

The Geography of Transport Systems

FIFTH EDITION

Jean-Paul Rodrigue

Transport, Economy and Society

CHAPTER 3

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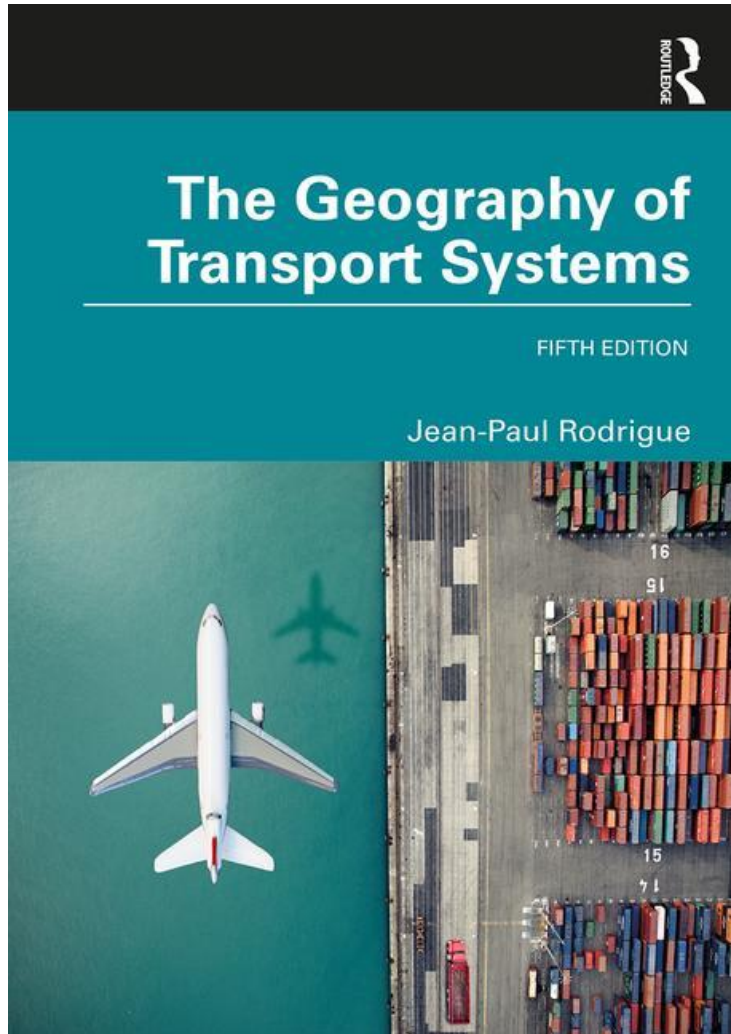
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Transport and Economic Development

Chapter 3.1

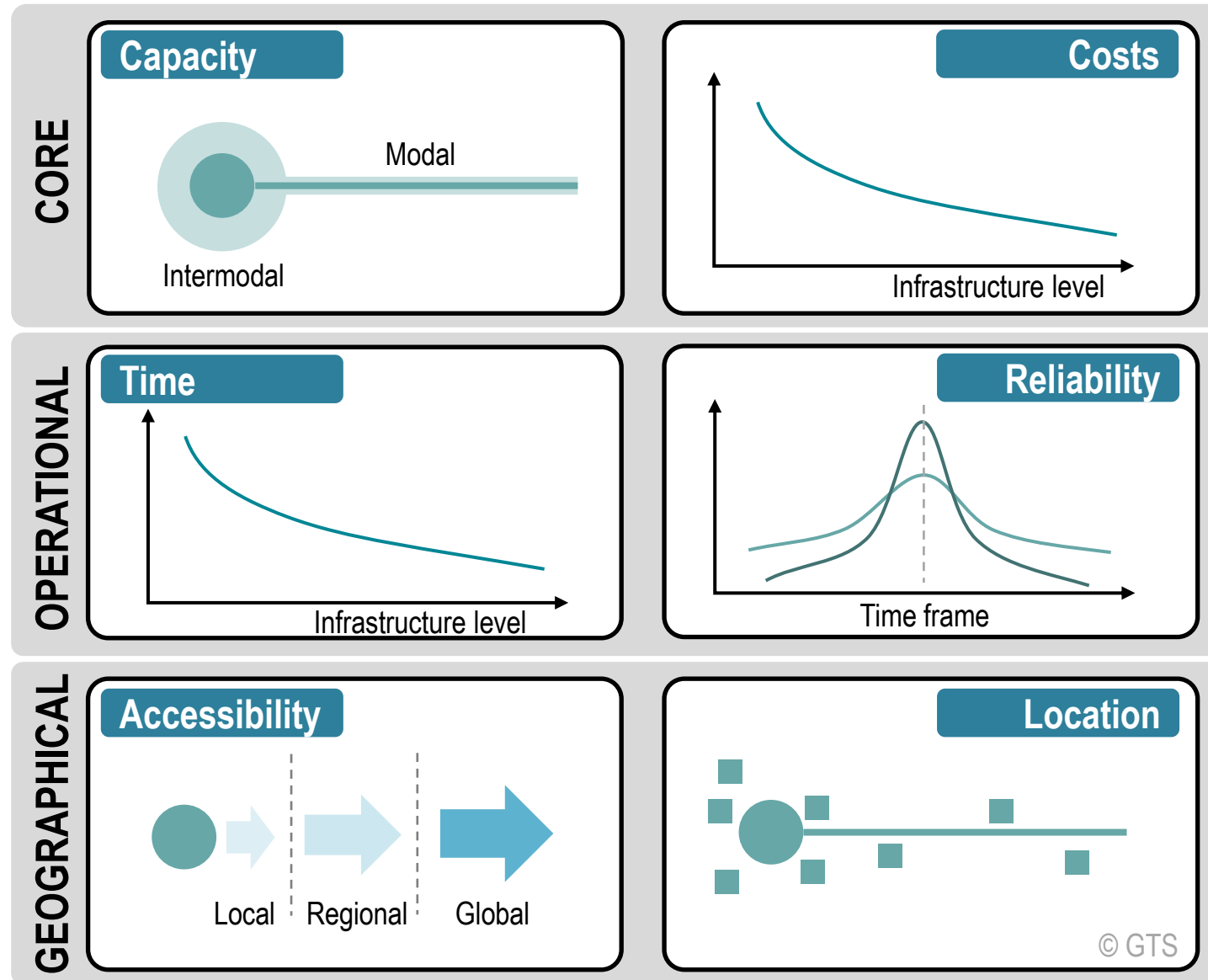
Factors behind the Development of Transport Systems

Scale	Environmental	Historical	Technological	Political	Economic
 Local	Hydrography and geomorphology	Culture and settlement patterns	Roads	Zoning	Employment and distribution
 Regional	Climate	Urban system	Railways and canals	Taxation and regulations	Modal competition and complementarity
 National / Transnational	Distance	Nation state / Colonialism / Imperialism	Corridors and sea routes	Trade agreements	Markets
 Global	Oceanic masses © GTS	Globalization	Air transport and telecommunications	Multilateral agreements (WTO)	Interdependency and comparative advantages

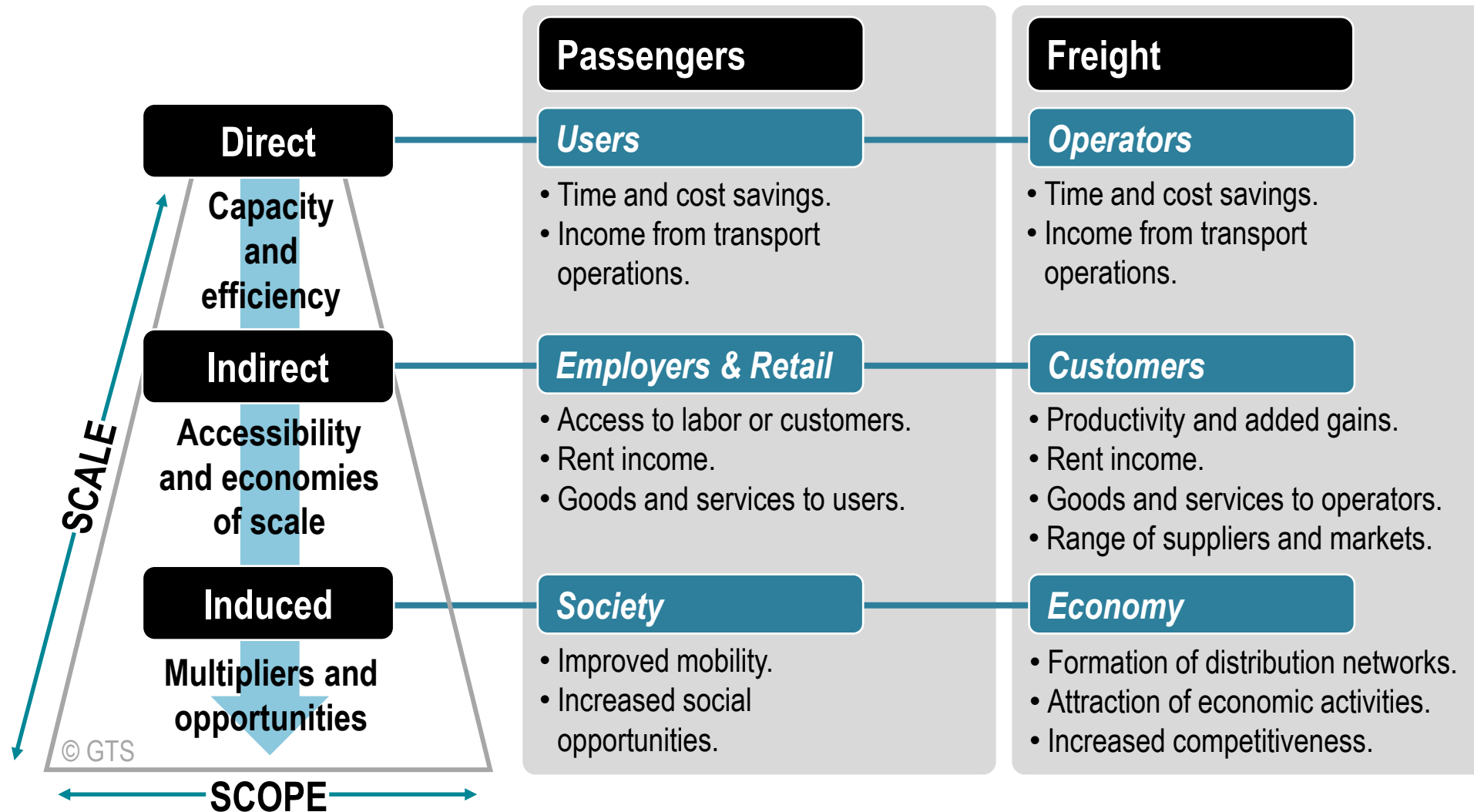
Services and their Associated Infrastructures

Service	Supporting Infrastructures
 Transportation	Roads, bridges, tunnels, rail tracks, ports, harbors, airports, distribution centers, etc.
 Water supply	Dams, reservoirs, pipes, treatment plants, etc.
 Water disposal	Sewers, used water treatment plants, etc. © GTS
 Irrigation	Dams, reservoirs, canals, sprinkling systems, etc.
 Garbage disposal	Landfills, incinerators, recycling facilities, compost units, etc.
 Telecommunications	Telephone exchanges, telephone lines, oceanic cables, cellular towers, fiber optic cables, web servers, etc.
 Power	Power plants, transmission & distribution lines, pipelines, etc.

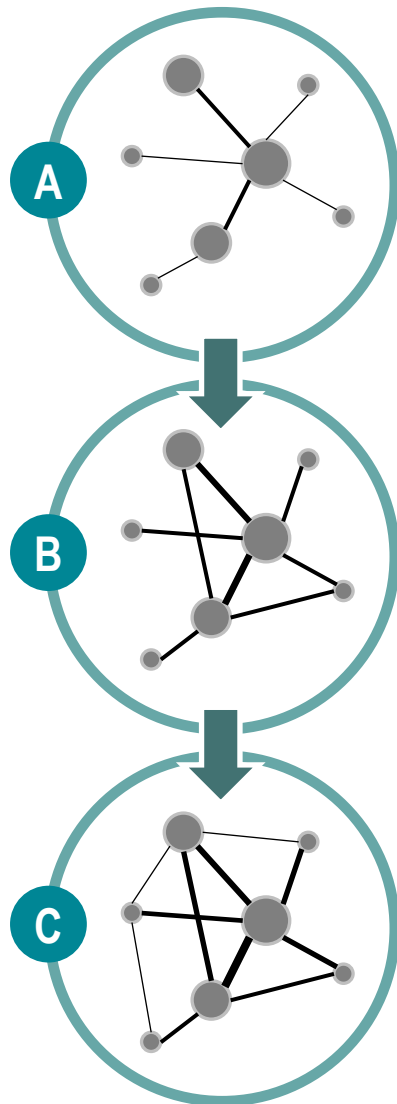
Economic Impacts of Transportation Infrastructure



Socioeconomic Benefits of Transportation



Diminishing Returns of Transport Investments



High Multiplying Effects

- New infrastructure built over limited existing infrastructure.
- Benefits from new connectivity and capacity.
- New economic opportunities (labor, resources, markets).

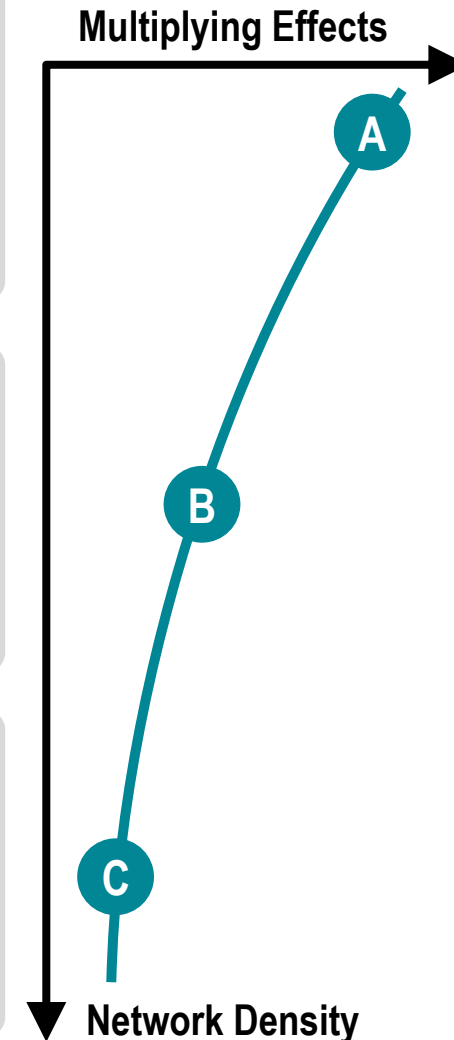
Average Multiplying Effects

- Expansion of existing infrastructure; emergence of corridors.
- Expanded connectivity, capacity and reliability.
- Productivity improvements.

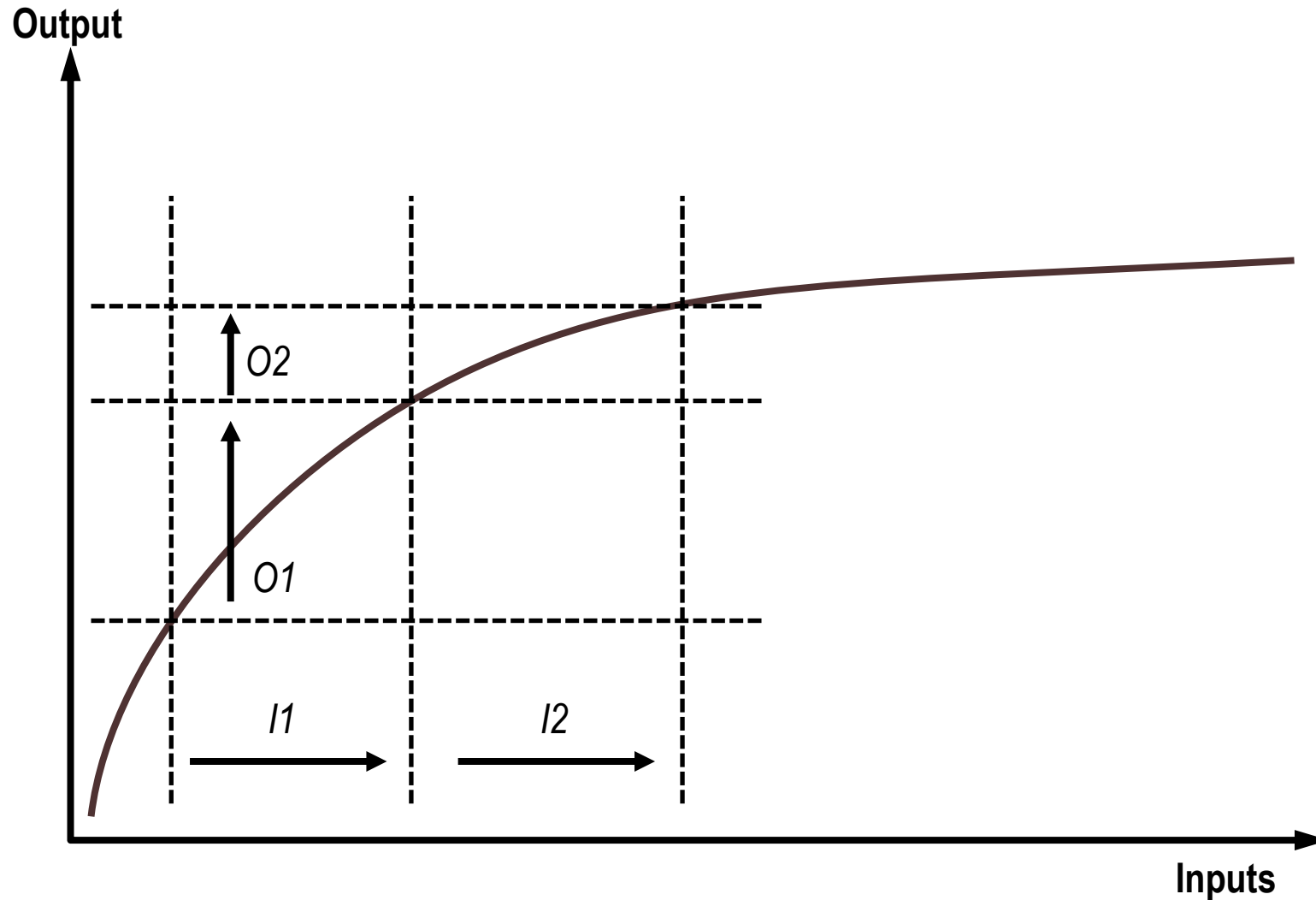
Low Multiplying Effects

- High infrastructure maintenance and upgrade costs.
- Niche connectivity.
- Peak capacity and reliability.
- Limited productivity improvements.

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Diminishing Marginal Returns



Types of Transport Economic Improvements (under construction)

Factor Driven	
Efficiency Driven	
Innovation Driven	

Transport Goals by the Public Sector (under construction)

Goal



Transport Economic Indicators

Type	Measures	Relevance
Transportation prices	Aggregate price of transportation services by mode or commodity	Input costs by economic sector. Market competitiveness.
Transportation productivity	Labor productivity and total-factor productivity (labor and assets)	Level of return on investment. Economic impacts by sector.
Logistics costs	Supply-chain distribution cost relative to GDP or total costs.	Efficiency by logistics function.
Transportation capacity utilization	Share of modal (vehicles and links) and intermodal (terminals) capacity	Assessment of investment needs for maintenance, upgrade and expansion.

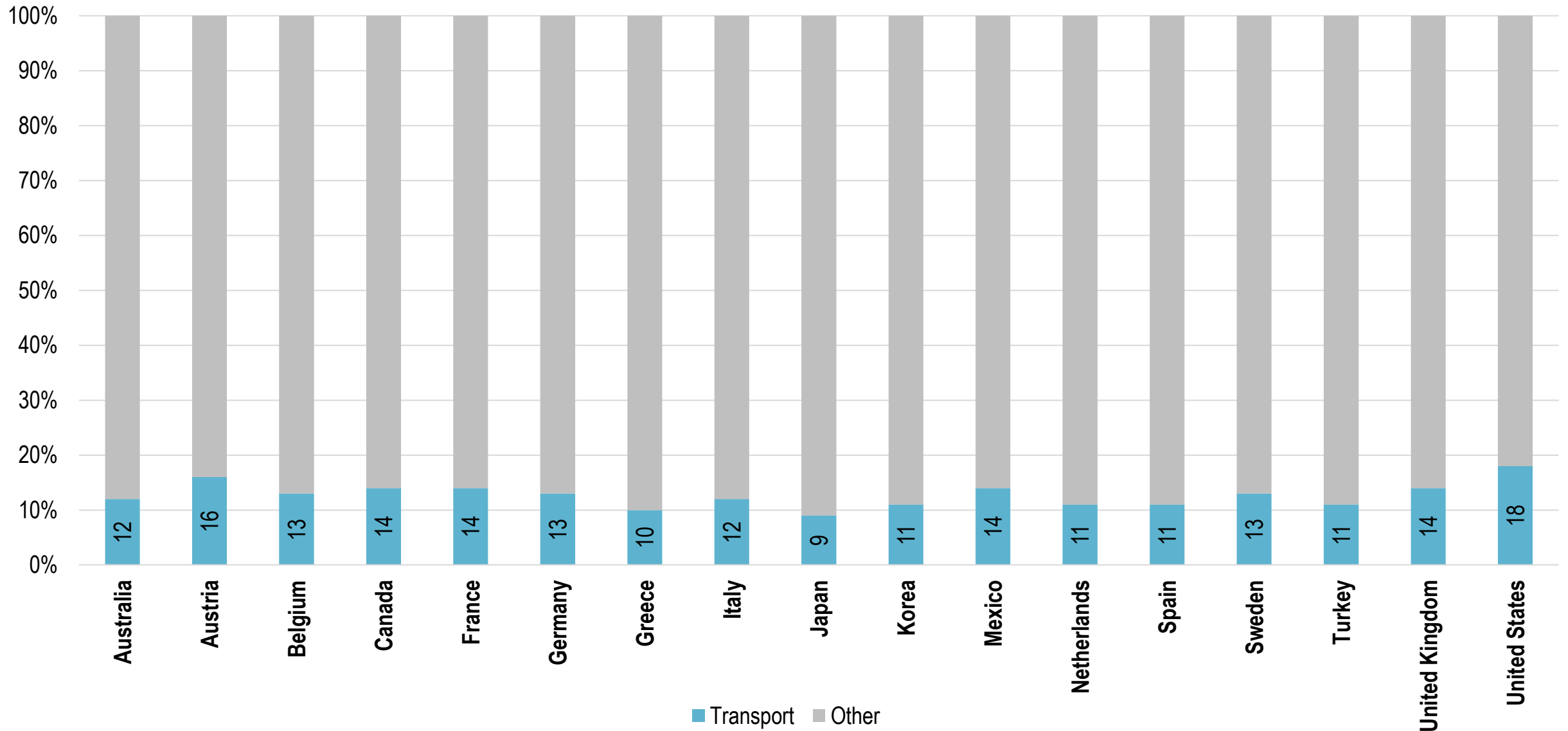
Transport Economic Indicators

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Transport Capacity Utilization	Share of modal (vehicles and links) and intermodal (terminals) capacity.	Assessment of investment needs for maintenance, upgrade and expansion.

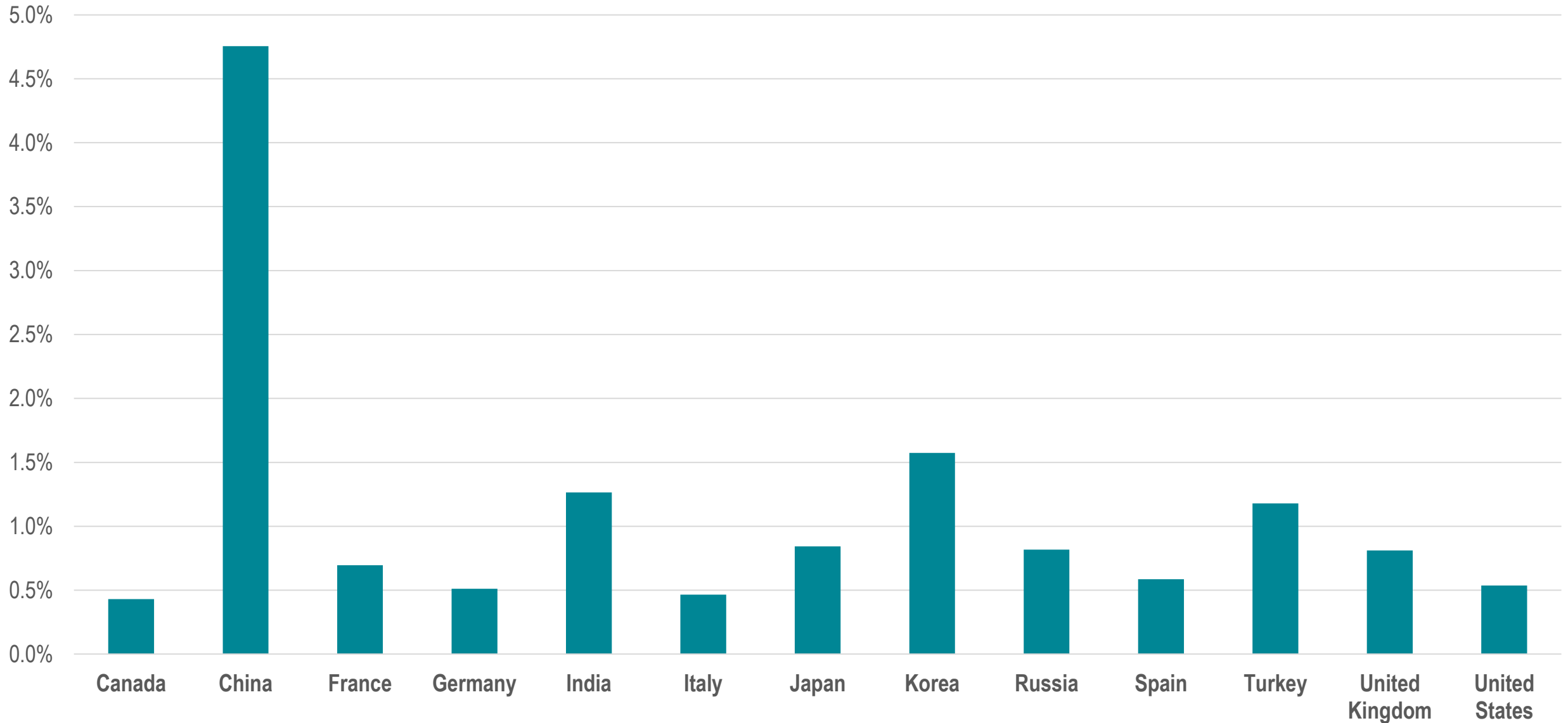
Economic Multiplier Effects of Transportation

Type	Effect	Context	Source
Transit time	One day in transit equivalent to a tariff of 0.6 to 2.1%	OECD	Hummels (2012)
Port	10% increase in port efficiency leads to 3.2% increase in real trade between a country pair	USA	Blonigen and Wilson (2006)
Port	1% increase in port efficiency leads to a 0.38% reduction in trade costs		World Bank (2017)

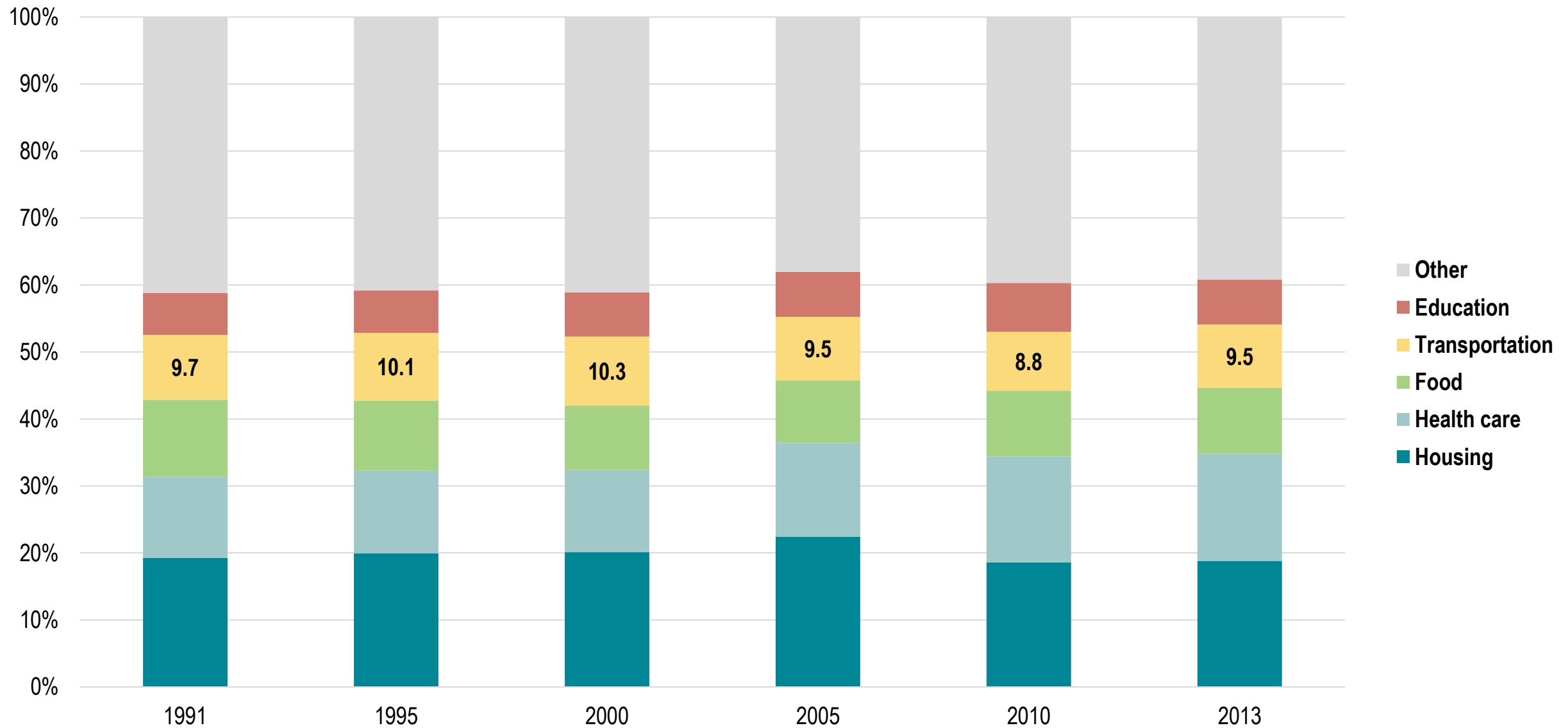
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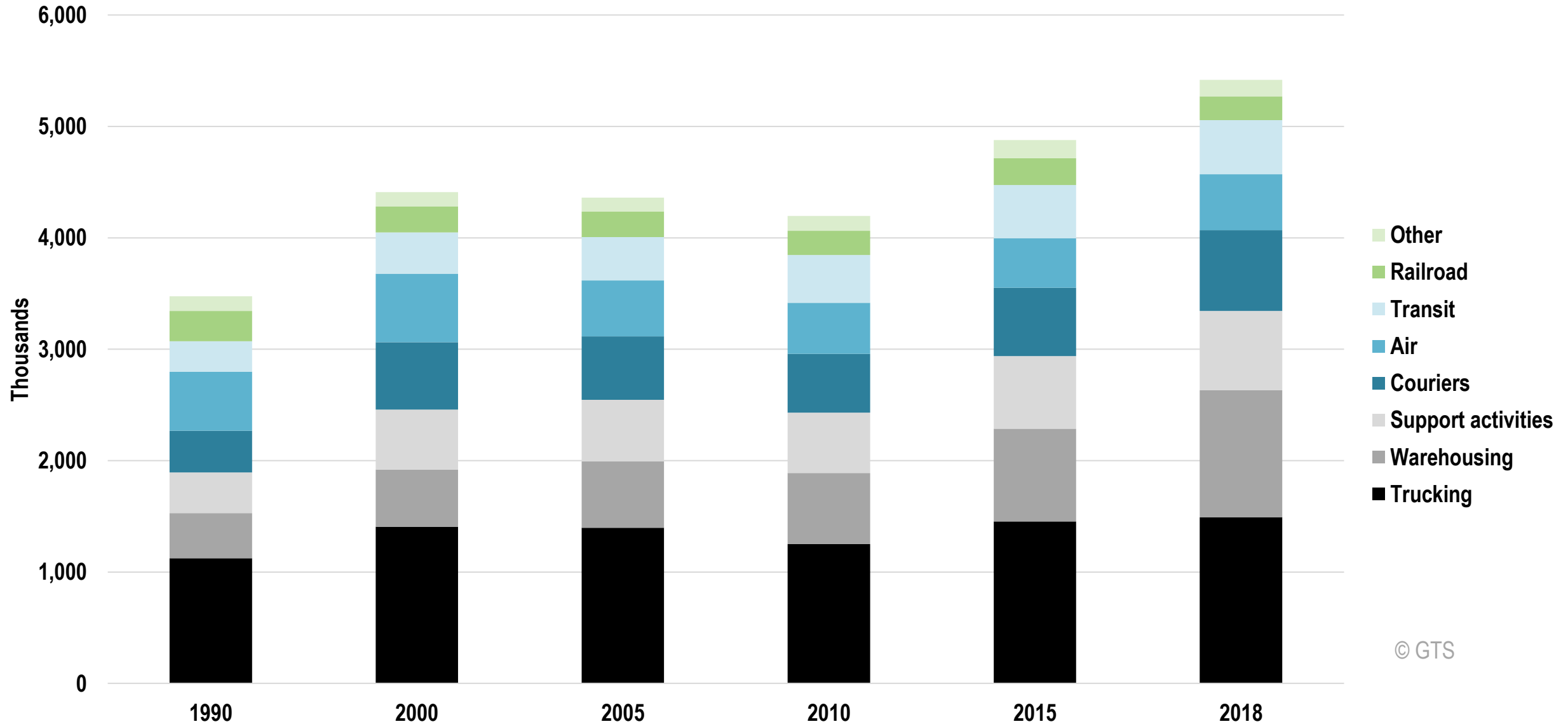
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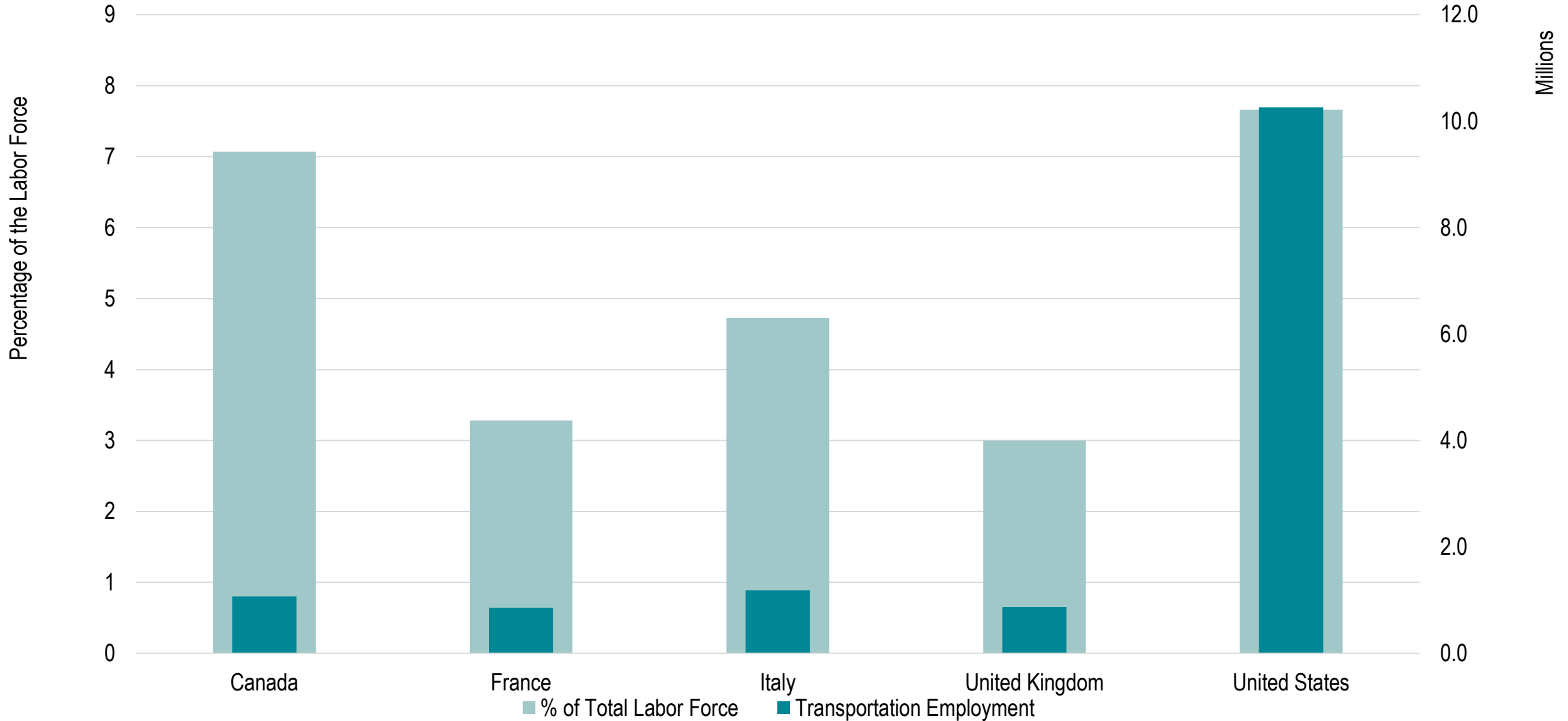


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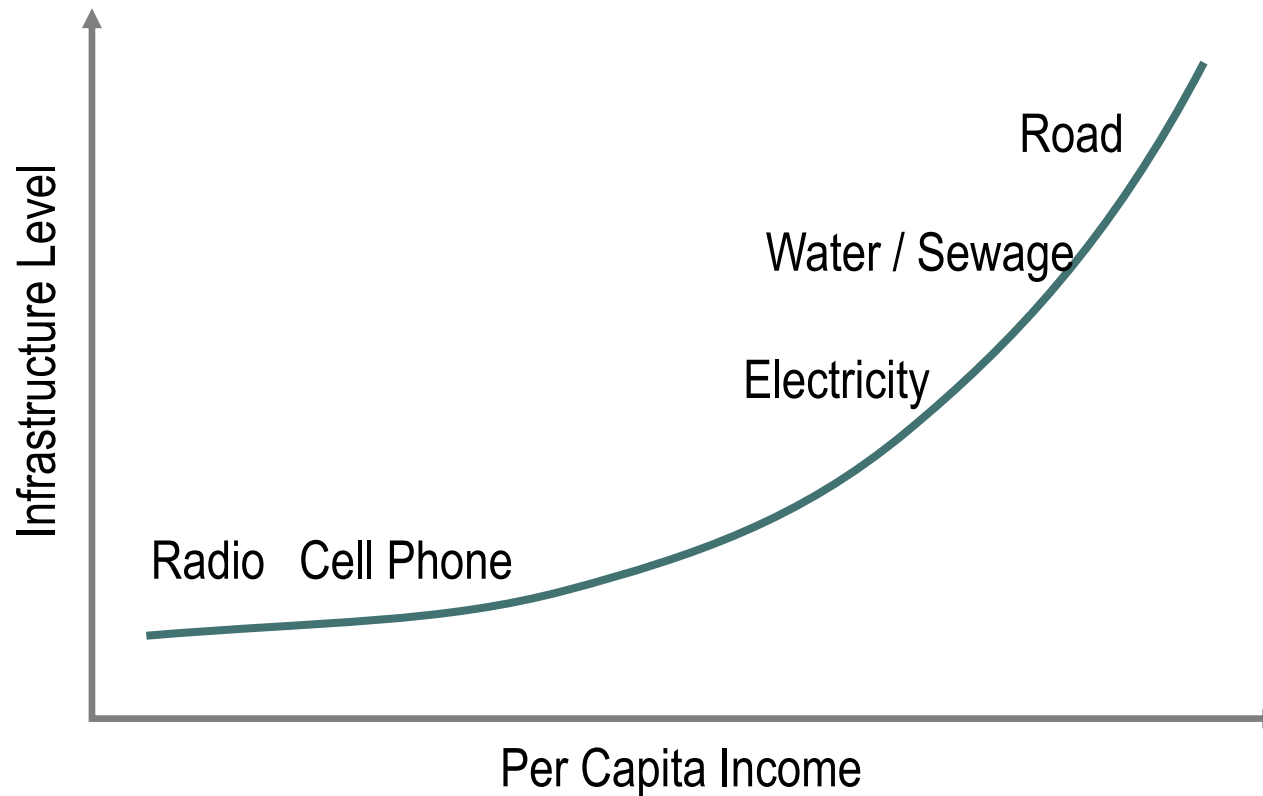


