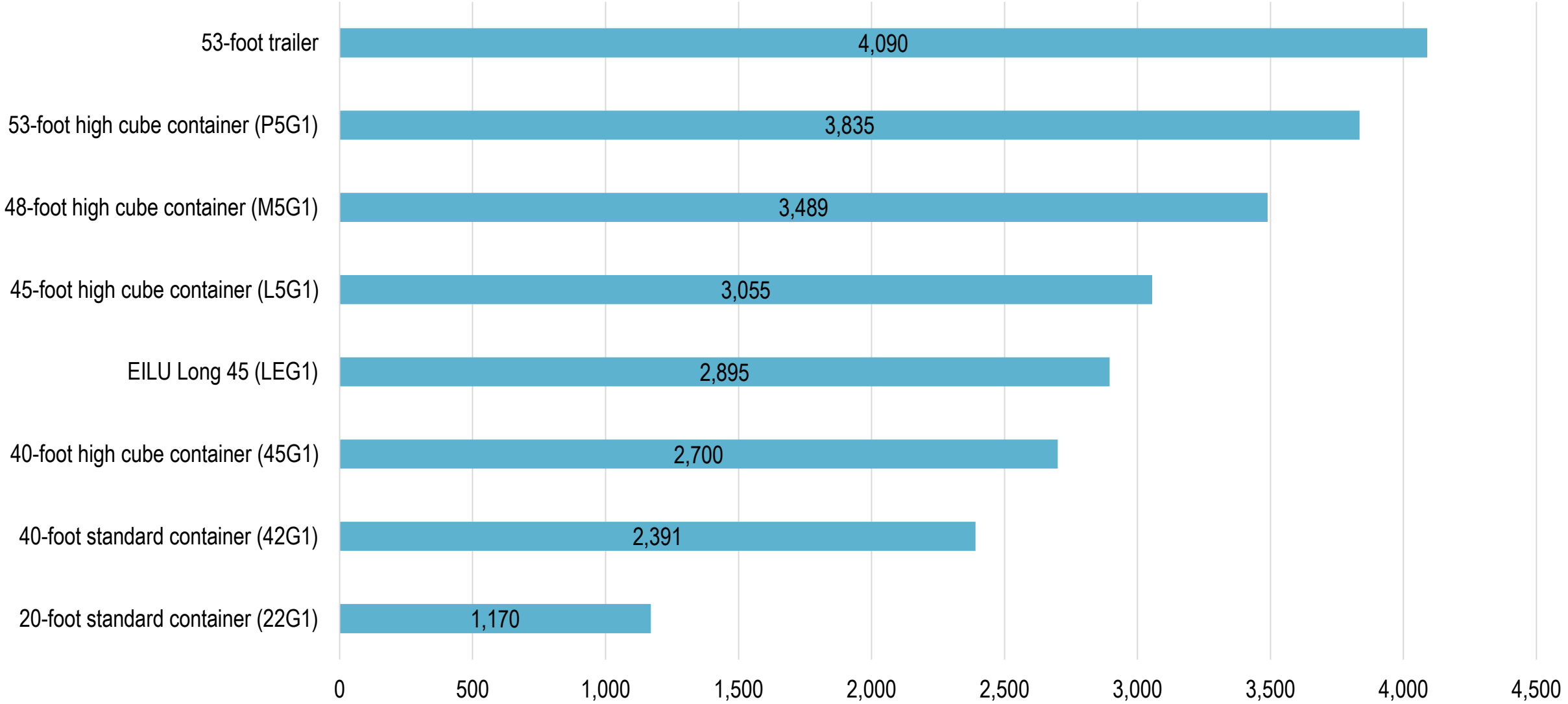
Multimodal Transport System



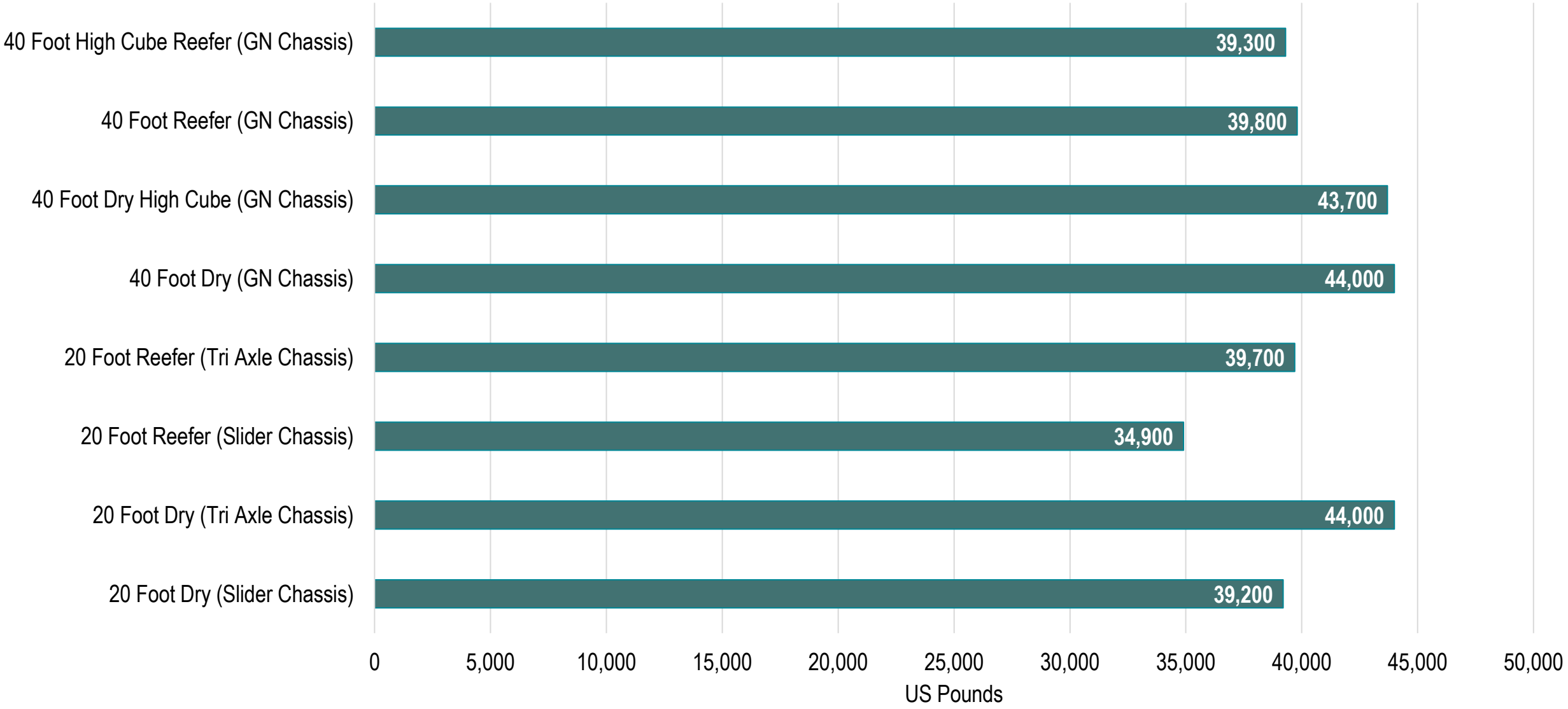
Driving Forces of Containerization and Intermodalism



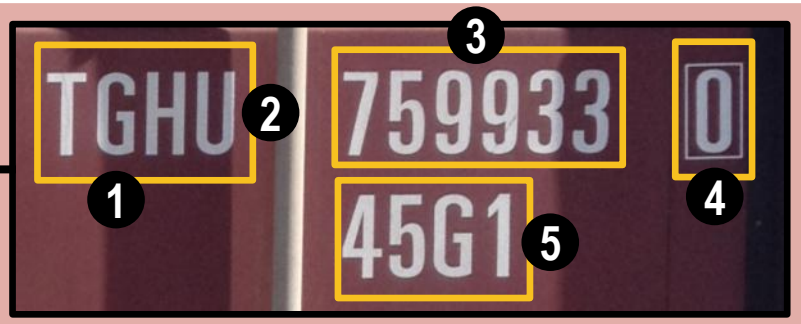
Carrying Capacity of Containers (in cubic feet)



Standard Container Road Weight Restrictions in the United States



Container Identification System

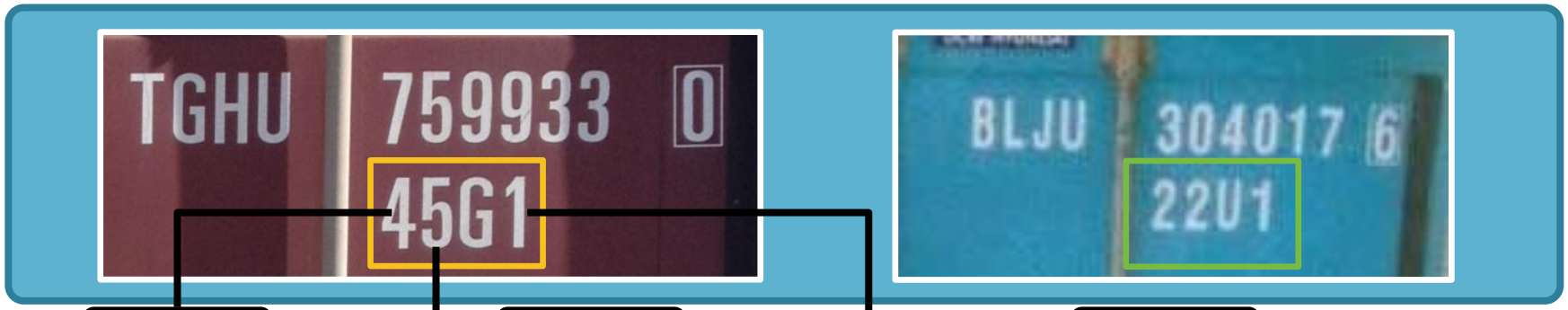


1. Owner Code (3 letters): TGH
2. Product Group Code (1 letter): U
3. Registration Number (6 digits): 759933
4. Check Digit (1 digit): 0
5. Size & Type Code (4 digits/letters): 45G1

Operational Characteristics

Maximum weight: 30,480 kg
Container weight: 3,870 kg
Payload weight: 26,610 kg
Cubic capacity: 2,700 cubic feet

Common ISO Container Size and Type Codes



Length

2	20 feet
4	40 feet
L	45 feet
M	48 feet

Height

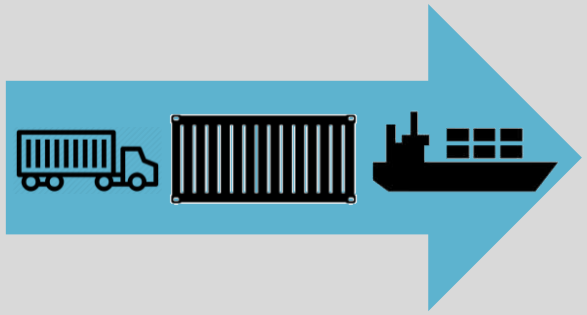
2	8 feet 6 inches
5	9 feet 6 inches

"High cube"

Type

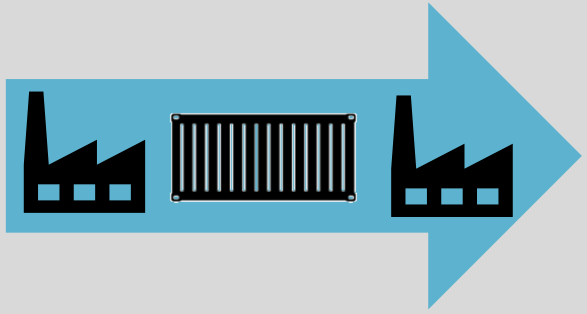
G1	General purpose container
R1	Refrigerated container
U1	Open top container
P1	Platform container
T1	Tank container

The Container as a Transport, Production and Distribution Unit



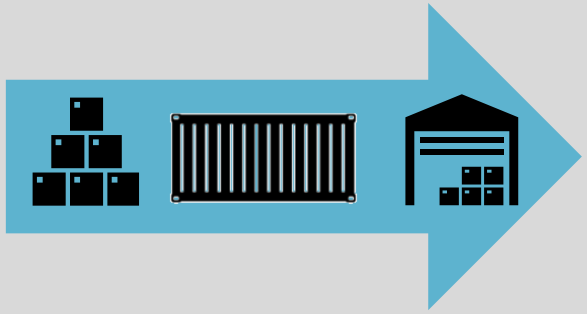
TRANSPORT

- Modes and terminals.
- Intermodal and transmodal operations.



PRODUCTION

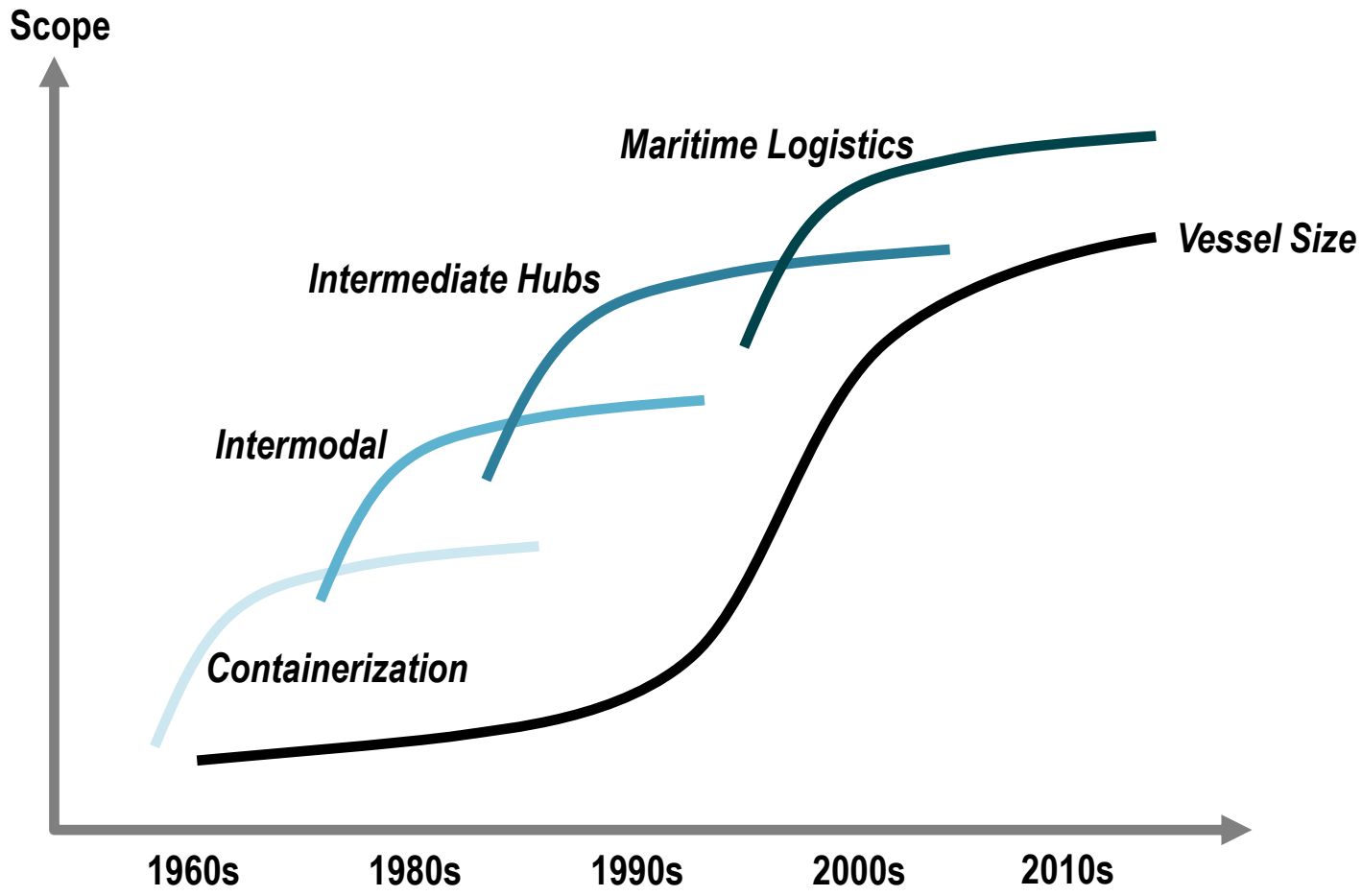
- Synchronization of inputs and outputs (batches).
- Manufacturing cycles.



