

# The Geography of Transport Systems

Jean-Paul Rodrigue

Sixth Edition



# Transportation and the Spatial Structure

## CHAPTER 2

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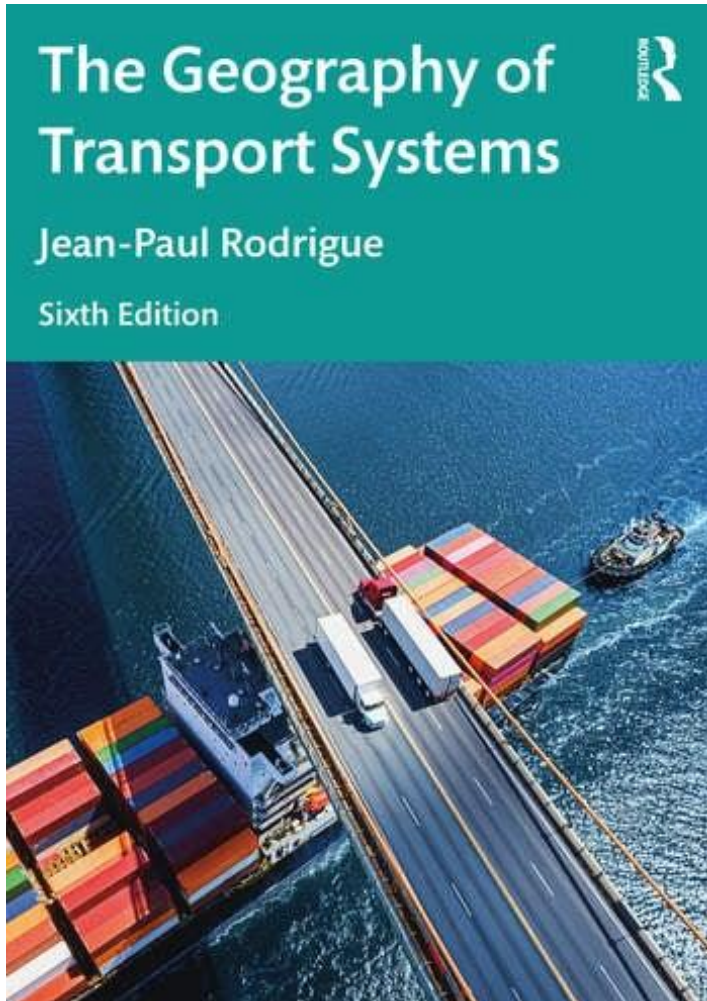
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# The Geography of Transportation Networks

## Chapter 2.1

# Types of Networks and Flows (under construction)

Physical / structural

Continuous / Discontinuous

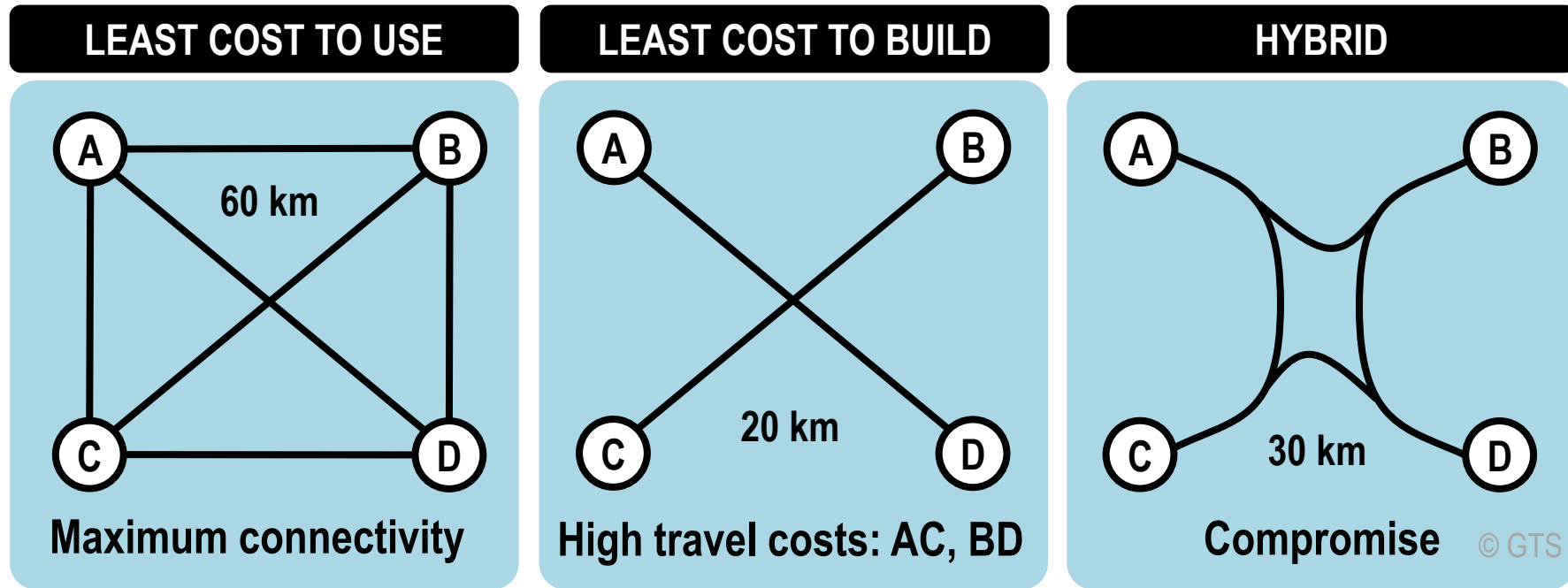
Relational / virtual

Symmetrical / Asymmetrical

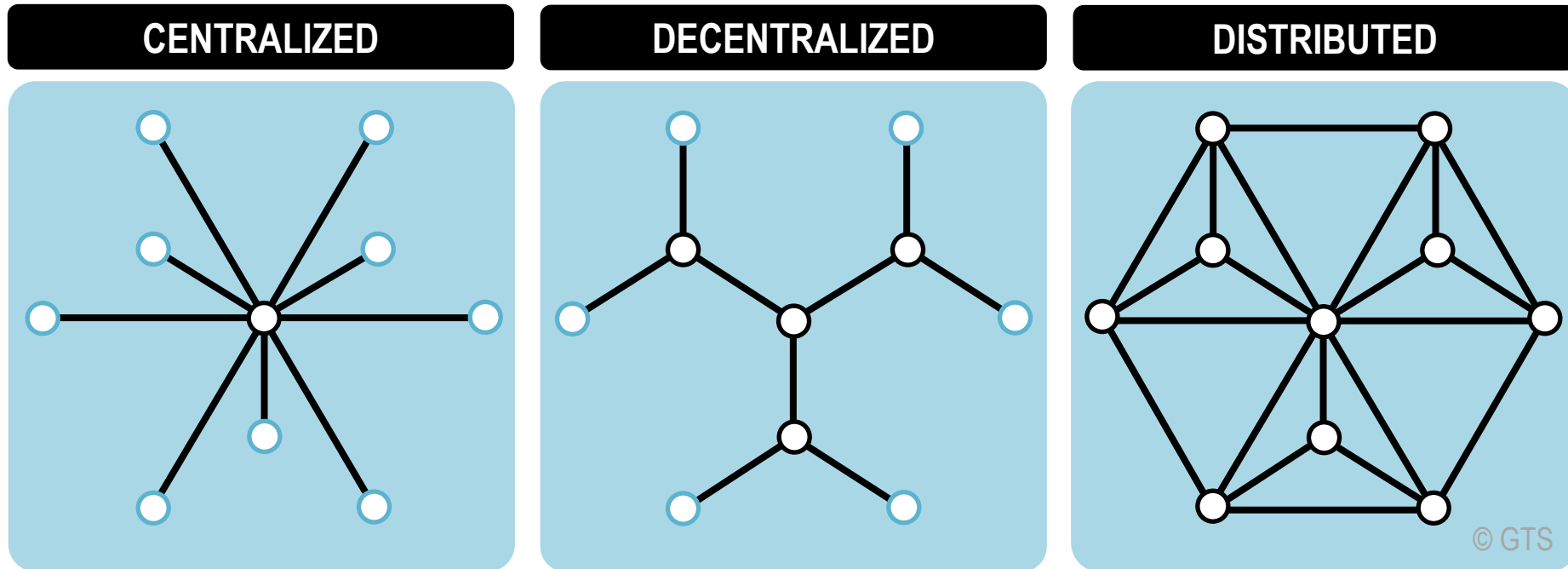
Distribution

Balanced / Imbalanced

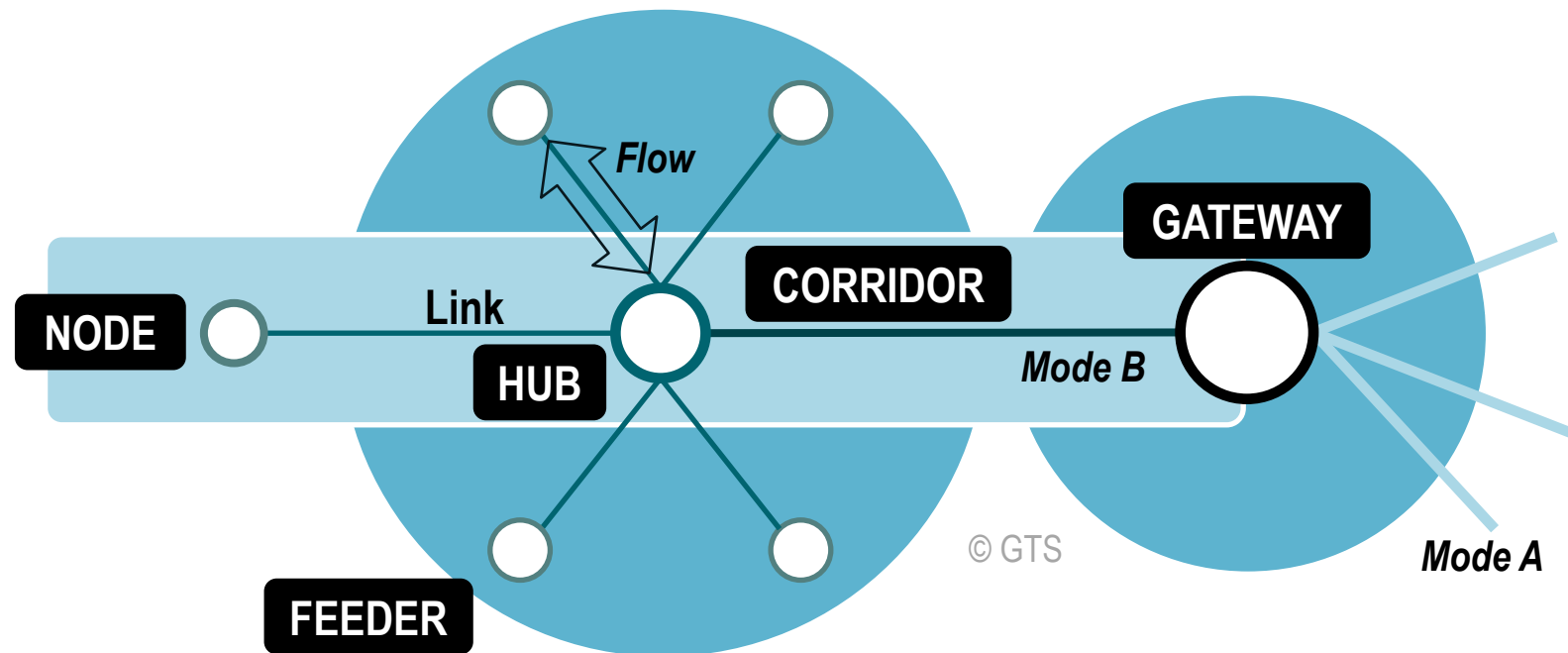
# Network Connectivity Options



# Network Structures

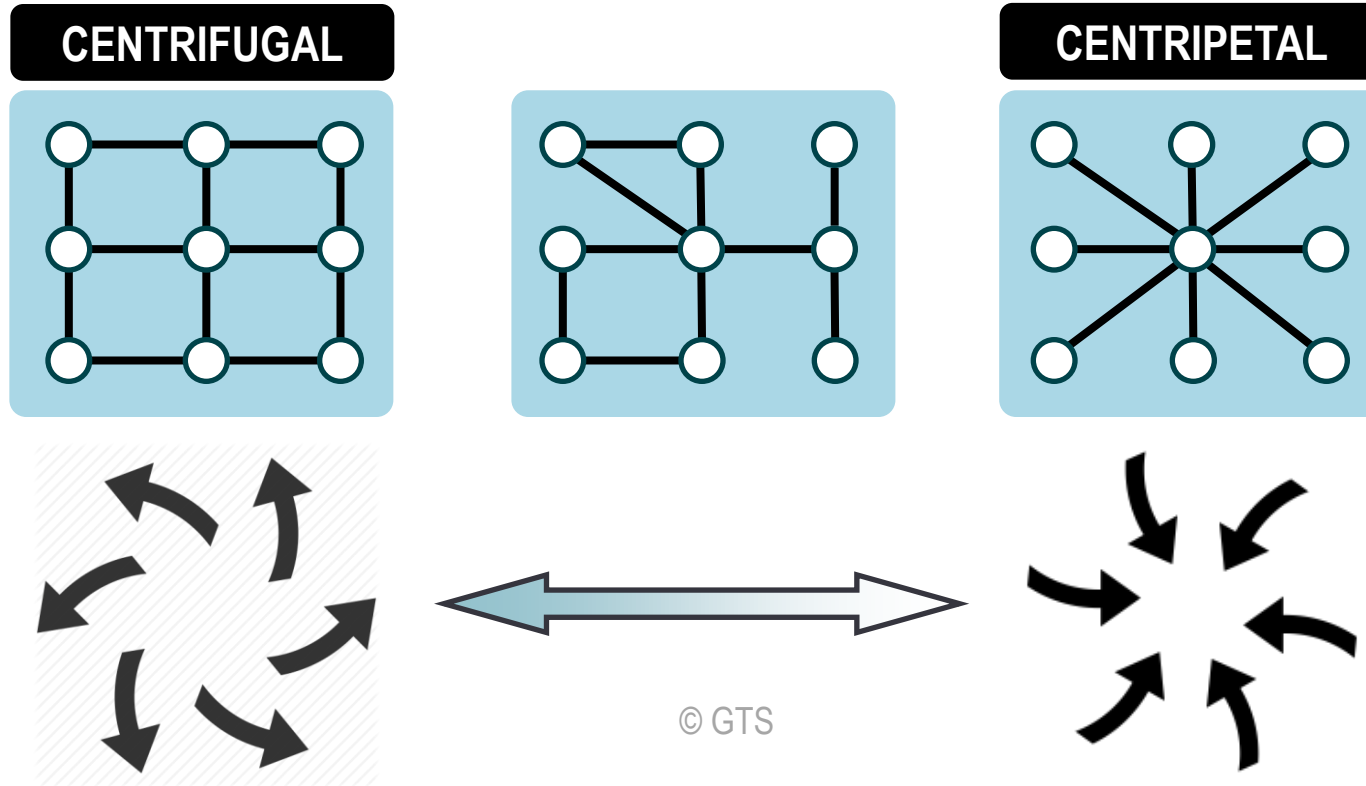


# Structural Components of Transport Networks

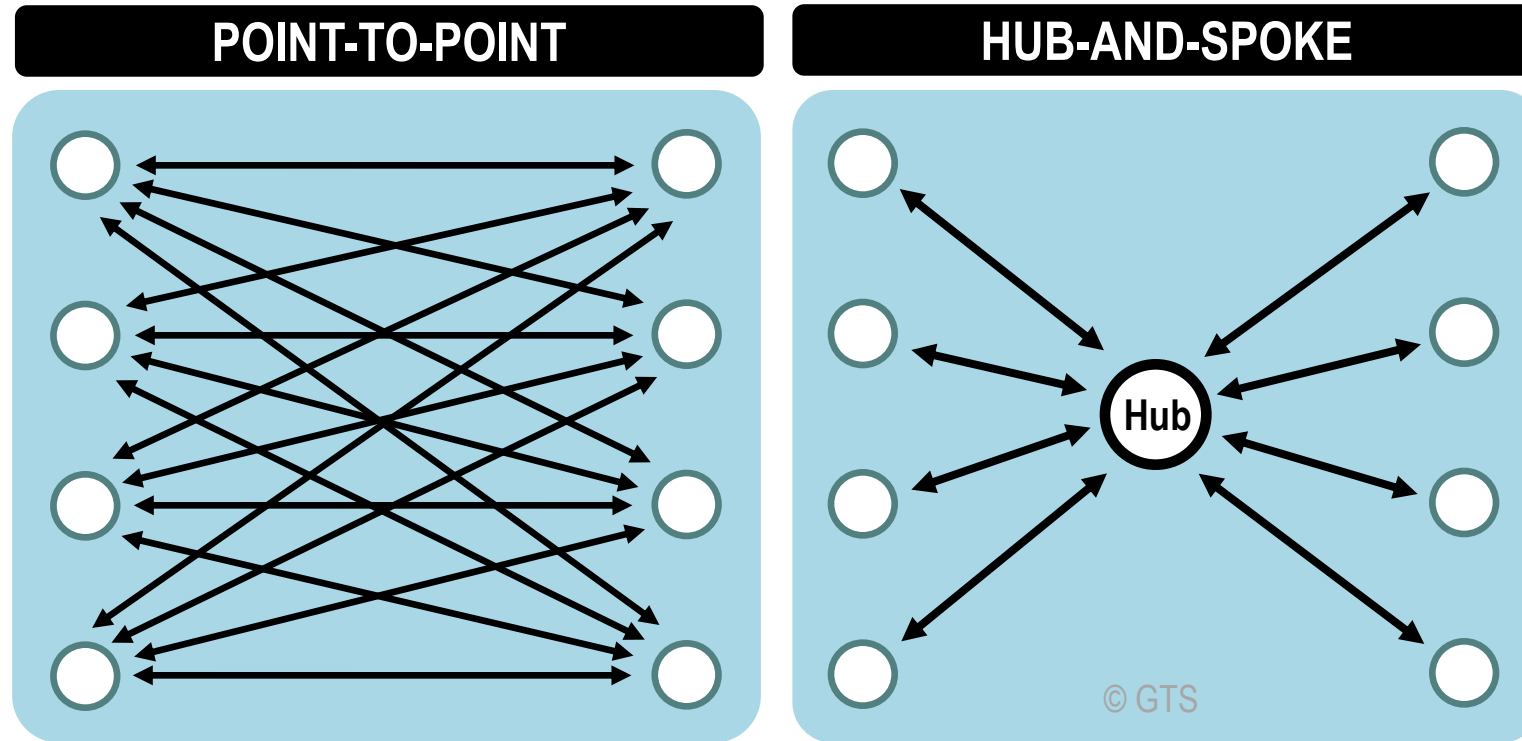




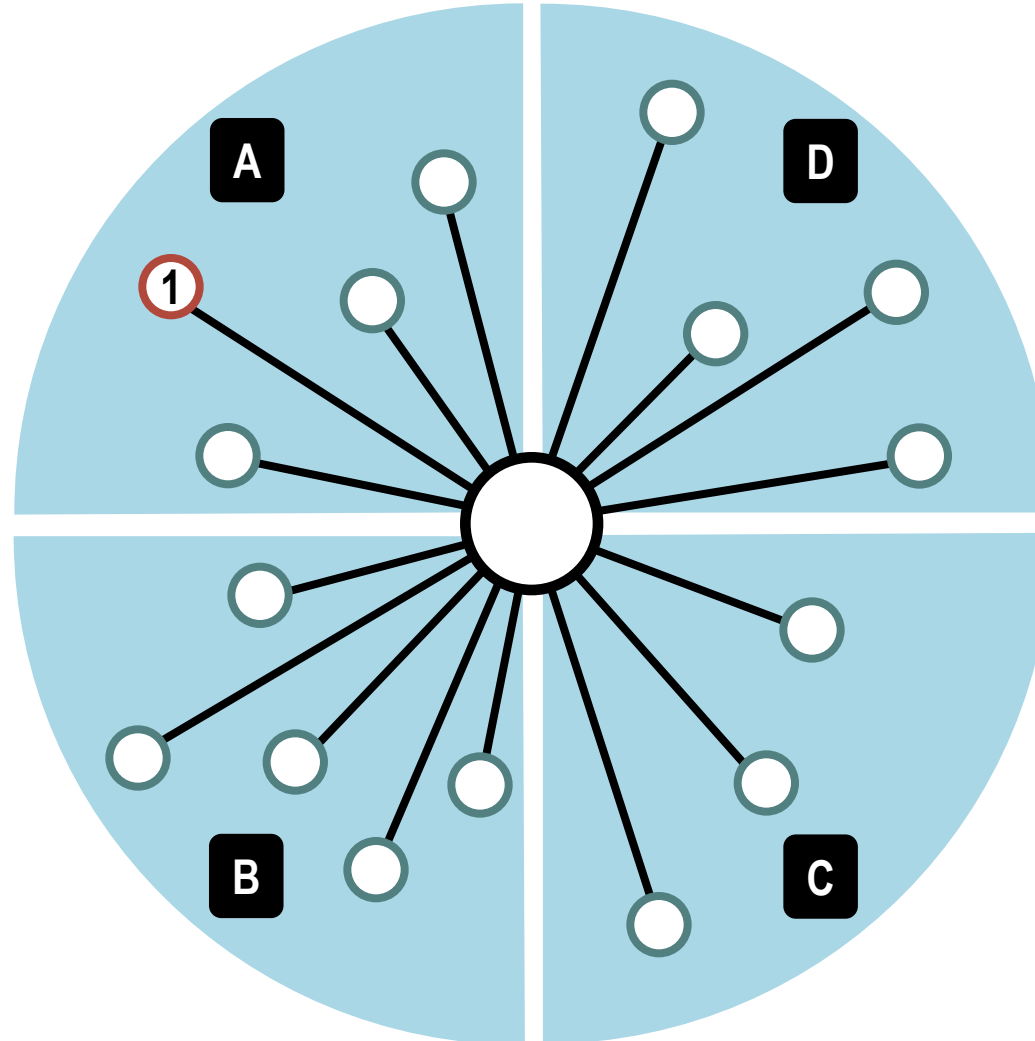
# Centrifugal and Centripetal Networks



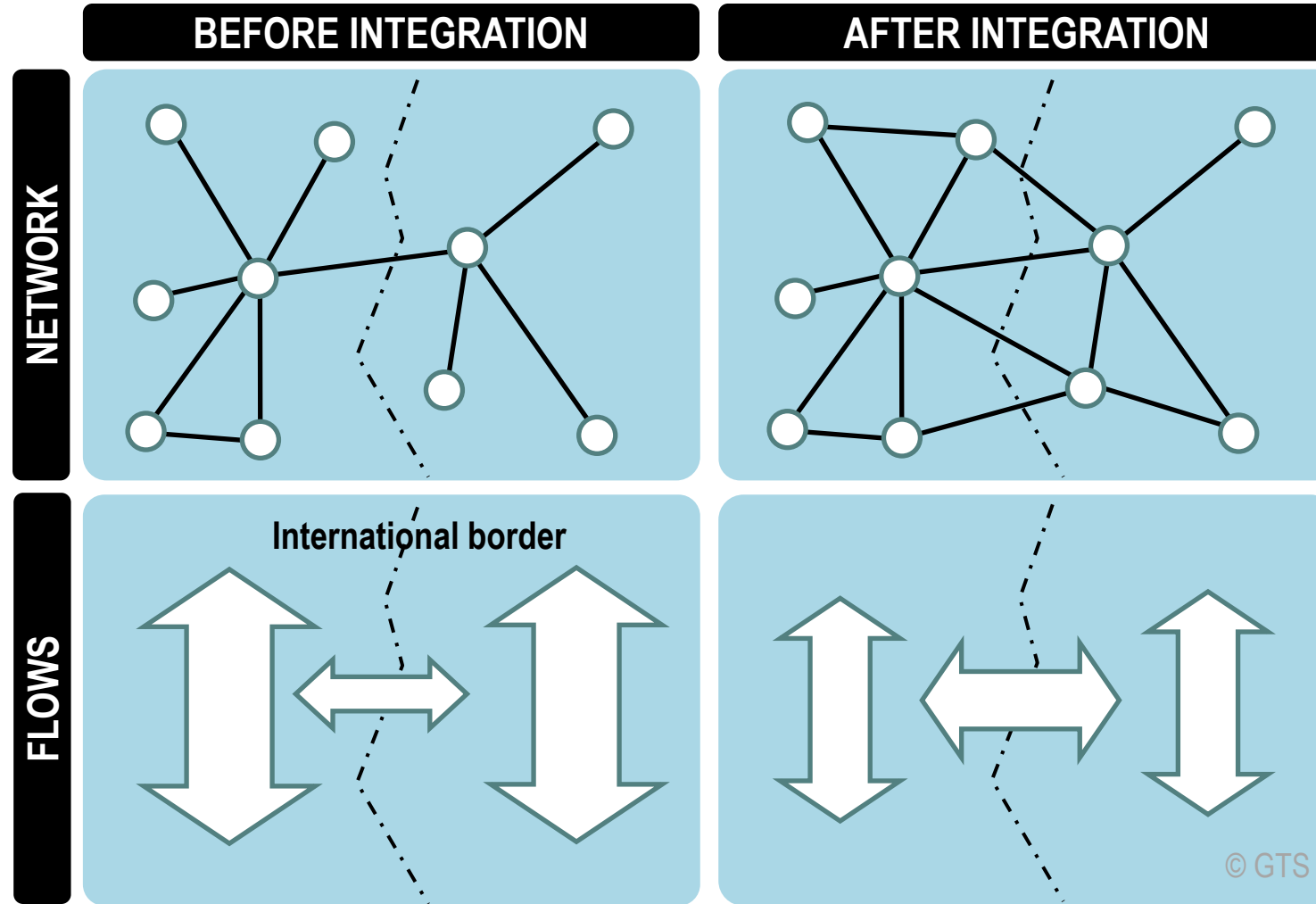
# Point-to-Point and Hub-and-Spoke Networks



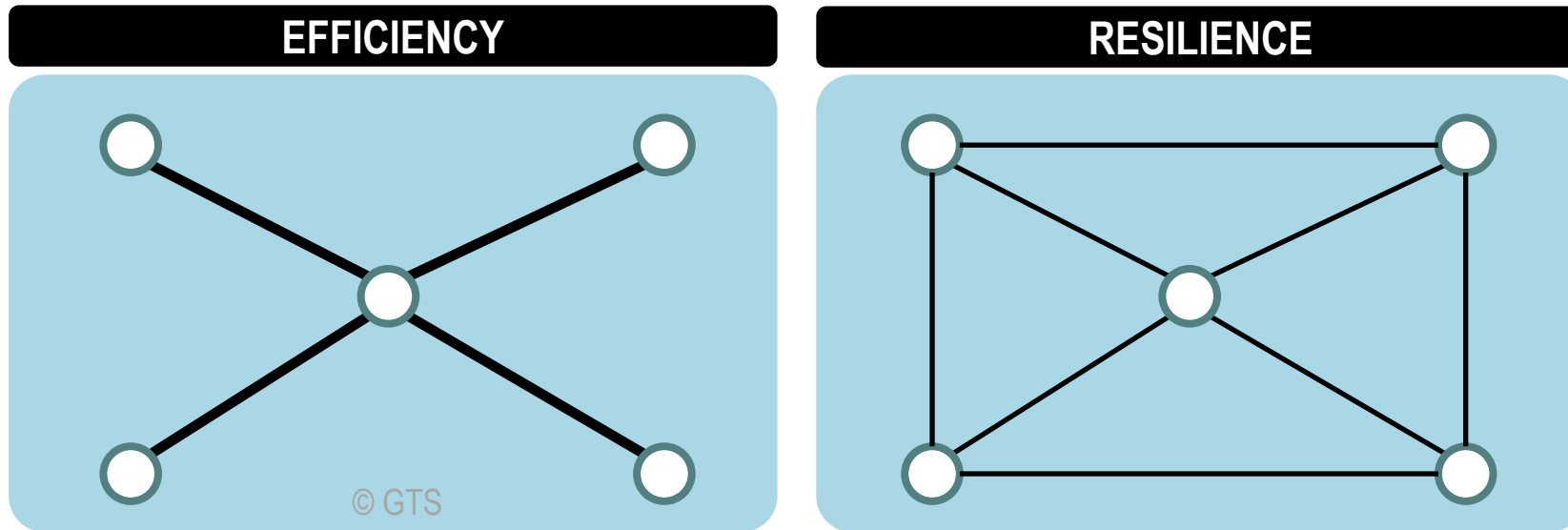
# Detour Level in a Hub-and-Spoke Network



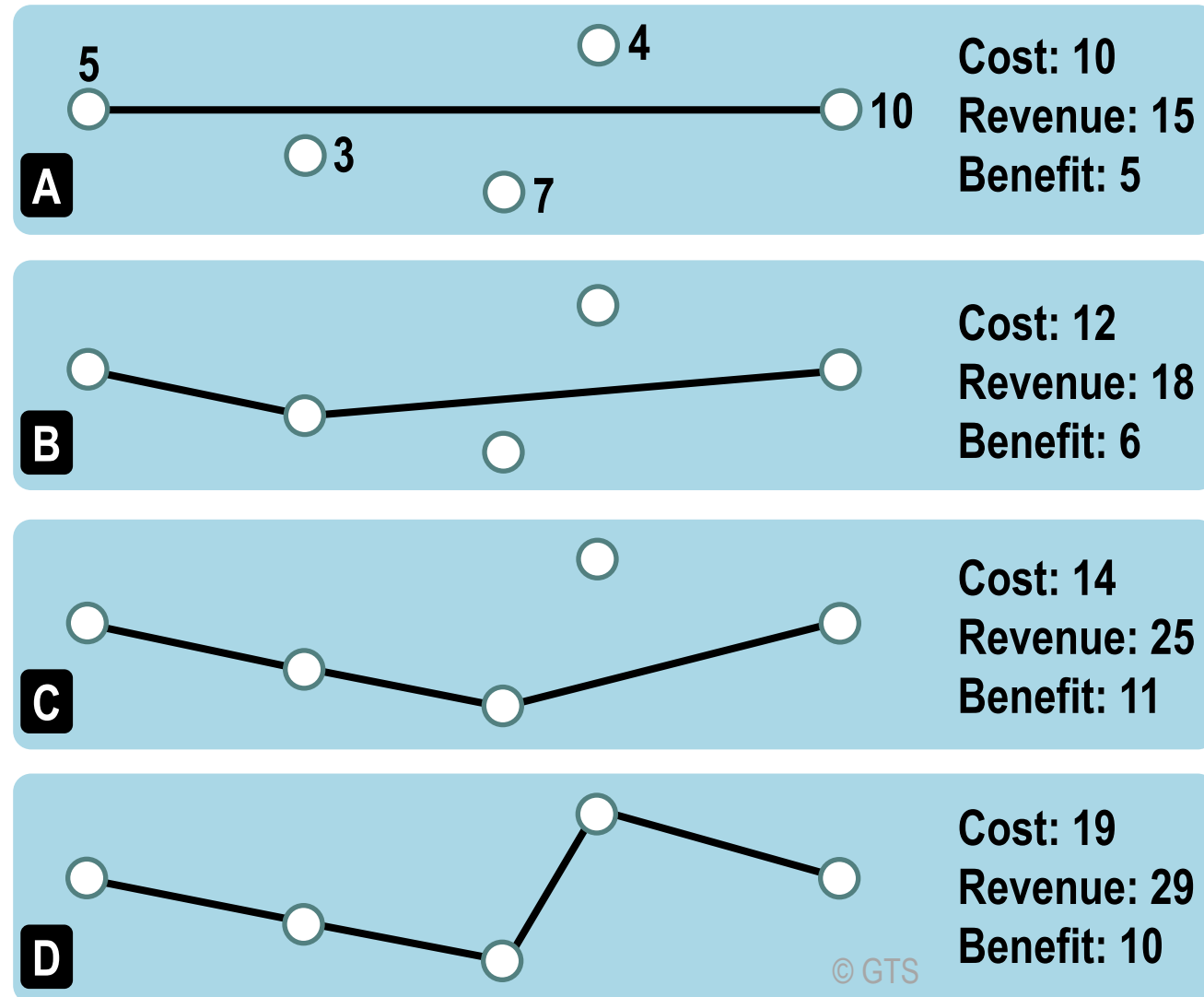
# Impacts of Integration Processes on Networks and Flows



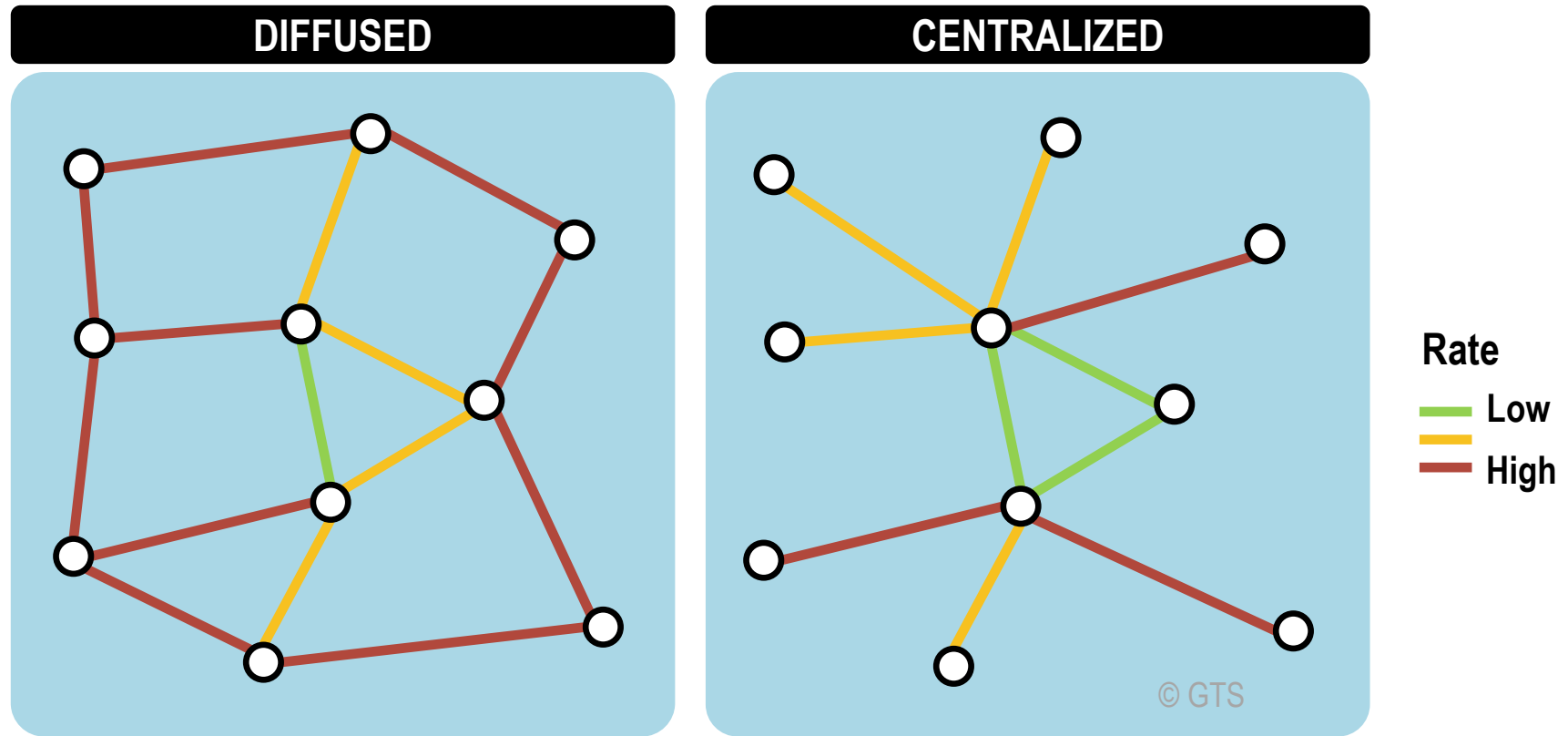
# Transportation Network Efficiency and Resilience



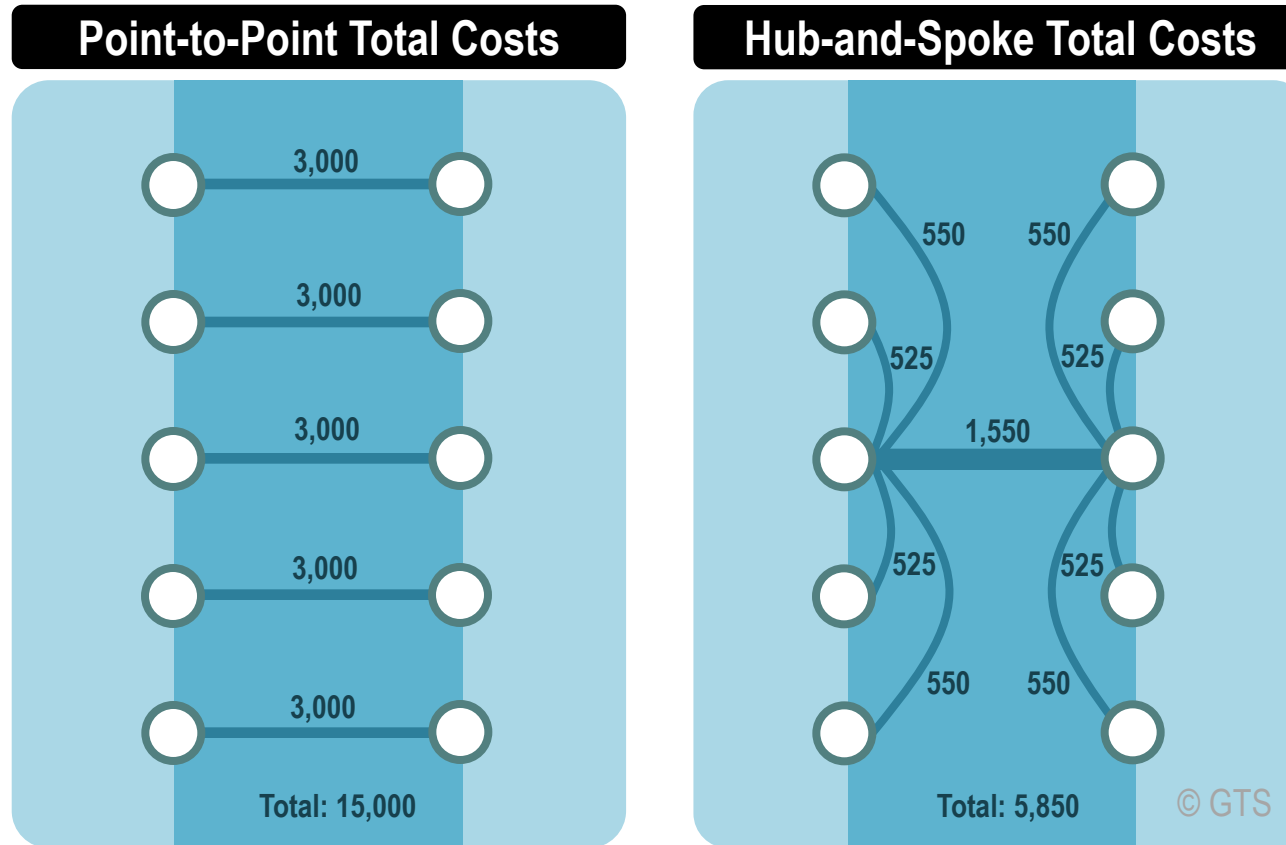
# Cost, Revenue and Level of Network Coverage



