

The Geography of Transport Systems

Jean-Paul Rodrigue

Sixth Edition



Transportation and the Spatial Structure

CHAPTER 2

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The Geography of Transport Systems



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The Geography of Transportation Networks

Chapter 2.1

Types of Networks and Flows (under construction)

Physical / structural

Continuous / Discontinuous

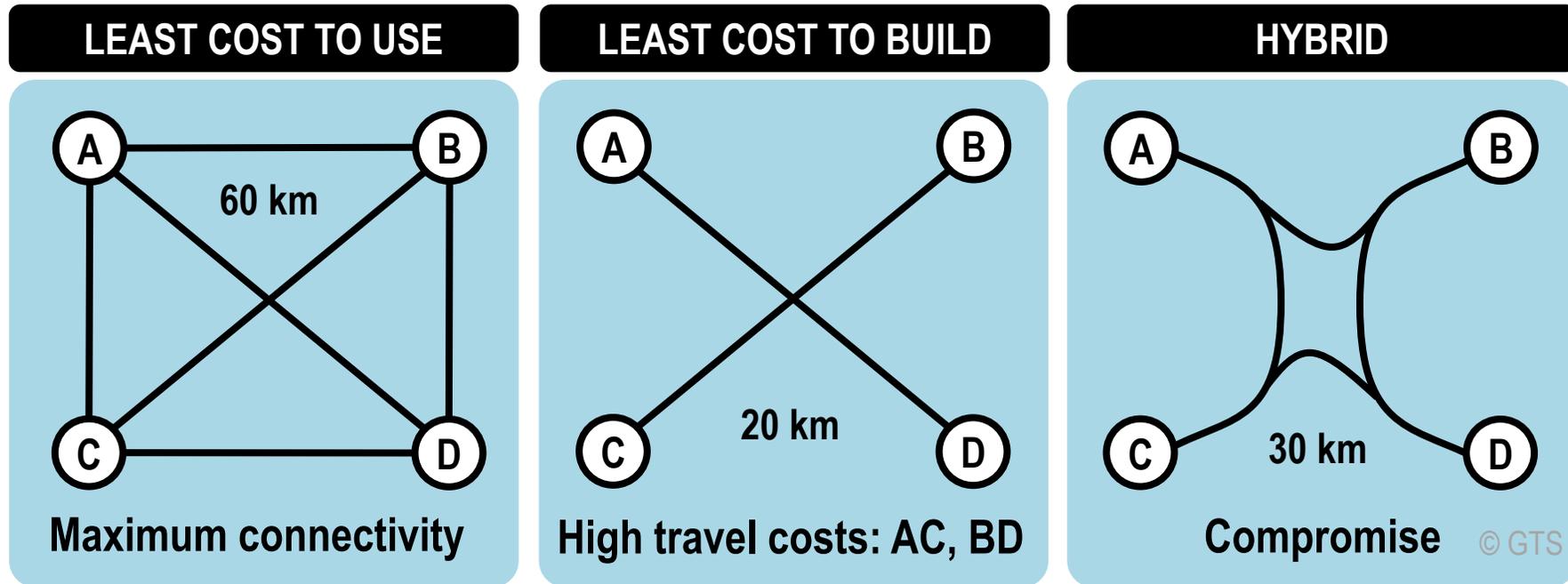
Relational / virtual

Symmetrical / Asymmetrical

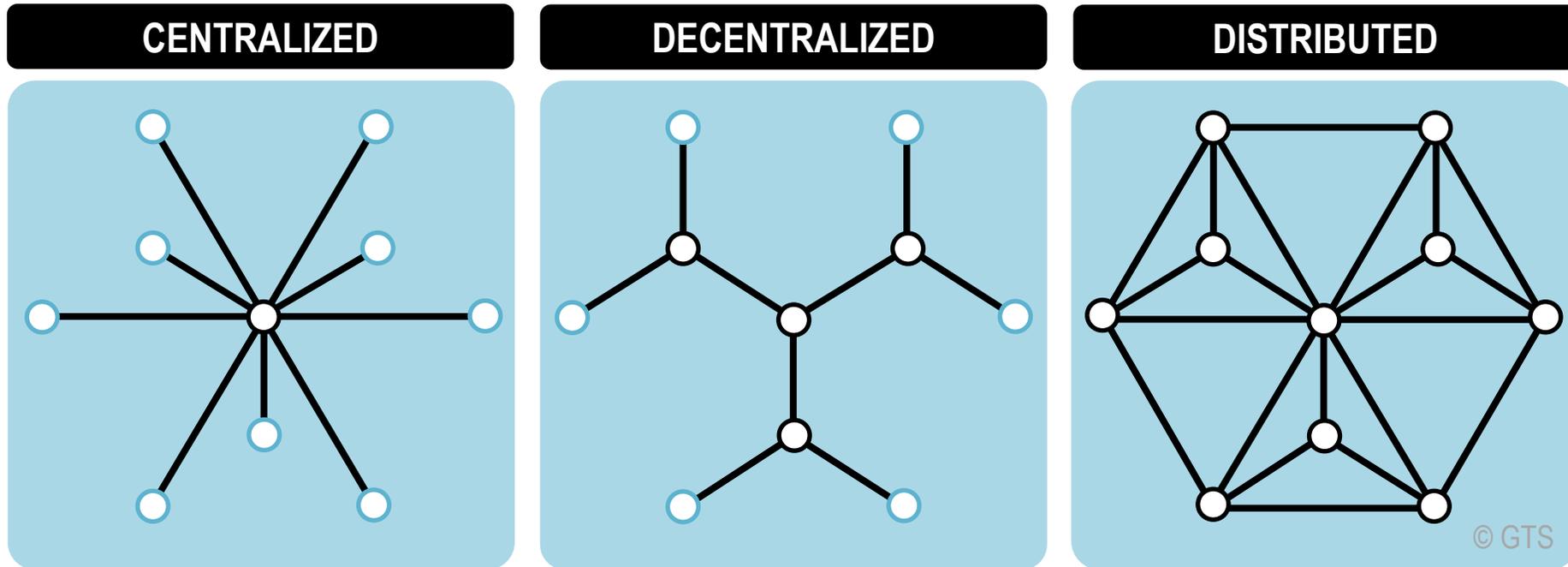
Distribution

Balanced / Imbalanced

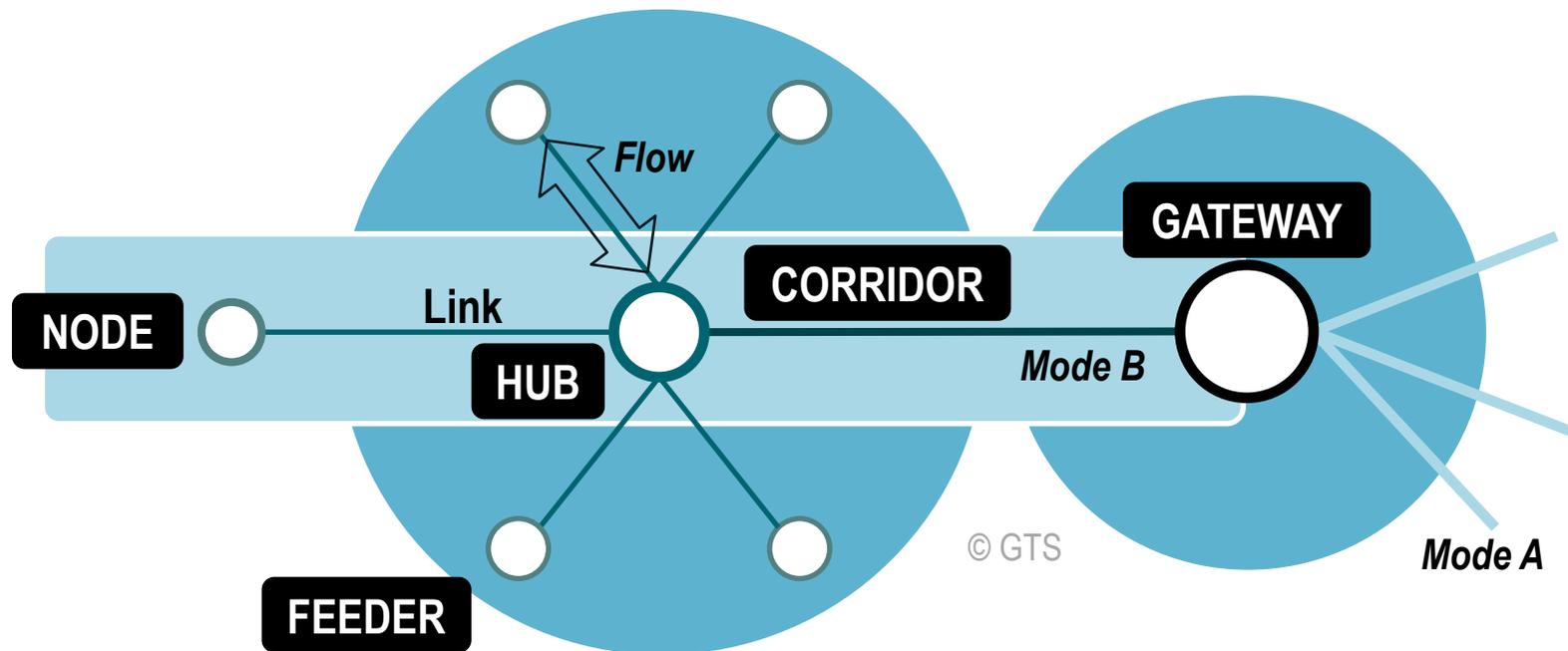
Network Connectivity Options



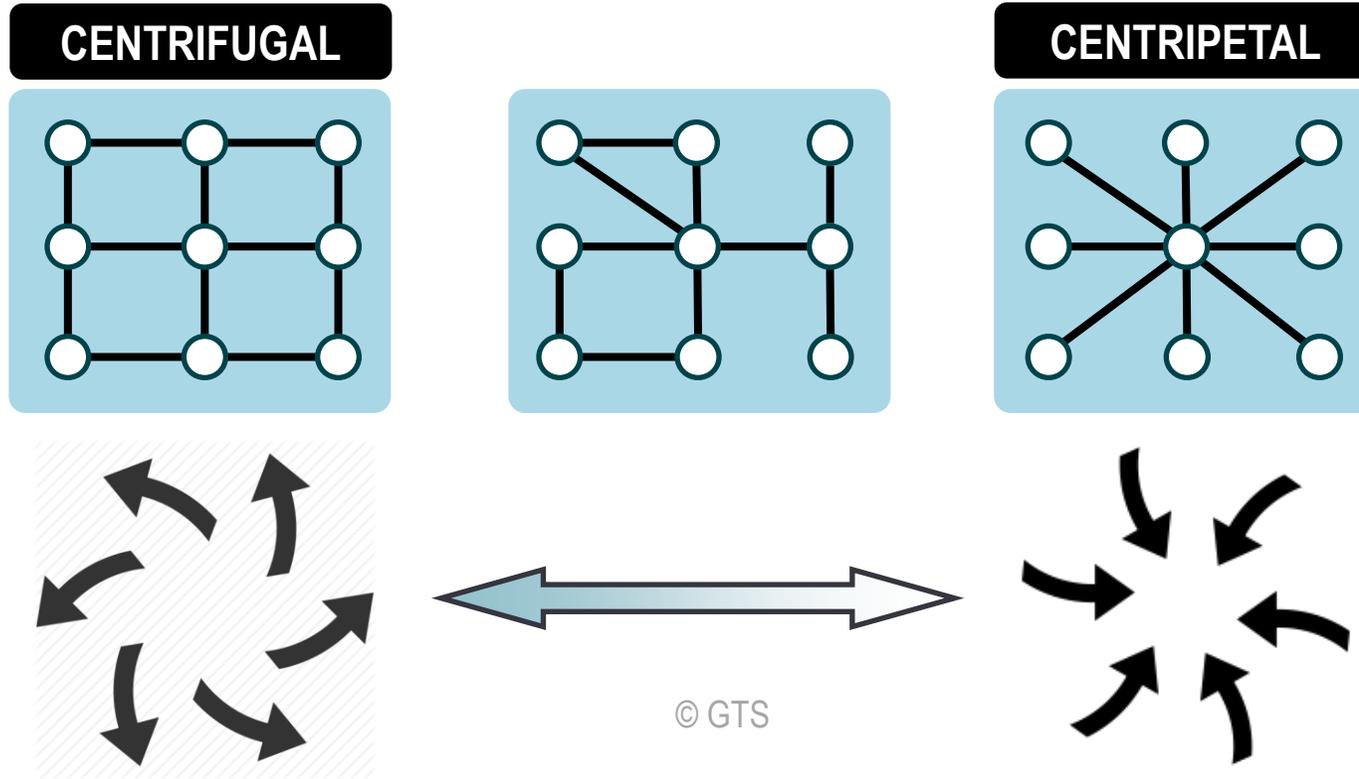
Network Structures



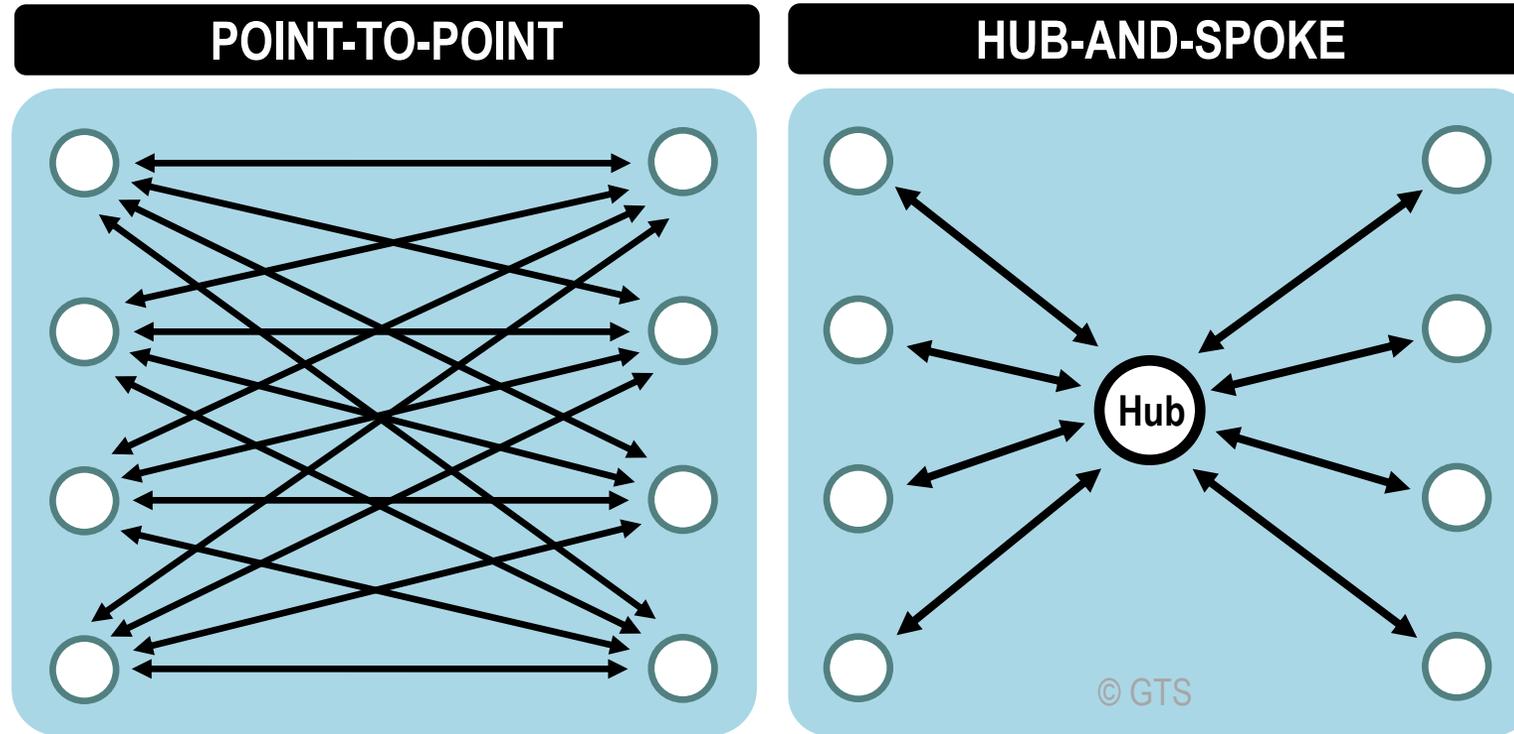
Structural Components of Transport Networks