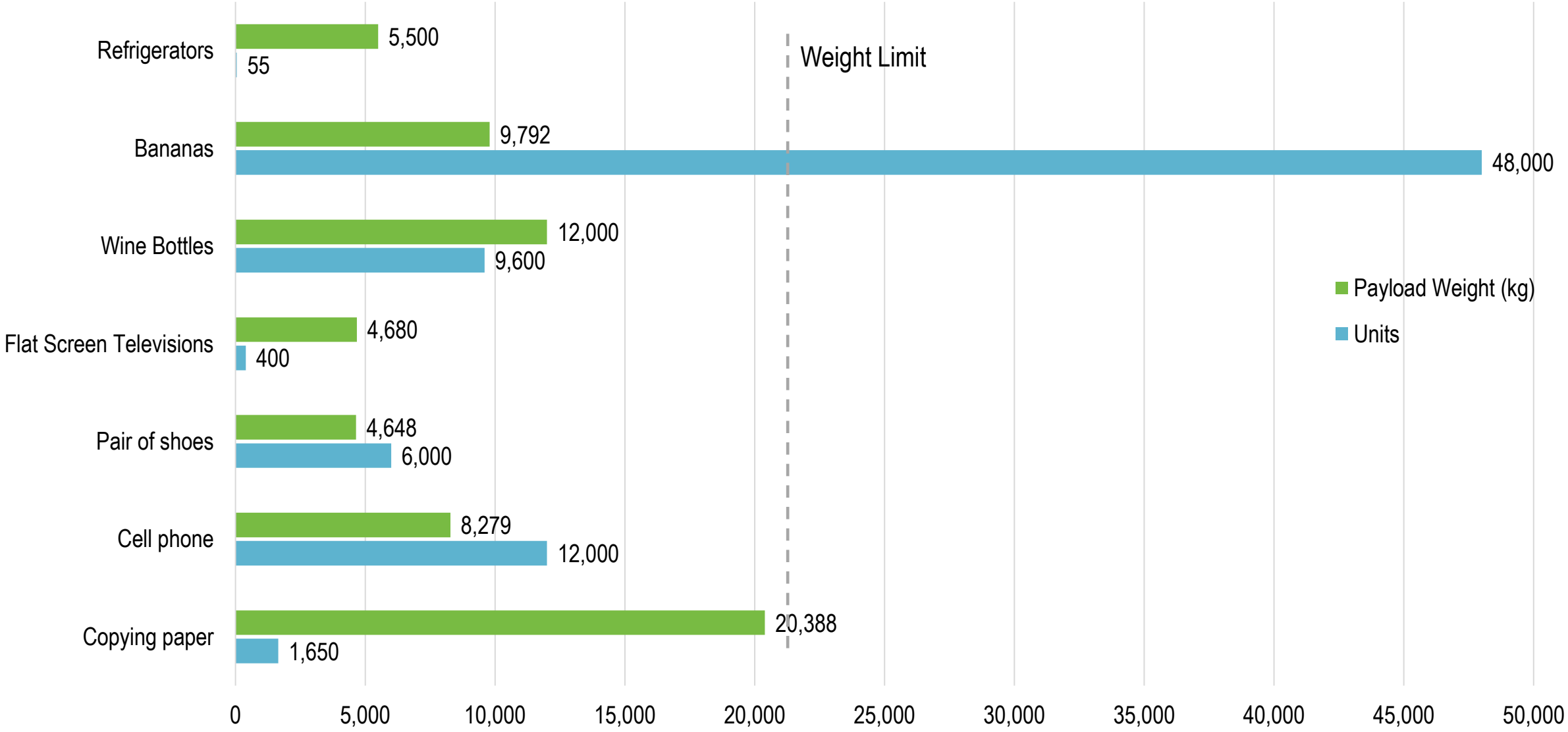
DISTRIBUTION

- Flow management (time-based).
- Inventory in transit (warehousing unit).

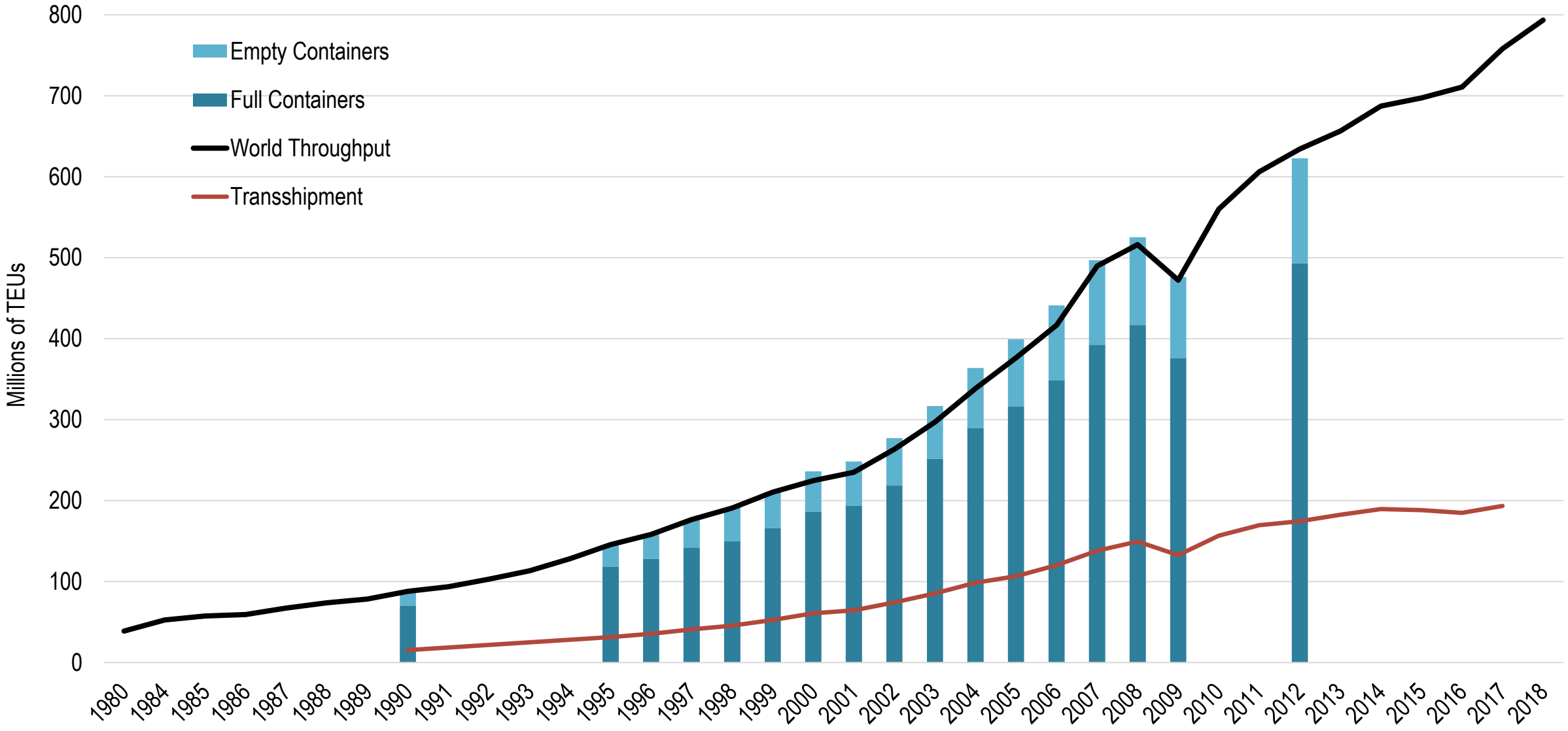
Shifts in Containerized Maritime Transportation



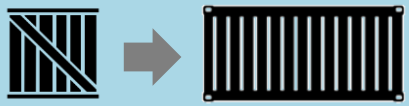
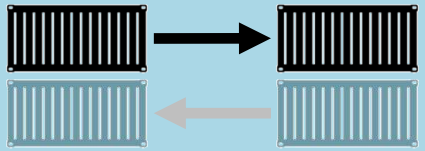
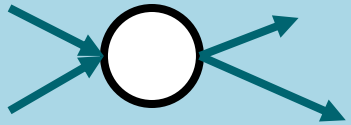
Number of Units and Weight of Standard Consumption Goods that Can be Carried by a 20 Foot Container



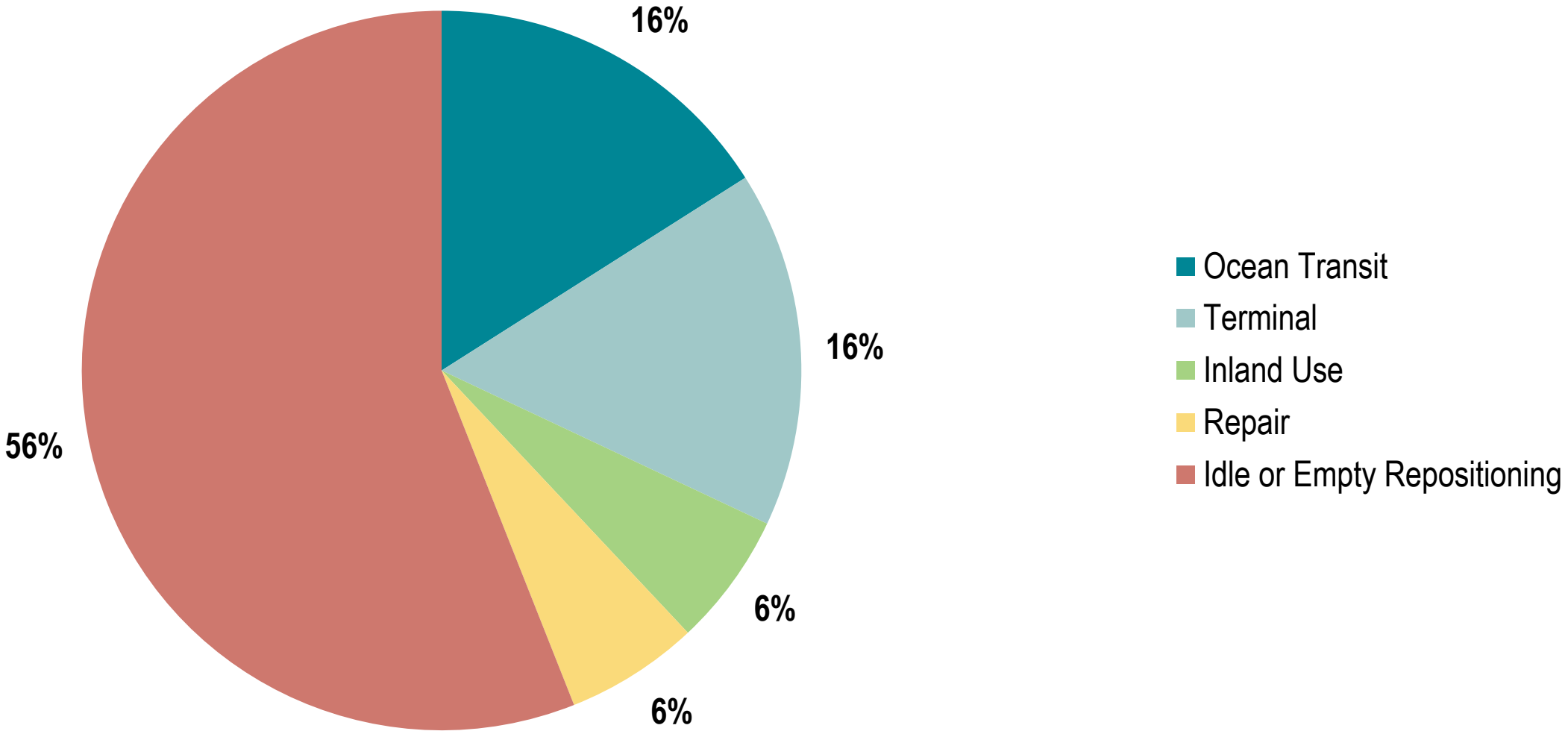
World Container Throughput, 1980-2018



Containerization Growth Factors

FACTOR	Volume Growth	Volume Decline
Derived 	• Economic and income growth • Outsourcing and offshoring • Complex supply chains	• Economic recessions • Trade protectionism • Automation
Substitution 	• Capture of bulk and break-bulk markets • New niches (commodities and cold chain)	• Peak substitution • Composition of container fleet
Incidental 	• Trade imbalances • Repositioning of empty containers	• Trade protectionism • Automation
Induced 	• Transshipment (hubbing, relay and intersection)	• Changes in shipping networks (more direct services)

Container Usage during its Life-Span



Advantages of Containerization

Factor	Advantage
Standard transport product	ISO standard. Specialized ships, trucks and wagons. Unique identification number and size type code.
Flexibility of usage	Commodities (coal, wheat), manufactured goods, cars, frozen products. Adapted containers for dry cargo, liquids (oil and chemical products) and refrigerated cargo. Reuse of discarded containers.
Costs	Low transport costs; 20 times less than bulk transport. Economies of scale at modes and terminals.
Velocity	Fast transshipment operations. Low terminal turnaround times (port time reduced from 3 weeks to about 24 hours).
Warehousing	Own warehouse; Simpler and less expensive packaging. Stacking capability on ships, trains (doublestacking) and on the ground.
Security and Safety	Contents of the container is unknown to carriers. Can only be opened at the origin, at customs and at the destination. Reduced spoilage and losses (theft).