# Transport Rates and Network Structure

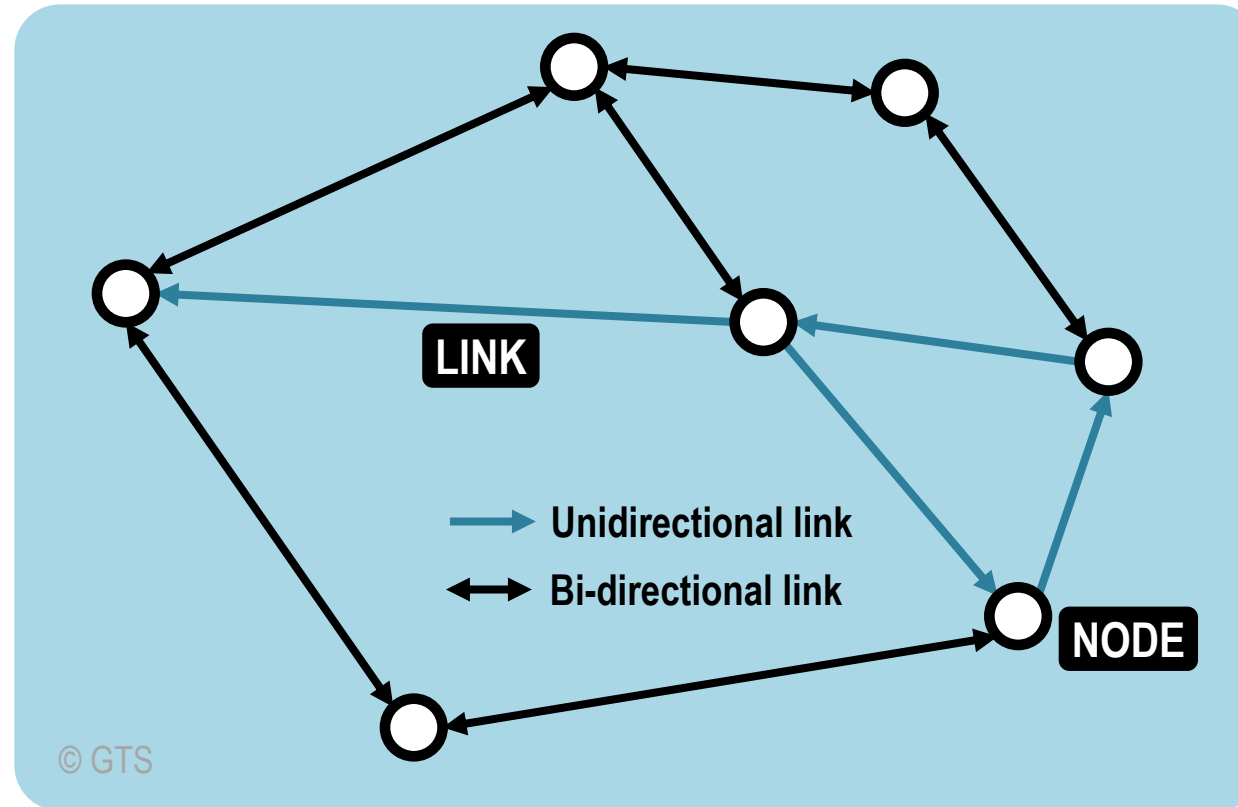


# Cost Structure of Point-to-Point and Hub-and-Spoke Networks



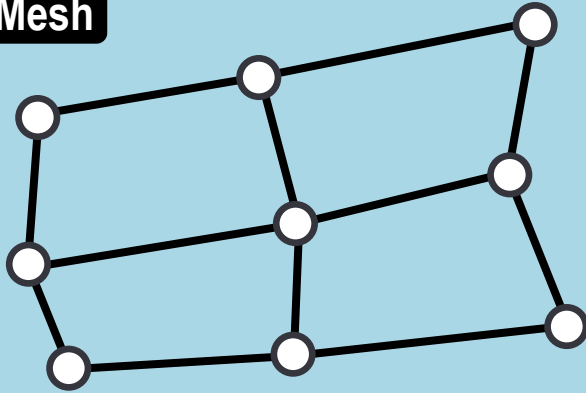


# Topology of a Network

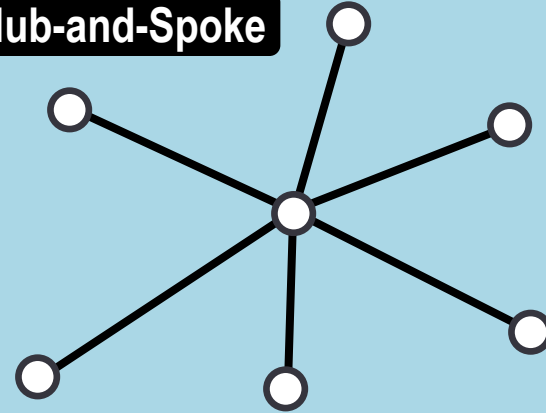


# Network Topologies

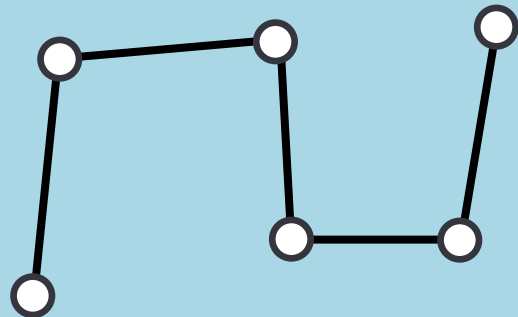
**Mesh**



**Hub-and-Spoke**

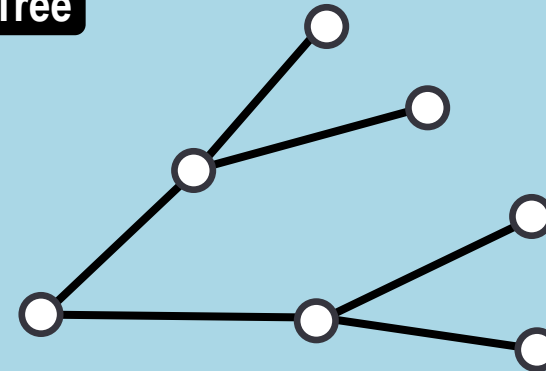


**Linear**



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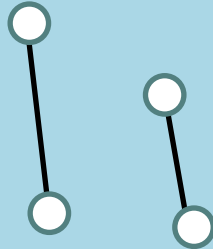
**Tree**



# Network Geometry and Number of Links

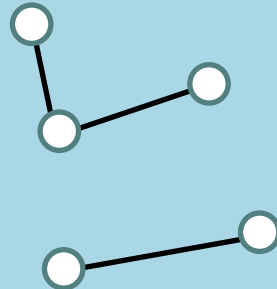
**For each node to be linked to another node**

*Even number of nodes*



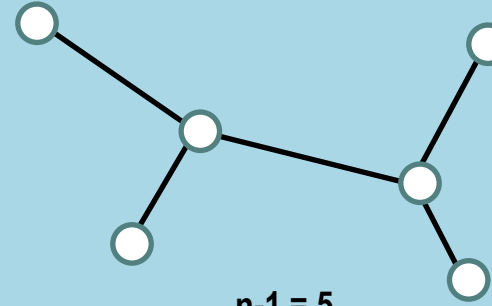
$$n/2 = 2$$

*Odd number of nodes*



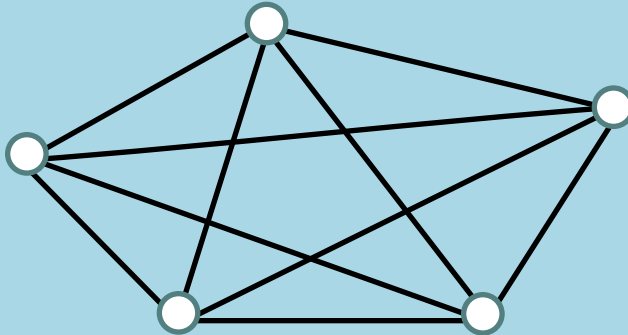
$$(n+1)/2 = 3$$

**For all the nodes to be linked together**



$$n-1 = 5$$

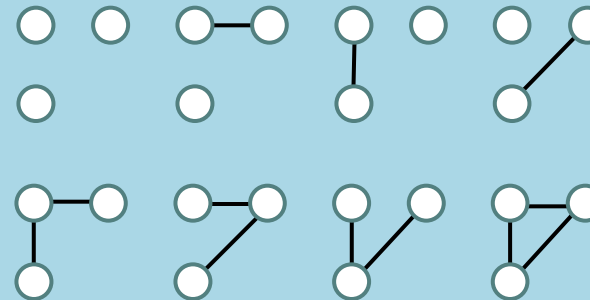
**For each node to be linked to all other nodes**



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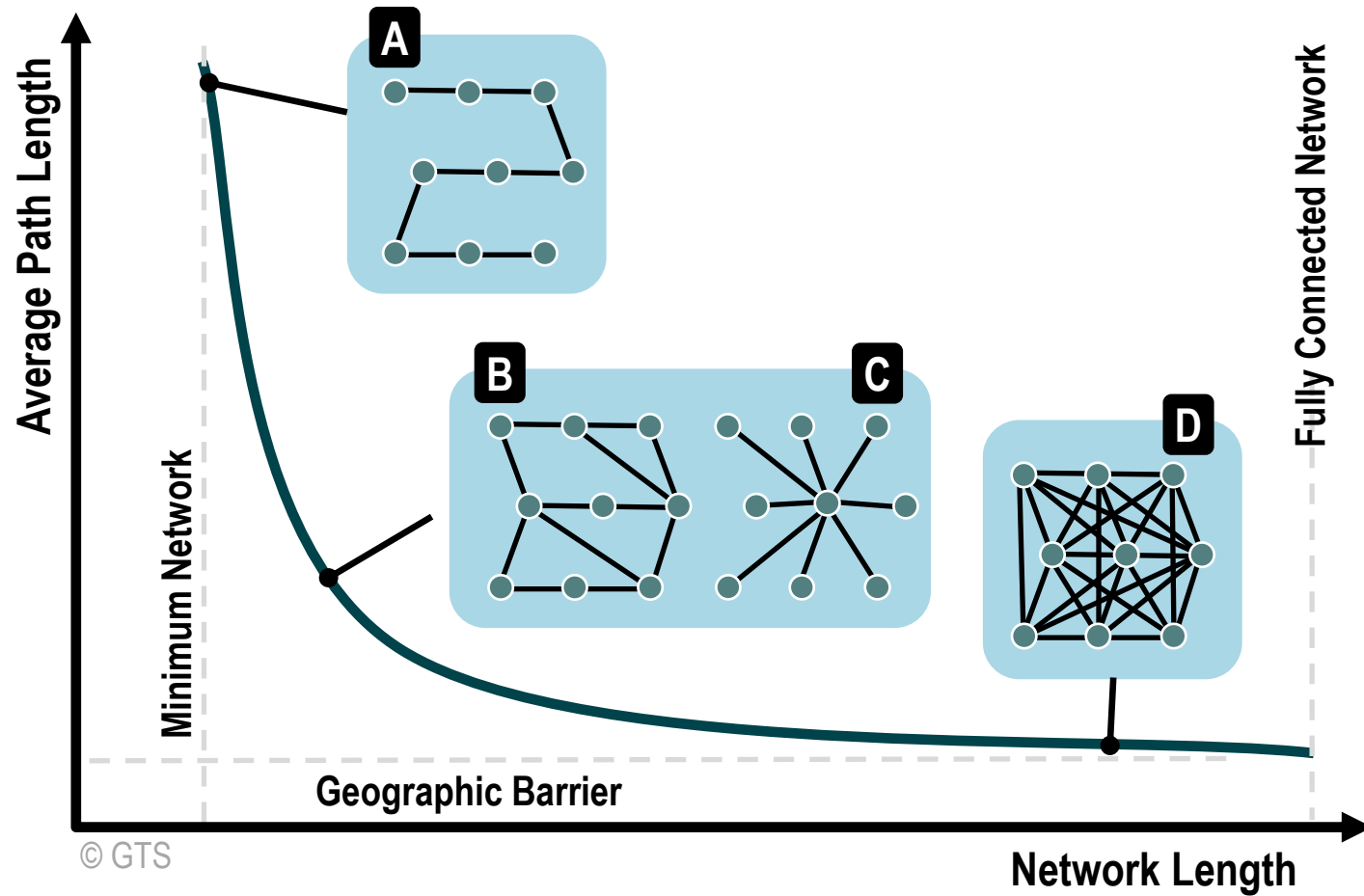
$$n(n-1)/2 = 10$$

**Number of possible combinations**

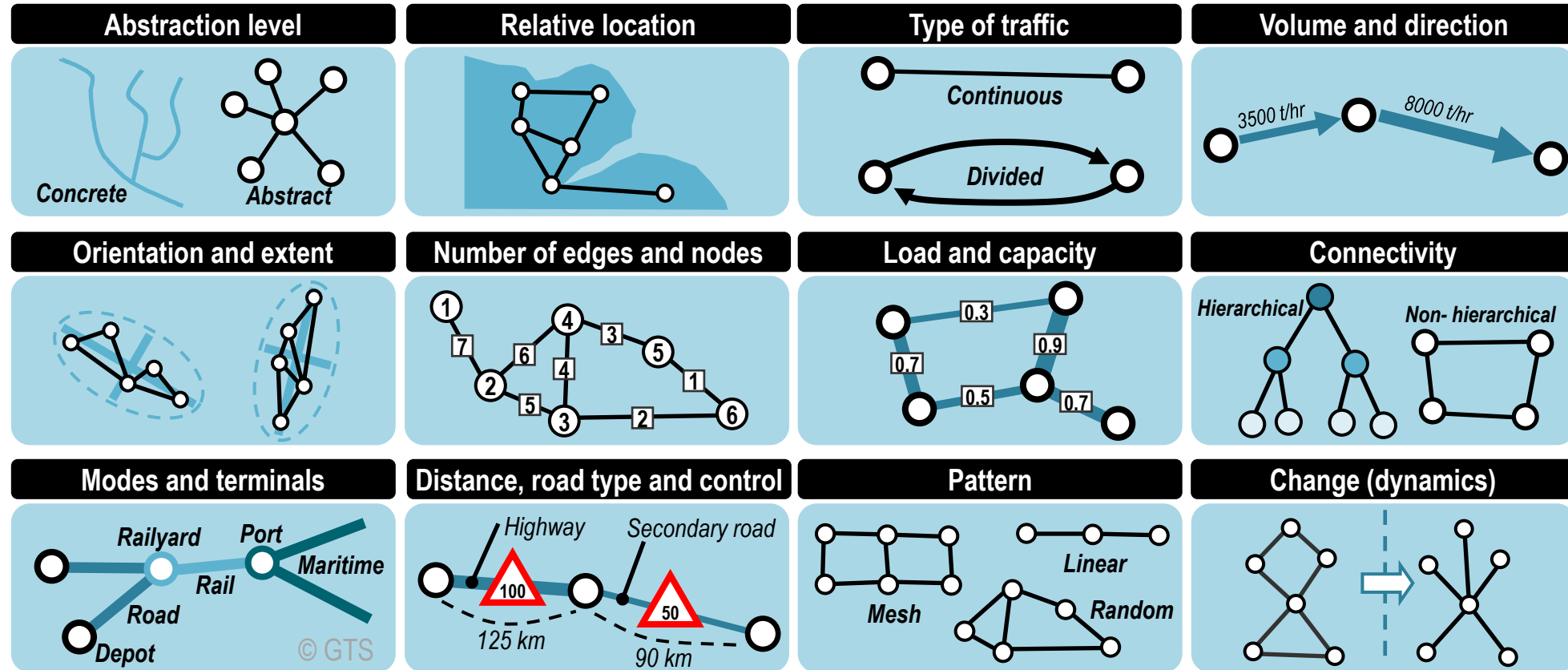


$$2^{n(n-1)/2} = 8$$

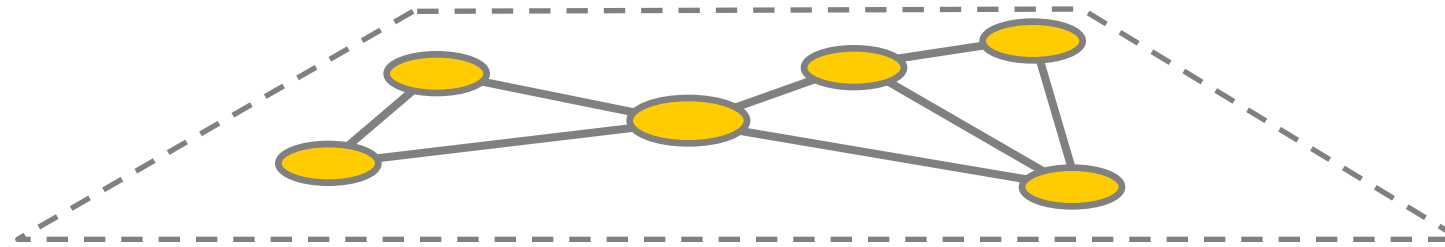
# Topology and Network Connectivity



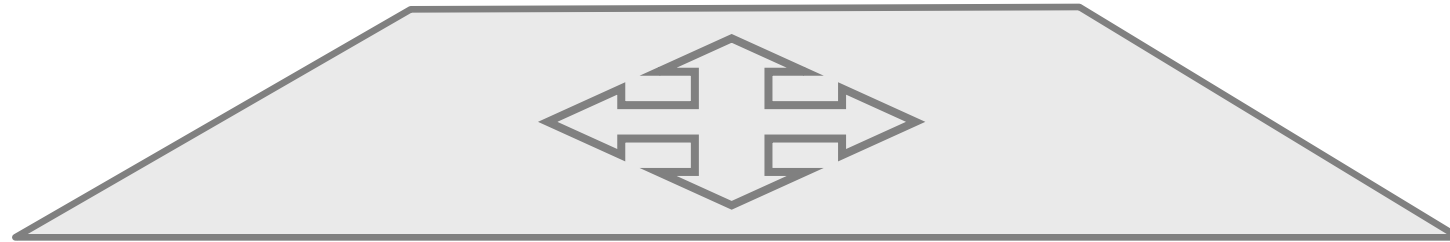
# Typology of Transportation Networks



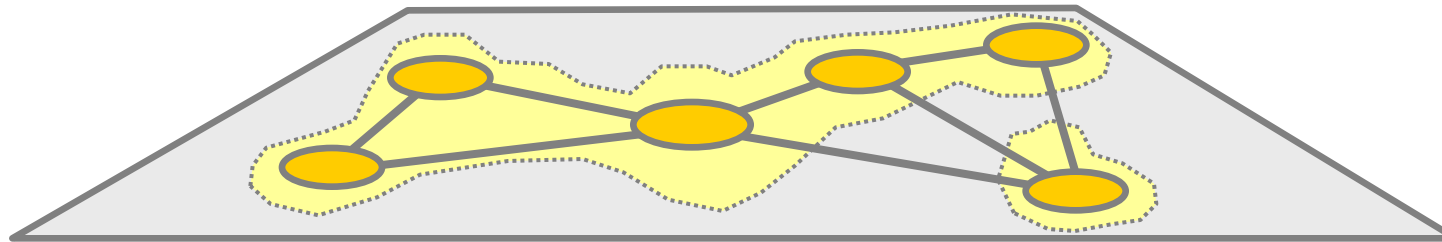
# Transport Networks and Space (to be updated)



**Transport Network**

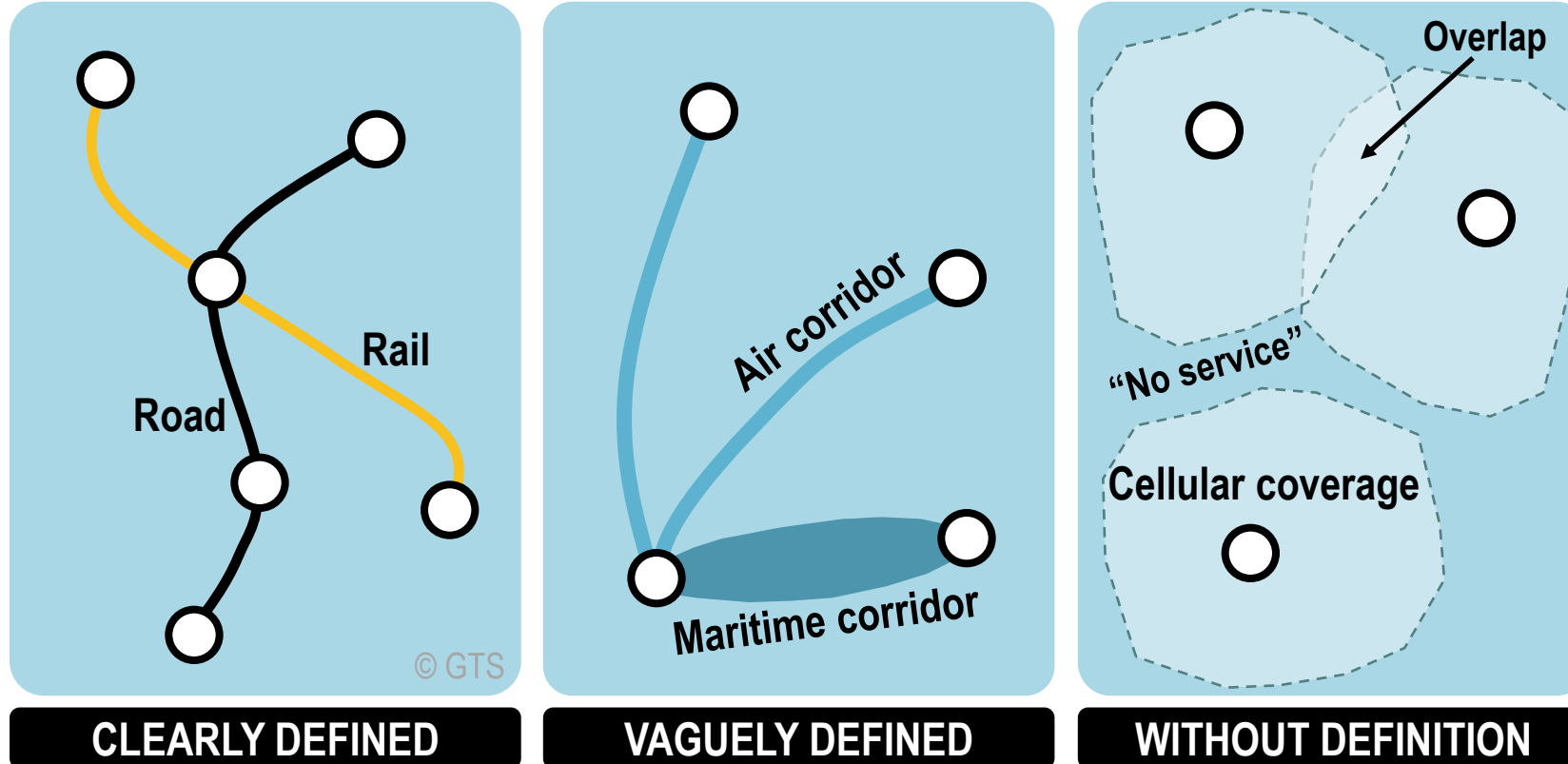


**Space**

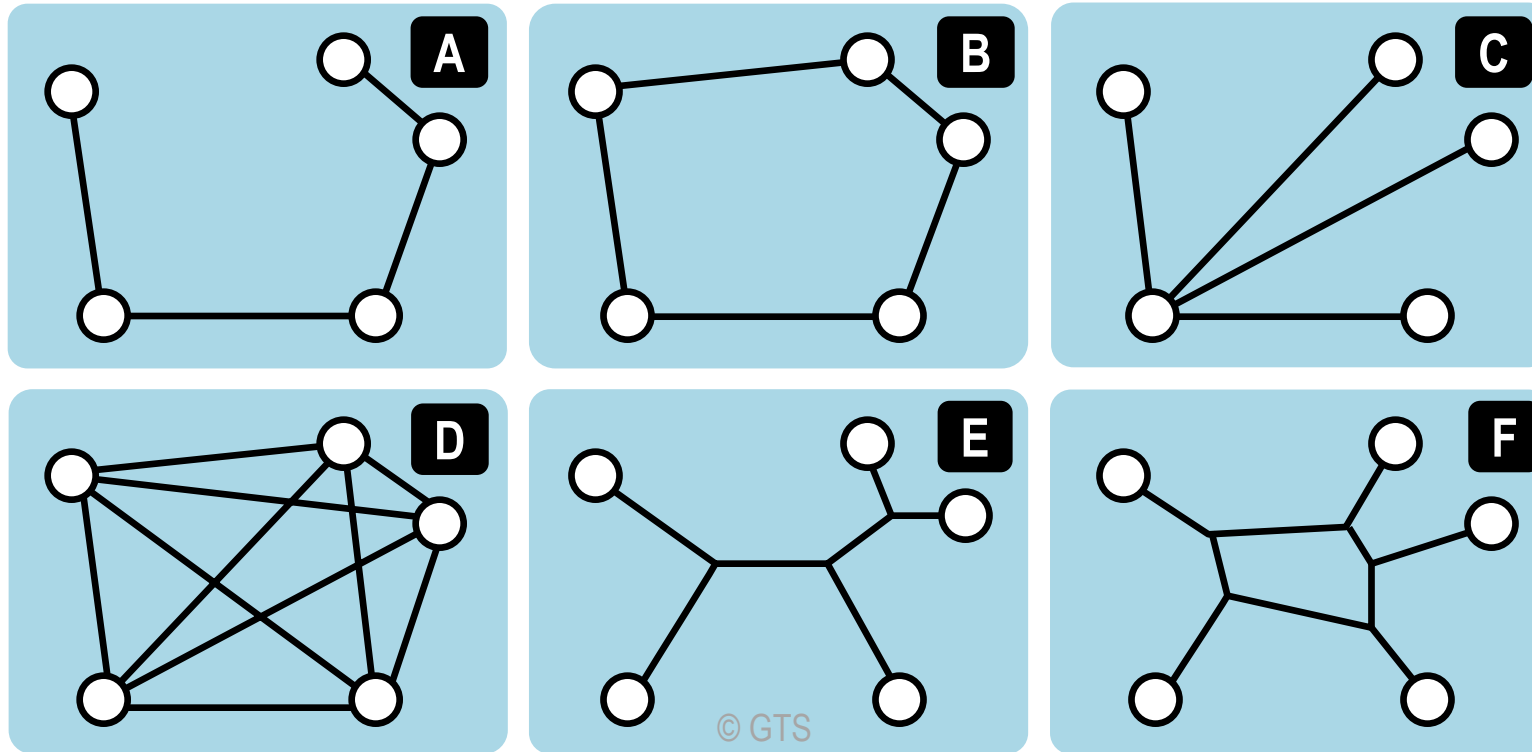


**Accessibility**

# Mode of Territorial Occupation by Transport Networks

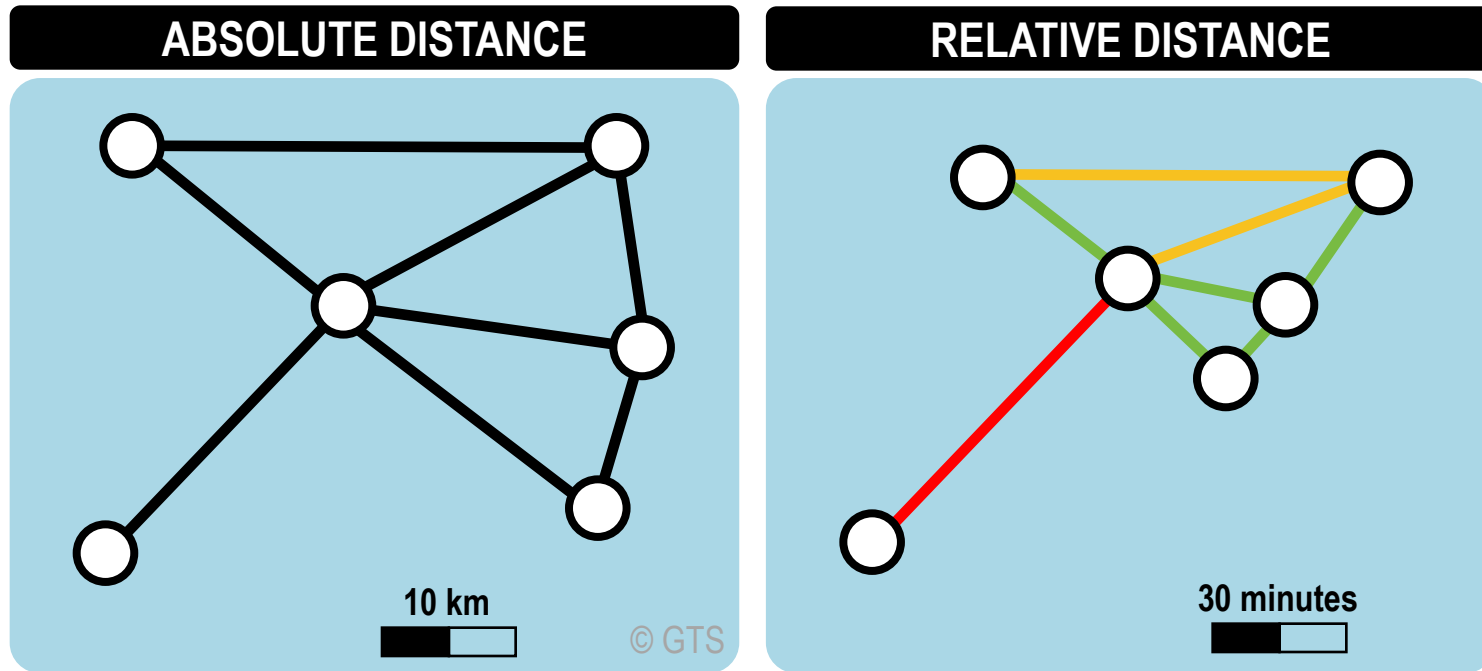


# Network Strategies to Service a Set of Locations

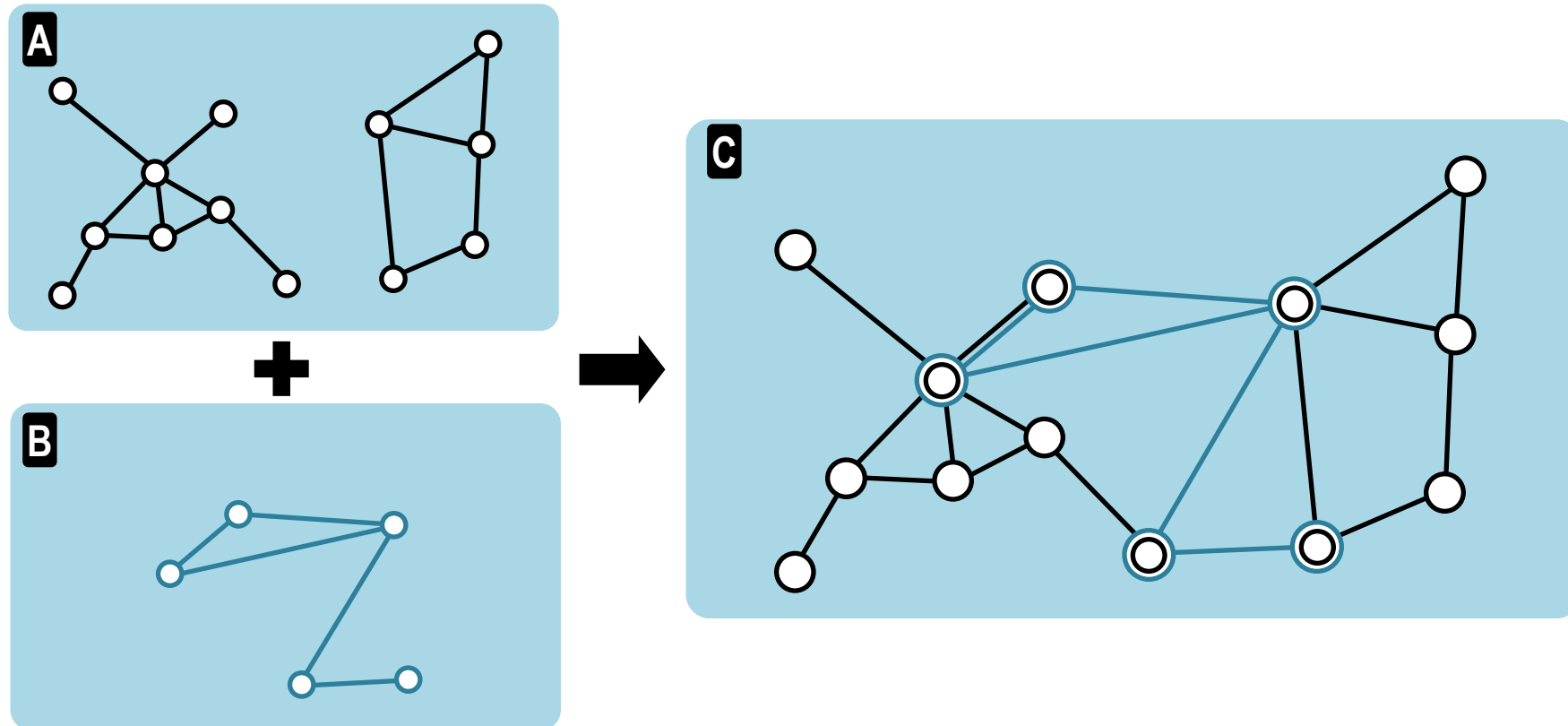




# Absolute and Relative Distance in a Network



# Networks and Spatial Continuity

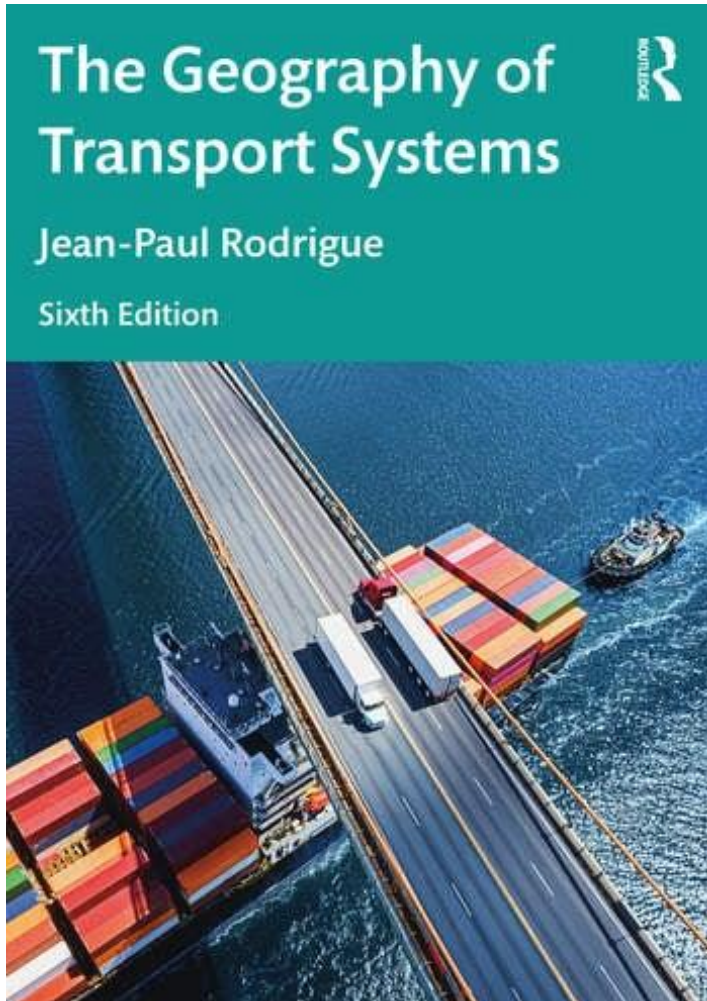


# Spatial Continuity by Transportation Mode

|                      | Ubiquity                                | Fractionalization                                   | Instantaneity                                    |
|----------------------|---|---|--|
| <b>Automobile</b>    | High (road coverage the most extensive) | None (1 passenger = 1 movement)                     | High (available on demand)                       |
| <b>Transit</b>       | Average (within metropolitan areas)     | Average (bus loads or train loads)                  | Average to high (fixed high frequency schedules) |
| <b>Air transport</b> | Limited to airports (common)            | Average (plane loads from 50 to 500 passengers)     | Average (fixed schedules and connections)        |
| <b>Maritime</b>      | Limited to ports (rare)                 | High (ship loads, reinforced by economies of scale) | Low (fixed schedules and connections)            |
| <b>Rail</b>          | Limited to rail terminals (common)      | Average (train loads)                               | Average (fixed schedule)                         |
| <b>Pipeline</b>      | Limited to network                      | Low (continuous flow)                               | High (continuous flow)                           |

# Networks as Tools of Spatial Cohesion (Control)

| Period                   | Emerging Network          | Outcome   |
|--------------------------|---------------------------|---|
| Pre-colonial             | Fluvial, coastal and road | Empire building                                 |
| Colonial Era             | Maritime                  | Exploration, trade, and political control       |
| 19 <sup>th</sup> Century | Canal and rail            | Nation building, commerce and political control |
| 20 <sup>th</sup> Century | Highways and air          | National and transnational integration          |
| 21 <sup>st</sup> Century | Telecommunication         | Global supply chains                            |



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# Transport and Spatial Organization

## Chapter 2.2

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# Transportation Infrastructures and their Constraints



## Physical and Environmental

- Conventional physical constraints impacting transport infrastructure.
- Climate constraints and weather disruptions.



## Demand

- Transport infrastructure designed to meet a specific demand level.
- Variations in the demand and accidents can create bottlenecks.



## Financing

- Transportation infrastructure is capital intensive.
- Securing financing can constrain infrastructure development.



## Construction and Maintenance

- Construction and maintenance of infrastructure create disruptions in existing operations.

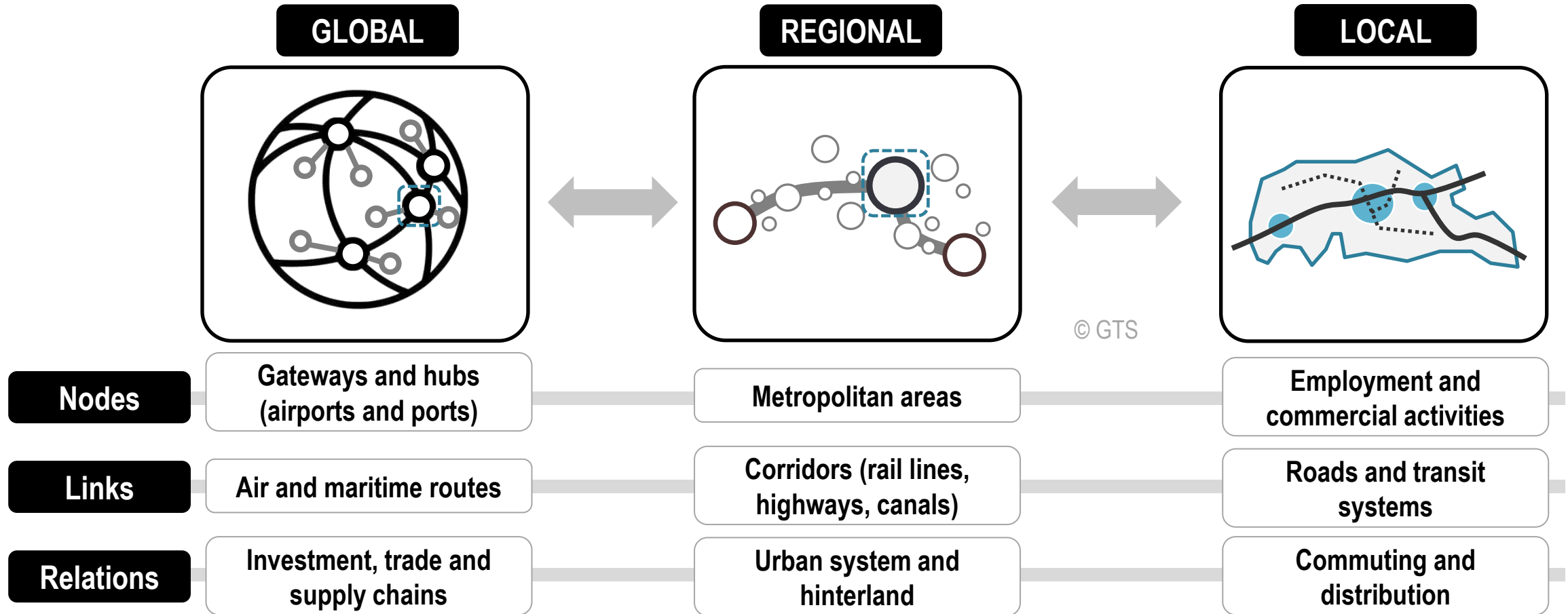


## Regulations

- Restrictions about how transport infrastructure can be developed, owned and operated.
- Pressures from advocacy groups.