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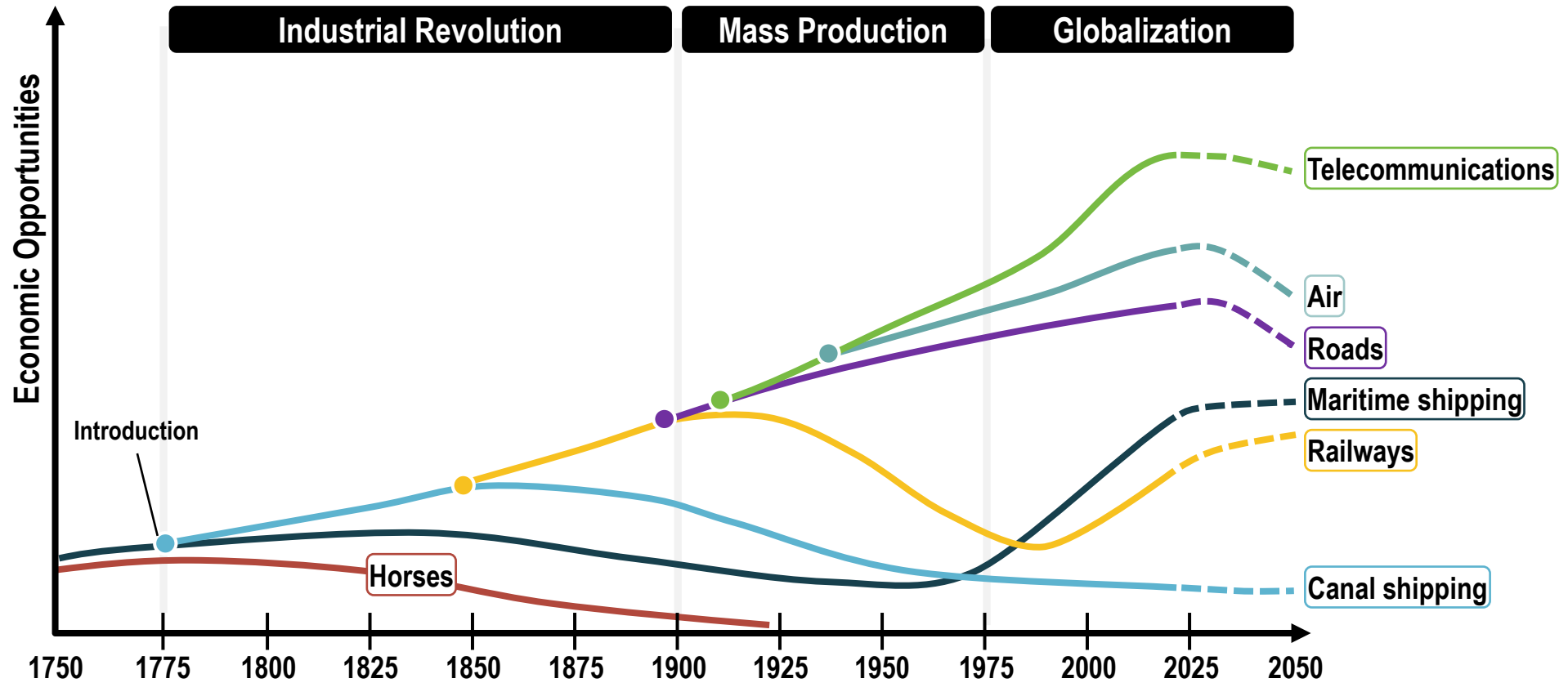
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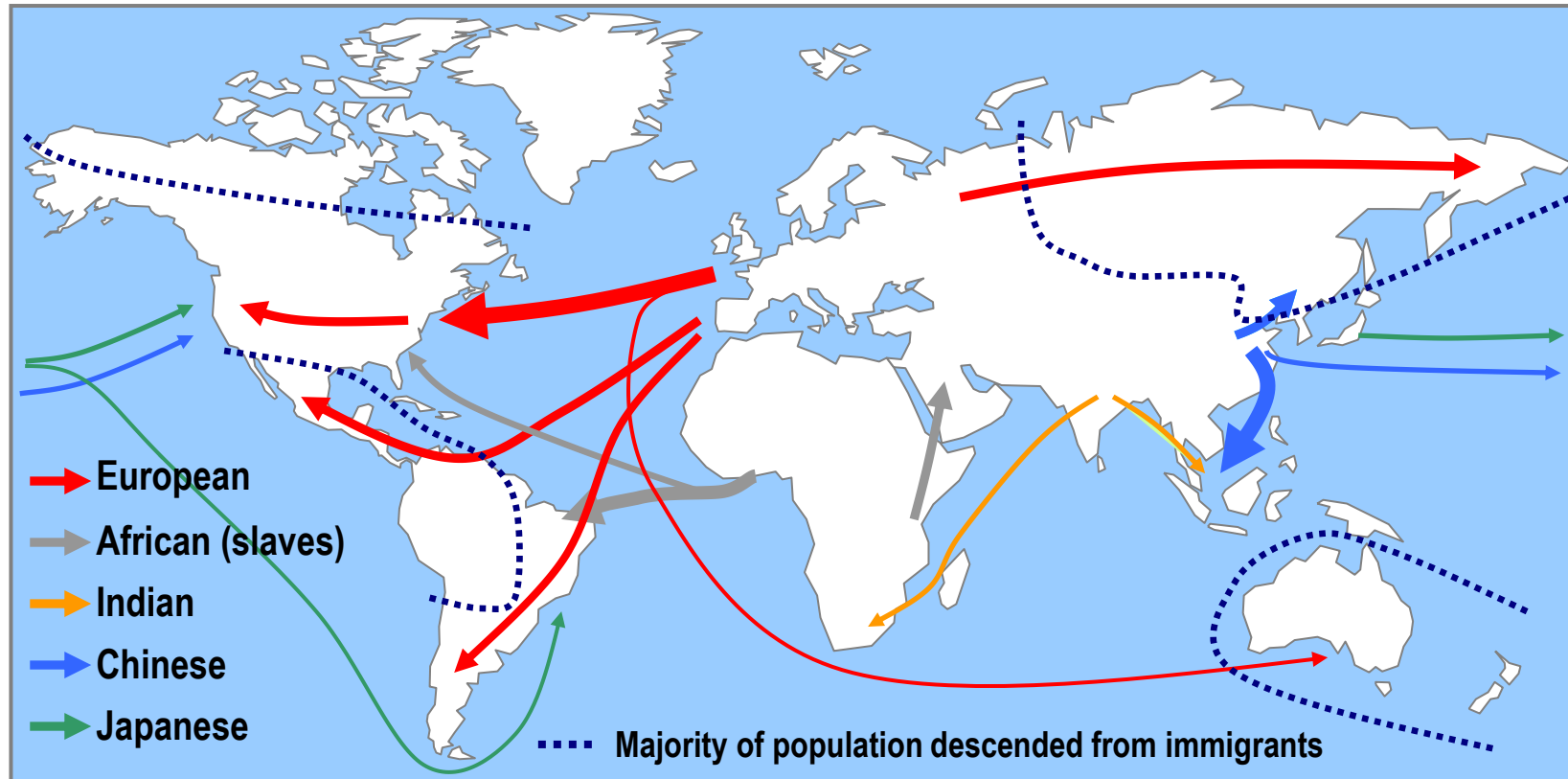
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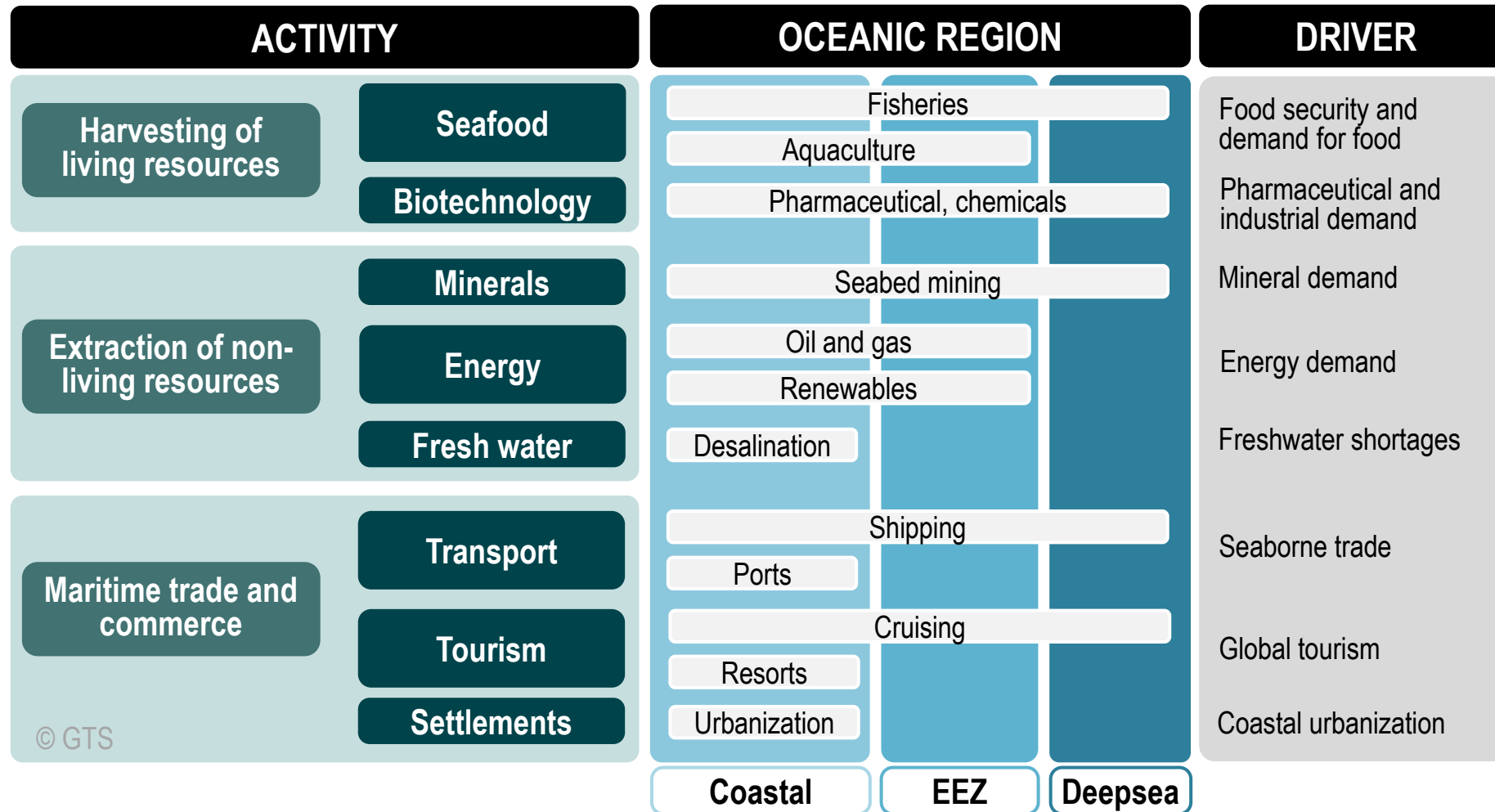
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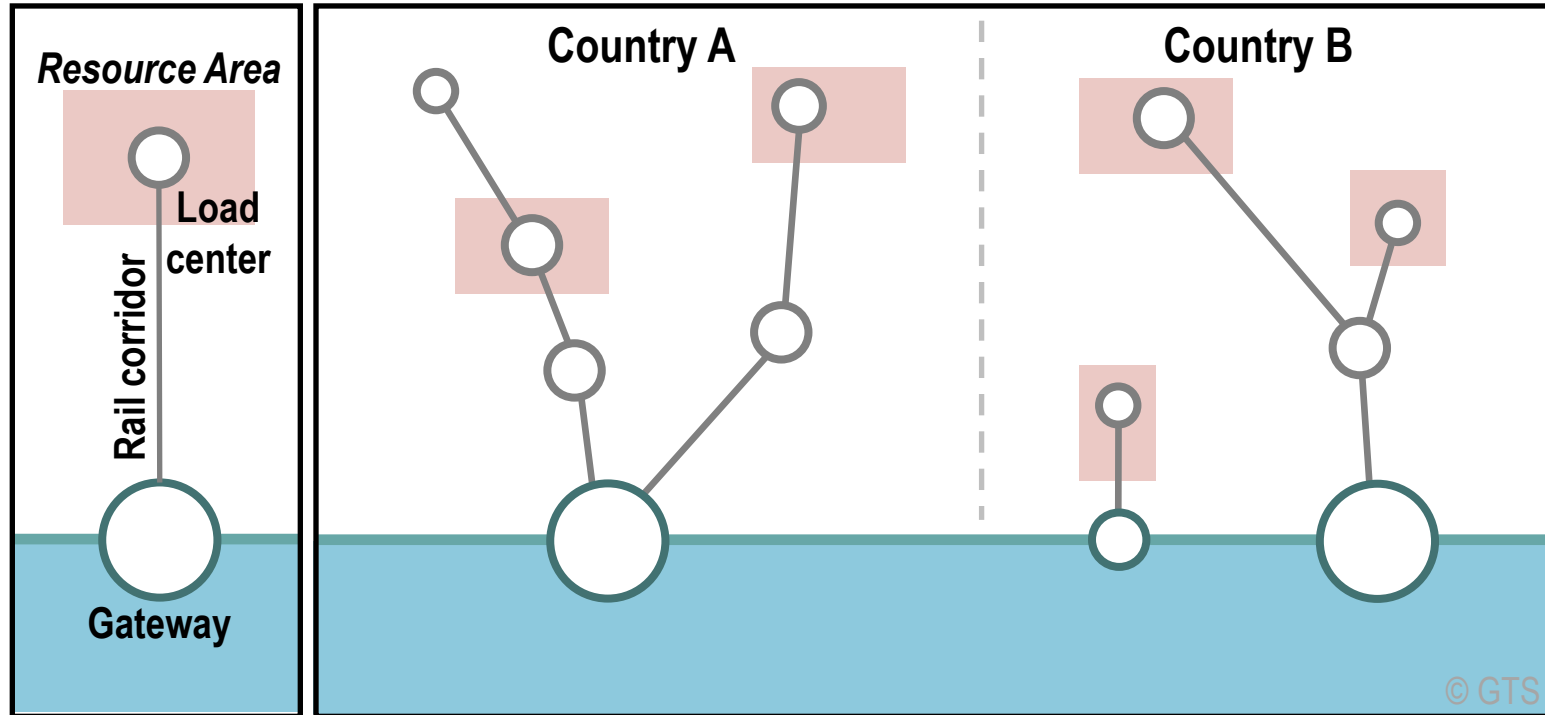


The Ocean Economy

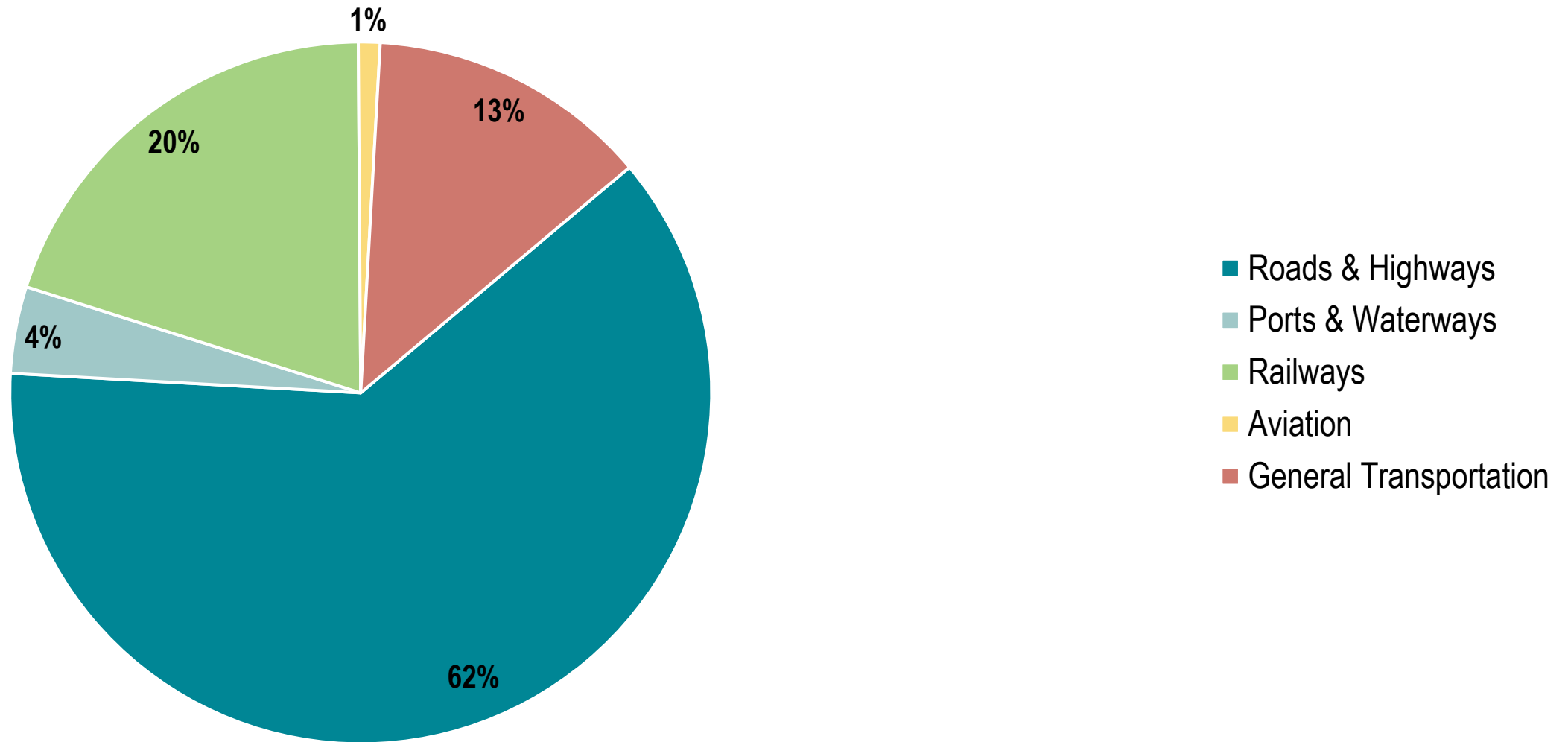


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Resource-Based Transport Systems



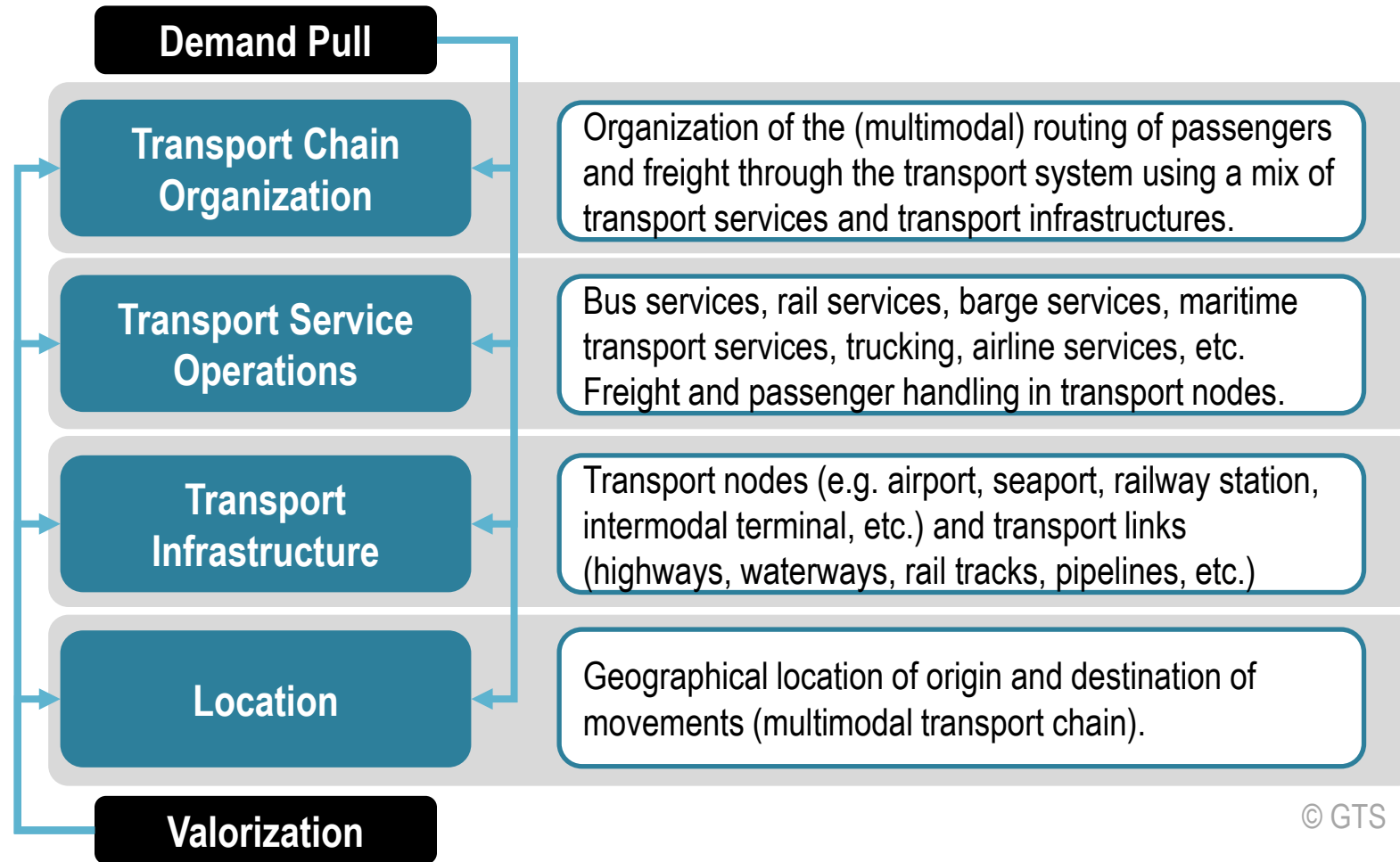
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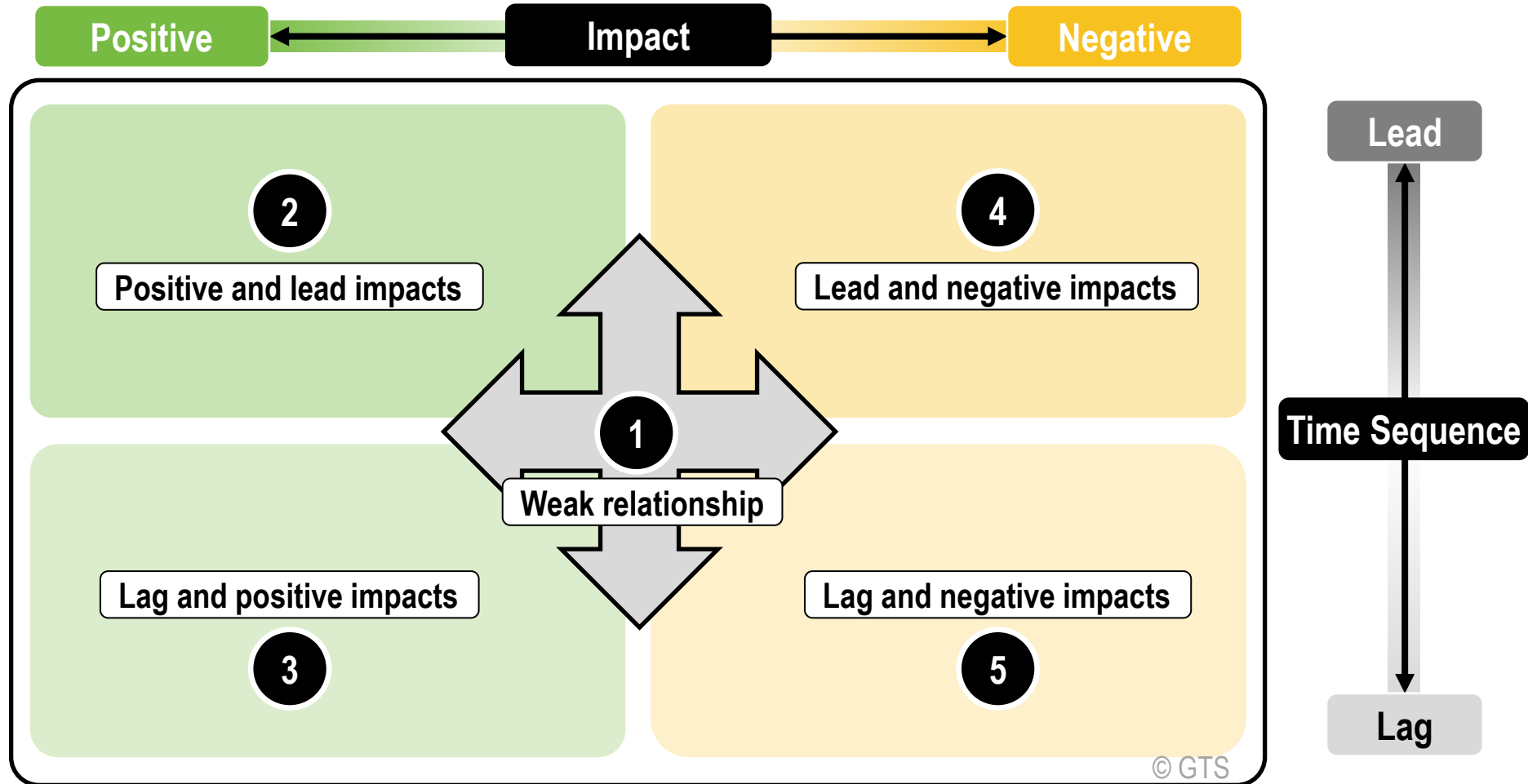
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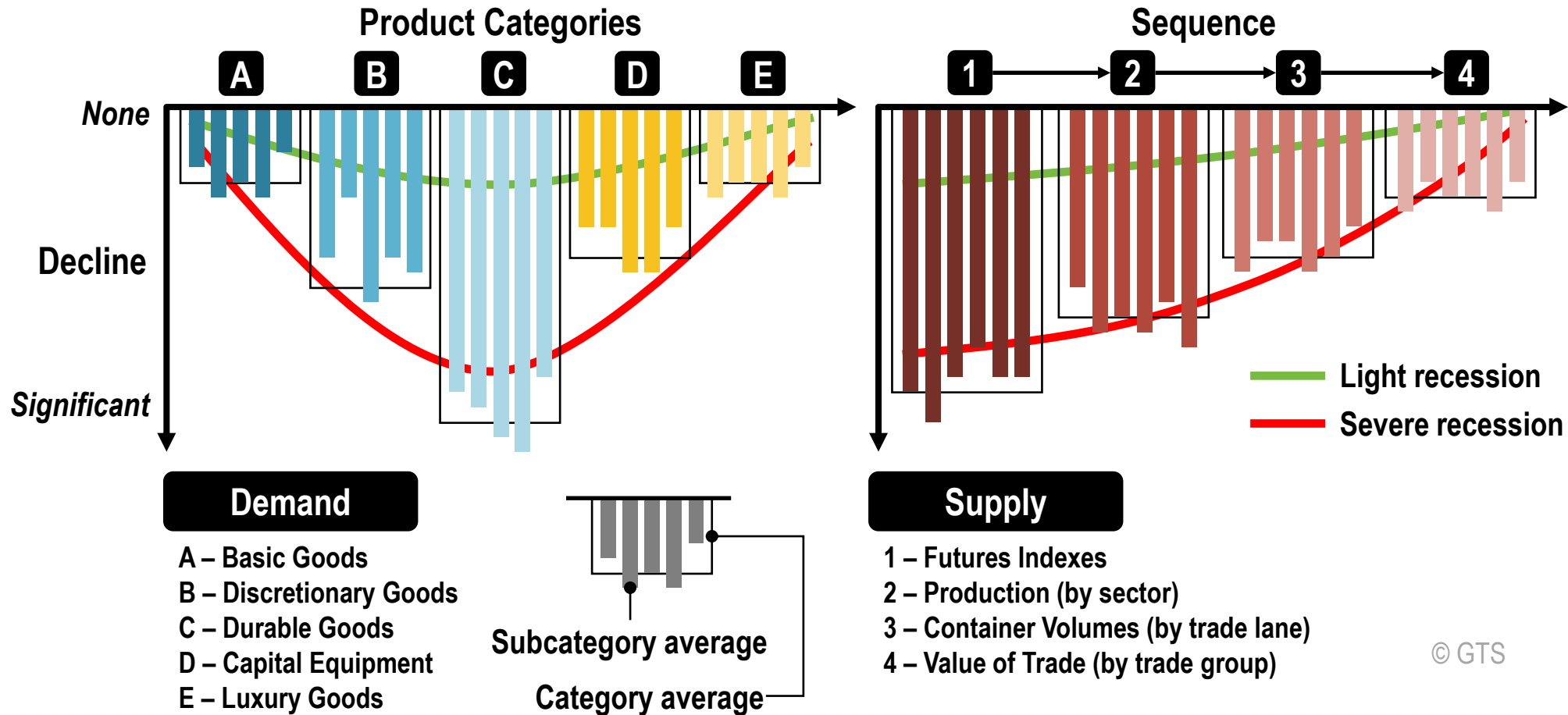
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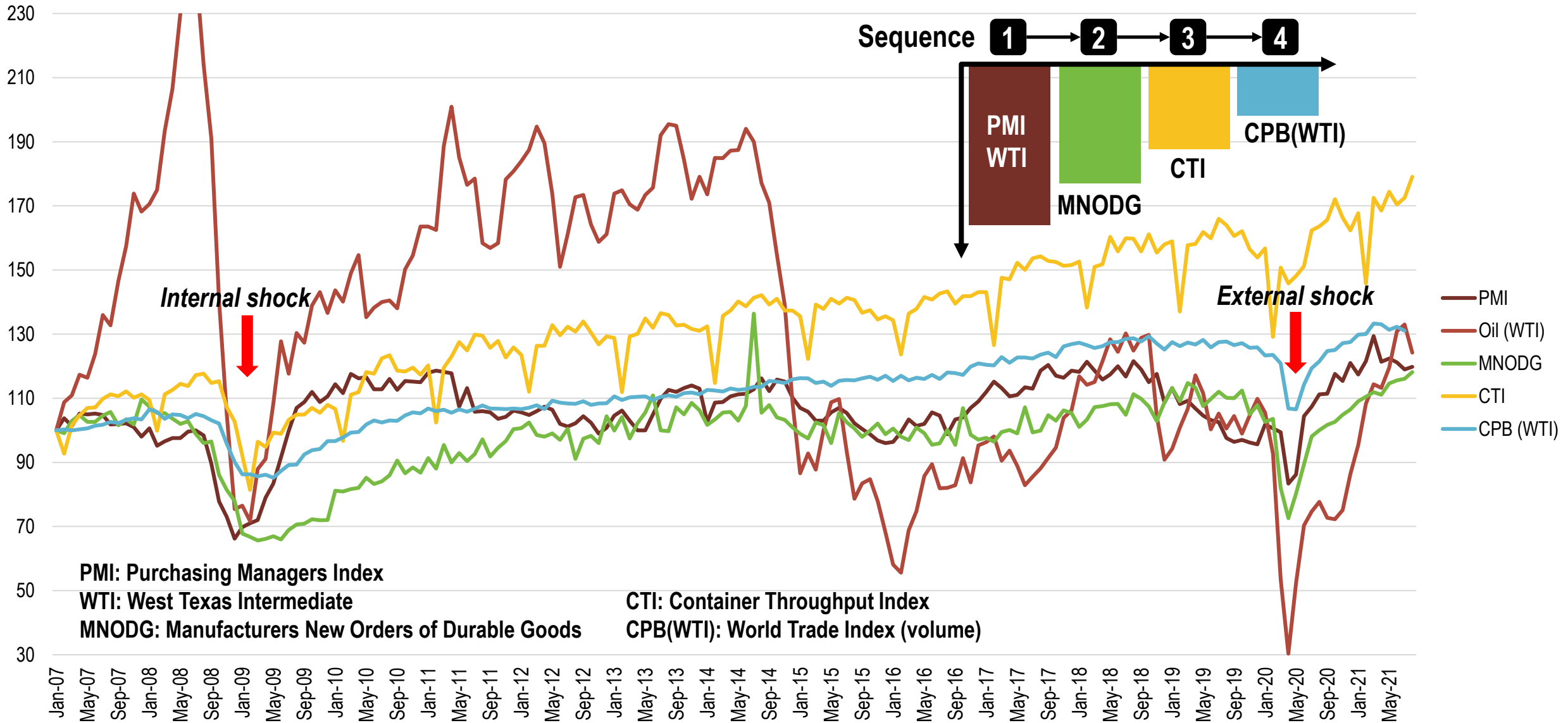
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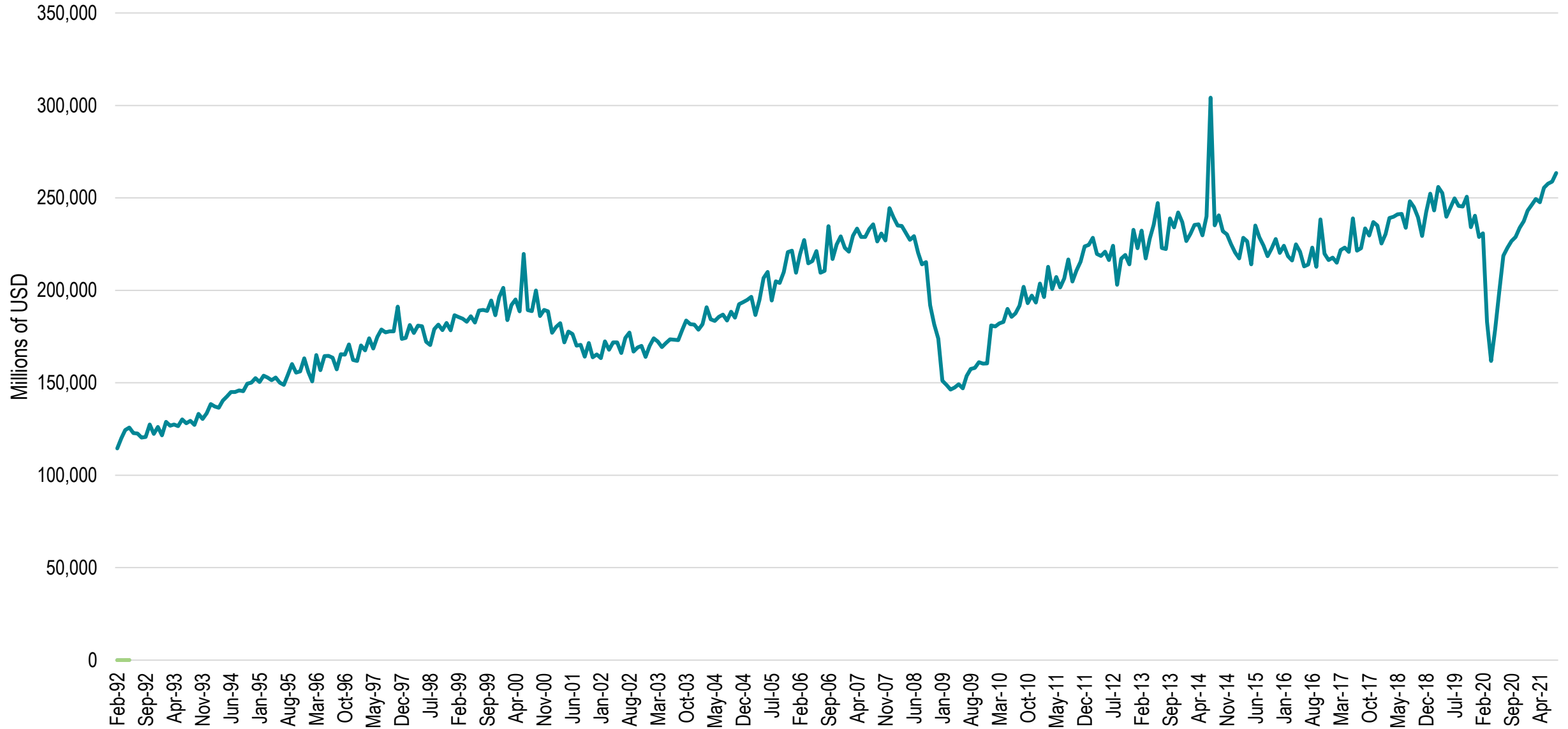
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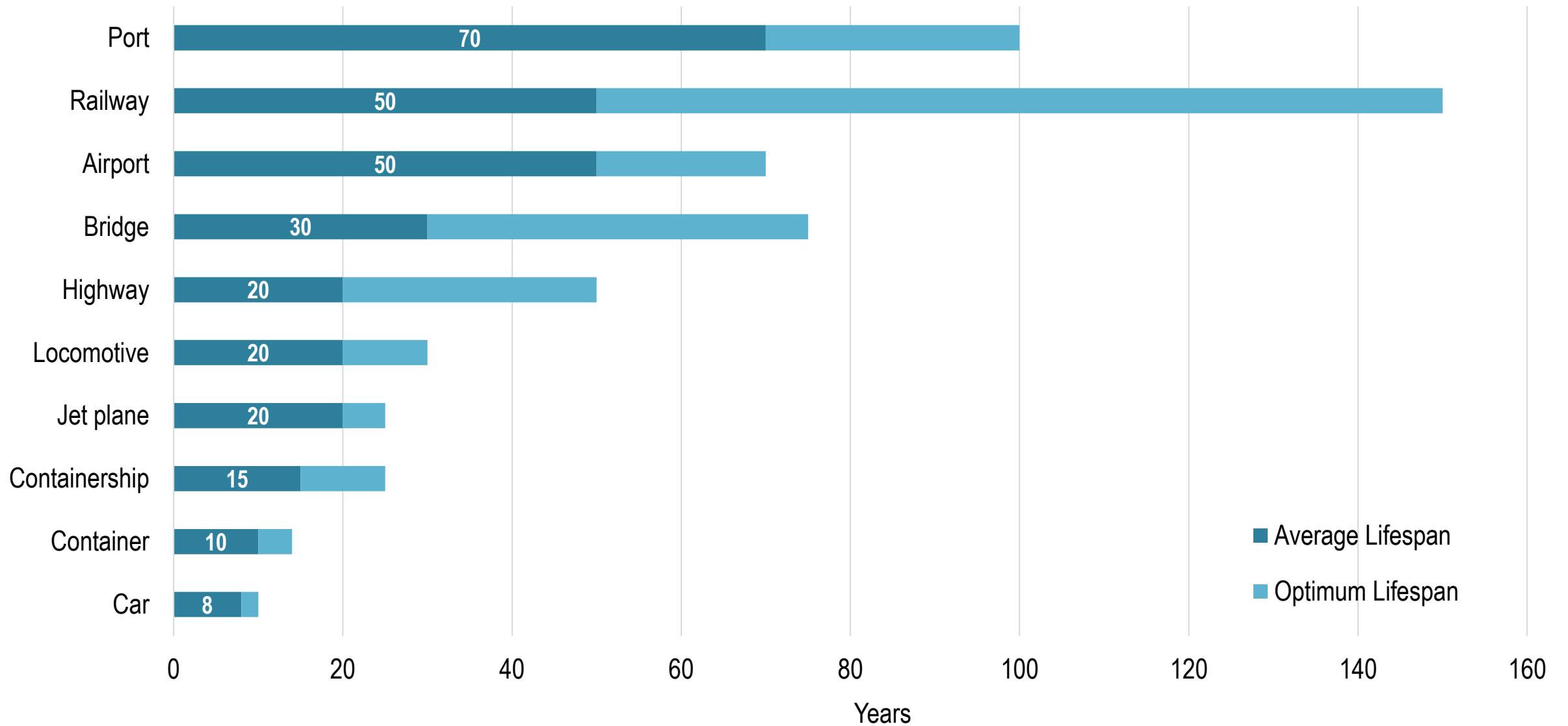
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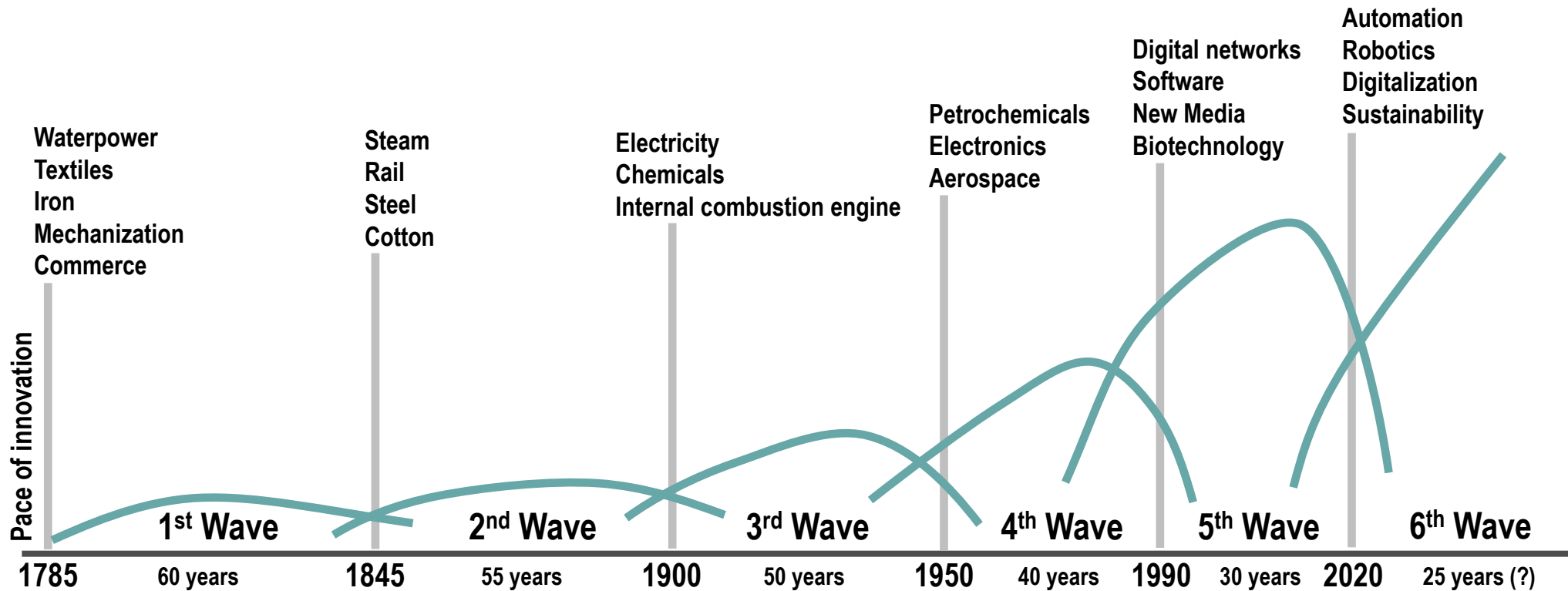
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Lifespan of Main Transport Assets



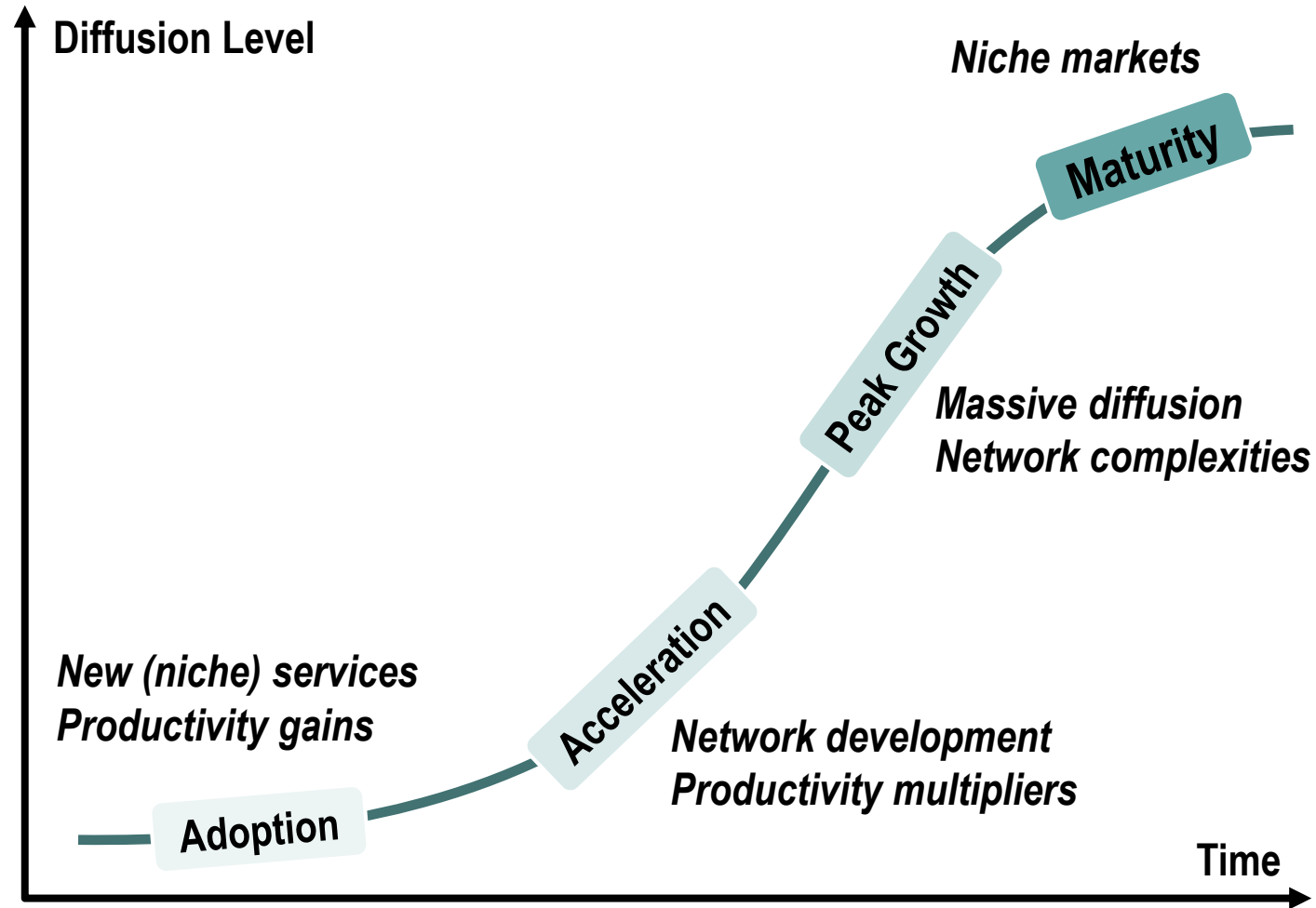
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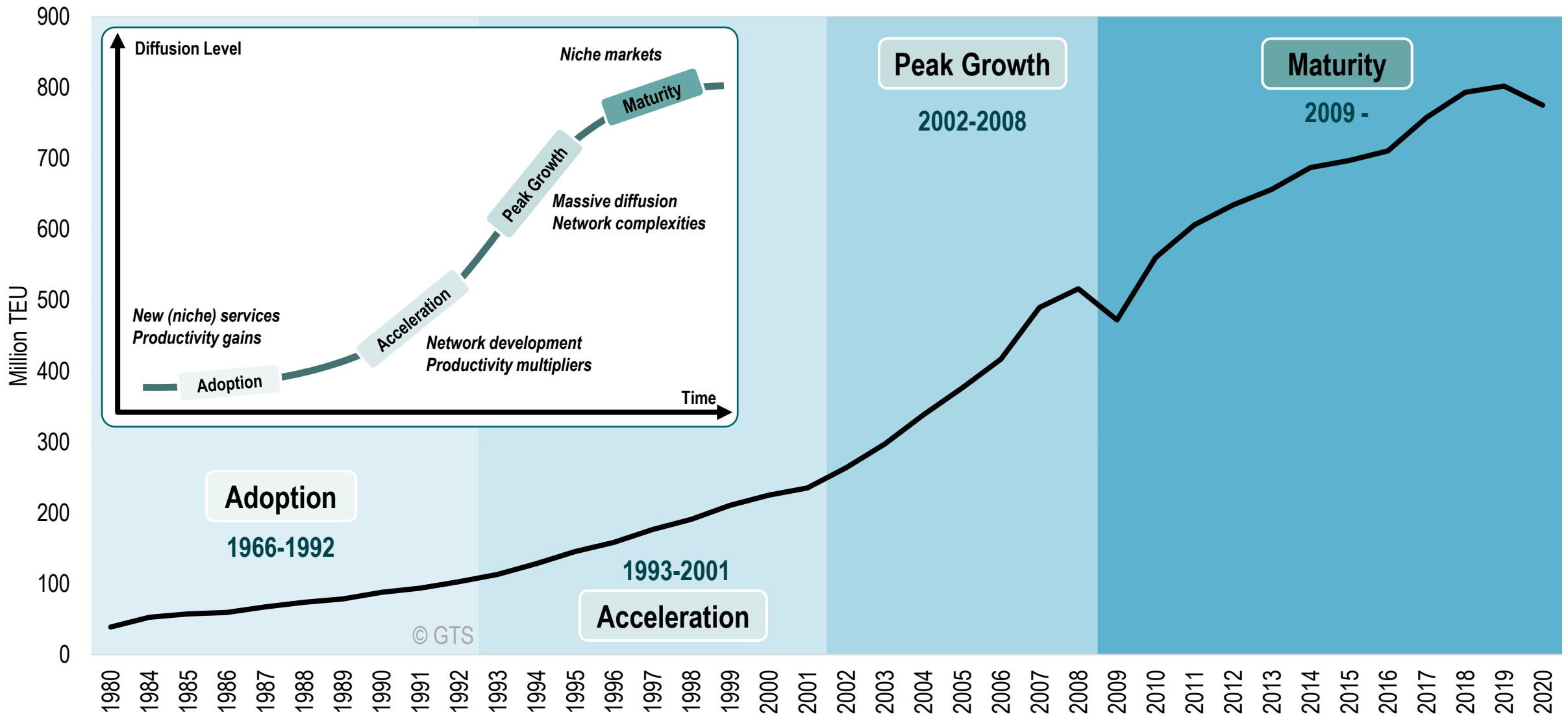
The Five Waves of Development

First wave (1785-1845)	Beginning of the industrial revolution (England). Agricultural surpluses, savings and investment. Productivity growth in agriculture and in new industrial activities. Textiles, iron and water power.
Second wave (1845-1900)	Acceleration in the generation of surpluses. Growth in the investment level (5 to 10% of the national income). Coal, steam engine and railways.
Third wave (1900-1950)	Phase of maturity (investment levels at 20% of national income). Electricity, chemicals and internal combustion engine.
Fourth wave (1950-1990)	Mass consumption society (surpluses, savings and investment). Tertiary sector taking a growing share of the economy. Petrochemicals, electronics and aviation.
Fifth wave (1990-2020?)	Technology and information are the driving forces. De-industrialization of several developed countries.

