CHAPTER 3

Transport, Economy and Society
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Transport and Economic Development

Chapter 3.1
Factors behind the Development of Transport Systems

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<td>National / Transnational</td>
<td>Distance</td>
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<td>Corridors and sea routes</td>
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<td>Global</td>
<td>Oceanic masses</td>
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<td>Air transport and telecommunications</td>
<td>Multilateral agreements (WTO)</td>
<td>Interdependency and comparative advantages</td>
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<td>Service</td>
<td>Supporting Infrastructures</td>
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<td>------------------</td>
<td>-------------------------------------------------------------------------------------------</td>
<td></td>
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</tr>
<tr>
<td>Transportation</td>
<td>Roads, bridges, tunnels, rail tracks, ports, harbors, airports, distribution centers, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water supply</td>
<td>Dams, reservoirs, pipes, treatment plants, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water disposal</td>
<td>Sewers, used water treatment plants, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td>Dams, reservoirs, canals, sprinkling systems, etc.</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Garbage disposal</td>
<td>Landfills, incinerators, recycling facilities, compost units, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telecommunications</td>
<td>Telephone exchanges, telephone lines, oceanic cables, cellular towers, fiber optic cables, web servers, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>Power plants, transmission &amp; distribution lines, pipelines, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Economic Impacts of Transportation Infrastructure

**CORE**
- **Capacity**
  - Modal
  - Intermodal

**OPERATIONAL**
- **Time**
  - Infrastructure level
- **Reliability**
  - Time frame

**GEOGRAPHICAL**
- **Accessibility**
  - Local
  - Regional
  - Global
- **Location**
  - © GTS
Socioeconomic Benefits of Transportation

- **Time and cost savings.**
- **Income from transport operations.**
- **Formation of distribution networks.**
- **Attraction of economic activities.**
- **Increased competitiveness.**
- **Productivity and added gains.**
- **Rent income.**
- **Goods and services to users.**
- **Improved mobility.**
- **Increased social opportunities.**
- **Formation of distribution networks.**
- **Attraction of economic activities.**
- **Increased competitiveness.**
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.
Diminishing Marginal Returns

The graph illustrates the concept of diminishing marginal returns. As inputs (I1 and I2) increase, the output (O1 and O2) initially increases at an increasing rate but then slows down, indicating diminishing returns. This means that each additional unit of input produces a smaller increase in output compared to the previous unit.
### Types of Transport Economic Improvements (under construction)

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor Driven</td>
<td></td>
</tr>
<tr>
<td>Efficiency Driven</td>
<td></td>
</tr>
<tr>
<td>Innovation Driven</td>
<td></td>
</tr>
</tbody>
</table>
## Transport Goals by the Public Sector (under construction)

<table>
<thead>
<tr>
<th>Goal</th>
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</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Type</td>
</tr>
<tr>
<td>----------------------------------</td>
</tr>
<tr>
<td>Transportation prices</td>
</tr>
<tr>
<td>Transportation productivity</td>
</tr>
<tr>
<td>Logistics costs</td>
</tr>
<tr>
<td>Transportation capacity utilization</td>
</tr>
</tbody>
</table>
## Transport Economic Indicators

<table>
<thead>
<tr>
<th>Type</th>
<th>Measures</th>
<th>Relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation Prices</td>
<td>Aggregate price of transportation services by mode or commodity.</td>
<td>Input costs by economic sector. Market competitiveness.</td>
</tr>
<tr>
<td>Transportation Productivity</td>
<td>Labor productivity and total-factor productivity (labor and assets).</td>
<td>Level of return on investment. Economic impacts by sector.</td>
</tr>
<tr>
<td>Logistics Costs</td>
<td>Supply-chain distribution cost relative to GDP or total costs.</td>
<td>Efficiency by logistics function.</td>
</tr>
<tr>
<td>Transport Capacity Utilization</td>
<td>Share of modal (vehicles and links) and intermodal (terminals) capacity.</td>
<td>Assessment of investment needs for maintenance, upgrade and expansion.</td>
</tr>
</tbody>
</table>
### Economic Multiplier Effects of Transportation