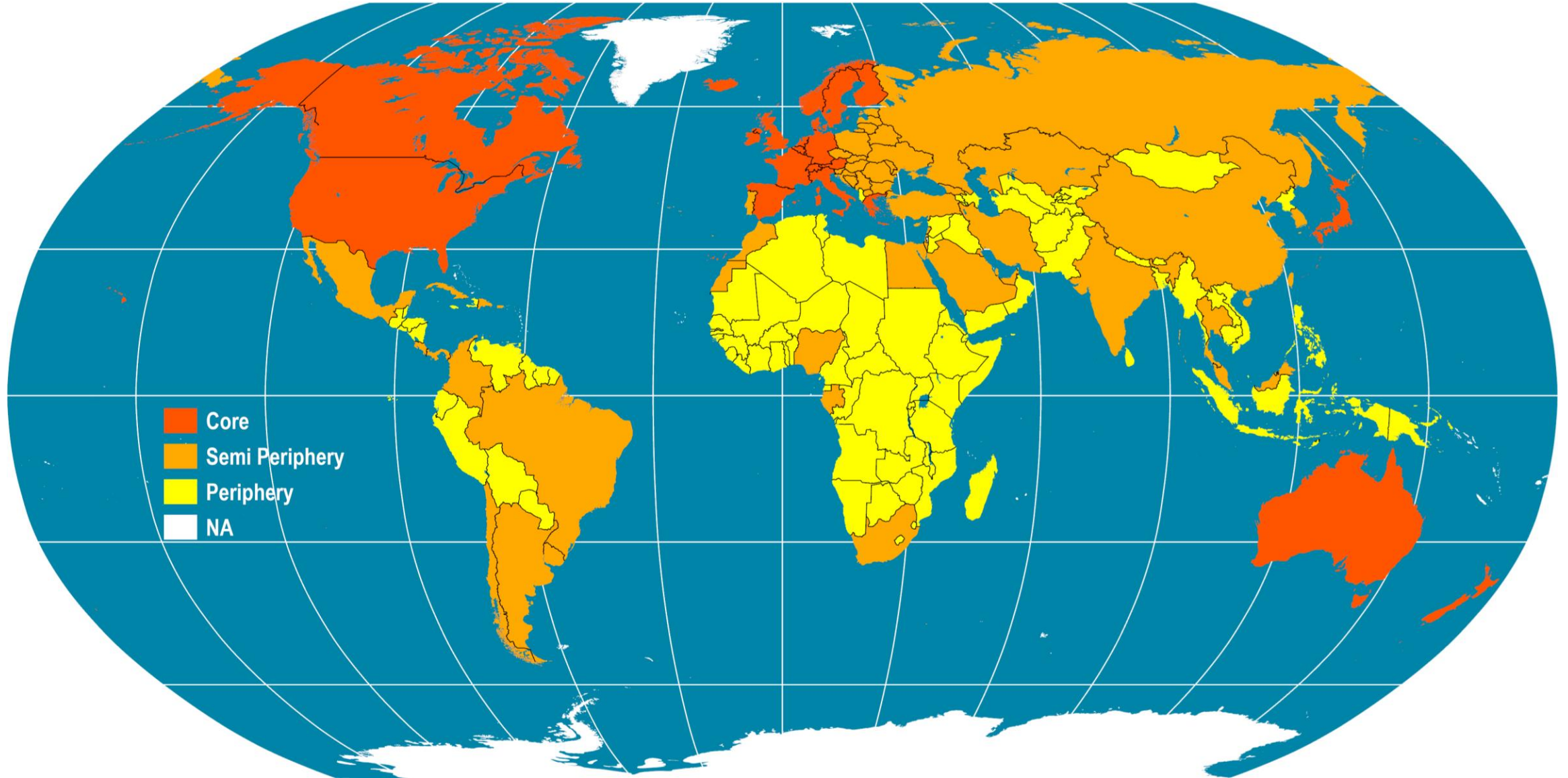
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# Scales of Spatial Organization for Transportation



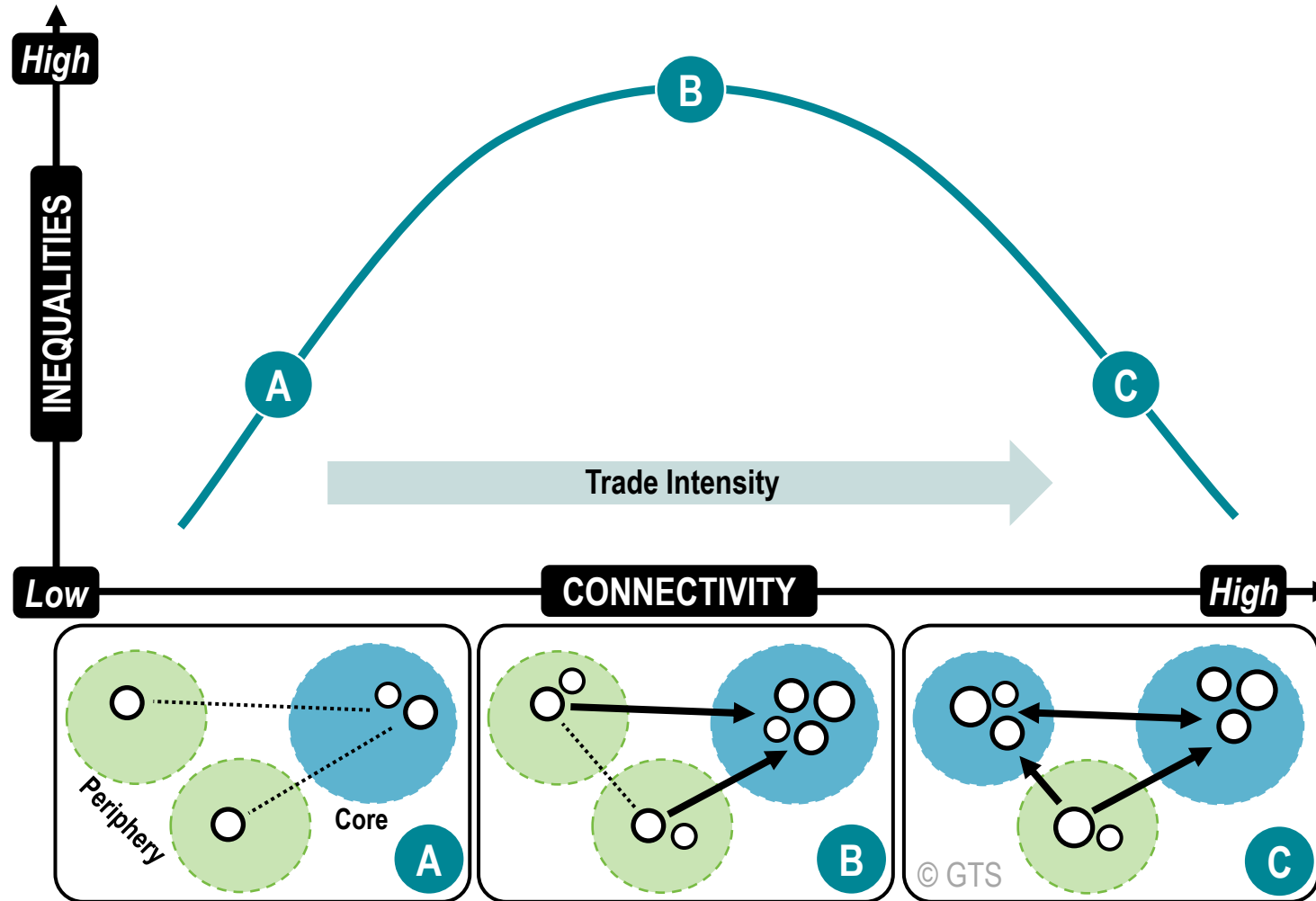


# Core / Periphery Division of the World

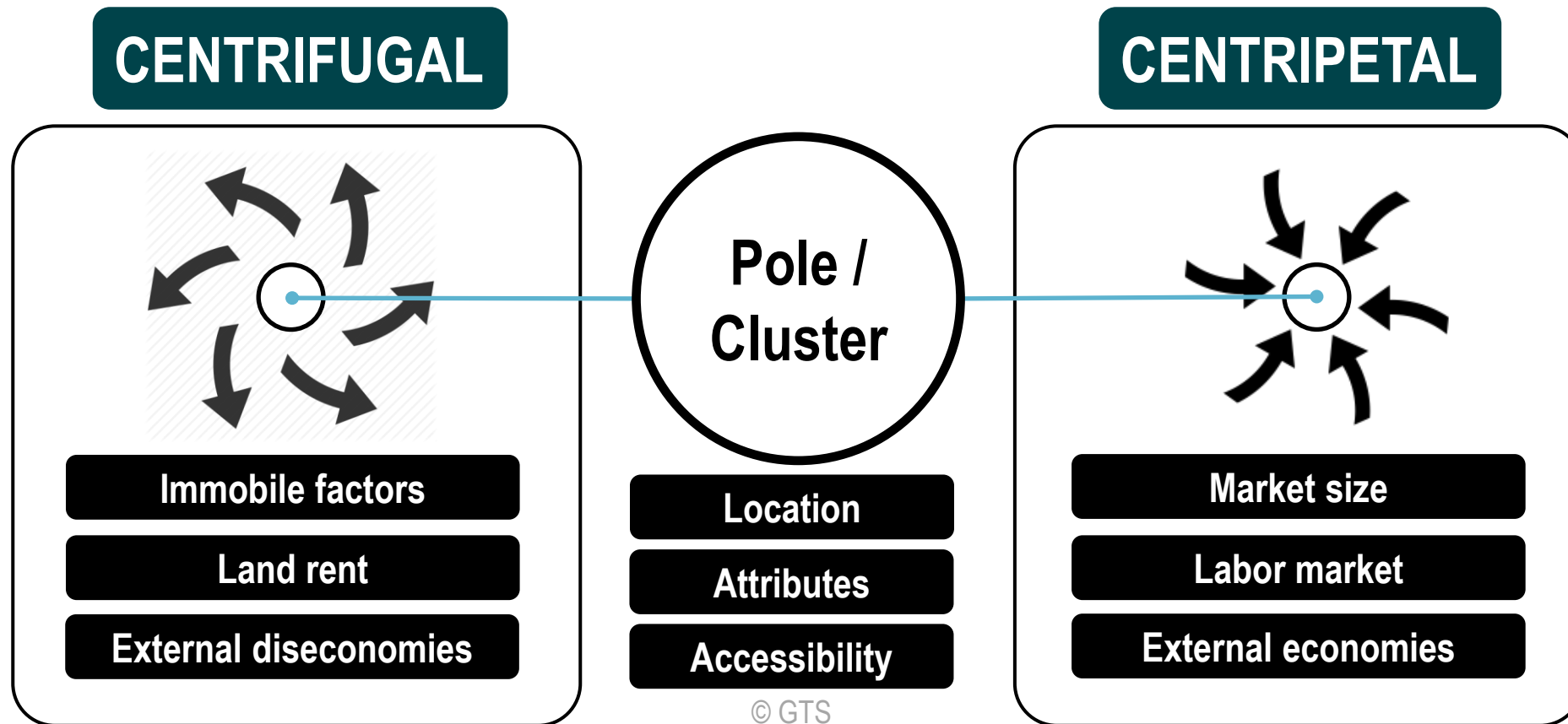




# Trade, Connectivity and Spatial Inequalities



# Forces of Geographical Concentration and Dispersion



# Factors of Polarization (under construction)

**Network**

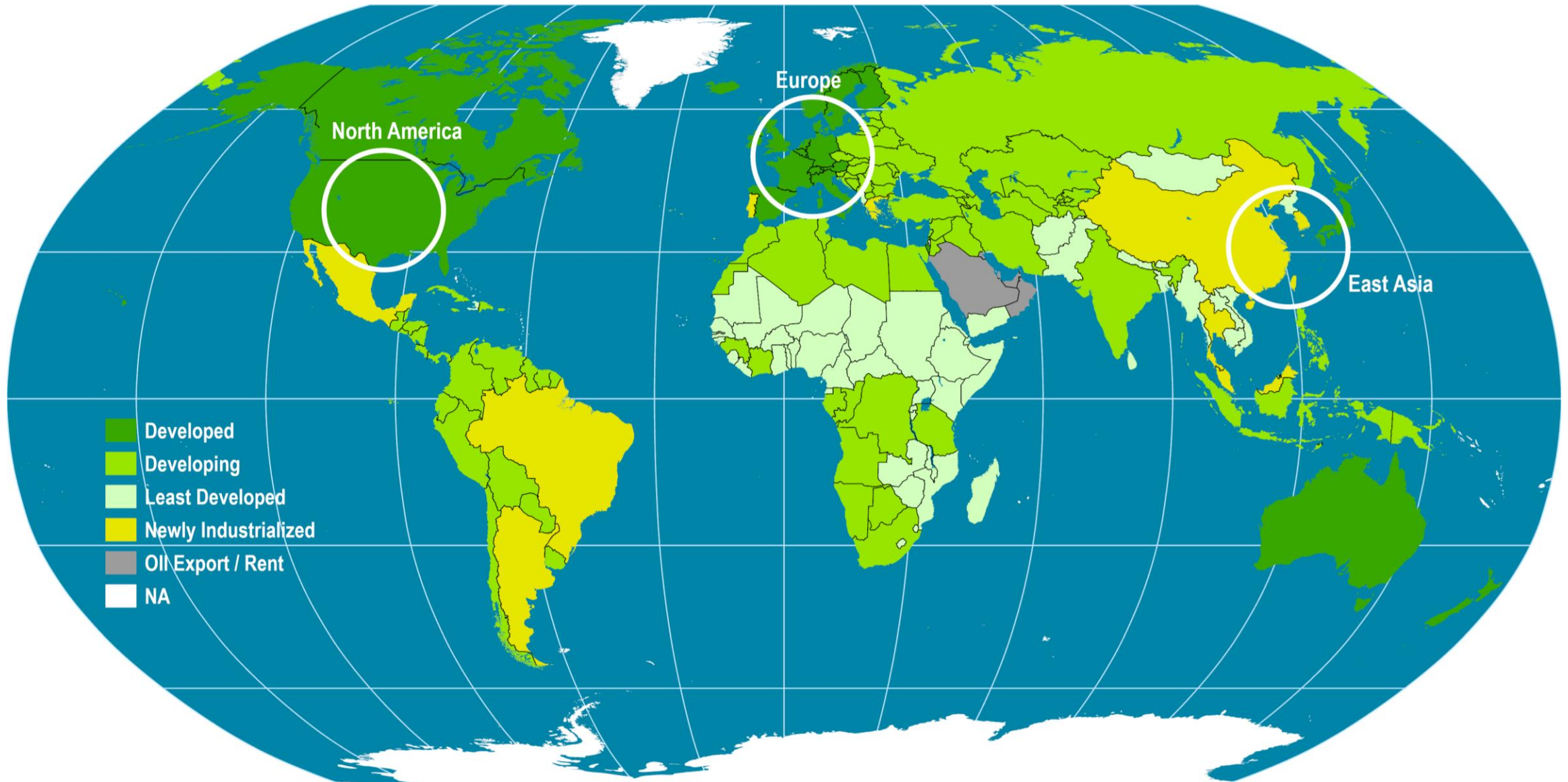
**Load break**

**Competition**

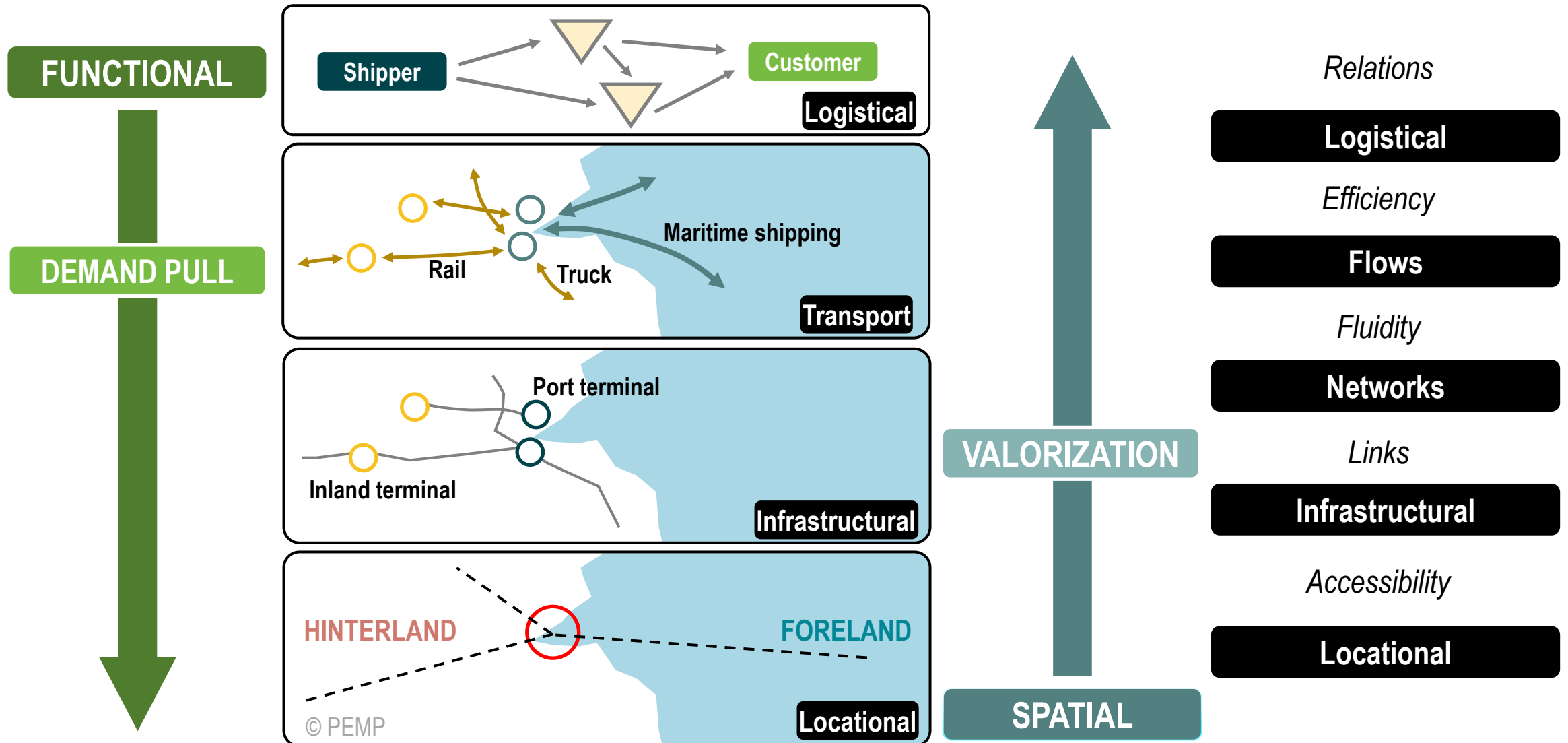
**Services**

**Agglomeration economies**

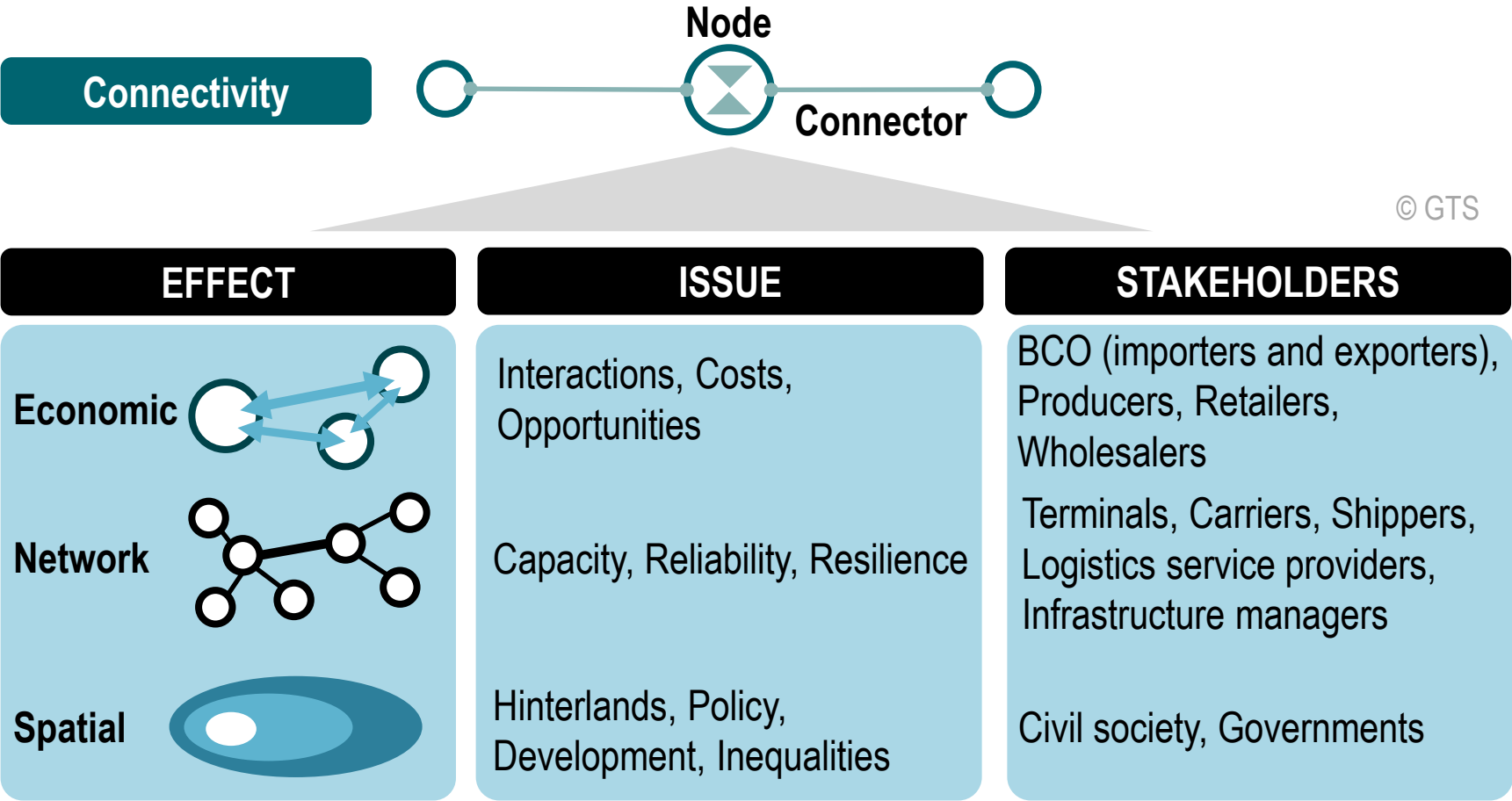
# Poles of the Global Economy



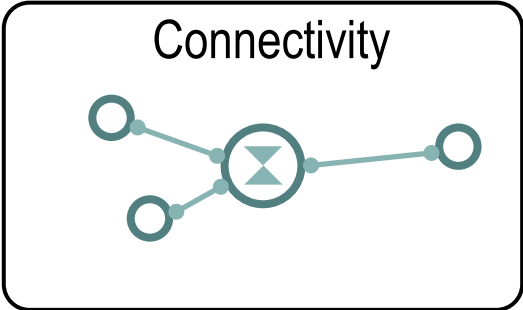
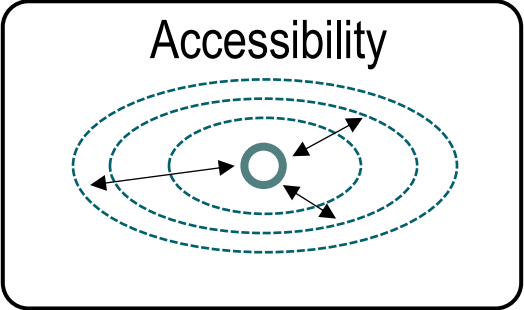
# The Layers of Connectivity



# The Relevance of Connectivity



# Accessibility and Connectivity



**FOCUS**

— Traffic potential  
(passengers and freight)

— Transportation network (modes  
and terminals)

**STRUCTURE**

— Market / Hinterland

— Gateways, hubs and links

**PERFORMANCE**

— Space / Time

— Capacity, reliability, resilience

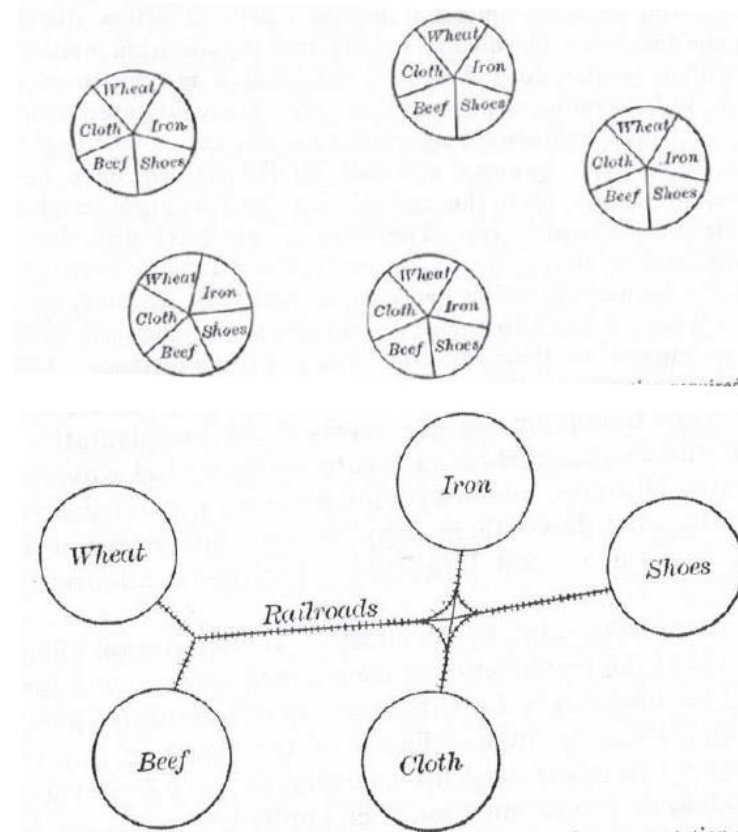
**GOVERNANCE**

— Trade or commercial policy

— Logistics (transport) policy

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# Transportation and the Regional Division of Labor

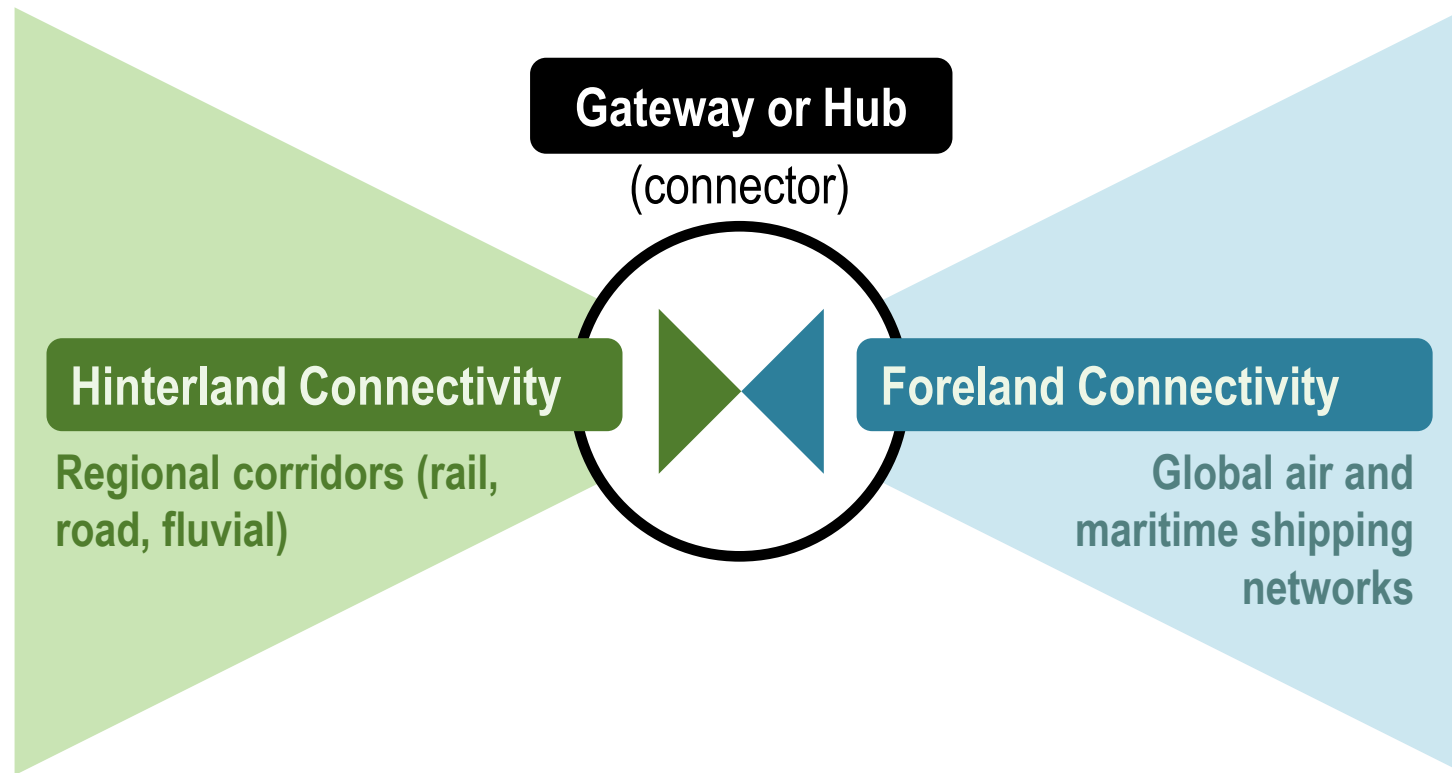


**Figures 27a et b. a)** (en haut) : Au XVIII<sup>e</sup> siècle, division locale du travail, pluriactivité, peu de transport requis. **b)** (en bas) : Au XIX<sup>e</sup> siècle, division territoriale du travail, spécialisation, beaucoup plus d'échanges requis sur un réseau de transport étendu.

Source : Cooley & Cooley, 1894.

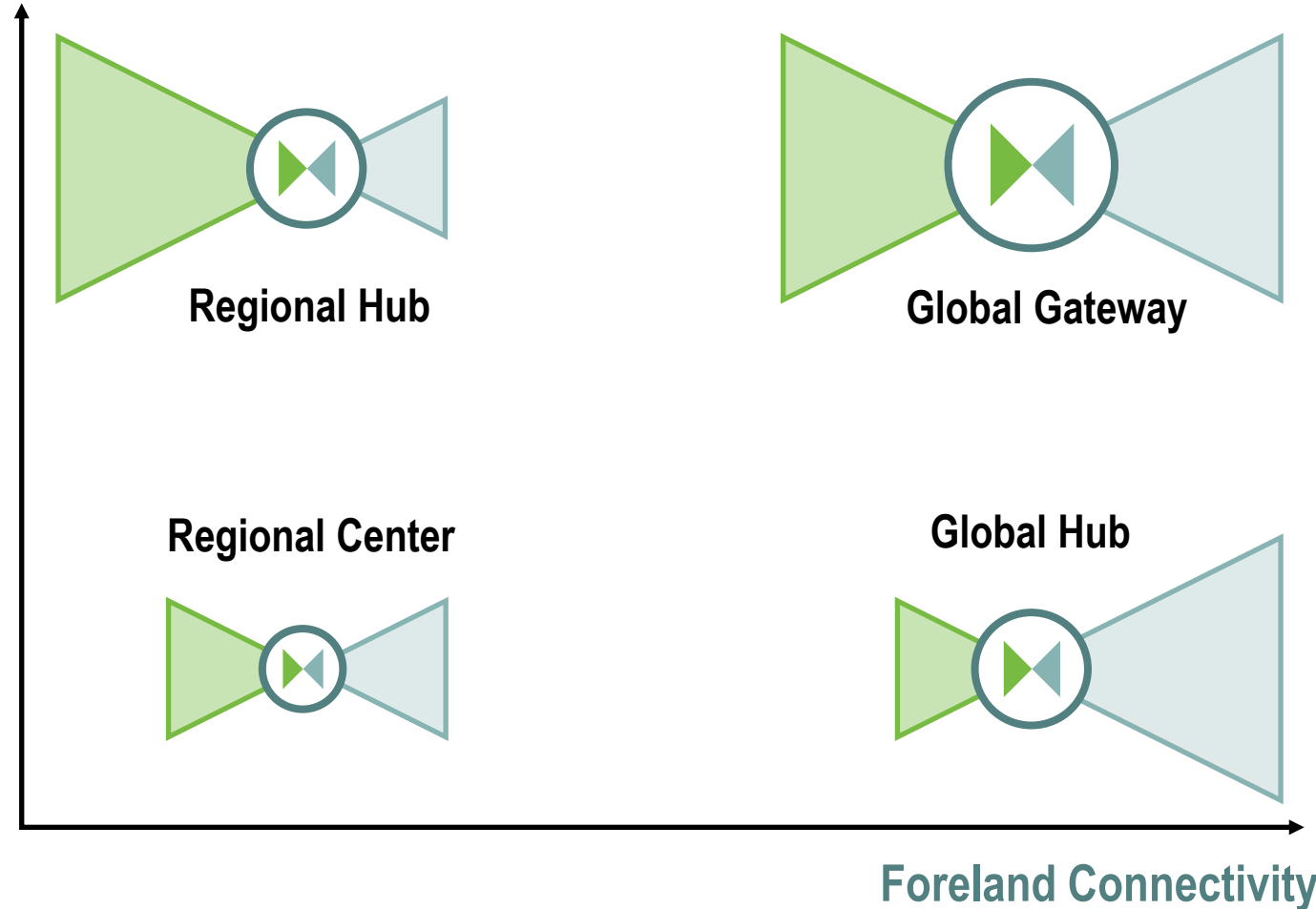


# The Components of Nodal Connectivity

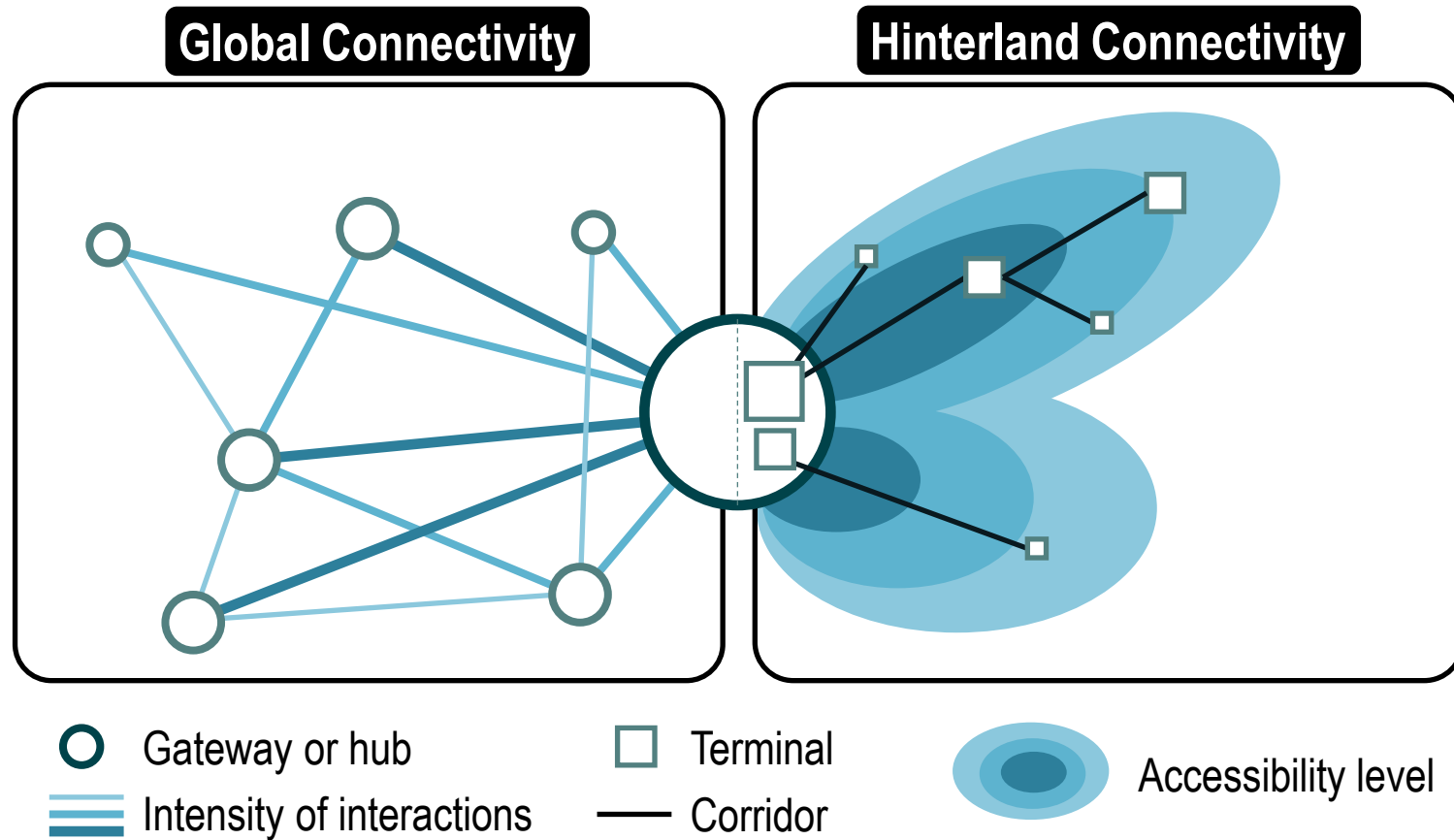


# Functional Variations in Connectivity

Hinterland Connectivity



# Global and Hinterland Connectivity



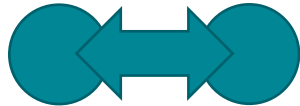
# The Three Tiers of Connectivity



Terminals (networks)

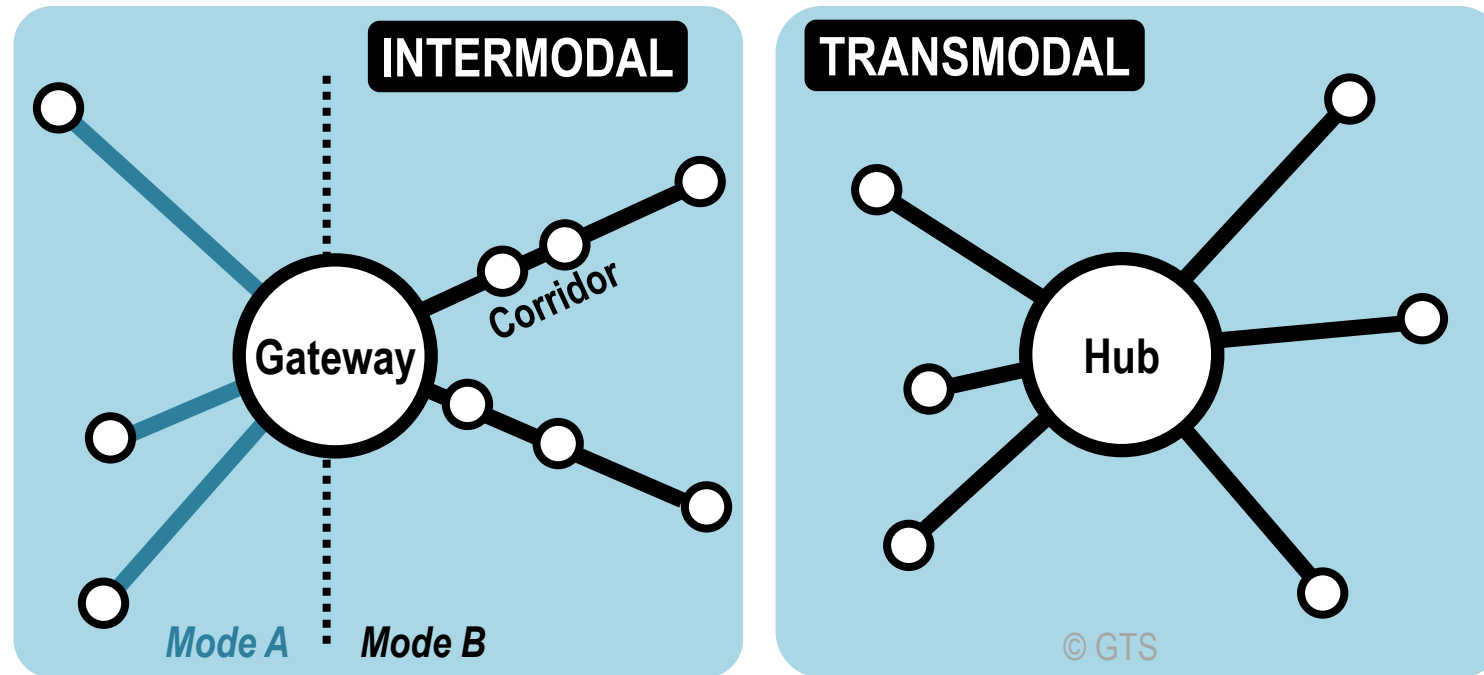


Distribution (supply chains)

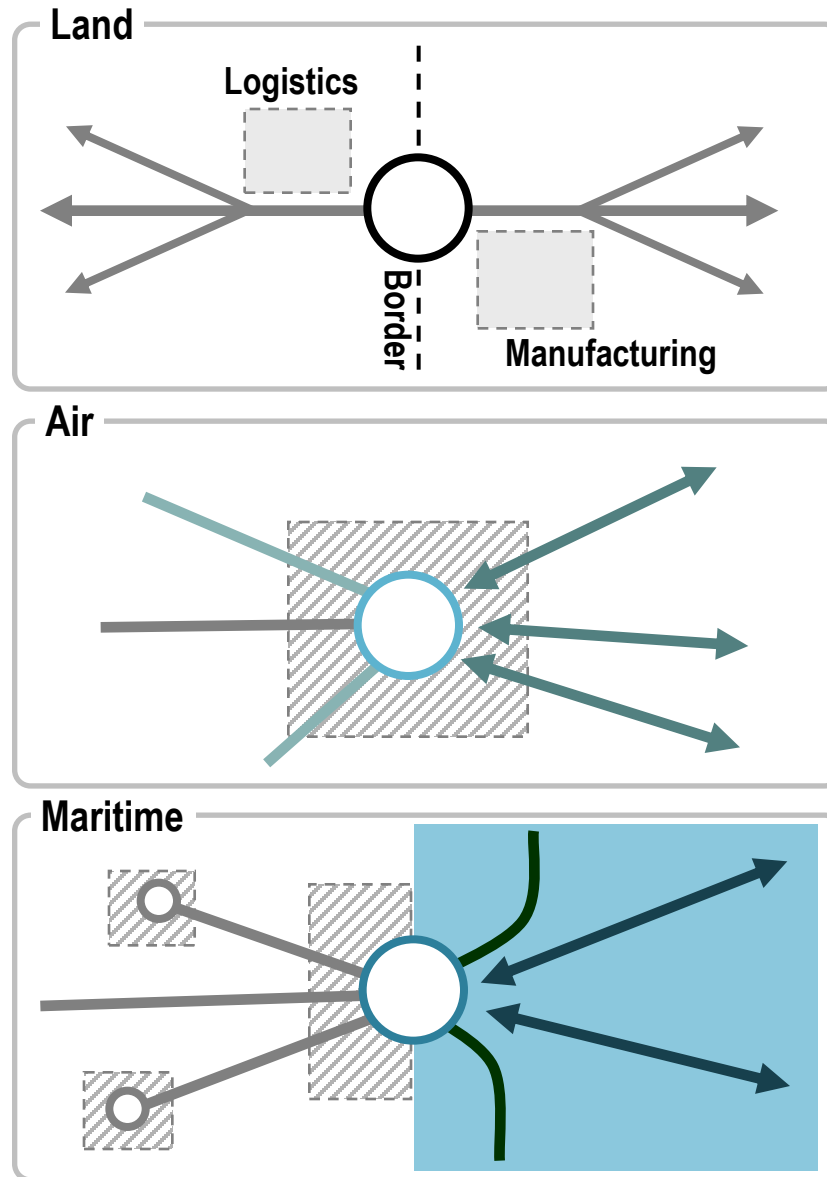


Production and consumption (trade)