Challenges of Containerization

Factor	Challenge
Site constraints	Large consumption of terminal space (mostly for storage); move to urban periphery. Draft issues with larger containerships (more than 13 meters).
Infrastructure costs	Container handling infrastructures and equipment (giant cranes, warehousing facilities, inland road, rail access), are important investments.
Stacking	Complexity of arrangement of containers, both on the ground and on modes (containerships and double-stack trains). Restacking difficult to avoid.
Empty movements	Many containers are moved empty (20% of all flows). Either full or empty, a container takes the same amount of space. Divergence between production and consumption; repositioning.
Theft and losses	High value goods and a load unit that can opened or carried (on truck). Vulnerability between terminal and final destination. 10,000 containers are lost at sea each year (fall overboard).
Illicit trade	Common instrument used in the illicit trade of goods, drugs and weapons, as well as for illegal immigration. Concerns about the usage of containers for terrorism.

Advantages and Drawbacks of Containerization

ADVANTAGES

Standardization

ISO standard (modes and equipment). Unique identification number and size type code.

Flexibility

Commodities, manufactured goods, liquids and refrigerated goods.

Costs

Low transport costs. Economies of scale at modes and terminals.

Velocity

Fast transshipment operations. Low terminal turnaround times.

Warehousing

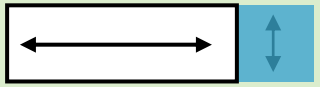
Own warehouse; simpler and less expensive packaging. Stacking capability.

Security & Safety

Contents unknown to carriers. Reduced spoilage and losses.

DRAWBACKS

Site constraints



Large consumption of terminal space. Draft issues with larger containerships.

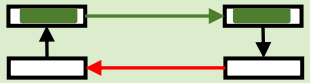
Capital intensiveness

Container handling infrastructures and equipment are important investments.

Stacking

Complexity of arrangement of containers, both on the ground and on modes.

Repositioning



Divergence between production and consumption; repositioning. 20% of all containers.

Theft and losses

High value goods vulnerable to thefts, particularly between terminal and final destination.

Illicit trade

Illicit trade of goods, drugs and weapons, as well as for illegal immigration.

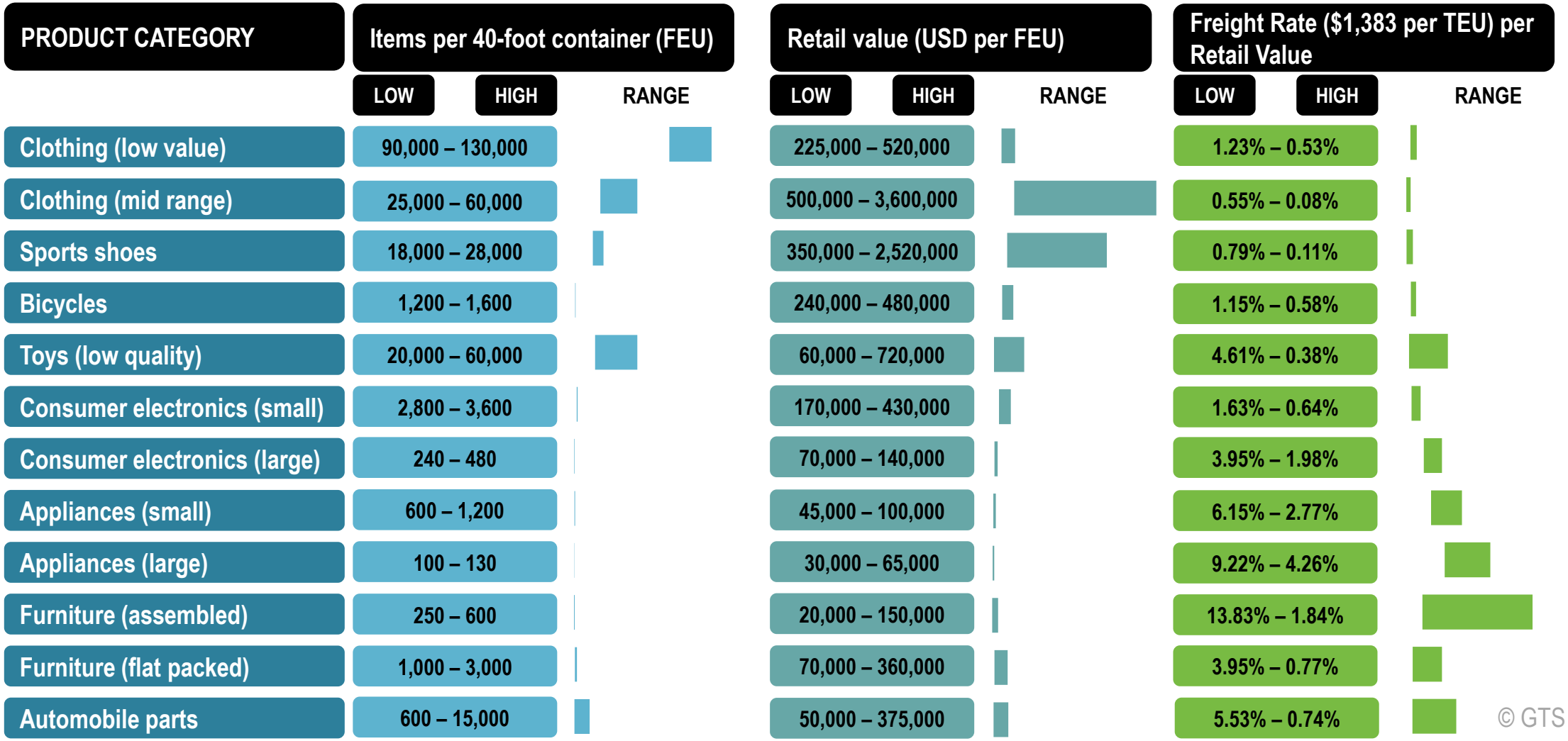
Container Shipping Costs and Cargo Value

Products	Items / 40 Foot Container		Retail Value (USD)		Freight / Value (%)	
	Low	High	Low	High	Low	High
Clothing (low value)	90,000	130,000	225,000	520,000	0.56	1.91
Clothing (mid range)	25,000	60,000	500,000	3,600,000	0.08	0.86
Sports shoes	18,000	28,000	350,000	2,520,000	0.12	0.23
Bicycles	1,200	1,600	240,000	480,000	0.60	1.79
Toys (low quality)	20,000	60,000	60,000	720,000	0.40	7.17
Consumer electronics (small)	2,800	3,600	170,000	430,000	0.67	2.53
Consumer electronics (large)	240	480	70,000	140,000	2.07	6.14
Appliances (small)	600	1,200	45,000	100,000	2.90	9.56
Appliances (large)	100	130	30,000	65,000	4.16	14.33
Furniture (assembled)	250	600	20,000	150,000	1.93	21.50
Furniture (flat packed)	1,000	3,000	70,000	360,000	0.80	6.14
Automobile parts	600	15,000	50,000	375,000	0.77	8.60

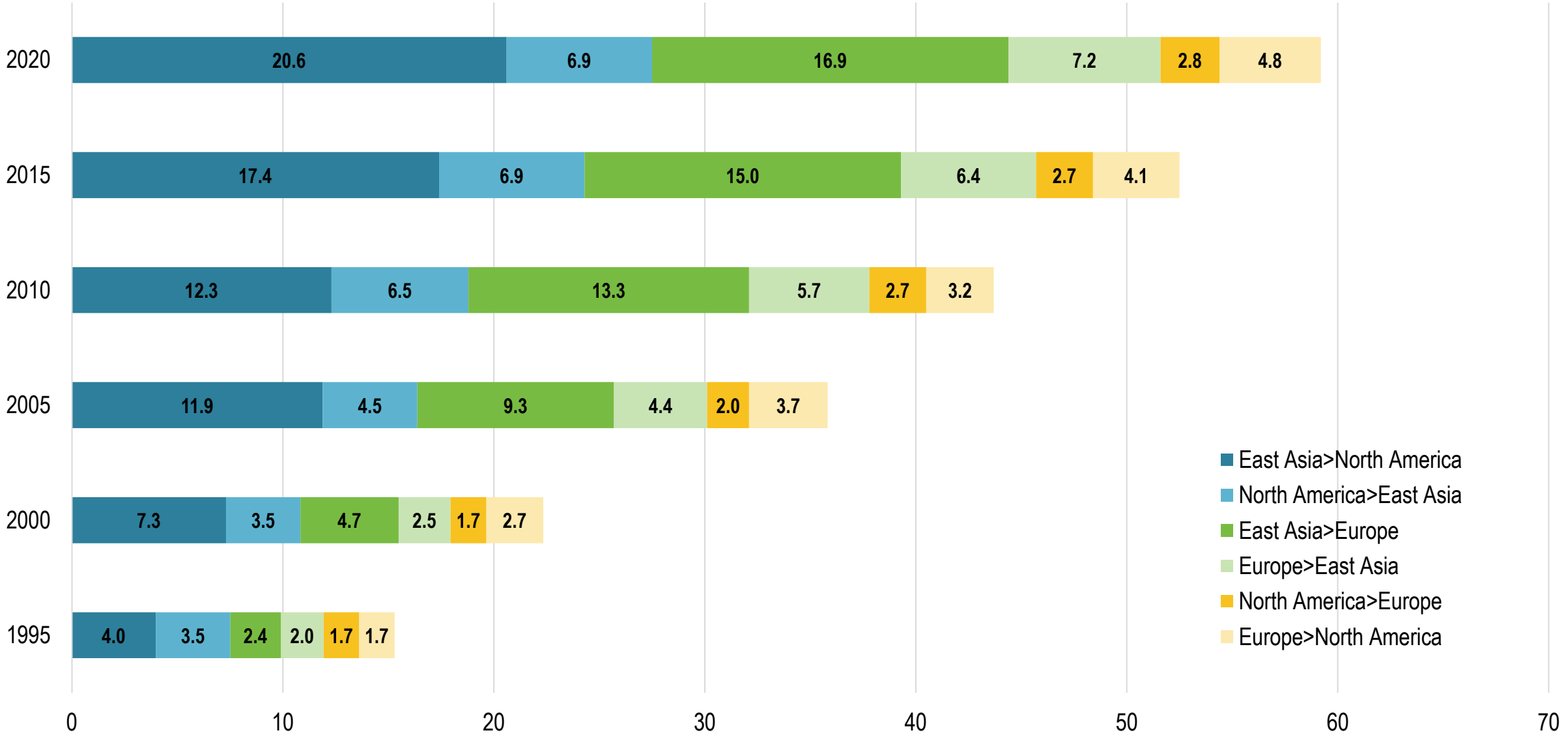
Container Shipping Costs and Cargo Value (updated)

Products	Items per 40 Foot Container (FEU)		Retail Value (USD per FEU)		Freight Rate ($1,383 per TEU) per Retail Value (%)	
	Low	High	Low	High	Low	High
Clothing (low value)	90,000	130,000	225,000	520,000	1.23	0.53
Clothing (mid range)	25,000	60,000	500,000	3,600,000	0.55	0.08
Sports shoes	18,000	28,000	350,000	2,520,000	0.79	0.11
Bicycles	1,200	1,600	240,000	480,000	1.15	0.58
Toys (low quality)	20,000	60,000	60,000	720,000	4.61	0.38
Consumer electronics (small)	2,800	3,600	170,000	430,000	1.63	0.64
Consumer electronics (large)	240	480	70,000	140,000	3.95	1.98
Appliances (small)	600	1,200	45,000	100,000	6.15	2.77
Appliances (large)	100	130	30,000	65,000	9.22	4.26
Furniture (assembled)	250	600	20,000	150,000	13.83	1.84
Furniture (flat packed)	1,000	3,000	70,000	360,000	3.95	0.77
Automobile parts	600	15,000	50,000	375,000	5.53	0.74

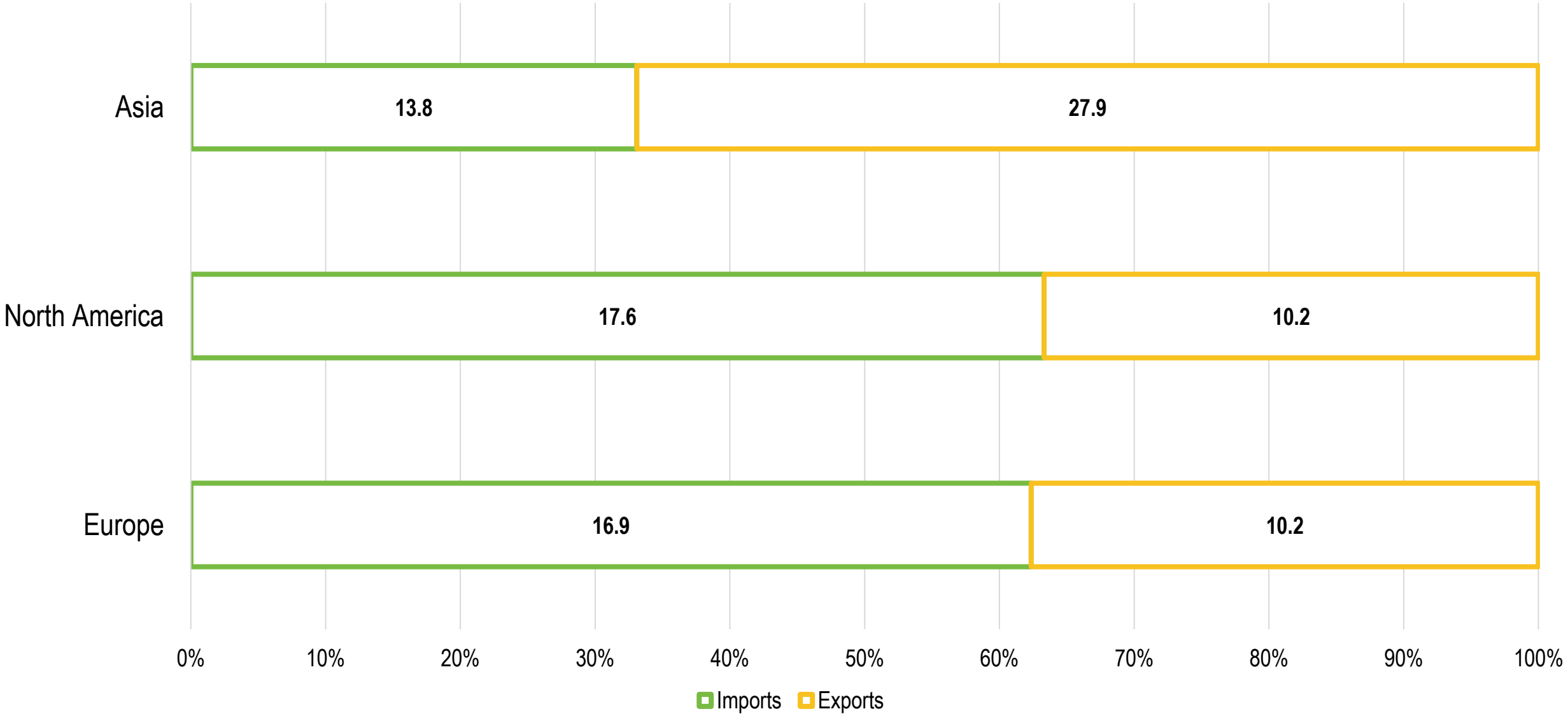
Container Shipping Costs and Cargo Value



