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# Table of Contents

- 1.1 - What is Transport Geography?
- 1.2 - Transportation and the Physical Environment
- 1.3 - The Emergence of Mechanized Transportation Systems
- 1.4 - The Setting of Global Transportation Systems
- 1.5 - Transport and Commercial Geography
What is Transport Geography?

Chapter 1.1
# The Core Principles of Transport Geography

<table>
<thead>
<tr>
<th>Number</th>
<th>Image</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><img src="image1.png" alt="Diagram" /></td>
<td>Transportation is the spatial linking of a <strong>derived demand</strong></td>
</tr>
<tr>
<td>2</td>
<td><img src="image2.png" alt="Diagram" /></td>
<td>Distance is a relative concept involving space, time and effort (cost)</td>
</tr>
<tr>
<td>3</td>
<td><img src="image3.png" alt="Diagram" /></td>
<td>Space can be a generator, a support and a constraint for mobility</td>
</tr>
<tr>
<td>4</td>
<td><img src="image4.png" alt="Diagram" /></td>
<td>The relation between space and time can <strong>converge</strong> or <strong>diverge</strong></td>
</tr>
<tr>
<td>5</td>
<td><img src="image5.png" alt="Diagram" /></td>
<td>A <strong>location</strong> can be a central or an intermediate element of mobility</td>
</tr>
<tr>
<td>6</td>
<td><img src="image6.png" alt="Diagram" /></td>
<td>To overcome <strong>geography</strong>, transportation requires a footprint</td>
</tr>
<tr>
<td>7</td>
<td><img src="image7.png" alt="Diagram" /></td>
<td>Transportation seeks <strong>massification</strong> but is constrained by <strong>atomization</strong></td>
</tr>
<tr>
<td>8</td>
<td><img src="image8.png" alt="Diagram" /></td>
<td><strong>Velocity</strong> is a modal, intermodal and managerial effort</td>
</tr>
</tbody>
</table>

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The Scales of Transport Geography

**Network**
- Transit systems
- Street networks

**Flows**
- Commuting
- Personal and social trips
- Deliveries

**Spatial Constructs**
- Activity space
- District / Neighborhood
- Terminal / Development zone
- City

- Commuter rail
- Regional air networks
- National highway systems
- National railway systems
- Short sea shipping / feeders

- Intercity passenger flows
- Distribution

- Metropolitan area
- Market area
- Hinterland / Corridor
- Urban region

- International air networks
- Maritime shipping networks

- Trade
- Tourism and business trips
- Migration

- Value chains
- Landbridge
- Trade area

© GTS
The Sisyphus Analogy in Transportation
## Mobility of Freight

<table>
<thead>
<tr>
<th>Weight</th>
<th>Storage</th>
<th>Fragility</th>
<th>Perishability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ores</td>
<td>Piling</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Heavy</td>
<td>(0.83 g/cc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grain</td>
<td>Silos</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Heavy</td>
<td>(0.83 g/cc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Petroleum</td>
<td>Tanks</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Heavy</td>
<td>(0.88 g/cc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apparel</td>
<td>Warehouse</td>
<td>Low</td>
<td>None</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruits &amp; vegetables</td>
<td>Temperature controlled warehouse</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Containers</td>
<td>Stacks</td>
<td>Cargo dependent</td>
<td>Cargo dependent</td>
</tr>
<tr>
<td>Average (15-20 tons)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Transportation as a Derived Demand

- **Activity**
  - Working
  - Vacationing
  - Shopping
  - Manufacturing

- **Direct**
  - Commuting
  - Travel
  - Travel & Deliveries
  - Transport & Distribution

- **Indirect**
  - Services
  - Warehousing

- **Derived Demand**
  - Energy
Different Representations of Distance

Euclidean Distance

Transport Distance

Logistical Distance

Order Processing
Packing
Scheduling

Order

Transshipment

Warehousing

Sorting

Inventory Management
Unpacking

Pickup

Mode 1

Mode 1

Mode 2

Mode 2

Delivery

Delivery

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The Spatial Consideration of a Movement

Walking (W) 
Cycling (C) 
Driving (D)

Time

Distance (D)

Friction of Distance
Transportation and the Mobility of Passengers and Freight

Share of total passengers or tons-km

- Commuting
- Shopping
- Recreation
- Waste disposal
- Local distribution
- Commodity / Supply Chains
- Business
- Tourism
- Migration
- Freight
- Trade
- Energy & Raw Materials

Distance
Operational Differences between Passengers and Freight Transportation

**Passengers**
- Board, get off and transfer without assistance.
- Process information and act on it without assistance.
- Make choices between transport modes without assistance but often irrationally.
- Require travel accommodations related to comfort and safety.

**Freight**
- Must be loaded, unloaded and transferred.
- Information must be processed through logistics managers.
- Logistics managers meet choices between transport modes rationally.
- Require accommodations related to storage.
Space / Time Convergence

Travel Time (A–B)

ΔTT

Time

ΔT

T1 (1950)

T2 (2000)

6.2 hours

2.6 hours

A

B

A

B

\( STC = \frac{\Delta T}{\Delta TT} \)

\( STC = \frac{2.6 - 6.2}{2000 - 1950} \)

\( STC = -0.072 \text{ hours per year} \)
## Key Dimensions of Transportation

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Economic</strong></td>
<td>Transport and economic development (indirectly and directly). Factor in the production and added-value of goods and services. Facilitates economies of scale. Influences land (real estate) value. Contributes to the specialization of regions.</td>
</tr>
<tr>
<td><strong>Social</strong></td>
<td>Access to healthcare, welfare, and cultural events. Shape social interactions.</td>
</tr>
<tr>
<td><strong>Political</strong></td>
<td>Nation building and national unity. National defense. Rules and regulations. Subsidizing mobility (e.g. public transit or highways).</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td>Important environmental impacts. Pollution, exploitation of natural resources. Climate change.</td>
</tr>
</tbody>
</table>
Core Components of Transportation

**Modes**
- Conveyances used for the mobility of passengers and freight.
- Mobile elements of transportation.

**Infrastructures**
- Physical support of transport modes, such as routes and terminals.
- Fixed elements of transportation including superstructures.