<table>
<thead>
<tr>
<th>Type</th>
<th>Effect</th>
<th>Context</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit time</td>
<td>One day in transit equivalent to a tariff of 0.6 to 2.1%</td>
<td>OECD</td>
<td>Hummels (2012)</td>
</tr>
<tr>
<td>Port</td>
<td>10% increase in port efficiency leads to 3.2% increase in real trade between a country pair</td>
<td>USA</td>
<td>Blonigen and Wilson (2006)</td>
</tr>
<tr>
<td>Port</td>
<td>1% increase in port efficiency leads to a 0.38% reduction in trade costs</td>
<td>World Bank (2017)</td>
<td></td>
</tr>
</tbody>
</table>
Transport Infrastructure Investment and Maintenance Spending as Share of GDP, 2015

Canada, China, France, Germany, India, Italy, Japan, Korea, Russia, Spain, Turkey, United Kingdom, United States

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Infrastructure Level and Economic Development

Per Capita Income

Infrastructure Level

- Road
- Water / Sewage
- Electricity
- Radio
- Cell Phone
Majority of population descended from immigrants

- European
- African (slaves)
- Indian
- Chinese
- Japanese
# The Ocean Economy

## Activity vs. Oceanic Region vs. Driver

<table>
<thead>
<tr>
<th>Activity</th>
<th>Oceanic Region</th>
<th>Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvesting of living</td>
<td>Fisheries</td>
<td>Food security and demand for food</td>
</tr>
<tr>
<td>resources</td>
<td>Aquaculture</td>
<td>Pharmaceutical and industrial demand</td>
</tr>
<tr>
<td>Biotechnology</td>
<td>Pharmaceutical, chemicals</td>
<td>Mineral demand</td>
</tr>
<tr>
<td>Minerals</td>
<td>Seabed mining</td>
<td>Energy demand</td>
</tr>
<tr>
<td>Energy</td>
<td>Oil and gas</td>
<td>Energy demand</td>
</tr>
<tr>
<td>Fresh water</td>
<td>Renewables</td>
<td>Energy demand</td>
</tr>
<tr>
<td>Maritime trade and</td>
<td>Desalination</td>
<td>Freshwater shortages</td>
</tr>
<tr>
<td>commerce</td>
<td>Shipping</td>
<td>Seaborne trade</td>
</tr>
<tr>
<td>Transport</td>
<td>Ports</td>
<td>Global tourism</td>
</tr>
<tr>
<td>Tourism</td>
<td>Cruising</td>
<td>Coastal urbanization</td>
</tr>
<tr>
<td>Settlements</td>
<td>Resorts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Urbanization</td>
<td></td>
</tr>
</tbody>
</table>

**Oceanic Region:**
- Coastal
- EEZ
- Deepsea

**Driver:**
- Food security and demand for food
- Pharmaceutical and industrial demand
- Mineral demand
- Energy demand
- Energy demand
- Freshwater shortages
- Seaborne trade
- Global tourism
- Coastal urbanization

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Resource-Based Transport Systems
World Bank Average Annual Lending by Mode, 2007

- Roads & Highways: 62%
- Ports & Waterways: 20%
- Railways: 13%
- Aviation: 4%
- General Transportation: 1%
Wealth Consumption Investment in Transport Infrastructure: Repaving a Sidewalk
A Multi-Layer Perspective about Transport and Economic Development

**Transport Chain Organization**
- Organization of the (multimodal) routing of passengers and freight through the transport system using a mix of transport services and transport infrastructures.

**Transport Service Operations**
- Bus services, rail services, barge services, maritime transport services, trucking, airline services, etc.
- Freight and passenger handling in transport nodes.

**Transport Infrastructure**
- Transport nodes (e.g. airport, seaport, railway station, intermodal terminal, etc.) and transport links (highways, waterways, rail tracks, pipelines, etc.)

**Location**
- Geographical location of origin and destination of movements (multimodal transport chain).
Time Sequence and Nature of Impacts of Transport Investments

- **Positive Impact**:
  - Positive and lead impacts
  - Lag and positive impacts

- **Negative Impact**:
  - Lead and negative impacts
  - Lag and negative impacts

**Weak relationship**: connecting all four impacts.
Impact of Recessions on Consumption, Production and Trade

- **Product Categories**
  - A – Basic Goods
  - B – Discretionary Goods
  - C – Durable Goods
  - D – Capital Equipment
  - E – Luxury Goods