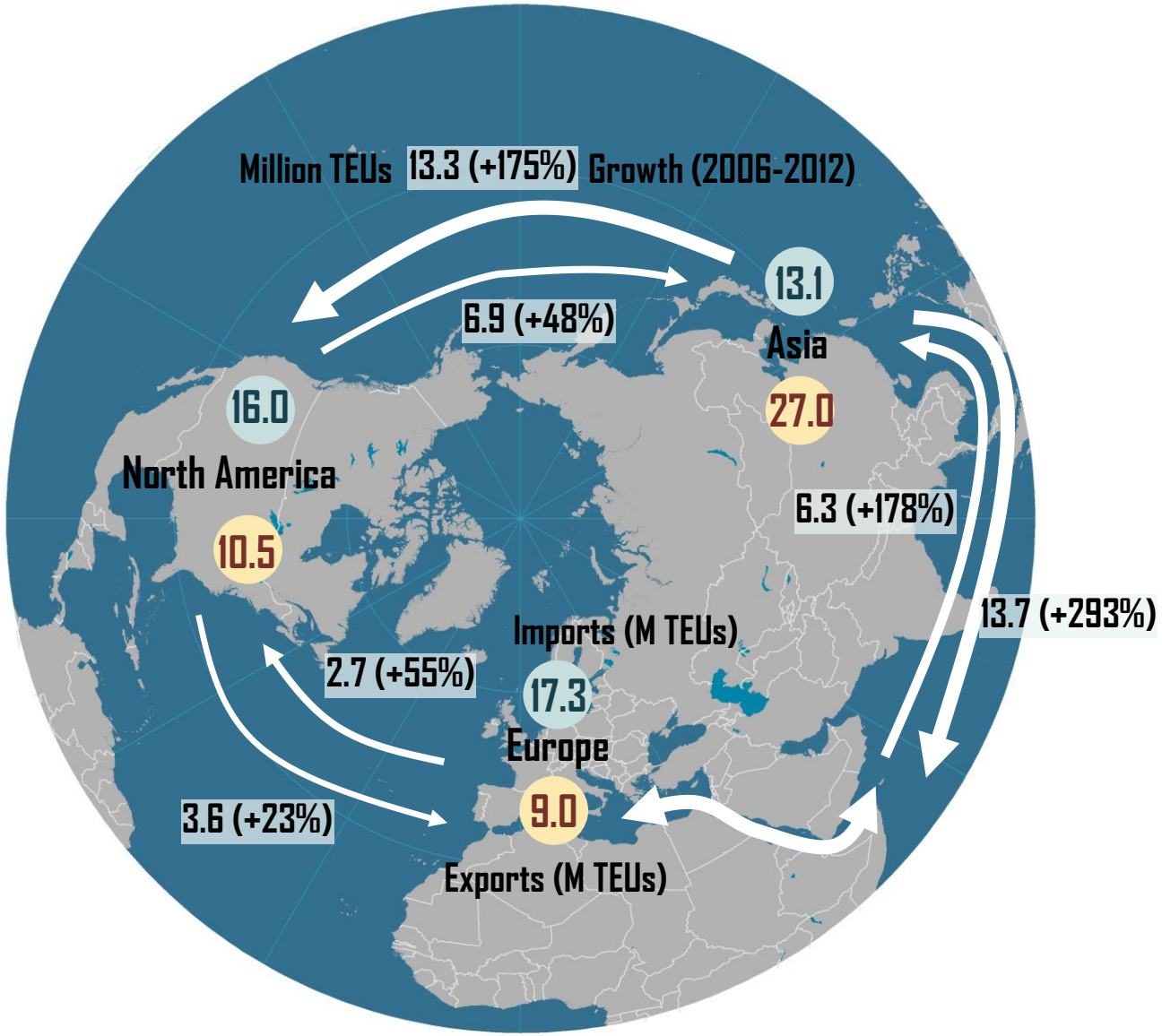
Containerized Cargo Flows along Major Trade Routes, 1995-2020 (in million TEUs)



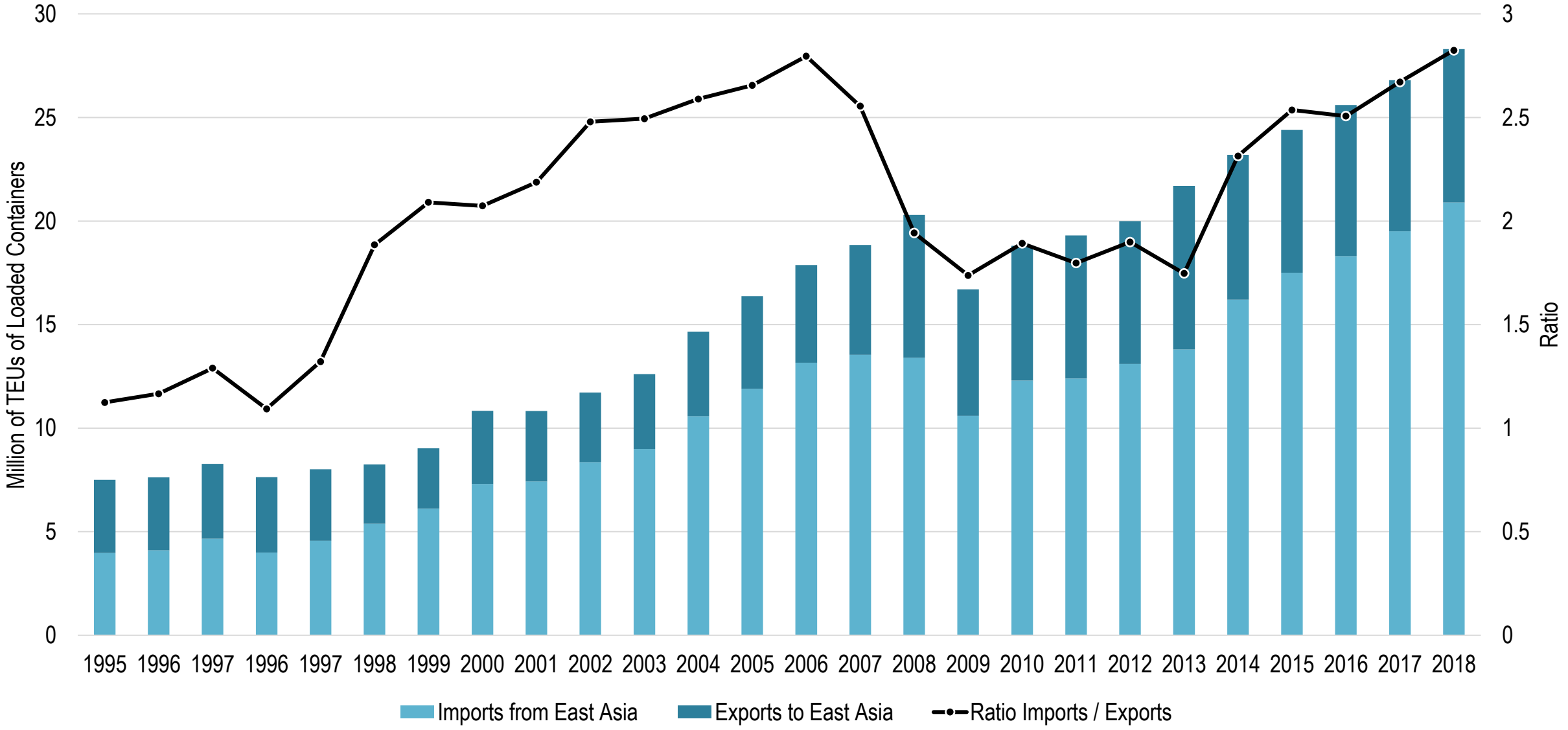
Containerized Imports and Exports between Main Economic Region, 2013



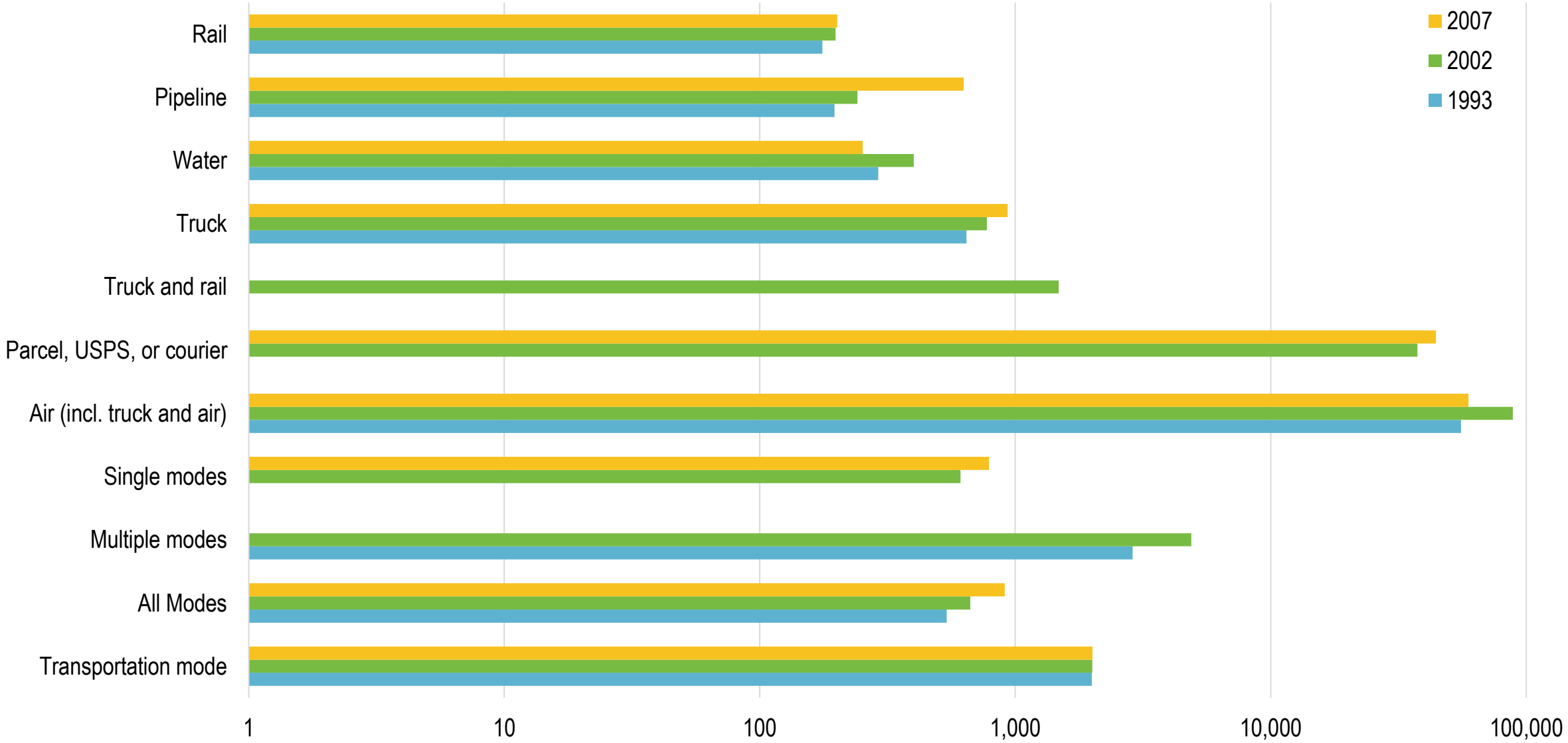
Containerized Cargo Flows along Major Trade Routes, 2012



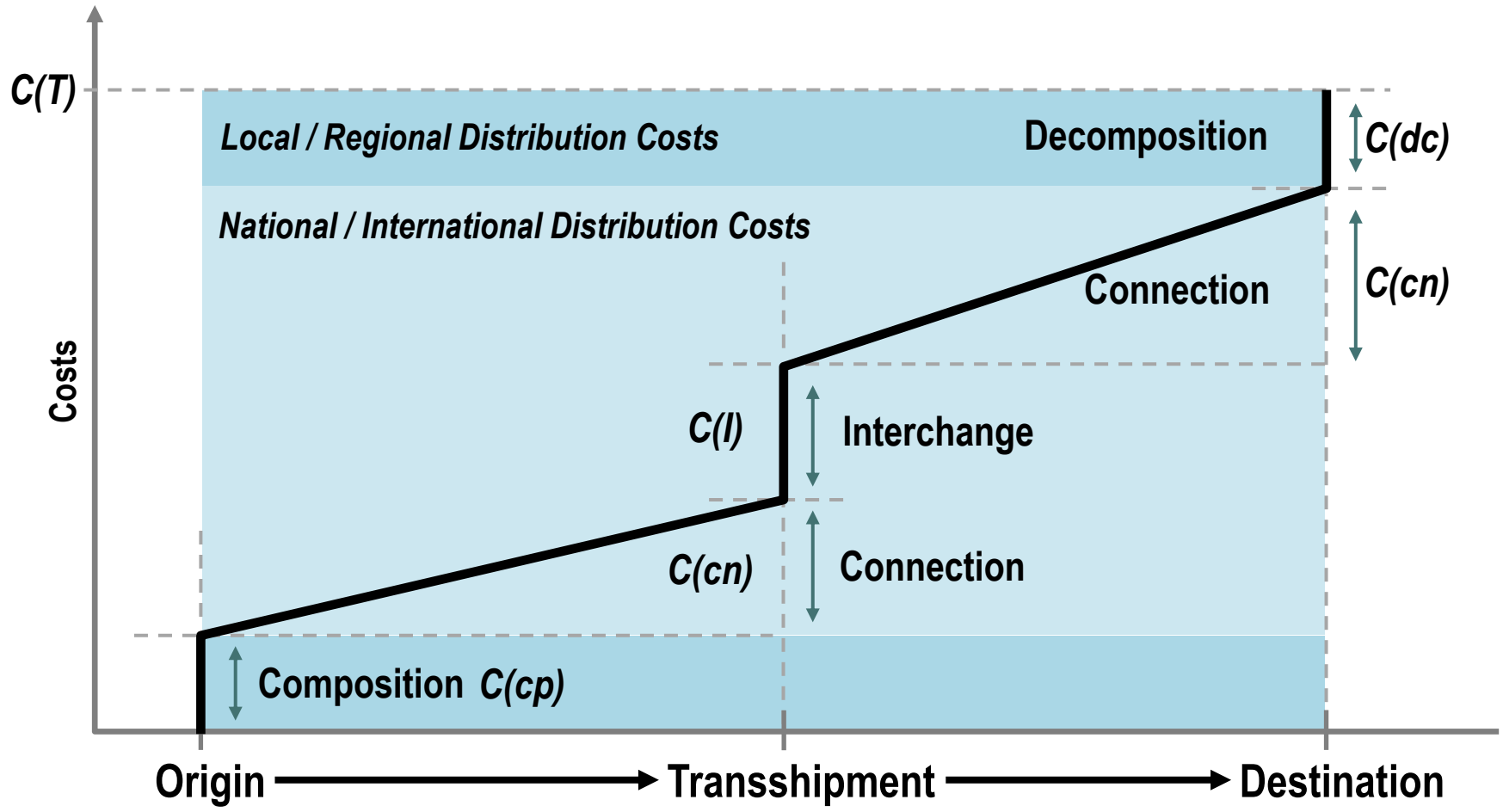
North American Containerized Trade with East Asia, 1996-2018 (TEUs)