**Networks**
- System of linked locations (nodes).
- Functional and spatial organization of transportation.

**Flows**
- Movements of people, freight and information over their network.
- Flows have origins, intermediary locations and destinations.
Adaptability
- Adaptation to the actions of other components.
- Adaptation to social, economic and technological changes.

Self-Organization
- Autonomous adaptation to changing conditions as a result of the adaptability of the individual components.

Stability
- A recognizable dynamic state of a system that may continuously reappear.

Cumulative
- Changes in one property or component may have a disproportionately large effect on another property or component.

Transition
- A system’s behavior may change radically, and sometimes irreversibly, when a tipping point is reached.

Competition
Routing
Land use
Congestion
Containerization
Dimensions of Transport Geography
Two Common Fallacies in Transport Geography

Access vs. Accessibility

Distance vs. Time
Common Problems for Transport Systems

- **Capacity**: Bottleneck, Route, Terminal
- **Transfer**: Hub / Gateway
- **Reliability**: Graph showing connectivity and robustness
- **Integration**: Network connections and interdependencies
Transportation and the Physical Environment
Absolute, Relative and Arbitrary Barriers

**Absolute Barrier**

- Absolute Barrier
- Modal Change
- Detour

**Relative Barrier**

- Relative Barrier
- Low Friction
- High Friction

# World’s Longest Tunnels Used for Transportation

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Traffic</th>
<th>Opening</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gotthard Base Tunnel</td>
<td>Swiss Alps</td>
<td>Rail</td>
<td>2017</td>
<td>57.1 km</td>
</tr>
<tr>
<td>Seikan Tunnel</td>
<td>Strait of Tsugaru, Japan</td>
<td>Rail</td>
<td>1988</td>
<td>53.8 km</td>
</tr>
<tr>
<td>Channel Tunnel</td>
<td>English Channel (UK-France)</td>
<td>Rail (High speed)</td>
<td>1994</td>
<td>50.4 km</td>
</tr>
<tr>
<td>Lötschberg Base Tunnel</td>
<td>Swiss Alps</td>
<td>Rail</td>
<td>2007</td>
<td>34.6 km</td>
</tr>
<tr>
<td>Guadarrama Tunnel</td>
<td>Sierra de Guadarrama, Spain</td>
<td>Rail (High speed)</td>
<td>2007</td>
<td>28.4 km</td>
</tr>
<tr>
<td>Taihang Tunnel</td>
<td>Taihang Mountains, China</td>
<td>Rail (High speed)</td>
<td>2008</td>
<td>27.8 km</td>
</tr>
<tr>
<td>Iwate-Ichinohe Tunnel</td>
<td>Ōu Mountains, Japan</td>
<td>Rail (High speed)</td>
<td>2002</td>
<td>25.8 km</td>
</tr>
<tr>
<td>Lærdal Tunnel</td>
<td>Lærdal - Aurland, Norway</td>
<td>Road</td>
<td>2000</td>
<td>24.5 km</td>
</tr>
<tr>
<td>Daishimizu Tunnel</td>
<td>Mount Tanigawa, Japan</td>
<td>Rail (High speed)</td>
<td>1982</td>
<td>22.2 km</td>
</tr>
<tr>
<td>Wushaoling Tunnel</td>
<td>Wuwei, China</td>
<td>Rail</td>
<td>2006</td>
<td>21.0 km</td>
</tr>
</tbody>
</table>
The Geographical Space of Maritime Transportation
Great Circle Distance between New York, Moscow and Tokyo
Global Wind Patterns

**Principle**
- Warm (Equator)
- Cold (Pole)

**Global Structure**
- Hadley Cell
- Ferrel Cell
- Polar Cell
- Intertropical Convergence Zone
- Polar Front
- Horse Latitudes
- TRADE WINDS
- WESTERLIES

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Global Wind Patterns

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Seasonal Variation of Global Wind Patterns
Transport, Site and Situation

Site (Amenities) - Local - Regional - Global

Situation (Connectivity)
The Spatial Structure and Transportation

- Location
- Distance
- Fixedness

- Attributes
- Relativity
- Dynamics
Transportation Networks and Geographical Concentration

Dispersion

Concentration
Transport as a Centralizing and Decentralizing Force (under construction)

- London - Edinburgh (520 km)
- New York - Boston (310 km)

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Global Space / Time Convergence: Days Required to Circumnavigate the Globe

1. Pre-Mechanization (1500-1840)
   - Average speed of horse and cart: 4 km/hr
   - Average speed sailships: 16 km/hr

2. Steam Engine (1850-1930)
   - Average speed of trains: 100 km/hr
   - Average speed of steamships: 25 km/hr

3. Internal Combustion (1930-50)
   - Average speed of airplanes: 480-640 km/hr

4. Jet Engine (1970s)
   - Average speed of jet planes: 800-1120 km/hr

5. Digitalization (1990s)
   - Numeric transmission: instantaneous

Average speed of horse and cart: 4 km/hr
Average speed sailships: 16 km/hr
Average speed of trains: 100 km/hr
Average speed of steamships: 25 km/hr
Average speed of airplanes: 480-640 km/hr
Average speed of jet planes: 800-1120 km/hr
Numeric transmission: instantaneous