- **Demand**
  - Subcategory average
  - Category average

- **Supply**
  - 1 – Futures Indexes
  - 2 – Production (by sector)
  - 3 – Container Volumes (by trade lane)
  - 4 – Value of Trade (by trade group)

- **Sequence**
  - 1 – Light recession
  - 2 – Light recession
  - 3 – Severe recession
  - 4 – Severe recession

**Severe recession**

**Light recession**

**None**

**Decline**

**Significant**
Lifespan of Main Transport Assets

- Port: Average Lifespan = 70 Years, Optimum Lifespan
- Railway: Average Lifespan = 50 Years, Optimum Lifespan
- Airport: Average Lifespan = 50 Years, Optimum Lifespan
- Bridge: Average Lifespan = 30 Years, Optimum Lifespan
- Highway: Average Lifespan = 20 Years, Optimum Lifespan
- Locomotive: Average Lifespan = 20 Years, Optimum Lifespan
- Jet plane: Average Lifespan = 20 Years, Optimum Lifespan
- Containership: Average Lifespan = 15 Years, Optimum Lifespan
- Container: Average Lifespan = 10 Years, Optimum Lifespan
- Car: Average Lifespan = 8 Years, Optimum Lifespan

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Long Wave Cycles of Innovation

1785 1845 1900 1950 1990

Waterpower
Textiles
Iron
Mechanization
Commerce

Pace of innovation

1st Wave
1785 60 years

2nd Wave
1845 55 years

3rd Wave
1900 50 years

4th Wave
1950 40 years

5th Wave
1990 30 years

6th Wave
2020 25 years (?)
# The Five Waves of Development

<table>
<thead>
<tr>
<th>Wave</th>
<th>Description</th>
</tr>
</thead>
</table>
| **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. |
Diffusion Cycle of Containerization

- New (niche) services
- Productivity gains
- Network development
- Productivity multipliers
- Network complexities
- Massive diffusion
- Maturity
- Niche markets

Diffusion Level vs. Time
Relationship between TEU and GDP Growth

TEU-to-GDP Multiplier

1985-1989
1990-1999
2000-2008
2009-2015

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Technology “Hype” Cycle

- **Hype Phase**
  - Introduction
  - Inflated expectations
  - Delusion
  - Abandonment
- **Realization Phase**
  - Learning curve
  - Productivity peak

Visibility: High during Introduction and peaks during Inflated expectations.

Utility: Increases during Learning curve and peaks during Productivity peak.
Spatial diffusion of a transport system
Business Cycles and Misallocations

Expansion Recession Expansion Depression

Trough Peak Normal Cycle Credit-Driven Cycle

Credit-Driven Boom Credit-Driven Bust

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Main Stages in a Bubble

- **Stealth Phase**
  - Media attention
  - Take off
  - First Sell off

- **Awareness Phase**
  - Enthusiasm

- **Mania Phase**
  - “New Paradigm”!!
  - Delusion
  - Greed

- **Blow off Phase**
  - Return to “normal”
  - Fear
  - Capitulation
  - Return to the mean

**Valuation**
- Bull trap
- Bear trap
- Mean

**Institutional investors**
- Smart Money
- Public

**Source:** Dr. Jean-Paul Rodrigue, Dept. of Global Studies & Geography, Hofstra University.
### Factors behind the Development of Transport Systems

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</tbody>
</table>
Economic Production and Specialization

1. Self-Reliance

Region A  Region B

2. Regional Trade

Trade and Transport

3. International Trade

Product A  Product B  Product C  Product D  Product E

Trade and Transport

Gateway

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Transport Impacts on Economic Opportunities

- **Transport Infrastructure Investments**
  - Transport Improvements
    - Capacity
    - Efficiency
    - Reliability
  - Lower Transport Costs
  - Shorter Transit Times
  - Business Expansion
  - Increased Productivity
    - Labor Market
    - Commodity Market
  - Increased Competitiveness
    - Economic Growth

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Just in Time and its Logistics

Supply Chain

Delivery Units for Parts
Moving storage units

Production Unit
Assembly line
Warehousing

Logistics

Delivery Units for Goods
Moving storage units

PARTS
GOODS
Transportation and Society

Chapter 3.2
Probability of Pedestrian Fatality by Impact Speed
Transport Costs

Chapter 3.3
Components of Transport Cost

Friction of Distance

Transaction Costs

A

B

Shipment
Household Expenditures on Transport, United States, 2005

- Transport services: 52%
- Operation of vehicles: 46%
- Purchase of vehicles: 6%