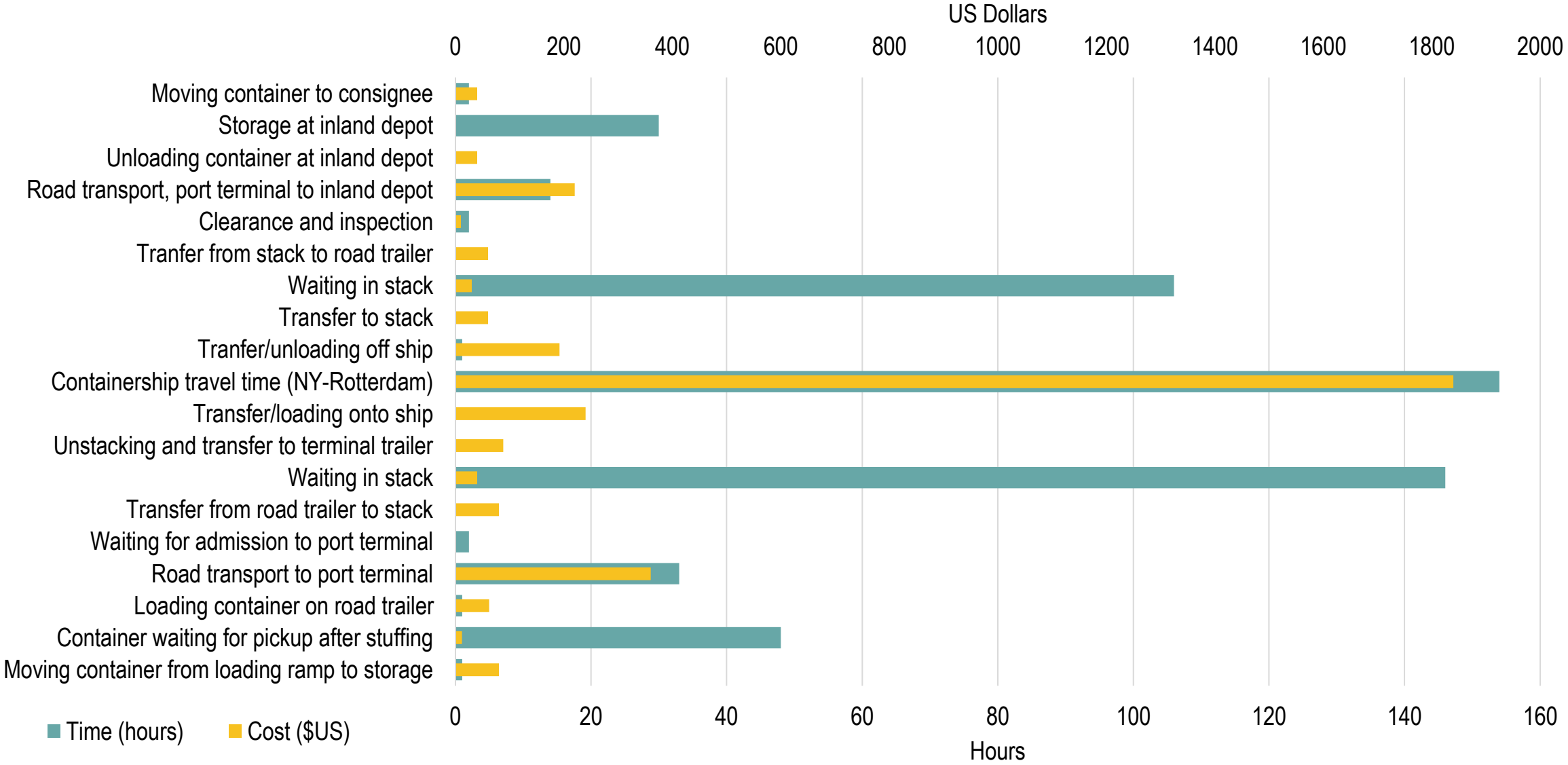
Value Per Ton of U.S. Freight Shipments by Transportation Mode, 1993-2007



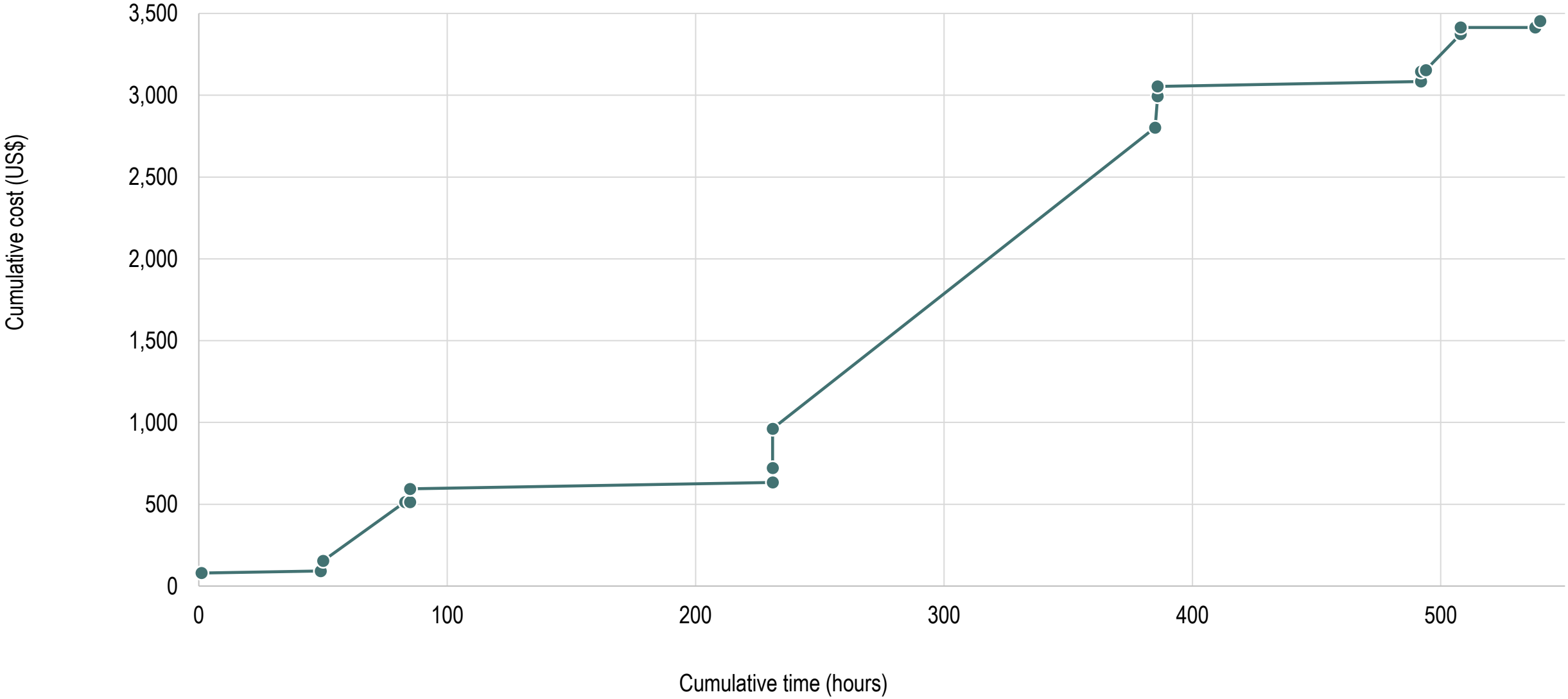
Intermodal Transportation Cost Function



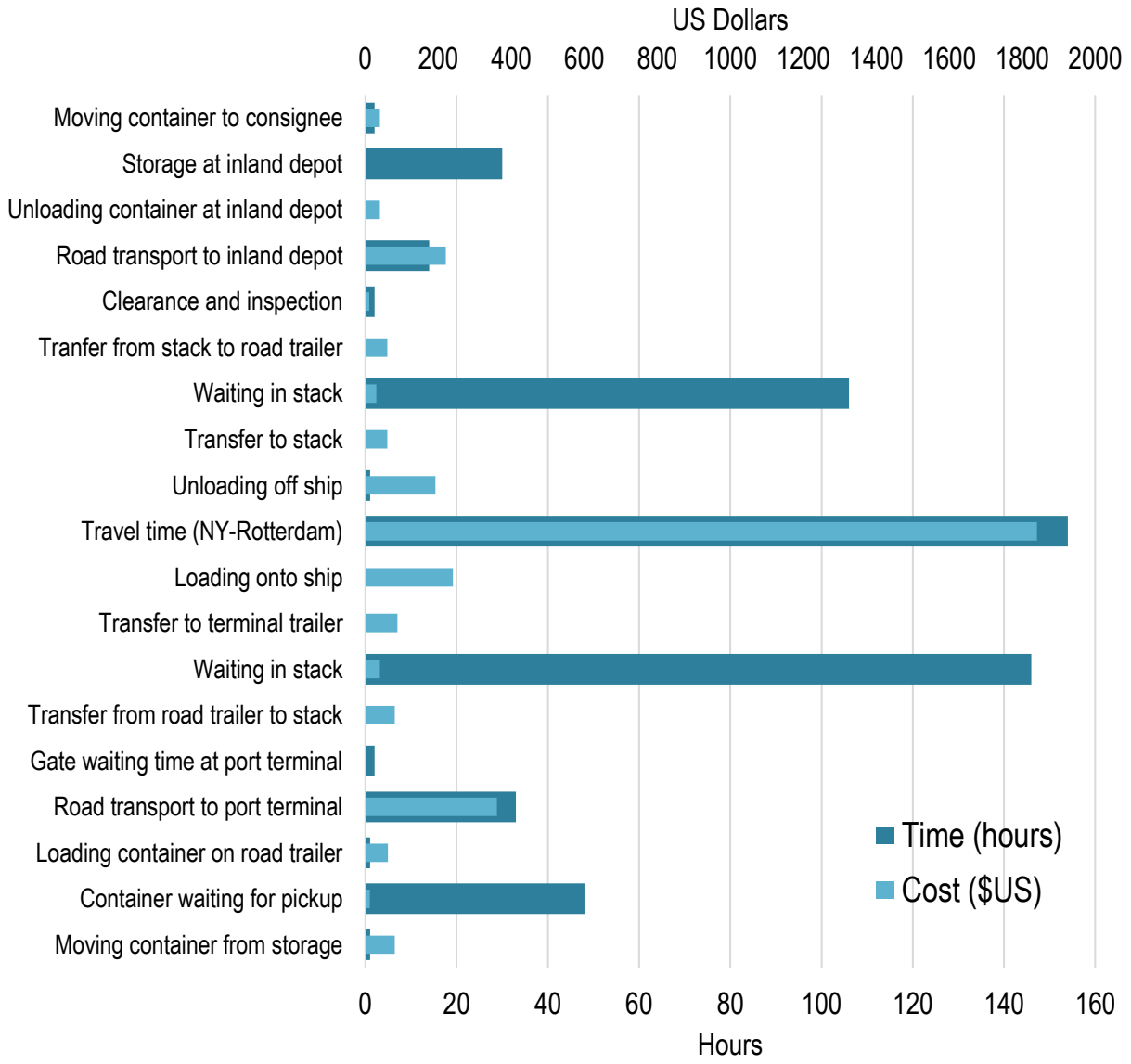
Time and Cost Involving Moving a 40 Foot Container between the American East Coast and Western Europe

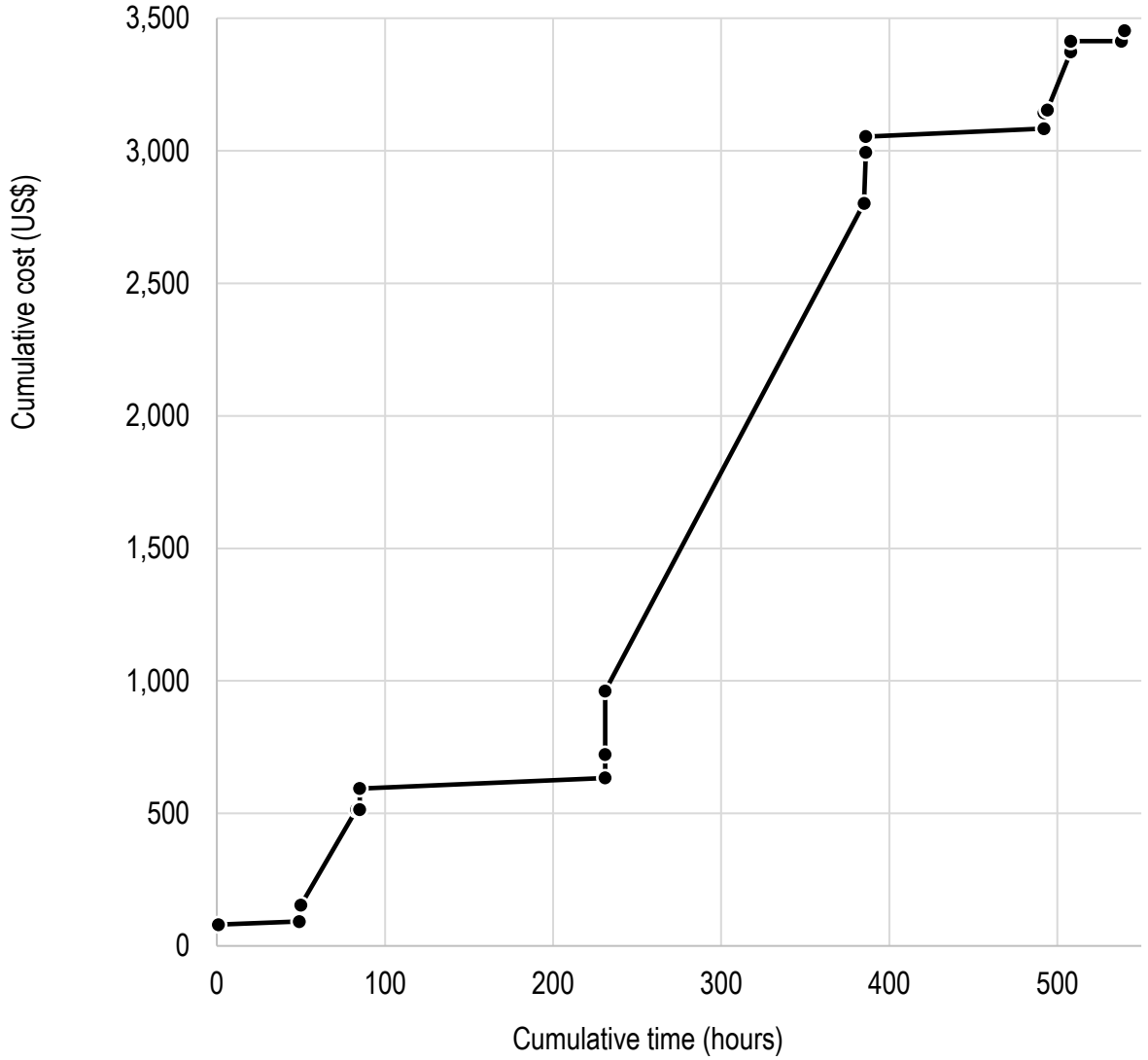


Cumulative Cost and Time of Moving a 40 Foot Container between the American East Coast and Western Europe