Space / Time Convergence

Global Space / Time Convergence: Days Required to Circumnavigate the Globe

Pre-Mechanization (1500-1840)
Steam Engine (1850-1930)
Internal Combustion (1930-50)
Jet Engine (1970s)
Digitalization (1990s)

Average speed of horse and cart: 4 km/hr
Average speed sailships: 16 km/hr
Average speed of trains: 100 km/hr
Average speed of steamships: 25 km/hr
Average speed of airplanes: 480-640 km/hr
Average speed of jet planes: 800-1120 km/hr
Numeric transmission: instantaneous
Mail Delivery Times between New York and San Francisco, 1840-2000

- Ocean route NYC to Panama, Overland Panama, Panama to San Francisco
- Transcontinental stagecoach
- Completion of Panama railroad
- Rail to S. Joseph (MO) and Pony Express
- Transcontinental rail service
- Air mail service
- FedEx overnight

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Cumulative Distribution of per Capita Trip Rate for all Modes by Trip Distance, 1995

The graph illustrates the cumulative distribution of per capita trip rates for different modes of transportation (USA, UK, and Developing countries) across various trip distances (0 to 50 kilometers) for the year 1995. Each line on the graph represents the proportion of trips made up to a certain distance, with the lines diverging to show the relative distribution of trips for each country category.
### Speed Improvement Potential by Transport Mode [TO BE UPDATED]

<table>
<thead>
<tr>
<th>Mode</th>
<th>Potential</th>
<th>Main Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road (automobiles, buses, trucks)</td>
<td>None to limited</td>
<td>Congestion. Operational safety (speed limits). Limited access highways.</td>
</tr>
<tr>
<td>Rail (Freight)</td>
<td>Limited</td>
<td>Operational safety (grade crossings). Availability of train slots. Terminal capacity.</td>
</tr>
<tr>
<td>Rail (Passengers)</td>
<td>Good to significant</td>
<td>Development of high speed rail systems. Long term potential of new technologies (e.g. Maglev).</td>
</tr>
<tr>
<td>Air</td>
<td>None to limited</td>
<td>Energy consumption. Congestion at airport terminals. Abandonment of supersonic services.</td>
</tr>
<tr>
<td>Maritime</td>
<td>None to limited</td>
<td>Energy consumption (slow steaming). Fast ferries.</td>
</tr>
</tbody>
</table>
Travel Time between London and the Rest of the World, 1914
Global Accessibility: Time to the Nearest Large City
The Emergence of Mechanized Transportation Systems
# The Genesis of Globalization

<table>
<thead>
<tr>
<th>Time Frame</th>
<th>Economic System</th>
<th>Foundation</th>
<th>Acceleration</th>
<th>Form</th>
<th>Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antiquity</td>
<td>Modern Era</td>
<td>Post-Modern</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Since the beginning of history</td>
<td>Nineteenth century</td>
<td>After World War II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imperialism / Mercantilism</td>
<td>Imperialism / Capitalism</td>
<td>Capitalism / Corporatism</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exploration, war (expansion) and trade</td>
<td>Mass production and consumption</td>
<td>Trade liberalization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age of exploration of colonialism (15-16th century)</td>
<td>Berlin Conference (1884)</td>
<td>Fall of the Soviet Union</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Empires</td>
<td>Nation-states</td>
<td>Entry of China in world trade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trails and sailships</td>
<td>Mechanized (steamship and rail)</td>
<td>Economic blocs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air transport, containerization and telecommunications</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Transport Revolutions in Human History