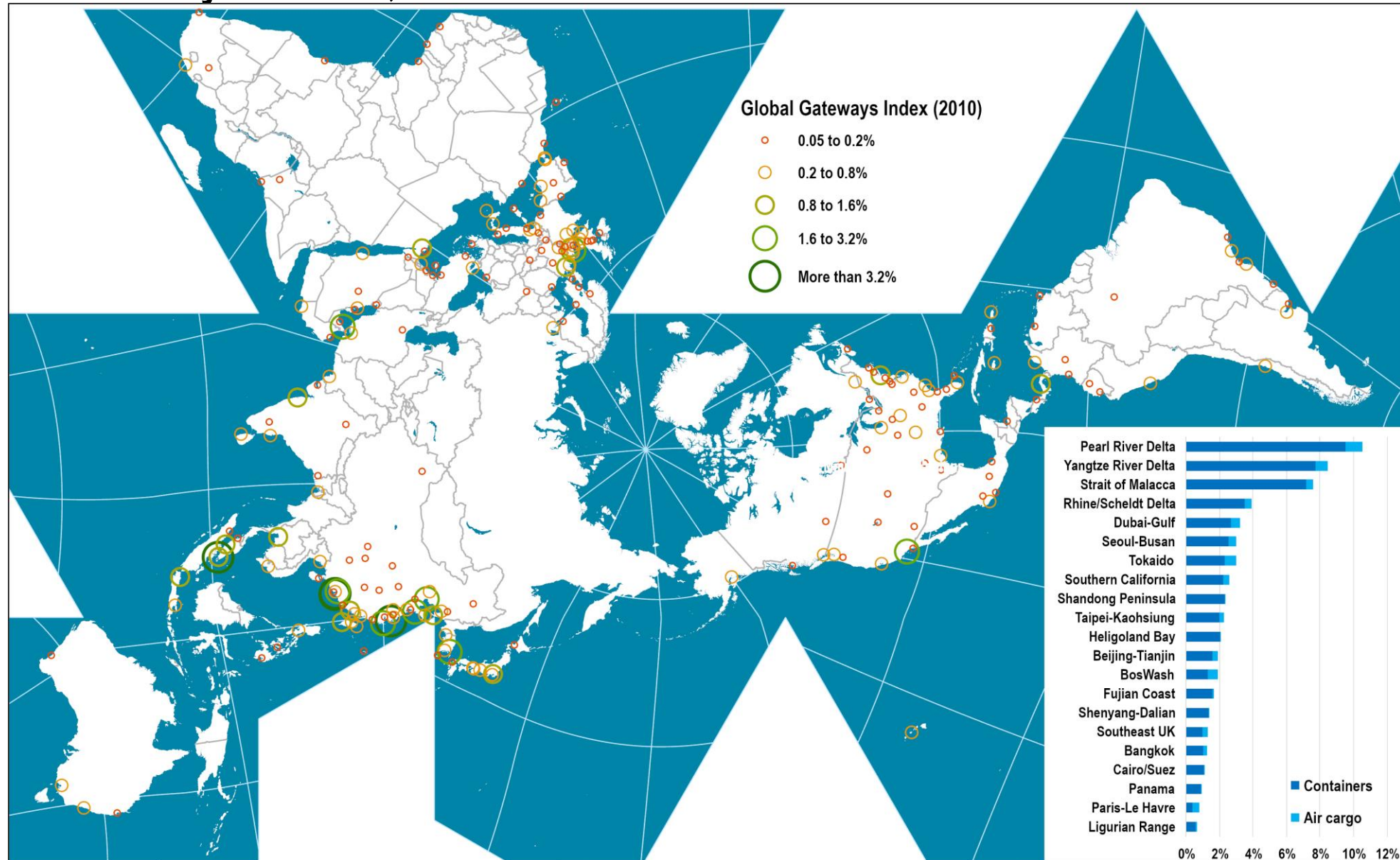
# Gateways and Hubs



# Modal Gateways

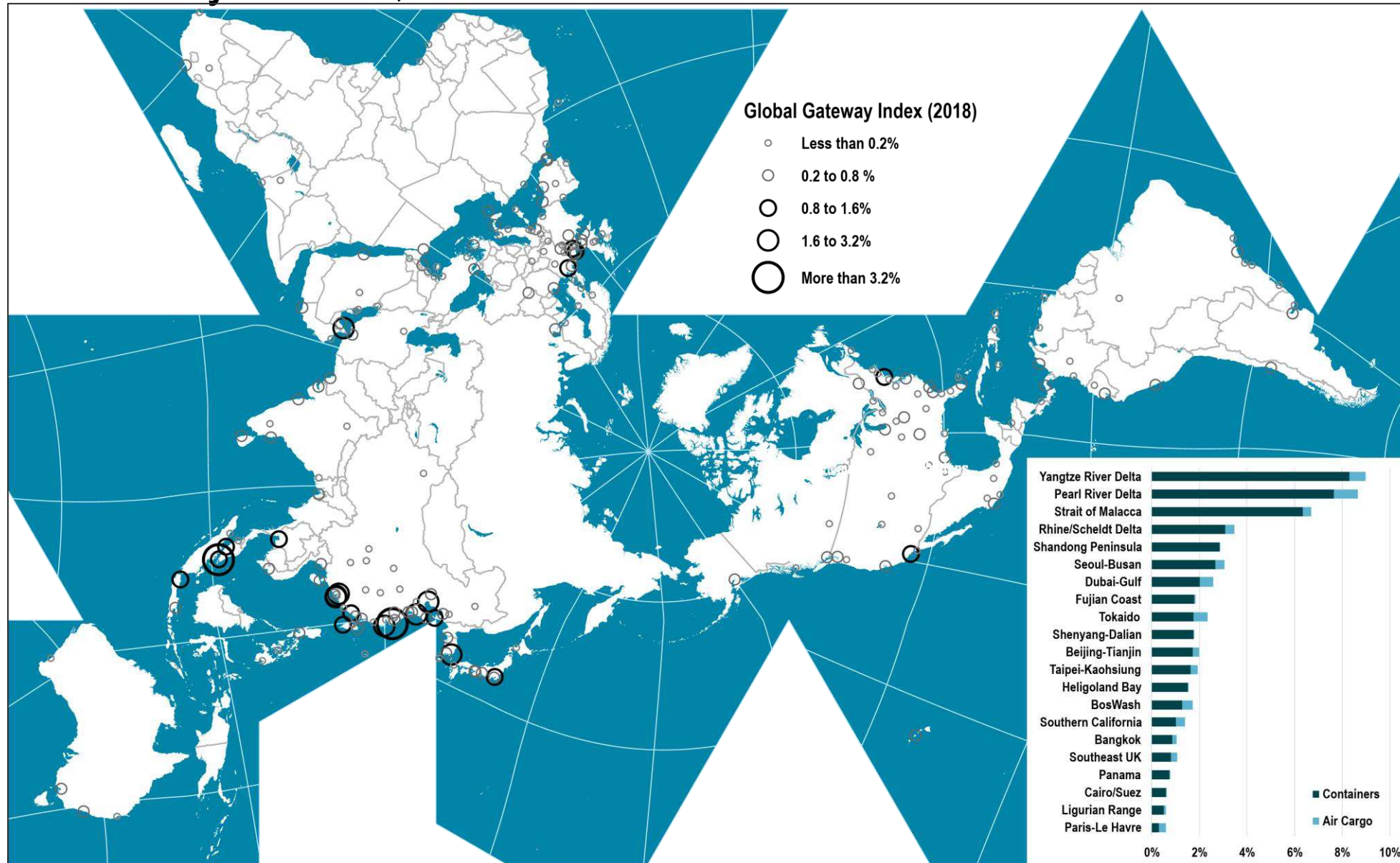


# Global Gateways Index, 2010



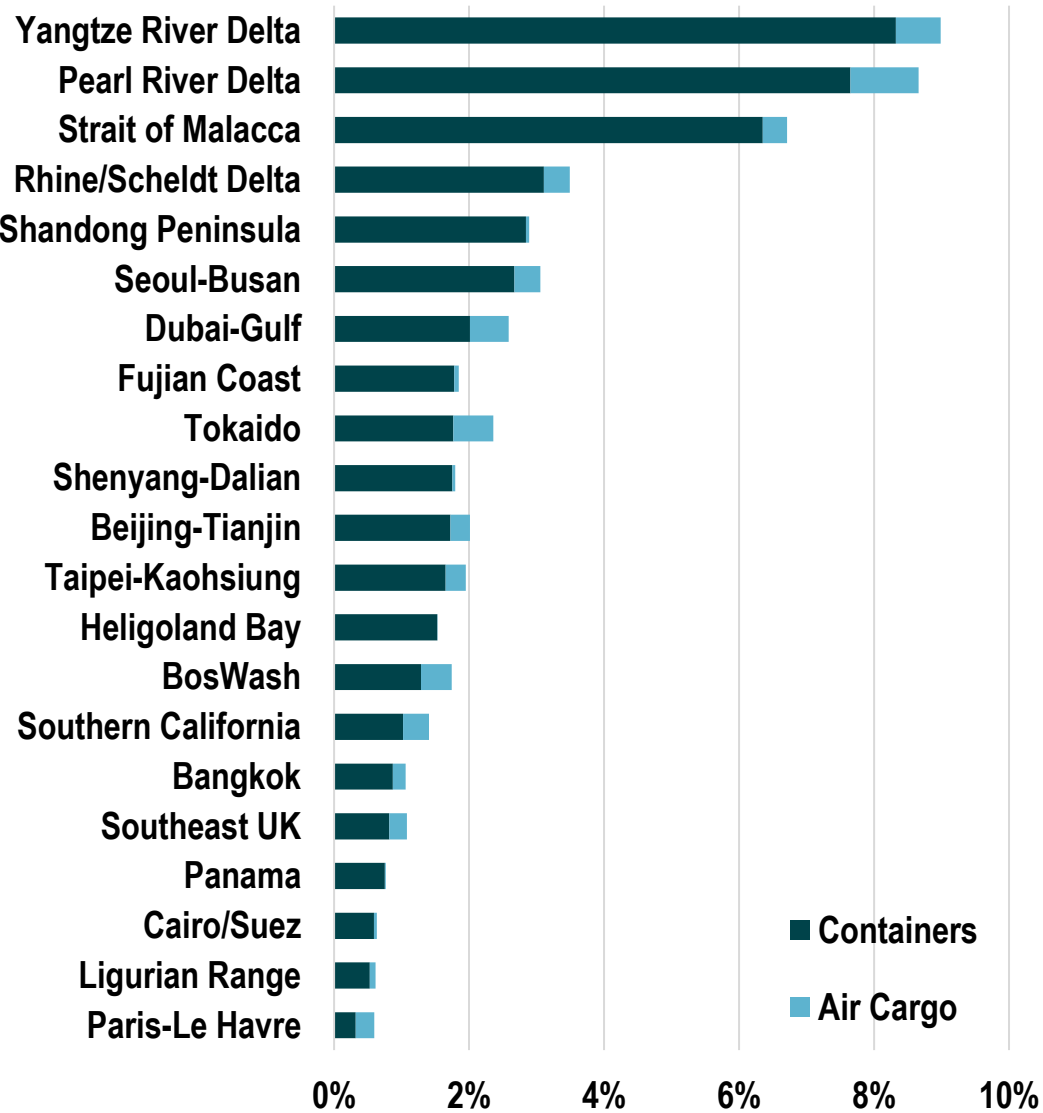
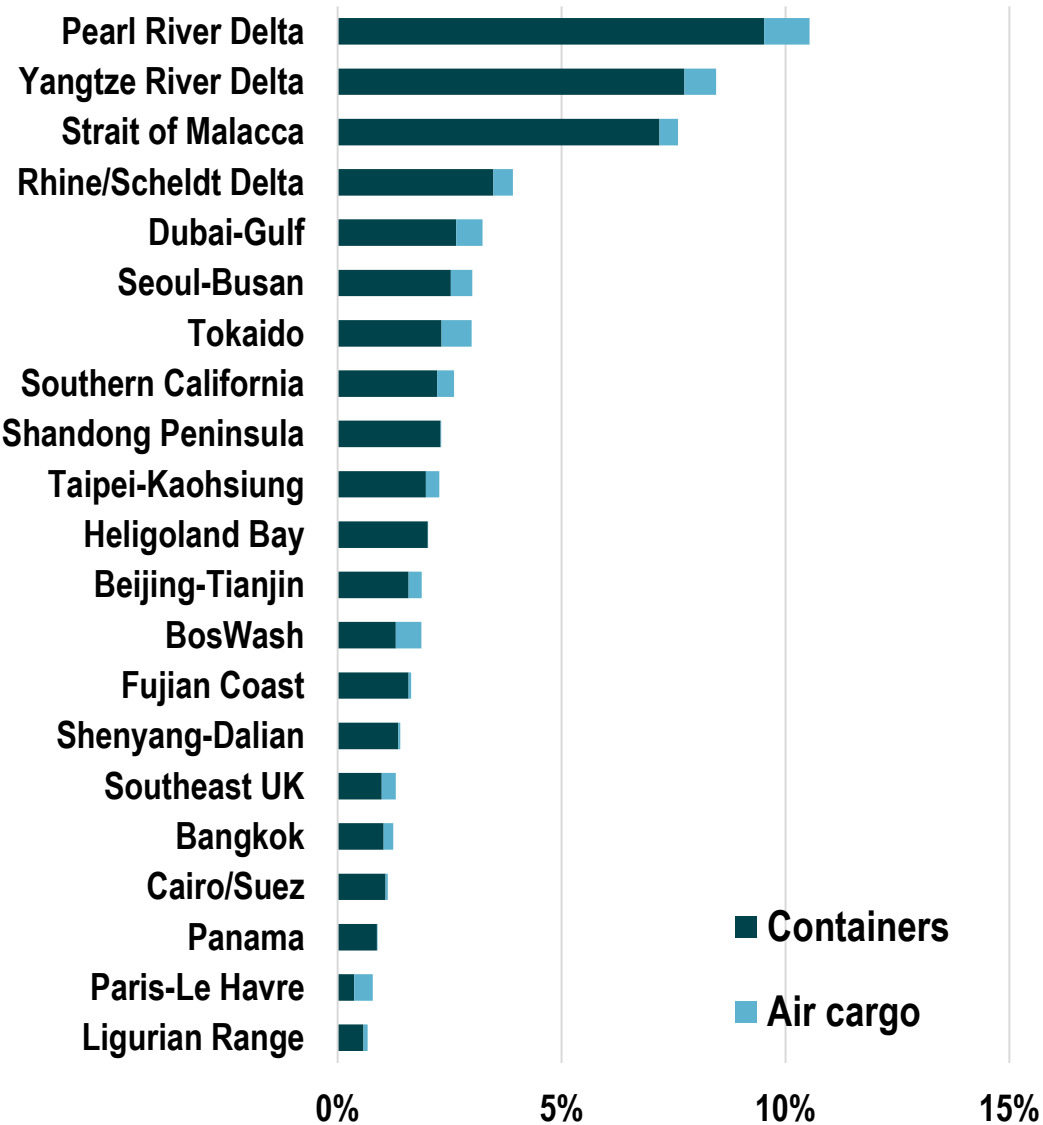


# Global Gateways Index, 2018

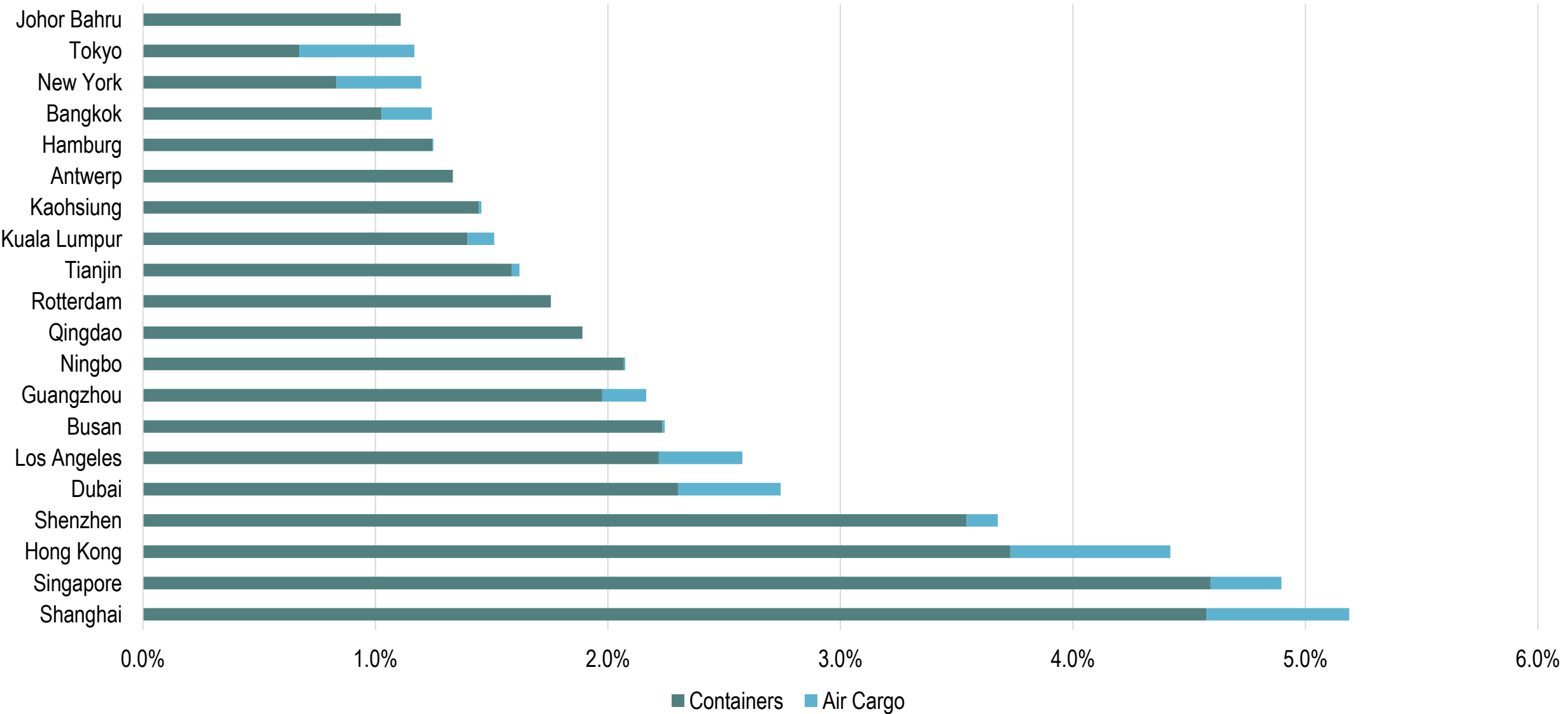




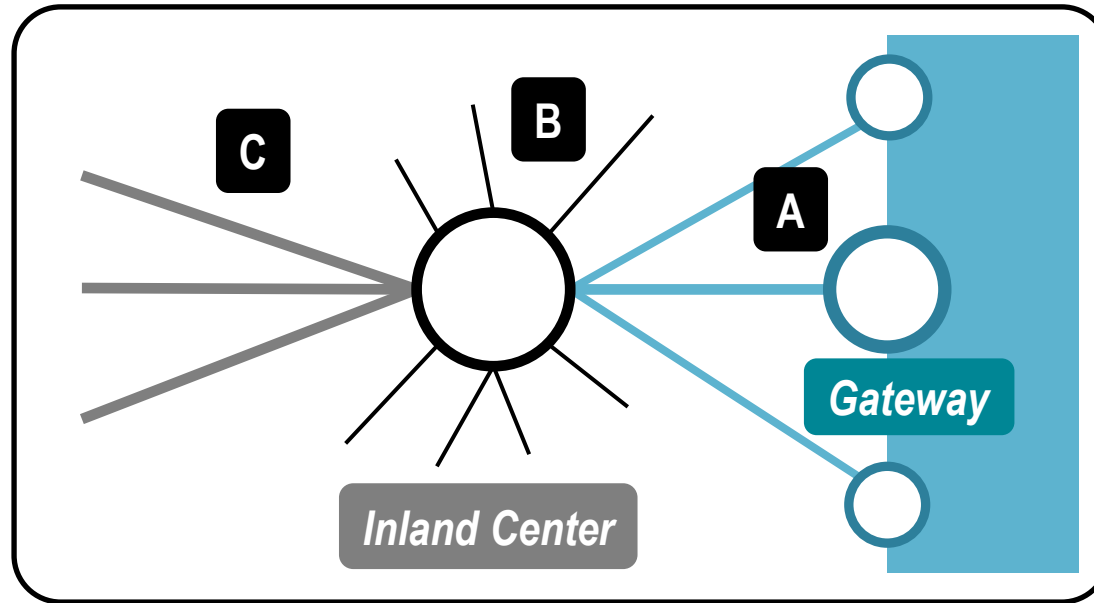
# Global Gateways Index by Gateway Region, 2010-2018



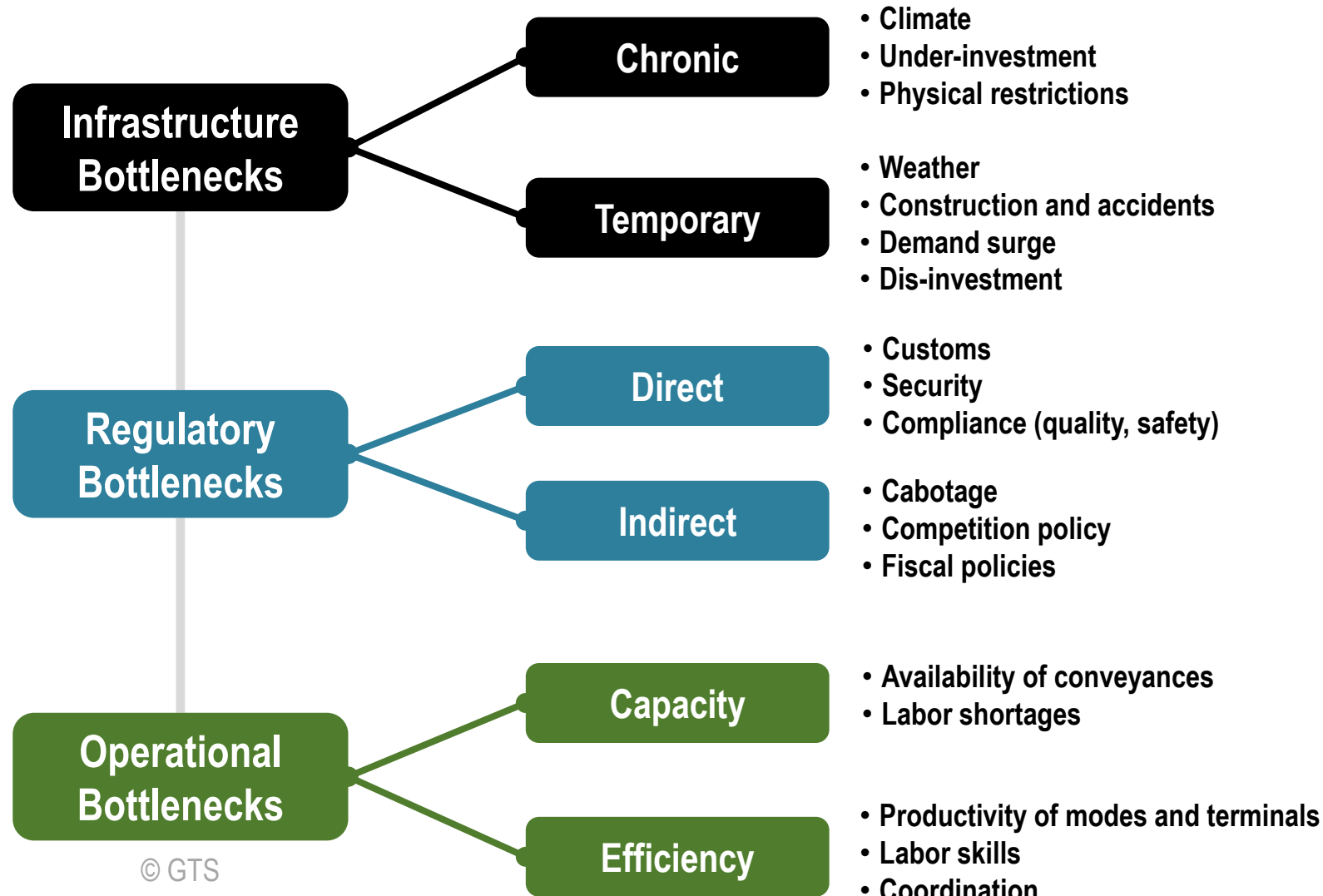
# Top 25 Gateways, Global Gateways Index, 2010



# Types of Hinterland Connectivity

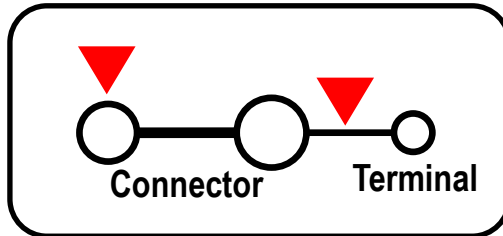


# Types of Bottlenecks



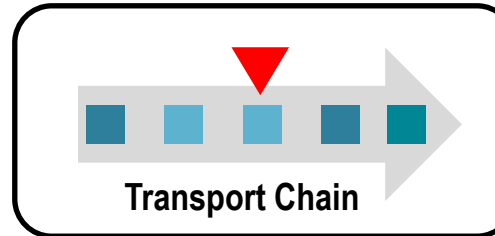
# Main Transportation Bottlenecks

## Infrastructure Bottlenecks



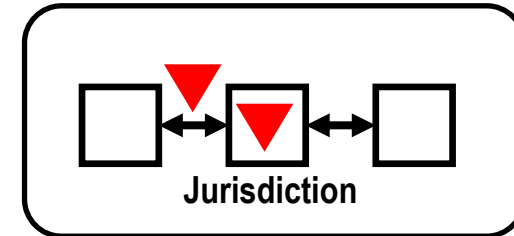
- Lack of terminal or connector capacity.
- Availability of conveyances.
- Natural or anthropogenic disruptions.
- Lack of investment and maintenance.

## Operational Bottlenecks



- Lack of logistical services.
- Lack of logistical performance (cost, time and reliability).
- Lack of labor flexibility.
- Lack of qualified labor.

## Regulatory Bottlenecks



- Customs clearance delays.
- Cabotage restrictions.
- Competition and fiscal policies.
- Lack of clear mandate and jurisdiction.
- Lack of coordination and cooperation.

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### Impact

Capacity

Efficiency

### Time Horizon

Chronic

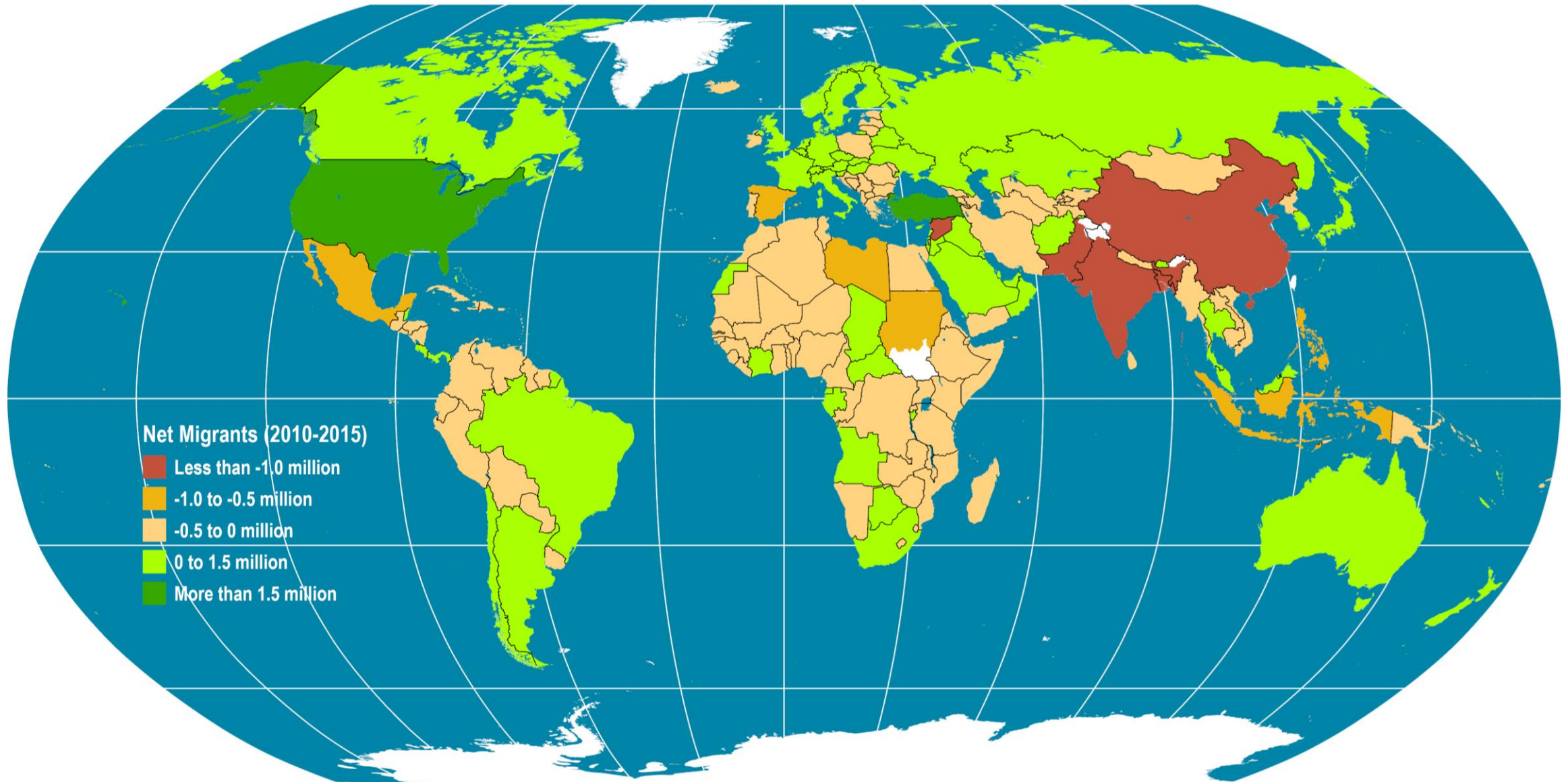
Temporary

### Extent

Direct

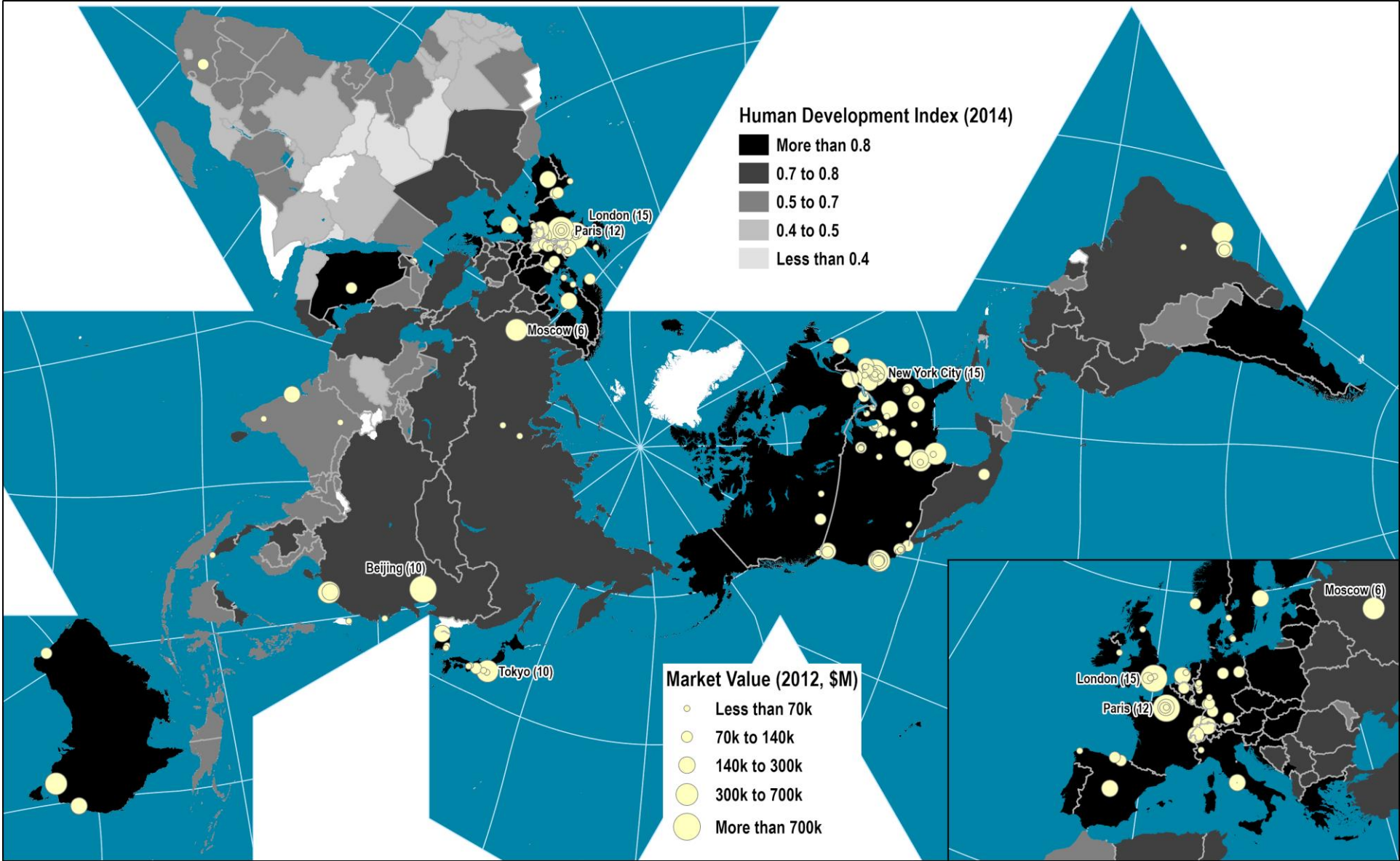
Indirect

# Global Net Migration (2010-2015)

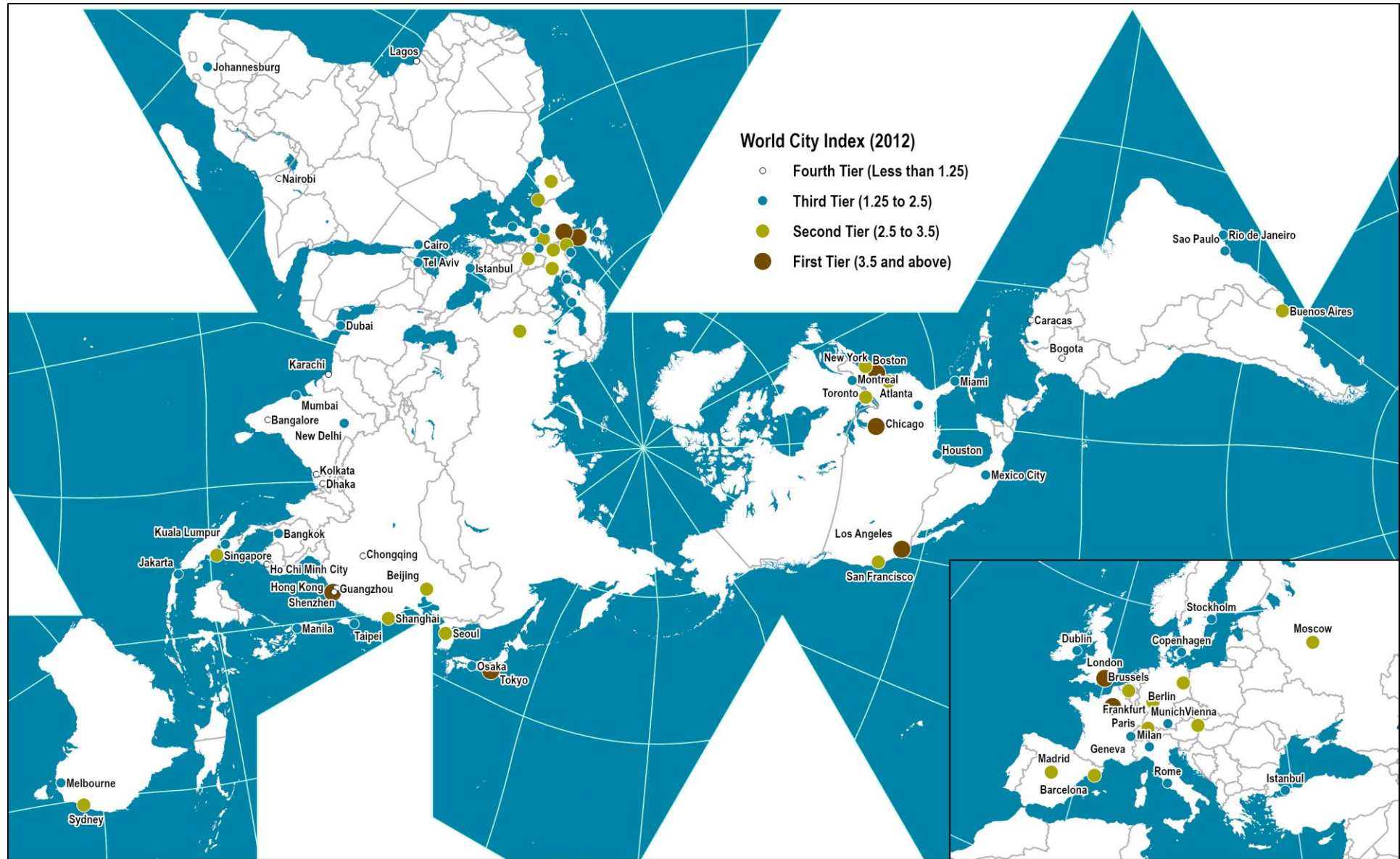




# World's 250 Largest Corporations by Head Office City



# World Cities, 2012





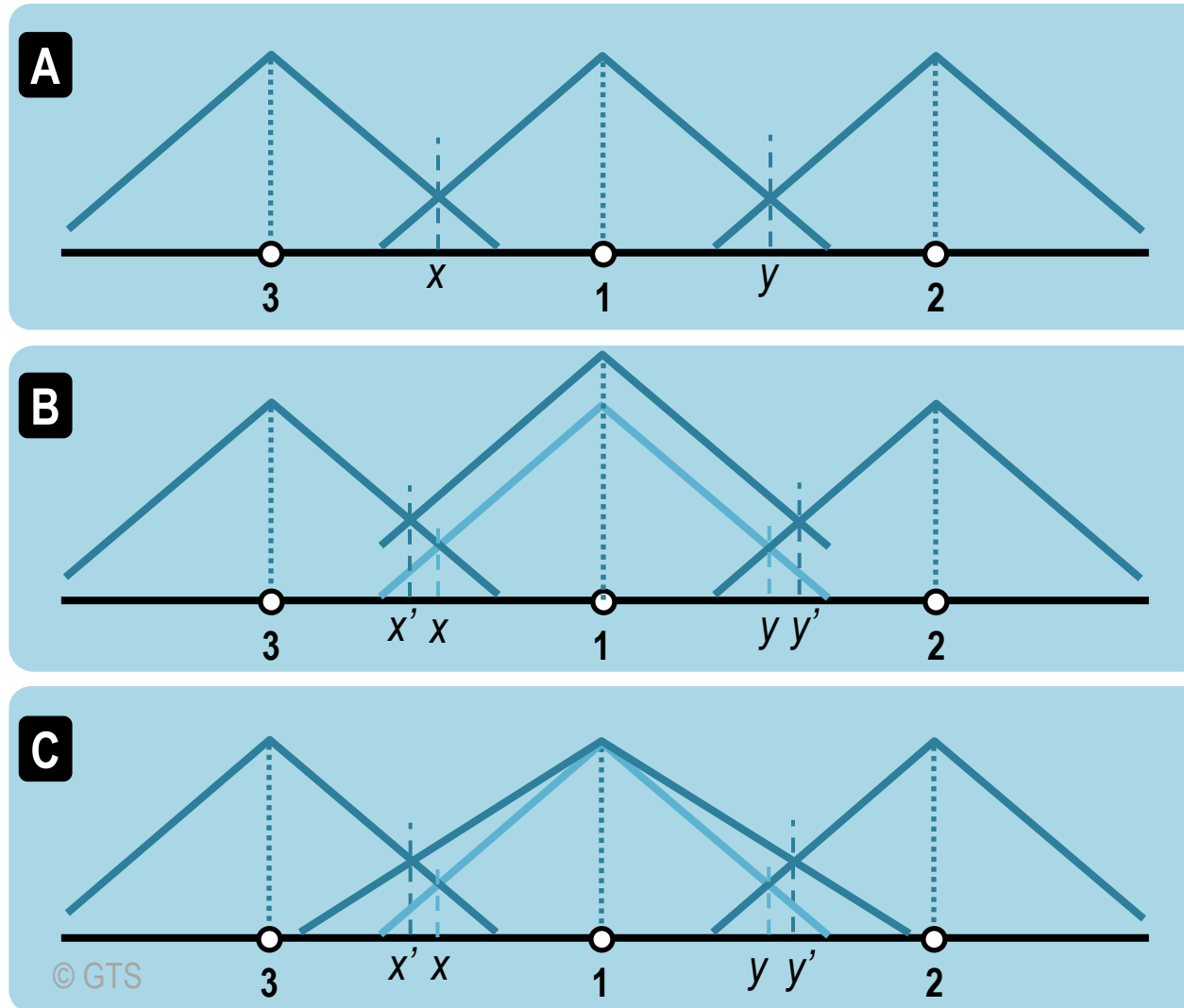
# Criteria to be a World City (Foreign Policy)

|   |  |
|---|--|
| <b>Recognition</b>                        | First-name familiarity; a city is recognized without the need for a political subdivision (e.g. London, UK or Paris, France).  |
| <b>Influence in international affairs</b> | Washington, Berlin, Brussels are major capitals of influence. New York; United Nations.  |
| <b>Large population</b>                   | Population of at least one million, typically several million.   |
| <b>Transport hub</b>                      | Major port and/or airport facilities. Several highways and/or a large mass transit network (rapid transit, light rail, regional rail, ferry, or bus).  |
| <b>Large cultural communities</b>         | Several international cultural groups and/or expatriate communities.   |
| <b>International institutions</b>         | Financial institutions, law firms, corporate headquarters, international conglomerates, and stock exchanges (influence on the global economy). Cultural institutions (museums and universities). |
| <b>Media and telecommunications</b>       | Several powerful and influential media outlets with an international reach. Advanced communications infrastructure (fiber optics, Wi-Fi networks, cellular phone services).                      |
| <b>International events</b>               | An active cultural scene (film festivals, music or theatre scene, an orchestra, an opera company, art galleries). Major sport events (e.g. Olympics, World Cup).                                 |