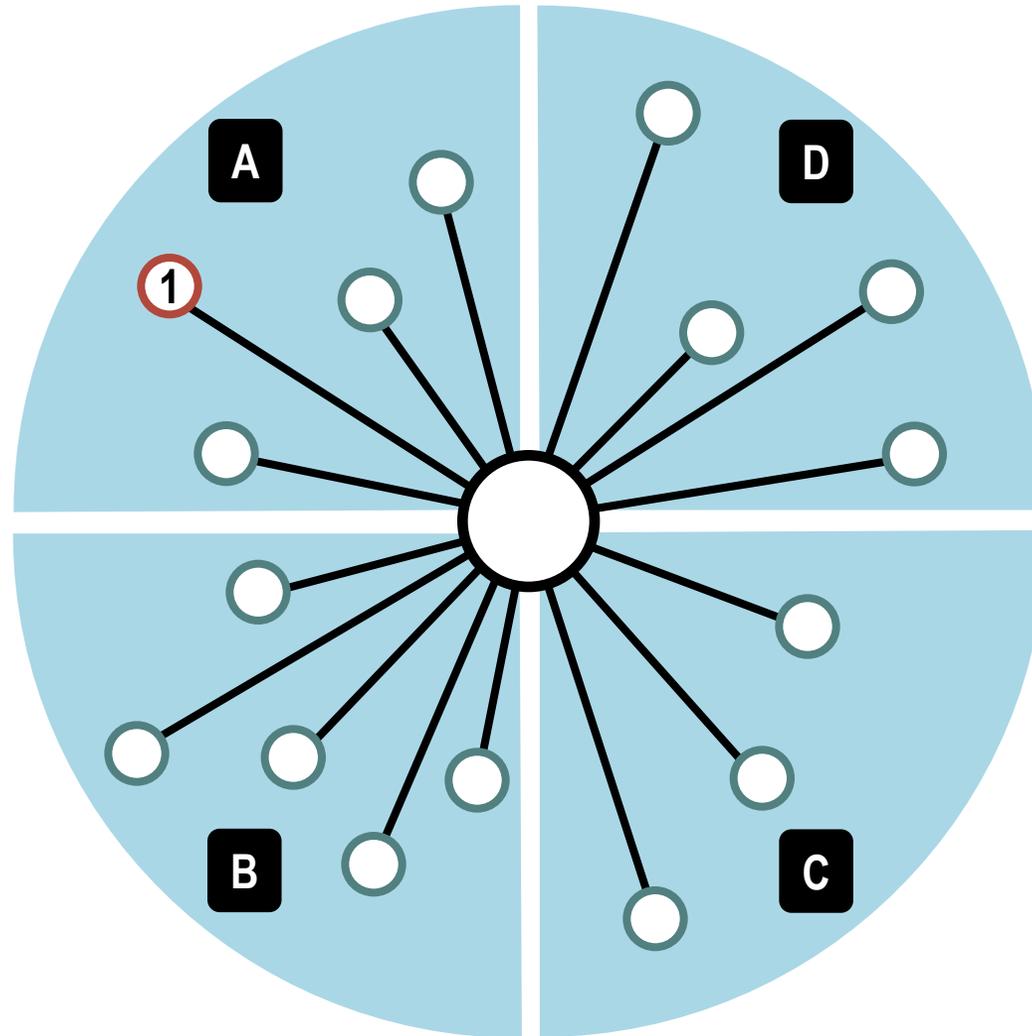
Centrifugal and Centripetal Networks



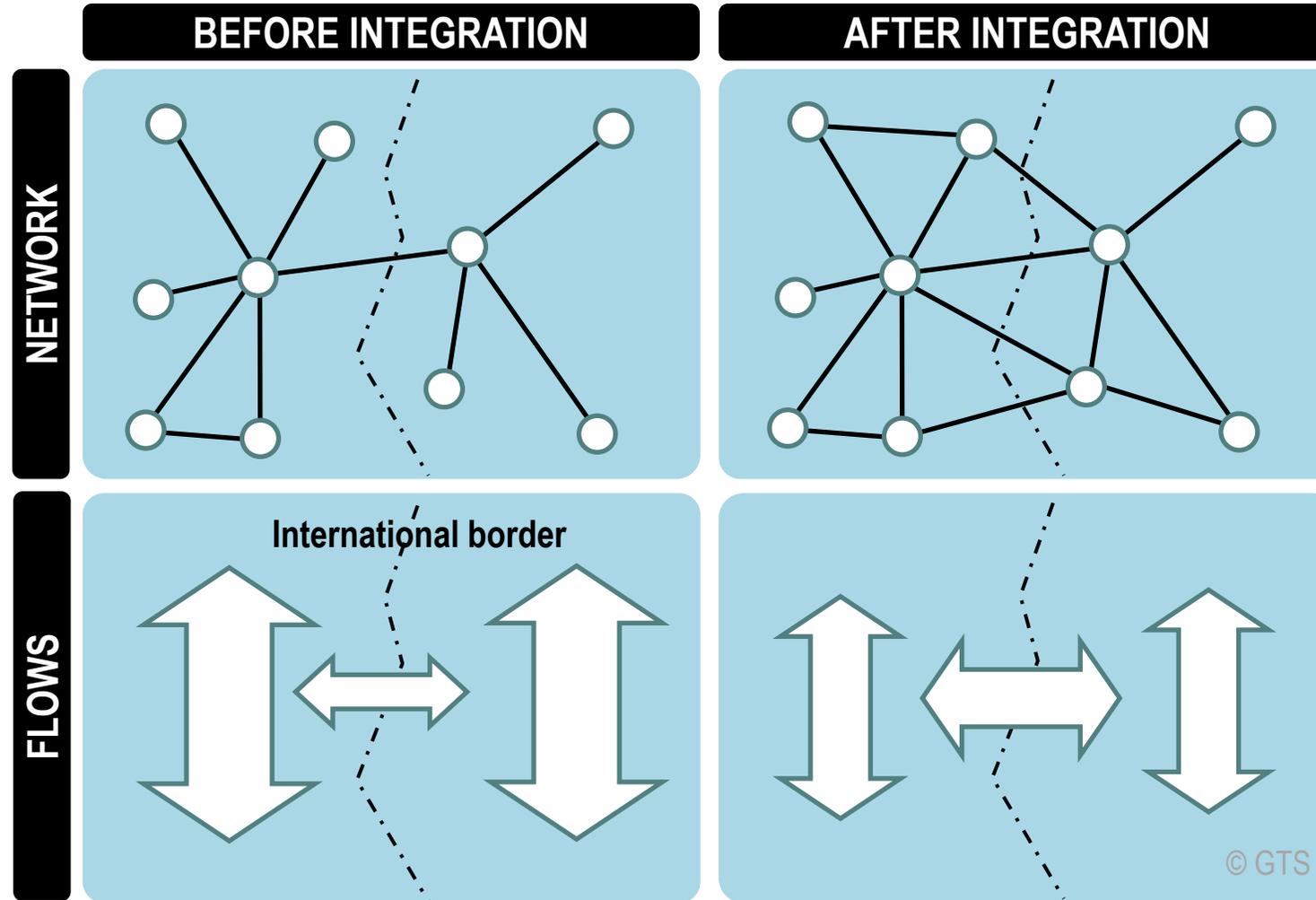
Point-to-Point and Hub-and-Spoke Networks