<table>
<thead>
<tr>
<th>Era</th>
<th>Date</th>
<th>Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paleolithic</td>
<td>c. 700,000 years ago</td>
<td>First migrations from Africa</td>
</tr>
<tr>
<td></td>
<td>c. 35,000 years ago</td>
<td>First migrations by sea to Australasia</td>
</tr>
<tr>
<td></td>
<td>c. 18,000 years ago</td>
<td>First migrations to the Americas</td>
</tr>
<tr>
<td></td>
<td>c. 4,000 BCE</td>
<td>Animal-powered transport</td>
</tr>
<tr>
<td>Agrarian</td>
<td>c. 3,500 BCE</td>
<td>Wheeled transport</td>
</tr>
<tr>
<td></td>
<td>c. 1,000 BCE</td>
<td>Long distance navigation in Polynesia</td>
</tr>
<tr>
<td>Modern</td>
<td>From 15th century</td>
<td>Improvements in shipbuilding and navigation</td>
</tr>
<tr>
<td></td>
<td>From early 19th century</td>
<td>Railways and steamships</td>
</tr>
<tr>
<td></td>
<td>From late 19th century</td>
<td>Internal combustion engines</td>
</tr>
<tr>
<td></td>
<td>From early 20th century</td>
<td>Air travel</td>
</tr>
<tr>
<td></td>
<td>From mid 20th century</td>
<td>Space travel</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Time Period</th>
<th>Transportation</th>
<th>Telecommunication</th>
</tr>
</thead>
<tbody>
<tr>
<td>3000 BCE</td>
<td>Horses; Sailing ships; Wheeled carts; Aqueducts</td>
<td>Writing systems; Mail services</td>
</tr>
<tr>
<td>300 BCE – 500 CE</td>
<td>Wheelbarrow; Paved roads; Stirrups; Canals</td>
<td>Paper</td>
</tr>
<tr>
<td>500 – 1000 CE</td>
<td>Horse collars; Compass</td>
<td>Moveable type</td>
</tr>
<tr>
<td>1000 – 1500 CE</td>
<td>Rudder, Locks; Three-mast ships</td>
<td>Printing press (1456); Paper currency</td>
</tr>
<tr>
<td>1500 – 1800 CE</td>
<td>Steam engine (1712); Steam car (1769); Balloons (1783)</td>
<td>Newspapers and magazines</td>
</tr>
<tr>
<td>1800 – 1850 CE</td>
<td>Steamboat (1807); Bicycles (1816); Surfaced roads (1816); Steam rail (1825);</td>
<td>Photographs (1830); Telegraph (1844)</td>
</tr>
<tr>
<td></td>
<td>Electric streetcars (1834); Iron hulls (1843)</td>
<td></td>
</tr>
<tr>
<td>1850 – 1875 CE</td>
<td>Airships (1852); Compound steam engine (1854); Subway (1863); Pipelines (1864);</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Internal combustion engine (1866); Asphalt roads (1872)</td>
<td></td>
</tr>
<tr>
<td>1875 – 1900 CE</td>
<td>Steam turbine (1884); Gasoline engine (1885); Pneumatic tires (1888); Diesel</td>
<td>Steamboat (1807); Bicycles (1816); Surfaced roads (1816); Steam rail (1825); Electric streetcars (1834); Iron hulls (1843)</td>
</tr>
<tr>
<td></td>
<td>engine (1895); Trucks (1886)</td>
<td>Electric streetcars (1834); Iron hulls (1843)</td>
</tr>
<tr>
<td>1900 – 1925 CE</td>
<td>Airplanes (1903); Helicopters (1907); Ford Model T (1908); Dirigibles (1910);</td>
<td>Steam turbine (1884); Gasoline engine (1885); Pneumatic tires (1888); Diesel engine (1895); Trucks (1886)</td>
</tr>
<tr>
<td></td>
<td>Diesel locomotives (1917); Air passenger services (1919)</td>
<td>Airplanes (1903); Helicopters (1907); Ford Model T (1908); Dirigibles (1910); Diesel locomotives (1917); Air passenger services (1919)</td>
</tr>
<tr>
<td>1925 – 1950 CE</td>
<td>Rockets (1926); Highways (1933); Jet engine (1940); Passenger jet (1949)</td>
<td>Rockets (1926); Highways (1933); Jet engine (1940); Passenger jet (1949)</td>
</tr>
<tr>
<td>1950 – 1975 CE</td>
<td>Intermodal containers (1957); Space travel (1957); Jumbo jets (1966); Supersonic</td>
<td>Integrated circuits (1958); Xerox copier (1959); Telecom satellites (1962); Internet (1970); Cell phones (1973)</td>
</tr>
<tr>
<td></td>
<td>passenger jets (1969); Maglev (1969)</td>
<td>Integrated circuits (1958); Xerox copier (1959); Telecom satellites (1962); Internet (1970); Cell phones (1973)</td>
</tr>
</tbody>
</table>
Ancient Trade Issues

Nature of Trade
- Limited market size.
- High value commodities (silk, spices, perfumes, gems, gold / silver, ivory).
- Bulk commodities could be traded when maritime transport was available (grain, wine, olive oil).
- Many intermediaries.

Limiting Factors
- Limited capacity and speed of inland transportation.
- Diversity of currencies and units of measure.
- High tariffs.
- Unreliable navigation.
- Insecurity / piracy.
Grand Canal System

Beijing

Tonghui Canal (Yuan)

Jizhou Canal (Yuan)

Tongji Canal (Song)

Jiao-Lai Canal (Yuan)

Old course of the Yellow River (Song)

Bian Canal (Song)

Yongji Canal (Sui and Yuan)

Tongji Canal (Sui)

Jiangnan Canal (Sui, Song and Yuan)

Yingzhou Canal (Song and Yuan)

Hangzhou

Suzhou

Yangzhou

Chuzhou

Kaifeng

Luoyang

Huayin

400 km

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Early European Maritime Expeditions, 1492-1522
The Eastern and Western Maritime Routes to Asia

From 1419 to 1487, Portuguese ships explore the west coast of Africa.

Portugal was able to trade with India without Arab middlemen (most of the Arab fleet was sunk by 1515).

The fall of the Byzantium Empire closed the land route to Asia.

Vasco da Gama rounded the Cape of Good Hope and reached India (1497-1499).

Malacca, the most important commercial center in Southeast Asia, fell to the Portuguese.

The Cape of Good Hope at the southernmost end of Africa is reached, involving the possibility to reach Asia.

Between 1565 and 1571 Spain conquered the Philippines and established their colonial capital at Manila.

Trade was established with China.

Portuguese explorers reached Canton in China.

Nagasaki (1543), Japan.

Magellan reached the Pacific Ocean by rounding the southern tip of South America (1520).

Straits of Malacca (1551).

Manila (1565).

Magellanian.

The fall of Constantinople (1453) rounded the land route to Asia.

From 1419 to 1487, Portugal and Spain explore the west coast of Africa.

Calicut (1498).

Hormuz (1515).

Cape of Good Hope (1488).

Timor (1515).

Magellan.

Atlantic Ocean.

Indian Ocean.

Indian Ocean.

Pacific Ocean.