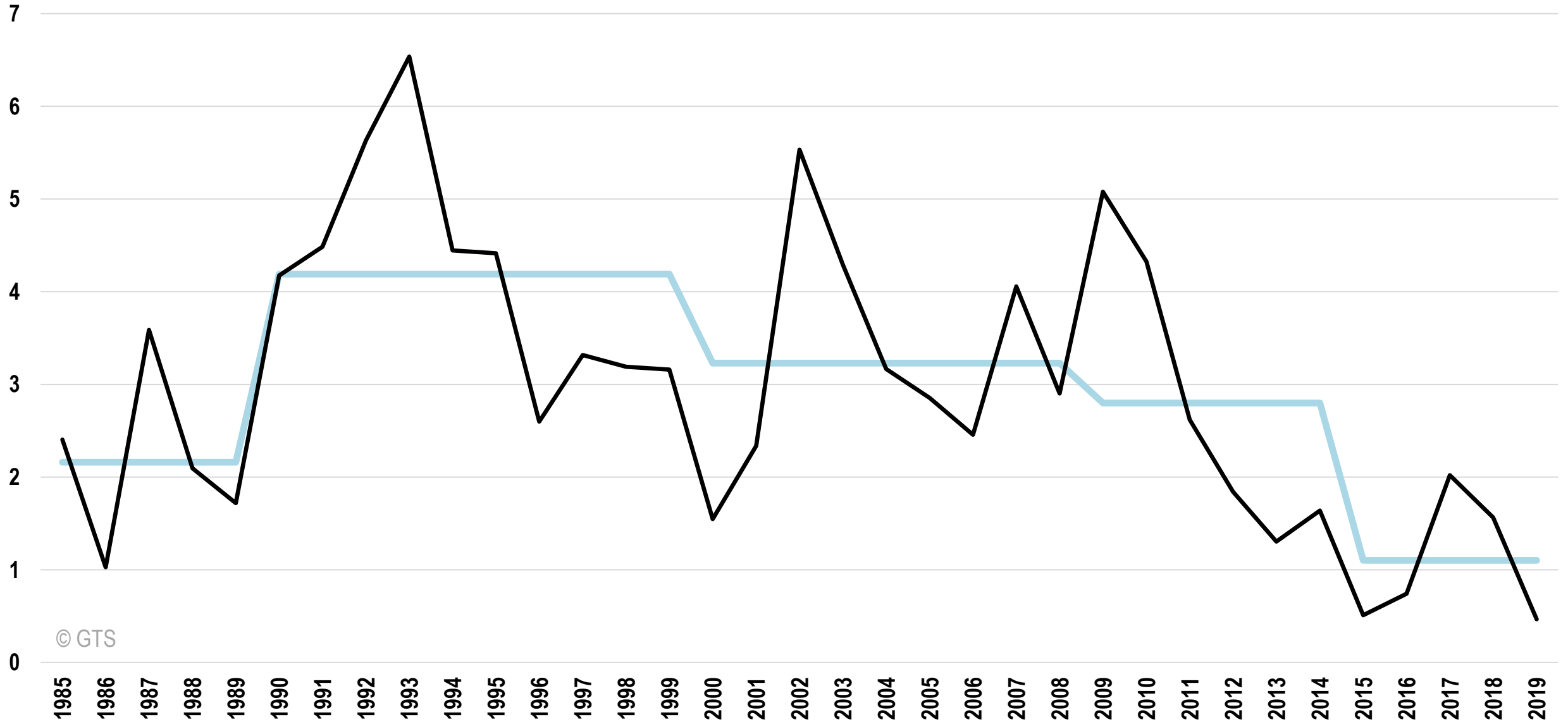
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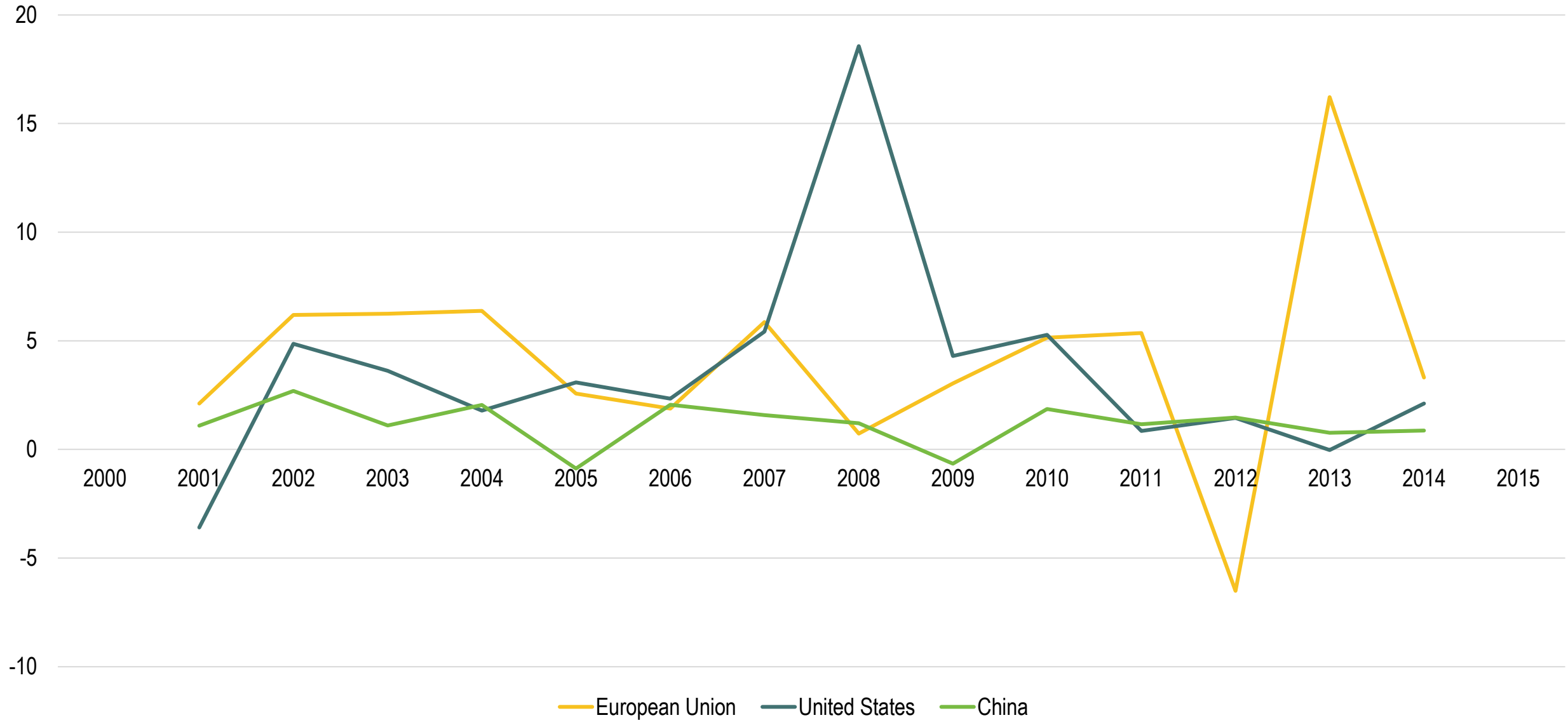


TEU to GDP Multiplier, 1985-2019



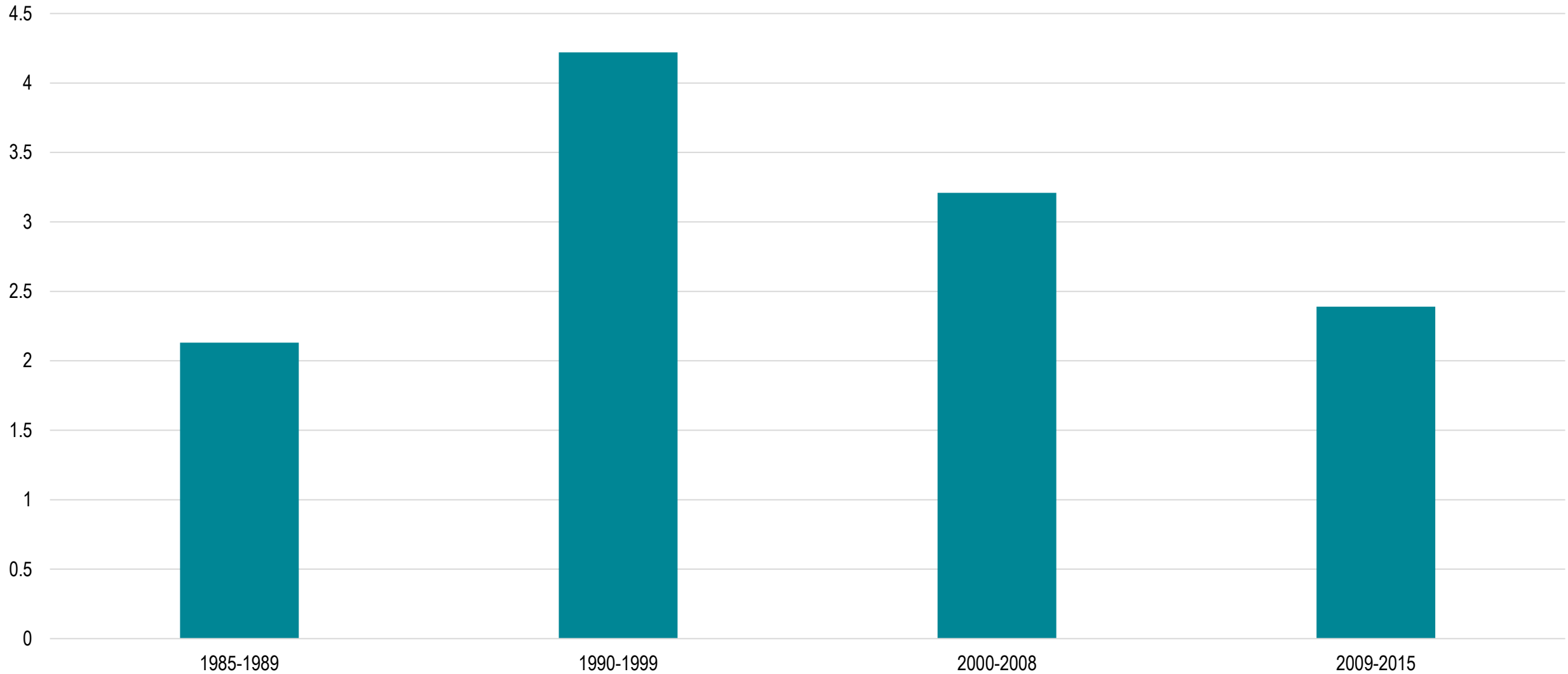
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TEU to GDP Multiplier, Selected Economies, 2000-2015

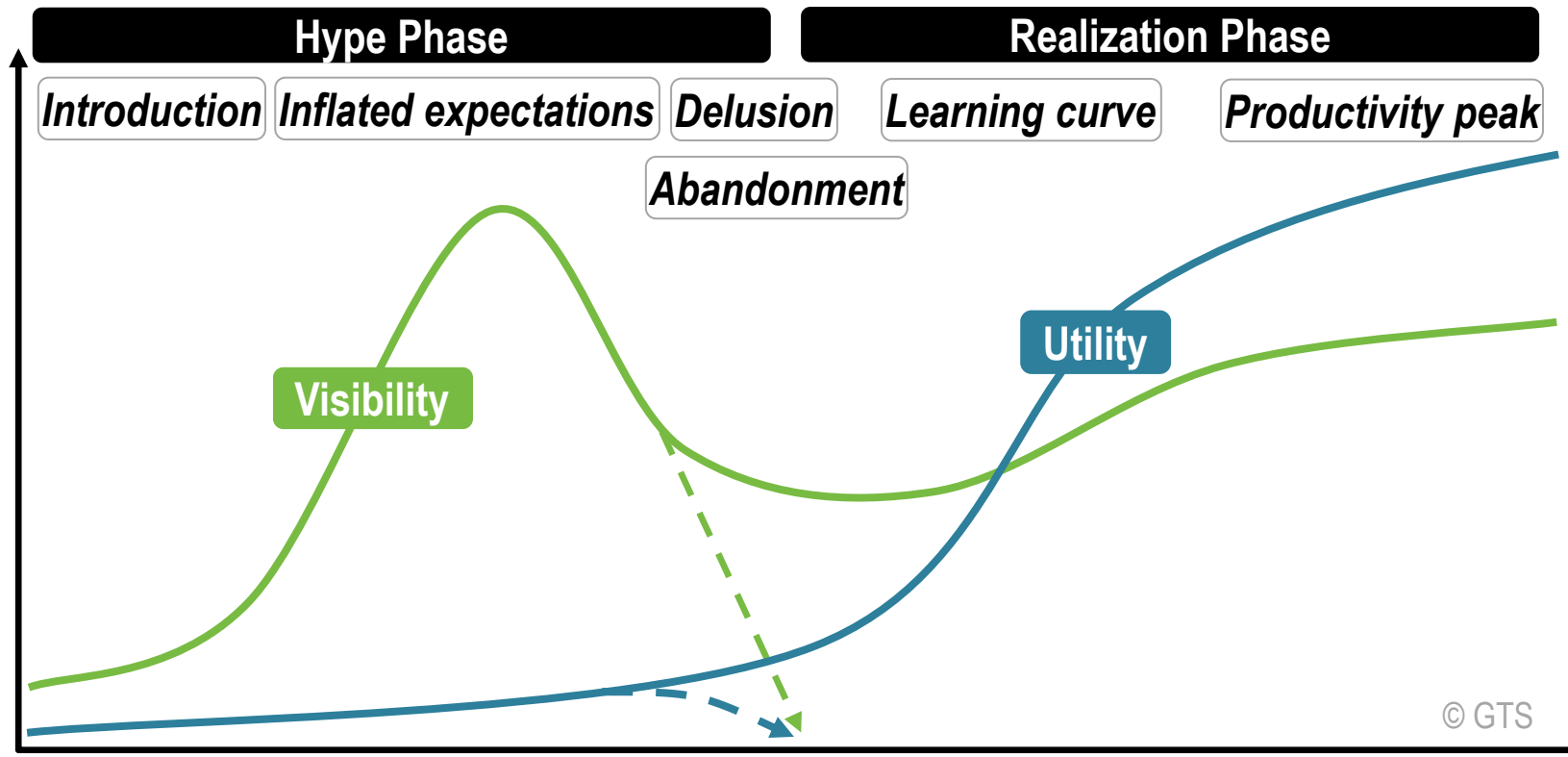


Relationship between TEU and GDP Growth

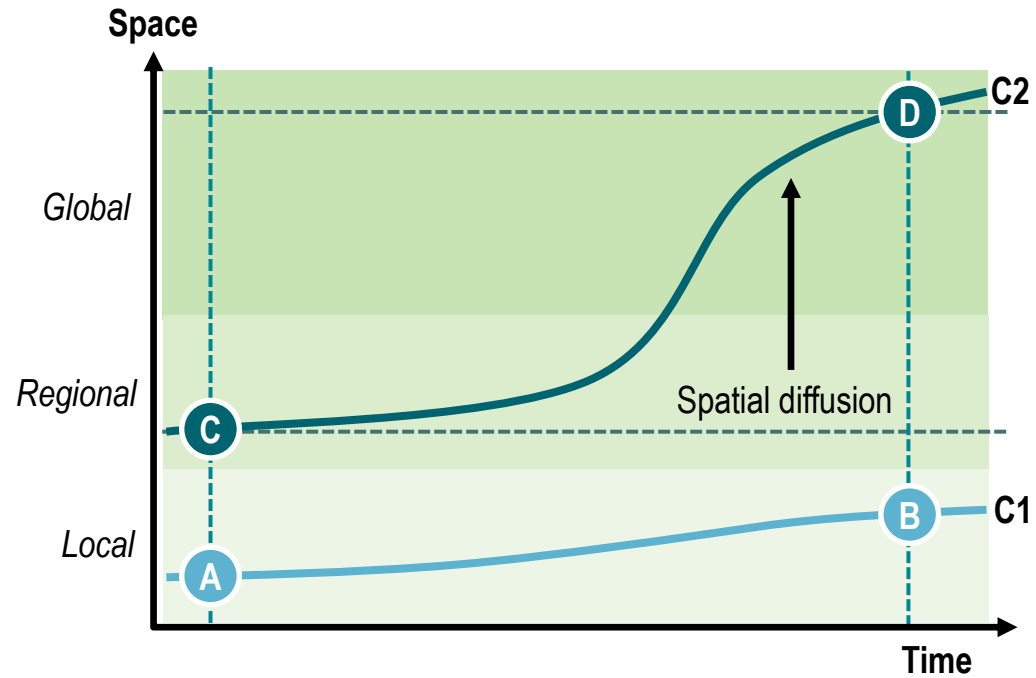
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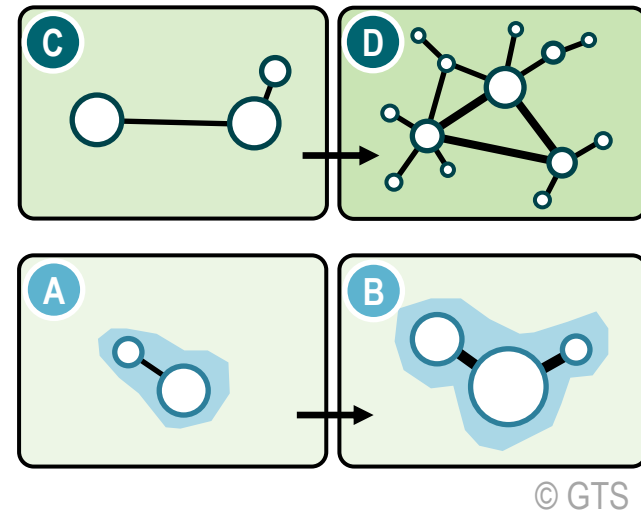
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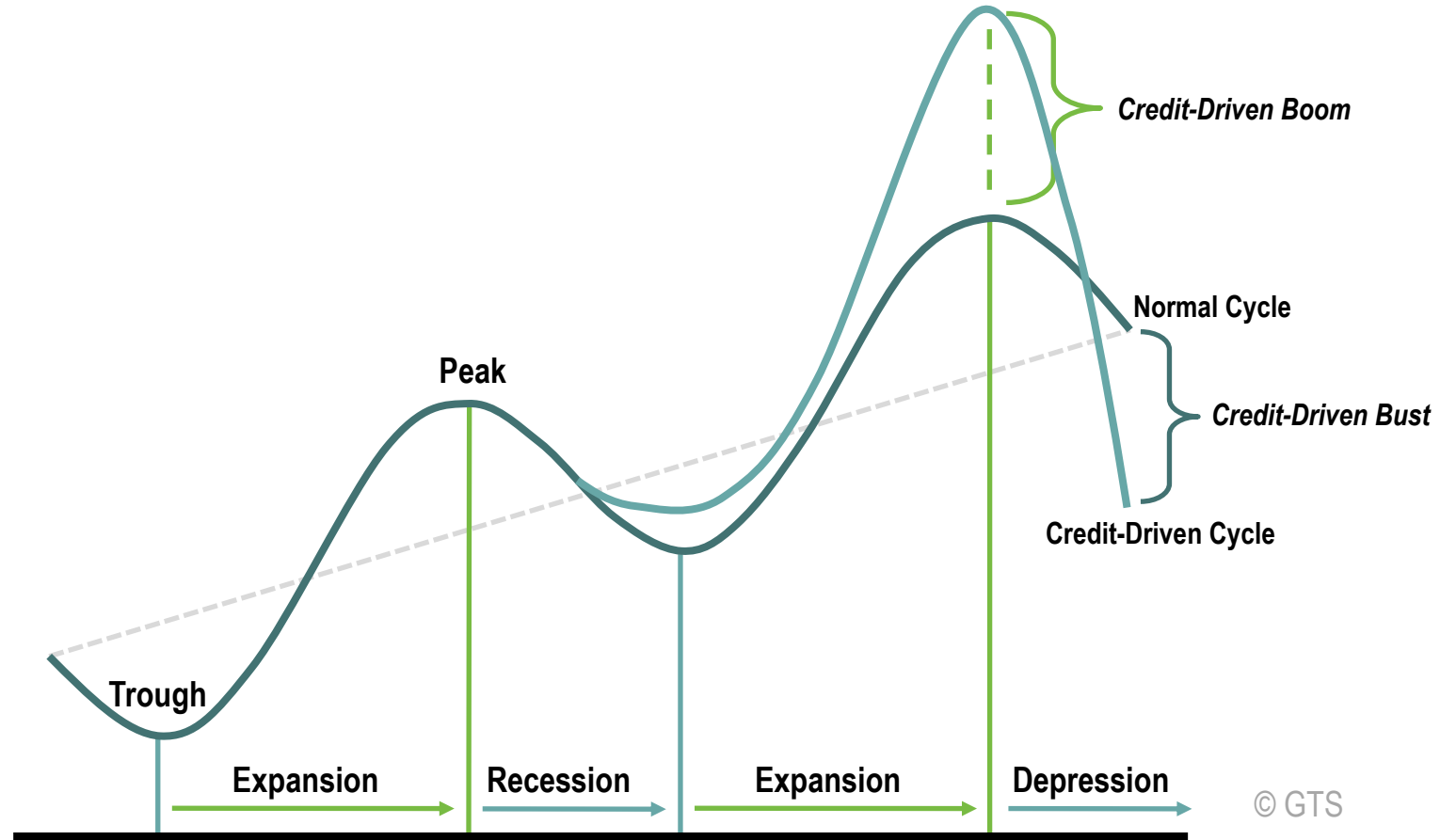
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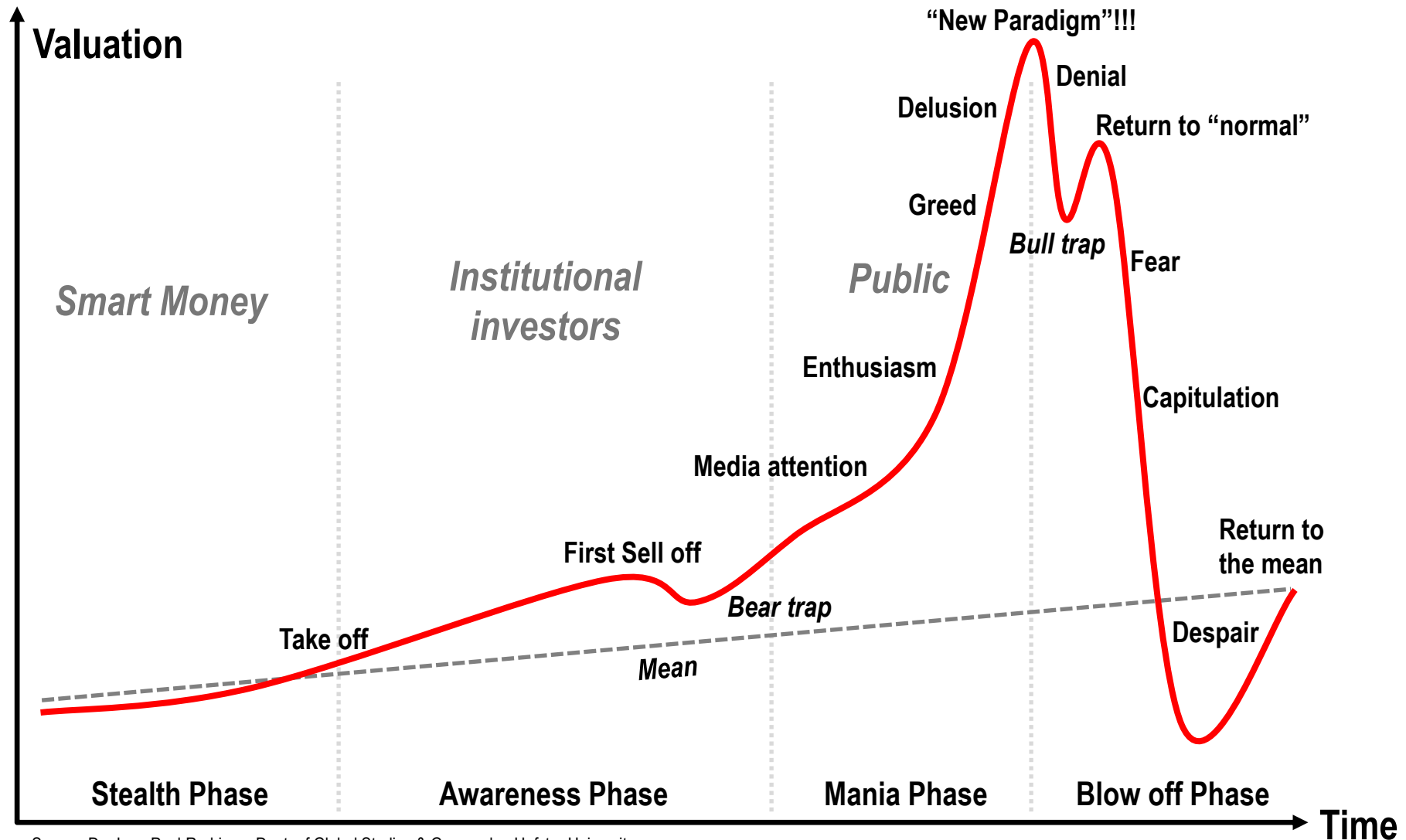
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Business Cycles and Misallocations



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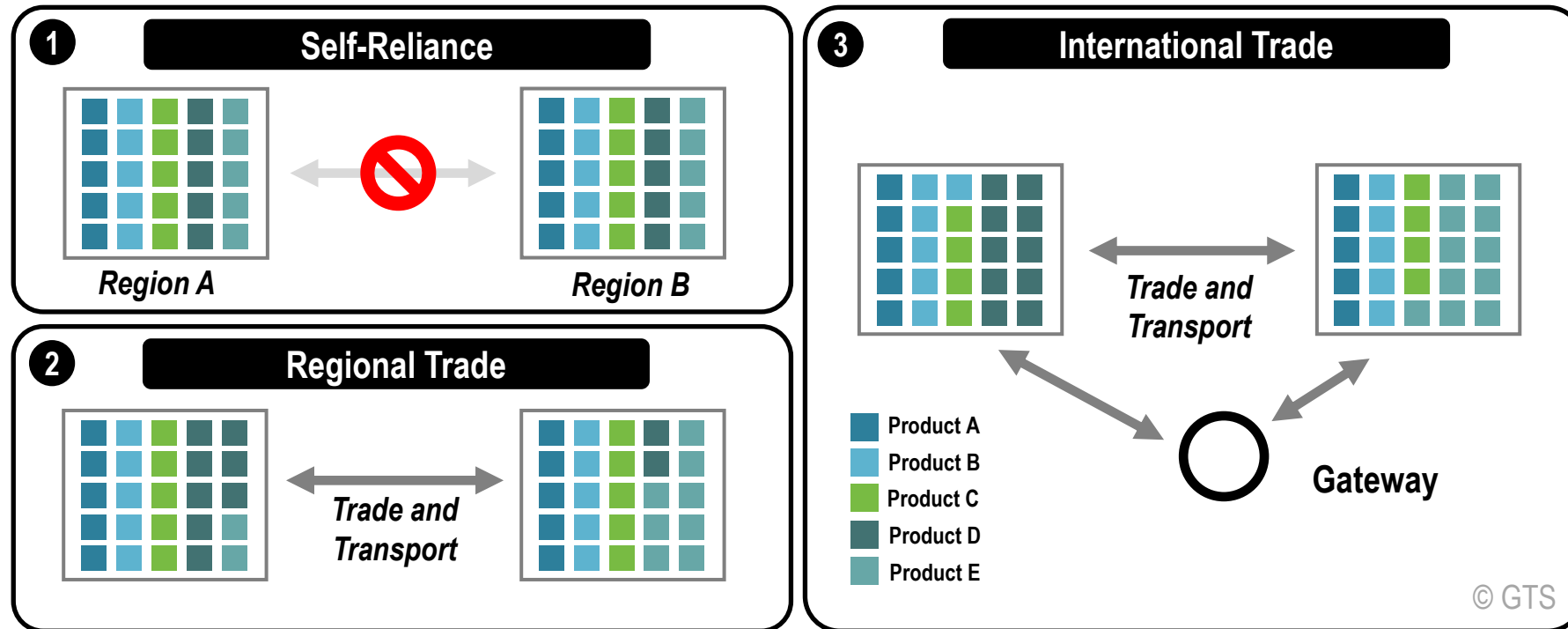


Source: Dr. Jean-Paul Rodrigue, Dept. of Global Studies & Geography, Hofstra University.

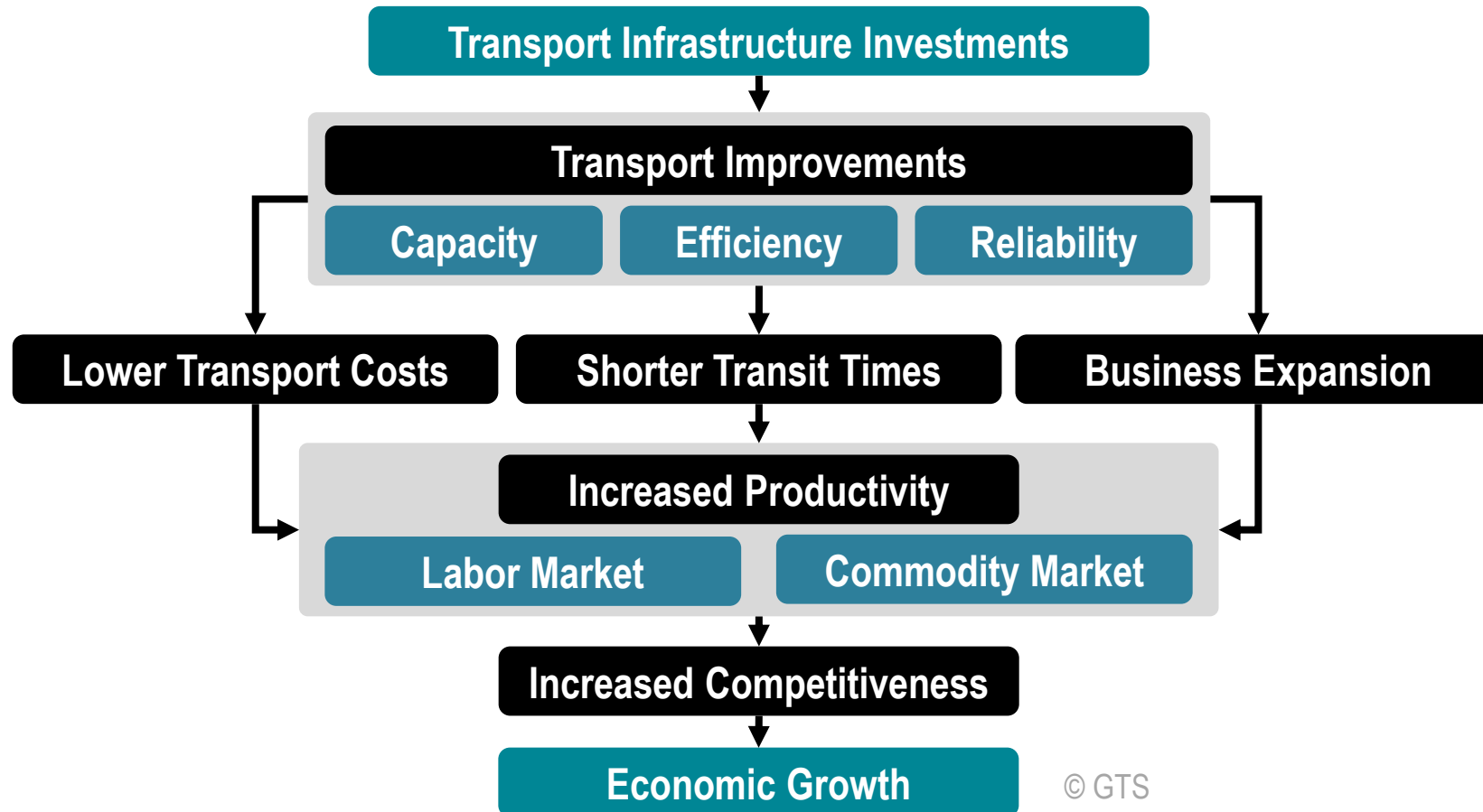
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Global	Oceanic masses	Globalization	Air transport and tele-communications	Multilateral agreements (WTO)	Interdependency and comparative advantages

Economic Production and Specialization

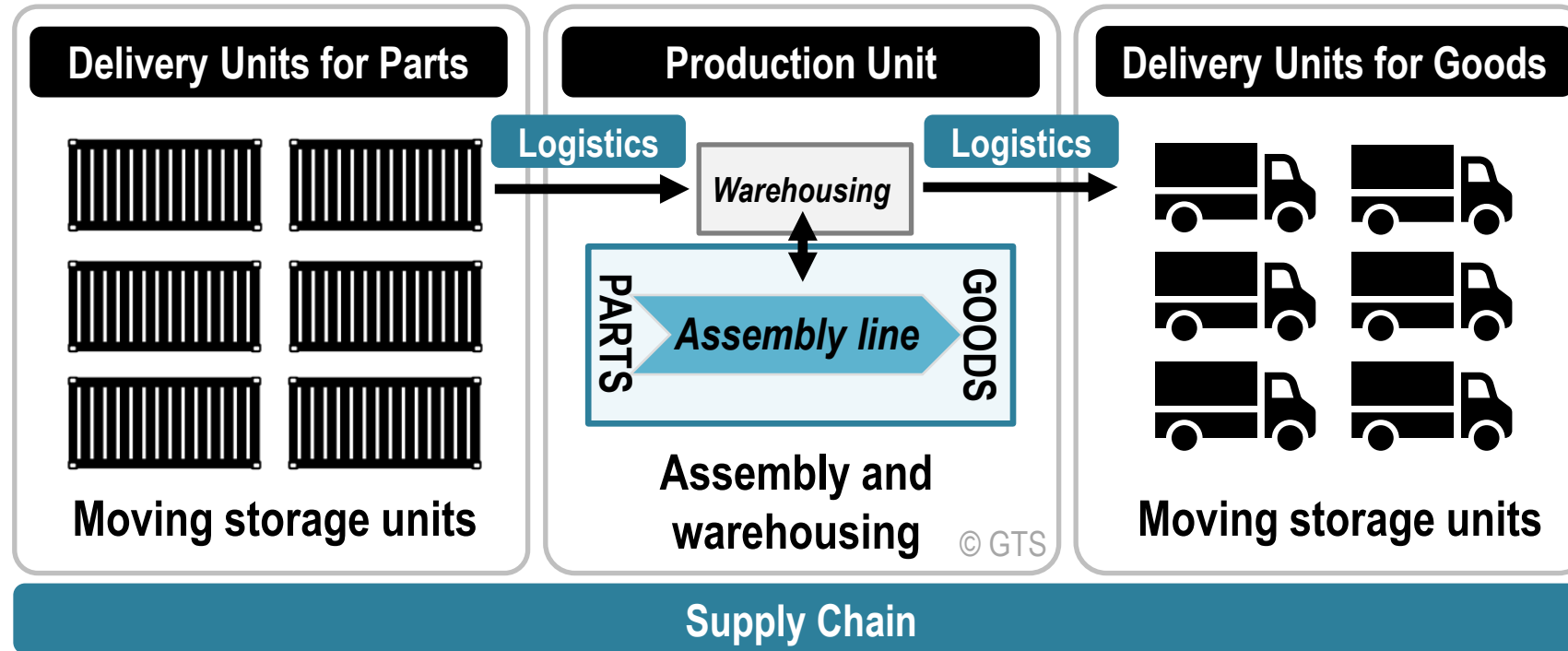


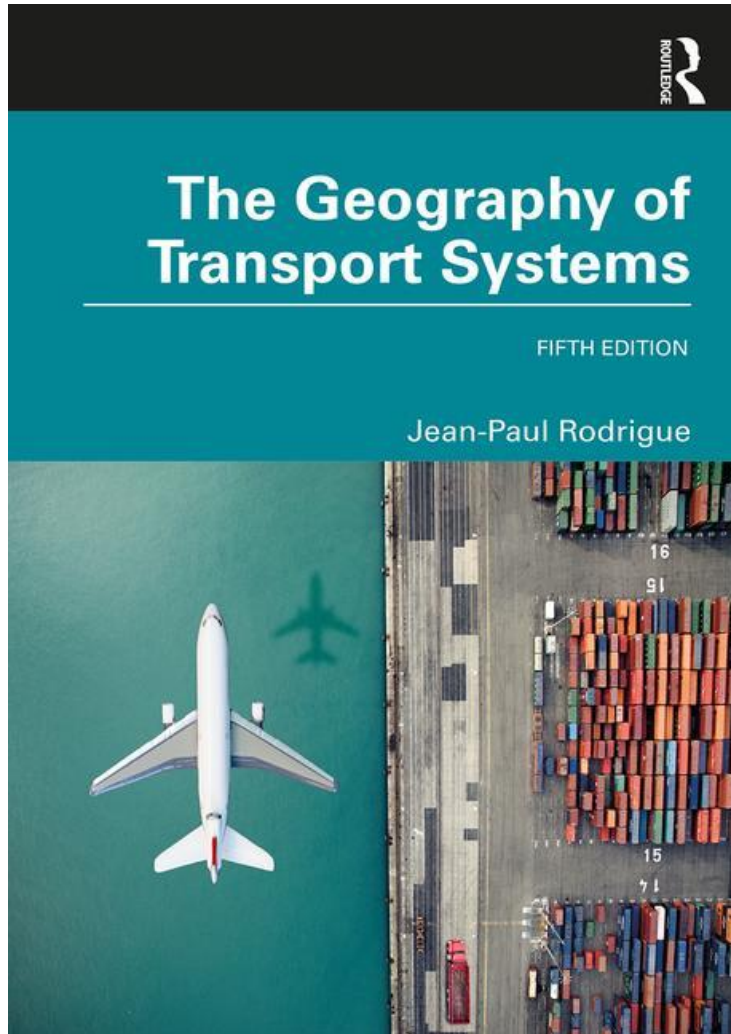
Transport Impacts on Economic Opportunities



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Just in Time and its Logistics