- Vehicle finance charges: 15%
- Other vehicle charges: 22%
- Maintenance and repairs: 43%
- Vehicle insurance: 55%
- Gasoline and motor oil: 3%

- Other vehicles: 11%
- Car used: 6%
- Car new: 6%
## Fixed and Operating Transport Costs

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fixed/Capital Costs</th>
<th>Operating Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail or Highway</td>
<td>Land, Construction, Rolling Stock</td>
<td>Maintenance, Labor, Fuel</td>
</tr>
<tr>
<td>Pipeline</td>
<td>Land, Construction</td>
<td>Maintenance, Energy</td>
</tr>
<tr>
<td>Air</td>
<td>Land, Field &amp; Terminal Construction, Aircraft</td>
<td>Maintenance, Fuel, Labor, Airport Charges</td>
</tr>
<tr>
<td>Maritime</td>
<td>Land for Port Terminals, Cargo Handling Equipment, Ships</td>
<td>Maintenance, Fuel, Labor, Port Charges</td>
</tr>
</tbody>
</table>
## Conditions Affecting Transport Costs

<table>
<thead>
<tr>
<th>Condition</th>
<th>Factors</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geography</td>
<td>Distance, physiography, accessibility</td>
<td>Shipping between France and England vs. shipping between France and the Netherlands</td>
</tr>
<tr>
<td>Type of product</td>
<td>Packaging, weight, perishable</td>
<td>Shipping coal, Shipping flowers or wine</td>
</tr>
<tr>
<td>Economies of scale</td>
<td>Shipment size</td>
<td>A 777 compared to 737 (passengers), Post-Panamax compared to Panamax (freight)</td>
</tr>
<tr>
<td>Trade imbalance</td>
<td>Empty travel</td>
<td>Trade between China and the United States</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Capacity, limitations, operational conditions</td>
<td>The Interstate</td>
</tr>
<tr>
<td>Mode</td>
<td>Capacity, limitations, operational conditions</td>
<td>A bus compared to a car</td>
</tr>
<tr>
<td>Competition and regulation</td>
<td>Tariffs, safety, ownership</td>
<td>The European Union, The Jones Act</td>
</tr>
</tbody>
</table>
# Truck Transport Cost Components, North America, 2005

<table>
<thead>
<tr>
<th>Cost Component</th>
<th>Cost Share Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver</td>
<td>27 to 36%</td>
</tr>
<tr>
<td>Fuel</td>
<td>18 to 24%</td>
</tr>
<tr>
<td>Administration and Interest</td>
<td>13 to 14%</td>
</tr>
<tr>
<td>Equipment Ownership</td>
<td>7 to 12%</td>
</tr>
<tr>
<td>Repairs</td>
<td>7 to 12%</td>
</tr>
<tr>
<td>Insurance</td>
<td>3%</td>
</tr>
<tr>
<td>Tires</td>
<td>2 to 4%</td>
</tr>
<tr>
<td>Miscellaneous (Licenses, Cleaning, etc.)</td>
<td>2 to 3%</td>
</tr>
<tr>
<td>Margin</td>
<td>5%</td>
</tr>
</tbody>
</table>
## Freight Transportation Service Spectrum

<table>
<thead>
<tr>
<th>Service Type</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Cargo</td>
<td>$4.50/kg</td>
<td>$1.00/kg</td>
</tr>
<tr>
<td>Truck</td>
<td>$1.00/kg</td>
<td>$1.00/kg</td>
</tr>
<tr>
<td>Rail Intermodal</td>
<td>50¢/kg</td>
<td>5¢/kg</td>
</tr>
<tr>
<td>Rail Carload</td>
<td>5¢/kg</td>
<td>5¢/kg</td>
</tr>
<tr>
<td>Rail Unit</td>
<td>2¢/kg</td>
<td>2¢/kg</td>
</tr>
<tr>
<td>Water</td>
<td>1¢/kg</td>
<td>1¢/kg</td>
</tr>
</tbody>
</table>

- **High**:
  - Fastest, most reliable and most visible.
  - Lowest weight, highest value and most time-sensitive cargo.