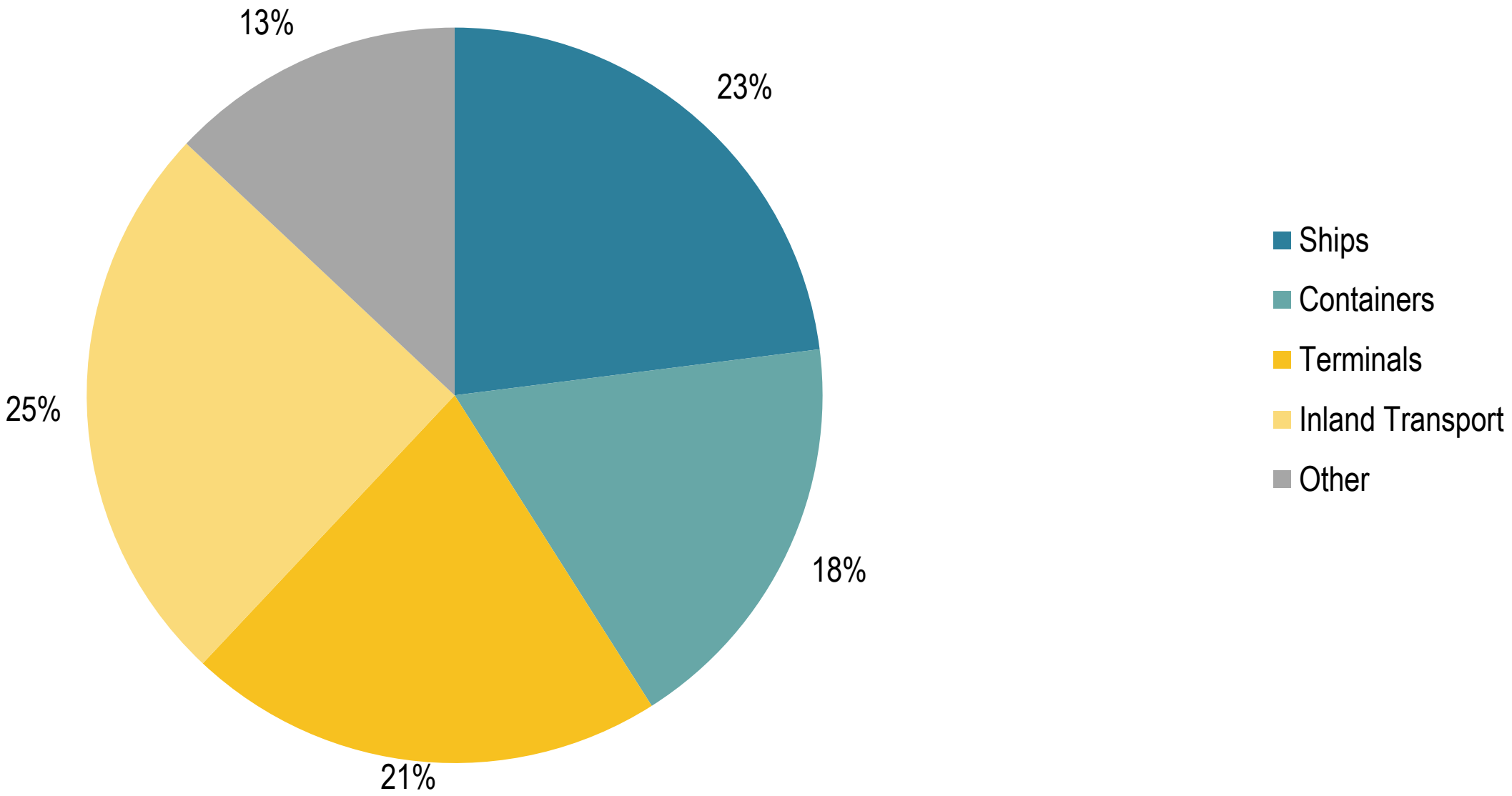


Time and Cost for Moving a 40 Foot Container between the American East Coast and Western Europe

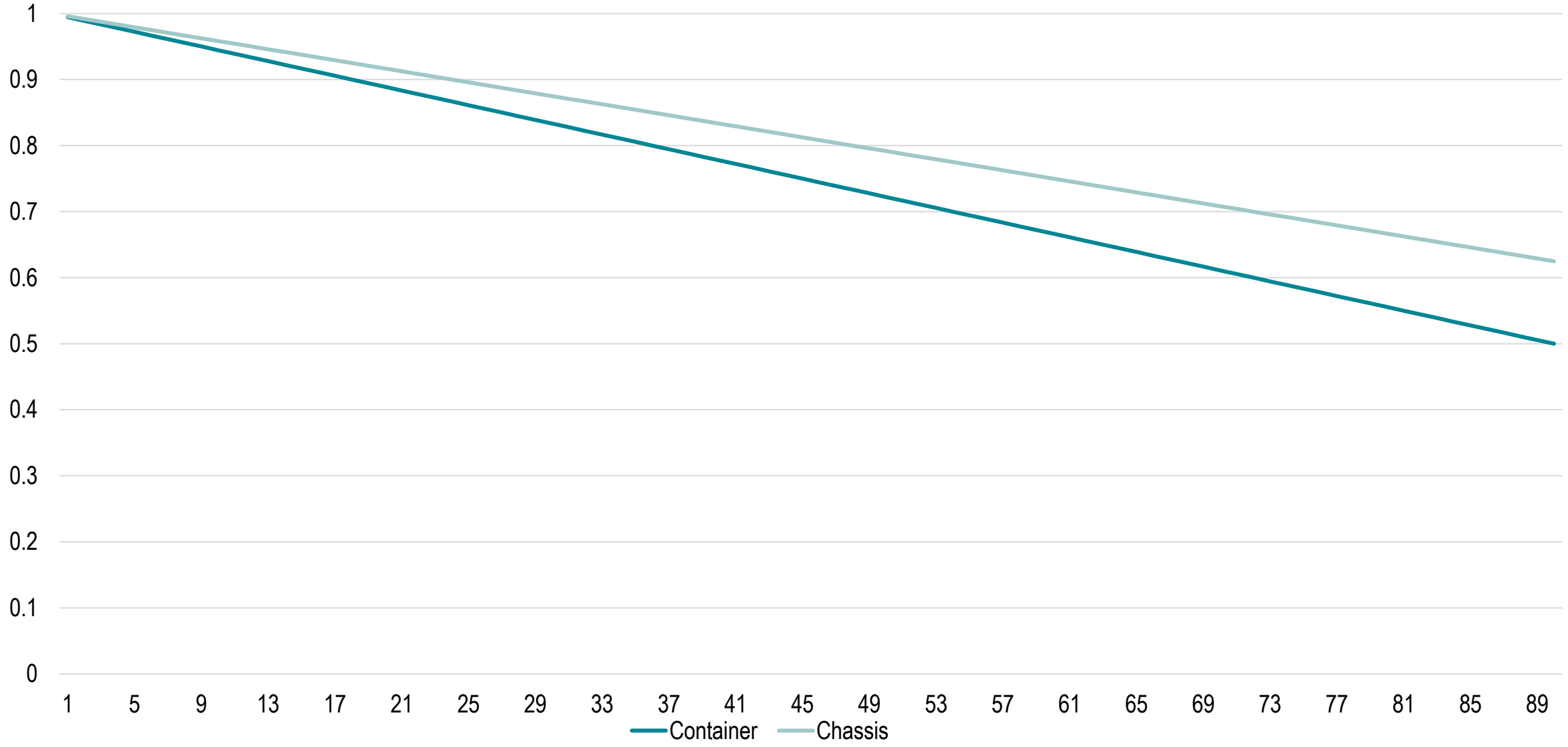




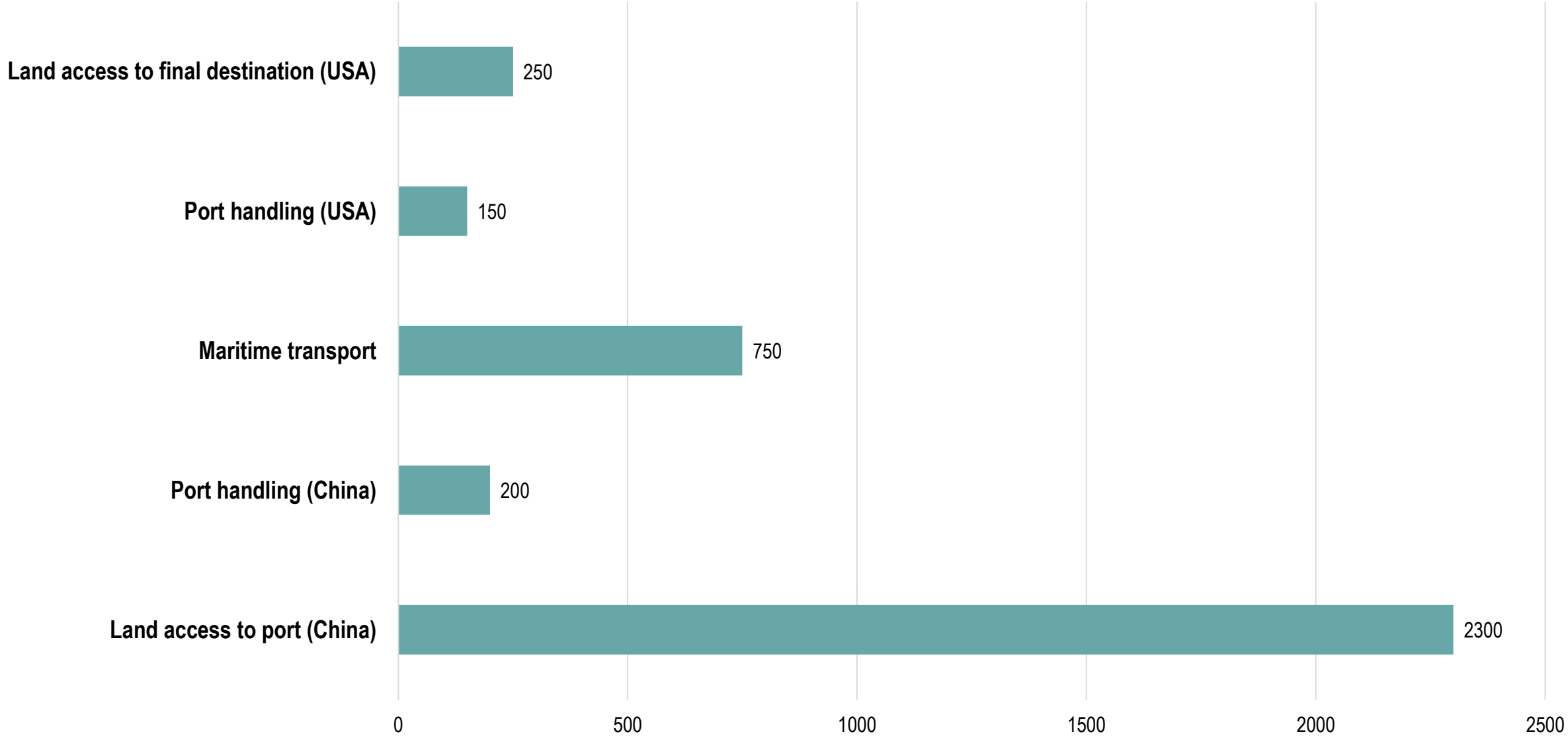
Container Transport Costs, 2000s



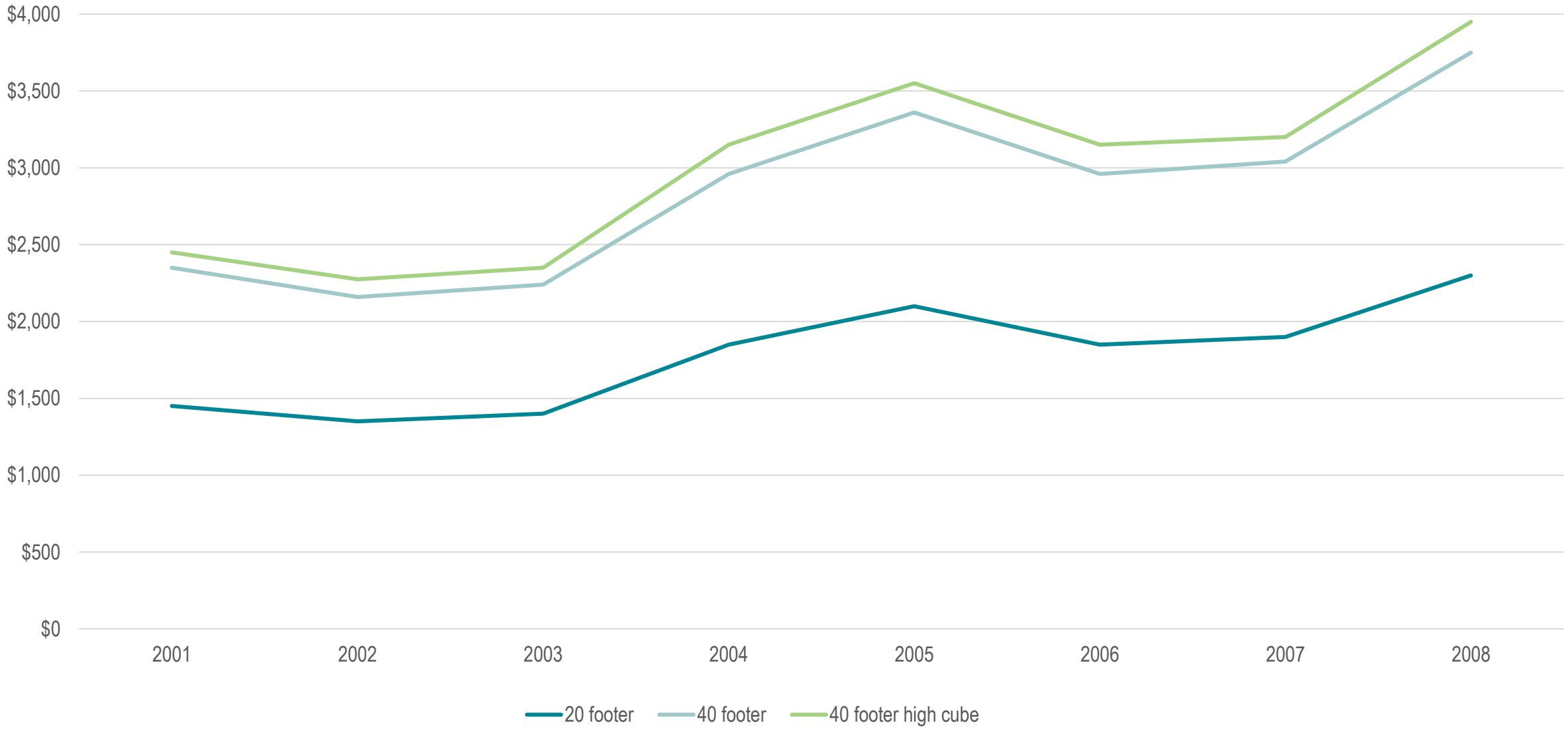
Monthly Intermodal Equipment Depreciation Factors