# Criteria to be a World City (AT Kearney)

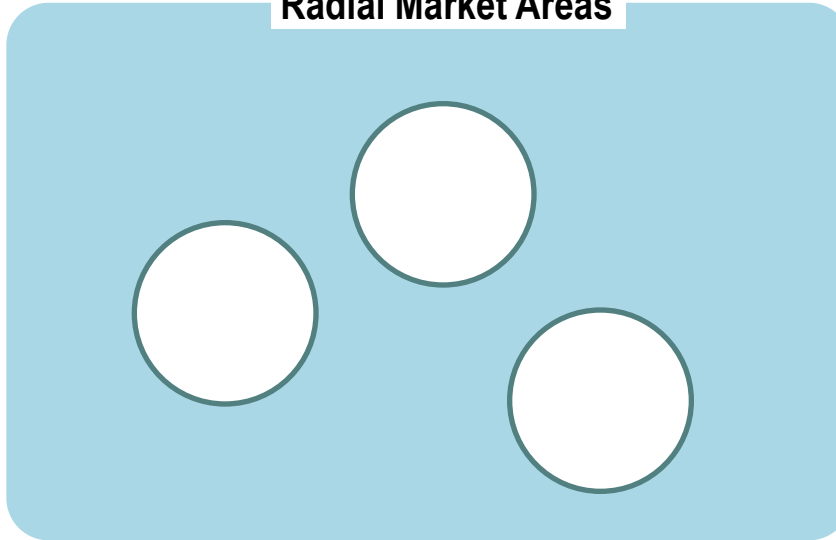
|                             |   |
|-----------------------------|---|
| <b>Business activity</b>    | The economic weight of the city; headquarters of major multinational corporations, locations of top business services firms, the value of capital (stock) markets, the number of international conferences, and the flow of goods through ports and airports. |
| <b>Human capital</b>        | Capacity to attract and train talent; size of foreign-born population, quality of universities, number of international schools, international student population, and number of residents with university degrees.   |
| <b>Information exchange</b> | The effectiveness of information flows; accessibility to major TV news channels, internet presence, number of international news bureaus, level of censorship and broadband subscriber rate.  |
| <b>Cultural influence</b>   | The cultural weight of the city; number of major sporting events, number of museums, performing-arts venues, culinary establishments, number of international travelers and number of sister-city relationships.  |
| <b>Political engagement</b> | The level of influence on global politics; number of embassies and consulates, major think tanks, international organizations and local institutions with international reach, and the number of political conferences.                                       |

# Delimitation and Variations in Market Areas

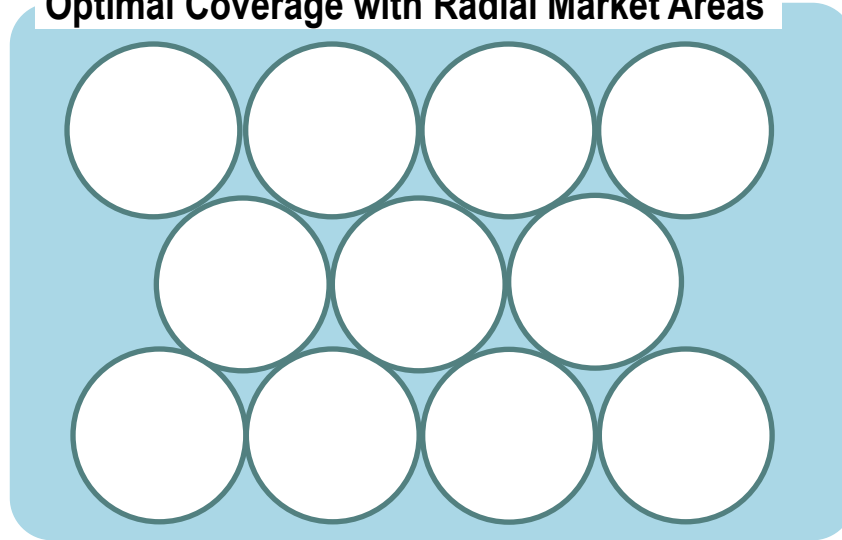


# The Spatial Setting of Market Areas

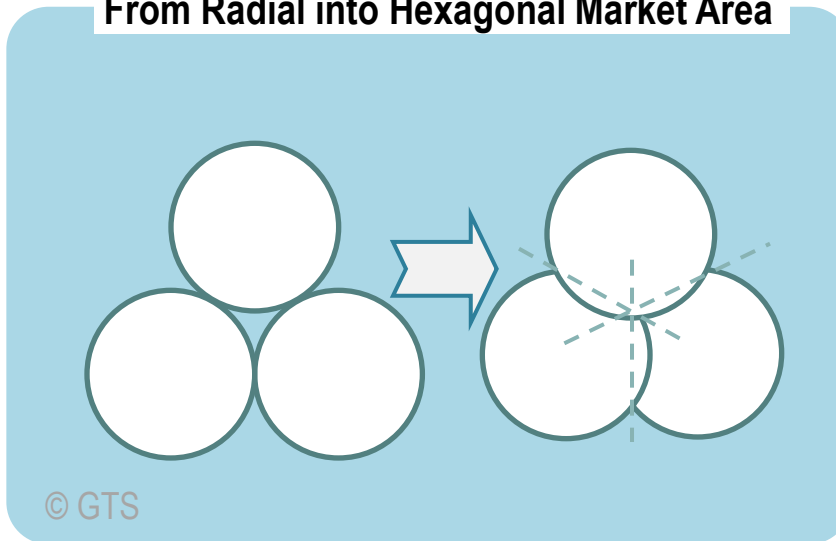
**Radial Market Areas**



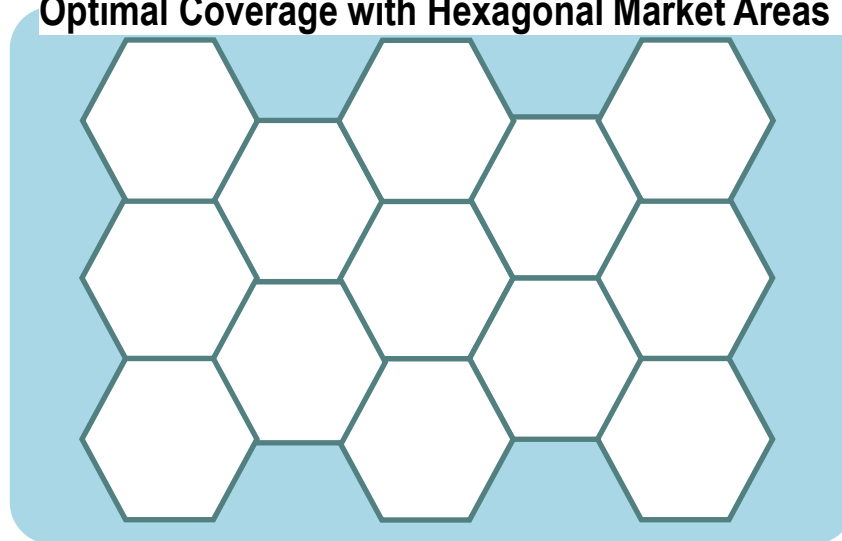
**Optimal Coverage with Radial Market Areas**



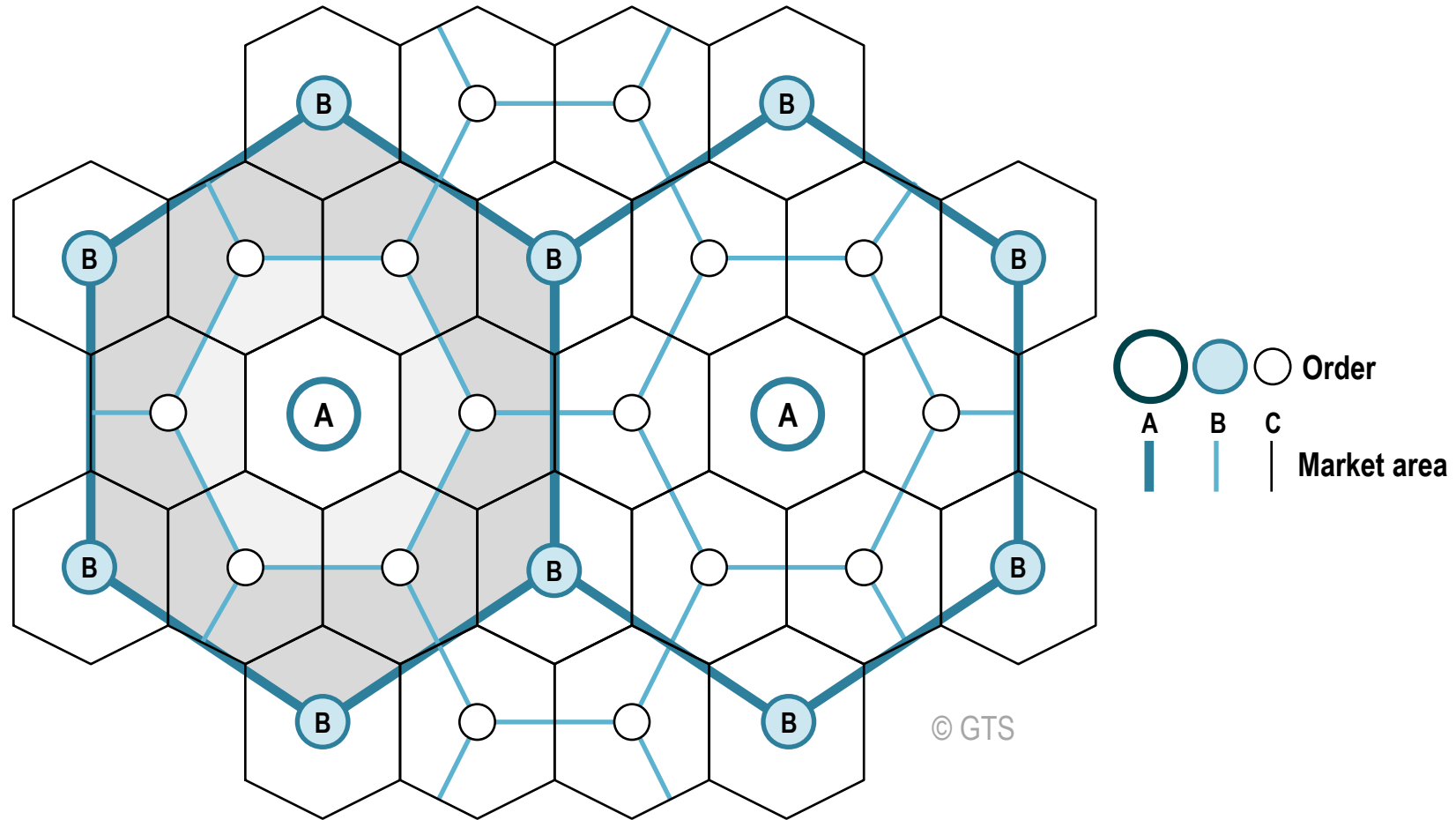
**From Radial into Hexagonal Market Area**



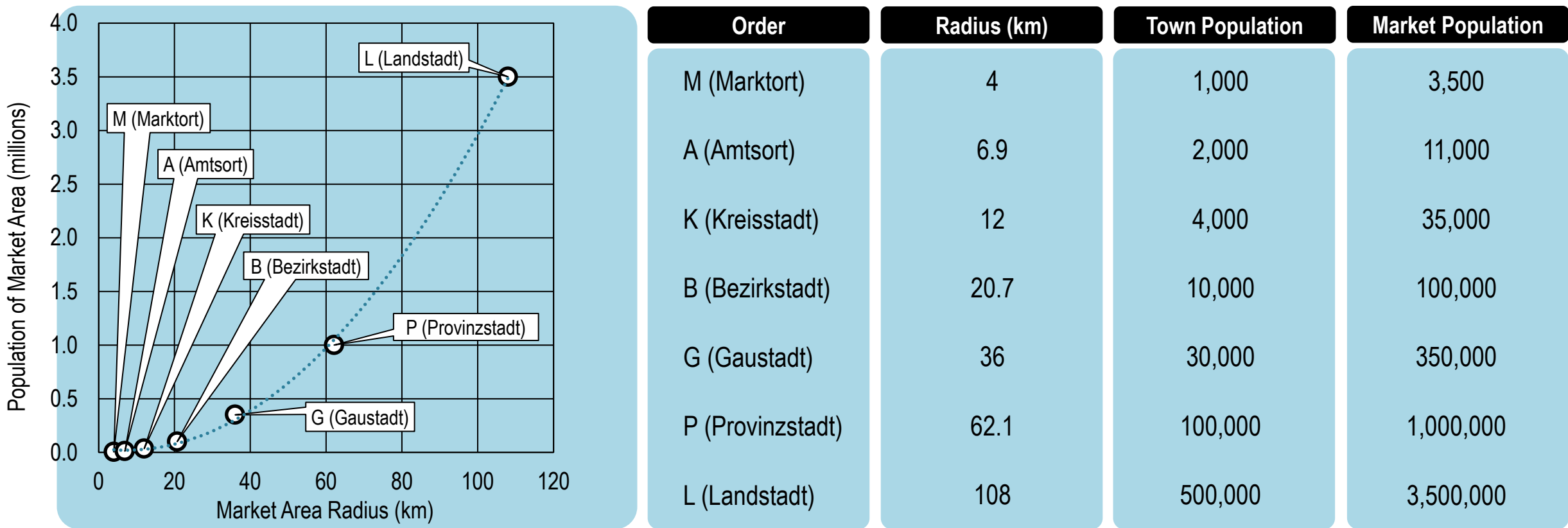
**Optimal Coverage with Hexagonal Market Areas**



# Central Places Theory (k=3)

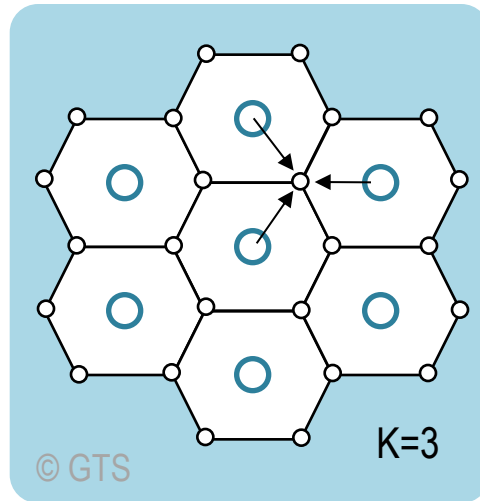


# Market Size / Area Relationships in the Central Places Theory

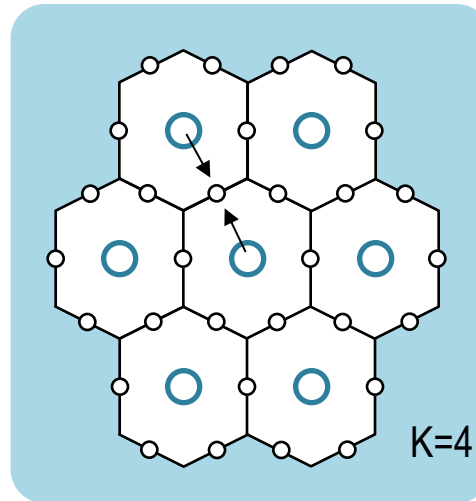


# Variations of the Central Places Theory

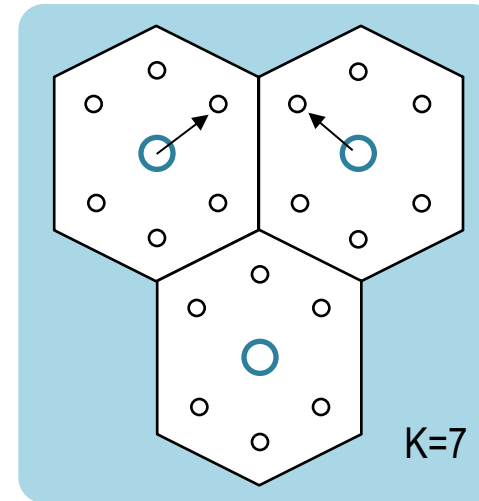
**Marketing Principle**



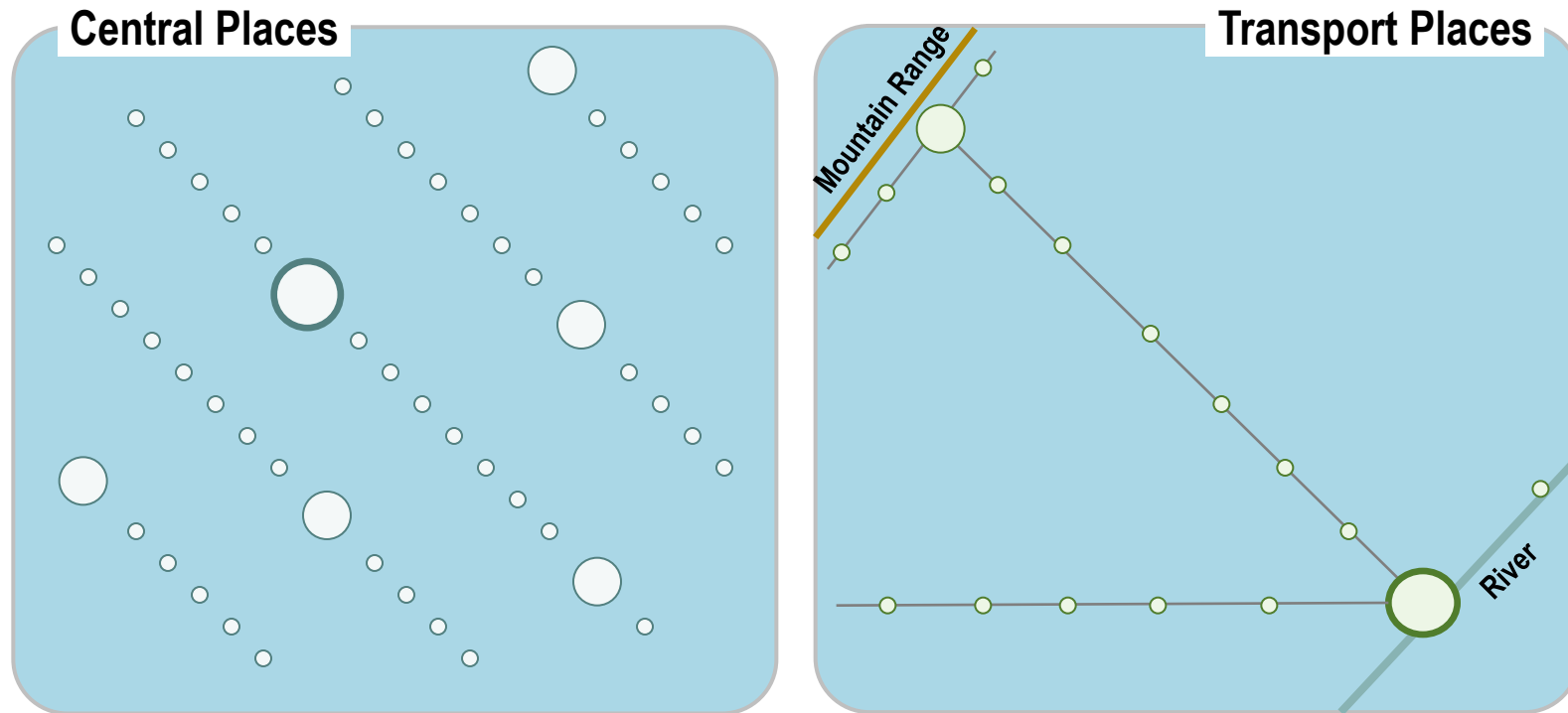
**Transport Principle**



**Administrative Principle**

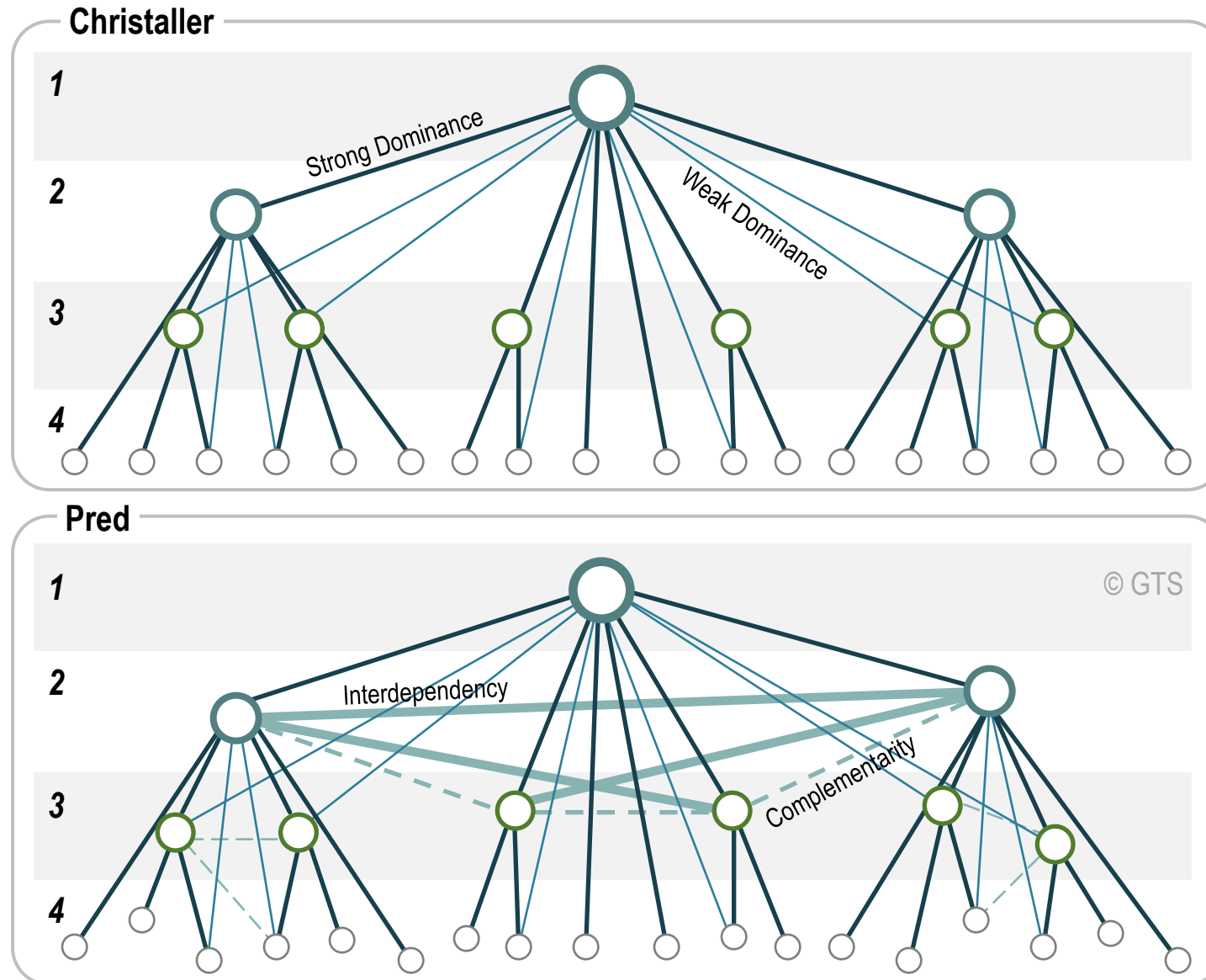


# Central Places and Transport Places

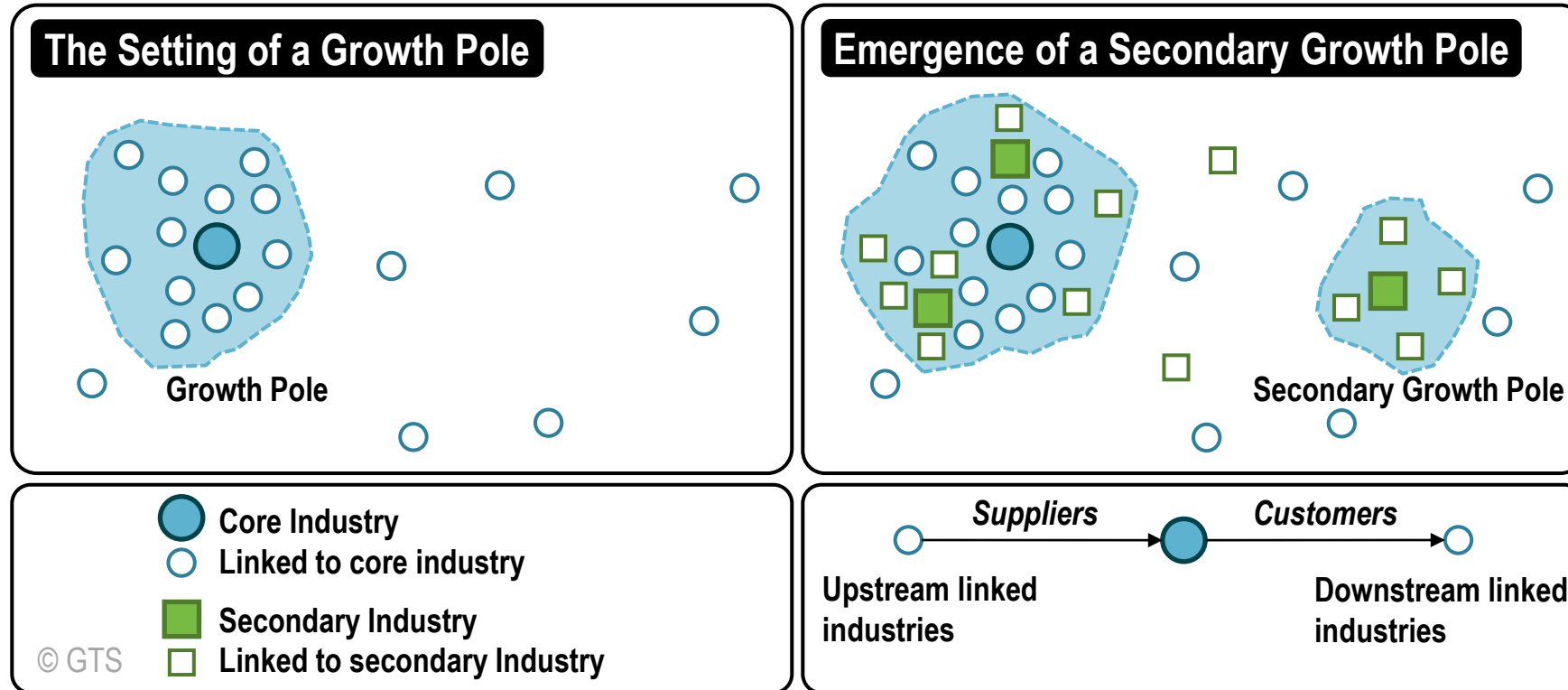




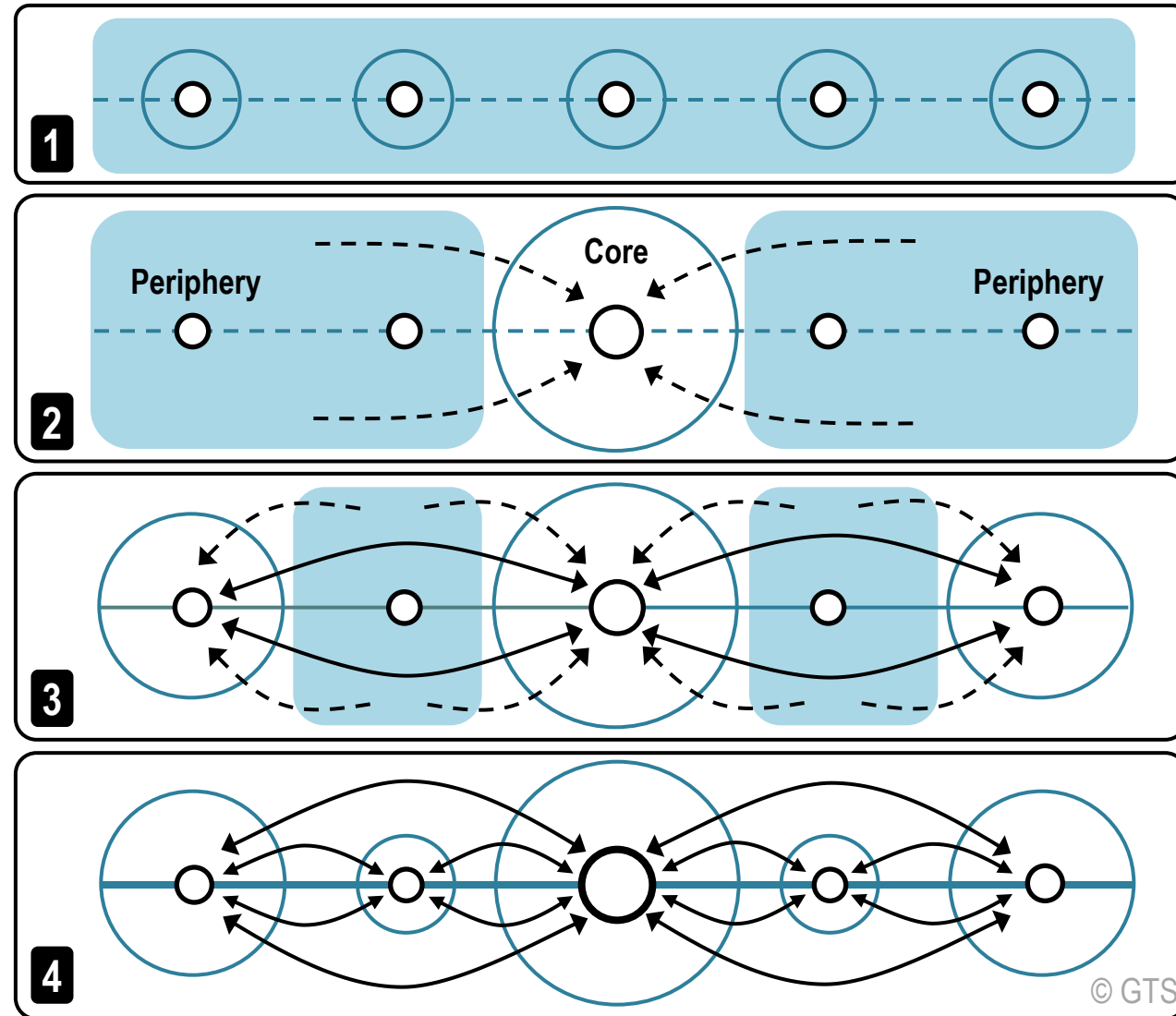
# Urban Hierarchy



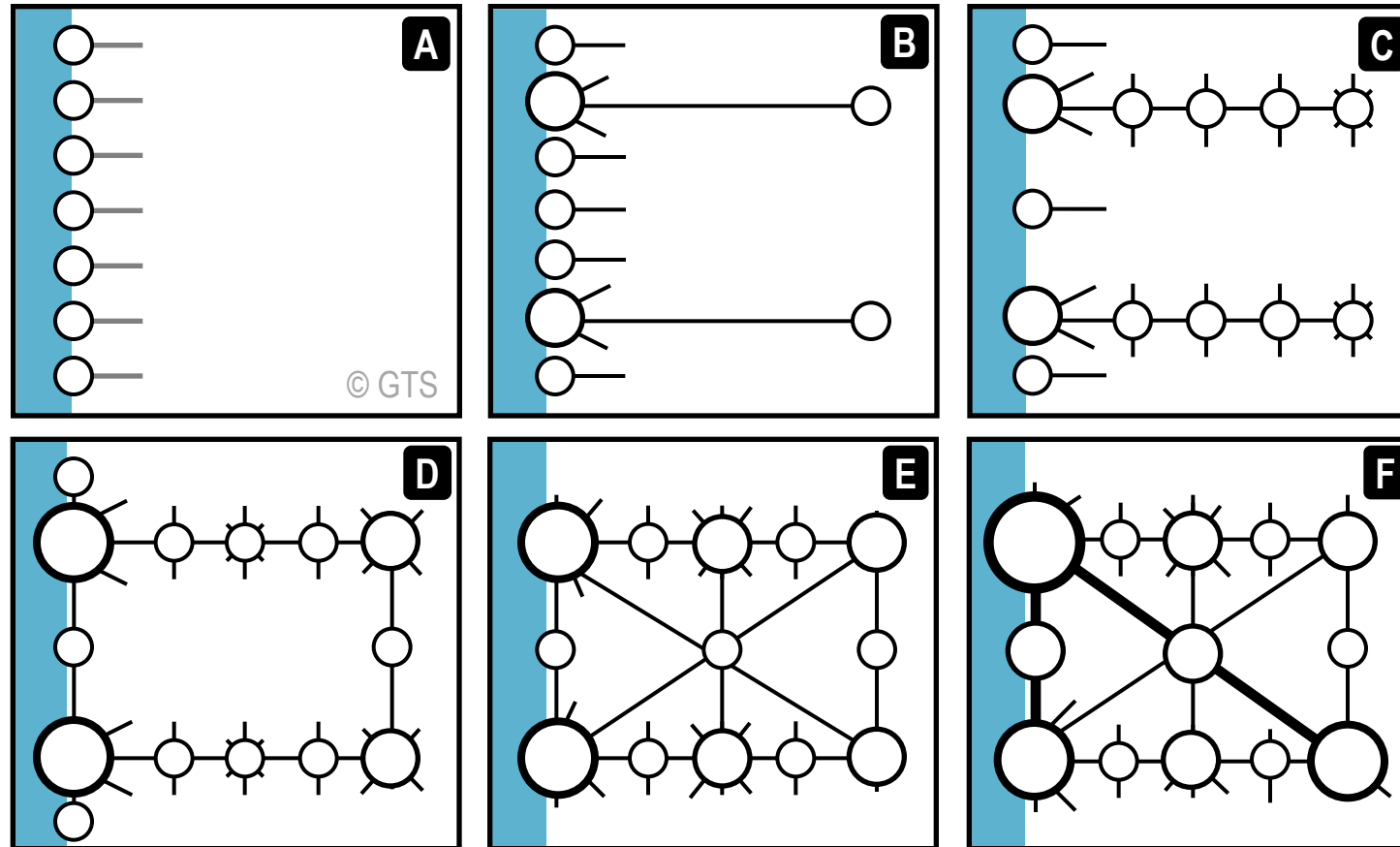
# Growth Poles Theory



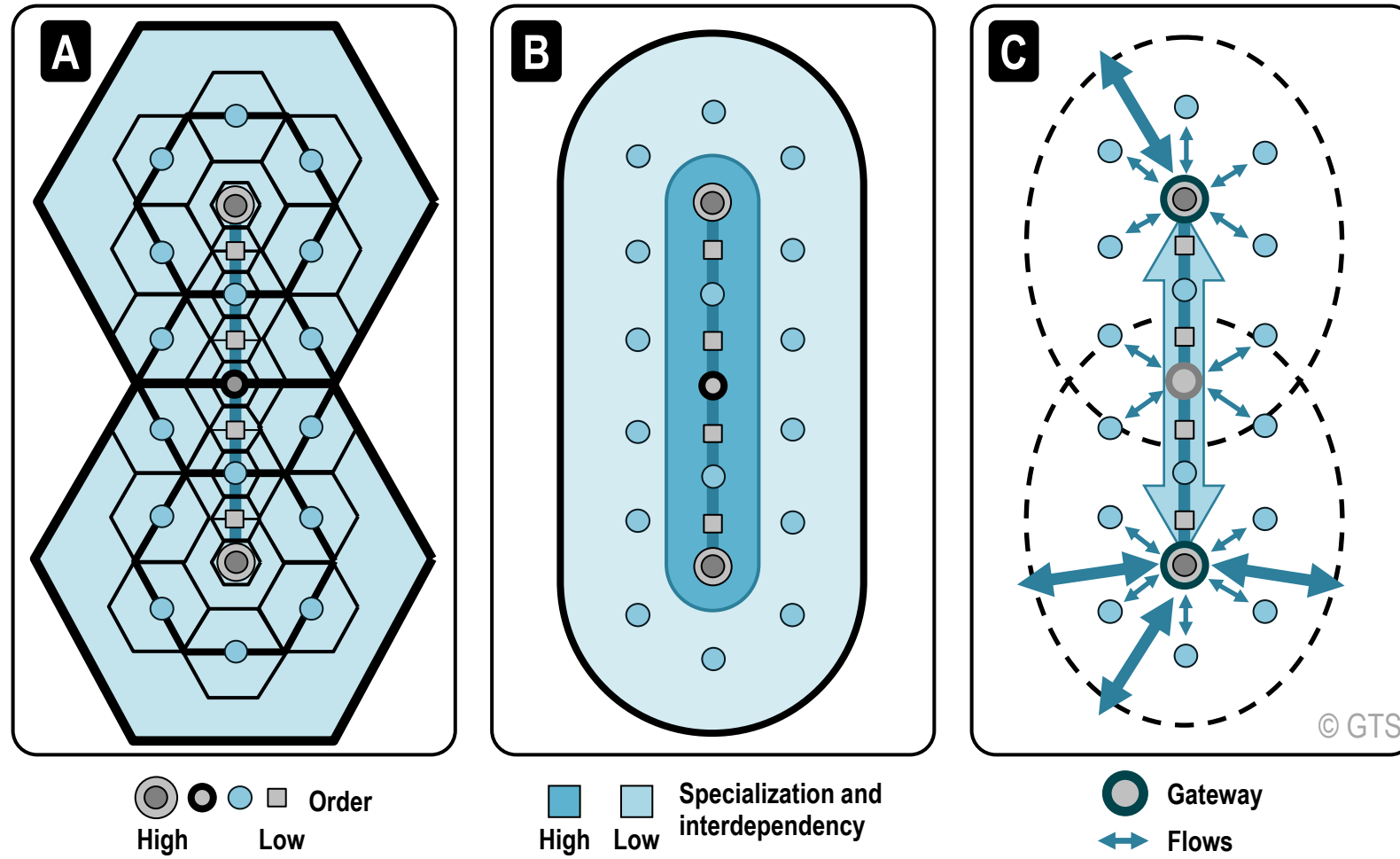
# Core-Periphery Stages of Development in an Urban System