- **Low**:
  - Slower, less reliable and less visible.
  - Highest weight, lowest value and less time-sensitive cargo.

- **Rail Intermodal**:
  - Fast, reliable and visible.
  - Range of weight and value.
  - Rail intermodal competitive with truck over longer distances.
Friction of Distance Functions

1. Costs vs. Distance
   - Fixed Costs
   - Zone Change

2. Transshipment Costs

3. (a) and (b)

4. Graph showing transshipment costs with steps.
Zonal Freight Rates

<table>
<thead>
<tr>
<th>Distance</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Flat zonal rate</td>
</tr>
<tr>
<td>III</td>
<td>Real transport cost</td>
</tr>
<tr>
<td>IV</td>
<td></td>
</tr>
</tbody>
</table>

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Different Components of Transport Time

- **Transport Time**
  - Time vs. Distance
  - Linear relationship

- **Timing**
  - Timing vs. Distance
  - Variability indicated by arrows

- **Punctuality**
  - Punctuality vs. Distance
  - Variability indicated by arrows

- **Frequency**
  - Frequency vs. Distance
  - Variability indicated by arrows
Freight Transport Revenue per Ton-Mile (in 2006 dollars)

- Water: $0.01
- Rail: $0.02
- Road: $0.27
- Air: $0.80
First and Last Mile Unit Cost Structure

Unit Transport Costs

“First Mile”  Transport sequence  “Last Mile”

Urban Area

International / Intercity
Letters of Credit and Bills of Lading in Commercial Transactions

1. **Seller** -> **Buyer** via **Letter of Credit**
   - **Seller's Bank**
   - **Buyer's Bank**

2. **Seller** -> **Shipper** via **Bill of Lading**
   - **Seller's Bank**
   - **Buyer's Bank**

3. **Payment**
   - **Seller**
   - **Shipper**
   - **Bill of Lading**
   - **Seller's Bank**
   - **Buyer's Bank**

4. **Consignment**
   - **Seller**
   - **Shipper**
   - **Bill of Lading**
   - **Seller's Bank**
   - **Buyer's Bank**
Selected International Commercial Terms (Incoterms)

- **EXW**: Seller's cost / risk
- **FCA**: Buyer's cost / risk
- **FAS**: Seller's cost / risk
- **FOB**: Buyer's cost / risk
- **CFR**: Seller's cost / risk
- **CIF**: Buyer's cost / risk
- **CIP**: Seller's cost / risk
Shipment Size and Inland Transport Costs

<table>
<thead>
<tr>
<th>Shipment Size (lbs)</th>
<th>Transport Charges ($/ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parcel</td>
<td></td>
</tr>
<tr>
<td>LTL Truck</td>
<td></td>
</tr>
<tr>
<td>Truckload</td>
<td></td>
</tr>
<tr>
<td>Railcar load</td>
<td></td>
</tr>
<tr>
<td>Multi-railcar</td>
<td></td>
</tr>
<tr>
<td>Unit train</td>
<td></td>
</tr>
<tr>
<td>Barge load</td>
<td></td>
</tr>
</tbody>
</table>
Share of Transport Costs in Product Prices and Average Domestic Haul Length

- Leather products
- Apparel
- Electronics
- Textiles
- Transport equipment
- Paper products
- Machinery
- Rubber and plastics
- Printing and publishing
- Fabricated metals
- Primary metals
- Furniture
- Food
- Lumber and wood
- Petroleum
- Tobacco
- Instruments
- Machinery
- Transportation
- Paper products
- Electronics
- Textiles
- Transport equipment
- Machinery
- Rubber and plastics
- Printing and publishing
- Fabricated metals
- Primary metals
- Furniture
- Food
- Lumber and wood
- Petroleum
- Tobacco
- Instruments
- Transportation