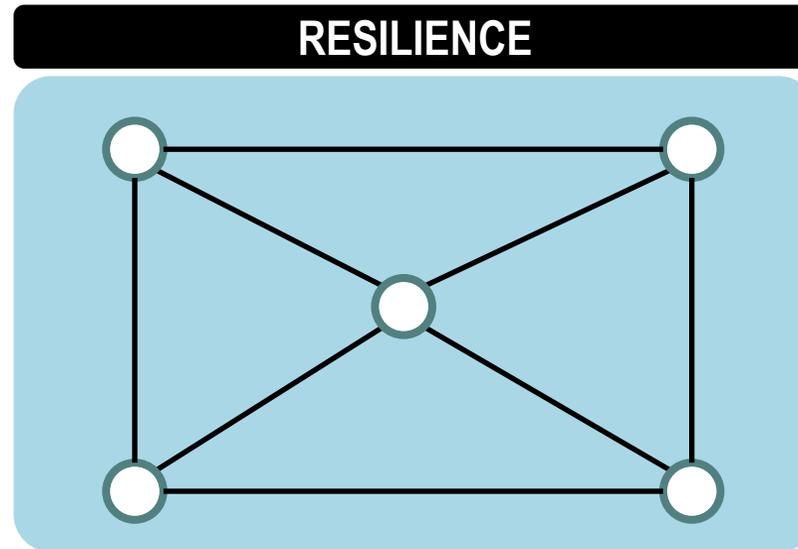
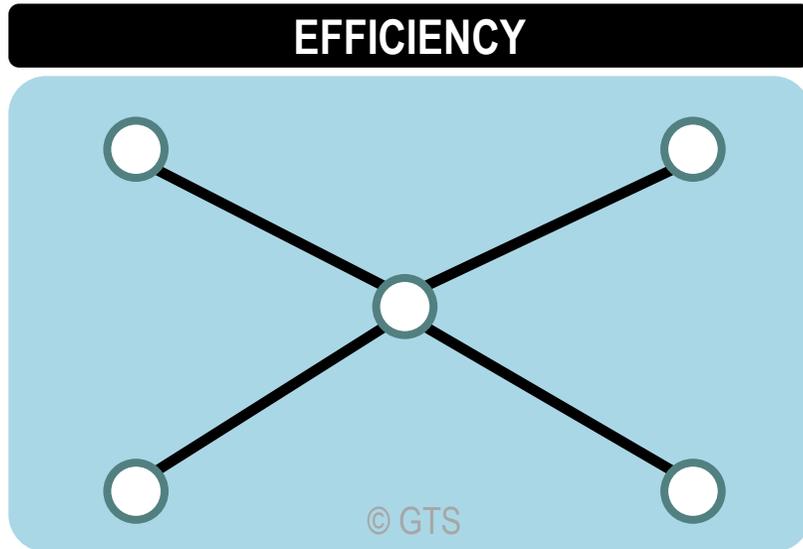
Detour Level in a Hub-and-Spoke Network