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Spanish and Portuguese Empires (1581–1640)
Density of Ship Log Entries, 1750–1810

Spain (1765–1799) n=43,691

Netherlands (1750–1799) n=33,315

United Kingdom (1750–1810) n=83,306

France (1750–1792) n=7,698

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Imports from the Dutch East India Company at Amsterdam, 17\textsuperscript{th} and 18\textsuperscript{th} Centuries

1650, 1670, 1700, 1740, 1780

- Textiles
- Spices
- Pepper
- Tea and Coffee
- Sugar

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North American Coastal Trade System, 18th Century
The Performance of Pre-industrial Means of Transportation

<table>
<thead>
<tr>
<th>Mode of Transportation</th>
<th>Weight</th>
<th>Speed</th>
<th>Distance/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>40 lbs / 18 kg</td>
<td>5 km/hr</td>
<td>30 km/day</td>
</tr>
<tr>
<td>Horse Riding</td>
<td>275 lbs / 125 kg</td>
<td>8 km/hr</td>
<td>60 km/day</td>
</tr>
<tr>
<td>Camel</td>
<td>350 lbs / 160 kg</td>
<td>5 km/hr</td>
<td>40 km/day</td>
</tr>
<tr>
<td>Horse &amp; cart</td>
<td>1 ton</td>
<td>3 km/hr</td>
<td>25 km/day</td>
</tr>
<tr>
<td>Barge pulled by horse</td>
<td>50-100 tons</td>
<td>4 km/hr</td>
<td>35 km/day</td>
</tr>
<tr>
<td>Dhow</td>
<td>15-300 tons</td>
<td>13 km/hr</td>
<td>150 km/day</td>
</tr>
<tr>
<td>Carrack (15th century)</td>
<td>500-1500 tons</td>
<td>10 km/hr</td>
<td>130 km/day</td>
</tr>
<tr>
<td>Galleon (17th century)</td>
<td>500-800 tons</td>
<td>15 km/hr</td>
<td>300 km/day</td>
</tr>
<tr>
<td>Clipper (19th century)</td>
<td>500-1500 tons</td>
<td>30 km/hr</td>
<td>700 km/day</td>
</tr>
</tbody>
</table>
## Major Technological Innovations of the Industrial Revolution

<table>
<thead>
<tr>
<th>Power Generation</th>
<th>Textiles</th>
<th>Metallurgy</th>
<th>Transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal energy used for mechanical energy</td>
<td>Mechanization of spinning and weaving</td>
<td>Mass production of steel (shipbuilding, rails, construction and machines)</td>
<td>Modern transport and telecommunication systems</td>
</tr>
<tr>
<td>• First water pump (1712) in mines.</td>
<td>• “Flying shuttle” (1733) doubled weaving productivity.</td>
<td>• Coke instead of coal for iron production (1709).</td>
<td>• Railroads (1825).</td>
</tr>
<tr>
<td>• Watt (1769); significant improvements.</td>
<td>• “Spinning jenny” (1765).</td>
<td>• Bessemer process (1855).</td>
<td>• Telegraph (1834).</td>
</tr>
<tr>
<td>• Steam locomotive (1824).</td>
<td>• “Water frame” (1768); hydraulic power.</td>
<td>• Sewing machine (1846).</td>
<td>• Steamship (1838).</td>
</tr>
<tr>
<td>• Electric generator (1831).</td>
<td>• “Spinning Mule” (1779); steam power.</td>
<td></td>
<td>• Telephone (1876).</td>
</tr>
<tr>
<td>• Steam turbine (1884).</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Inland Travel Time from New York, 1800 – 1830 (in Days)
American Rail Network, 1861
## Major Canals Built

<table>
<thead>
<tr>
<th>Year Range</th>
<th>Canal Name</th>
<th>Start City/Province</th>
<th>End City/Province</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>540-1320</td>
<td>Grand Canal</td>
<td>Beijing</td>
<td>Hangzhou</td>
<td>(2,500 km)</td>
</tr>
<tr>
<td>11th Century</td>
<td>Naviglio Grande</td>
<td>Milan</td>
<td>Adriatic</td>
<td>(30 km)</td>
</tr>
<tr>
<td>1390-97</td>
<td>Stecknitz Canal</td>
<td>Elbe</td>
<td>Trave</td>
<td>(11 km)</td>
</tr>
<tr>
<td>1604-42</td>
<td>Briare Canal</td>
<td>Seine</td>
<td>Loire</td>
<td>(58 km)</td>
</tr>
<tr>
<td>1667-81</td>
<td>Canal du Midi</td>
<td>Garonne</td>
<td>Mediterranean</td>
<td>(279 km)</td>
</tr>
<tr>
<td>1732</td>
<td>Ladoga canal</td>
<td>St. Petersburg</td>
<td>Volga</td>
<td>(110 km)</td>
</tr>
<tr>
<td>1759-61</td>
<td>Bridgewater Canal</td>
<td>Worsley</td>
<td>Manchester</td>
<td>(16 km)</td>
</tr>
<tr>
<td>1784-1833</td>
<td>Rhine-Rhone canal</td>
<td>Strasbourg-Mulhouse-Burgundy</td>
<td>(319 km)</td>
<td></td>
</tr>
<tr>
<td>1810-24</td>
<td>North Sea canal</td>
<td>Amsterdam</td>
<td>North Sea</td>
<td>(20 km)</td>
</tr>
<tr>
<td>1817-25</td>
<td>Erie canal</td>
<td>Buffalo</td>
<td>Albany</td>
<td>(544 km)</td>
</tr>
<tr>
<td>1836-45</td>
<td>Ludwigskanal</td>
<td>Main</td>
<td>Danube</td>
<td>(172 km)</td>
</tr>
<tr>
<td>1838-54</td>
<td>Rhine – Marne canal</td>
<td>Saverne gap</td>
<td>Mediterranean – Red Sea</td>
<td>(112 km)</td>
</tr>
<tr>
<td>1859-69</td>
<td>Suez canal</td>
<td>Manchester – Liverpool</td>
<td>(64 km)</td>
<td></td>
</tr>
<tr>
<td>1894</td>
<td>Manchester Ship Canal</td>
<td>Baltic Sea</td>
<td>North Sea</td>
<td>(99 km)</td>
</tr>
<tr>
<td>1887-95</td>
<td>Kiel canal</td>
<td>Atlantic Ocean</td>
<td>Pacific Ocean</td>
<td>(80 km)</td>
</tr>
<tr>
<td>1906-14</td>
<td>Panama canal</td>
<td>Rhine – Elbe</td>
<td>(320 km)</td>
<td></td>
</tr>
<tr>
<td>1905-38</td>
<td>Mittellandkanal</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Impacts of Maury’s Navigation Charts on Sailing Time, 1850s