$R^2 = 0.3988$
Table 4. HMT Average Payment for Containerized Cargo

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

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

<table>
<thead>
<tr>
<th>Product</th>
<th>Typical Shelf Price</th>
<th>Shipping Costs</th>
<th>Shipping Costs Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>LCD TV Set</td>
<td>$700</td>
<td>$4.00</td>
<td>0.5%</td>
</tr>
<tr>
<td>Digital Camera (high range)</td>
<td>$450</td>
<td>$0.15</td>
<td>0.03%</td>
</tr>
<tr>
<td>Vacuum Cleaner</td>
<td>$150</td>
<td>$1.00</td>
<td>0.6%</td>
</tr>
<tr>
<td>Scotch Whisky (bottle)</td>
<td>$50</td>
<td>$0.15</td>
<td>0.3%</td>
</tr>
<tr>
<td>Coffee (1 kg)</td>
<td>$15</td>
<td>$0.15</td>
<td>3.3%</td>
</tr>
<tr>
<td>Biscuits (Tin)</td>
<td>$3</td>
<td>$0.05</td>
<td>1.7%</td>
</tr>
<tr>
<td>Beer (Can)</td>
<td>$1</td>
<td>$0.01</td>
<td>1.0%</td>
</tr>
<tr>
<td>Apple</td>
<td>$0.75</td>
<td>$0.04</td>
<td>5.3%</td>
</tr>
</tbody>
</table>
Baltic Dry Index, Monthly Value, 1985-2019
World Container Index, 2011
Average Cost per TEU by Containership Capacity and By Route, 1997

Costs per TEU ($US)

Capacity in TEU

Europe - Far East (11,500 miles)
Trans Pacific (8,000 miles)
Trans Atlantic (4,000 miles)

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

Average Transit Time (29.8 hours for 430 km)

- Unloading (+2 hours)
- Weight station (+3 hours)
- Police checks (+2 hours)
- Other driver delays (+11 hours)

Total Logistics Costs (9,844 USD)

- 41% Sea Freight Shipping
- 17% Port Handling
- 15% Shipping Lines Charges
- 13% Inland Routing Costs
- 4% Clearing Agent Fees + VAT
- 4% Container Freight Station Charges
- 4% Direct Costs of Delays
- 3% Indirect Costs of Delays

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

- Total
- Developed
- Developing
- Africa
- Asia
- Europe
- South America
- Oceania
## Fixed and Variable Costs and Service in the Transportation System

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

Transport Supply

Transport Demand

A_{ij} 

Modal Supply

Intermodal Supply

T_{ij} 

Realized Demand

Potential Demand
Types of Transportation Demand

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

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

- **Stochastic**
  - Multiple parameters
  - Some unknown effects
  - Probability of demand
### Factors behind Freight Transport Demand