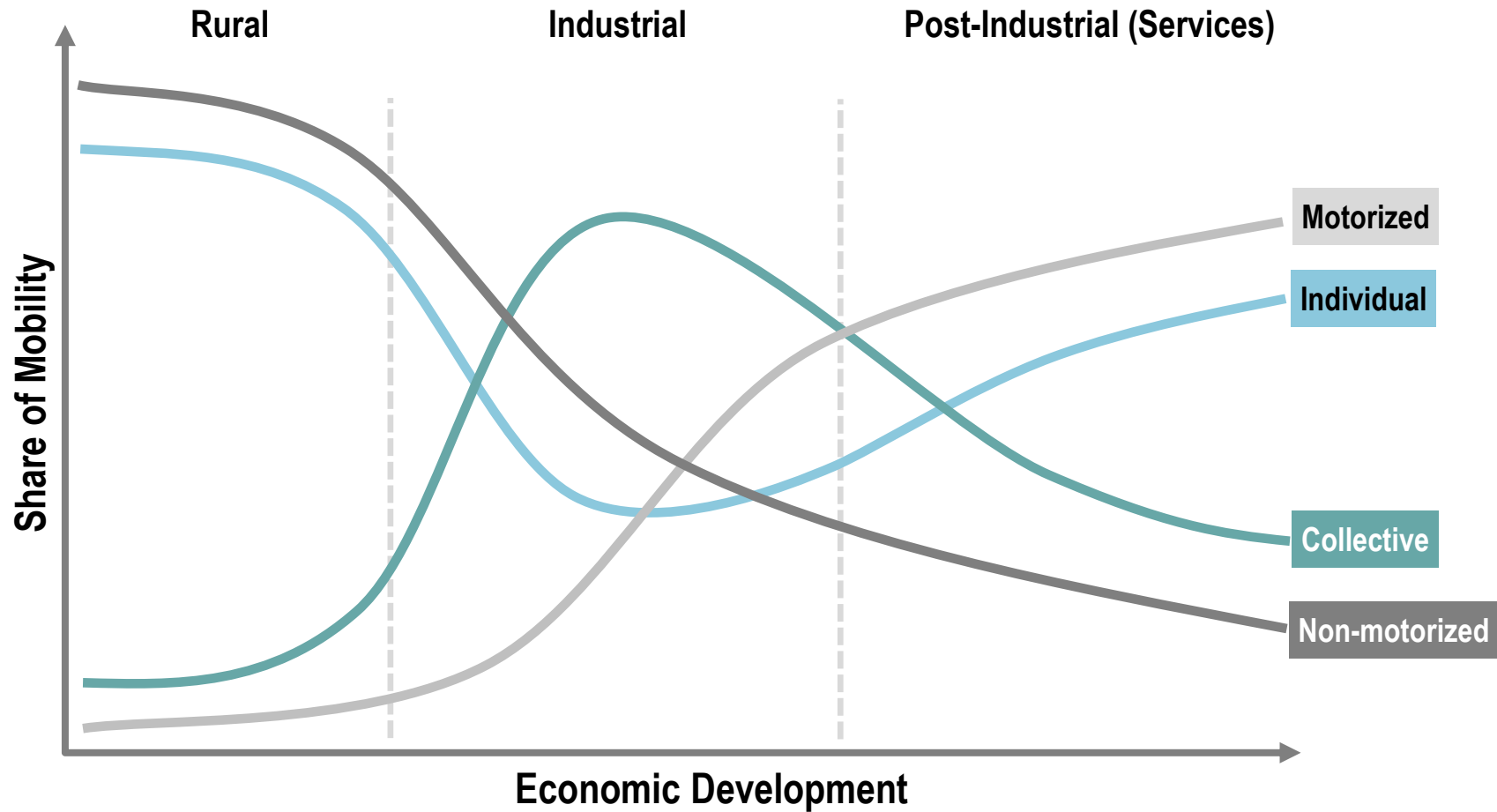




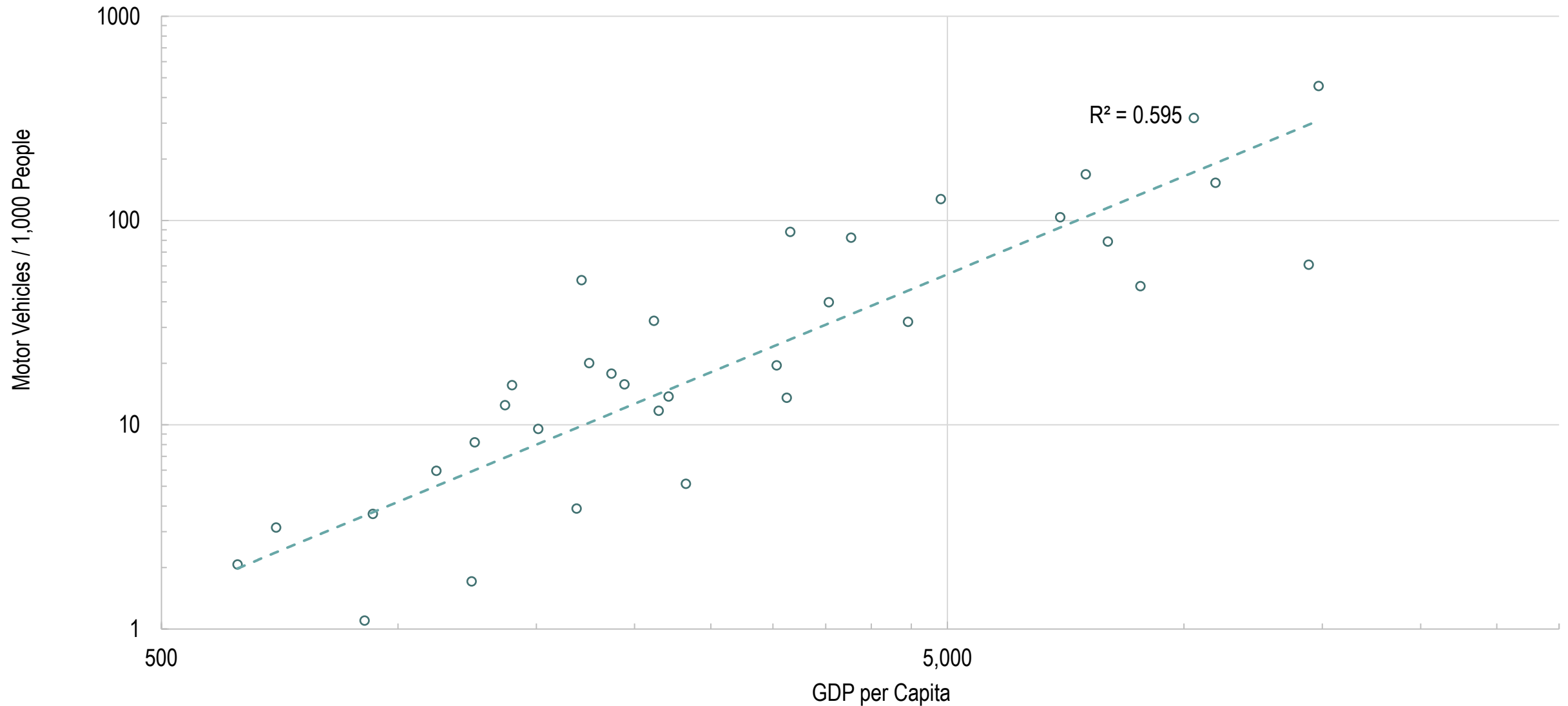
Transportation and Society

Chapter 3.2

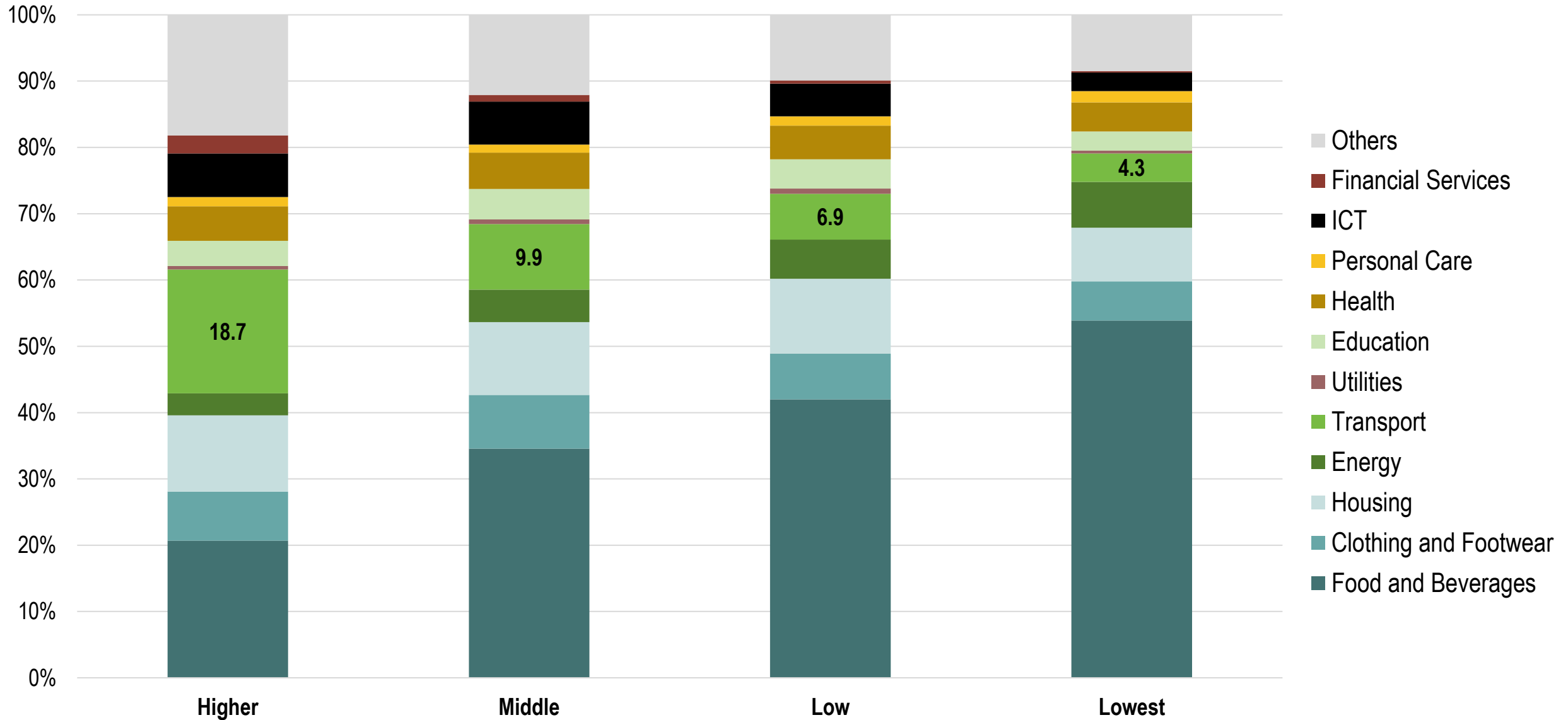
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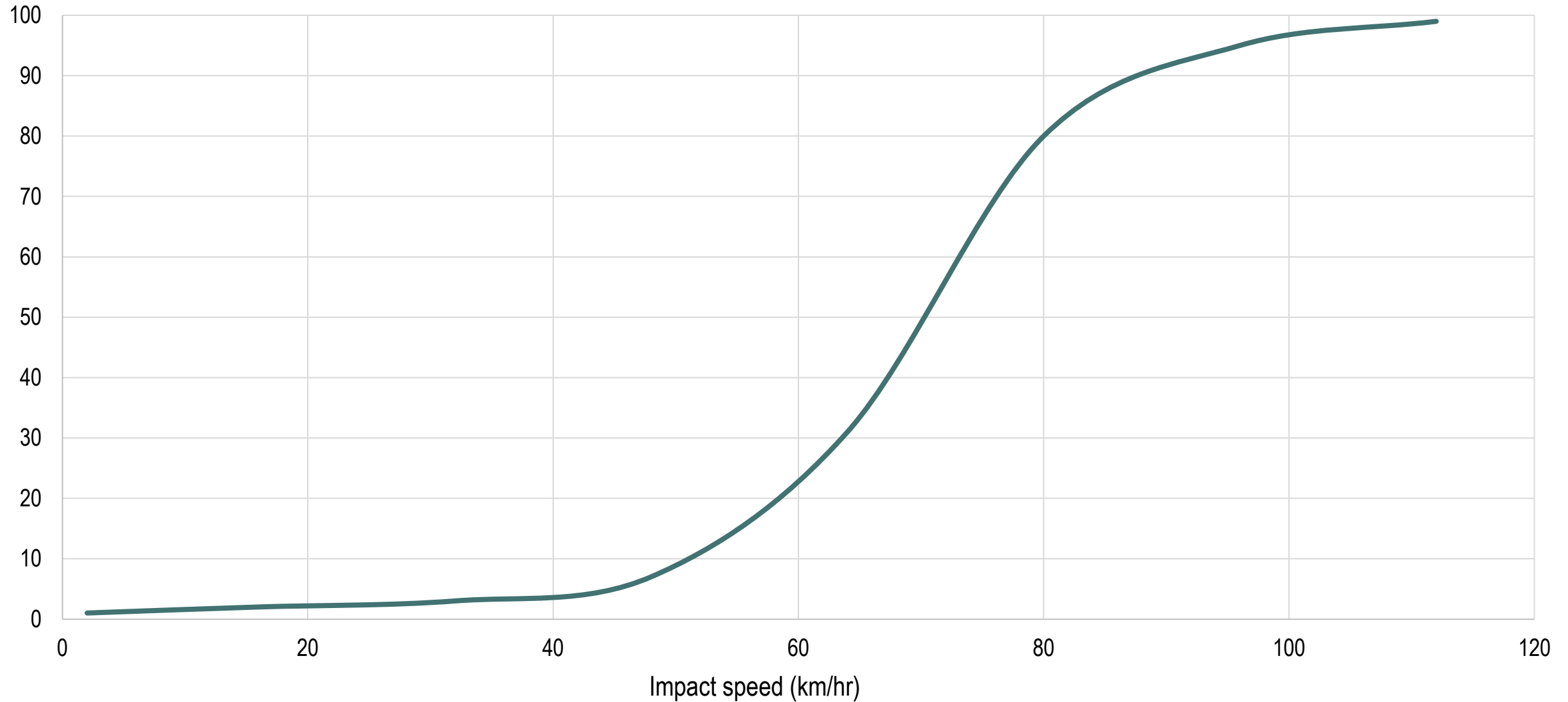
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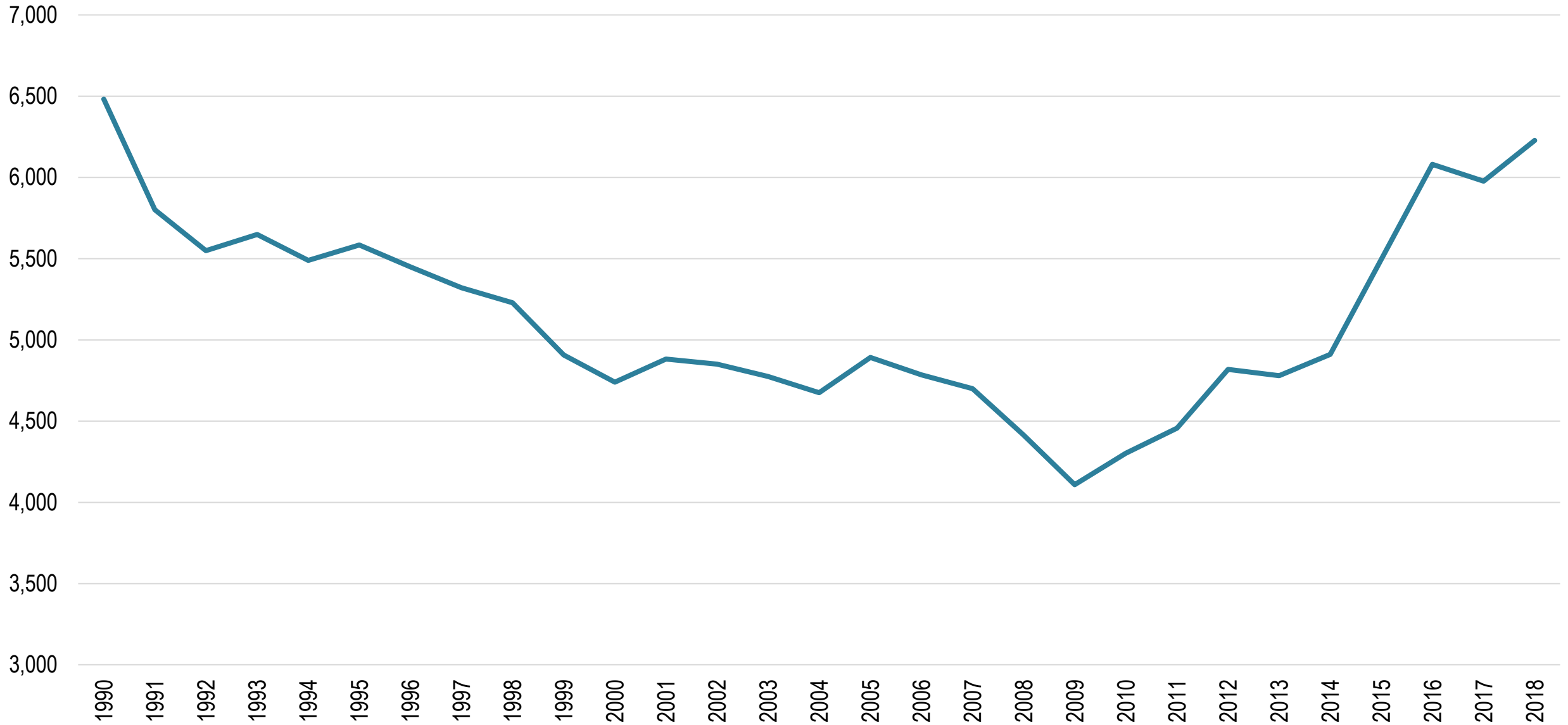
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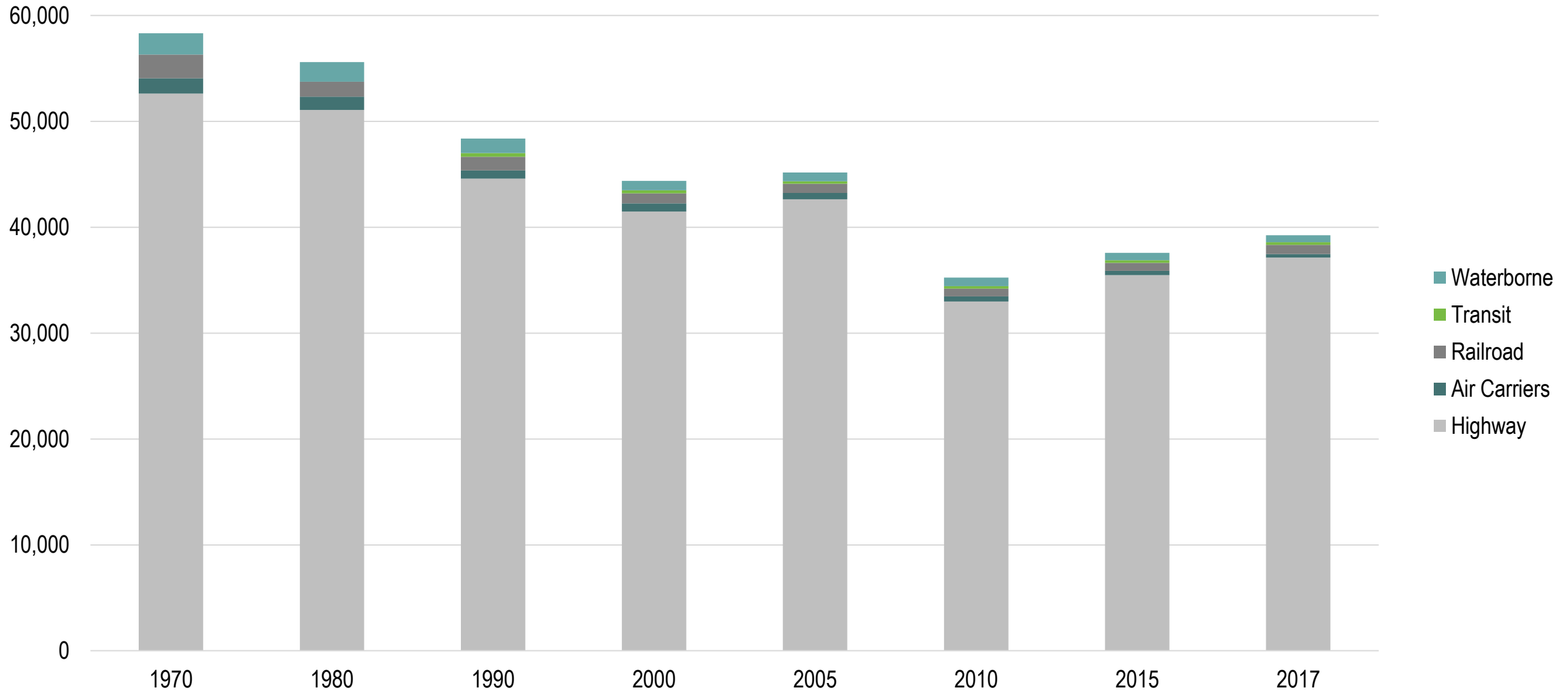
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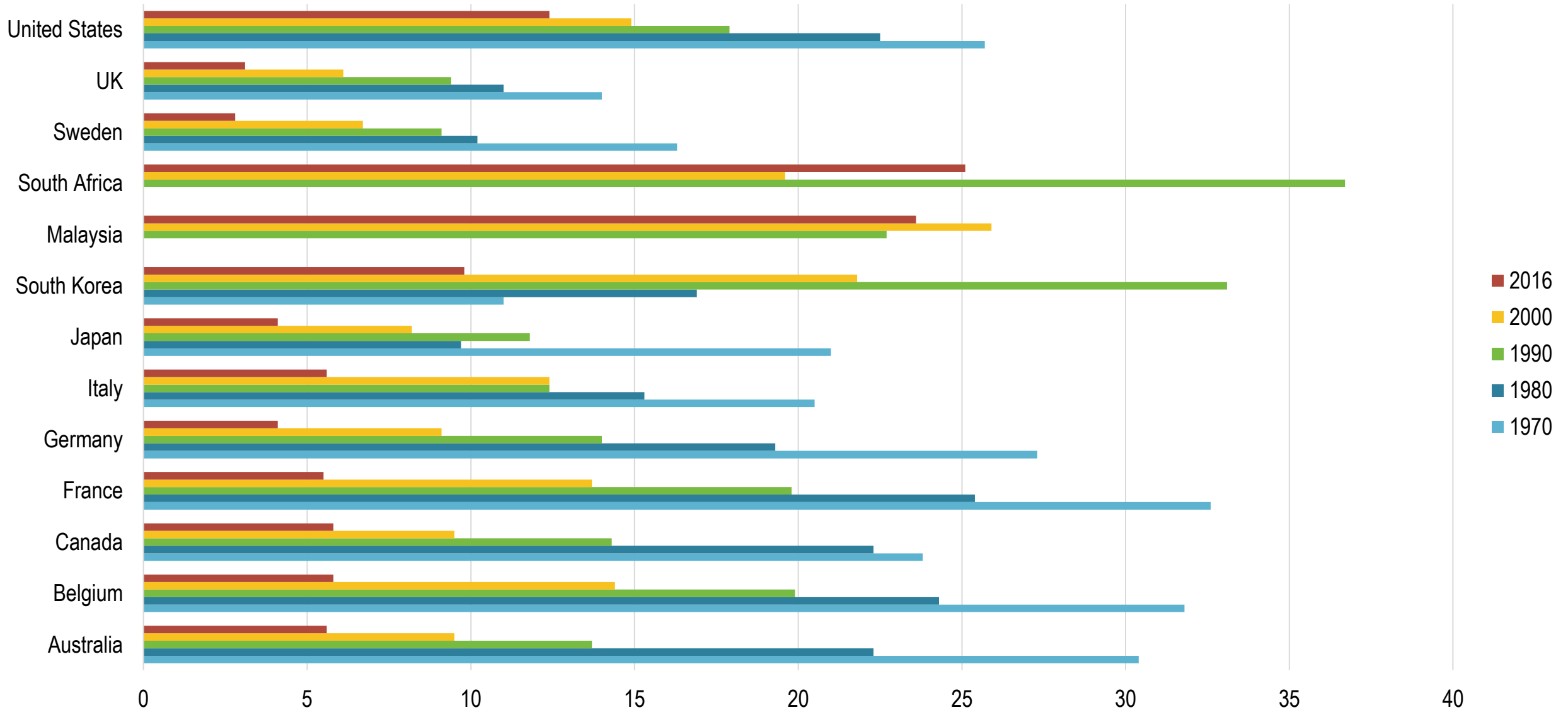
Pedestrian Fatalities, United States, 1990-2018



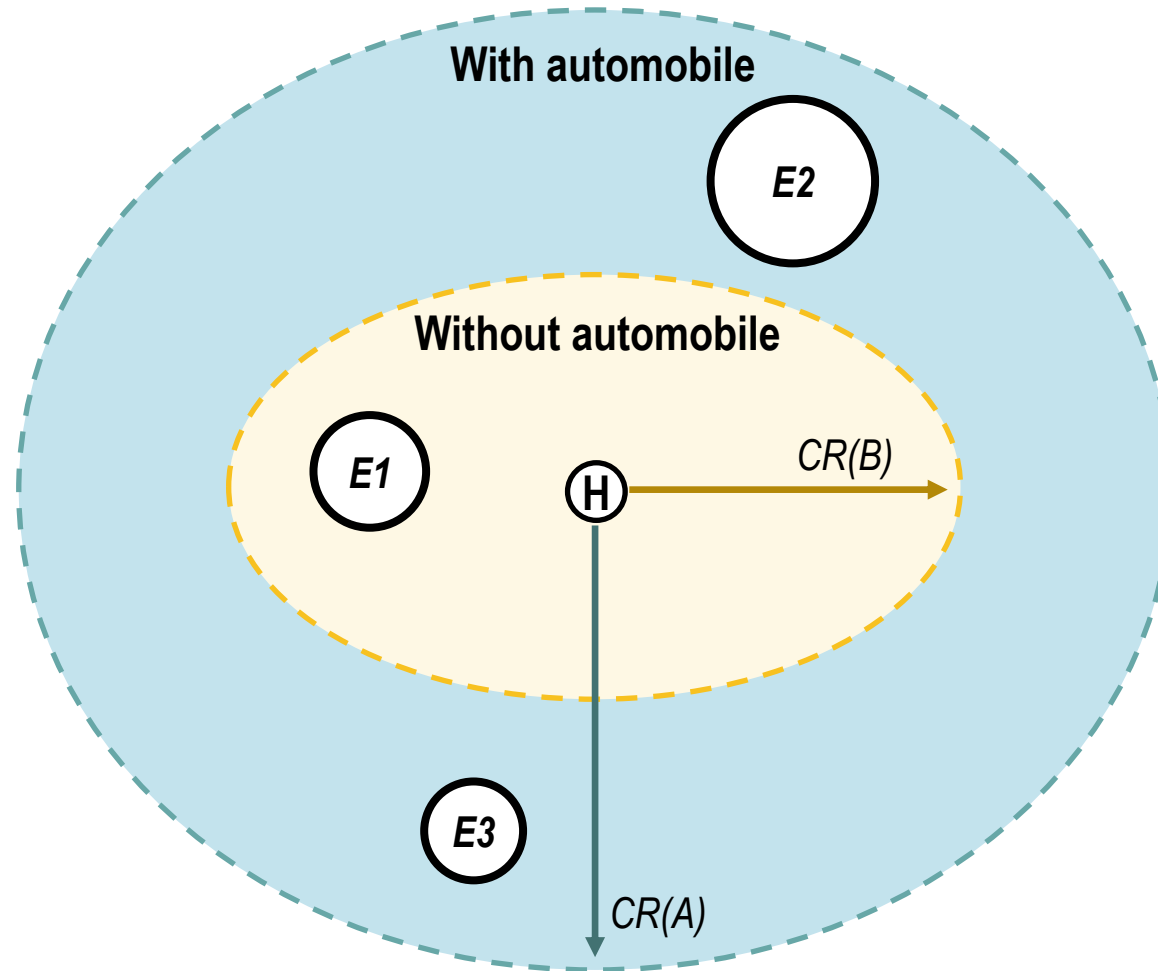
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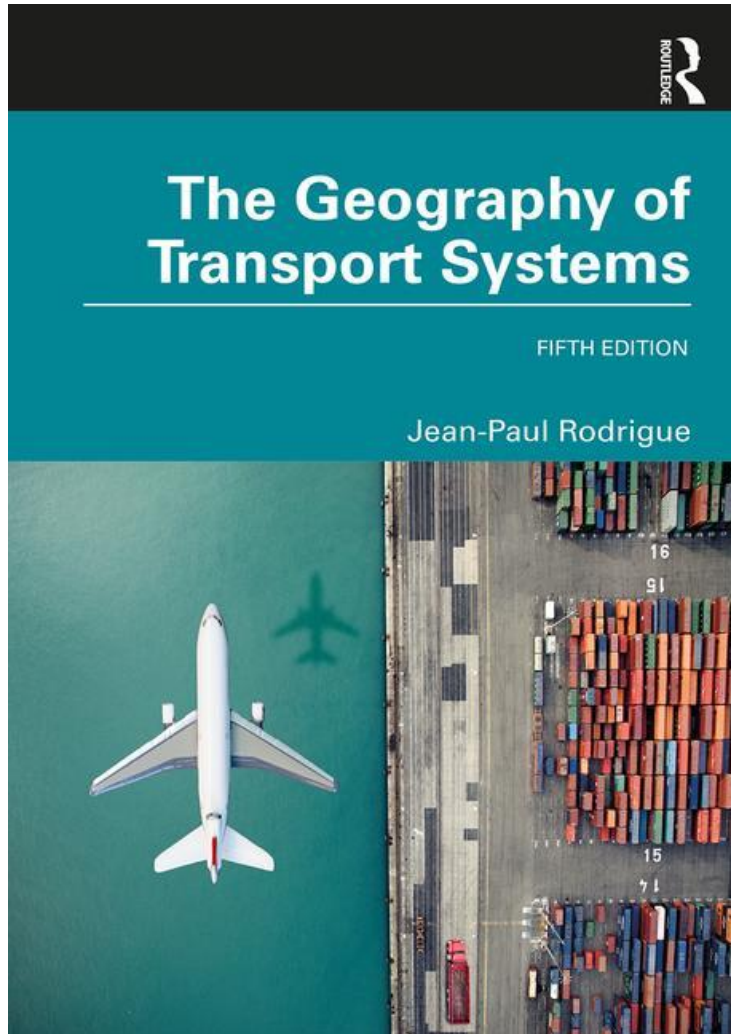


Road Fatalities per 100,000 People, Selected Countries



Economic Opportunities According to Automobile Ownership

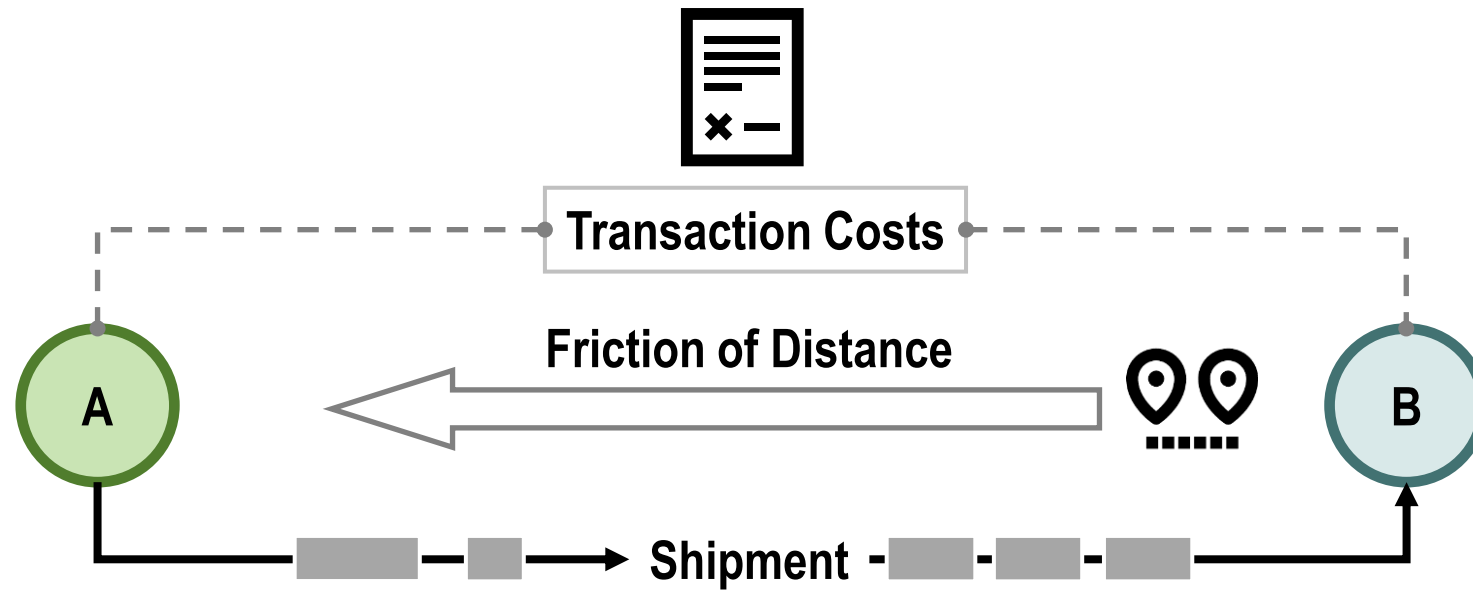




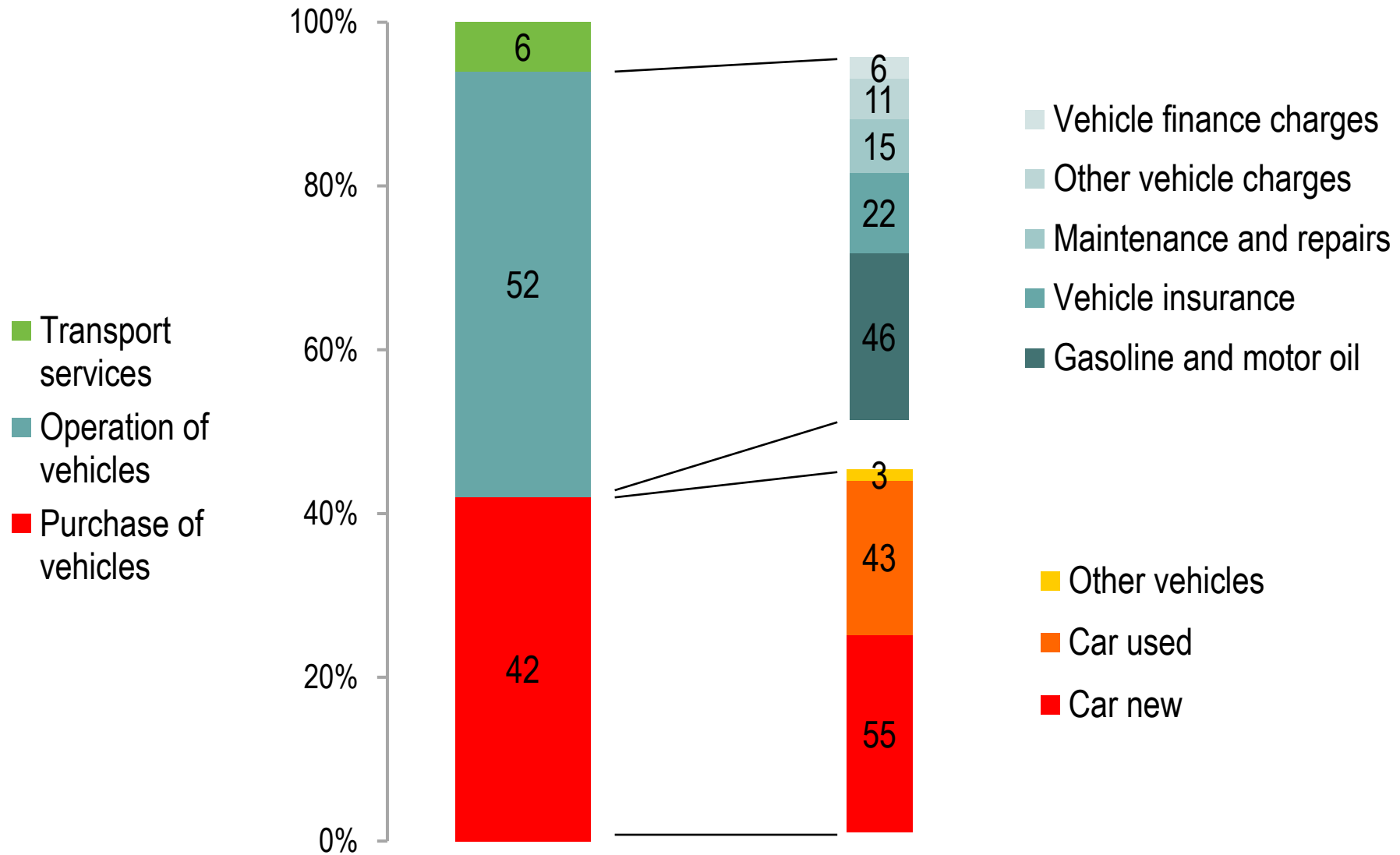
Transport Costs

Chapter 3.3

Components of Transport Cost



Household Expenditures on Transport, United States, 2005



Fixed and Operating Transport Costs

Mode	Fixed/Capital Costs	Operating Costs
Rail or Highway	Land, Construction, Rolling Stock	Maintenance, Labor, Fuel
Pipeline	Land, Construction	Maintenance, Energy
Air	Land, Field & Terminal Construction, Aircraft	Maintenance, Fuel, Labor, Airport Charges
Maritime	Land for Port Terminals, Cargo Handling Equipment, Ships	Maintenance, Fuel, Labor, Port Charges

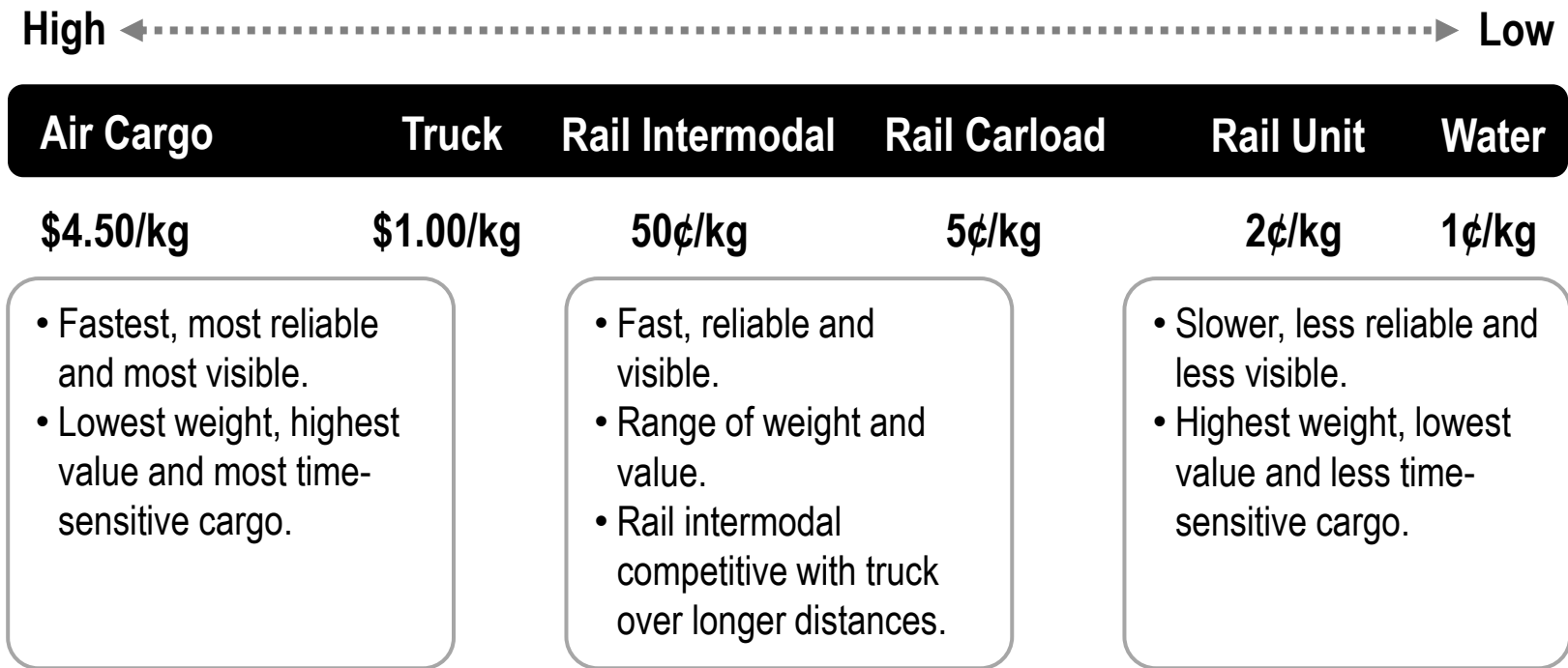
Conditions Affecting Transport Costs

Condition	Factors	Examples
Geography	Distance, physiography, accessibility	Shipping between France and England vs. shipping between France and the Netherlands
Type of product	Packaging, weight, perishable	Shipping coal Shipping flowers or wine
Economies of scale	Shipment size	A 777 compared to 737 (passengers) Post-Panamax compared to Panamax (freight)
Trade imbalance	Empty travel	Trade between China and the United States
Infrastructure	Capacity, limitations, operational conditions	The Interstate
Mode	Capacity, limitations, operational conditions	A bus compared to a car
Competition and regulation	Tariffs, safety, ownership	The European Union, The Jones Act

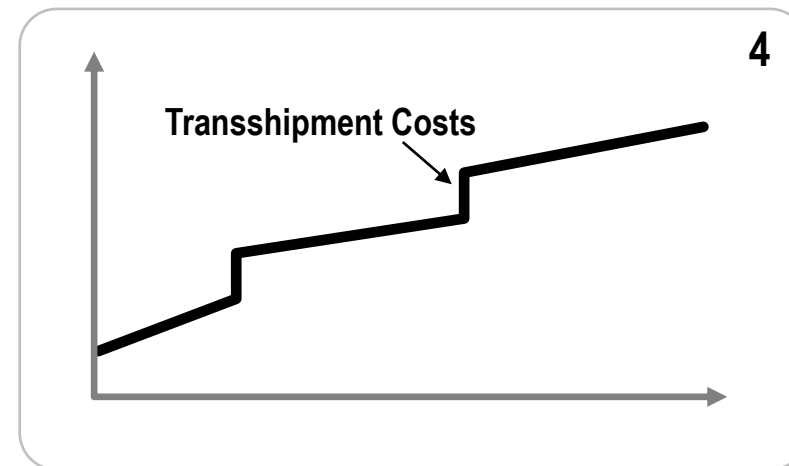
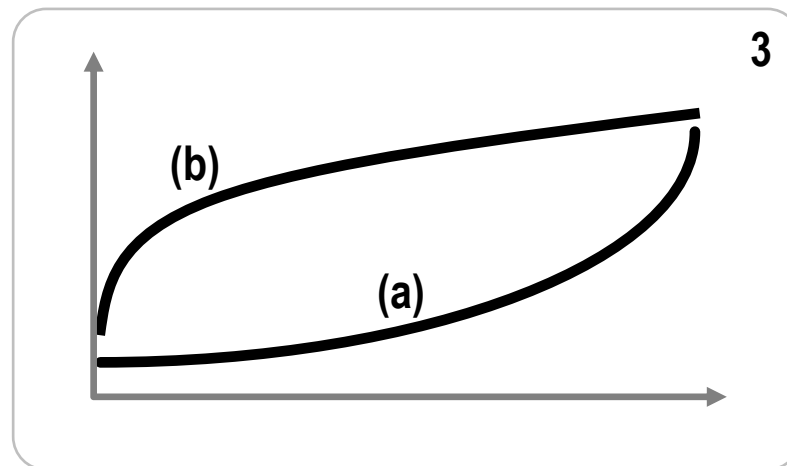
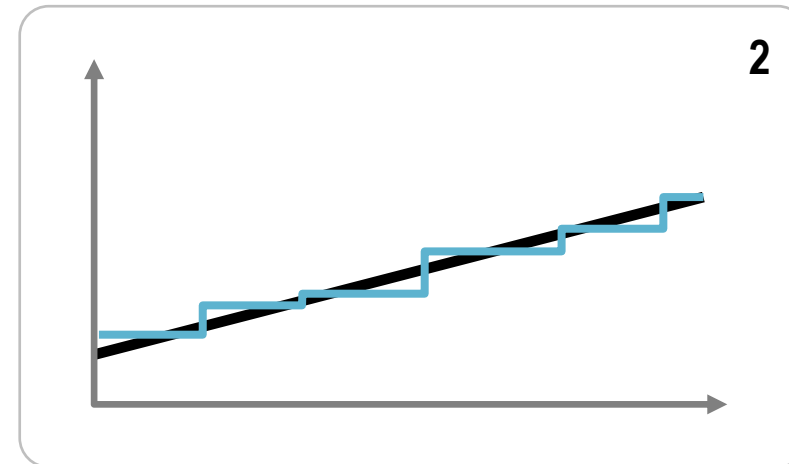
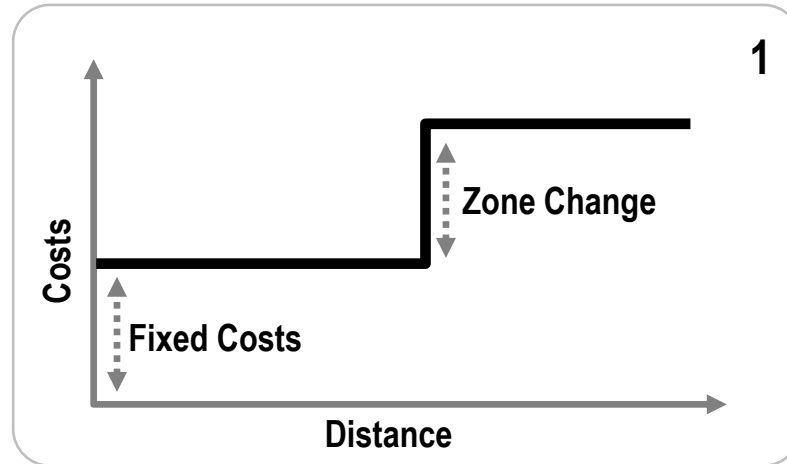
Truck Transport Cost Components, North America, 2005

Cost Component	Cost Share Range
Driver	27 to 36%
Fuel	18 to 24%
Administration and Interest	13 to 14%
Equipment Ownership	7 to 12%
Repairs	7 to 12%
Insurance	3%
Tires	2 to 4%
Miscellaneous (Licenses, Cleaning, etc.)	2 to 3%
Margin	5%