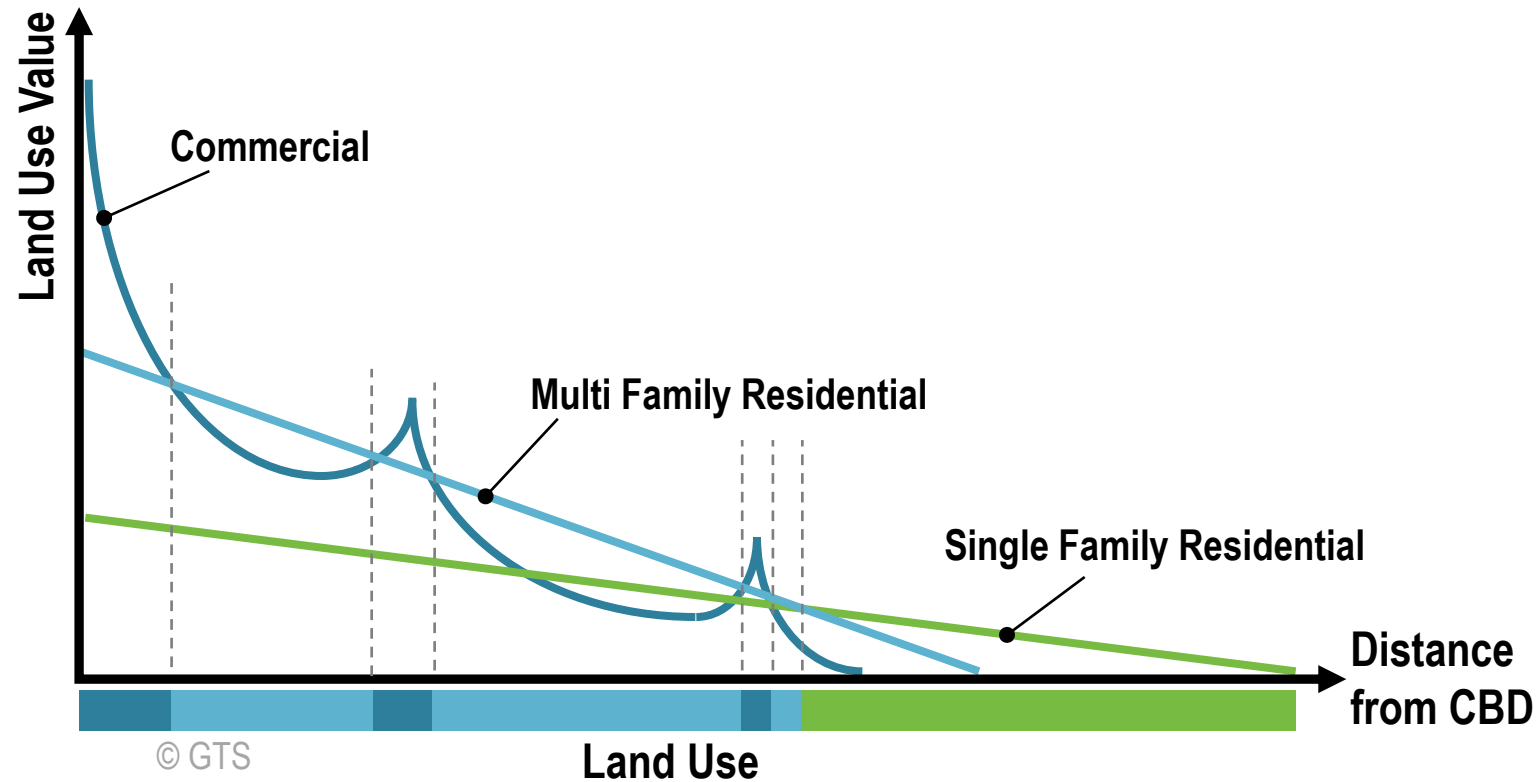
# Conceptual Corridor Development



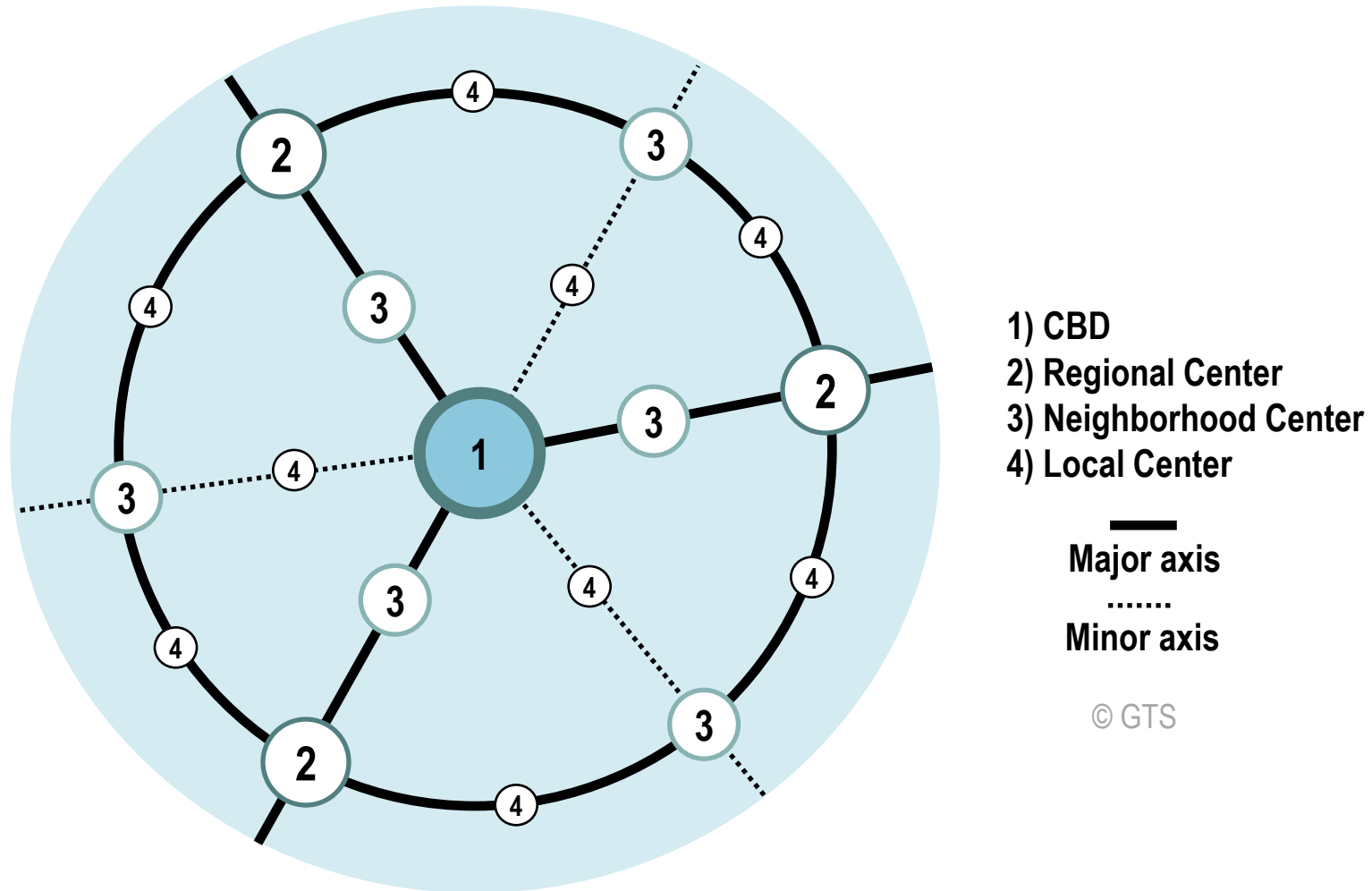
# Transport Corridors and the Regional Spatial Structure

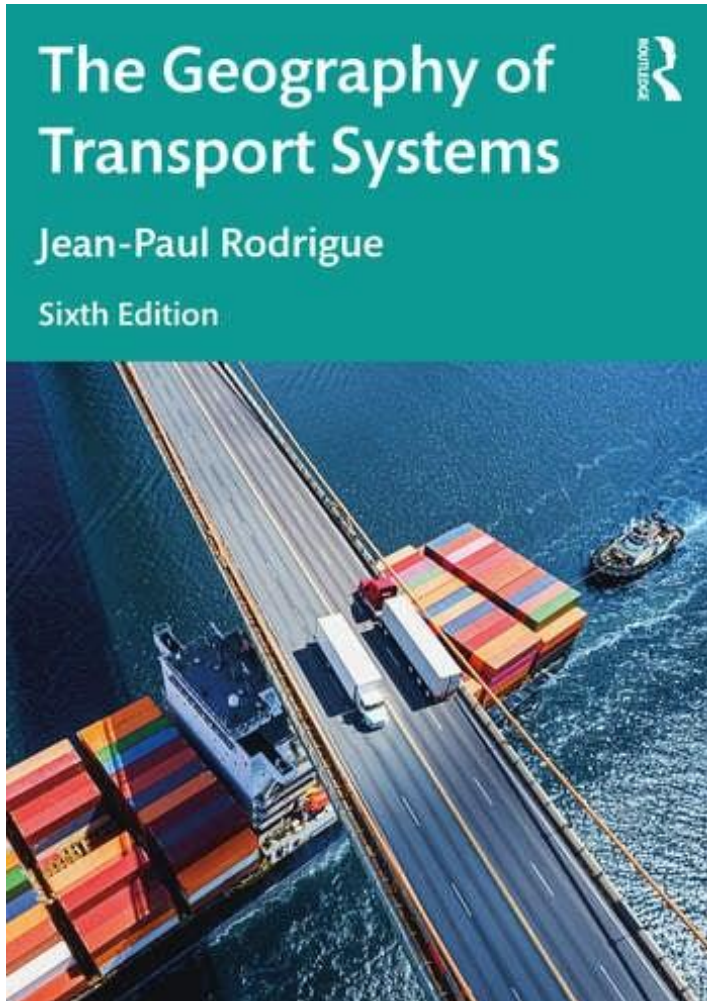


# Land Use Value by Activity Sector in Function of the Distance from the CBD



# Central Places in Urban Areas



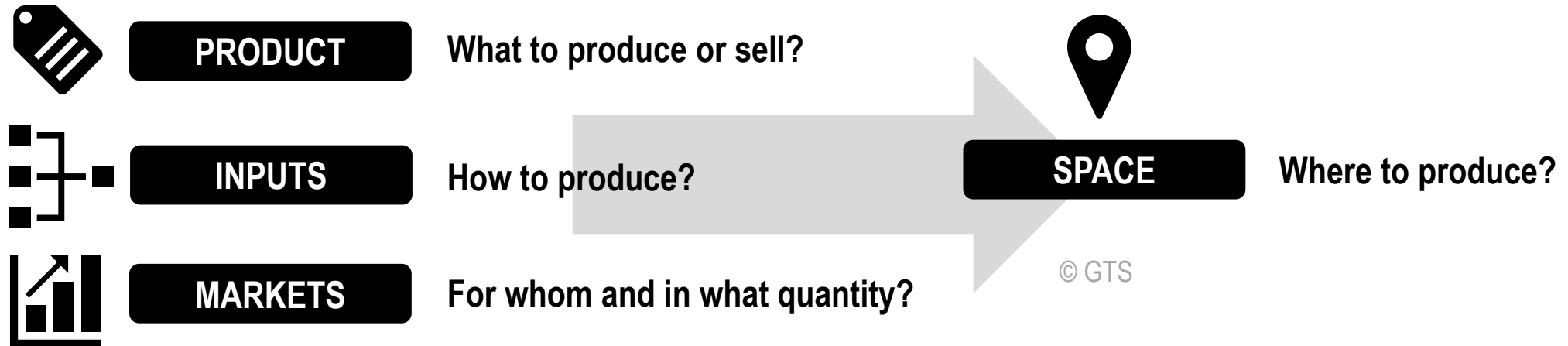


# Transportation and Location

## Chapter 2.3



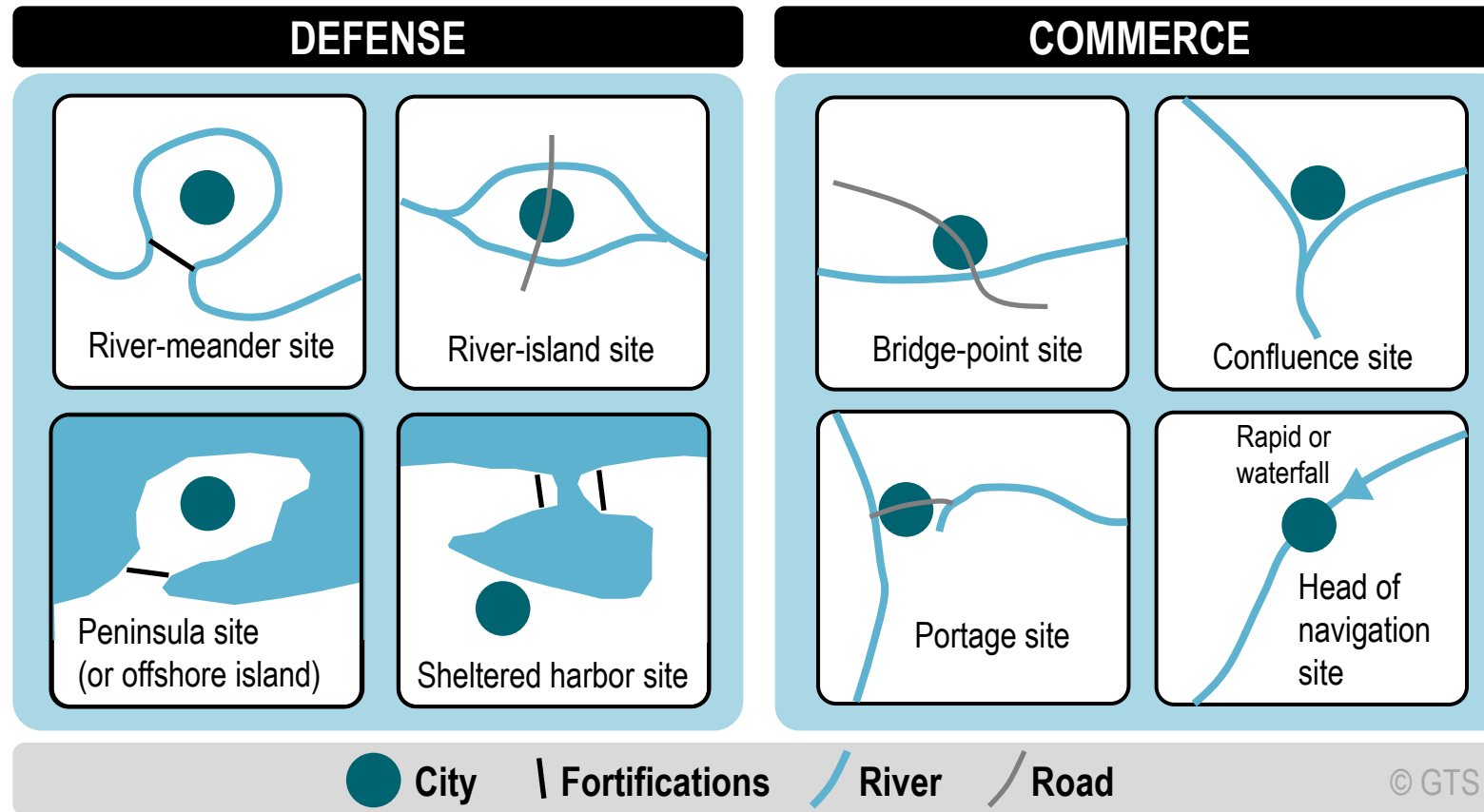
# Strategic Decision Making in Location



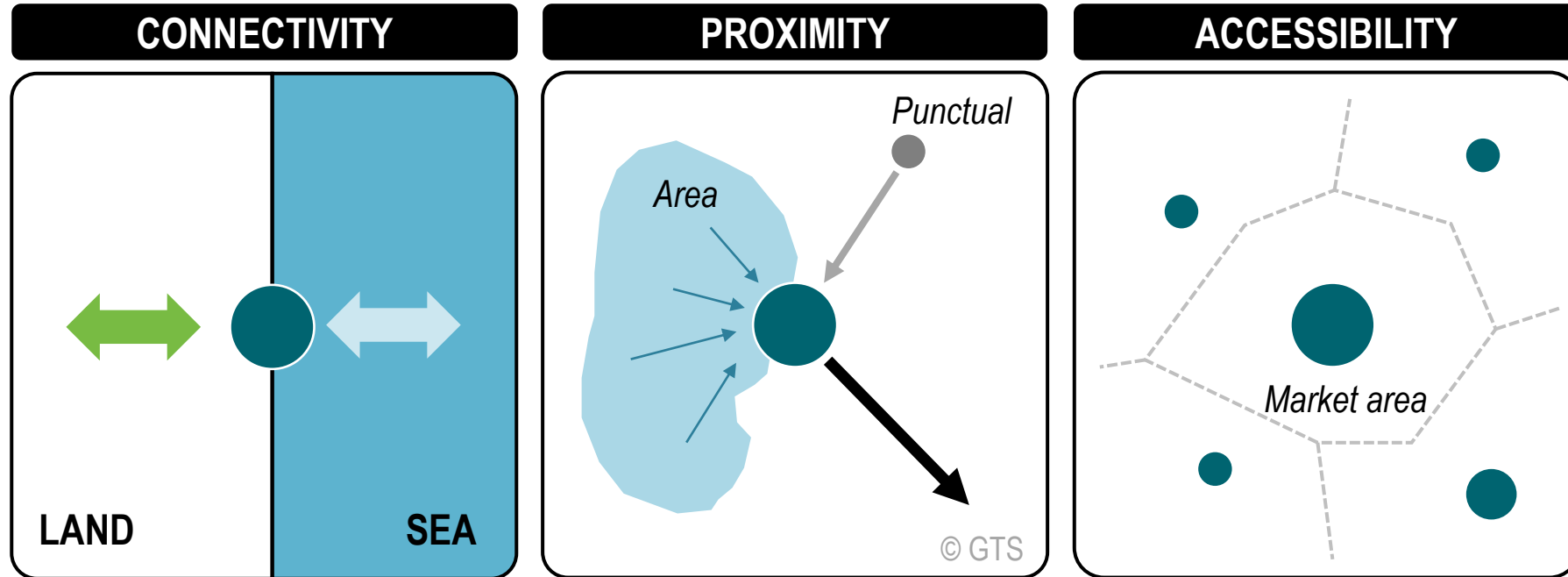
# Traditions in Location Theories

|                                      |  |
|--------------------------------------|--|
| <b>Neo-classical</b>                 | Location subject to free market forces, including transportation costs and competition.  |
| <b>Behavioral</b>                    | Behavior of individual business. Decisions are made with limited information. Sub-optimal location choice.                     |
| <b>Institutional</b>                 | External factors such as values and institutions. Mergers and acquisitions.  |
| <b>Economic base</b>                 | Related to the export industries of a region creating multiplying effects.   |
| <b>Location factors</b>              | Specific location factors. Agglomerations of economic activity. Regional characteristics.                                      |
| <b>Cumulative causation</b>          | Upward spiral where success breeds success (lack of success can lead to a downward spiral).                                    |
| <b>Core-periphery</b>                | Regional functions. Relationships between core regions and peripheral ones.  |
| <b>Industrial districts/clusters</b> | Focus on networks, entrepreneurship, innovation, co-operation, flexible production and specialization.                         |
| <b>Innovative milieu</b>             | Importance of the culture and institutions (synergies among local actors which give rise to fast innovation processes).        |
| <b>Competitive advantage</b>         | Competition between locations subject to factors related to labor, energy, resources, capital as well as proximity to markets. |

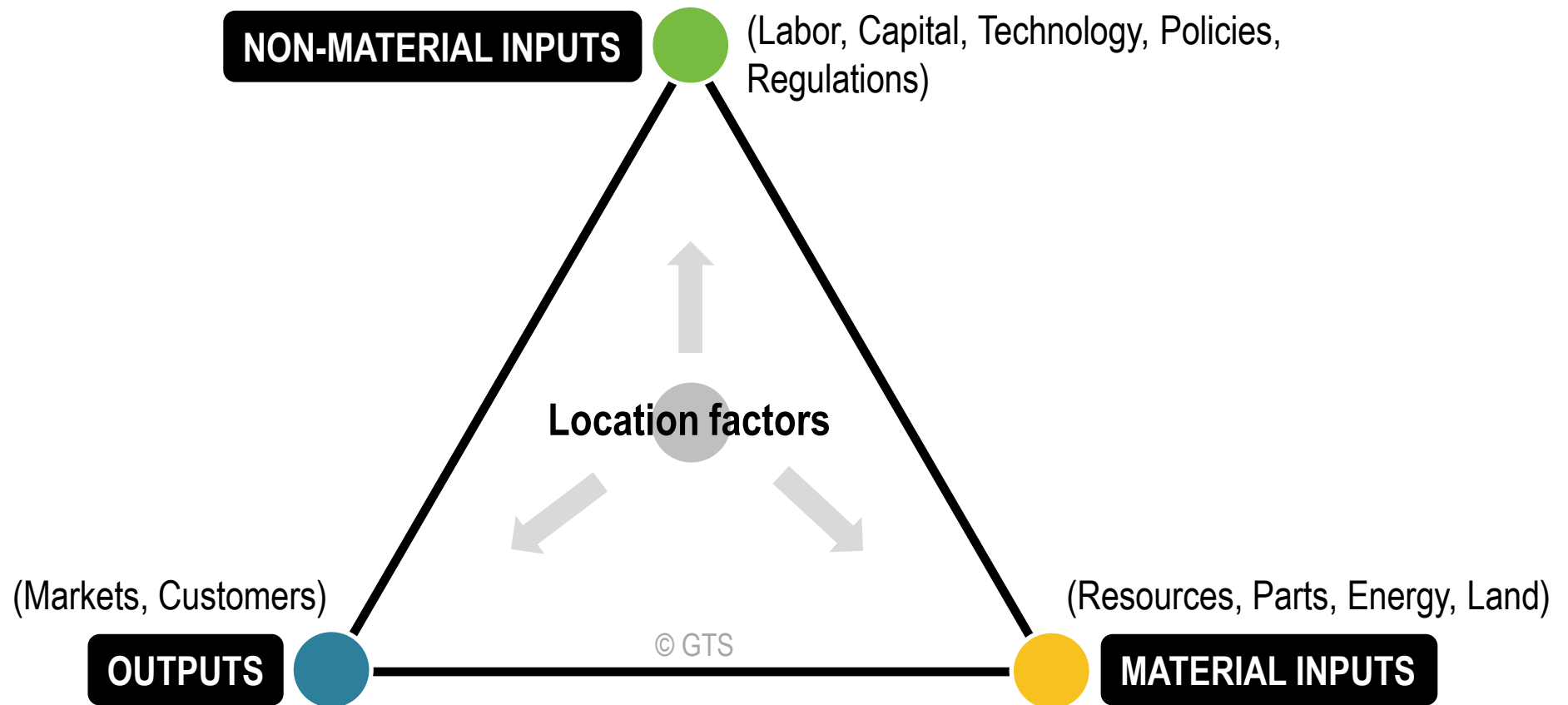
# Historical Urban Location Factors



# Factors in Urban Location

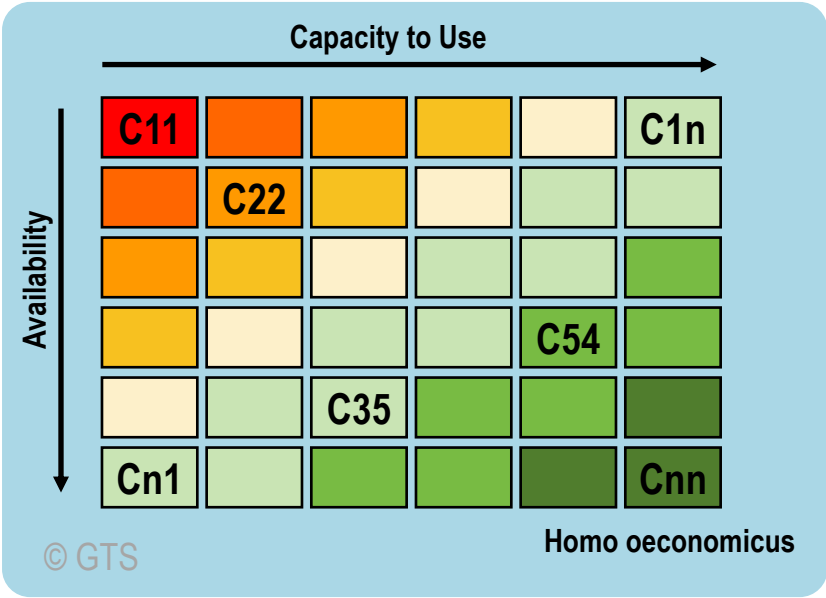


# The Location Spectrum

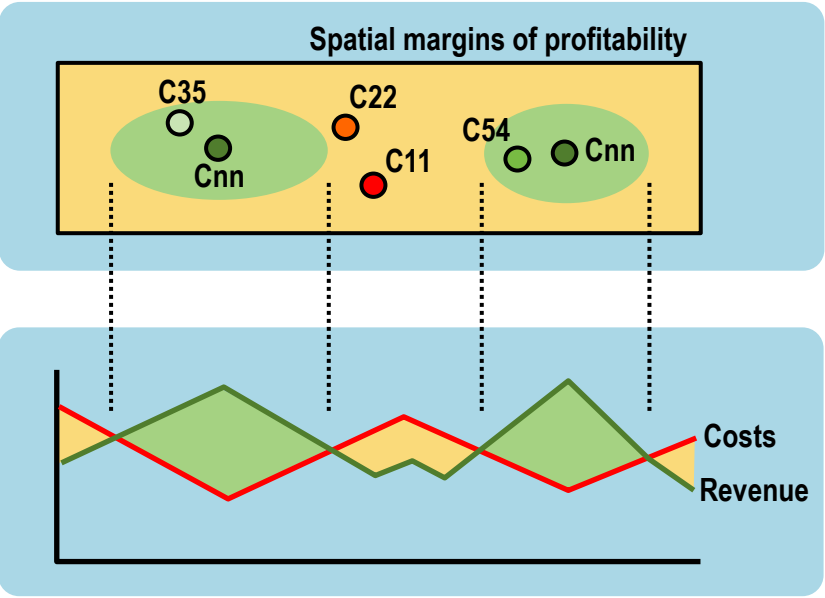


# Behavioral Approach to Location

## INFORMATION

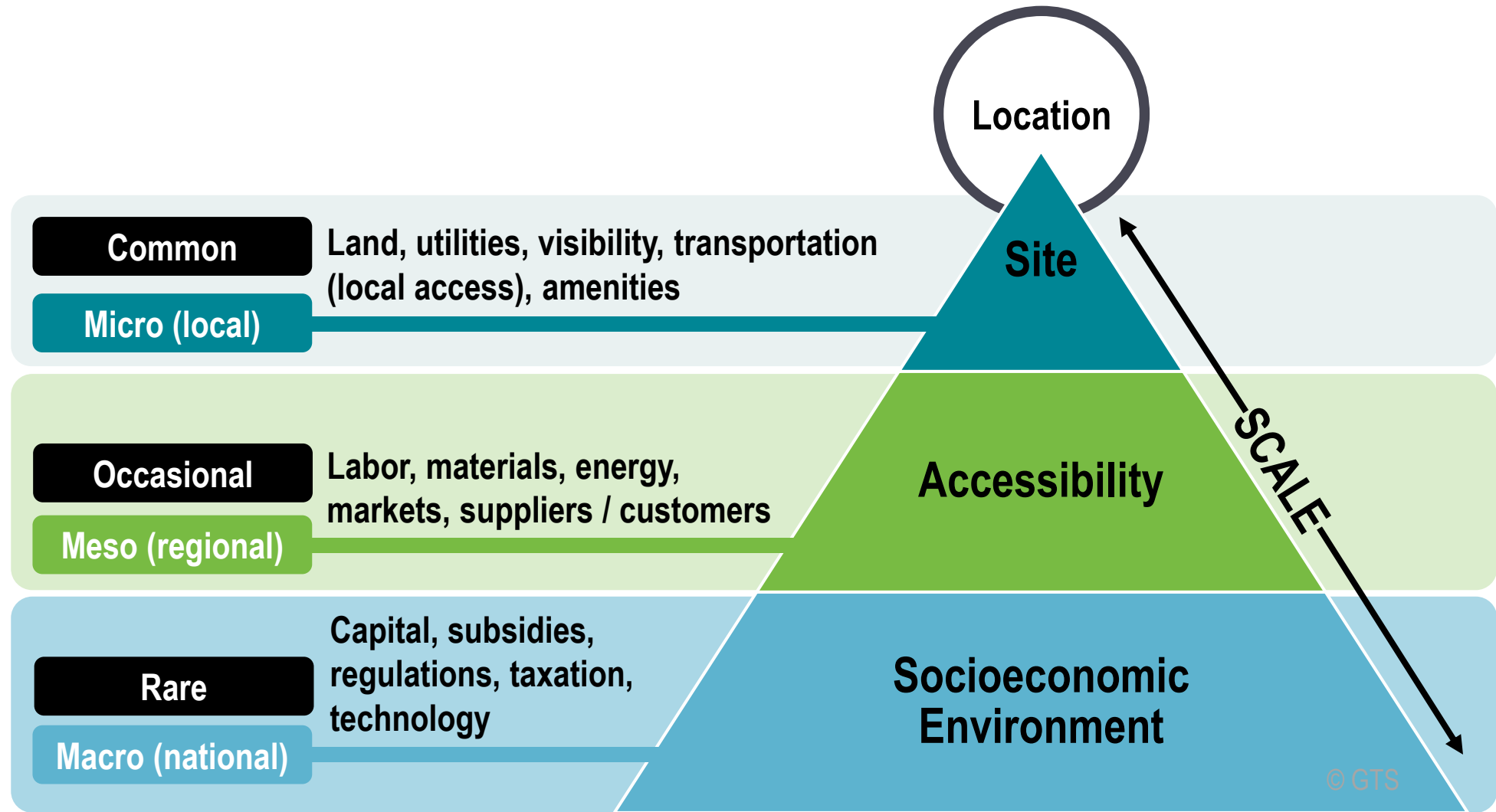


## TERRITORY

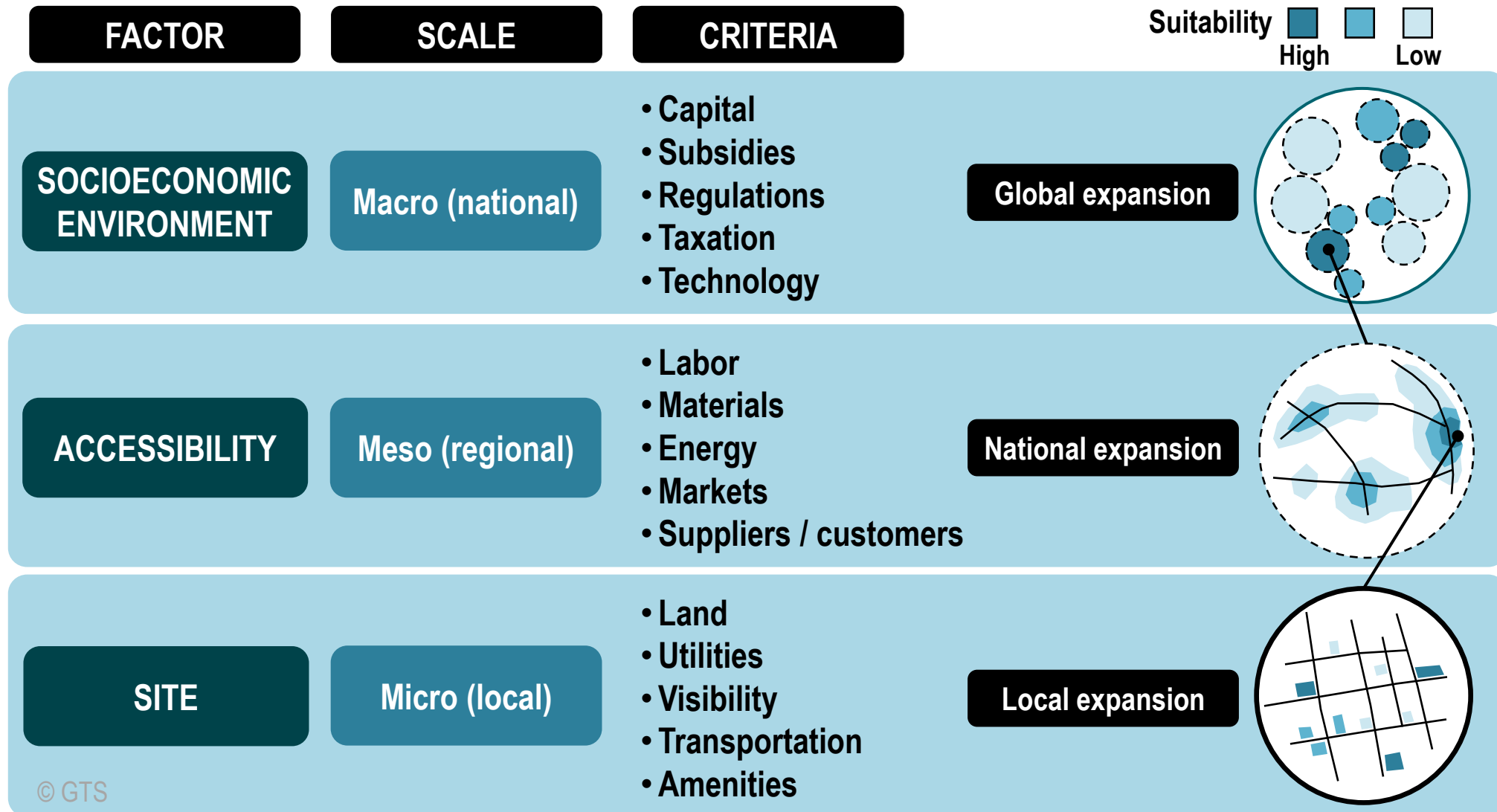


## PROFITABILITY

# Basic Location Factors



# Basic Location Factors

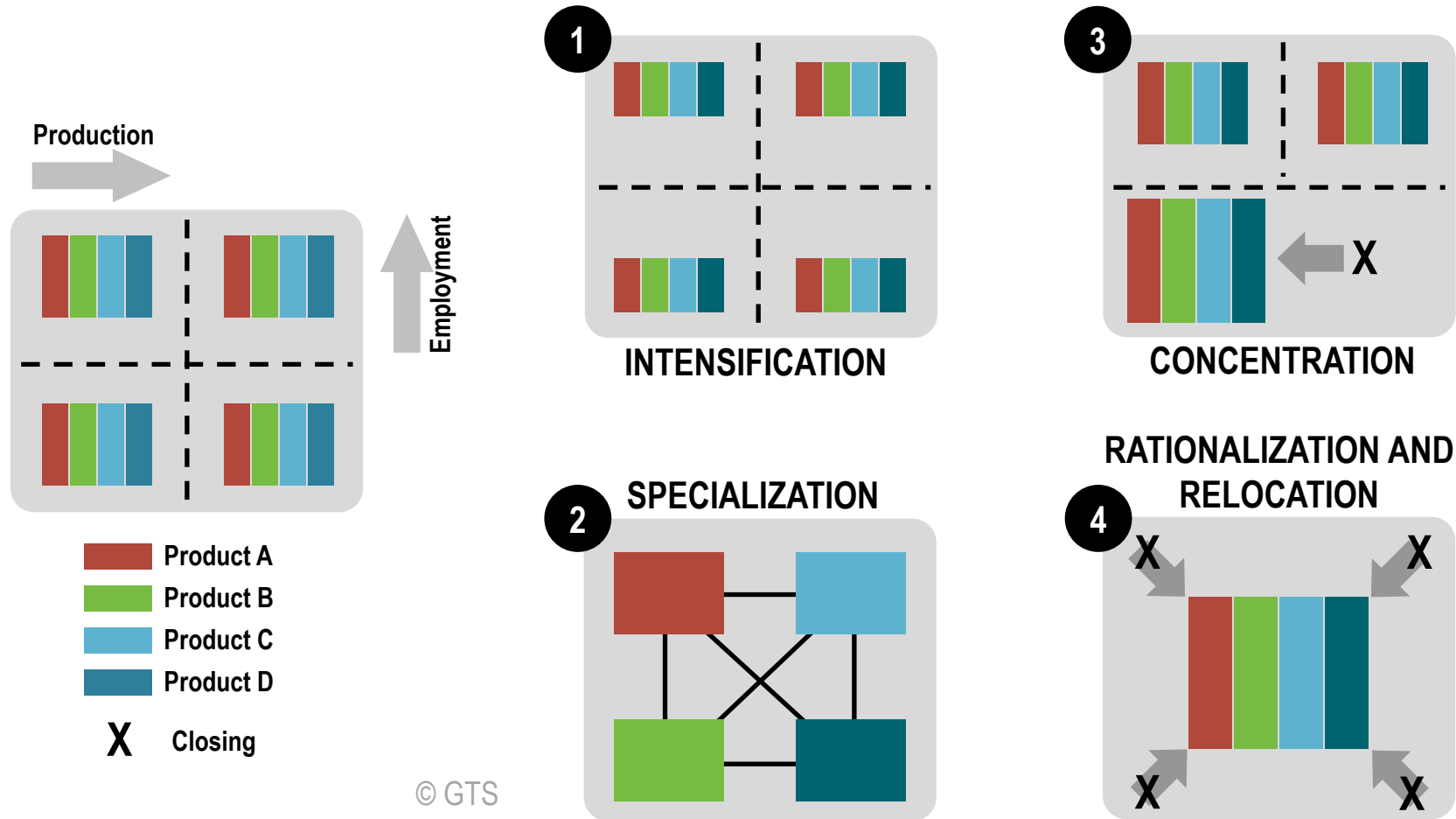




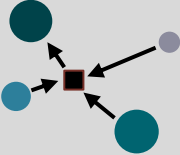
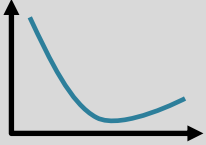


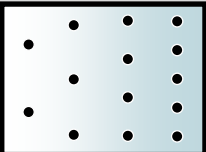
# Factors Affecting Location Decisions (To be updated)

| Country Factors  | Region Factors  | Local Factors  |
|--|---|--|
| <ul style="list-style-type: none"><li>• Government rules, attitudes, political risk, incentives</li><li>• Culture &amp; economy</li><li>• Market location</li><li>• Labor availability, attitudes, productivity, and cost</li><li>• Availability of supplies, communications, energy</li><li>• Exchange rates and currency risks</li></ul> | <ul style="list-style-type: none"><li>• Attractiveness of region (culture, taxes, climate, etc.)</li><li>• Labor, availability &amp; costs</li><li>• Costs and availability of utilities</li><li>• Environmental regulations of state and town</li><li>• Government incentives</li><li>• Proximity to raw materials &amp; customers</li><li>• Land/construction costs</li></ul> | <ul style="list-style-type: none"><li>• Site size and cost</li><li>• Air, rail, highway, and waterway systems</li><li>• Zoning restrictions</li><li>• Nearness of services / supplies needed</li><li>• Environmental impact issues</li></ul> |