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economy</td>
<td>General derived demand impact. Linked with the GDP. Function of the structure of the economy in terms of resources, goods, and services.</td>
</tr>
<tr>
<td>Industrial location</td>
<td>Effect on ton-kms and on modal choice.</td>
</tr>
<tr>
<td>Spatial Structure</td>
<td>Effect on ton-kms. Function of international trade structure. Containerization and intermodal transportation.</td>
</tr>
<tr>
<td>International Agreements</td>
<td>Both concerning trade and transportation. Economic specialization. Increased transborder traffic. Simplified custom procedures.</td>
</tr>
<tr>
<td>JIT practices and warehousing</td>
<td>Decreased inventories. More shipments. Smaller line hauls. Shift to faster and more reliable modes. Use of 3rd party logistics providers.</td>
</tr>
<tr>
<td>Strategic alliances</td>
<td>Between carriers, shippers and often producers and retailers. Lower distribution costs.</td>
</tr>
<tr>
<td>Packaging and recycling</td>
<td>Increased transportability of products. Lower freight density. Reverse distribution.</td>
</tr>
<tr>
<td>Regulation and deregulation</td>
<td>Increased competition, level of service and lower costs. Growth of intermodal transportation.</td>
</tr>
<tr>
<td>Fuel costs, taxes and subsidies</td>
<td>Large and volatile cost components, specifically for energy intensive modes. Preferred mode or carrier.</td>
</tr>
<tr>
<td>Infrastructure and congestion</td>
<td>Efficiency, operating costs and reliability.</td>
</tr>
<tr>
<td>Safety and environmental policies</td>
<td>Operating speed, conditions and costs. Capacity and weight limits.</td>
</tr>
<tr>
<td>Technology</td>
<td>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.</td>
</tr>
<tr>
<td><strong>Factors behind Freight Transport Demand</strong></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Economy</strong></td>
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<td></td>
</tr>
<tr>
<td><strong>Industrial location</strong></td>
<td></td>
</tr>
<tr>
<td>Effect on ton-kms and modal choice. Outsourcing and offshoring.</td>
<td></td>
</tr>
<tr>
<td><strong>Spatial structure</strong></td>
<td></td>
</tr>
<tr>
<td>Effect on ton-kms. Function of international trade structure. Major hubs, gateways and corridors.</td>
<td></td>
</tr>
<tr>
<td><strong>International agreements</strong></td>
<td></td>
</tr>
<tr>
<td>Concerning trade and transportation. Economic specialization. Increased transborder traffic. Trade facilitation. Simplified custom procedures.</td>
<td></td>
</tr>
<tr>
<td><strong>JIT practices</strong></td>
<td></td>
</tr>
<tr>
<td>Low inventory levels. More shipments. Smaller line hauls. Shift to faster and more reliable modes. Use of 3rd party logistics providers.</td>
<td></td>
</tr>
<tr>
<td><strong>Strategic alliances</strong></td>
<td></td>
</tr>
<tr>
<td>Between carriers, shippers and often producers and retailers. Lower distribution costs.</td>
<td></td>
</tr>
<tr>
<td><strong>Packaging and recycling</strong></td>
<td></td>
</tr>
<tr>
<td>Increased transportability of products. Lower freight density. Reverse distribution.</td>
<td></td>
</tr>
<tr>
<td><strong>Deregulation</strong></td>
<td></td>
</tr>
<tr>
<td>Increased competition, level of service and lower costs. Growth of intermodal transportation.</td>
<td></td>
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<td><strong>Fuel costs and subsidies</strong></td>
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<td>Large and volatile cost components, specifically for energy intensive modes. Preferred mode or carrier.</td>
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<tr>
<td><strong>Infrastructure</strong></td>
<td></td>
</tr>
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<td>Efficiency, operating costs and reliability.</td>
<td></td>
</tr>
<tr>
<td><strong>Safety</strong></td>
<td></td>
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<td>Operating speed, conditions and costs. Capacity and weight limits.</td>
<td></td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td></td>
</tr>
<tr>
<td>Containerization, automation and robotics. Information systems. Lower costs, increased efficiency and reliability and new opportunities.</td>
<td></td>
</tr>
</tbody>
</table>
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

- Static Capacity
- Dynamic Capacity

Optimum nominal capacity

Technical and Managerial Improvement

Facility Expansion
### Major Supply Variables for Transportation Modes

<table>
<thead>
<tr>
<th>Routes</th>
<th>Road</th>
<th>Rail</th>
<th>Air</th>
<th>Maritime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lanes</td>
<td>Tracks</td>
<td>Corridors</td>
<td>Canals</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>Grade</td>
<td>Air control</td>
<td>Locks</td>
<td></td>
</tr>
<tr>
<td>Speed limit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terminals</td>
<td>Parking</td>
<td>Yards</td>
<td>Docks</td>
<td></td>
</tr>
<tr>
<td>Parking</td>
<td>Yards</td>
<td>Runways</td>
<td>Transshipment</td>
<td></td>
</tr>
<tr>
<td>Transshipment</td>
<td></td>
<td>Gates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicles</td>
<td>Speed</td>
<td>Speed</td>
<td>Speed</td>
<td></td>
</tr>
<tr>
<td>Speed</td>
<td>Capacity</td>
<td>Capacity</td>
<td>Capacity</td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Impacts of Modal Competition and Intermodal Capacity on Transport Supply

Modal Competition

\[ C = T(A) + T(B) \]

Intermodal Capacity

\[ T(AB) = C(B) \]
Classic Transport Demand / Supply Function

\[ \text{Elasticity} = \frac{T_2 - T_1}{C_2 - C_1} \]
Transport Supply, Demand and Travel Time

- **Transport Supply (A)**
- **Transport Demand (T)**
- **Morning peak**
- **Afternoon peak**

**Travel time**
- **T>A**
- **T<A**

**Time of the Day**
Rate / Fare / Toll

Remaining capacity

Operating costs

Remaining time before scheduled capacity
Average Fares Disbursed for JFK–LAX Route, 2009 (April to July)

$0
$500
$1,000
$1,500
$2,000
$2,500
$3,000
$3,500
$4,000

0 10,000 20,000 30,000 40,000 50,000 60,000 70,000 80,000 90,000 100,000

Paid Airfare

R² = 0.9435

No elasticity

Low elasticity

High elasticity