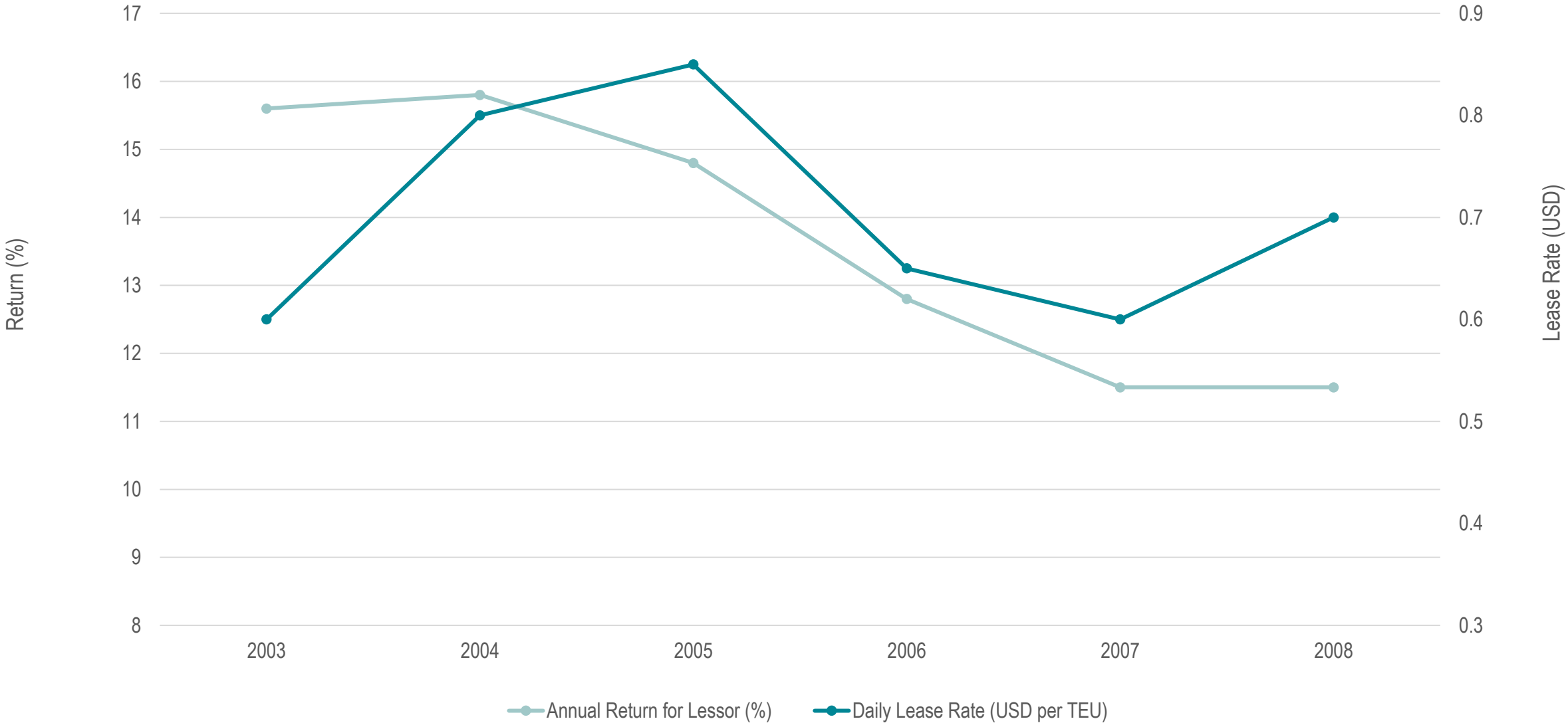
Container Transport Costs from Inland China to US West Coast ($US per TEU)



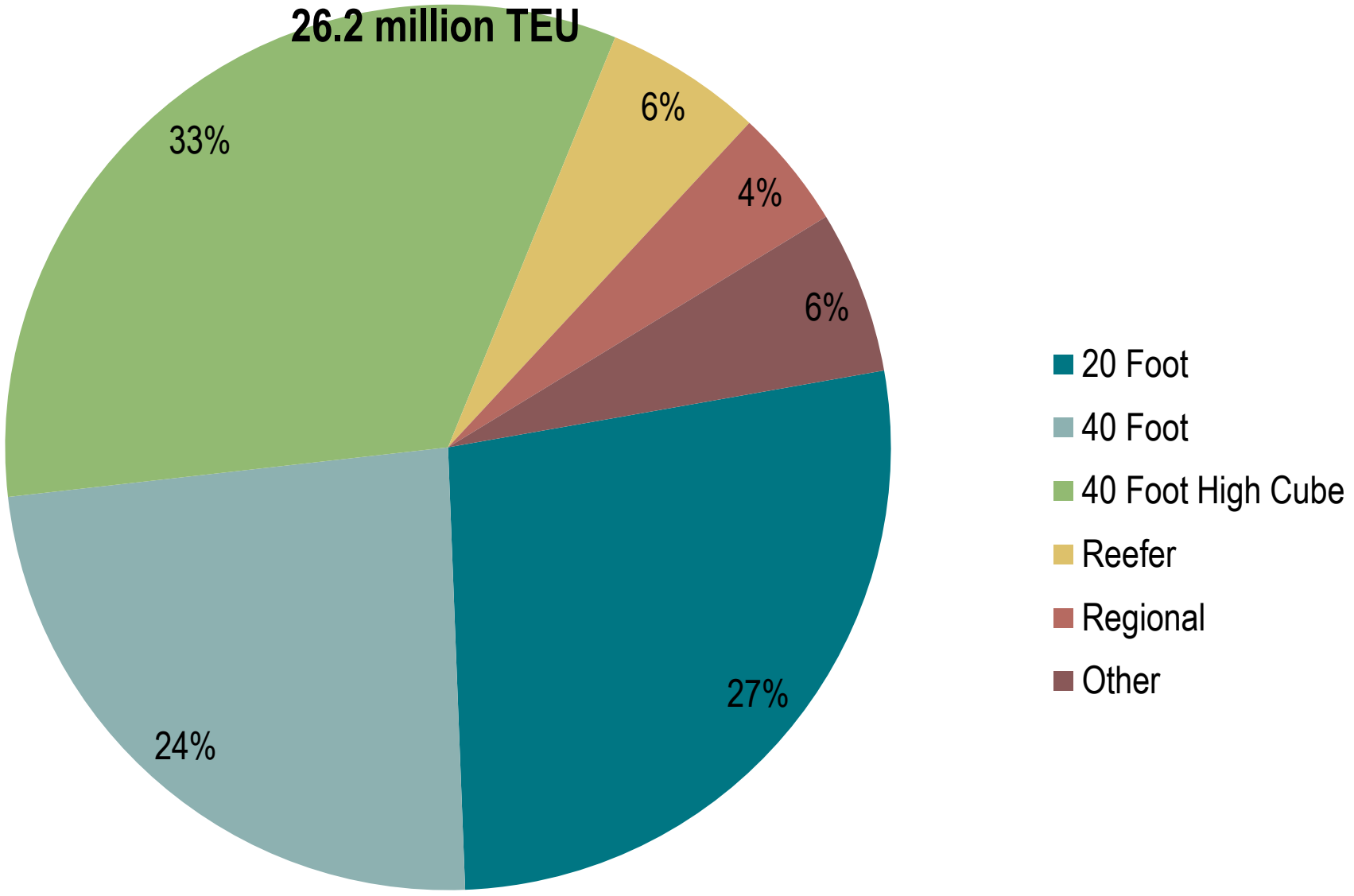
Price of New Containers, 2001-2008



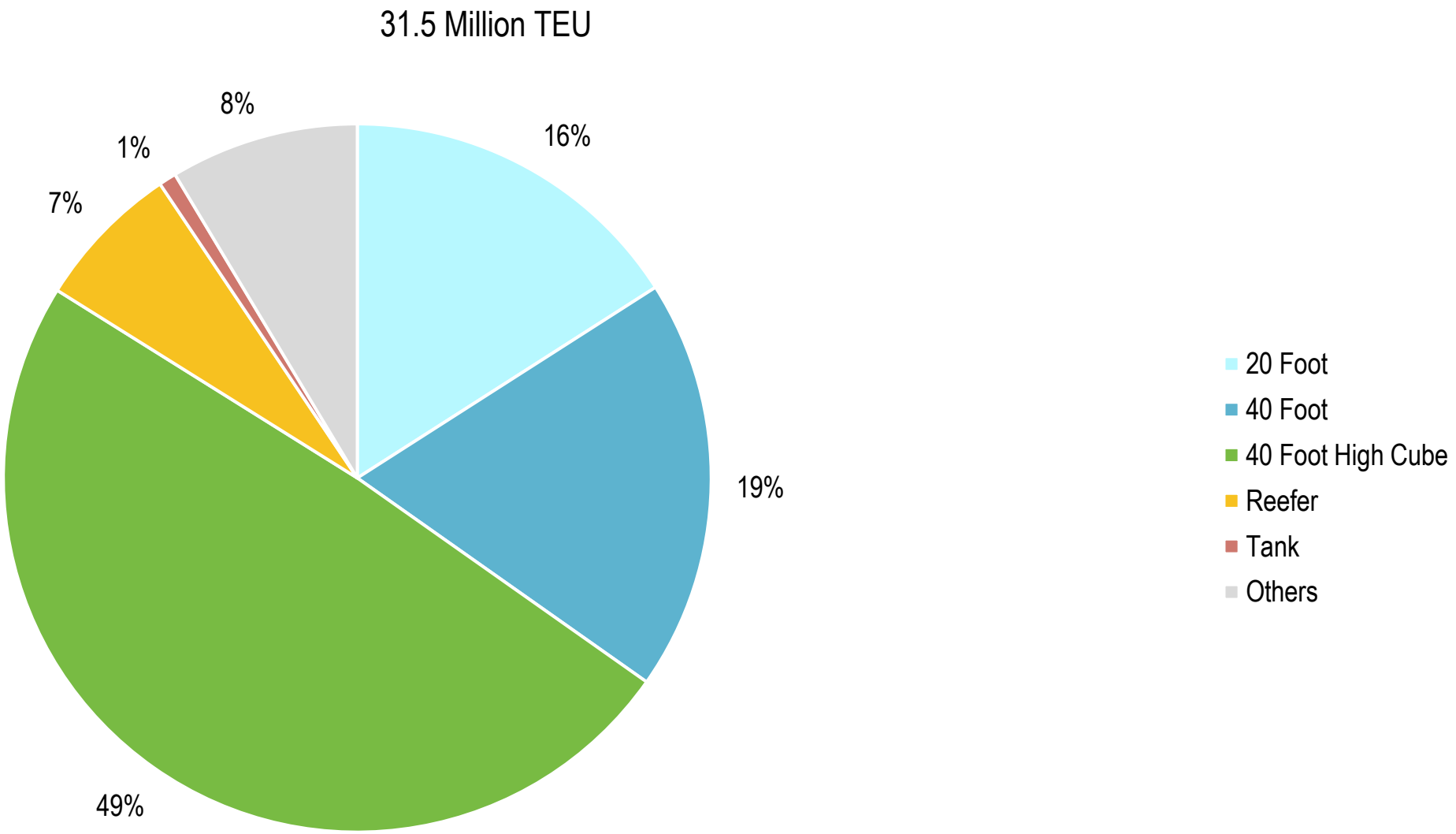
Container Lease Rates, 2003-2008



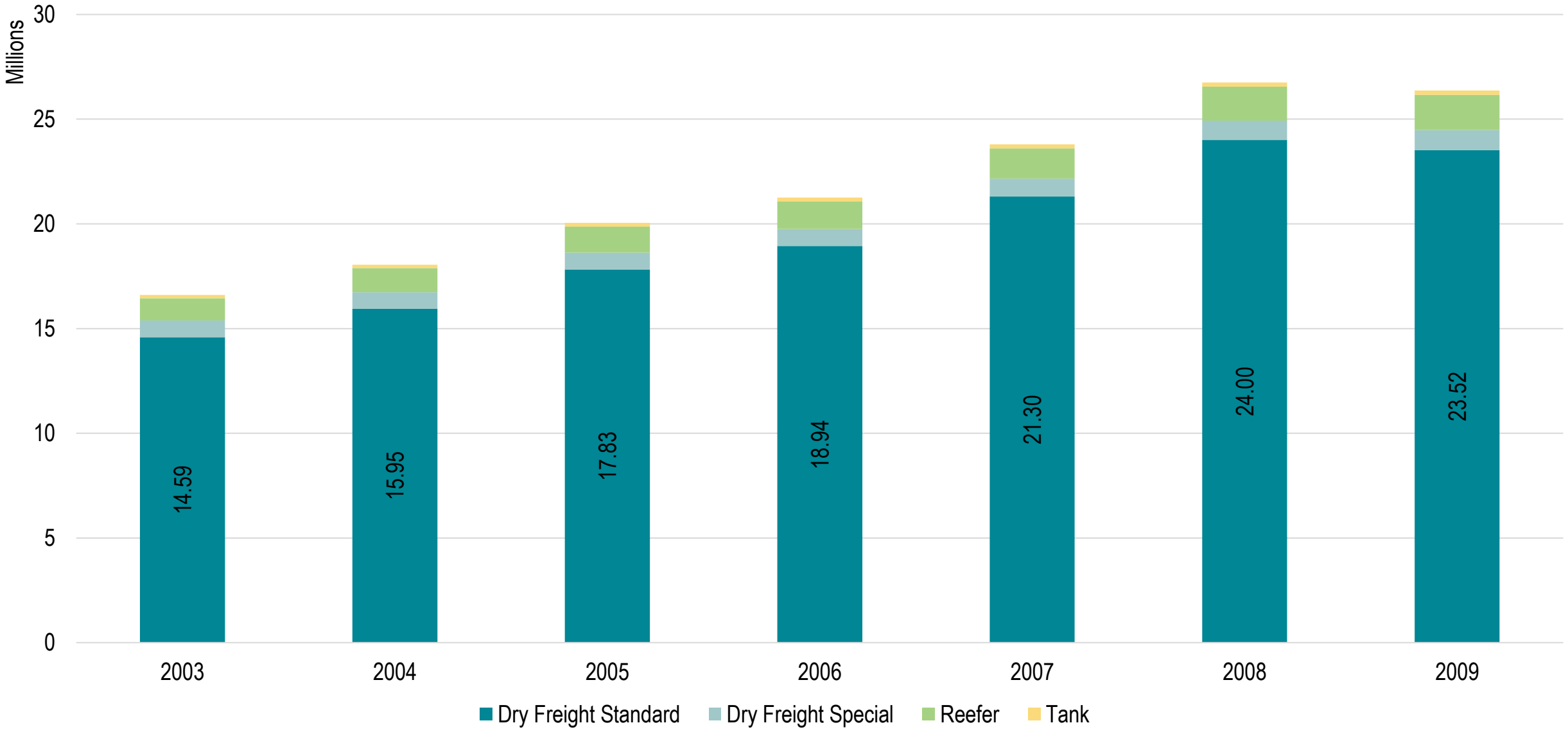
Composition of the Global Fleet of Containers, 2008