# Locational Changes in Manufacturing



# Main Types of Economies in Production, Distribution and Consumption

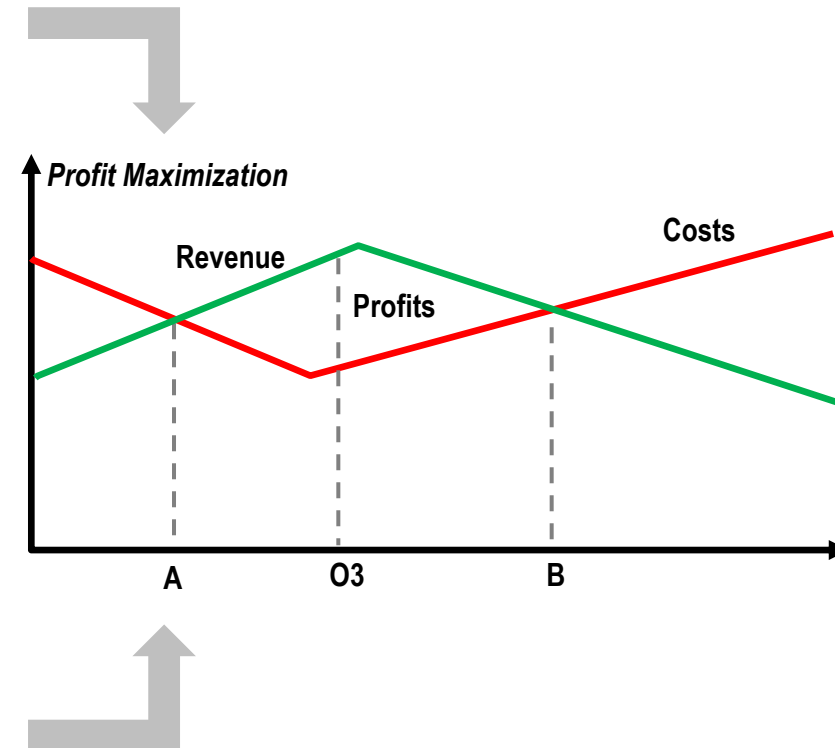
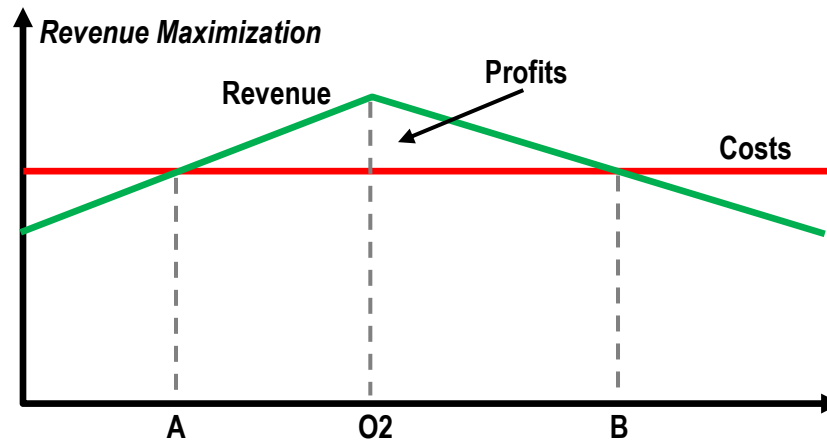
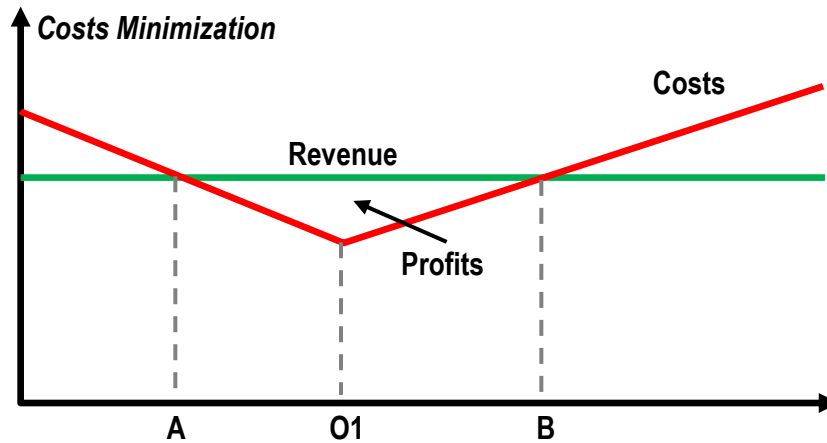
|                                    |   | PRODUCTION  | DISTRIBUTION  | CONSUMPTION  |
|------------------------------------|---|---|---|--|
| <b>Economies of transportation</b> |    | Lower unit costs through accessibility to suppliers and customers | Lower unit distribution costs through transport chains management | Lower unit output costs through accessibility to suppliers and customers |
| <b>Economies of scale</b>          |    | Lower unit costs with larger plants                               | Lower unit transport costs through larger modes and terminals     | Lower unit costs with larger retail outlets                              |
| <b>Economies of scope</b>          |    | Lower unit output costs with more product types                   | Lower transport costs with bundling of different loads            | Product diversification attracts more customers                          |
| <b>Economies of agglomeration</b>  |   | Industrial and service linkages with manufacturing clusters       | Lower input costs with clustering of distribution activities      | Lower input costs with clustering of retail activities                   |
| <b>Economies of density</b>        |  | Increased accessibility to labor (skills) with higher densities   | Lower unit distribution costs with higher densities               | Increased accessibility to goods and services with higher densities      |

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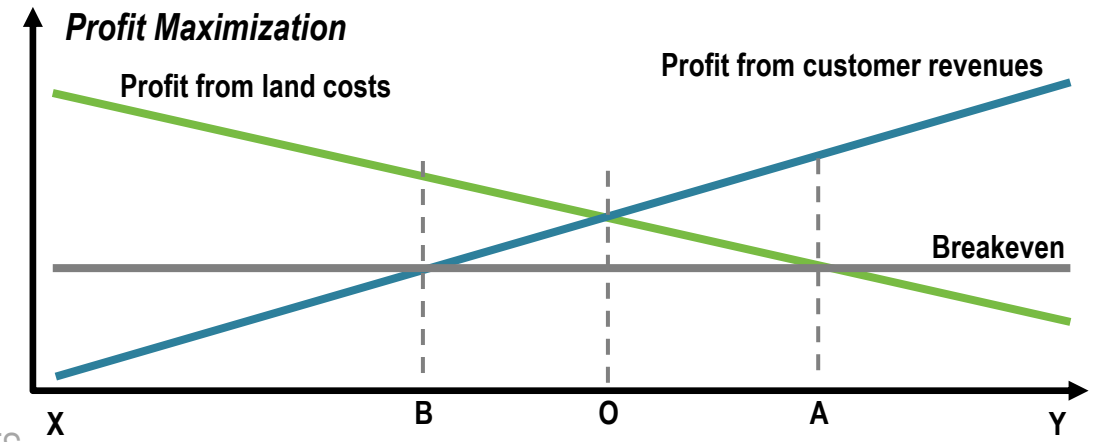
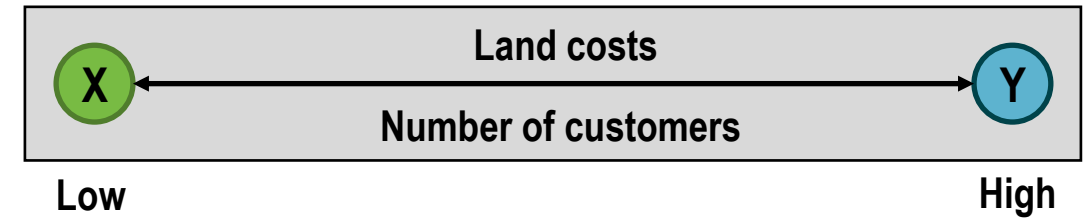
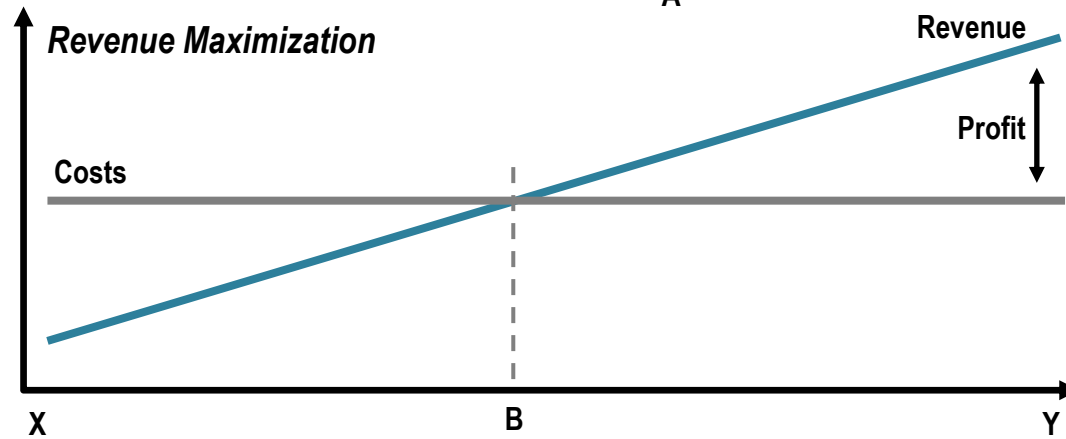
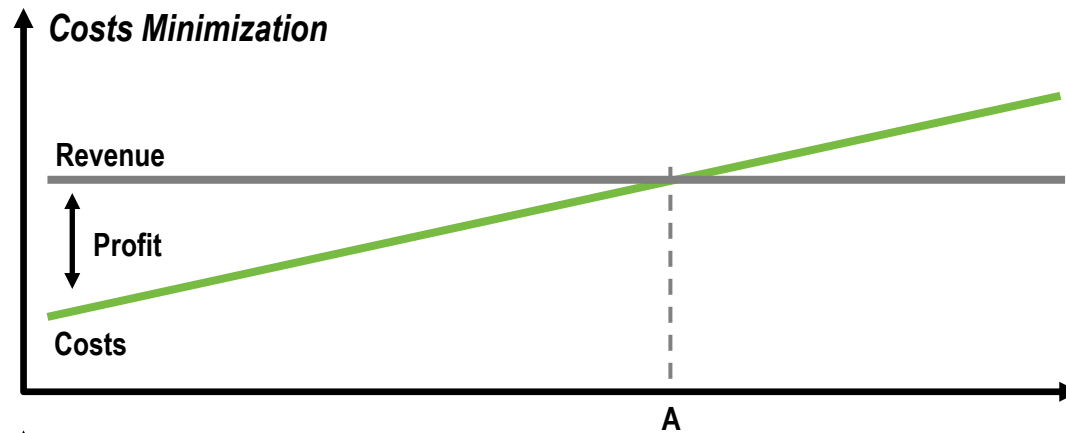
# Main Location Factors for Distribution Activities

| Influences                                 | Factors  |
|--|--|
| <b>Production and transport economics</b>  | <ul style="list-style-type: none"> <li>• Relative availability and cost of land and labour at port or inland location</li> <li>• Danger of diminishing returns such as congestion, energy and empty movements.</li> </ul>  |
| <b>Capacity and congestion</b>             | <ul style="list-style-type: none"> <li>• Congestion in the port and access infrastructure.</li> <li>• Quality and capacity of hinterland connections.</li> <li>• Availability of inland distribution centres, custom clearance, container depots and logistics facilities.</li> </ul>  |
| <b>Market structure and trade strategy</b> | <ul style="list-style-type: none"> <li>• Trade structure of the region: physical geography, resource endowment, centrality/ intermediacy, mix of foreign and locally sourced inputs, regional specialisations, history of the region.</li> <li>• Degree of vertical cooperation and integration between port and inland transport operators</li> <li>• Strong port competition driving new initiatives to extend their cargo base, either by securing hinterlands or by anchoring tenants at the port.</li> </ul>    |
| <b>Supply chain management</b>             | <ul style="list-style-type: none"> <li>• Supply chain strategy of local shippers and distributors (e.g. push vs pull, high or low inventory, primary/secondary distribution needs). Integration of inland terminals within supply chain management practices (e.g. acting as stock buffers).</li> <li>• Dominance of merchant vs carrier haulage in the region.</li> <li>• Economic development strategies of public sector agencies leading to favourable land use policy, zoning, financial incentives.</li> </ul> |
| <b>Policy and regulation</b>               | <ul style="list-style-type: none"> <li>• Policies related to foreign trade zones and customs procedures.</li> <li>• Cargo safety and security procedures.</li> </ul>   |

# Basic Location Strategies

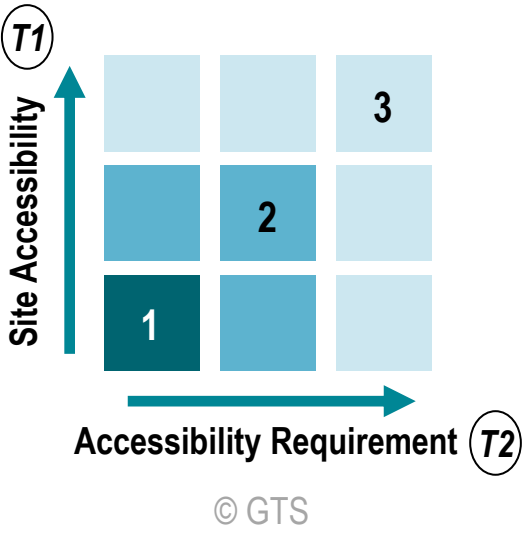
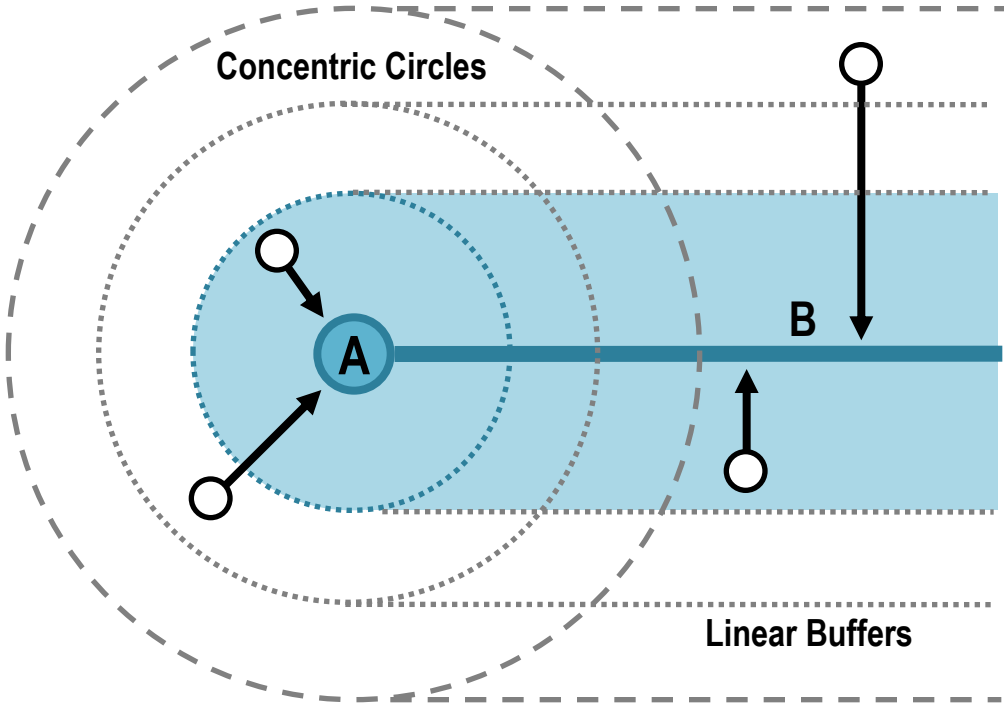


# Basic Location Strategies

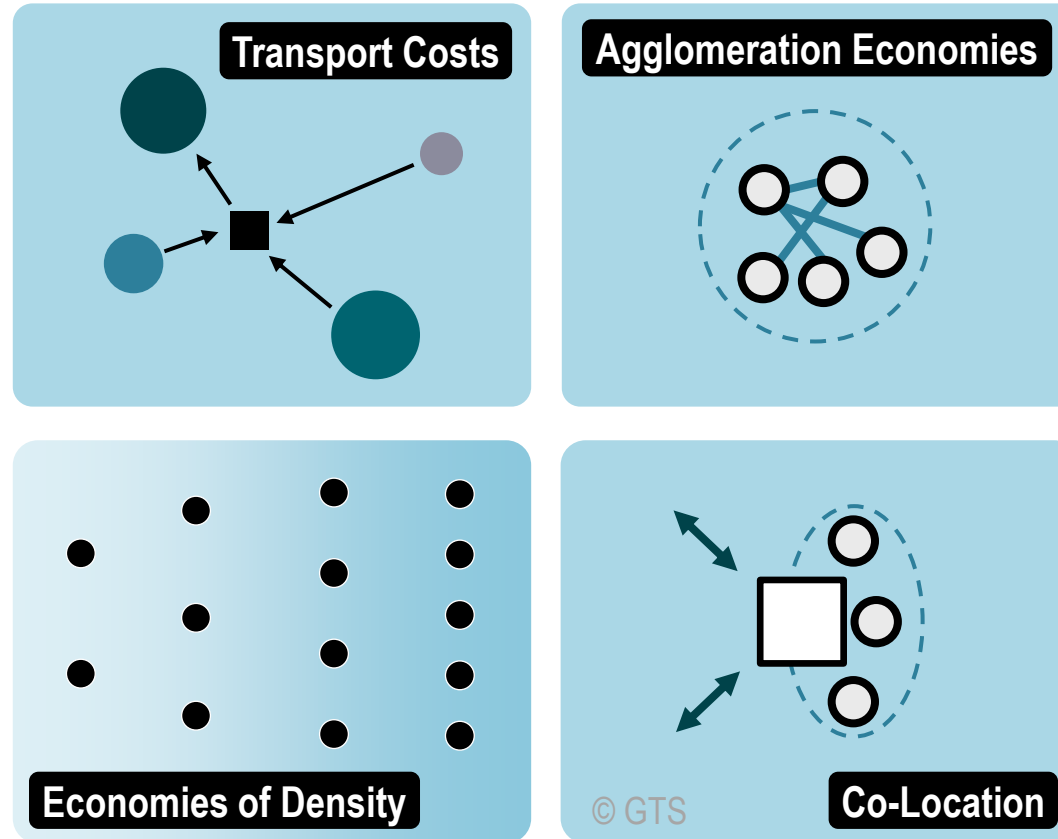


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# Accessibility and Location

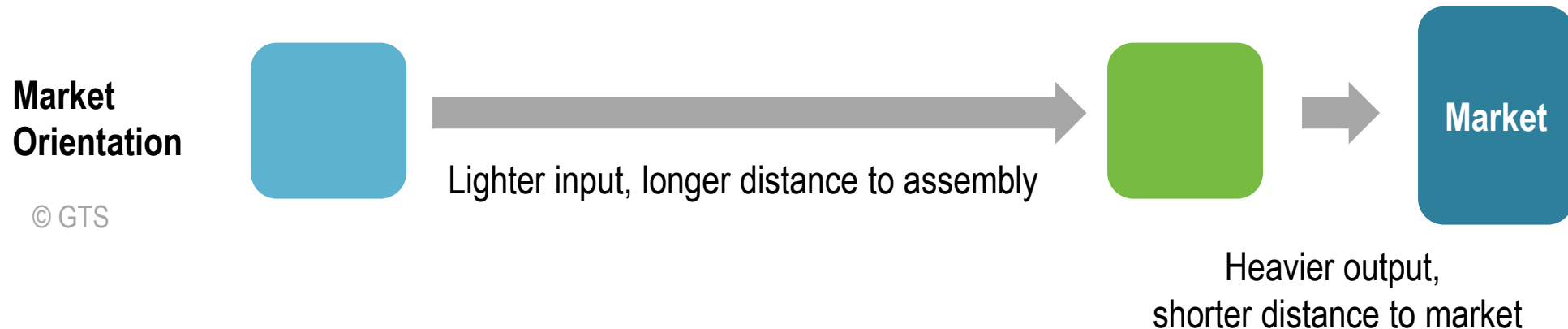
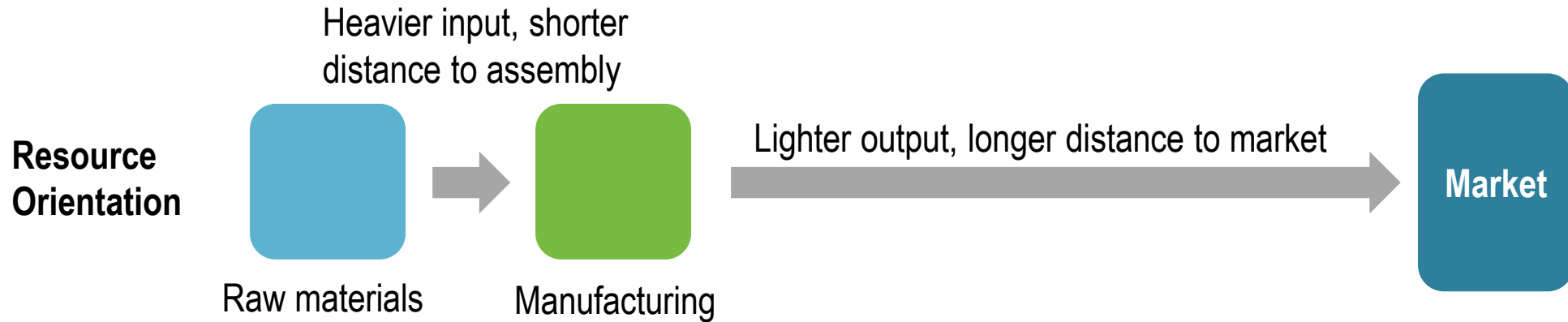


# The Four Main Locational Influences of Transportation



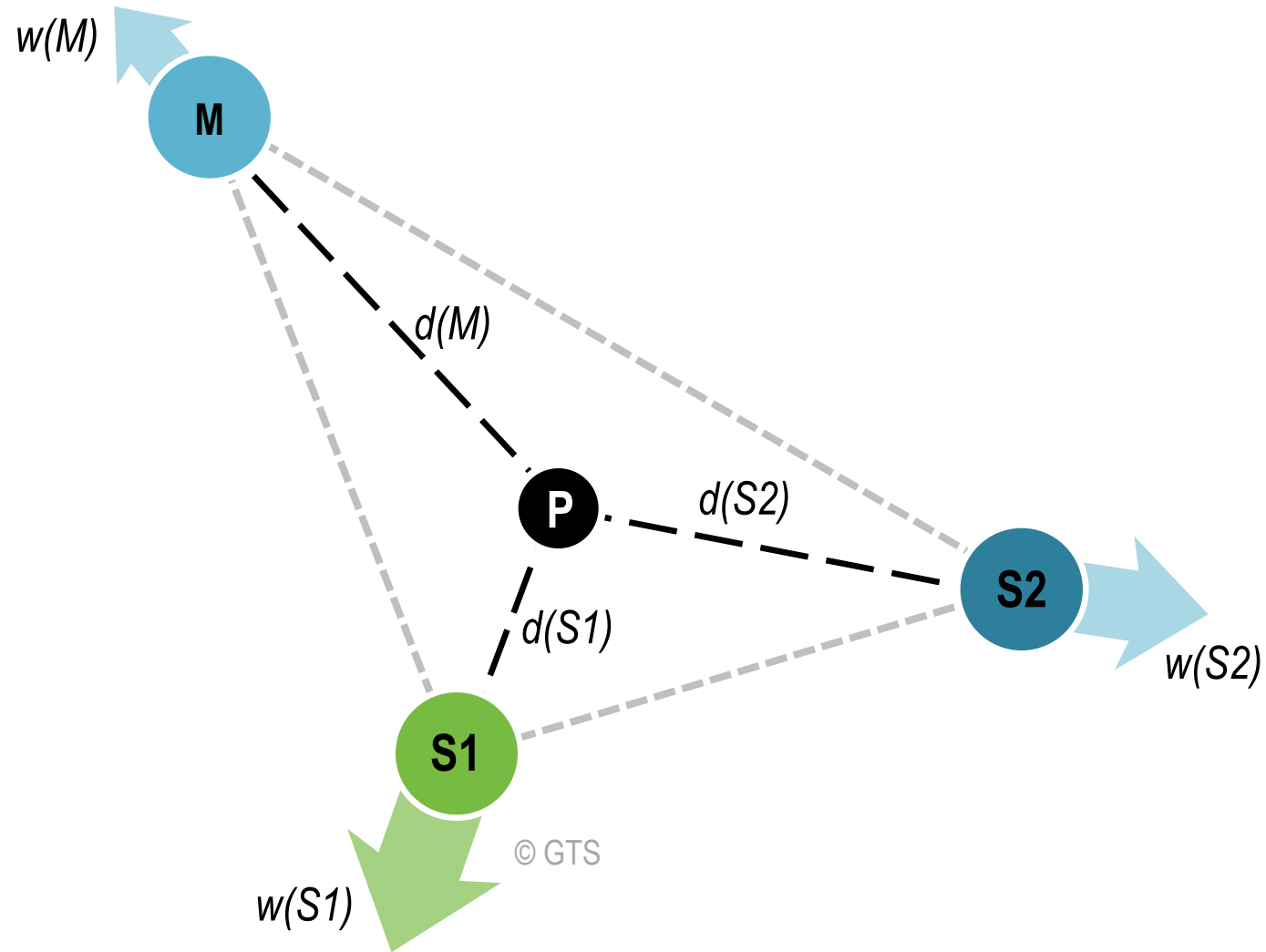


# Resource and Market Orientation

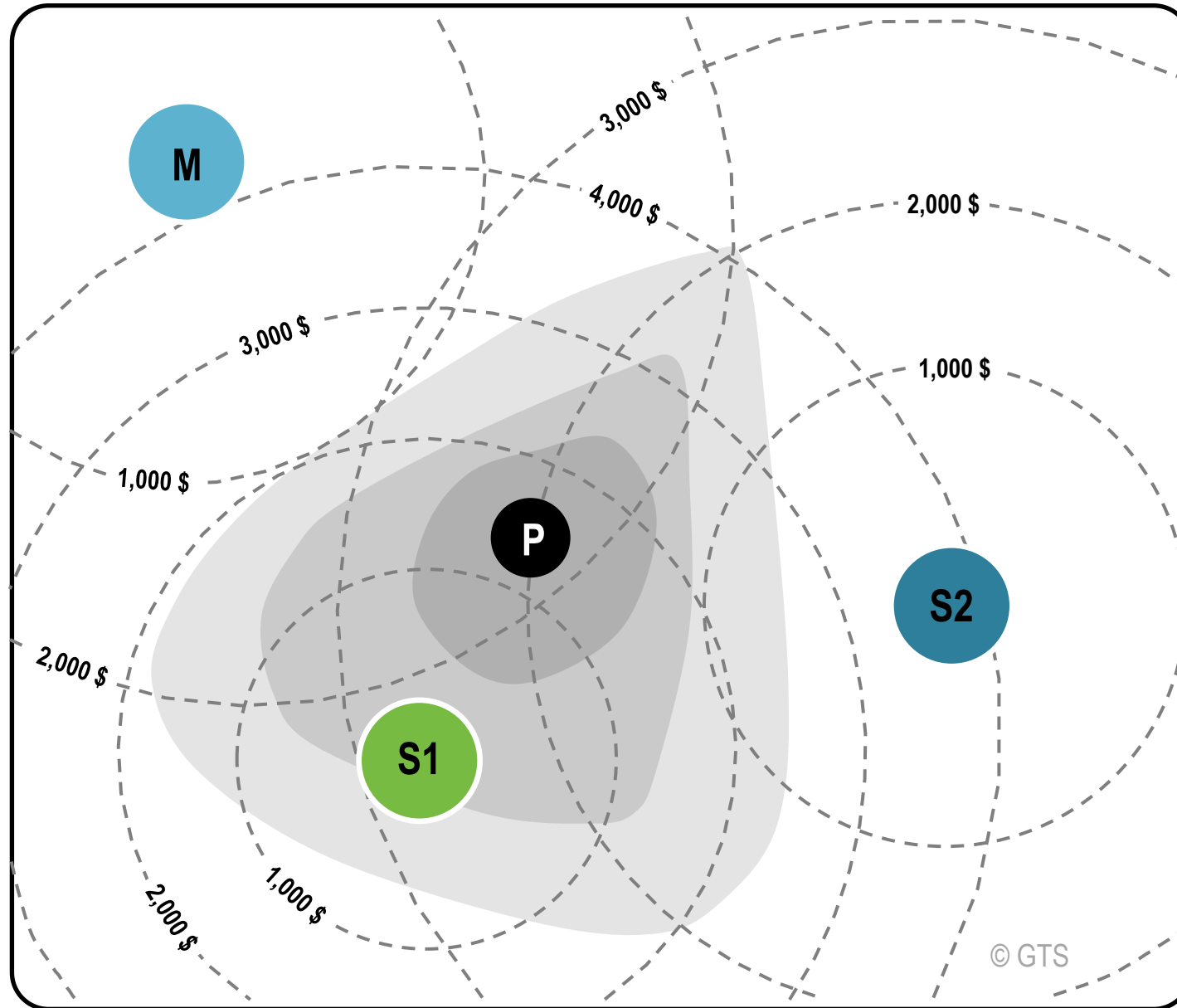


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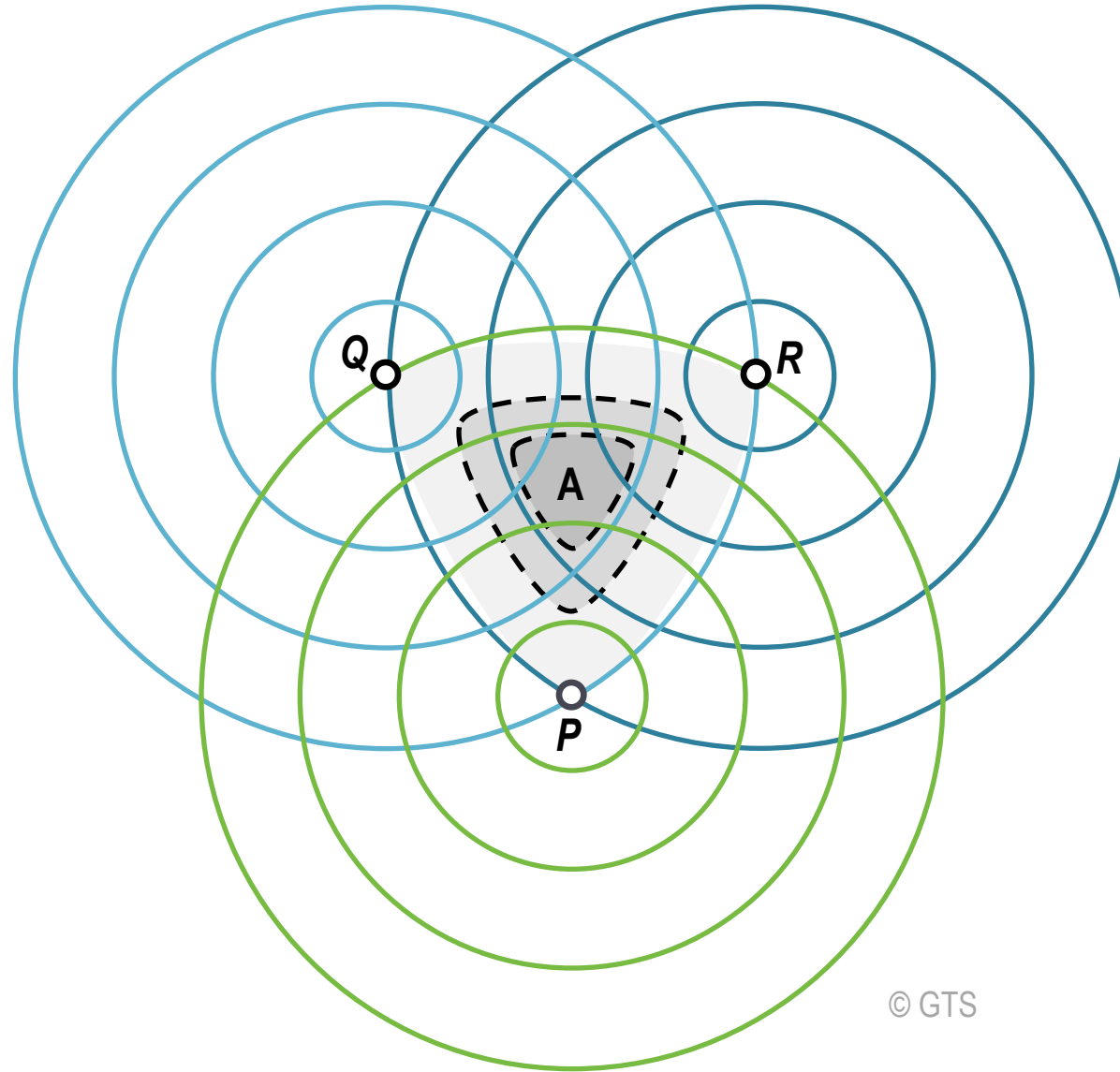
# Weber's Location Triangle



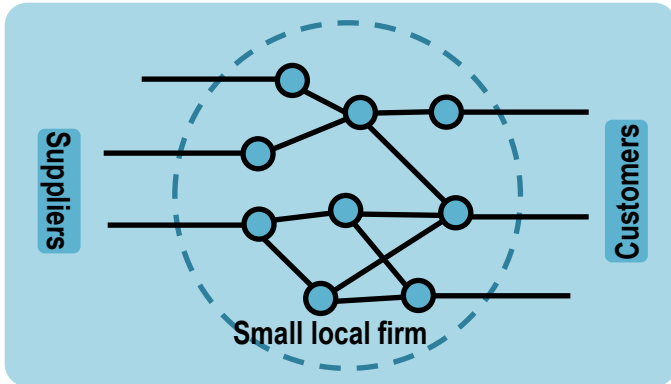
# Transport Costs Surfaces and Location



# Economies of Agglomeration

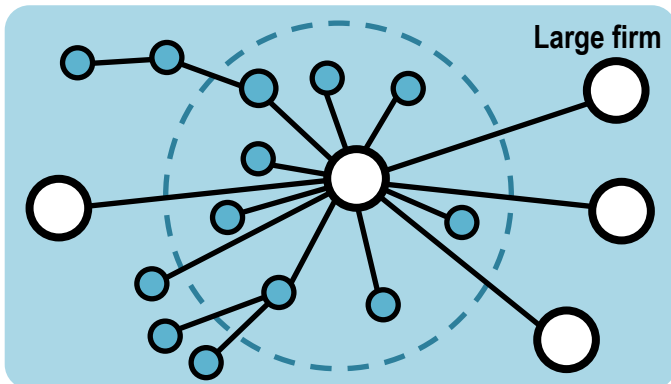


# Types of Manufacturing Clusters



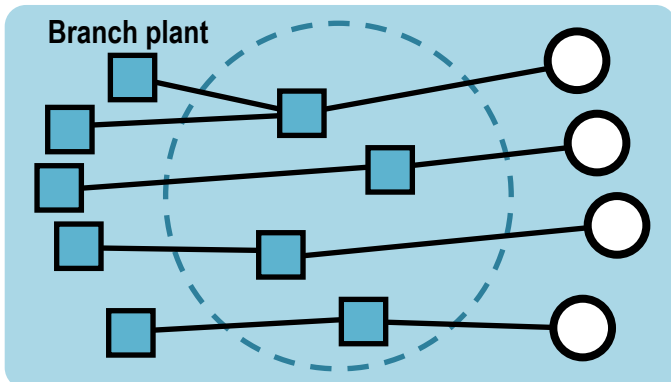
## MARSHALLIAN INDUSTRIAL CLUSTER

- Small and medium-sized firms mostly locally owned.
- Temporal development of skills and techniques around a specialization.
- High level of inter-firm competitiveness and complementarity.
- Enduring through time (proto-industrialization, industrial revolution, global economy).



## HUB-AND-SPOKE CLUSTER

- Large driving firm(s) with several suppliers and service providers.
- Economies of scale allowing large outputs.
- Cooperation by driving firm(s).
- Late industrial revolution and with Fordism.



## SATELLITE PLATFORM CLUSTER

- Medium and large-sized branch plants and distribution centers.
- Transport and market accessibility.
- Limited cluster interactions (internal to the supply chains of each plant).
- Globalization, outsourcing and offshoring.

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**Technology Clusters**

**Manufacturing Clusters**

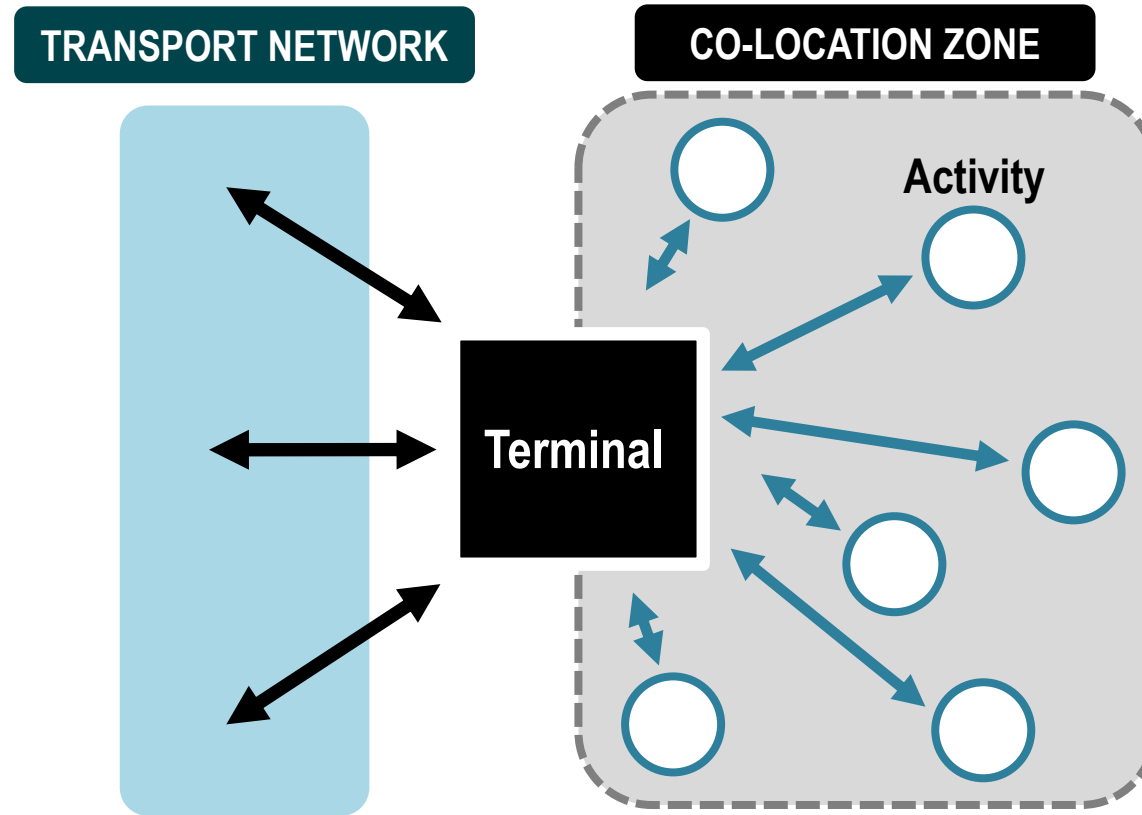
**Resource Clusters**

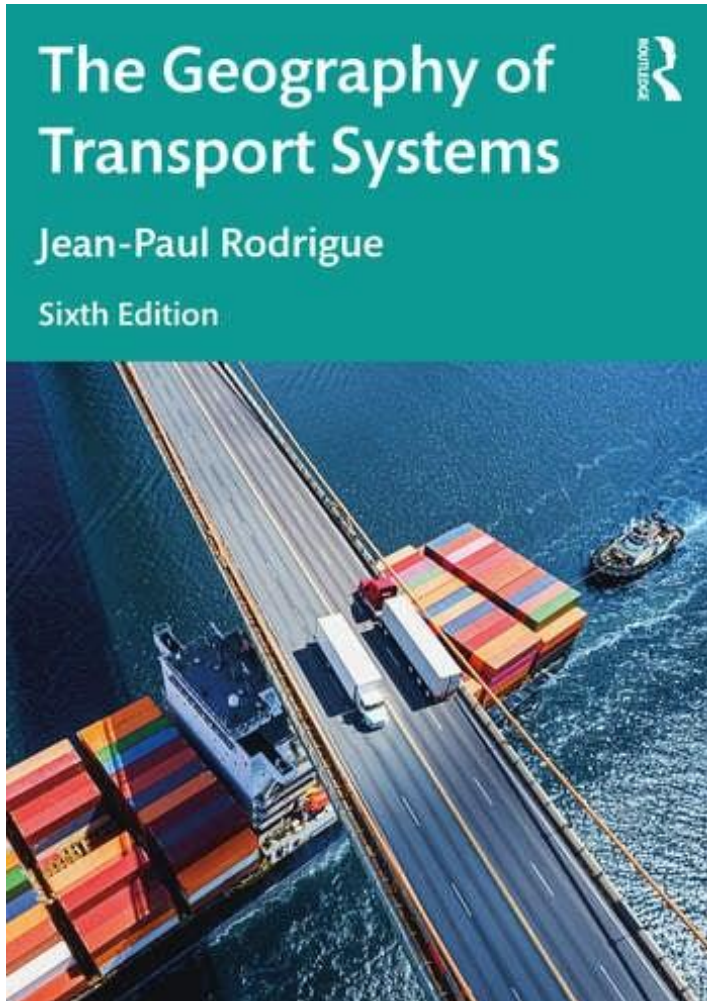
**Logistics Clusters**

**Producer Service Clusters**

**Retail Clusters**

# Transport and Co-Location





# Information Technologies and Mobility

## Chapter 2.4



# Organizational Forms in Human Societies



## **Agricultural (First Wave)**

- Hierarchy based on heredity
- Feudal structures



## **Industrial (Second Wave)**

- Vertically oriented bureaucracies
- Democratic representation



## **Information (Third Wave)**

- Networked bureaucracies
- Multilateral consensus

# Global Media Systems



## Newspapers

**1630s**

Emerged with the printing press and movable types (17th century). Many specializations (general and financial).



## Radio

**1920**

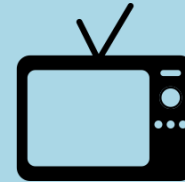
Media access to the private home. First radio shows: to sell radios and consumer goods (“soap operas”). Rapid diffusion of news / portable.



## Magazines

**1730**

Periodicals (weekly, monthly) focusing on specific topics (events, politics, people, fashion, technology).



## TV / Cable

**1945 / 1980**

Visual access to the private home. Richer content. Specialization of channels (cable).



## News agencies

**1835**

Provide news to the media (Reuters, Bloomberg, Associated Press, Agence France Presse).



## Internet

**1990**

Global digital information exchange. Media-rich environment. Video streaming (1995) and video on demand (1998).



## Movies

**1910**

“Theatre for the masses”. Quick and low-cost diffusion of entertainment. Current news (pre-shows).