<table>
<thead>
<tr>
<th>Route</th>
<th>Mean Sailing Days (before)</th>
<th>Mean Sailing Days (after)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York - San Francisco</td>
<td>180</td>
<td>133</td>
</tr>
<tr>
<td>Australia - England</td>
<td>63</td>
<td>126</td>
</tr>
<tr>
<td>England - Australia</td>
<td>97</td>
<td>124</td>
</tr>
<tr>
<td>New York - Rio de Janeiro</td>
<td>55</td>
<td>23</td>
</tr>
</tbody>
</table>

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Impacts of Maury’s Navigation Charts on Sailing Time, 1850s
Break-Even Distance between Sail and Steam, 1850-1890
Liner Transatlantic Crossing Times, 1833 – 1952 (in days)
Maritime Journey from Britain to Australia, 1788-1960

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Share of the Population in Agriculture, Early Industrial Countries, 1820-1910

Great Britain France Germany United States

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Global Telegraph System, c1901 (the Victorian Internet)
European Control of the World, 1500-1950

- 1800 (37%)
- 1878 (67%)
- 1913 (84%)
Colonies Controlled by Main Colonial Powers, 1500-2000

- Netherlands
- France
- Britain
- Spain
- Portugal

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The Setting of Global Transportation Systems
# United States Maritime Commission Cargo Ships, 1938-1947

<table>
<thead>
<tr>
<th>Type</th>
<th>Function</th>
<th>Period</th>
<th>Total constructed</th>
<th>Length (feet)</th>
<th>Beam (feet)</th>
<th>Deadweight tonnage</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1</td>
<td>Small cargo</td>
<td>1940-1945</td>
<td>173</td>
<td>418</td>
<td>60</td>
<td>8,075</td>
</tr>
<tr>
<td>C-2</td>
<td>General cargo</td>
<td>1938-1945</td>
<td>173</td>
<td>460</td>
<td>63</td>
<td>8,794</td>
</tr>
<tr>
<td>C-3</td>
<td>General cargo</td>
<td>1940-1947</td>
<td>465</td>
<td>492</td>
<td>70</td>
<td>12,500</td>
</tr>
<tr>
<td>C-4</td>
<td>General cargo; Troop ship</td>
<td>1941-1946</td>
<td>75</td>
<td>523</td>
<td>72</td>
<td>6,100</td>
</tr>
<tr>
<td>EC-2</td>
<td>Emergency cargo; Liberty ship</td>
<td>1941-1945</td>
<td>2,710</td>
<td>442</td>
<td>57</td>
<td>10,419</td>
</tr>
<tr>
<td>VC-2</td>
<td>General cargo; Victory ship</td>
<td>1944-1946</td>
<td>534</td>
<td>455</td>
<td>62</td>
<td>10,734</td>
</tr>
<tr>
<td>T-2</td>
<td>Tanker</td>
<td>1940-1945</td>
<td>536</td>
<td>524</td>
<td>68</td>
<td>16,400</td>
</tr>
<tr>
<td>T-3</td>
<td>Tanker</td>
<td>1939-1946</td>
<td>63</td>
<td>553</td>
<td>75</td>
<td>18,400</td>
</tr>
</tbody>
</table>
### United States Maritime Commission Cargo Ships, 1938-1947

<table>
<thead>
<tr>
<th>Type</th>
<th>Function</th>
<th>Period</th>
<th># Constructed</th>
<th>Length (m)</th>
<th>Beam (m)</th>
<th>DWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1</td>
<td>Small cargo</td>
<td>1940-45</td>
<td>173</td>
<td>127</td>
<td>18</td>
<td>8,075</td>
</tr>
<tr>
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<td>21</td>
<td>12,500</td>
</tr>
<tr>
<td>C-4</td>
<td>General cargo; Troop ship</td>
<td>1941-46</td>
<td>75</td>
<td>159</td>
<td>22</td>
<td>6,100</td>
</tr>
<tr>
<td>EC-2</td>
<td>Emergency cargo; Liberty ship</td>
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<td>2,720</td>
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<td>17</td>
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<td>16,400</td>
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<td>1939-46</td>
<td>63</td>
<td>159</td>
<td>23</td>
<td>18,400</td>
</tr>
</tbody>
</table>

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Comparison between a Contemporary and Second World War Tanker
Major Commodity Flows over the Great Lakes, 1940
Long Term Freight Market Index (LFI), 1741-2015
Route of the Graf Zeppelin into the Arctic (1931)
$y = 0e^{0.4408x}$

$R^2 = 0.7256$
Computer Storage Space, 1956-2016 (Dollars per Megabyte)
Diffusion of Telecommunication Services, 1985-2019

- Cellular Phone Subscribers
- Fixed Broadband Subscriptions
- Mobile Broadband Subscriptions
- Internet Users

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Typical Hard Drive Capacity, New Computer, 1981-2011

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## Some Long Distance Travel Costs