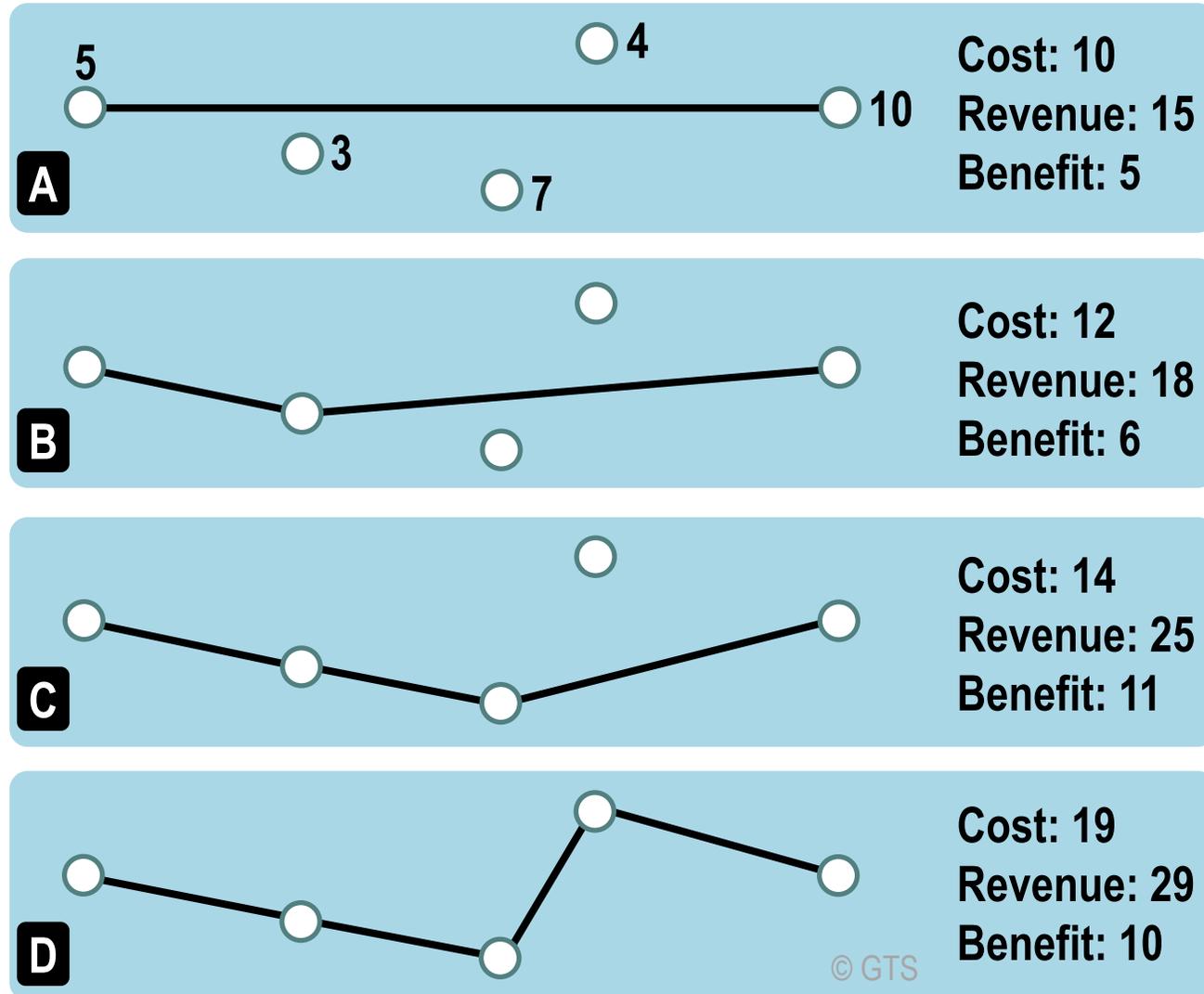
Impacts of Integration Processes on Networks and Flows



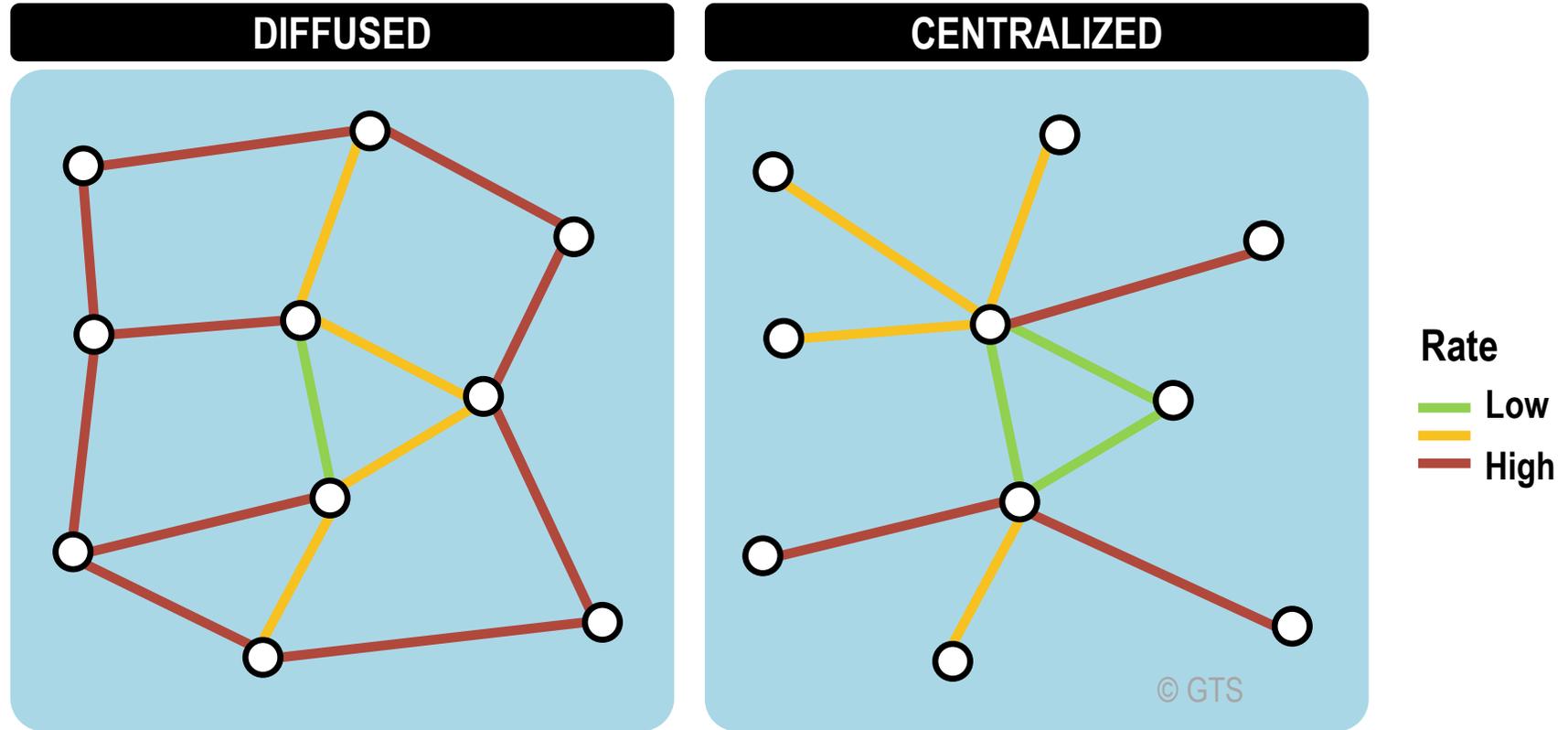
Transportation Network Efficiency and Resilience