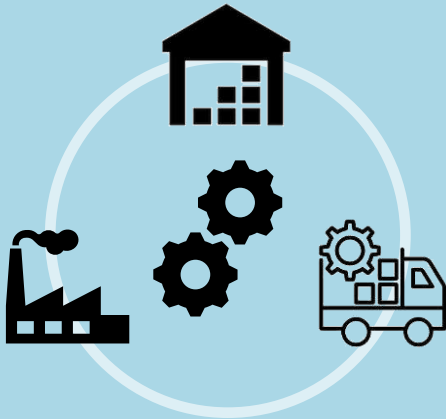
## Cell phones / Smartphones

**1983 / 2001**

Portable telecommunication / Portable media access. Multifunctional device (camera, recorder, GPS).

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# Paradigms of the Dematerialization of the Economy



## PLATFORM CORPORATION

- Focus on core competencies.
- Outsourcing low added value activities.

*Apple focuses on product design and retailing (Apple Store). Relies on a massive network of original equipment manufacturers.*



## E-COMMERCE

- Lessen the footprint of retail stores.
- Developing a network of distribution centers.

*Amazon owns a network of e-fulfillment centers (distribution centers) processing large volumes of cargo (orders). It also operates parcel delivery services.*



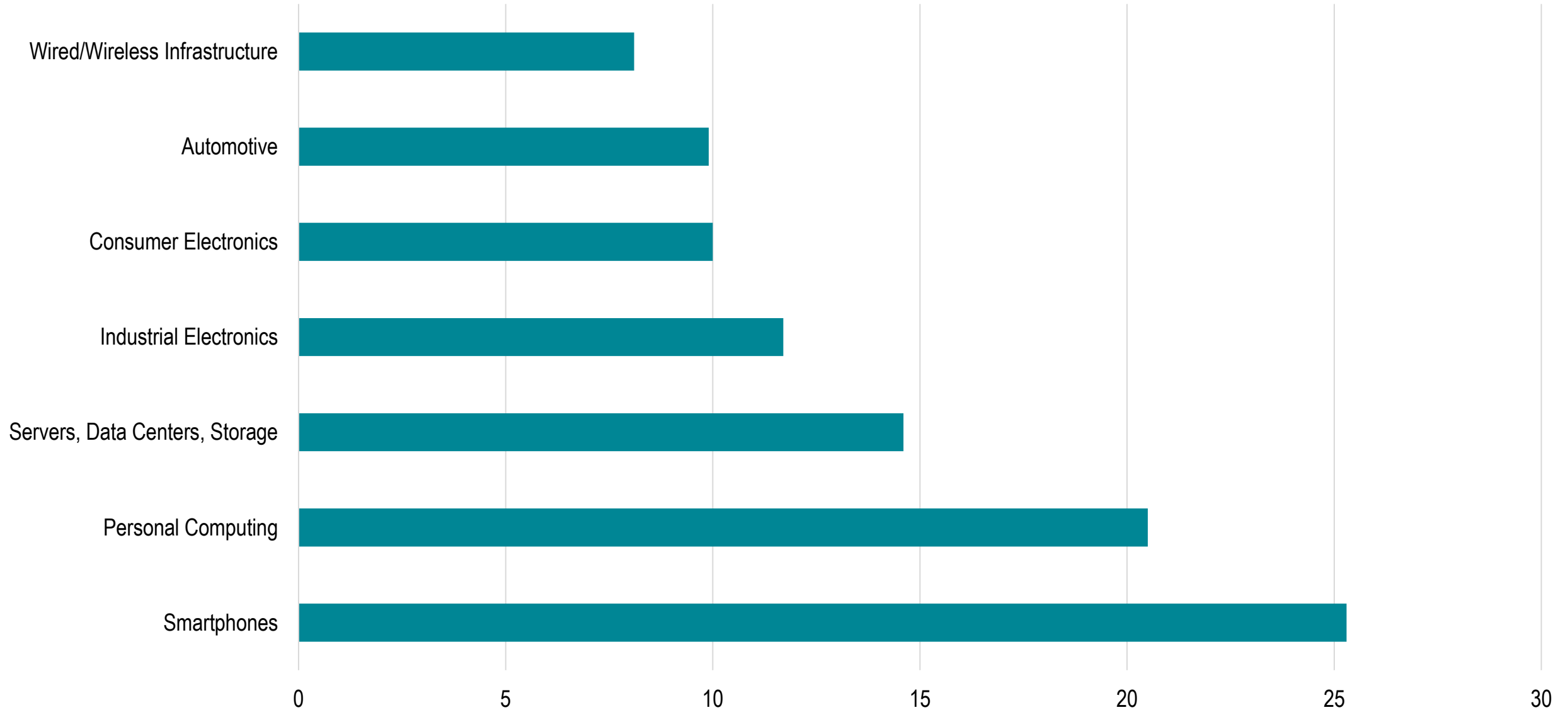
## ASSET MANAGEMENT

- Manage existing assets more efficiently.
- Developing platforms connecting the supply and demand of services.

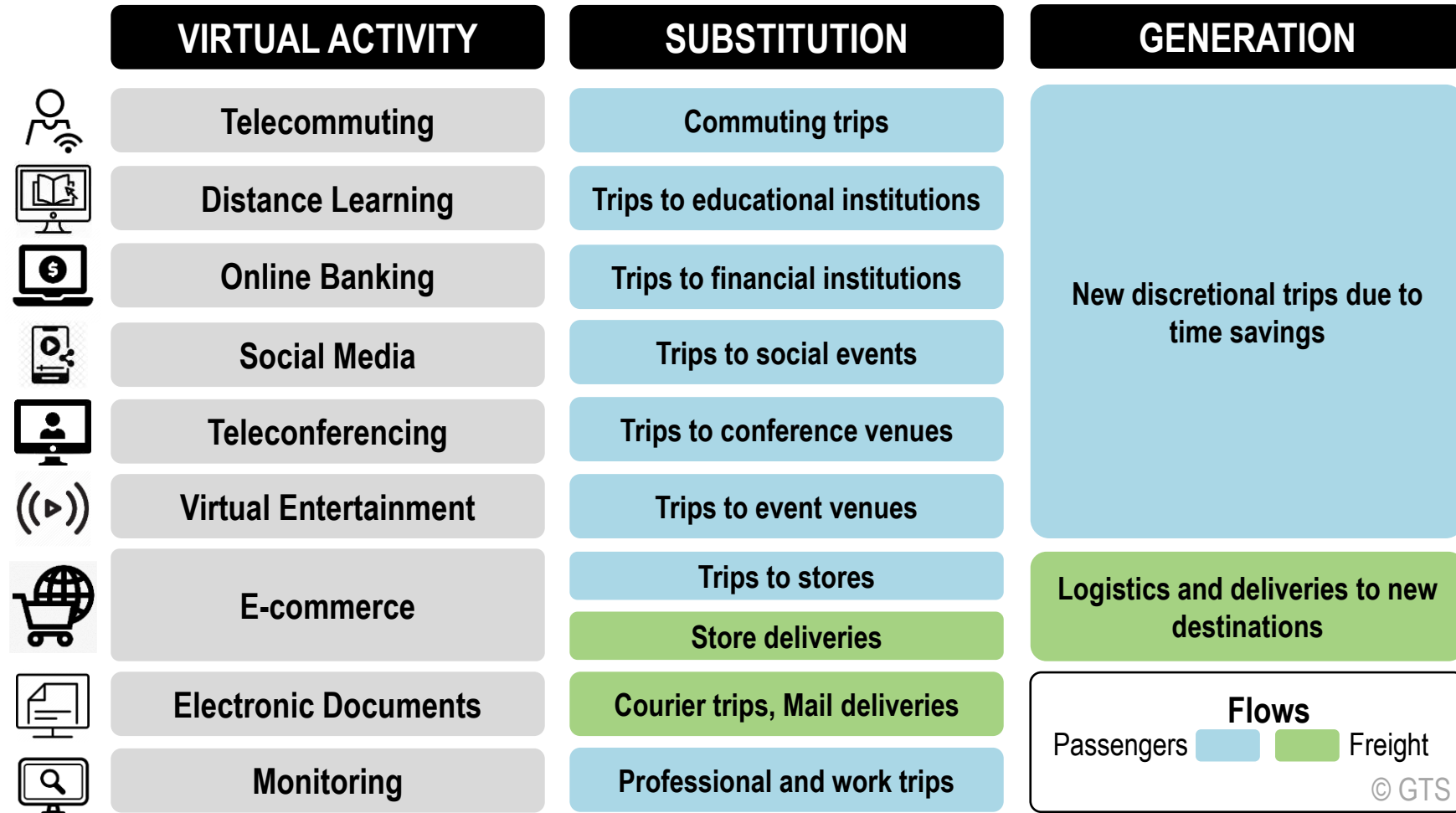
*Uber links users with individual car owners willing to provide a taxi service. Airbnb links users with property owners.*

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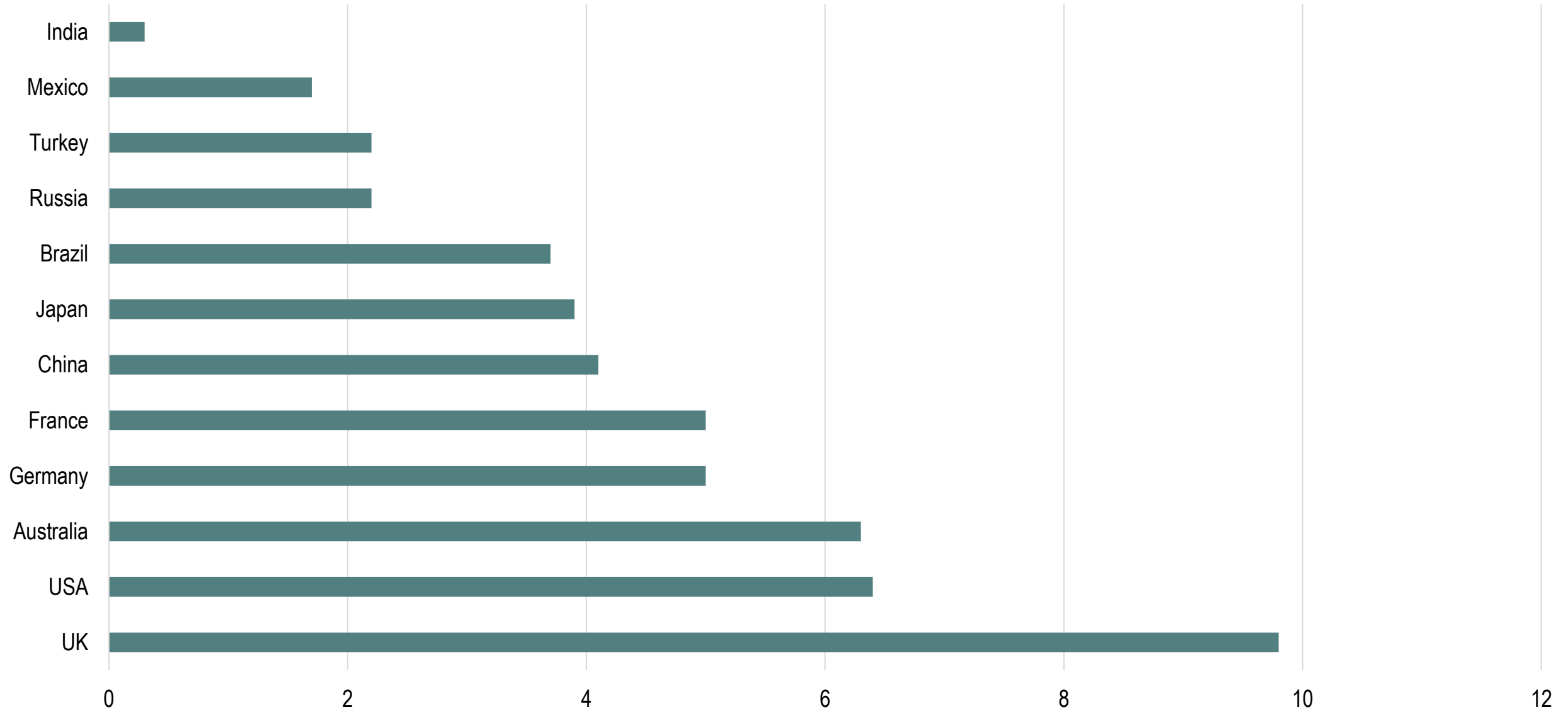
# Main Semiconductors Application Markets, 2019



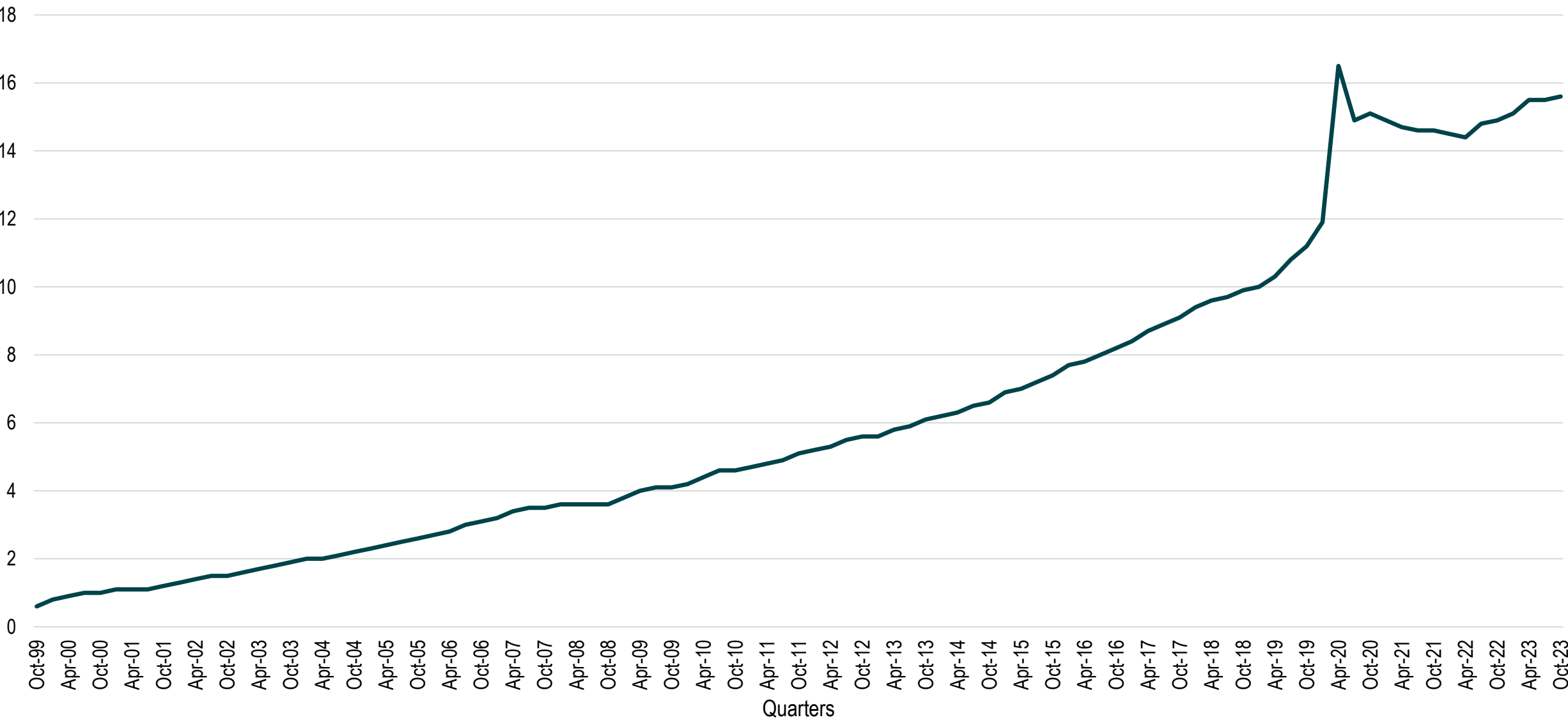
# The Substitution and Generation Effects of Information Technologies on Mobility



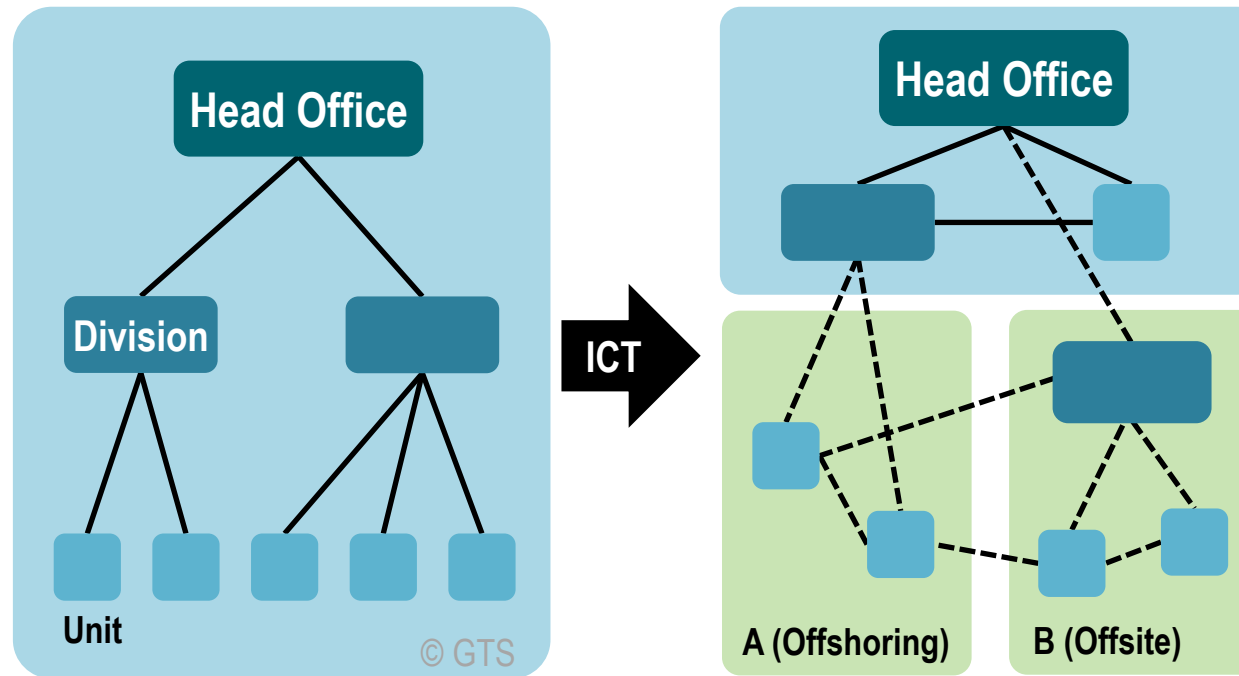
# Online Retail Sales as Share of Total Retail Sales, 2012



# E-Commerce Retail Sales as a Percent of Total Sales, United States

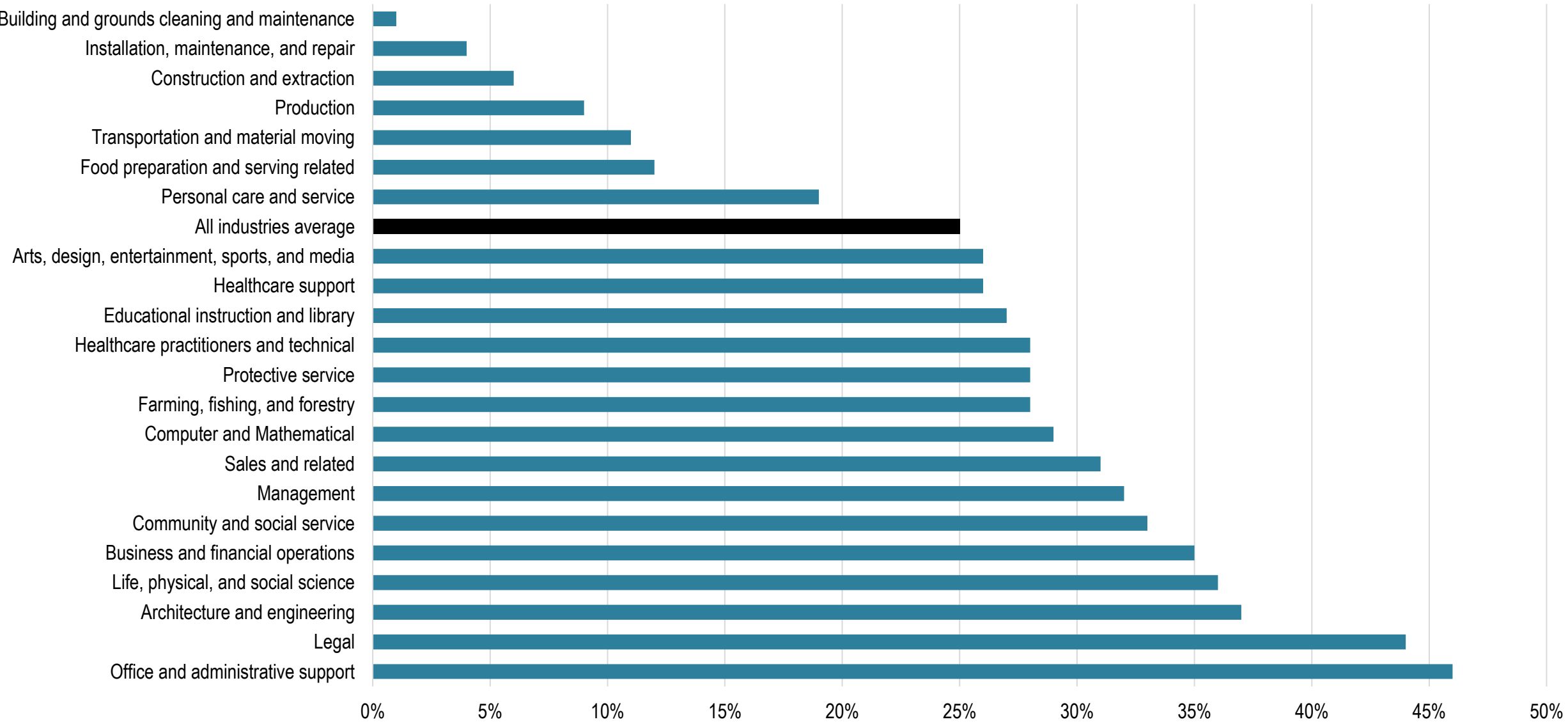


# Information Technologies and the Corporate Structure

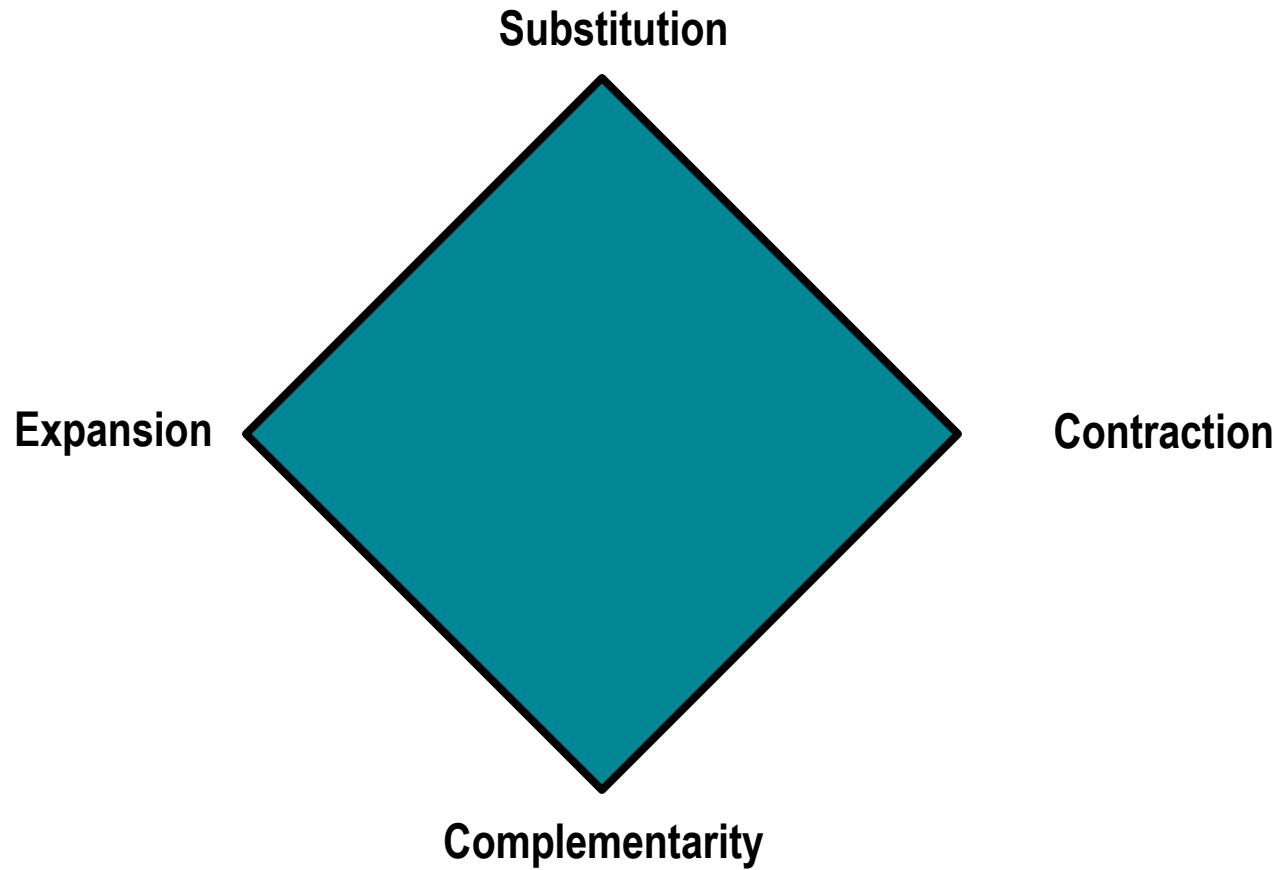




# Estimated Share of U.S. Employment Exposed to AI



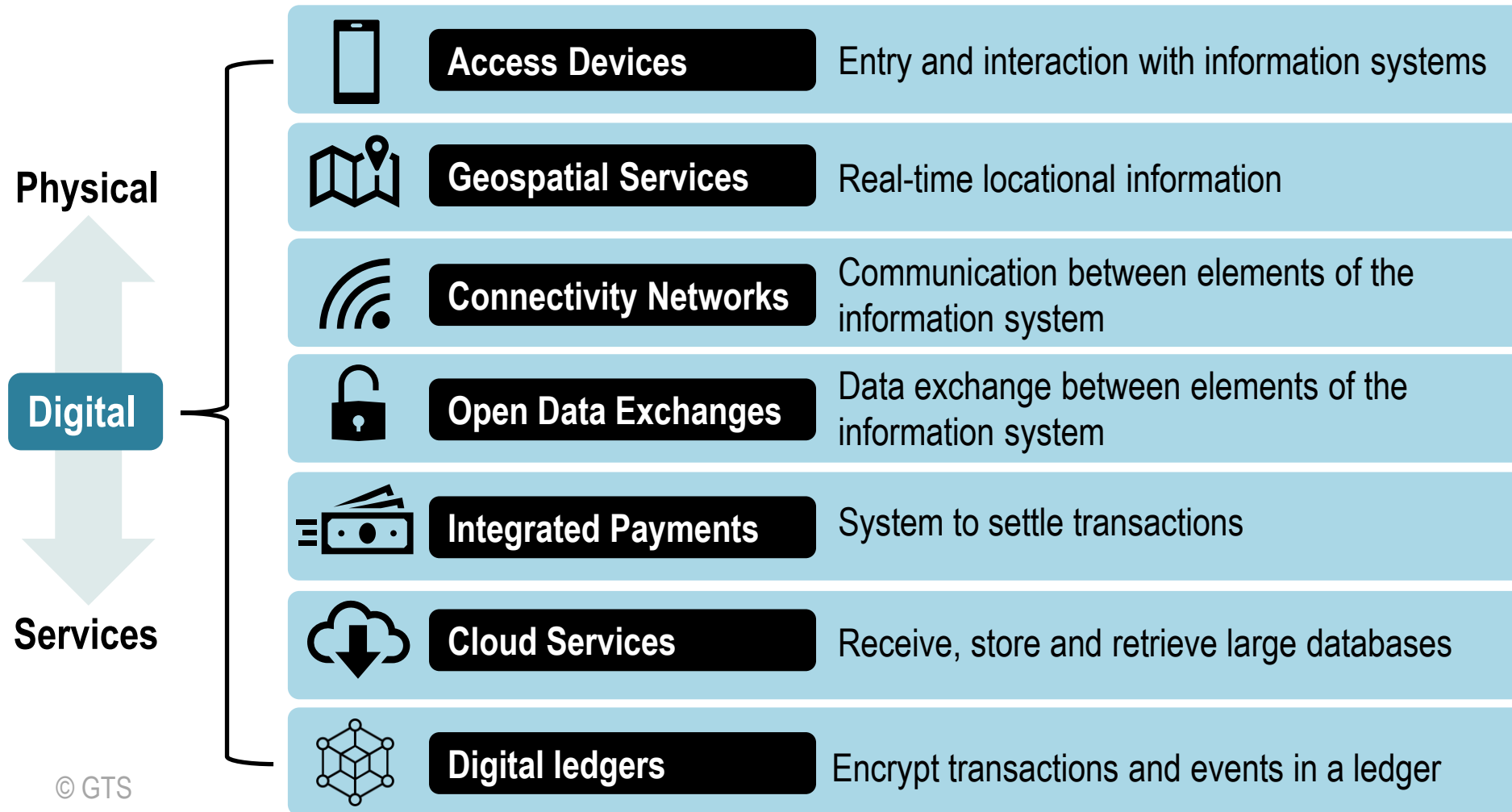
# Possible Impacts of ICT on Mobility (under construction)















# Factors behind the Impacts of ICT on Mobility Mitigation

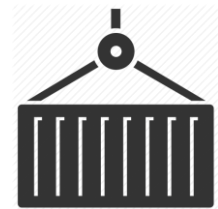
|   |   |
|---|---|
| No ICT counterpart                        | Mobility cannot be substituted. Mandatory co-location.        |
| No practical or desirable ICT counterpart | Mobility can be substituted, but outcome much less practical. |
| Positive utility of mobility              |   |
| ICT not a replacement for travel          |   |
| Time and cost substitution                |   |
| Cheaper mobility                          |   |
| Efficiency improvements                   |   |
| Travel productivity                       |   |
| Additional travel demand                  |   |
| Globalization                             |   |
| Decentralization                          |   |

# The Digitalization of Mobility



| “X-pooling”   |   | “X-hailing”   |   | “X-sharing”  |  |
|---|---|---|---|--|--|
| Bus-pooling   | Vanpooling  | Ride-hailing/<br>Ride-sourcing  | e-hailing   | Sharing of vehicles  | Ride sharing   |
|    |  | <br><br>   |  |  <br>  | <br> |
| On-demand operation of bus-like services but using dynamic routing in buses or vans owned by the platform with sharing of the space inside the vehicle by passengers. |   | On-demand operation of taxi-like personal transport directly from origin to destination. The service comes with a driver, either through privately-owned vehicles that connect to the platform (ride-hailing/ride-sourcing), or through official taxi services that are enabled by digital platforms (e-hailing). |   | <p>Shared access to vehicles which can either be owned by the platform, or by individual owners that share such assets.</p> <p>In addition, “rides” can also be shared, wherein vehicle trips (activity-based) which would have happened anyway (i.e. from A to B) are shared with other users (thus making use of latent vehicle capacity).</p>   |  |

# Forms of Digitalization in Freight Transportation



## GOODS

- RFID.
- Sensors.

## CONVEYANCES

- Sensors.
- Navigation.
- Routing.
- Vehicle automation.



## INFRASTRUCTURE

- Sensors.
- Traffic management.
- Terminal automation.



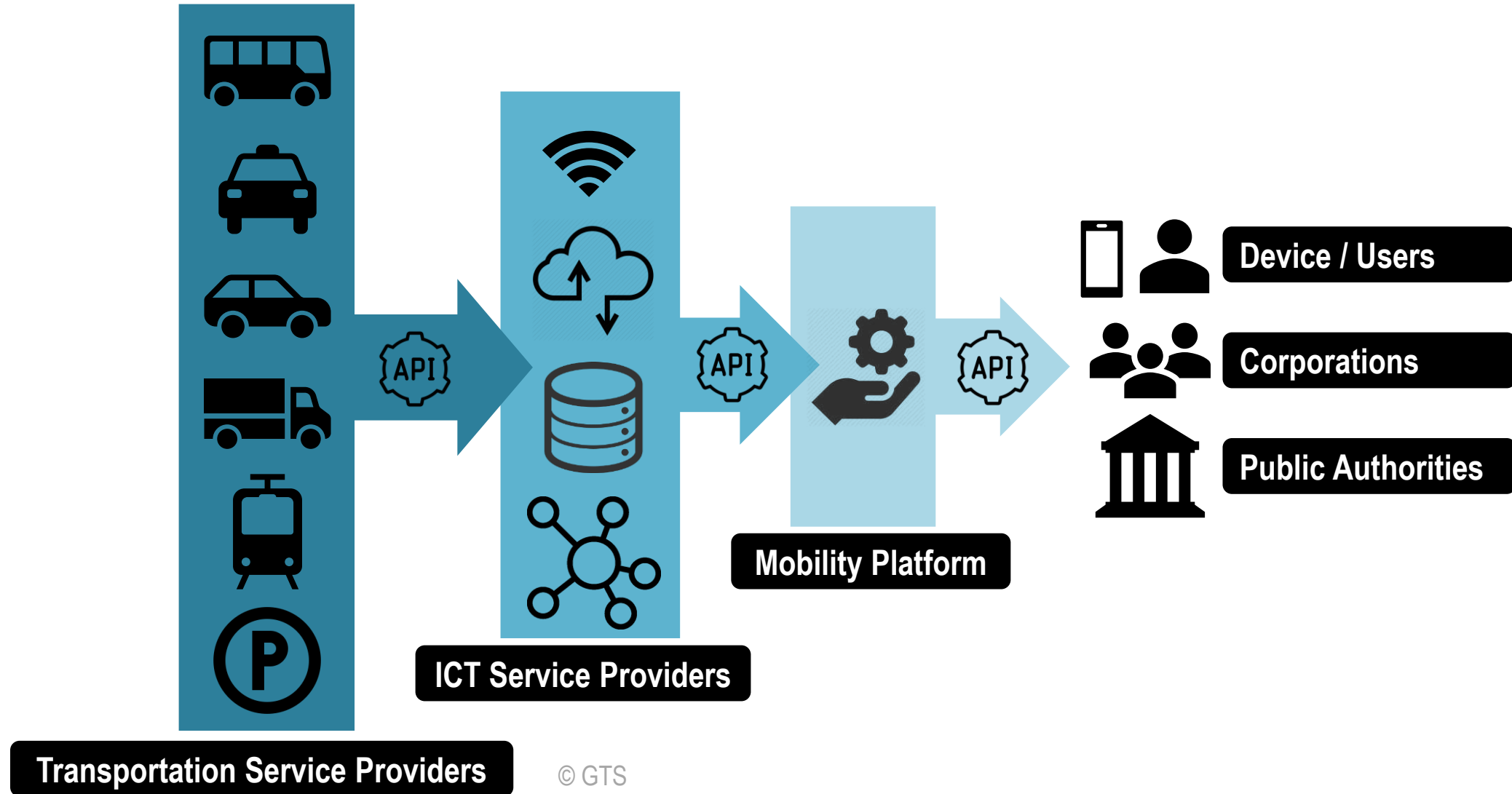
## BUSINESS PROCESS

- Electronic data exchange.
- Blockchain.

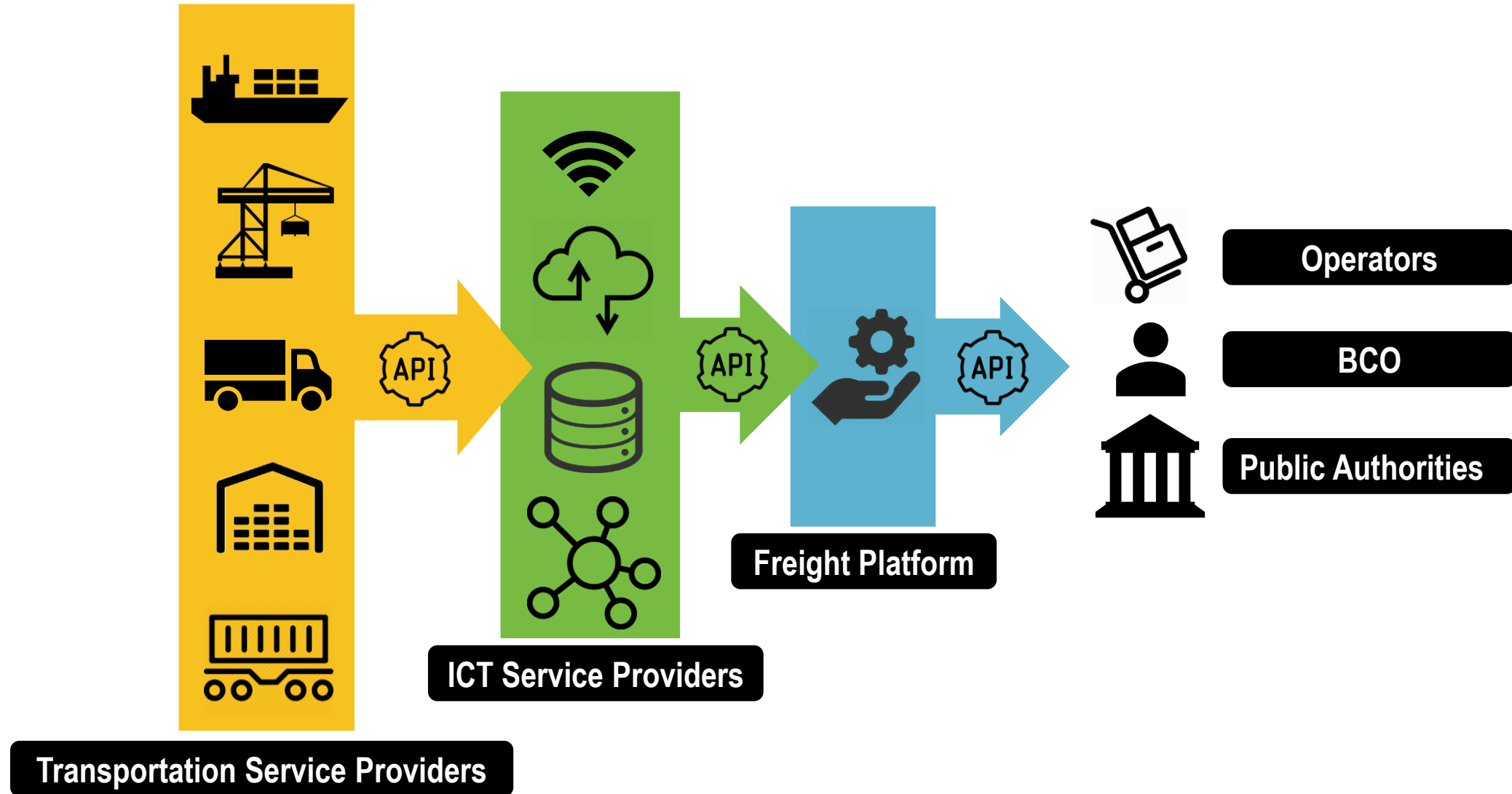


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# Mobility as a Service (Digitalization)

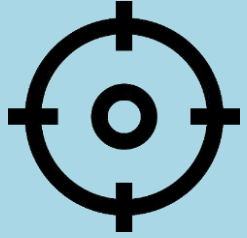


# Digital Freight Platform



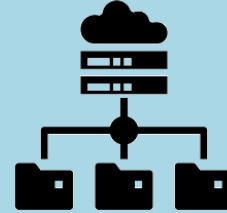


# Key Information Technology Drivers in Freight Distribution



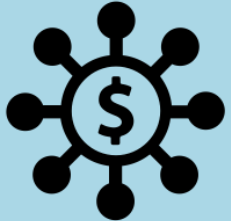
## FREIGHT VISIBILITY/TRACKING

- Improve the reliability of supply chain management.
- Status and locations of shipments (vehicles, rail cars, containers, and individual loads).
- Mobile communications and Global positioning systems (GPS).
- Radio-frequency identification (RFID) tags and bar codes.



## FREIGHT INFORMATION EXCHANGE

- Information exchange using web-based technologies and electronic data interchange (EDI).
- Real-time terminal information systems.
- Blockchains.



## ASSET MANAGEMENT

- Maximize equipment utilization.
- Equipment location (tractors, trailers, rail cars, containers, ships).
- Real Time Locating Systems (GPS and RFID tags).
- Status monitoring of vehicle and cargo conditions.



## REGULATORY COMPLIANCE

- Pre-screen shipments and direct low-risk freight to quick clearance.
- Enhance security at international borders.
- Electronic pre-notification of shipment information.



## EFFICIENCY IMPROVEMENTS

- Improve productivity and reduce data errors.
- Verification and exchange of shipment information.
- Non-intrusive inspection and information technologies such as optical character readers (OCR), RFID tags, and bio-metrics (to identify drivers).

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