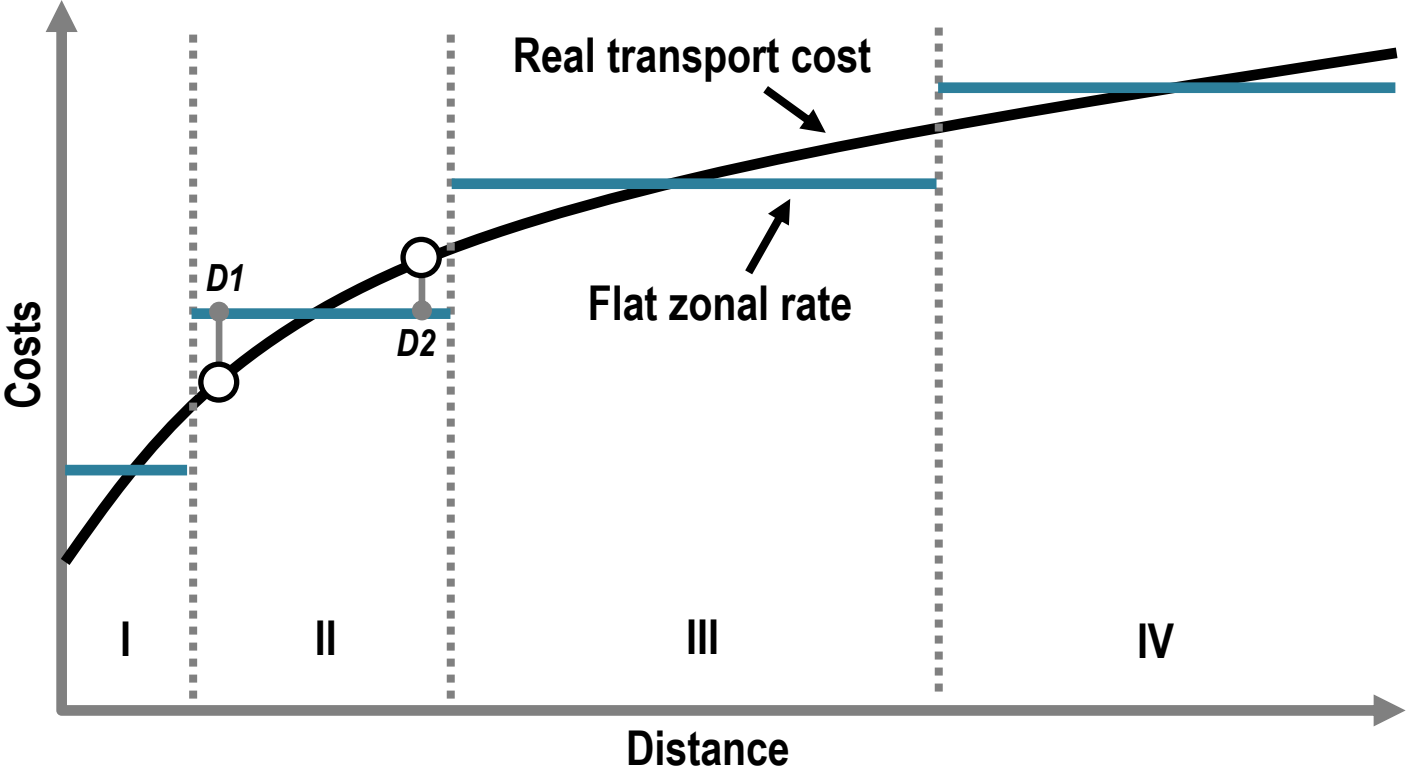
Freight Transportation Service Spectrum



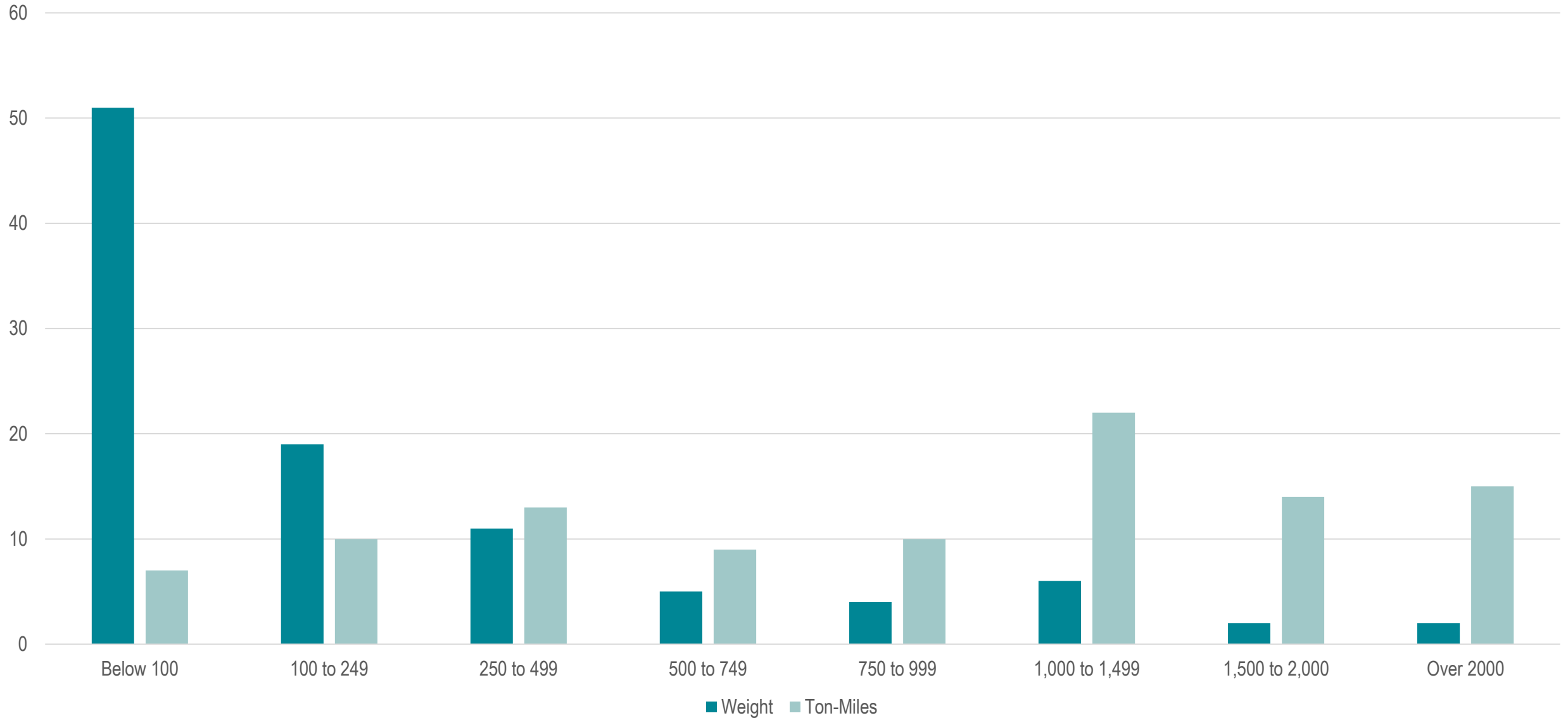
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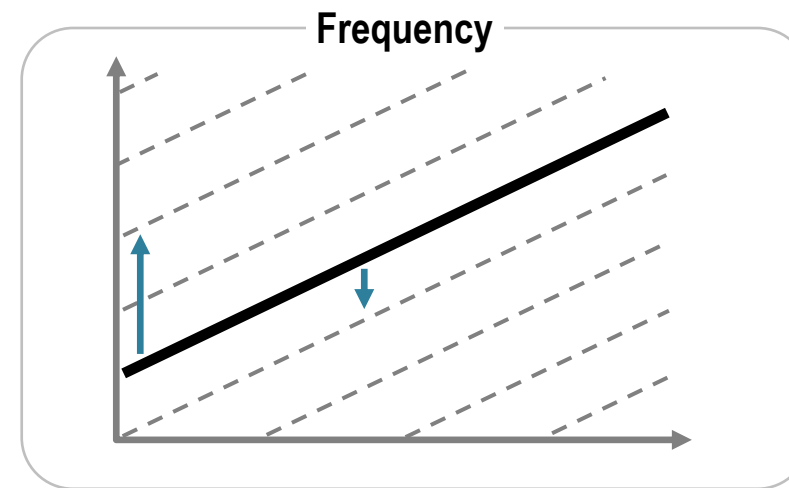
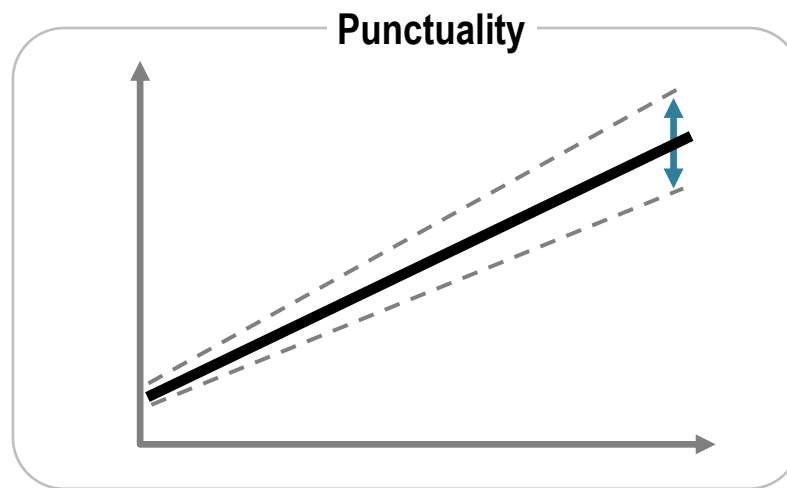
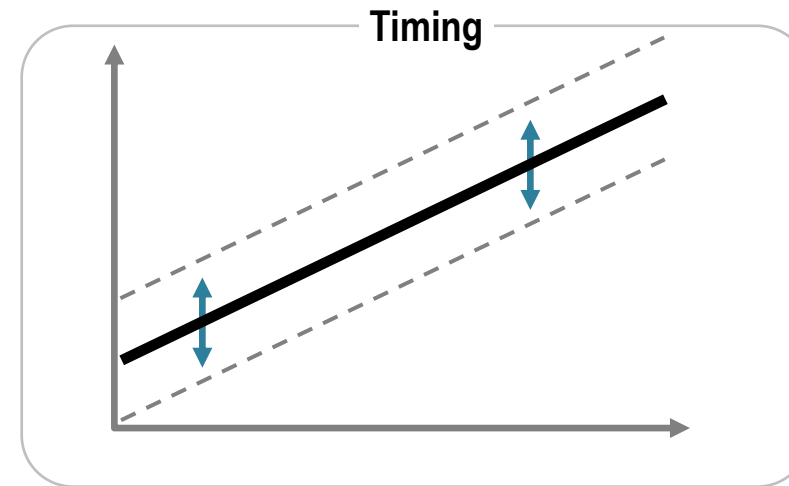
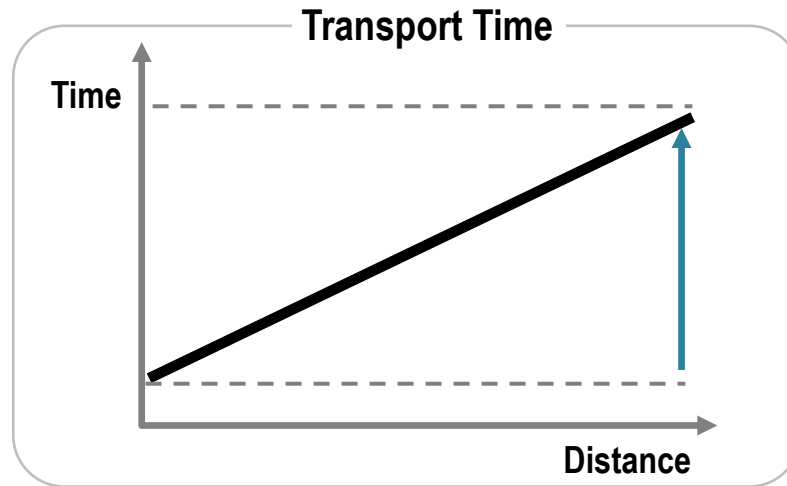
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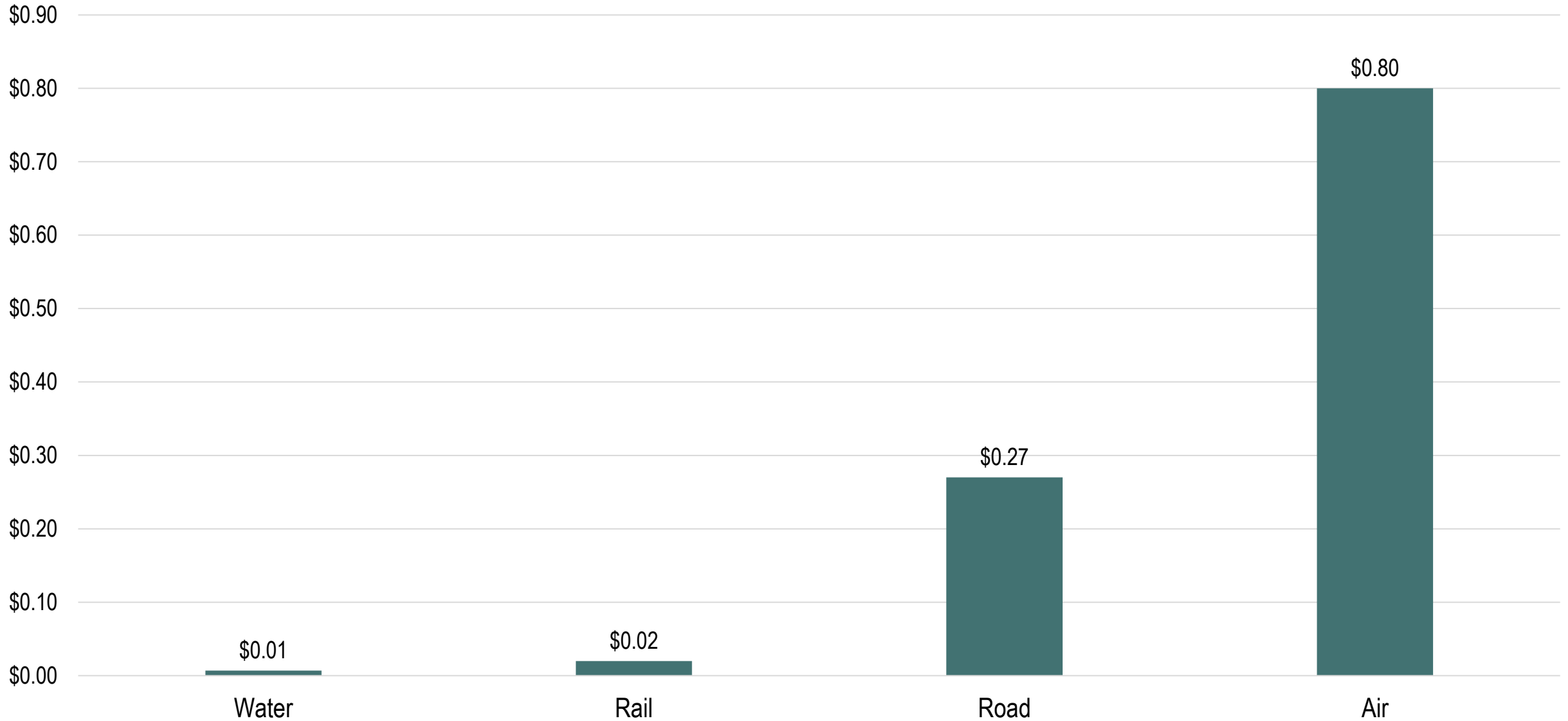
Total Freight Moved by Distance, United States, 2007



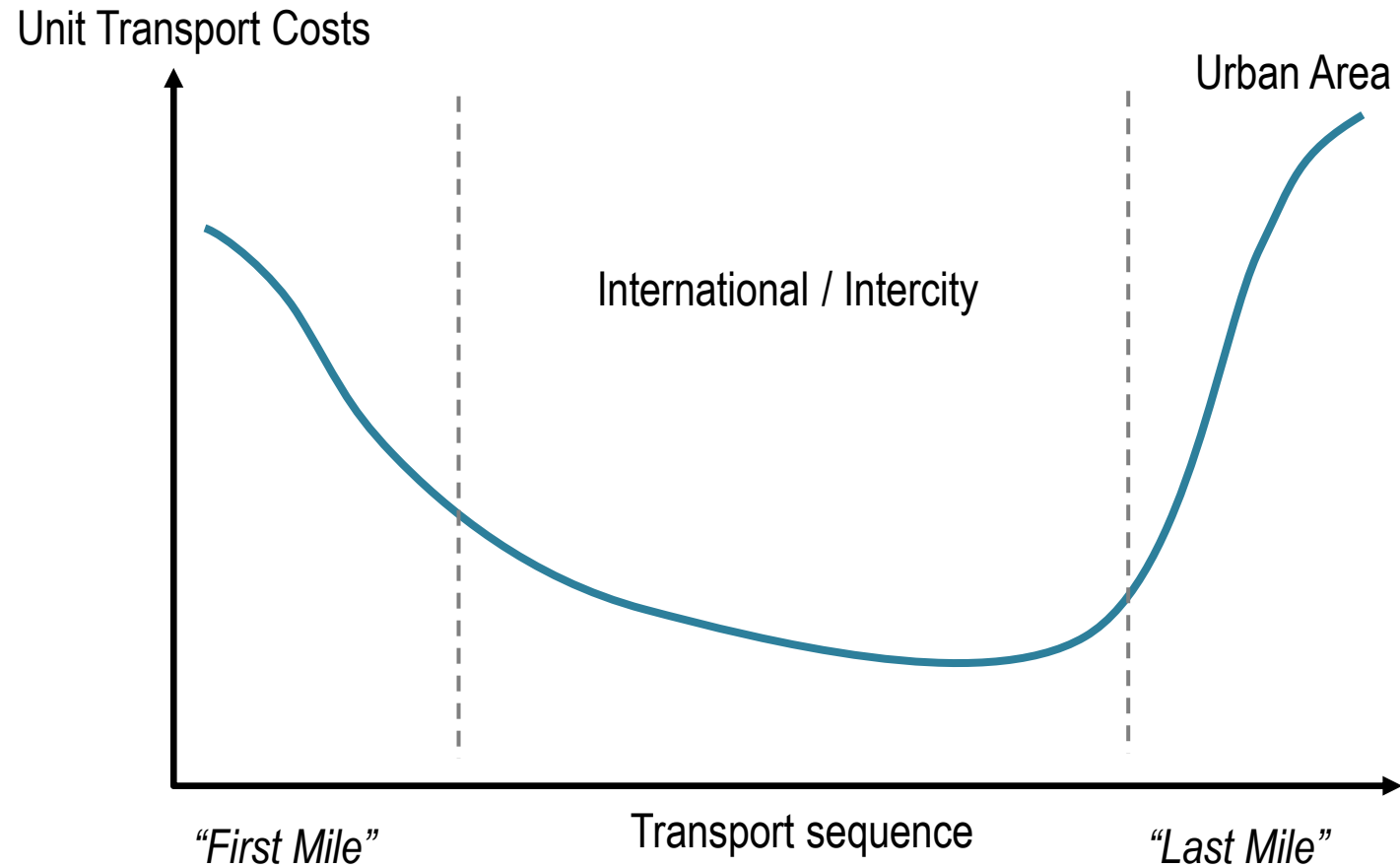
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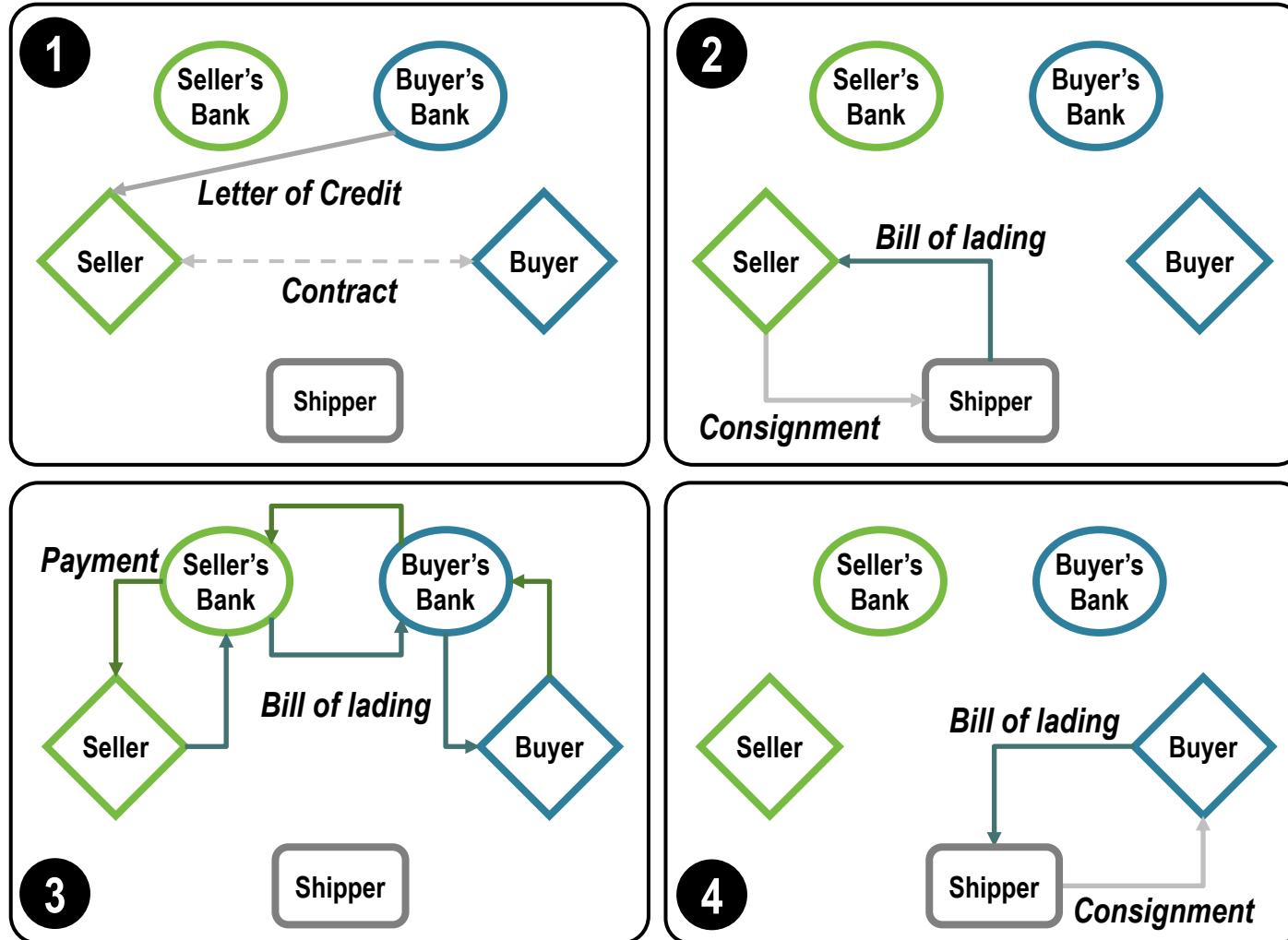
Freight Transport Revenue per Ton-Mile (in 2006 dollars)



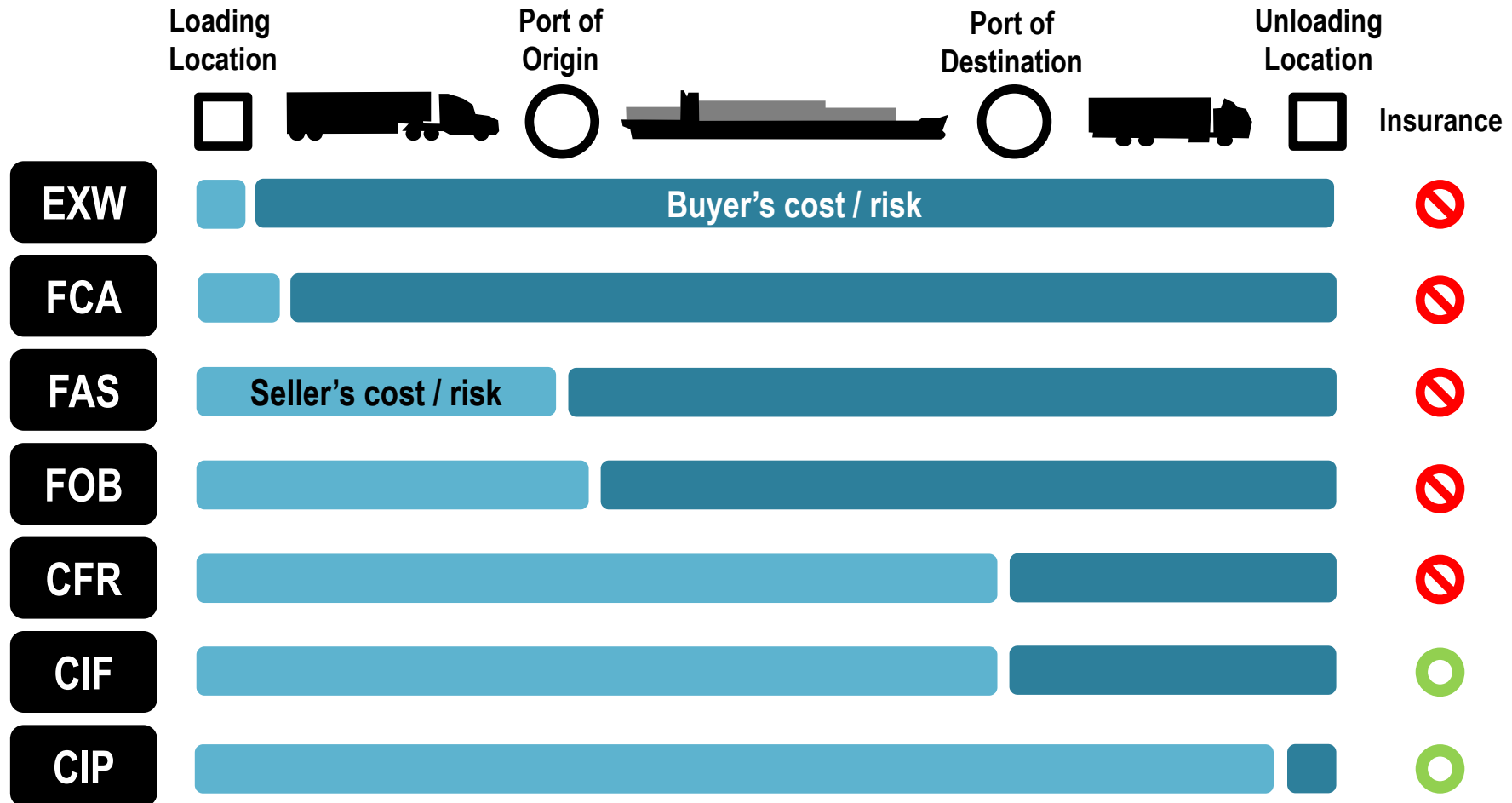
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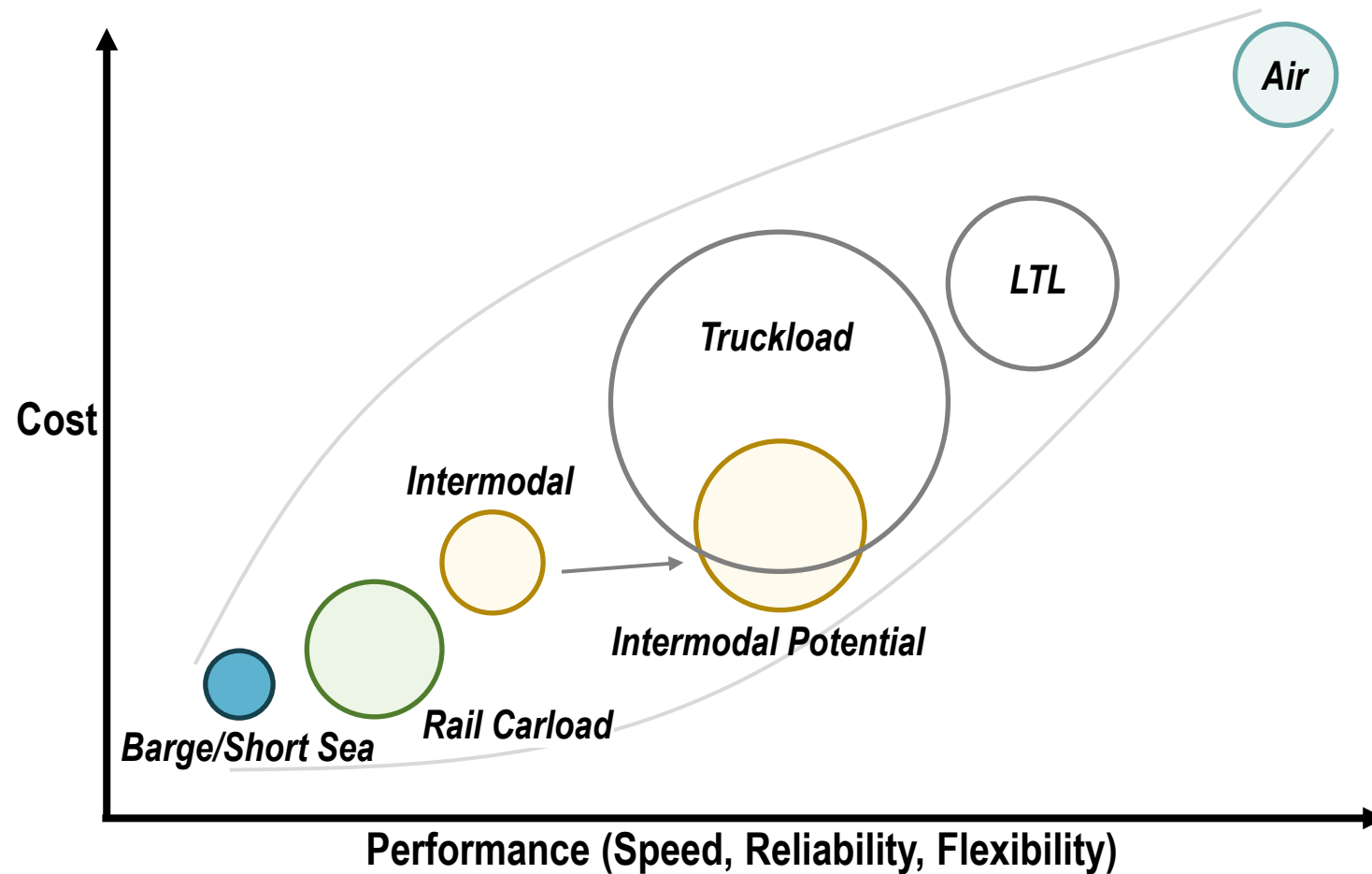
Letters of Credit and Bills of Lading in Commercial Transactions



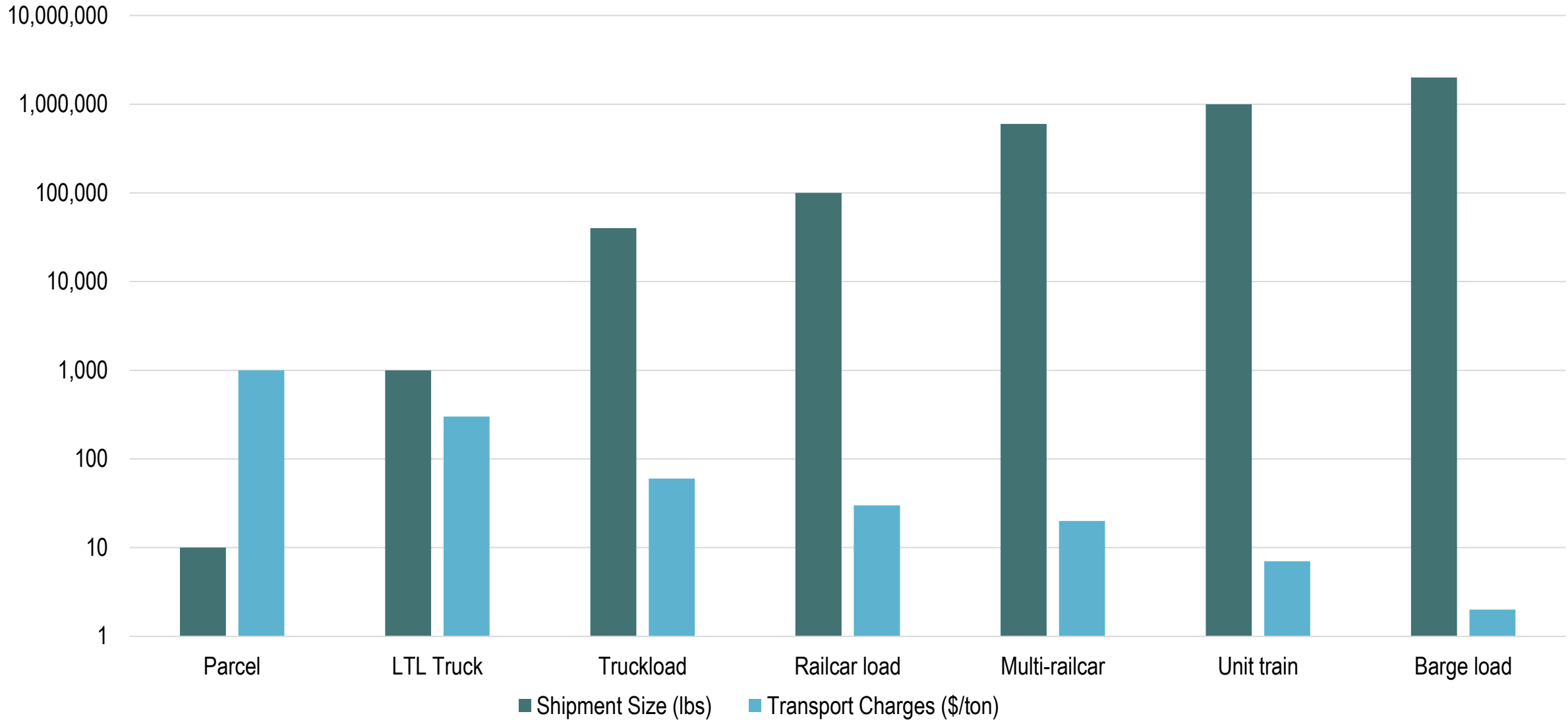
Selected International Commercial Terms (Incoterms)



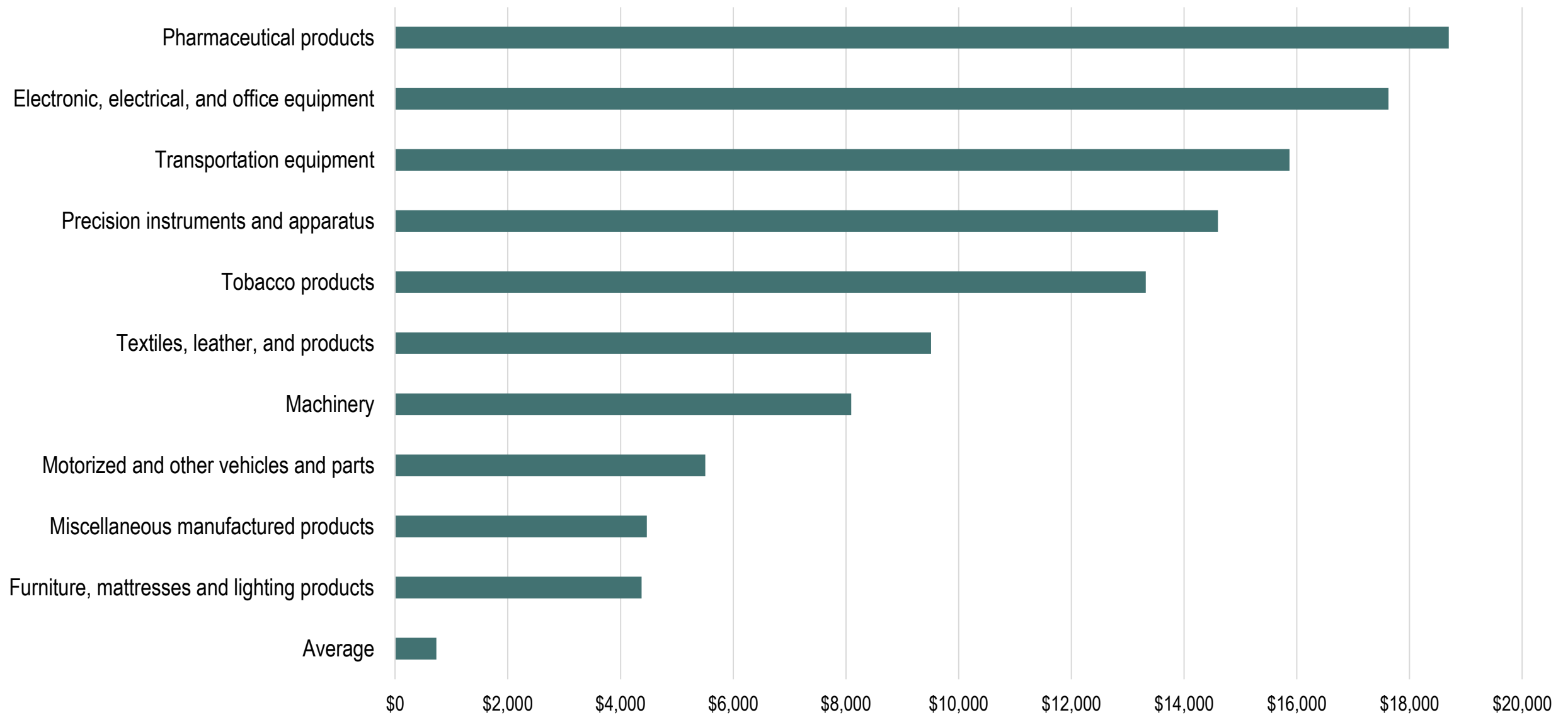
Cost / Performance Relationships for Inland Freight Transportation Modes



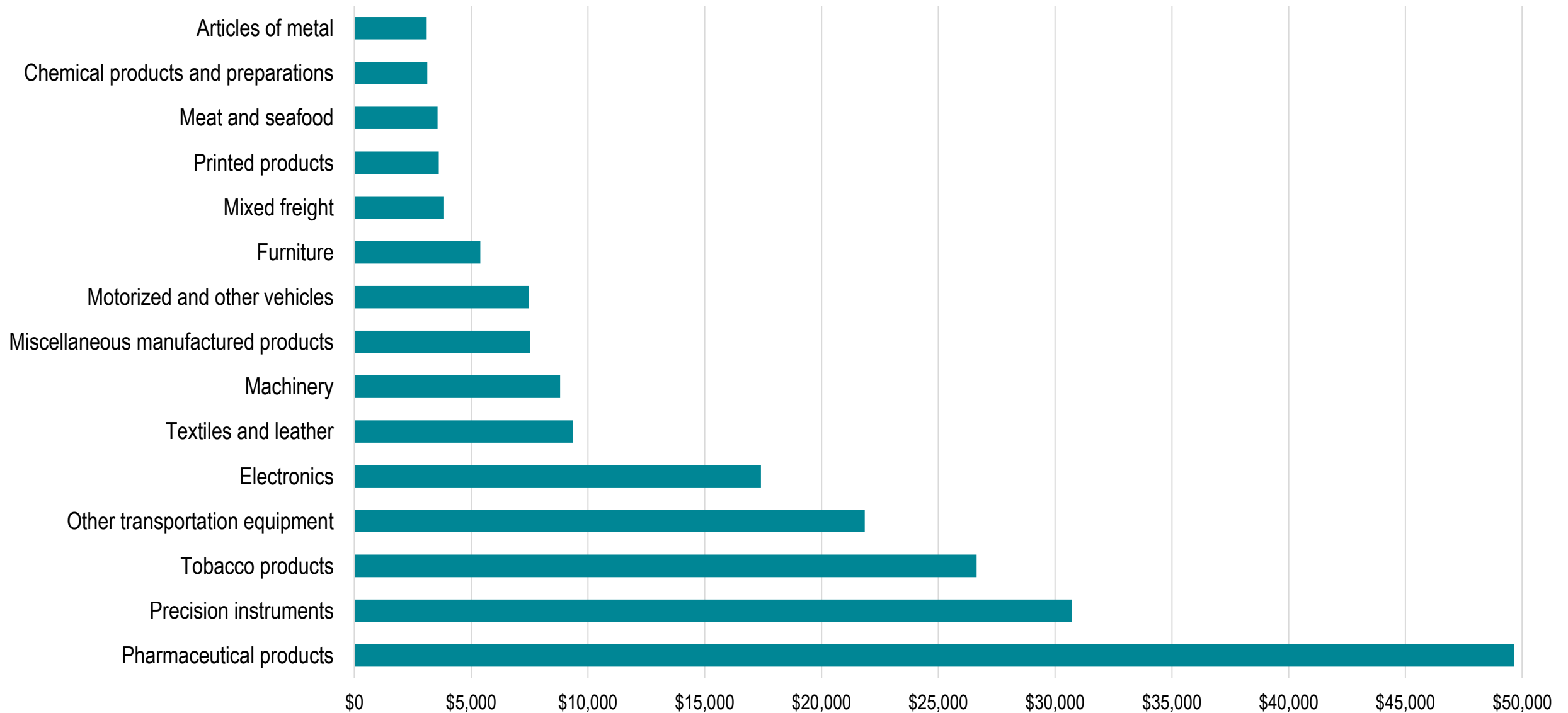
Shipment Size and Inland Transport Costs



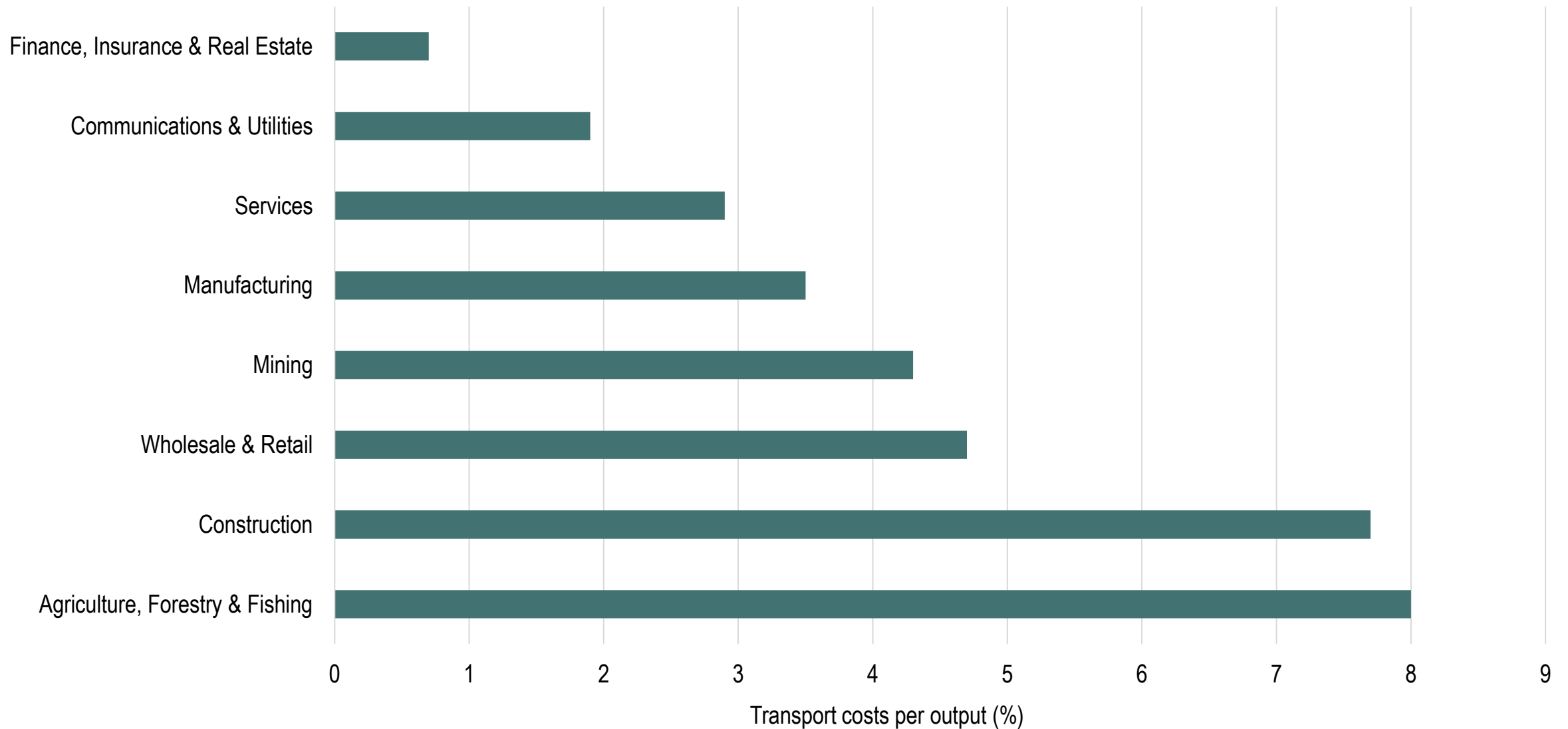
Top 10 Commodity Groups Ranked by Value Per Ton, United States, 2002