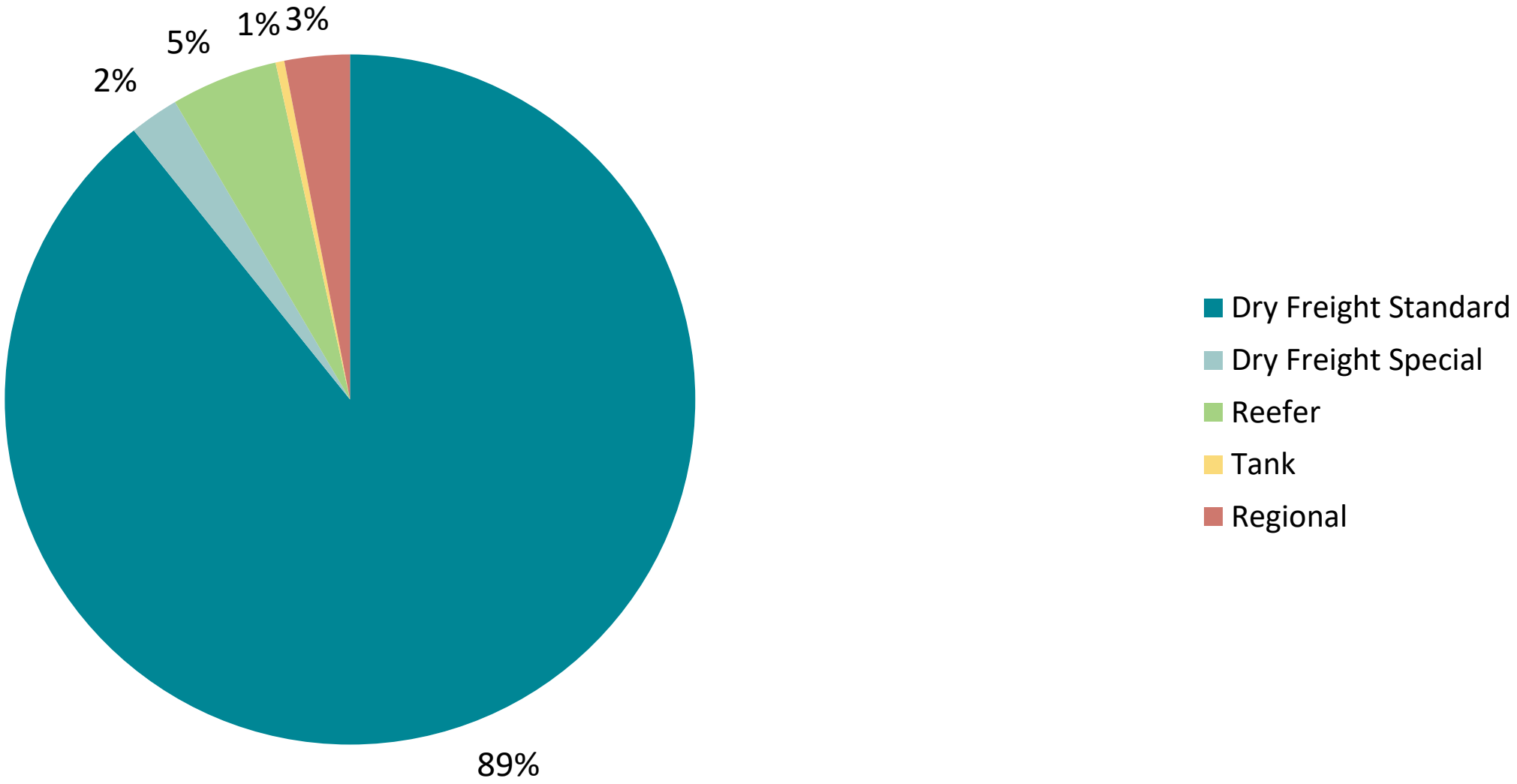
Composition of the Global Fleet of Containers, 2012



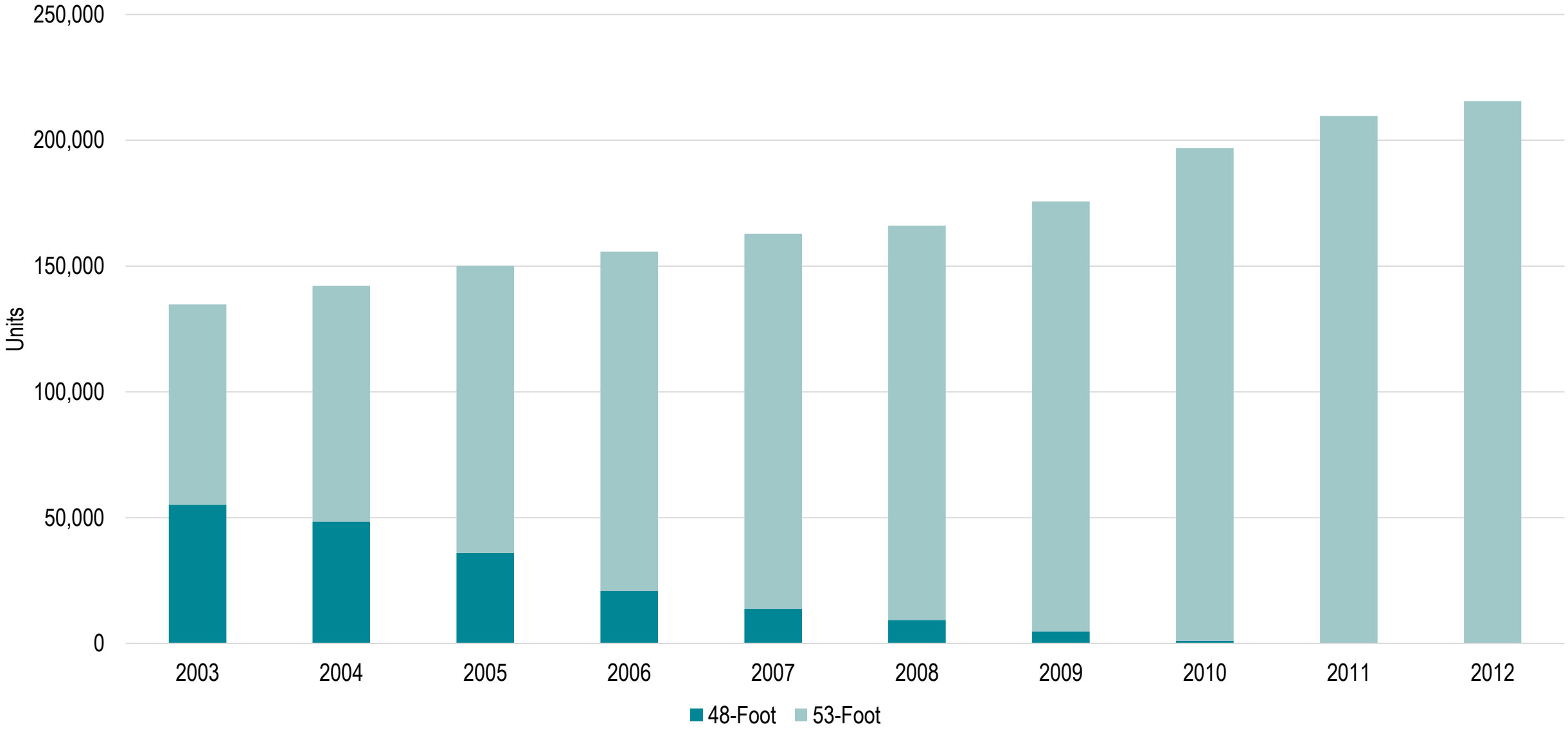
Global Container Fleet, 2003-2009



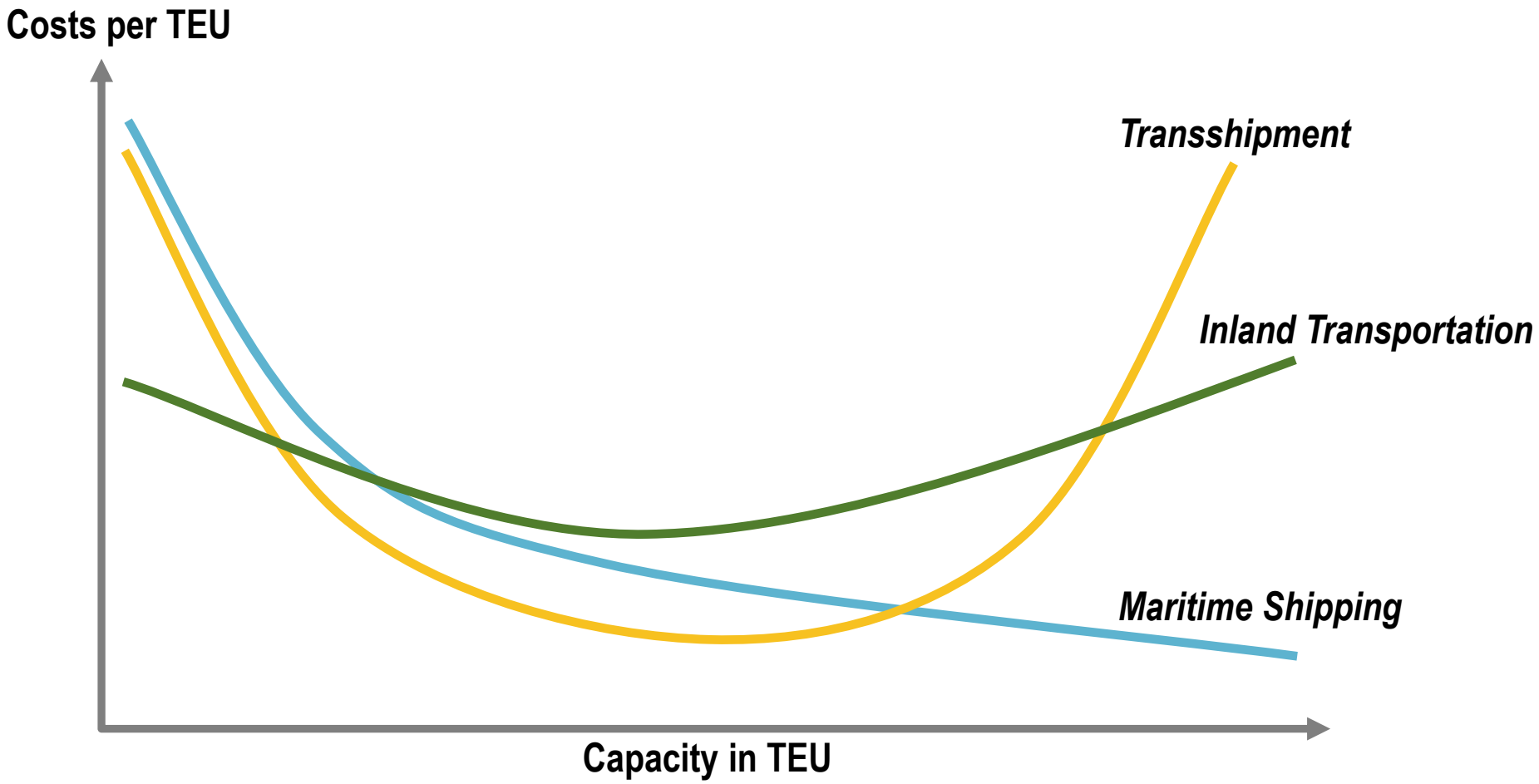
World Container Production, 2007



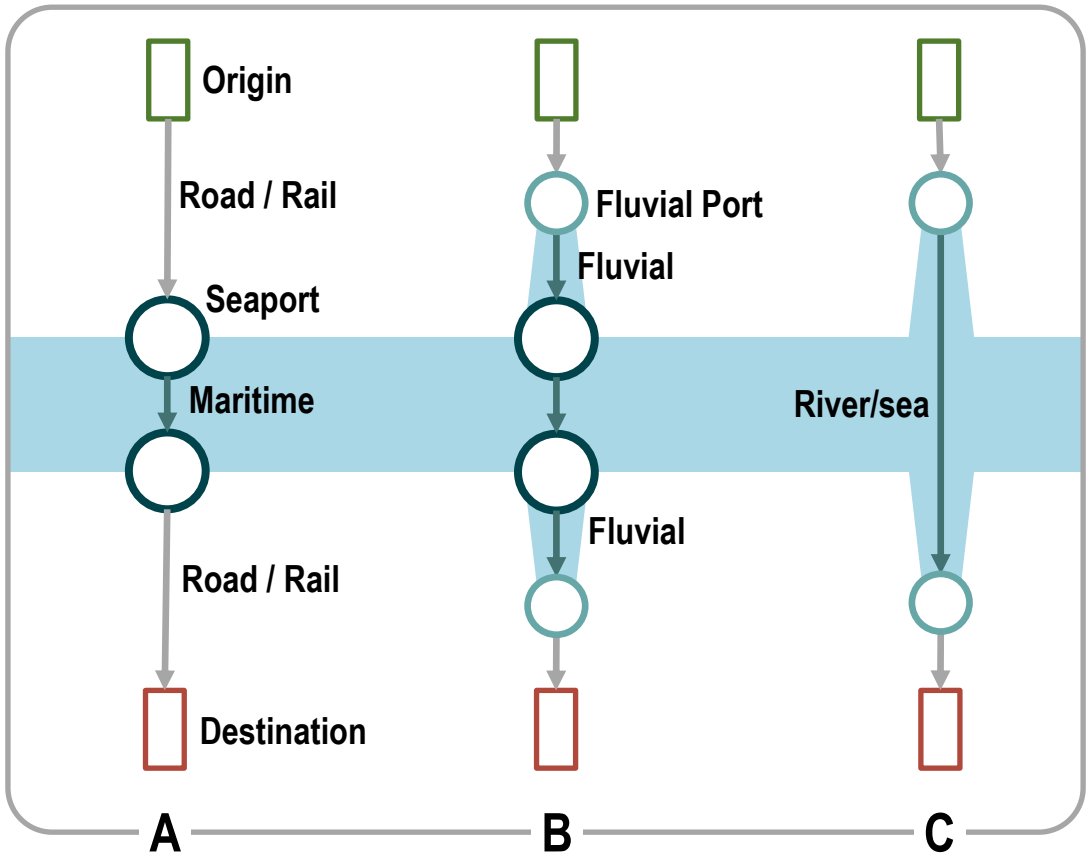
Composition of the American Domestic Container Fleet, 2003-2012



Economies and Diseconomies of Scale in Container Shipping



Impacts of River / Sea Shipping



Digital Intermodalism: Blockchains and Intermodal Transportation