<table>
<thead>
<tr>
<th>Link</th>
<th>Cost in Dollars (Current 2005 Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transatlantic steamship (1880s)</td>
<td>$35 to $100 ($1,000 to $3,000)</td>
</tr>
<tr>
<td>Transcontinental rail (1880s)</td>
<td>$100 to $200 ($3,000 to $6,000)</td>
</tr>
<tr>
<td>Transcontinental rail (1940s)</td>
<td>$70 to $100 ($250 to $350)</td>
</tr>
<tr>
<td>Transcontinental air (1940s)</td>
<td>$300 ($3,600)</td>
</tr>
<tr>
<td>Transcontinental air (1960s)</td>
<td>$150 ($1,200)</td>
</tr>
<tr>
<td>Transcontinental air (2000s)</td>
<td>$600</td>
</tr>
</tbody>
</table>
## Evolution of Mobility, United States, 1800-2000

<table>
<thead>
<tr>
<th>Year</th>
<th>Average ground travel speed</th>
<th>Average mobility</th>
<th>Per capita GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1800</td>
<td>3 mph</td>
<td>1,500 miles per year</td>
<td>$1,200</td>
</tr>
<tr>
<td>1850</td>
<td>4 mph</td>
<td>1,600 miles per year</td>
<td>$1,900</td>
</tr>
<tr>
<td>1900</td>
<td>8 mph</td>
<td>2,000 miles per year</td>
<td>$5,000</td>
</tr>
<tr>
<td>1950</td>
<td>23 mph</td>
<td>6,900 miles per year</td>
<td>$12,000</td>
</tr>
<tr>
<td>2000</td>
<td>34 mph</td>
<td>18,000 miles per year</td>
<td>$35,000</td>
</tr>
</tbody>
</table>
## Some Impacts of Early Containerization

<table>
<thead>
<tr>
<th></th>
<th>Pre-Containerization (1965)</th>
<th>Post-Containerization (1970-71)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dock labor productivity</td>
<td>1.7 tons per hour</td>
<td>30 tons per hour</td>
</tr>
<tr>
<td>Port concentration (loading ports servicing Europe/Australia trade)</td>
<td>11 ports</td>
<td>3 ports</td>
</tr>
<tr>
<td>Insurance costs (Australia / Europe imports)</td>
<td>£0.24 per ton</td>
<td>£0.04 per ton</td>
</tr>
<tr>
<td>Inventory holding costs (Hamburg/Sydney)</td>
<td>£2 per ton</td>
<td>£1 per ton</td>
</tr>
</tbody>
</table>
Corporate Adaptation to Transport Innovations: American Express and Wells Fargo

**Interstate Wagon Services**
- **American Express**
  - 1850: Established in Buffalo, NY

**Rail Services**
- **American Express**
  - 1883: Express trains
  - 1918: Exiting the express business

**Financial Services**
- **American Express**
  - 1857: Money orders
  - 1891: Traveler's cheques
  - 1958: Credit cards

- **Wells Fargo**
  - 1852: Established in San Francisco, CA
  - 1866: Stagecoach services
  - 1888: Express trains
  - 1905: Wells Fargo Bank
  - 1967: Credit cards
  - 1995: Web banking accounts
Cumulative Waves of Transport Development

- **AIR**
  - Airports
  - Global mobility systems

- **LAND**
  - Canals: Punctual inland access
  - Railways: Inland and national accessibility
  - Highways: National mobility systems

- **MARITIME**
  - Sailships: Empires and global trade networks
  - Steamships: International trade and mobility
  - Containerships: Global distribution systems

**Periods:**
- 17-18th Century
- 19th Century
- 20th Century
- 21st Century
Growth of the US Transport System, 19th - 21st Century

- Canals: 1825 Paradigm shift, 1836 Peak year, Δt = 30 years
- Rail: 1869, Δt = 55 years
- Roads: 1913, Δt = 65 years
- Air: 1969, Δt = 70 years
- Maglev: 2001, 2050

Annual Growth

1800 1850 1900 1950 2000 2050

Δt = 30 years

Δt = 55 years

Δt = 65 years

Δt = 70 years

Δt = 55 years

Δt = 65 years

Δt = 70 years

1825
1836
1869
1913
1946
1969
2001
2050

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Transportation and Commercial Geography
Dimensions of Economic Geography

A: Product
B: Production
C: Innovation
D: Diffusion
The Drivers of Trade and Globalization

Integration
- Regulatory chains.
- Harmonization of regulatory regimes.
- Trade agreements.

Production
- Supply / value chains.
- Offshoring.
- Global production networks.

Transportation
- Transport chains.
- Containerization.
- Transborder transportation.

Transactions
- Information chains (ICT).
- Investment capital.
- Credit for transactions.

Standards

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Globalization as a Driver of Added Value

- **Research and Development**
  Finding better products and processes.

- **Input Costs**
  Using the labor and resources advantages of locations.

- **Transportation**
  Effectively transporting and distributing resources, parts and finished goods.