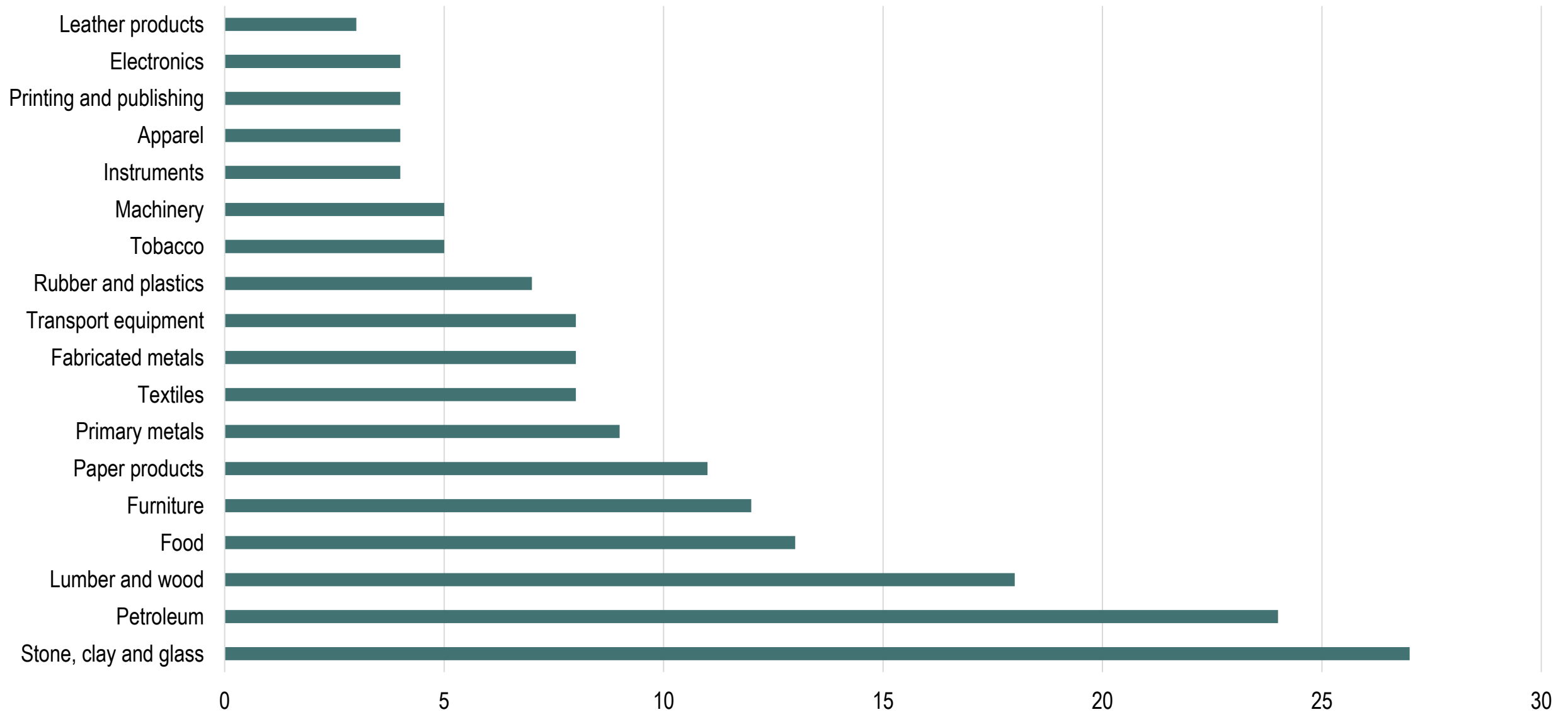
Top 15 Commodity Groups Ranked by Value Per Ton, United States, 2017



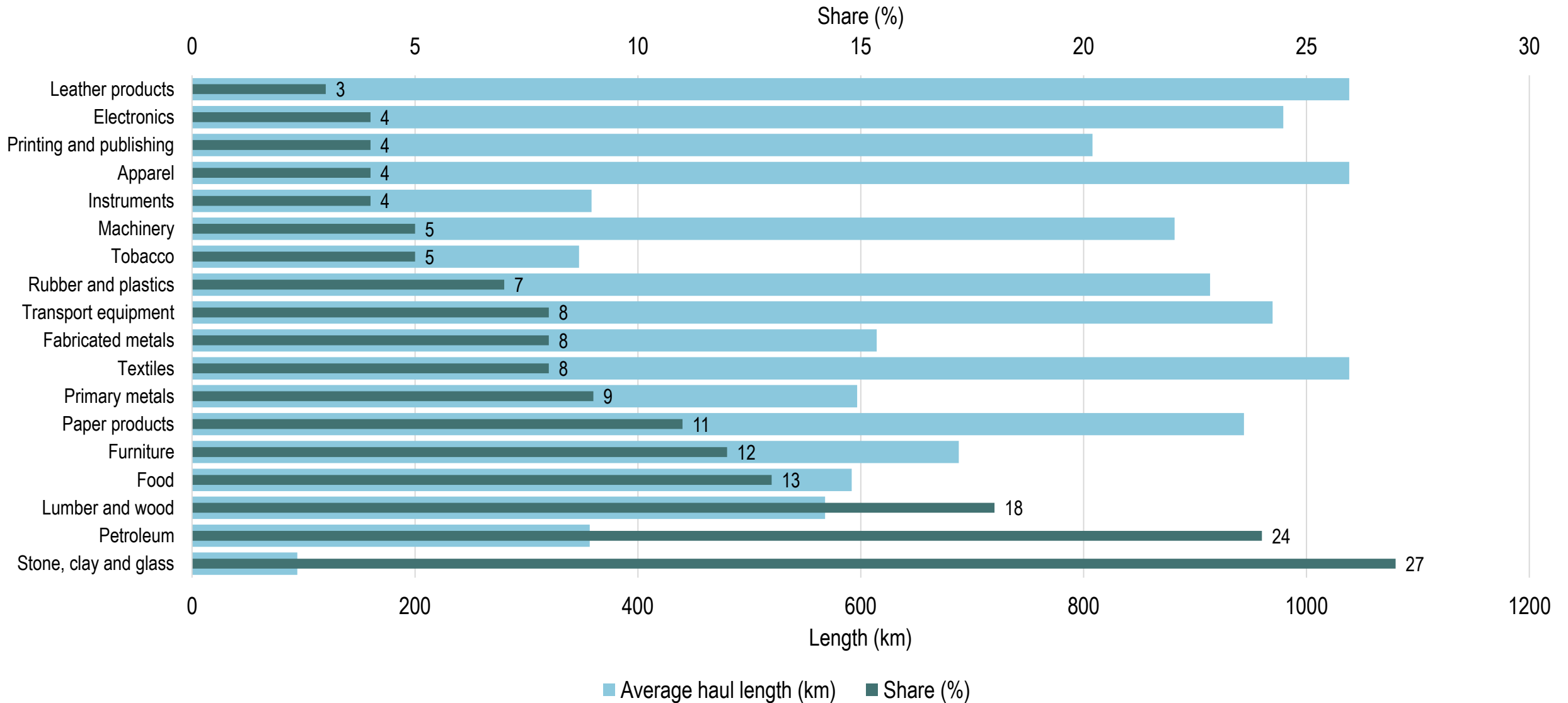
Transport Costs by Industry Type, 1999



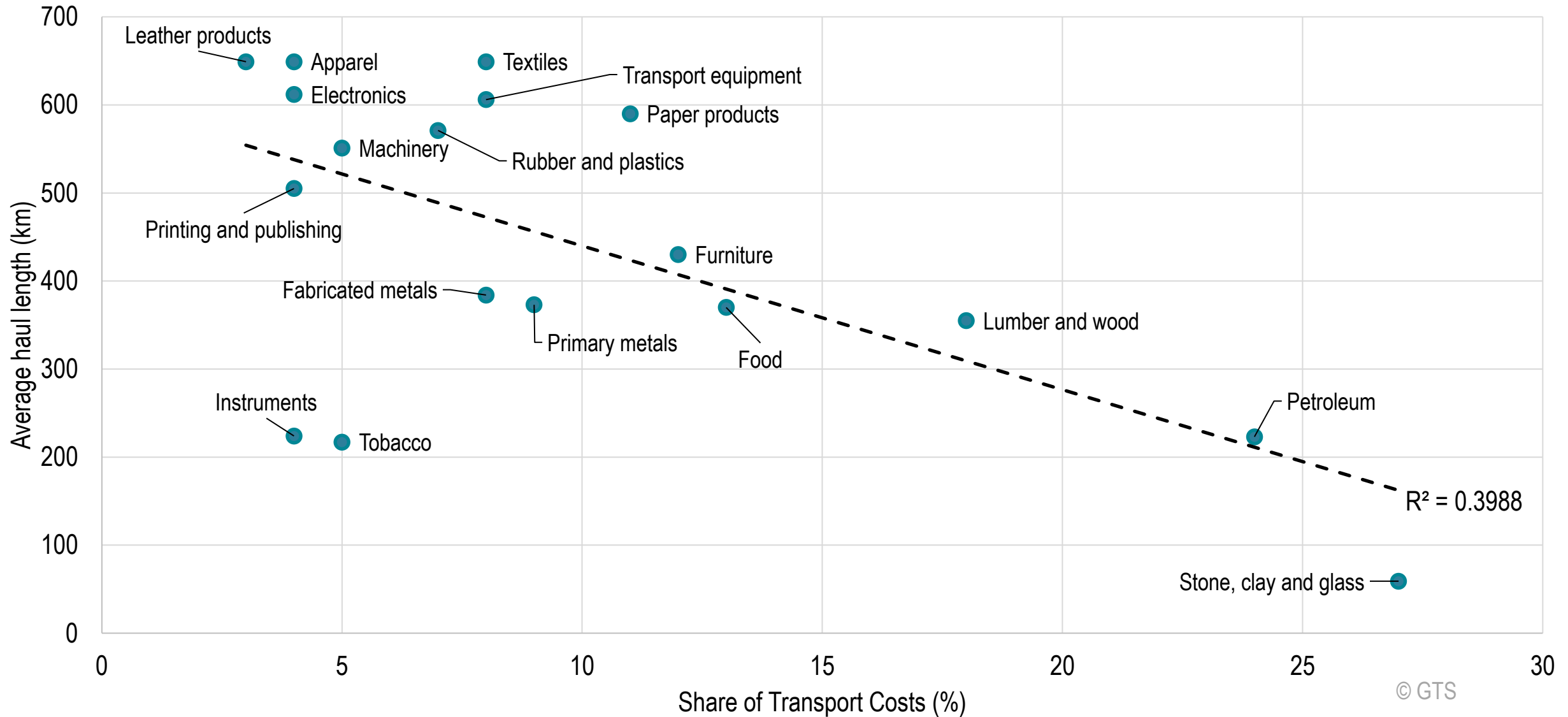
Share of Transport Costs in Product Prices



Share of Transport Costs in Product Prices and Average Haul Length



Share of Transport Costs in Product Prices and Average Domestic Haul Length



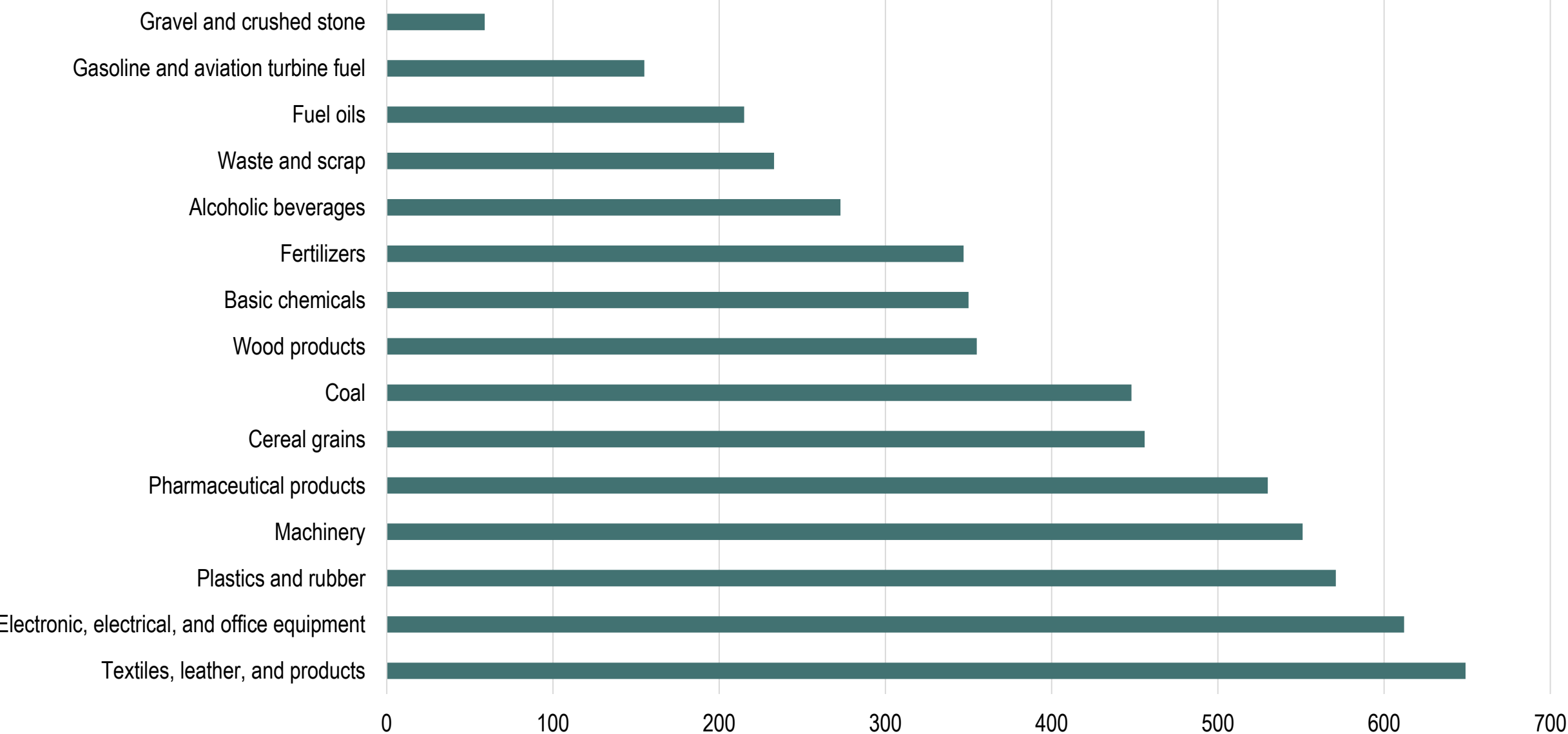
© GTS

Table 4. HMT Average Payment for Containerized Cargo

Commodity	\$ Value/ton	\$ Value/40' container	HMT/40' container
Electronics	12,104	117,606	\$147.01
Apparel	14,517	114,274	\$142.84
Hardware	7,096	107,916	\$134.90
Autos and Auto Parts	6,452	90,248	\$112.81
Footwear	11,745	84,310	\$105.39
Toys and Sport Equipment	7,964	68,032	\$85.04
Beverages, Spirits, Vinegar	2,128	49,546	\$61.93
Plastic Products	3,421	37,168	\$46.46
Furniture	3,268	27,210	\$34.01
Woodenware	1,315	21,860	\$27.32

Source: FMC, *Study of U.S. Inland Containerized Cargo Moving Through Canadian and Mexican Seaports*, July 2012, p. 42.

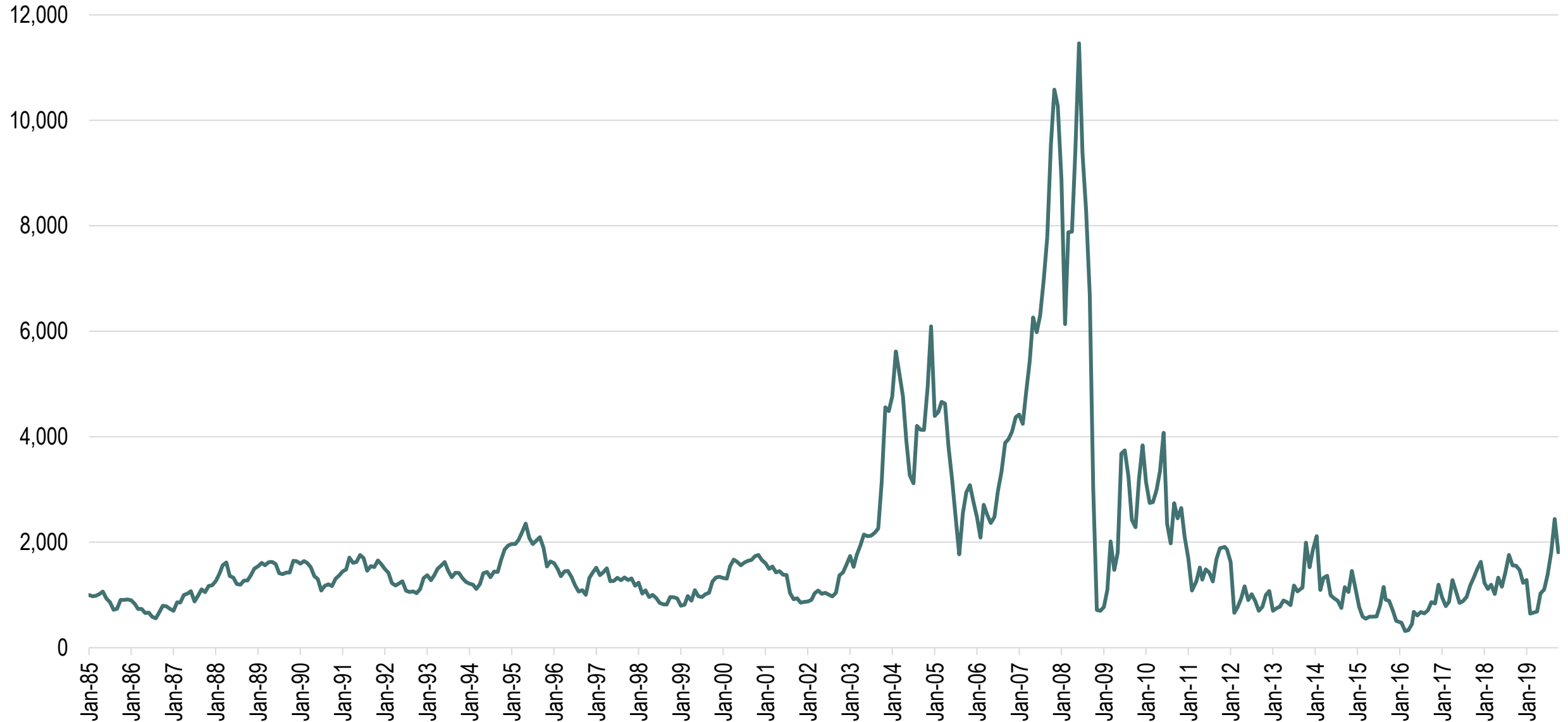
Average Length of Haul by Major Commodity Group, 2002 (in miles)



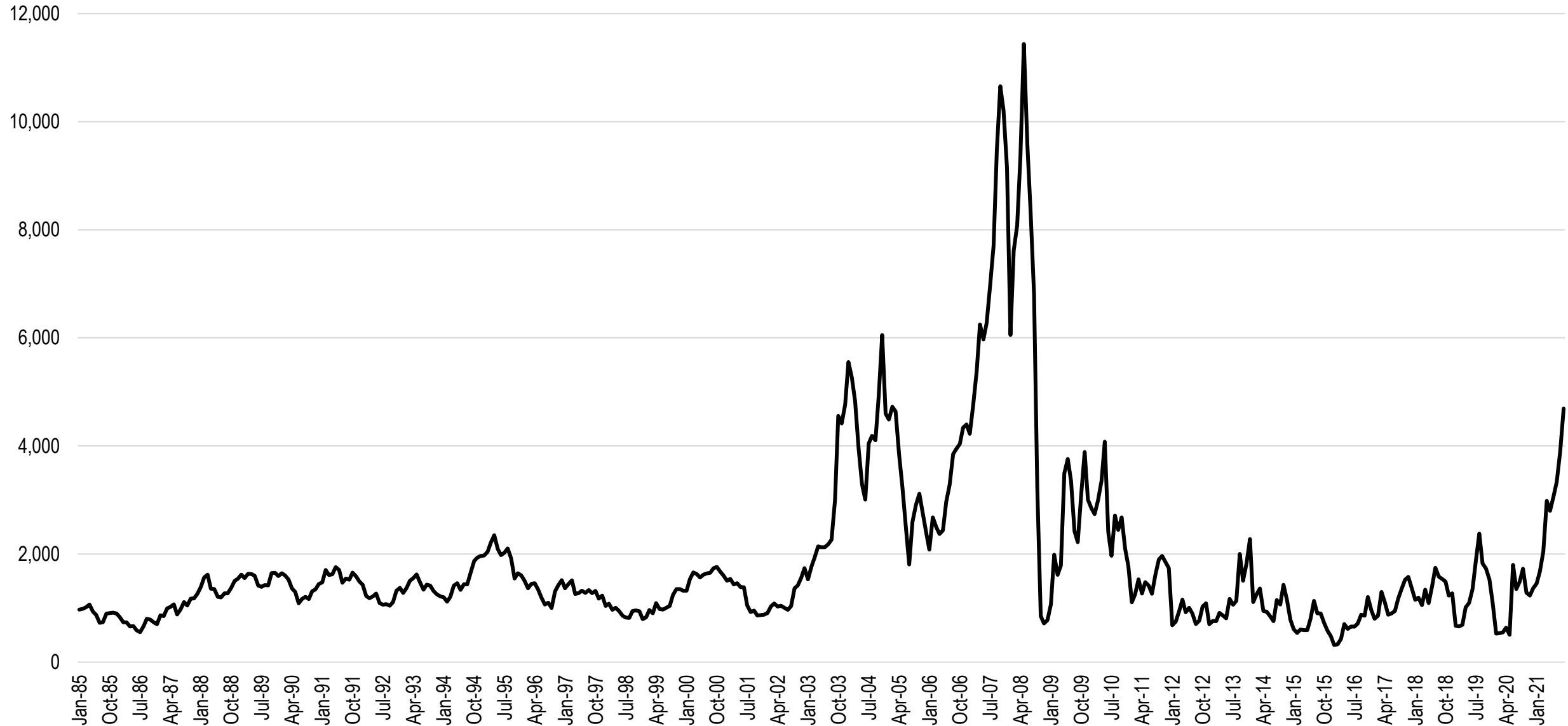
Typical Ocean Freight Costs for some Products (Asia – United States or Asia – Europe)

	Typical Shelf Price	Shipping Costs	Shipping Costs Share
LCD TV Set	\$700	\$4.00	0.5%
Digital Camera (high range)	\$450	\$0.15	0.03%
Vacuum Cleaner	\$150	\$1.00	0.6%
Scotch Whisky (bottle)	\$50	\$0.15	0.3%
Coffee (1 kg)	\$15	\$0.15	3.3%
Biscuits (Tin)	\$3	\$0.05	1.7%
Beer (Can)	\$1	\$0.01	1.0%
Apple	\$0.75	\$0.04	5.3%

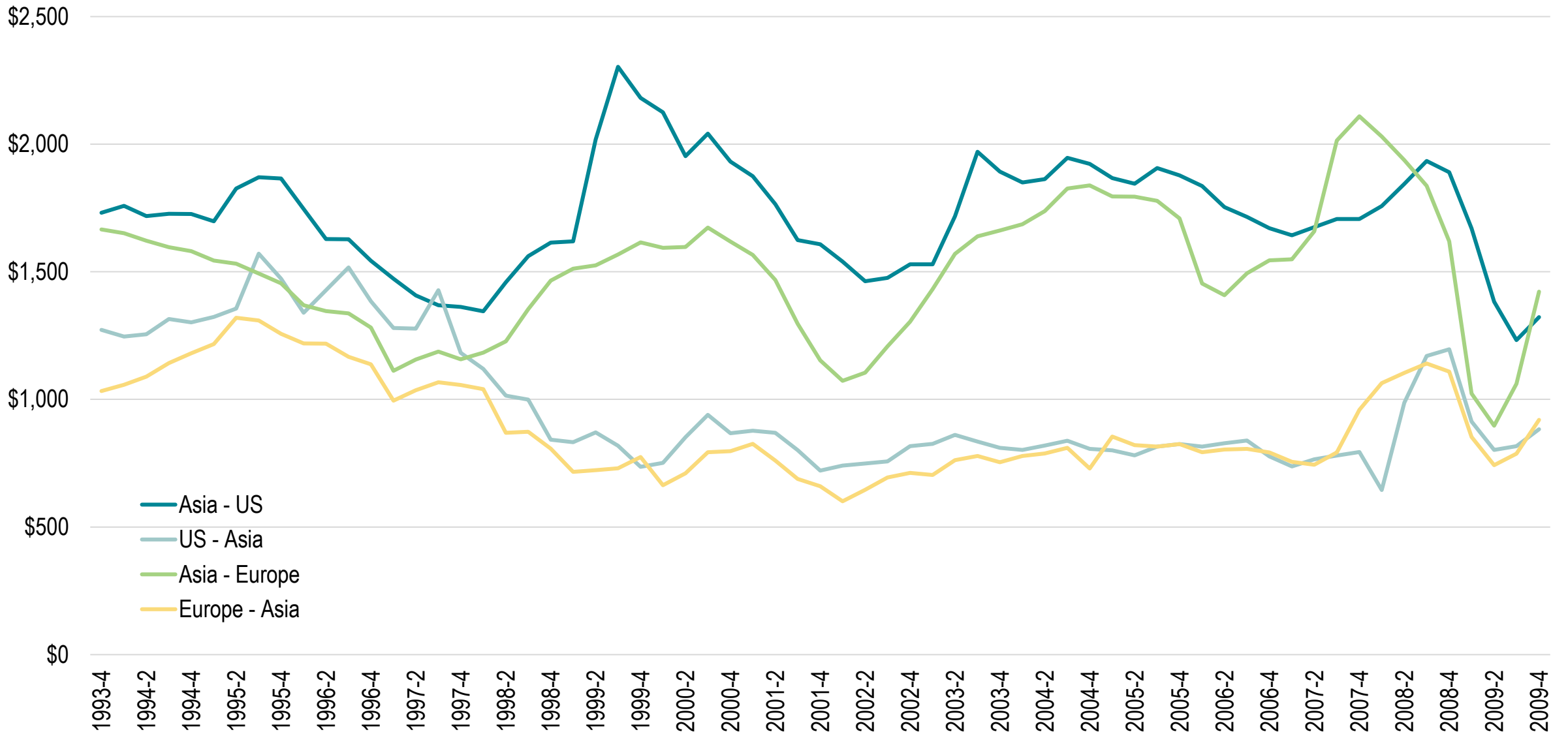
Baltic Dry Index, Monthly Value, 1885-2019 (remove)



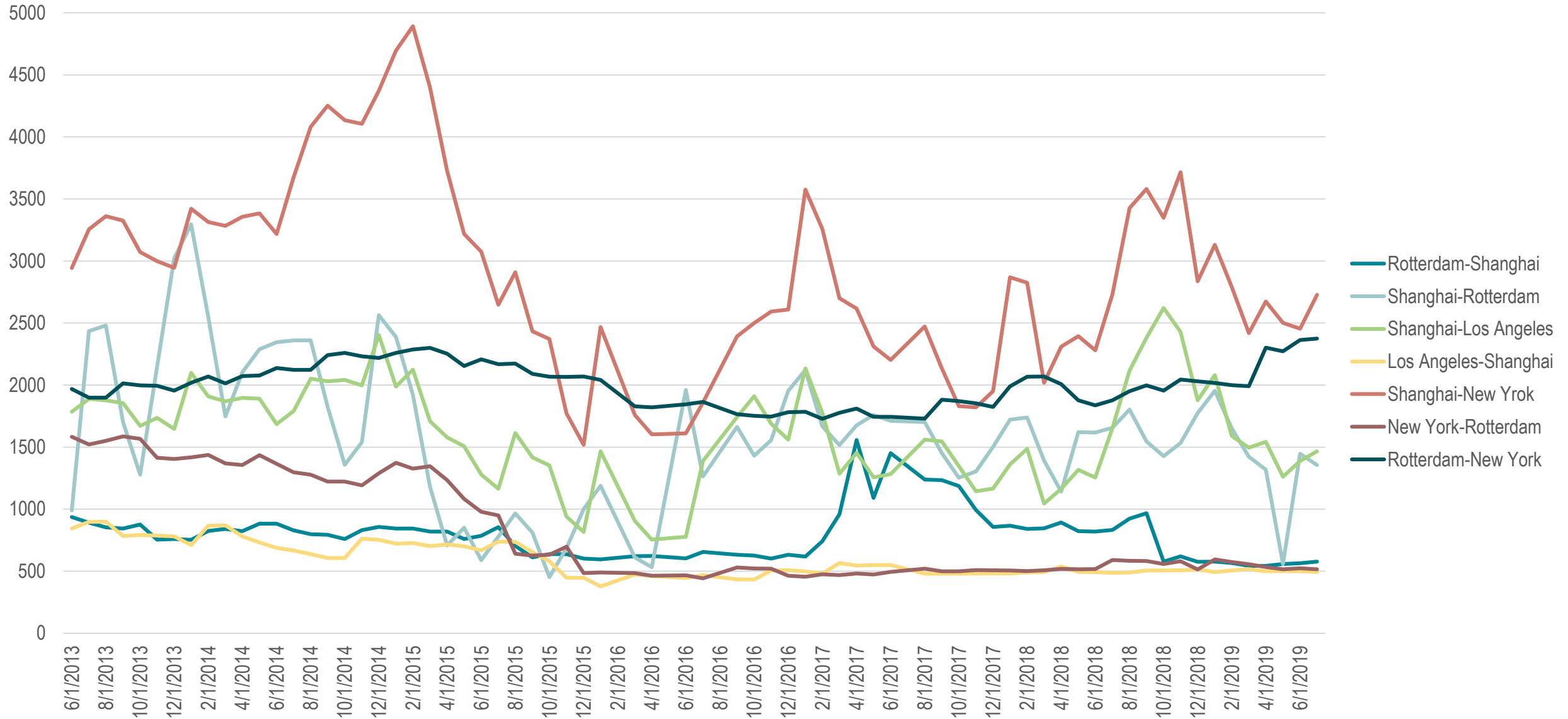
Baltic Dry Index, Monthly Value, 1985-2021



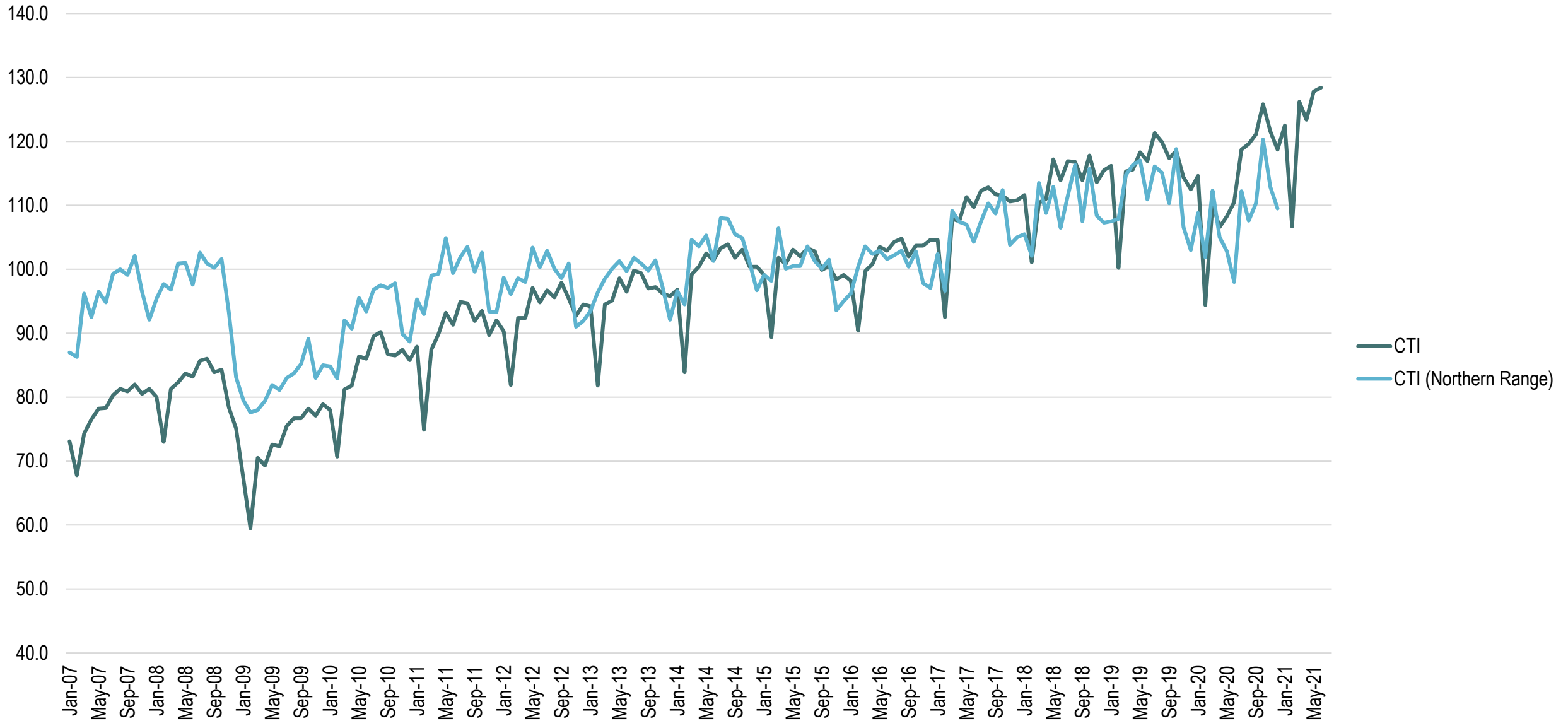
Maritime Freight Rates (Nominal USD per TEU), 1993-2009



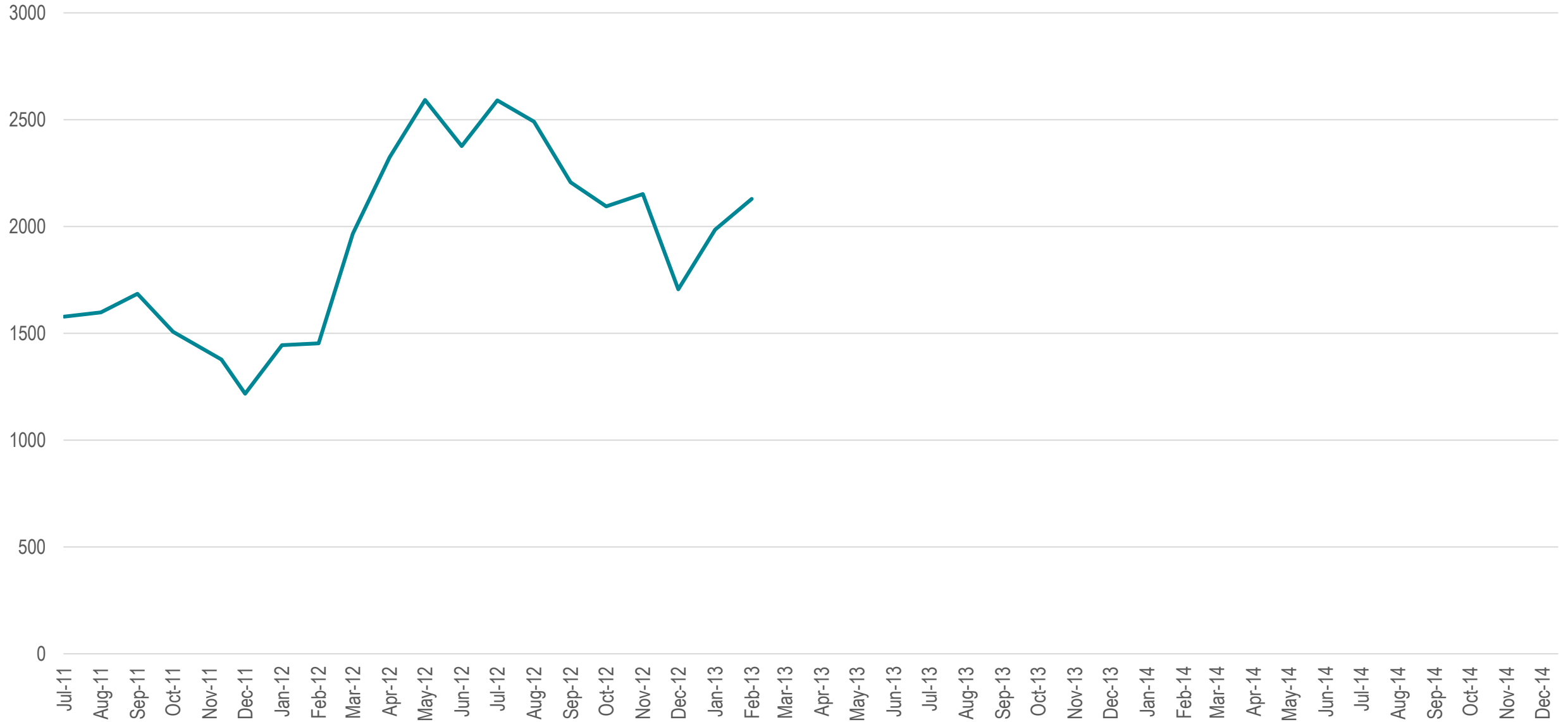
World Container Route Index, Monthly



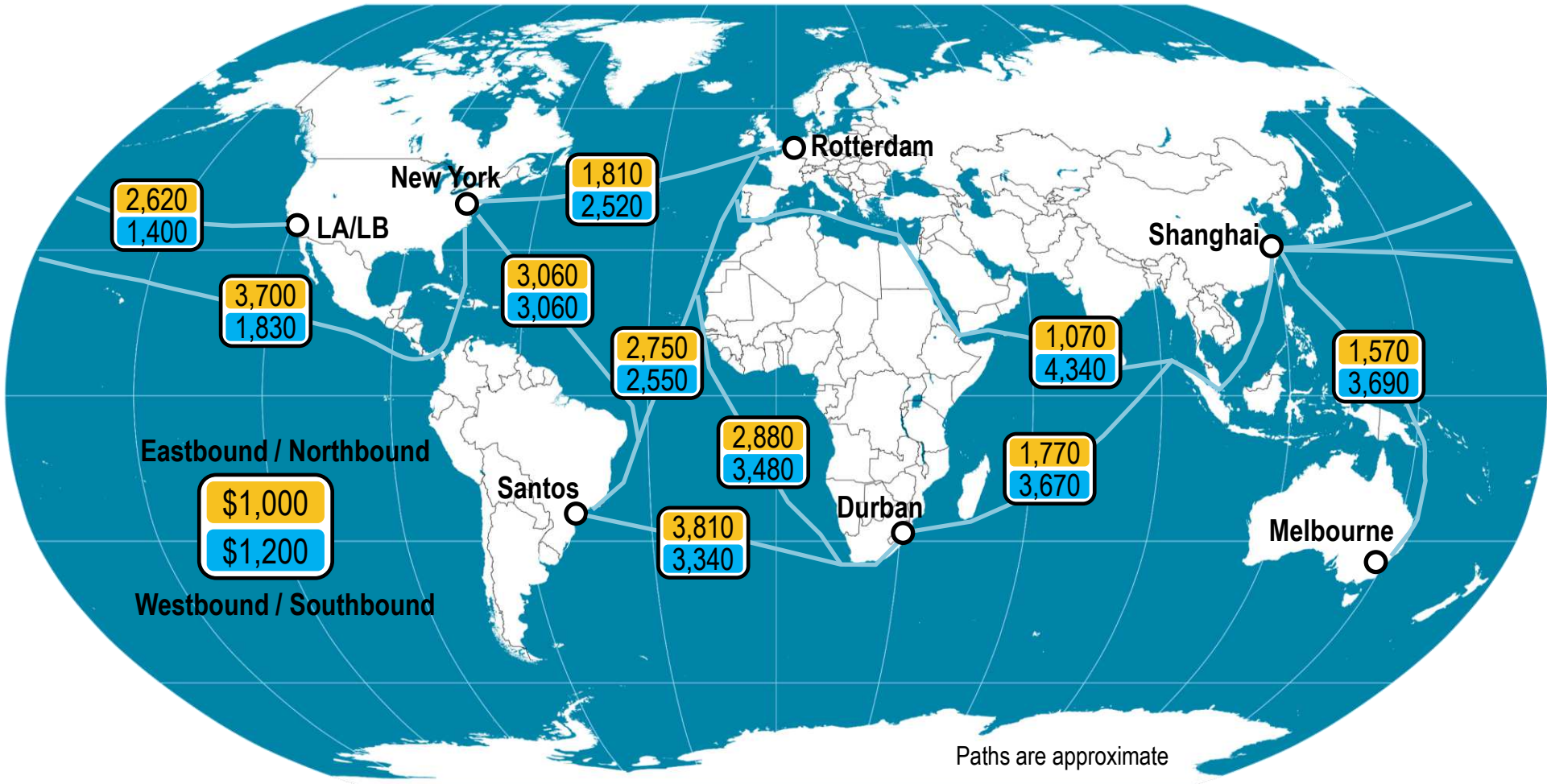
RWI/ISL Container Throughput Index, 2007-2021 (2015 = 100)



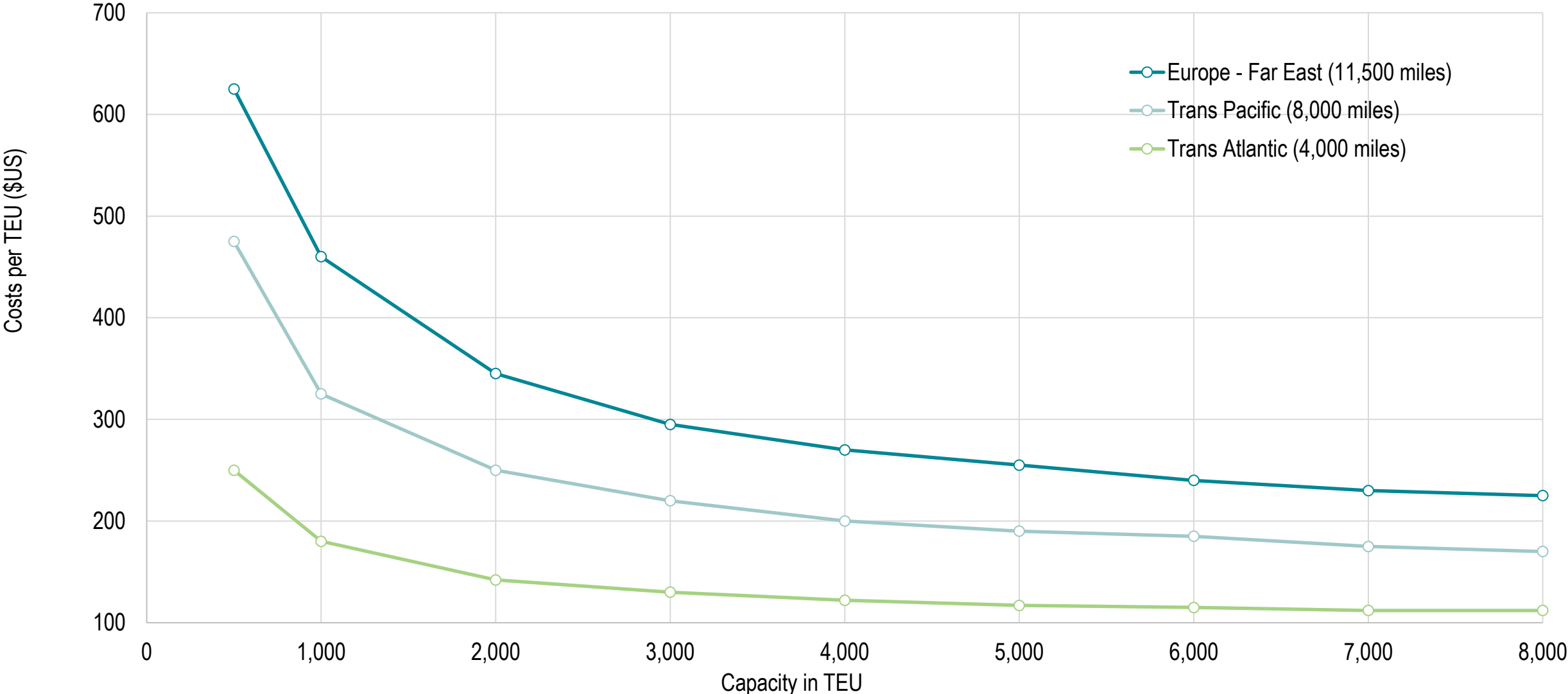
World Container Index, 2011



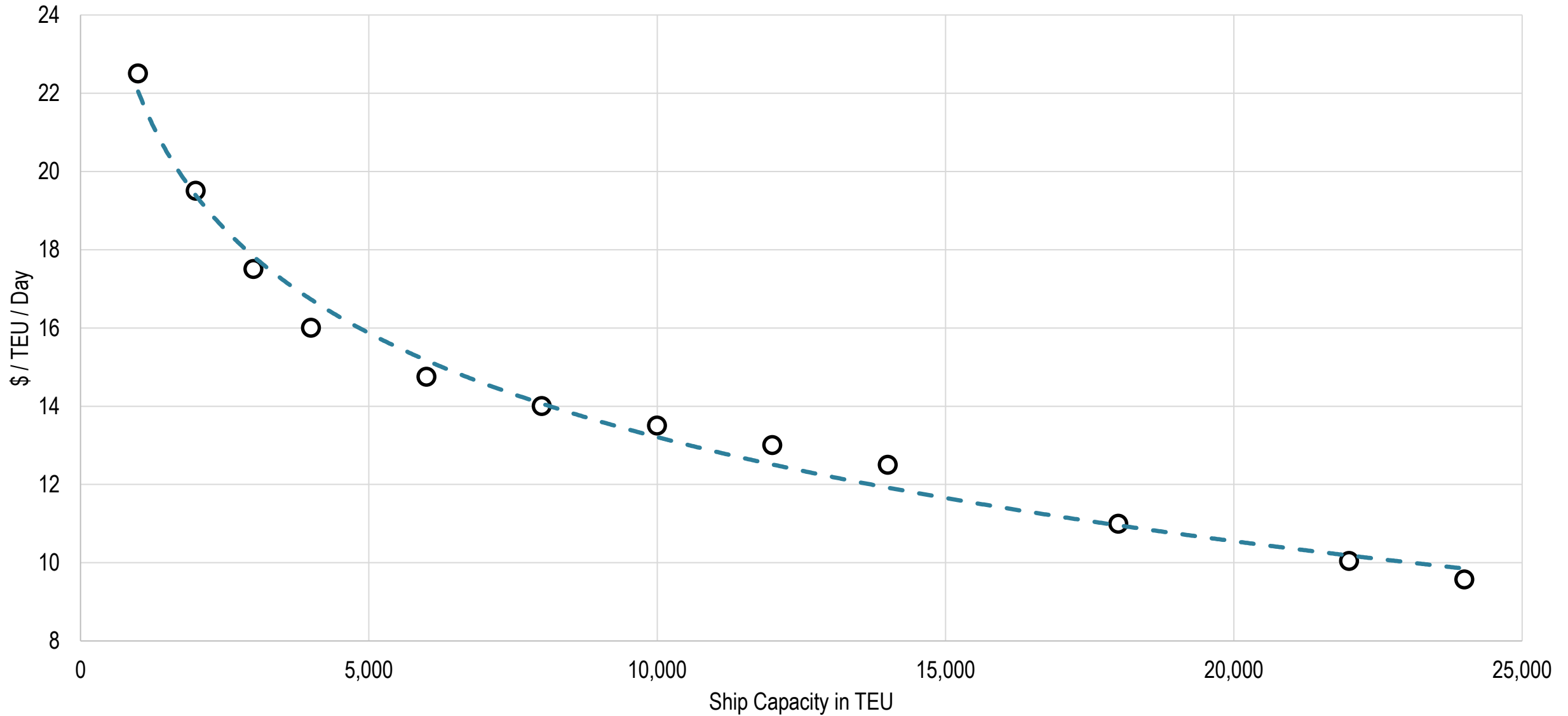
Maritime Transportation Rates for a 40 Foot Container between Selected Ports, 2010