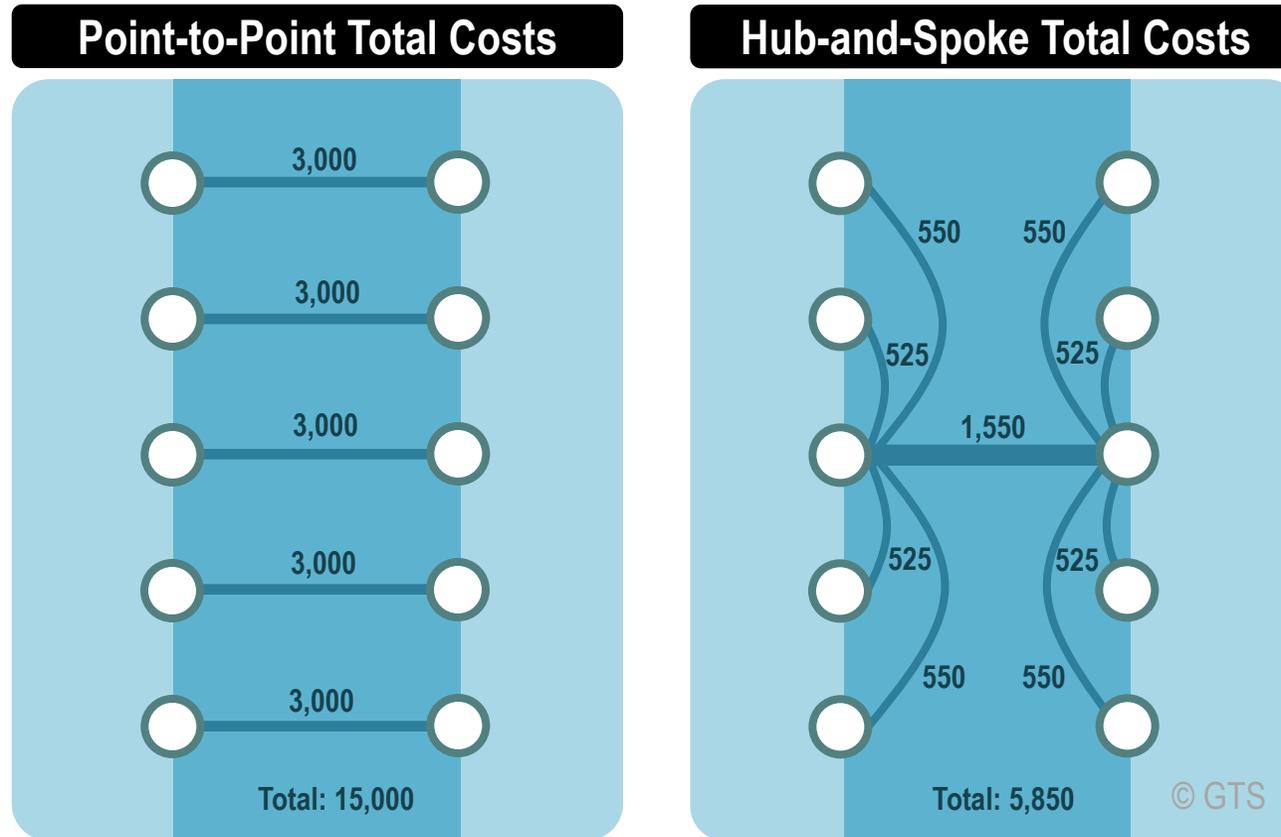
Cost, Revenue and Level of Network Coverage