- **Sustainability**
  Improving resource, environmental and energy efficiency.
Share of the World GDP, 2016 (Current USD)

- United States: 24%
- China: 15%
- Japan: 6%
- Germany: 5%
- United Kingdom: 4%
- India: 3%
- France: 3%

Rest of the world: 40%
The Economic Output of the World's Major Metropolitan Areas, 2012

Nominal GDP, PPP $M (2012)
- Less than 100,000
- 100,000 to 200,000
- 200,000 to 400,000
- 400,000 to 800,000
- More than 800,000
Economic, Transport and Commercial Geography

Sphere of Transactions
Commercial Geography

Sphere of Circulation
Transport Geography

Movements

Transactions
Main Forms of Competitiveness in Transportation (under construction)

- Costs
- Differentiation
- Focus
Types of Competitive Advantages

- **Added Value**
  - Competitive Disadvantage
  - Competitive Parity
  - Temporary Competitive Advantage
  - Sustained Competitive Advantage

- **Scarcity**
  - LOW

- **Imitation Cost**
  - HIGH
Types of Innovation

- Organization
- Process
- Product
- Distribution
Worldwide Centers of Commerce Index, 2008
Global Financial Centers, 2012

Global Financial Centers Index, 2012

- Less than 525
- 525 to 600
- 600 to 650
- 650 to 700
- More than 700
Global Manufacturing, 2015
GDP Share of Manufacturing, Selected Countries, 1970-2020
Employment in Industry (in % of total Employment), 1980-2011
Drivers of Change in Manufacturing and the Transition Towards Added-Value

**Market Forces**
- Growth in emerging markets
- Demographic shifts

**Technologies**
- Digitalization and automation
- Production costs
- Improved logistics

**Resources**
- Energy costs
- Natural resources

**Policy**
- Environmental regulation
- Trade agreements
- Industrial policy

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**Graph: Comparative Advantages, Competitiveness, Capabilities vs. GDP per capita**

- **Share of Manufacturing**
- **Added-value / Complexity**

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Share of East Asia in the Value of World Trade, 1980-2019
The World’s 20 Largest Corporations by Market Value, 2015 ($US millions)

1. Apple
2. Exxon Mobil
3. Berkshire Hathaway
4. Google (Alphabet)
5. Microsoft
6. PetroChina
7. Wells Fargo
8. Johnson & Johnson
9. Industrial & Commercial Bank of China
10. Novartis
11. China Mobile
12. General Electric
13. Wal-Mart
14. China Mobile
15. Nestle
16. Toyota
17. Roche
18. JP Morgan Chase
19. Procter & Gamble
20. Samsung

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Global Inflows of Foreign Direct Investments, 1990-2019 (in Millions of Current $US)

- Developed economies
- Developing economies

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## Selection of Transport Route

<table>
<thead>
<tr>
<th>Type</th>
<th>Passengers</th>
<th>Freight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I</td>
<td>Individual selects route (private transport)</td>
<td>Shipper or consignee selects route (own account)</td>
</tr>
<tr>
<td>Type II</td>
<td>Charterer selects route</td>
<td>Freight forwarder selects route</td>
</tr>
<tr>
<td>Type III</td>
<td>Transport company selects route</td>
<td>Transport company selects route</td>
</tr>
</tbody>
</table>
## Major Commercial Actors in Freight Distribution (to update)

<table>
<thead>
<tr>
<th>Transport Sector</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maritime shipping companies</td>
<td>Control long distance segments of the global freight distribution linking major markets. Highly capital intensive industry. Decide of their network configuration (ports of call and routing).</td>
</tr>
<tr>
<td>Global port terminal operators</td>
<td>Control important intermodal infrastructures (terminals) within the world's largest container ports. Have strong linkages with maritime shipping companies.</td>
</tr>
<tr>
<td>Port authorities</td>
<td>Manage and plan port infrastructures. Tend to lease terminal operations. Important intermediaries for regional distribution (hinterland).</td>
</tr>
<tr>
<td>Real estate promoters</td>
<td>Develop logistics zones (build to lease, build to suit), often in coordination with terminals (rail and port). Manage a real estate portfolio of distribution centers (leases).</td>
</tr>
<tr>
<td>Maritime lock and canal operators</td>
<td>Operate strategic passages in global and national distribution (e.g. the Panama Canal, the Suez Canal or the St. Lawrence Seaway).</td>
</tr>
<tr>
<td>Rail and rail terminal operators</td>
<td>Strategic inland freight carriers transporting a wide array of raw materials and commodities. Responsible for many of the transshipments between rail and road, particularly for containerized freight.</td>
</tr>
<tr>
<td>Trucking industry</td>
<td>Control vast and diverse assets that include critical segments of freight distribution in all economic sectors. Short and medium haul transport.</td>
</tr>
<tr>
<td>Third party logistics providers</td>
<td>Important managerial and organizational skills within supply chains. Often act as brokers between transport customers and service providers. Some own and operate transport assets.</td>
</tr>
<tr>
<td>Air freight transport companies and air freight terminals</td>
<td>Important assets for the rapid distribution of high value added freight. Decide of their network configuration (airports serviced).</td>
</tr>
<tr>
<td>Freight forwarders</td>
<td>Perform tasks such as packaging, labeling and the consolidation of shipments on behalf of their customers. Operate distribution centers. Define how markets are serviced. Can subcontract to third party providers.</td>
</tr>
</tbody>
</table>

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The Relevance of Logistics

**Costs**
- Friction of distribution
  - Efficient logistics has commercial benefits (costs, time and reliability).
  - Logistics cost 10-15% of national GDP.

**Growth**
- Growing material demand
  - Growth of global consumption and income.
  - Diversity of consumption patterns.

**Complexity**
- Complex value chains
  - Goods are getting more complex (parts and processes).
  - Embeddedness of design, manufacturing, distribution and marketing.

**Geography**
- Spatial division of manufacturing
  - Stages of production are spatially separated.
  - Final production and markets are spatially separated.

**Environment**
- Sustainability
  - Energy and material efficiency.
  - Reverse logistics / recycling.
Footprint of Retail-Based and Distribution-Based Commercial Activities

- Commercial Footprint
- Total Footprint
- Distribution Footprint
- Retail Footprint

- Retail-Based
- Distribution-Based

Digitalization

© GTS

Store
Distribution center
Consumer

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Retail Space per Capita, 2017 (in square foot)

- Germany
- China
- France
- Sweden
- UK
- Australia
- Canada
- United States