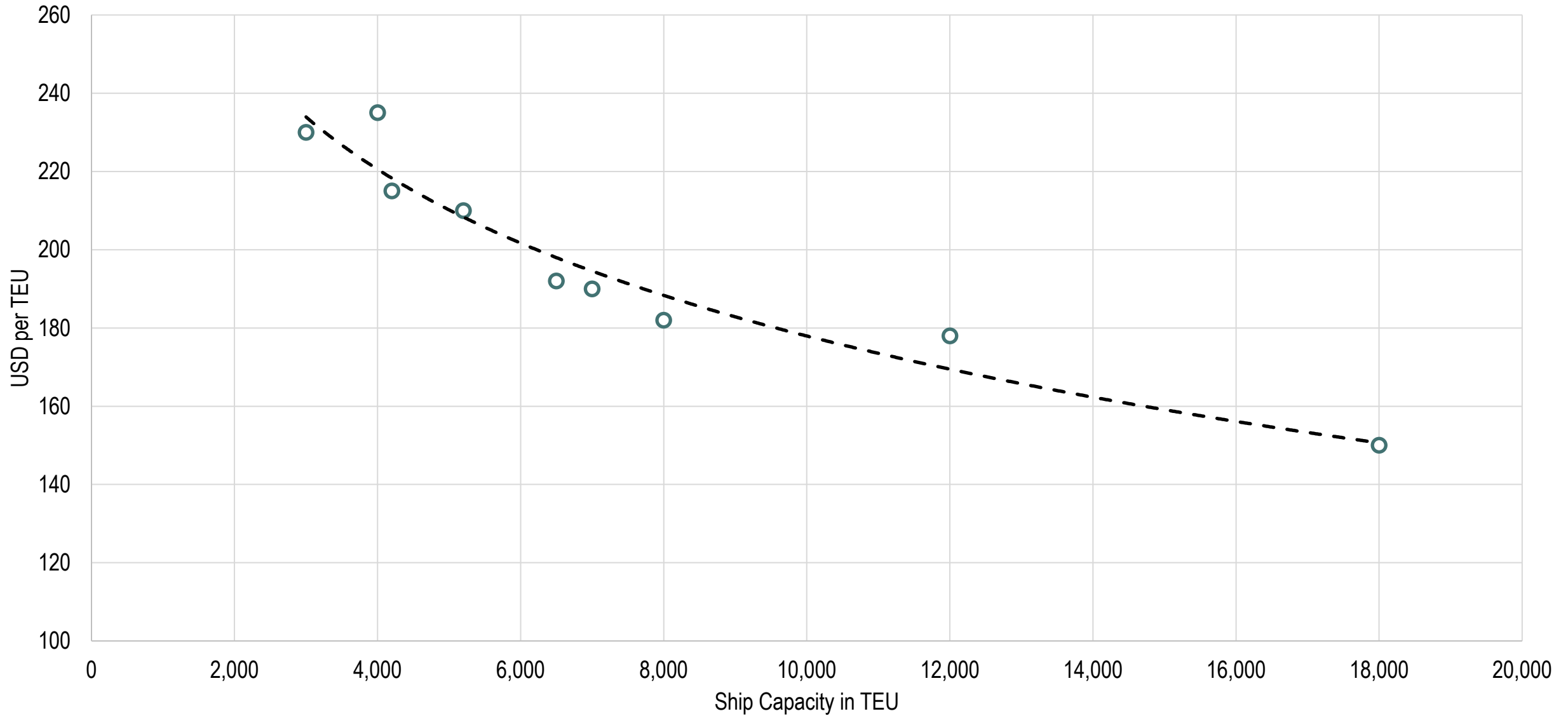
Average Cost per TEU by Containership Capacity and By Route, 1997



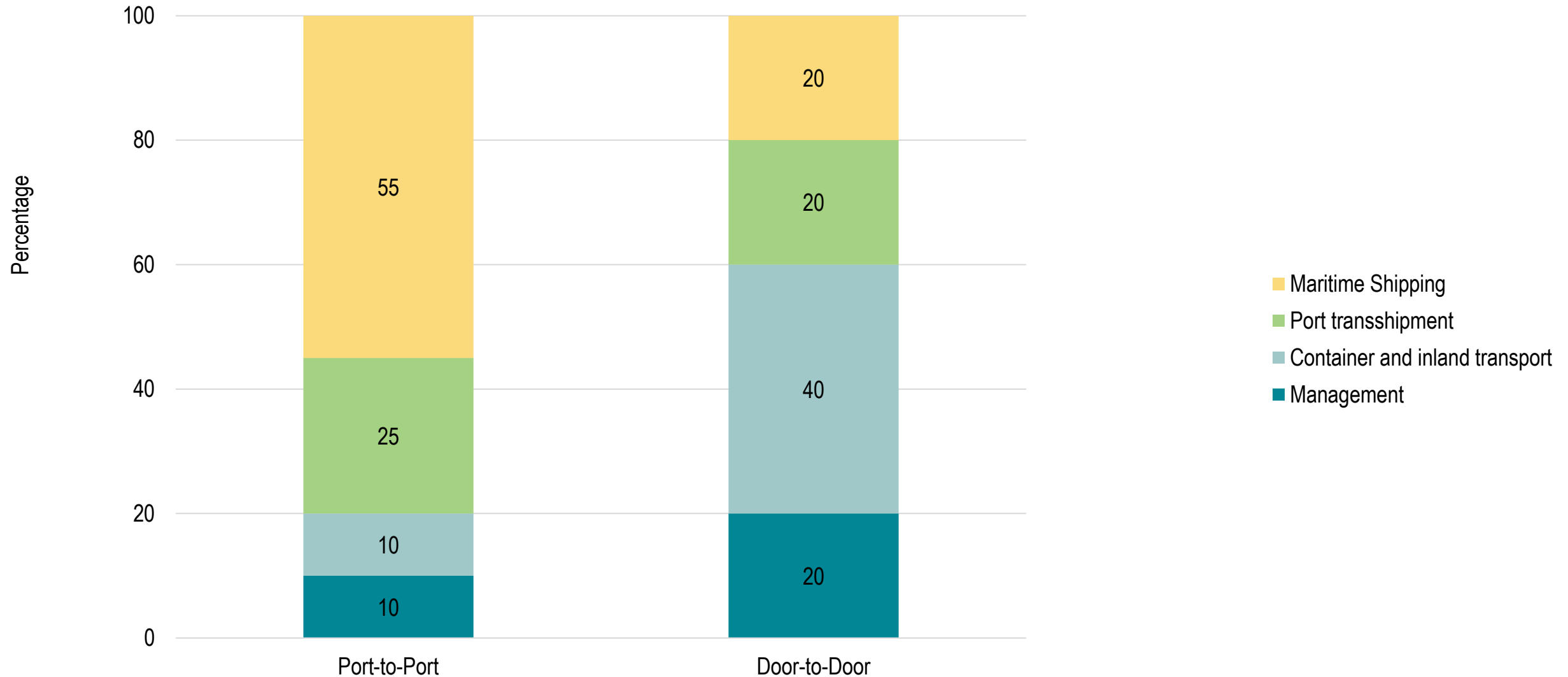
Daily Operating Expenses for Containerships per TEU



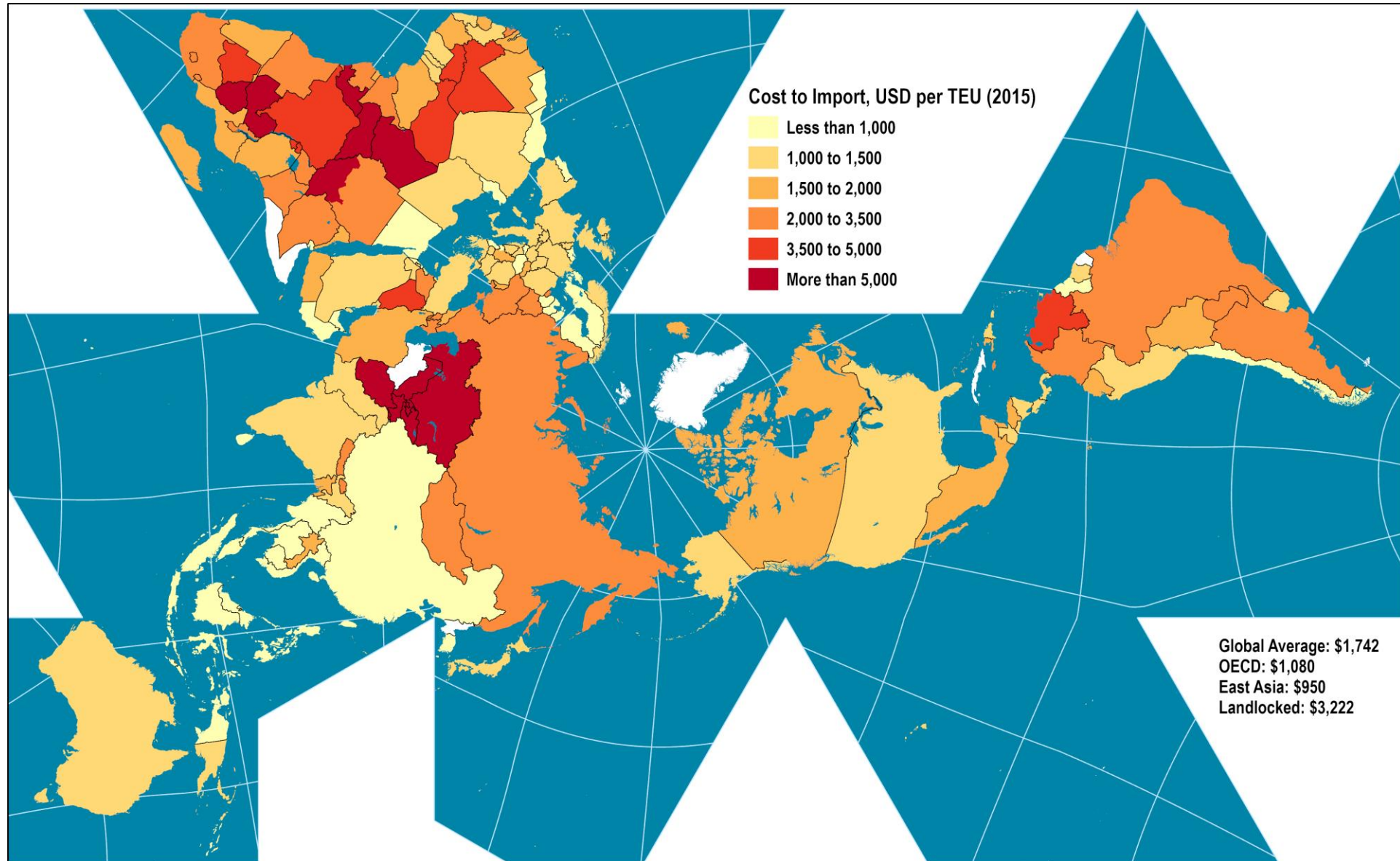
Freight Rates in TEU Between Singapore and Rotterdam



Container Shipping Costs

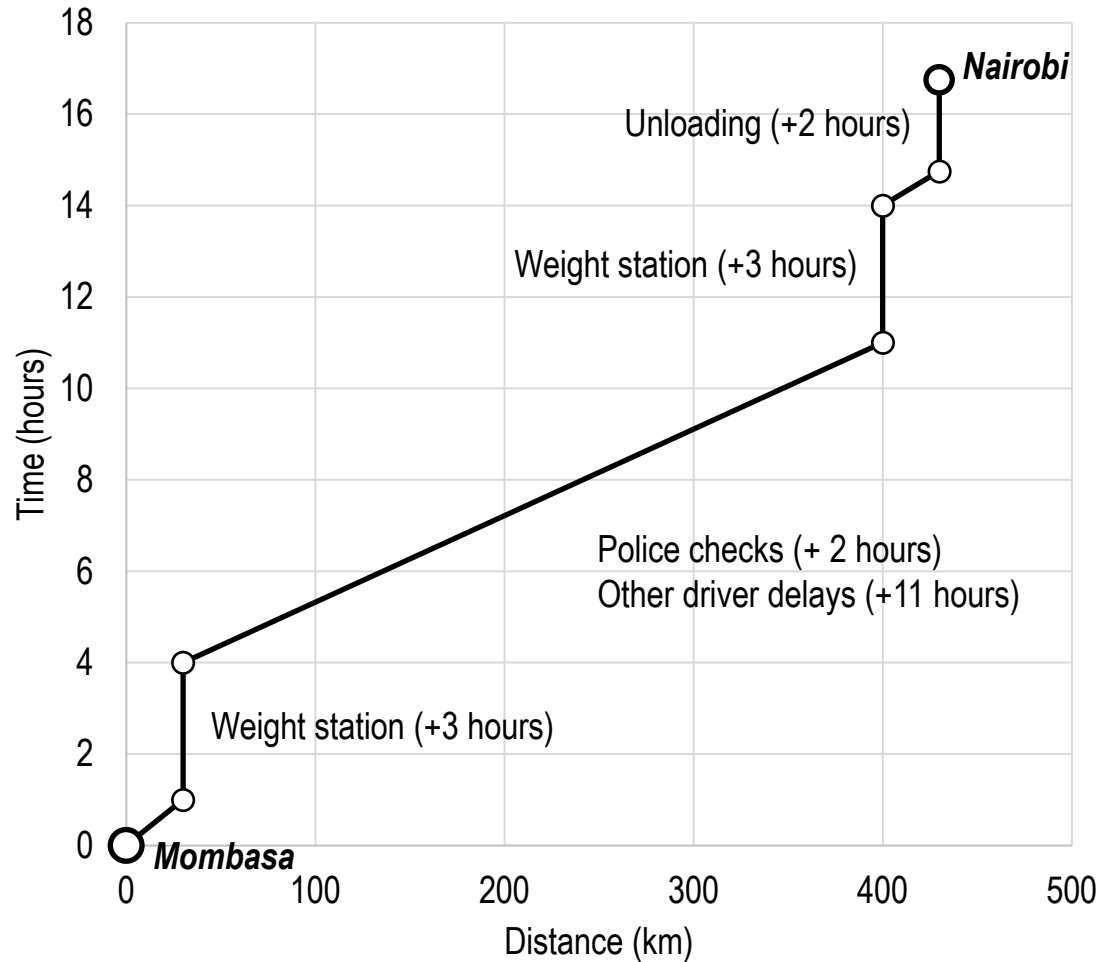


Cost to Import a 20 Foot Container, 2015

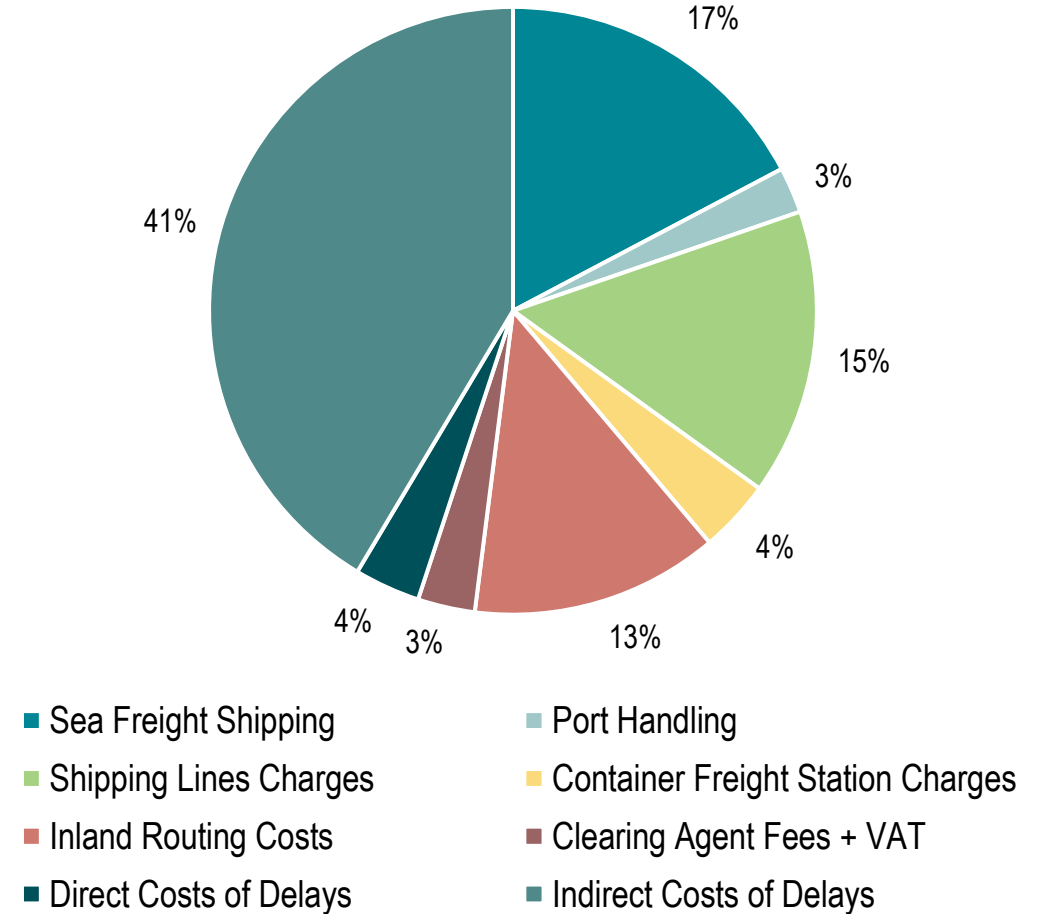


Logistics Costs and Average Transit Time of a 20 Foot Container, Mombasa – Nairobi (Kenya)

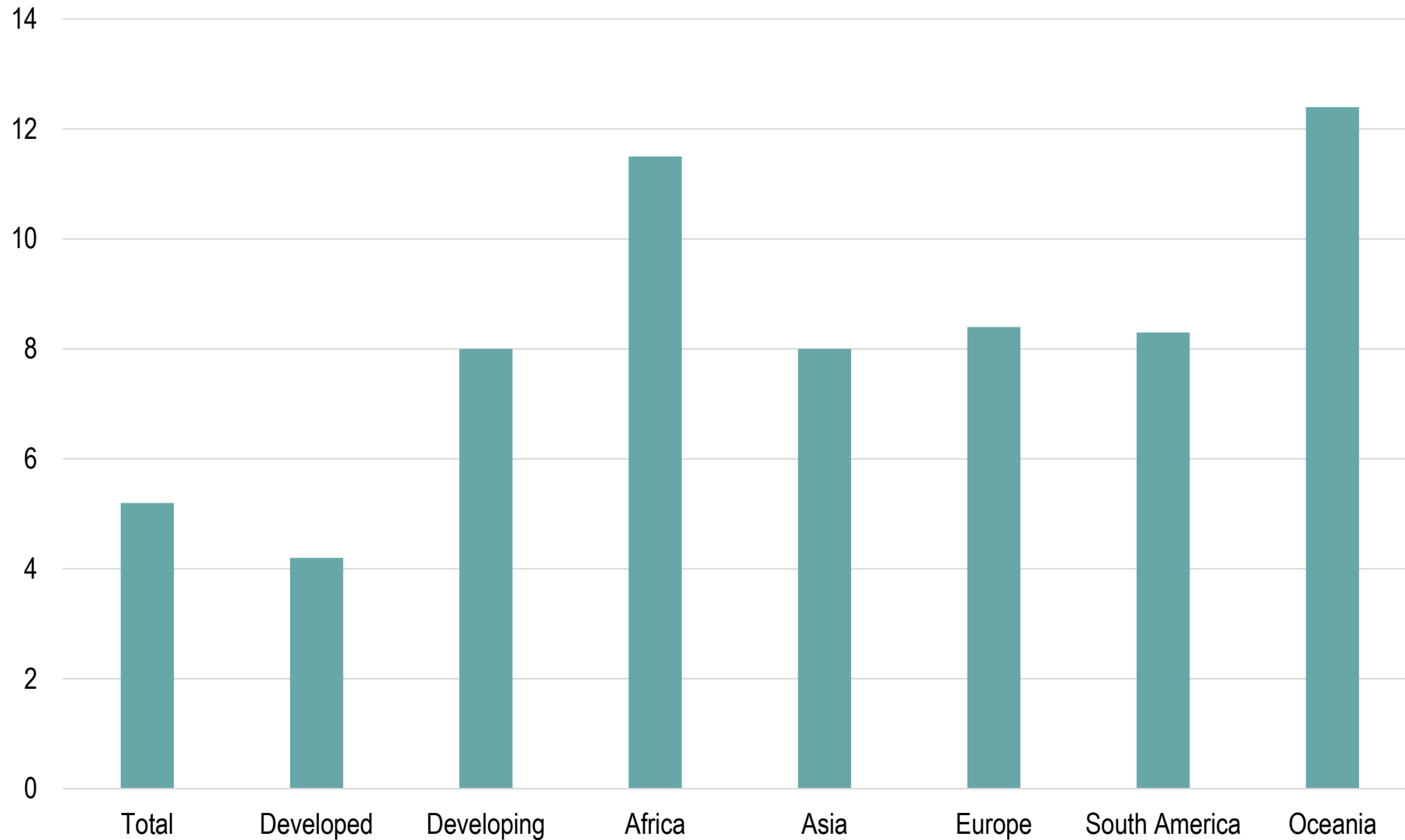
Average Transit Time (29.8 hours for 430 km)



Total Logistics Costs (9,844 USD)



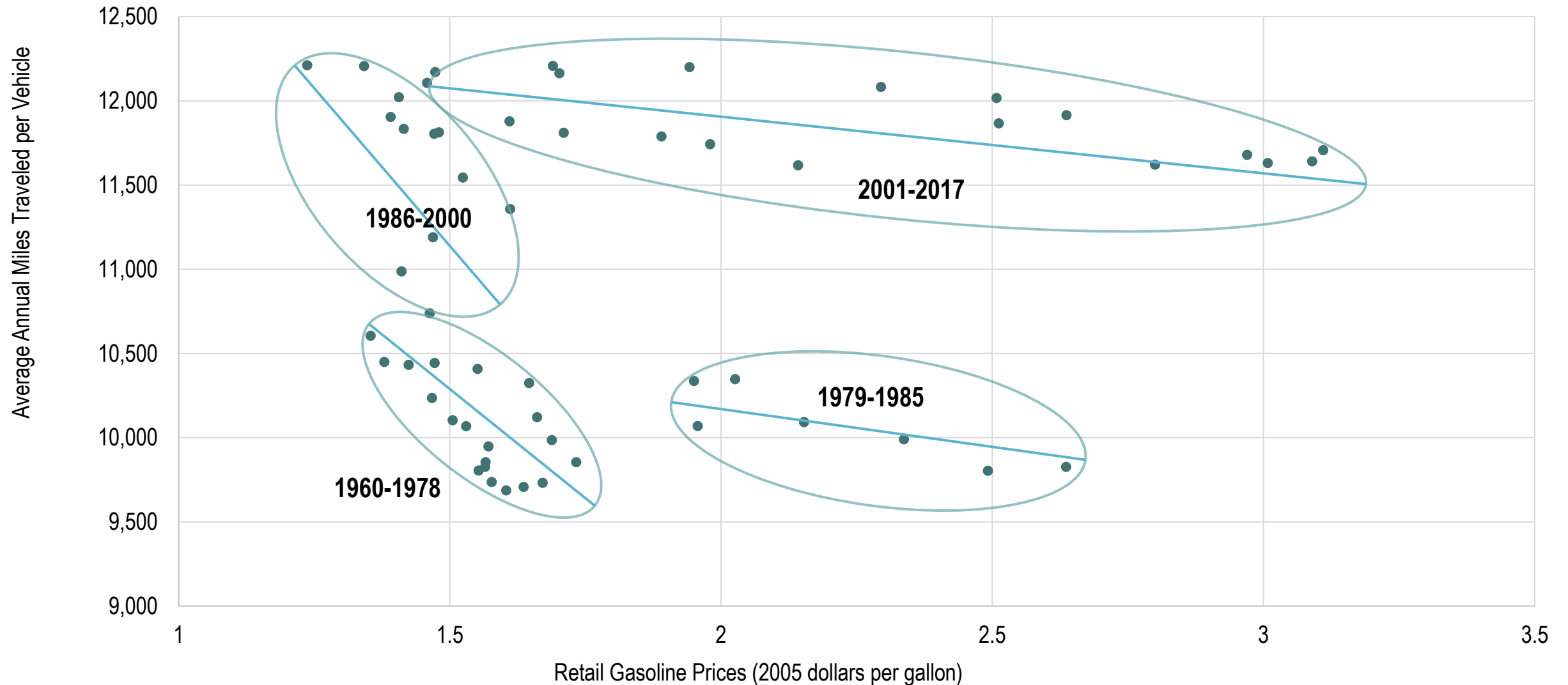
Estimates of Total Imports Freight Costs Relative to Imports (CIF), 1997



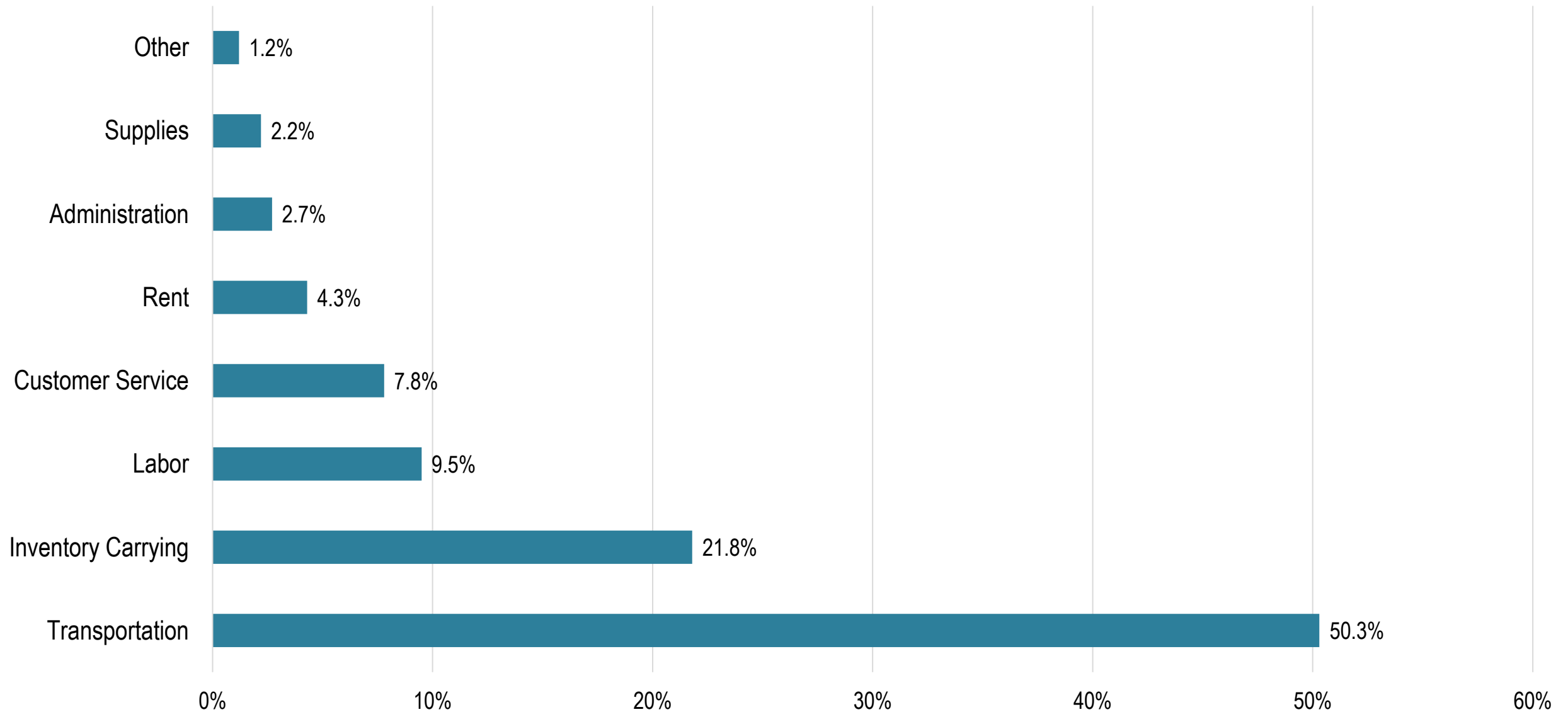
Fixed and Variable Costs and Service in the Transportation System

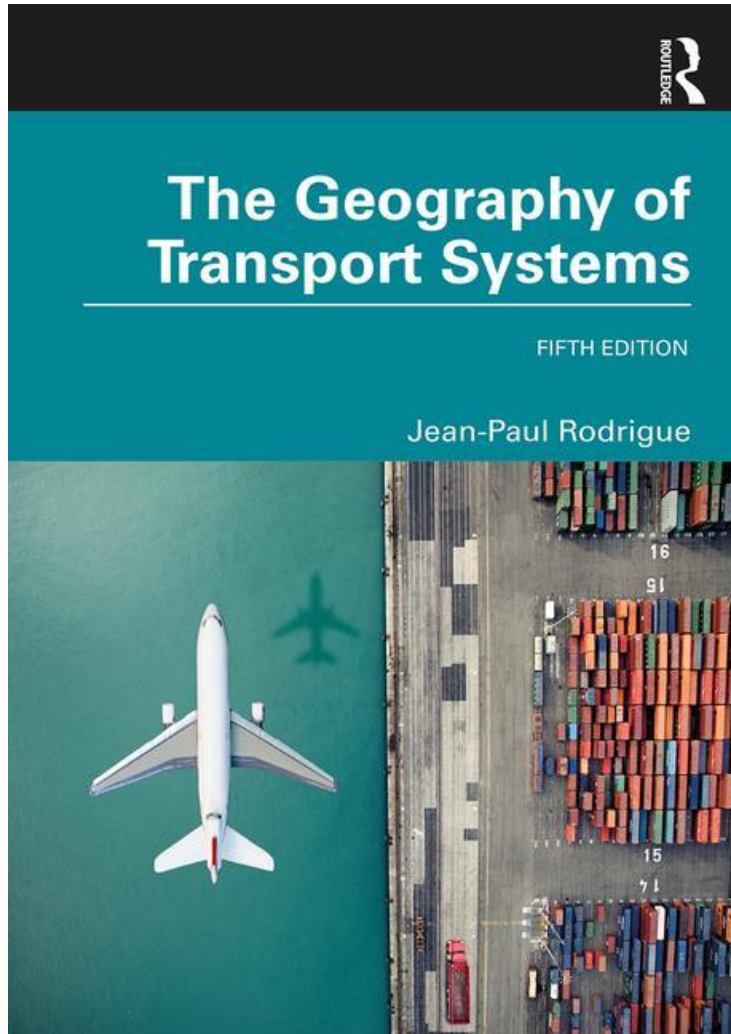
Characteristic	Fixed Infrastructure	Variable Costs
Examples	Highways, rail tracks, airports, ports	Trucks, railcars, planes, ships
Ownership	Mostly public	Mostly private
Lifespan	Very long (decades)	Short to average (5 to 20 years)
Rate of change	Slow	Rapid redeployment
Impact on service	Shapes accessibility	Shapes level of service
Competition	Level the playing field	Source of comparative advantages

Retail Gasoline Prices and Annual Vehicle Mileage, United States, 1960-2018



Composition of Logistics Costs

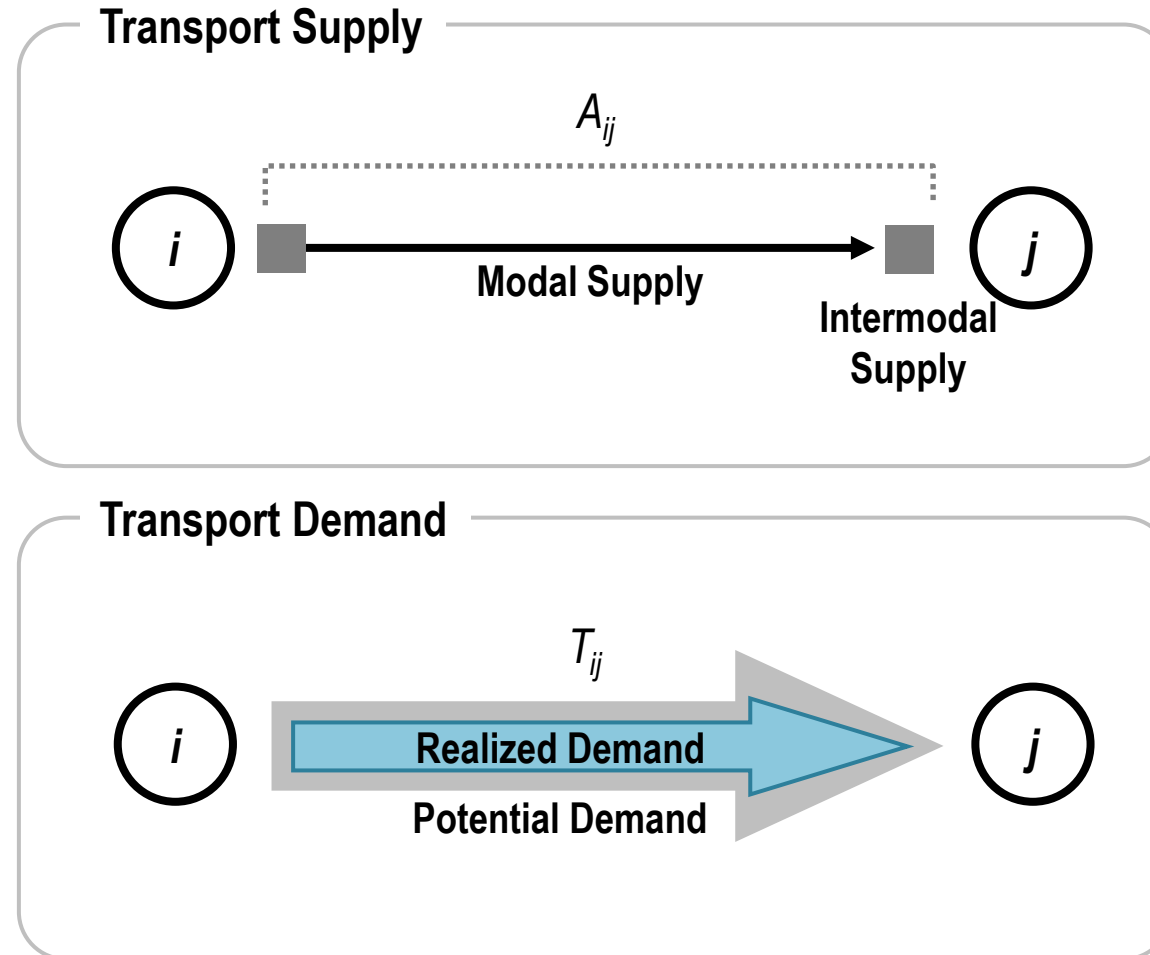




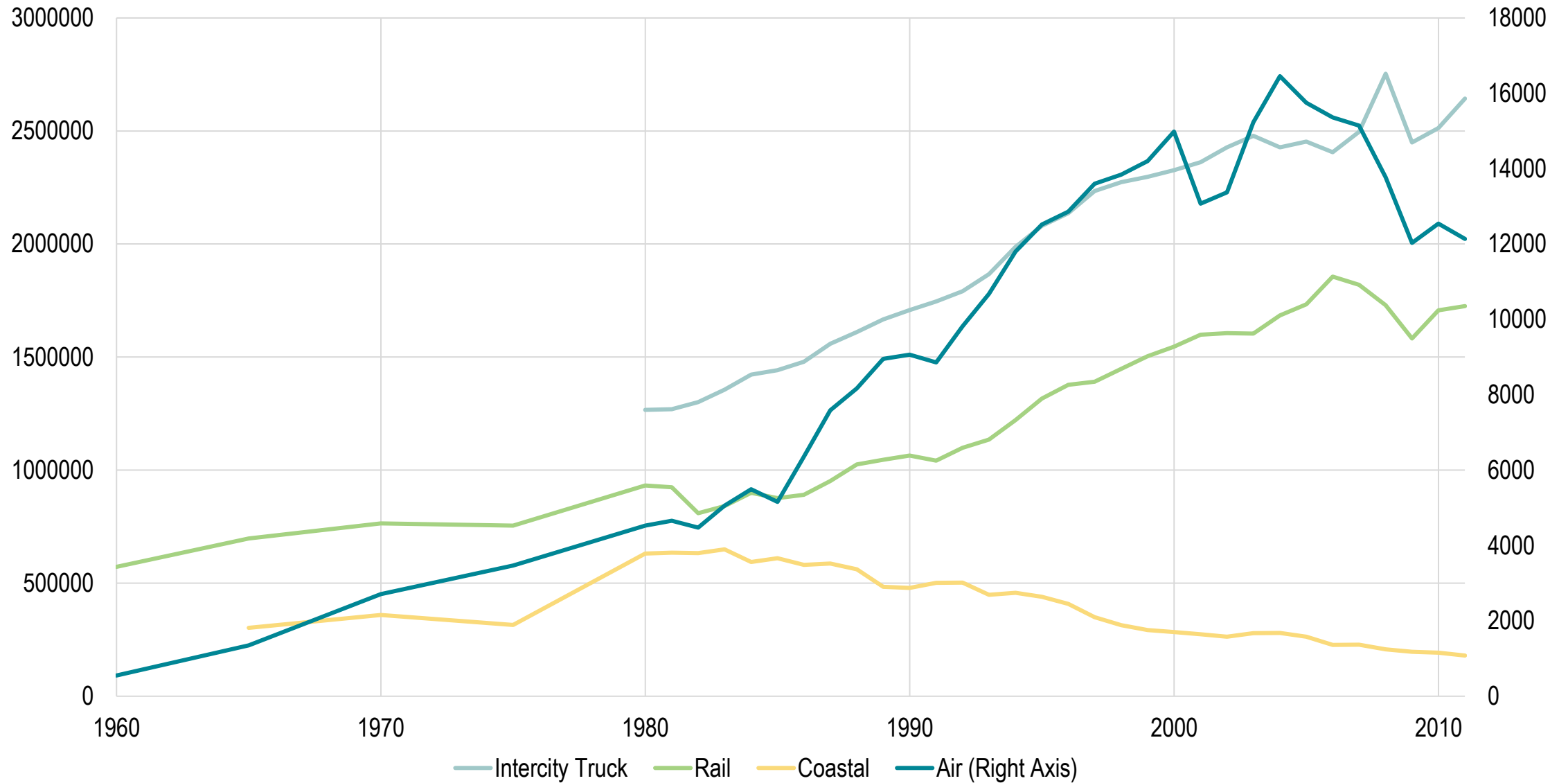
The Provision and Demand of Transport Services

Chapter 3.4

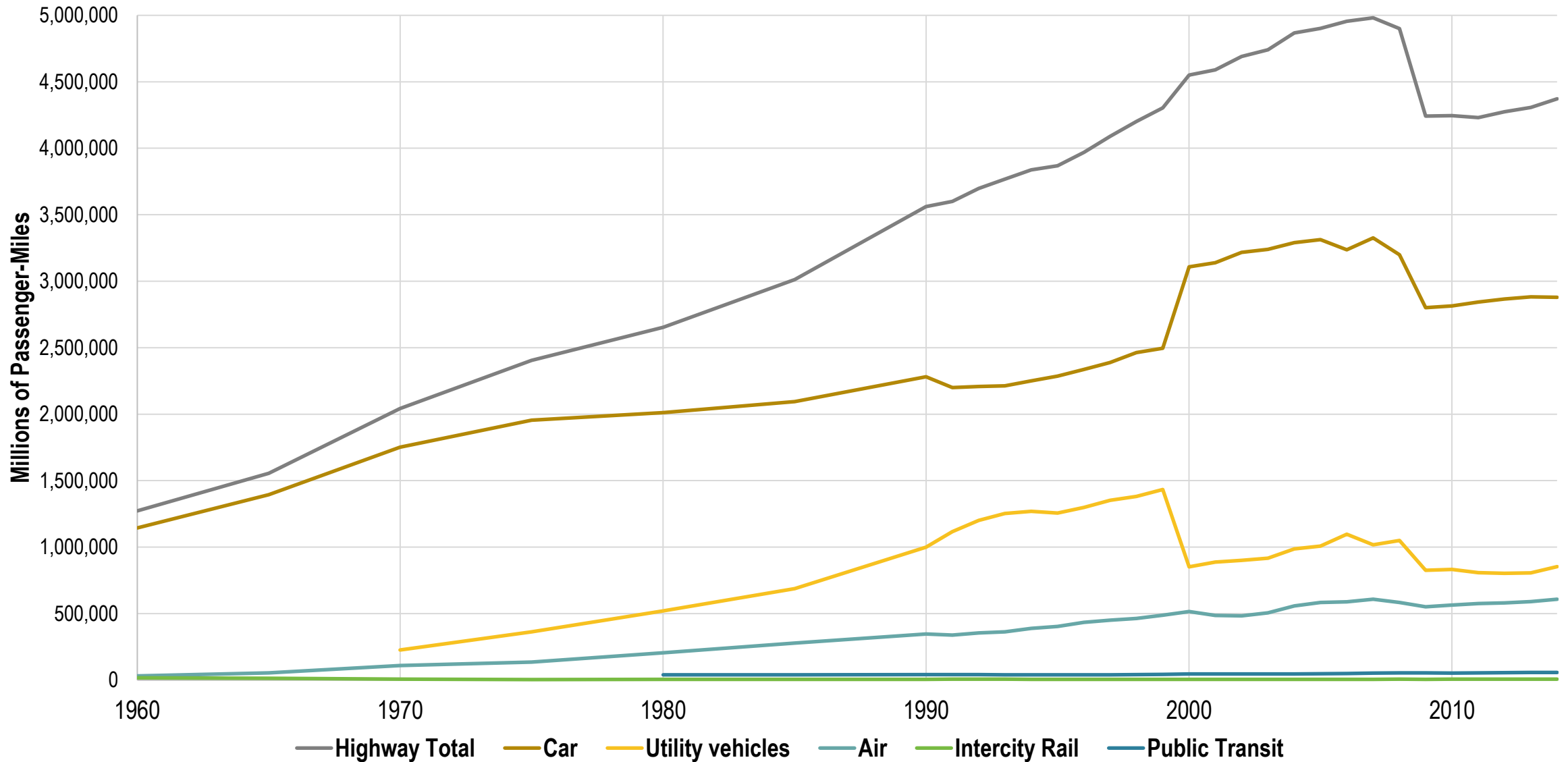
Transport Supply and Demand



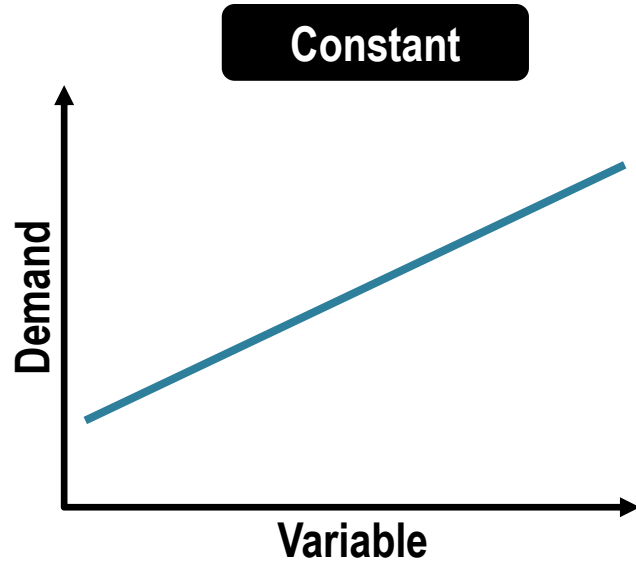
Ton-Miles of Transported Freight, United States, 1960-2011 (millions)