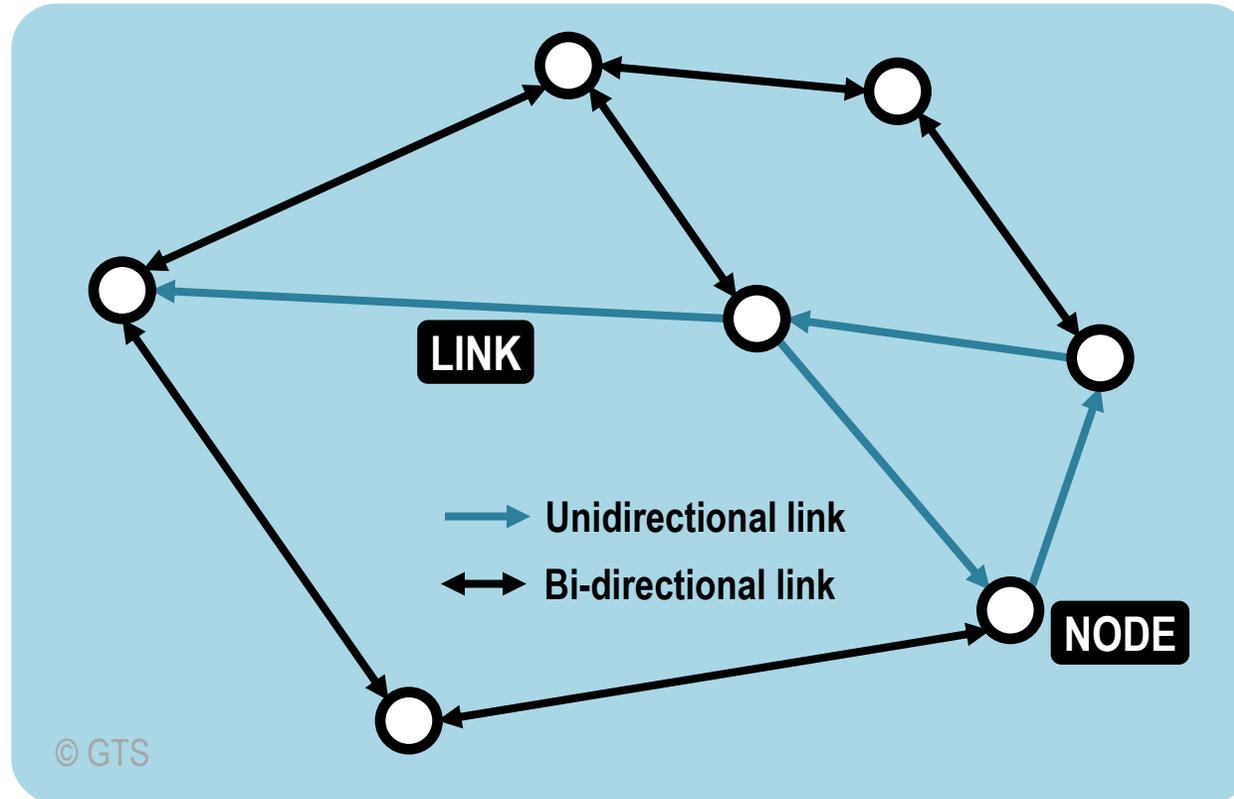
Transport Rates and Network Structure



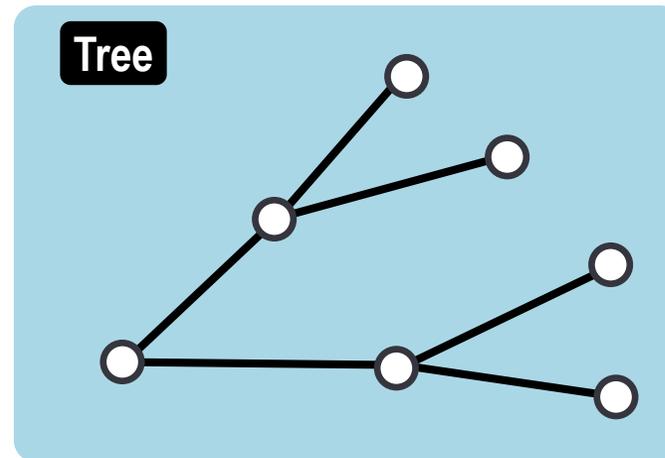
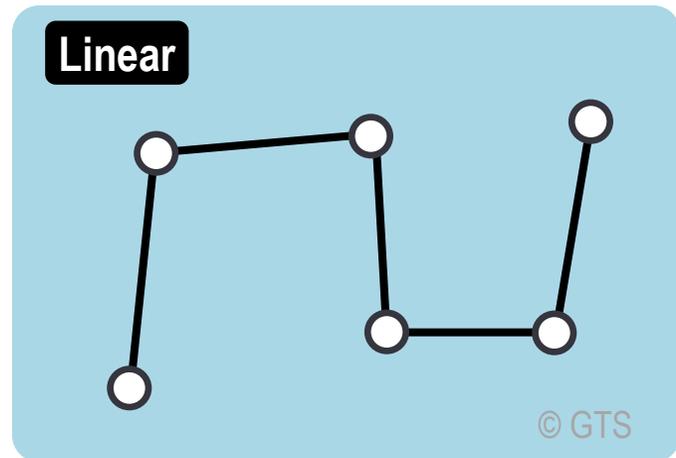
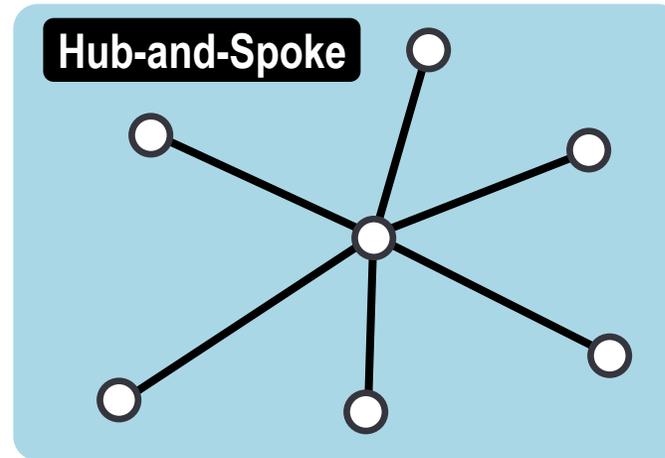
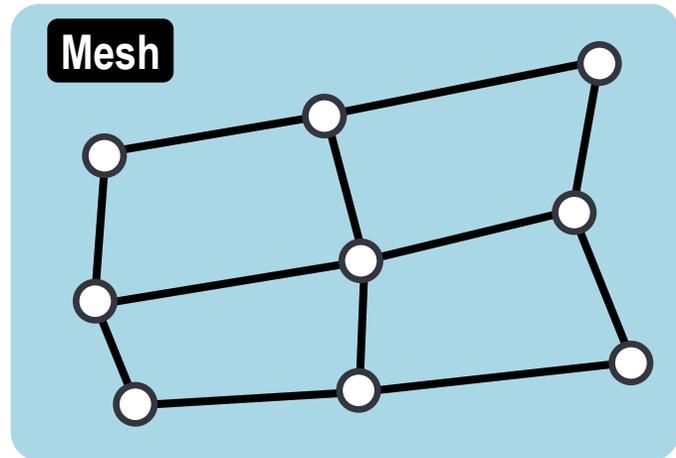
Cost Structure of Point-to-Point and Hub-and-Spoke Networks



Topology of a Network



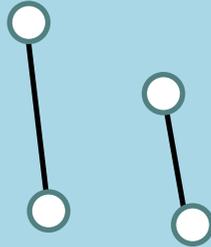
Network Topologies



Network Geometry and Number of Links

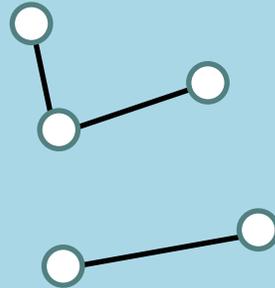
For each node to be linked to another node

Even number of nodes



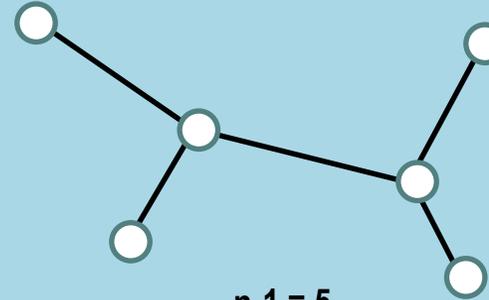
$$n/2 = 2$$

Odd number of nodes



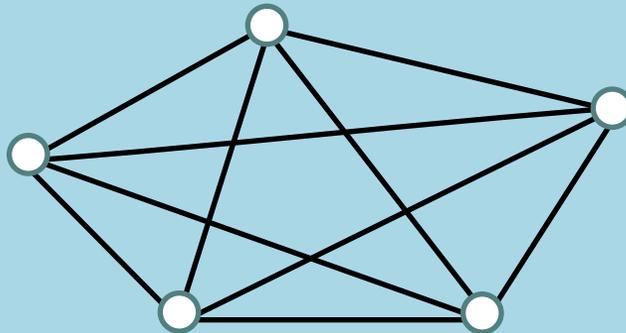
$$(n+1)/2 = 3$$

For all the nodes to be linked together



$$n-1 = 5$$

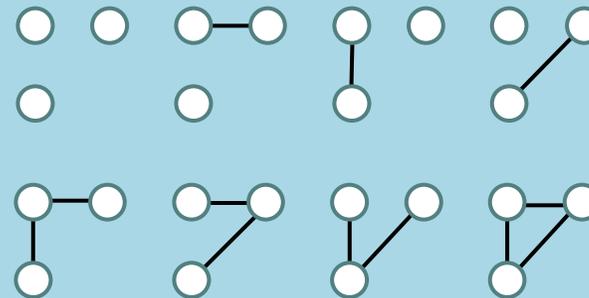
For each node to be linked to all other nodes