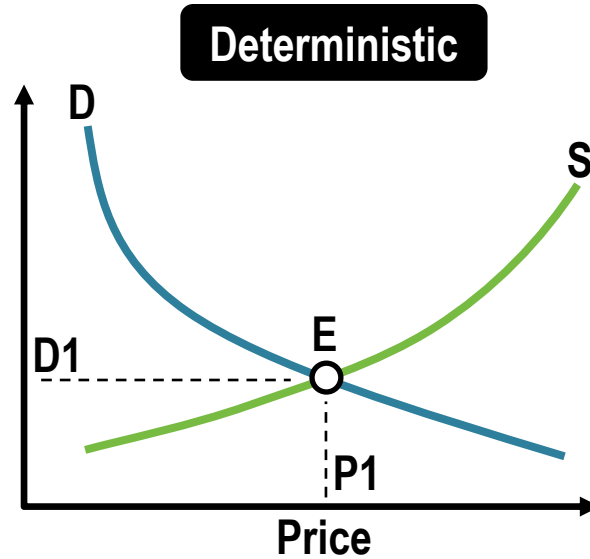
Passenger-Miles Transported within the United States, 1960-2014



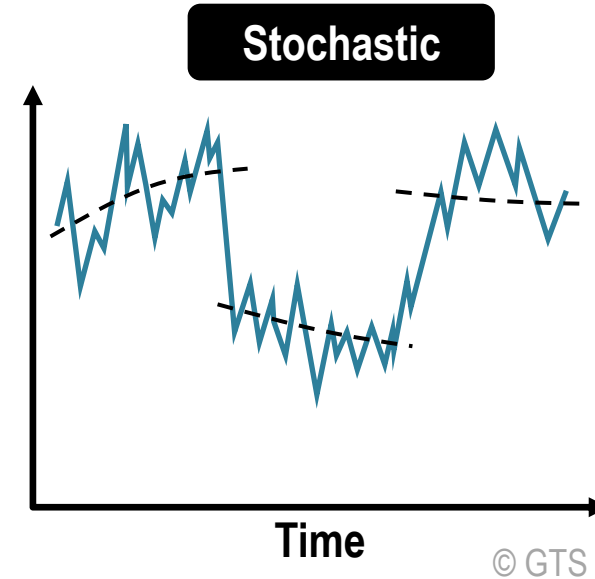
Types of Transportation Demand



- Proportional to a variable
- Usually linear function
- Multiplier effect

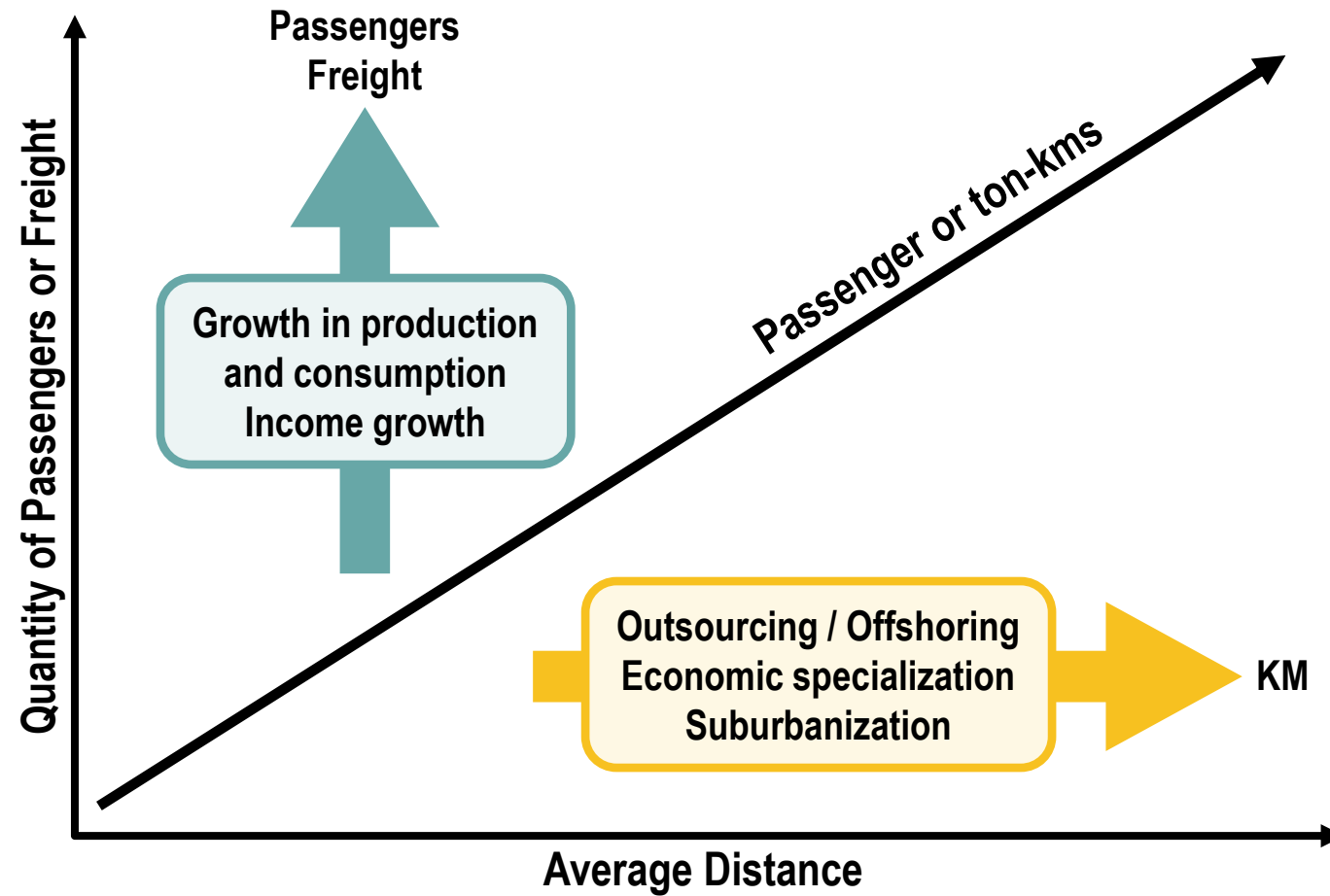


- Direct function of parameters
- All parameters known
- No uncertainty



- Multiple parameters
- Some unknown effects
- Probability of demand

Growth Factors in Transport Demand



Factors behind Freight Transport Demand

Economy	General derived demand impact. Linked with the GDP. Function of the structure of the economy in terms of resources, goods, and services.
Industrial location	Effect on ton-kms and on modal choice.
Spatial Structure	Effect on ton-kms. Function of international trade structure. Containerization and intermodal transportation.
International Agreements	Both concerning trade and transportation. Economic specialization. Increased transborder traffic. Simplified custom procedures.
JIT practices and warehousing	Decreased inventories. More shipments. Smaller line hauls. Shift to faster and more reliable modes. Use of 3 rd party logistics providers.
Strategic alliances	Between carriers, shippers and often producers and retailers. Lower distribution costs.
Packaging and recycling	Increased transportability of products. Lower freight density. Reverse distribution.
Regulation and deregulation	Increased competition, level of service and lower costs. Growth of intermodal transportation.
Fuel costs, taxes and subsidies	Large and volatile cost components, specifically for energy intensive modes. Preferred mode or carrier.
Infrastructure and congestion	Efficiency, operating costs and reliability.
Safety and environmental policies	Operating speed, conditions and costs. Capacity and weight limits.
Technology	Containerization, double-stacking, automation and robotics, handling and interchange systems and automated terminals. Information systems (IDE). Lower costs, increased efficiency and reliability and new opportunities.

Factors behind Freight Transport Demand



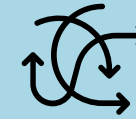
Economy

General derived demand impact. Linked with the GDP. Function of the structure of the economy in terms of resources, goods, and services.



Industrial location

Effect on ton-kms and modal choice. Outsourcing and offshoring.



Spatial structure

Effect on ton-kms. Function of international trade structure. Major hubs, gateways and corridors.



International agreements

Concerning trade and transportation. Economic specialization. Increased transborder traffic. Trade facilitation. Simplified custom procedures.



JIT practices

Low inventory levels. More shipments. Smaller line hauls. Shift to faster and more reliable modes. Use of 3rd party logistics providers.



Strategic alliances

Between carriers, shippers and often producers and retailers. Lower distribution costs.



Packaging and recycling

Increased transportability of products. Lower freight density. Reverse distribution.



Deregulation

Increased competition, level of service and lower costs. Growth of intermodal transportation.



Fuel costs and subsidies

Large and volatile cost components, specifically for energy intensive modes. Preferred mode or carrier.



Infrastructure

Efficiency, operating costs and reliability.



Safety

Operating speed, conditions and costs. Capacity and weight limits.

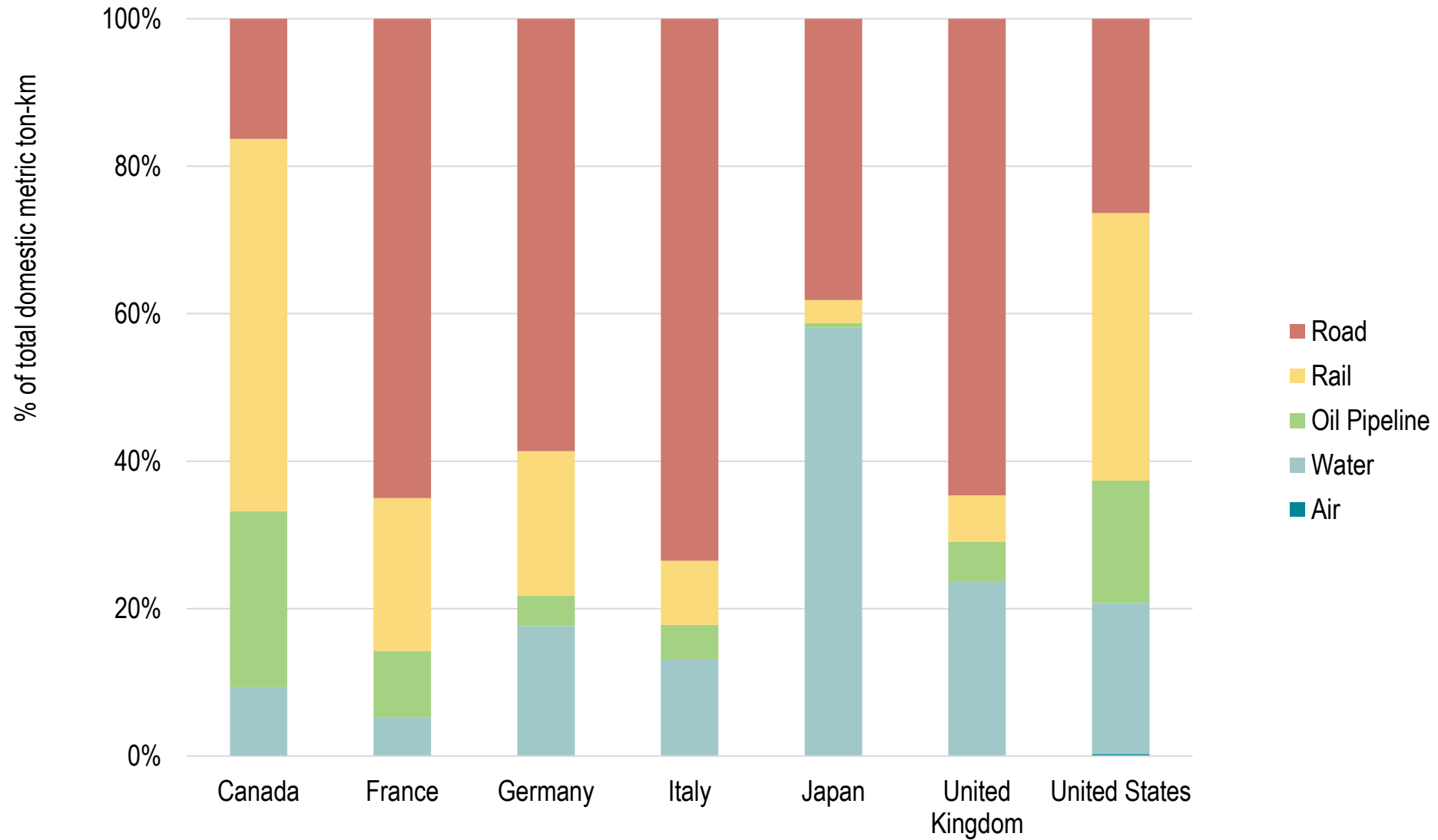


Technology

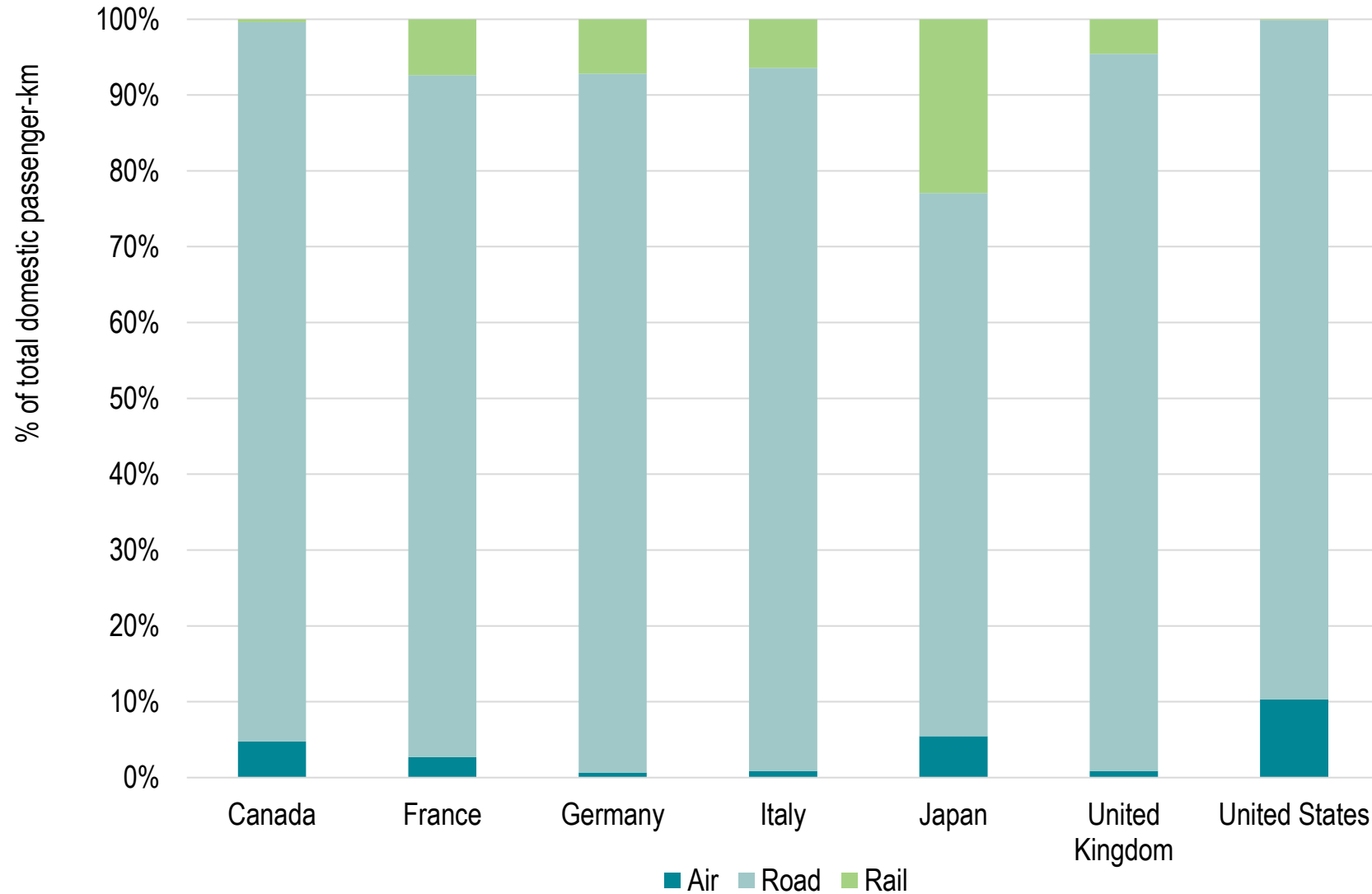
Containerization, automation and robotics. Information systems. Lower costs, increased efficiency and reliability and new opportunities.

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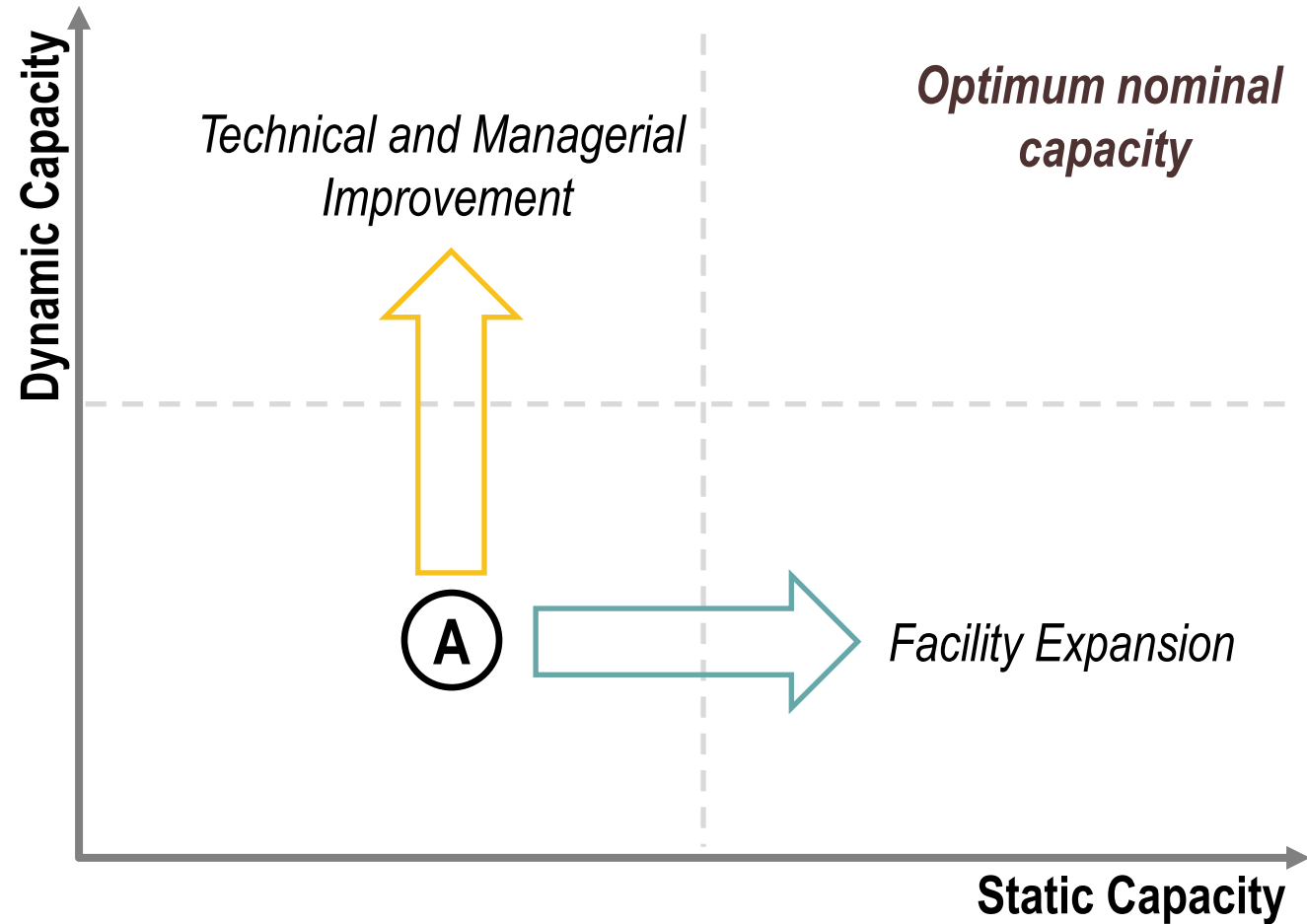
Share of Total Domestic Freight Activity by Mode, Selected Countries, 1996



Share of Total Domestic Passenger Activity by Mode, G7 Countries, 1996



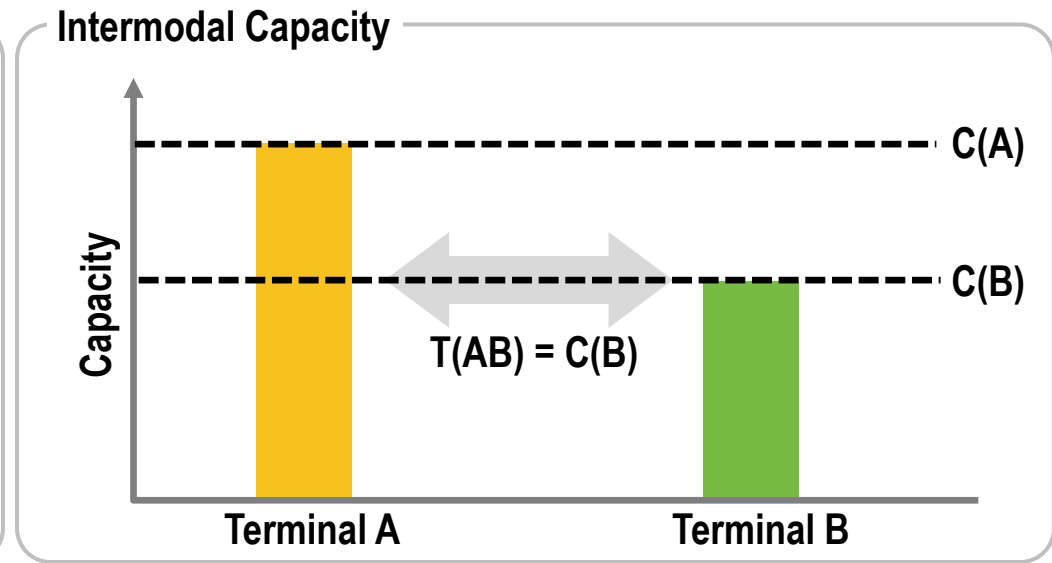
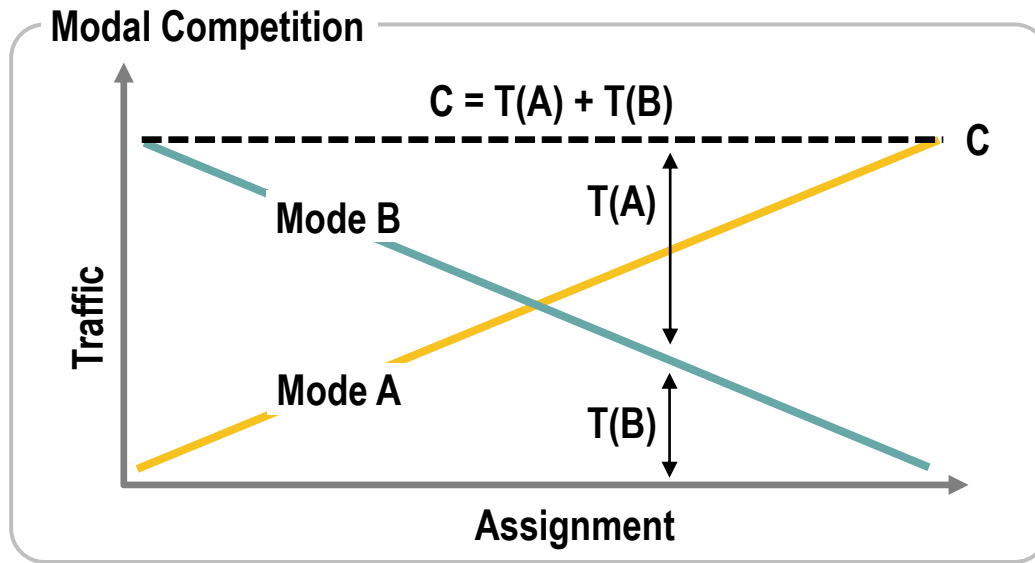
Static and Dynamic Capacity of Transport Infrastructure



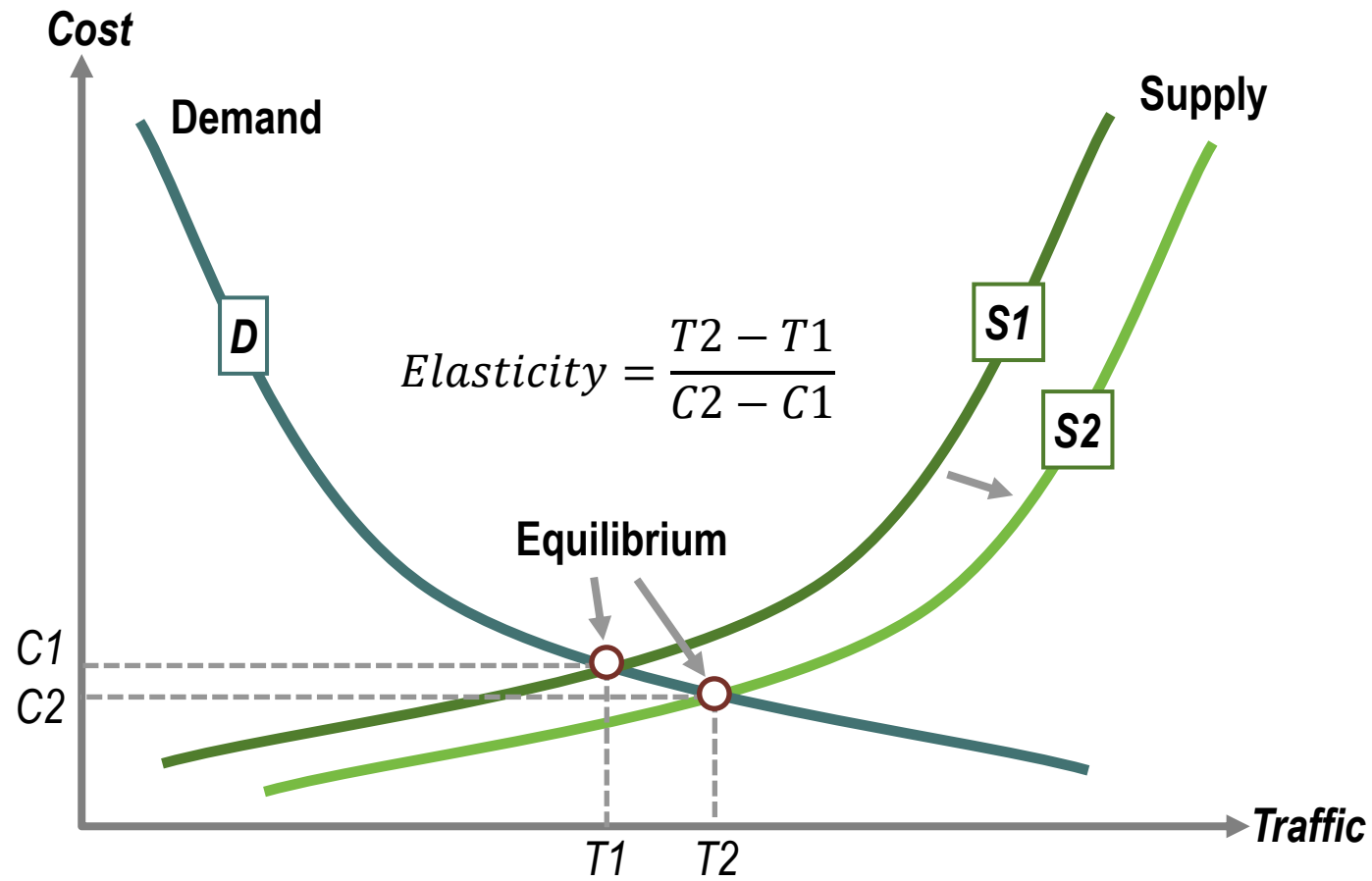
Major Supply Variables for Transportation Modes

	Road	Rail	Air	Maritime
Routes	<ul style="list-style-type: none">•Lanes•Width•Speed limit	<ul style="list-style-type: none">•Tracks•Grade	<ul style="list-style-type: none">•Corridors•Air control	<ul style="list-style-type: none">•Canals•Locks
Terminals	<ul style="list-style-type: none">•Parking	<ul style="list-style-type: none">•Yards•Transshipment	<ul style="list-style-type: none">•Runways•Gates	<ul style="list-style-type: none">•Docks•Transshipment
Vehicles	<ul style="list-style-type: none">•Speed•Capacity	<ul style="list-style-type: none">•Speed•Capacity	<ul style="list-style-type: none">•Speed•Capacity	<ul style="list-style-type: none">•Speed•Capacity

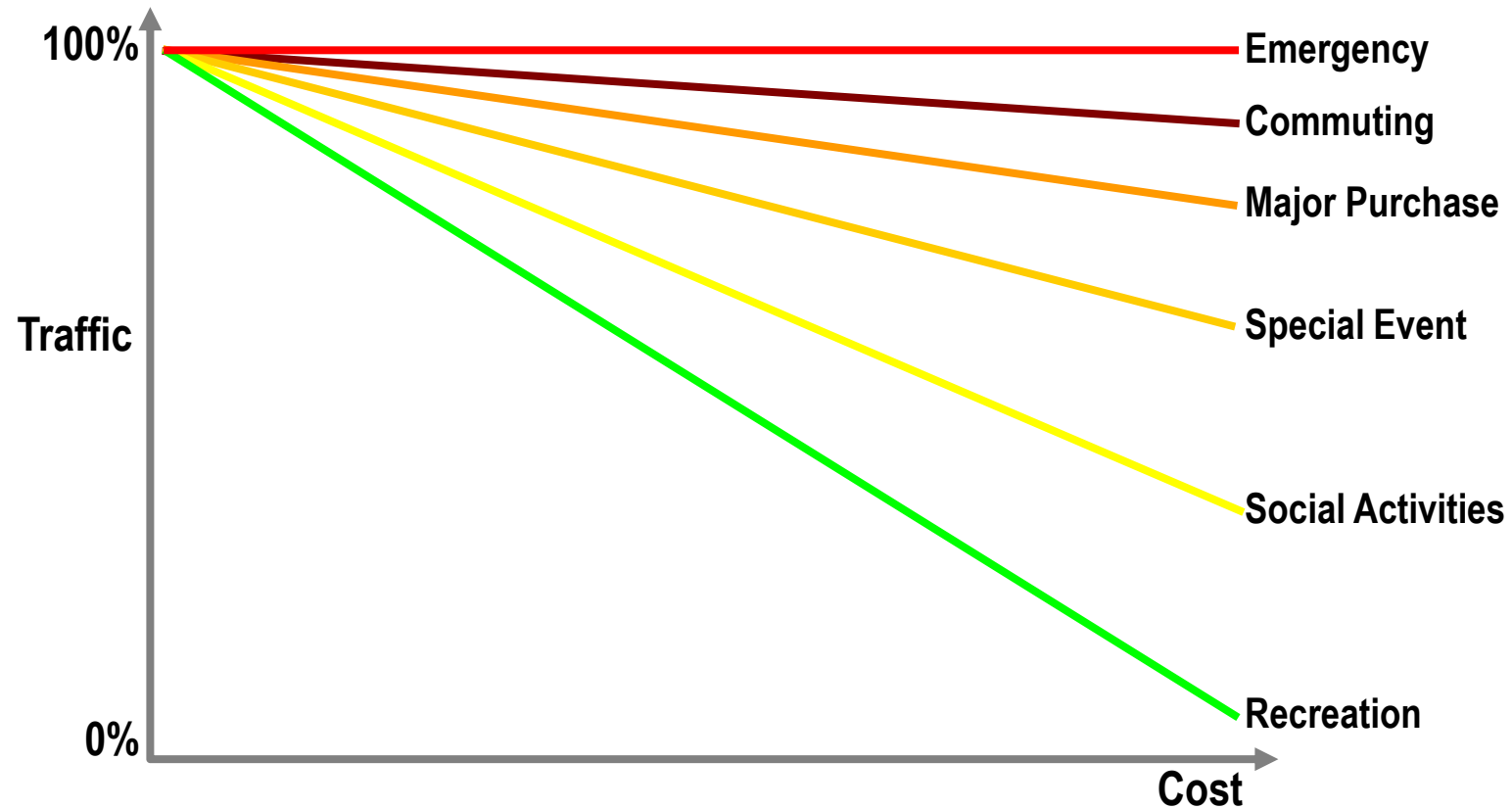
Impacts of Modal Competition and Intermodal Capacity on Transport Supply



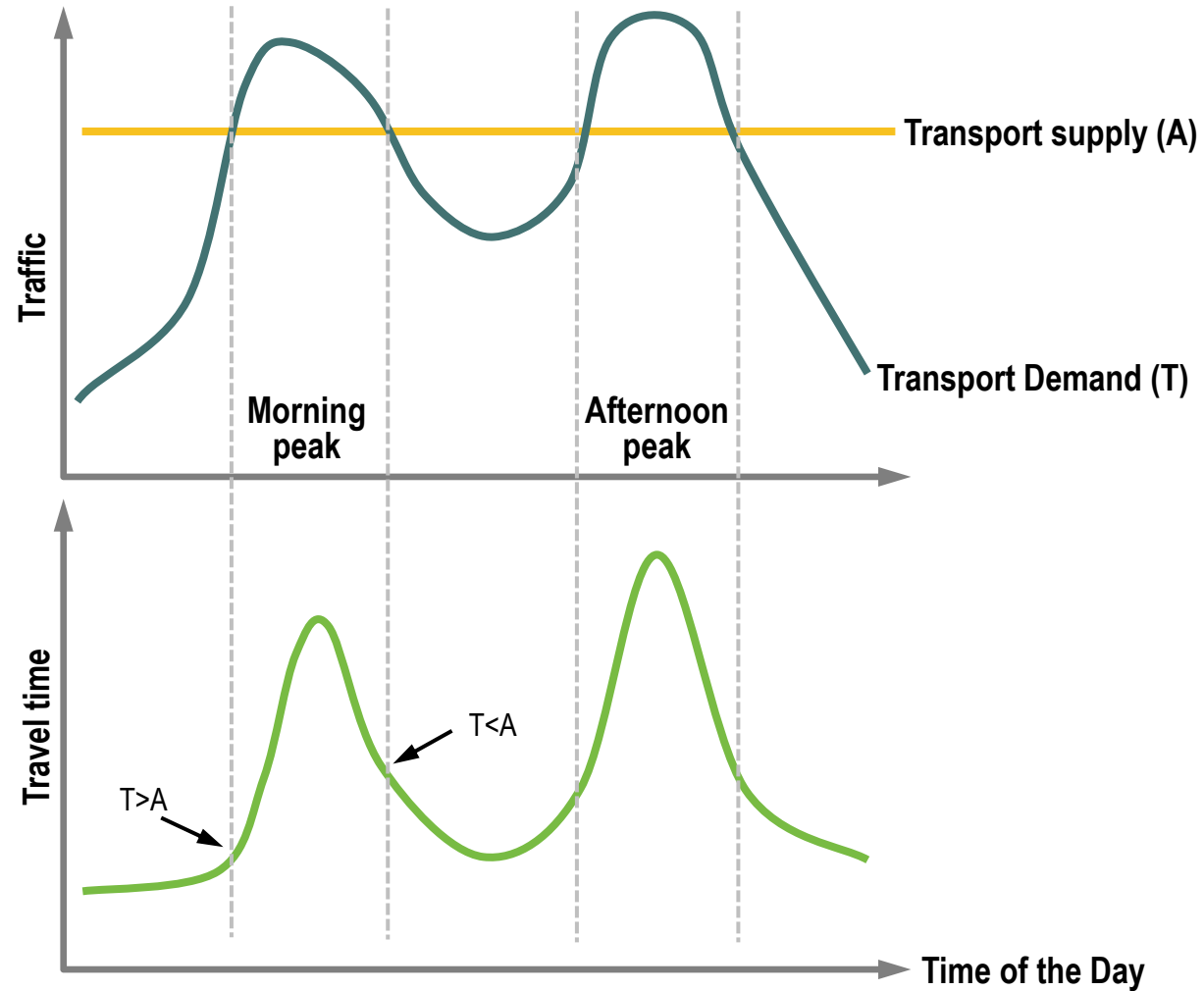
Classic Transport Demand / Supply Function



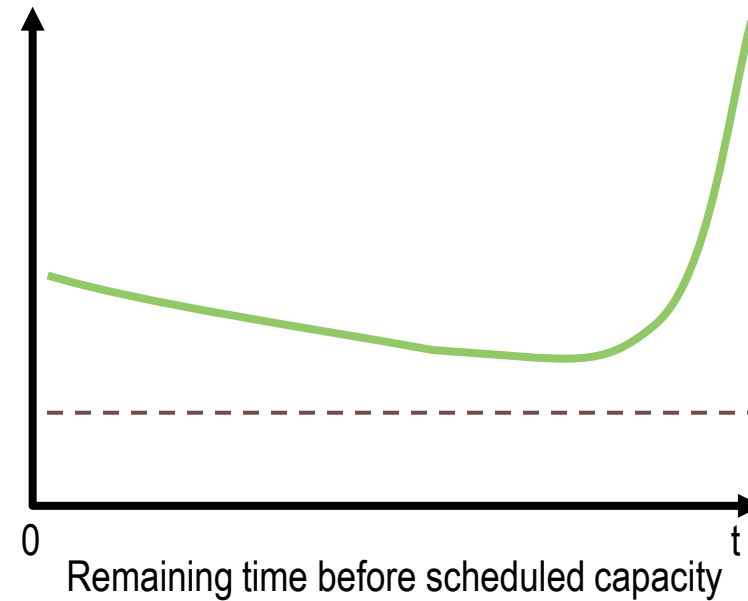
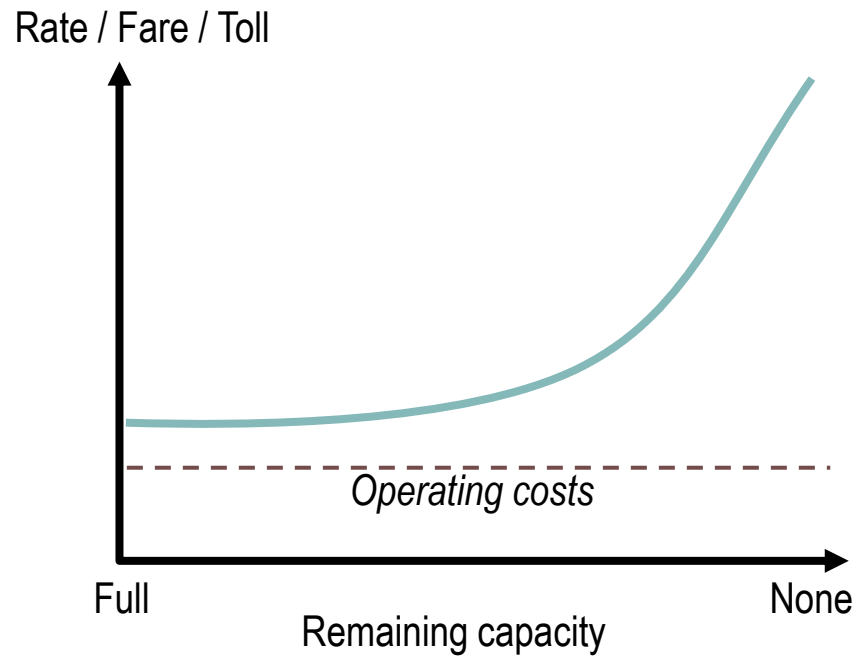
Road Transport Elasticity by Activity



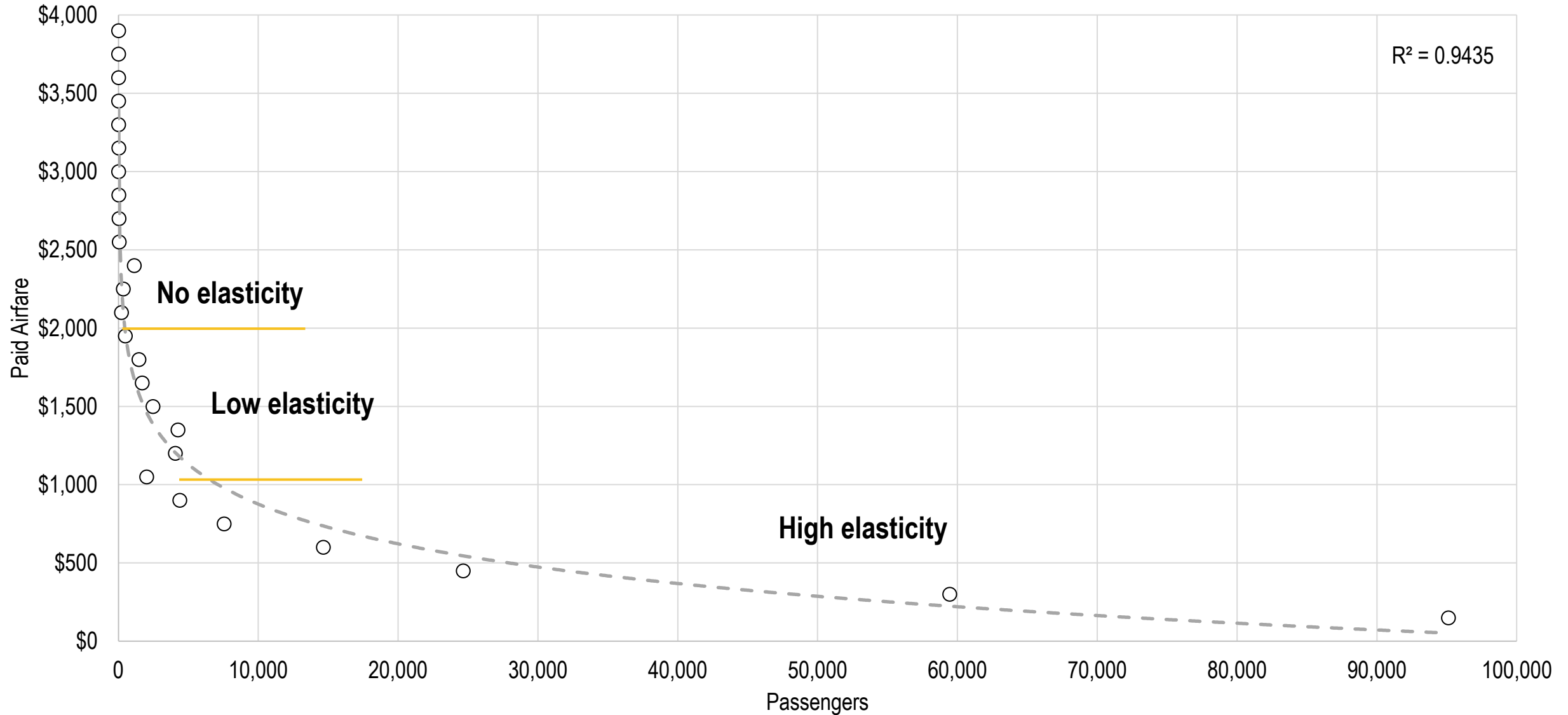
Transport Supply, Demand and Travel Time



Transportation Yield Management



Average Fares Disbursed for JFK–LAX Route, 2009 (April to July)



Average Price of a Domestic Airfare Based on Advance Purchase, United States, 2013