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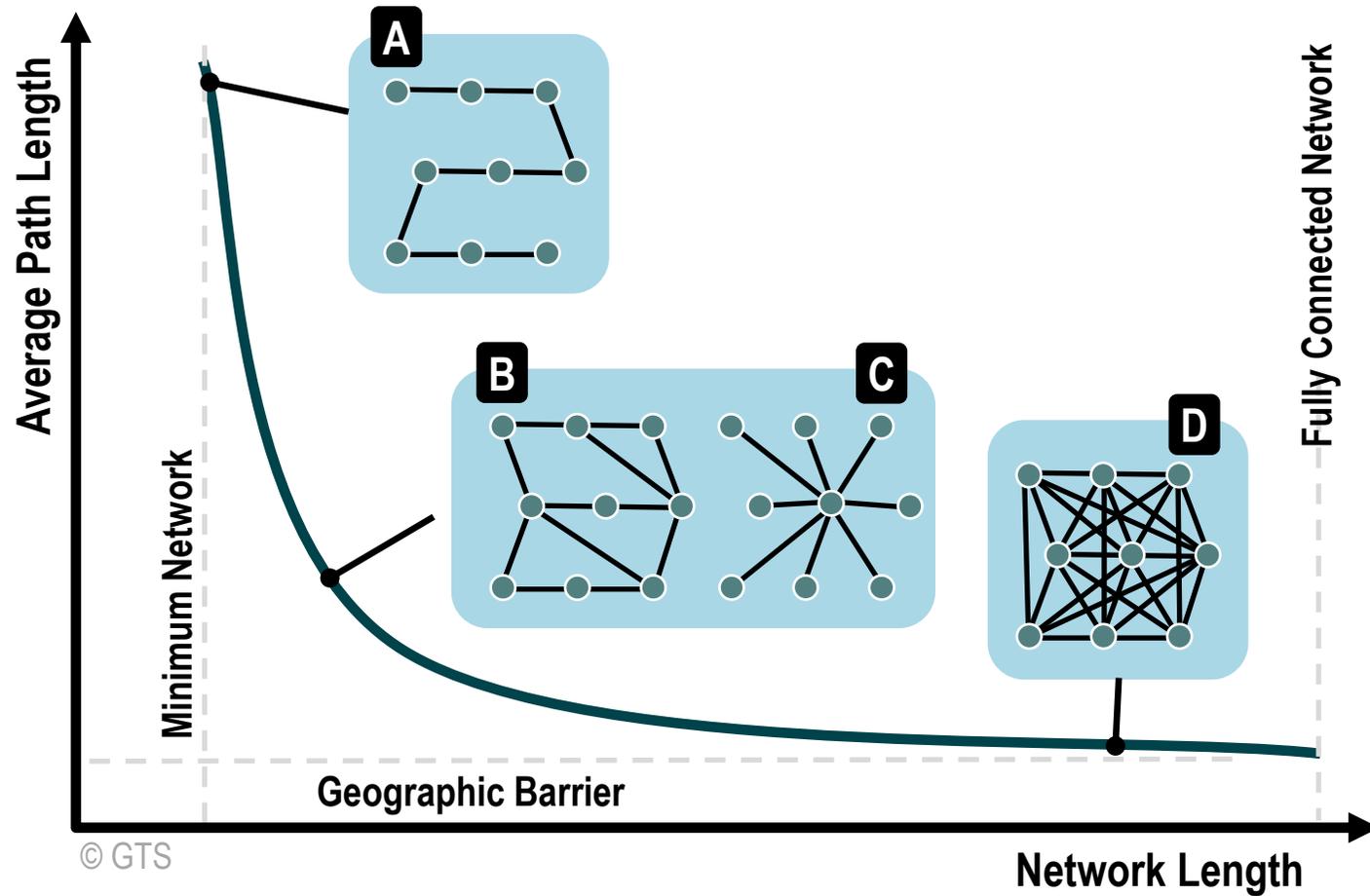
$$n(n-1)/2 = 10$$

Number of possible combinations

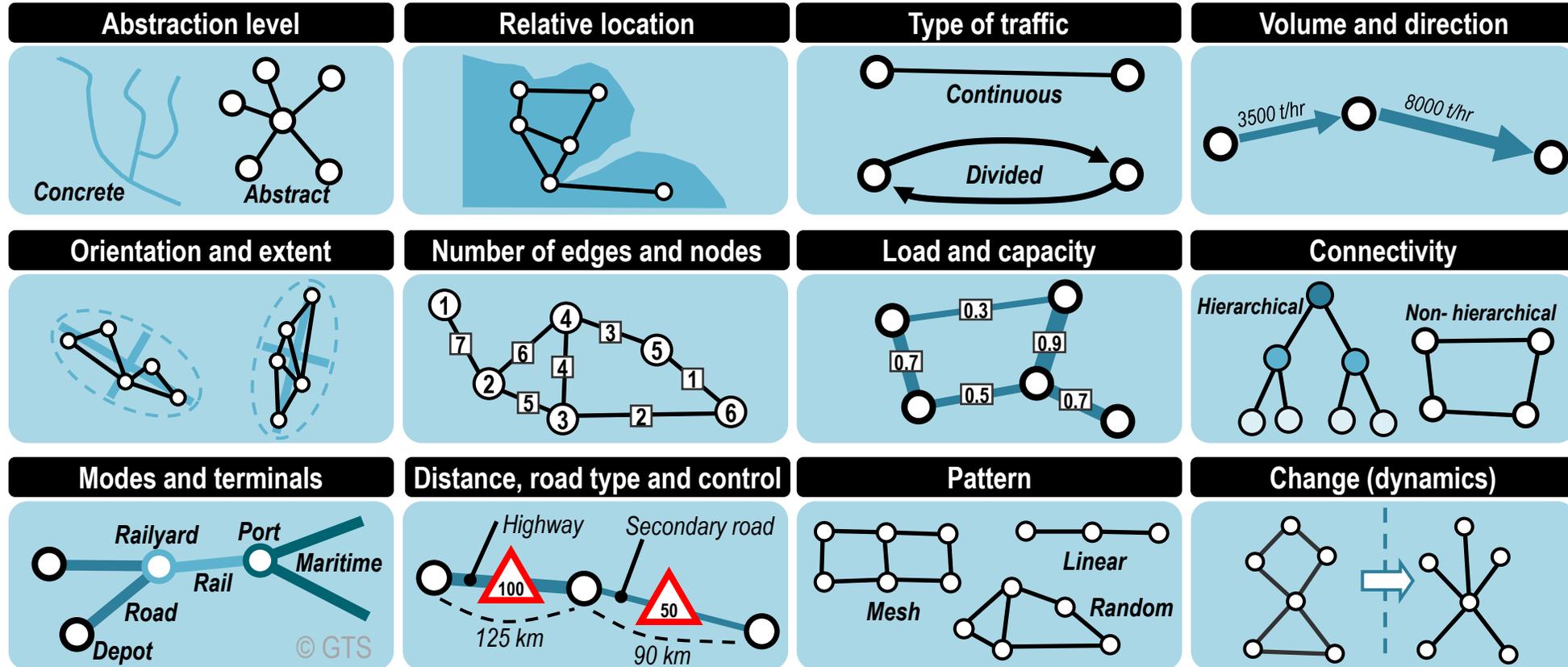


$$2^{n(n-1)/2} = 8$$

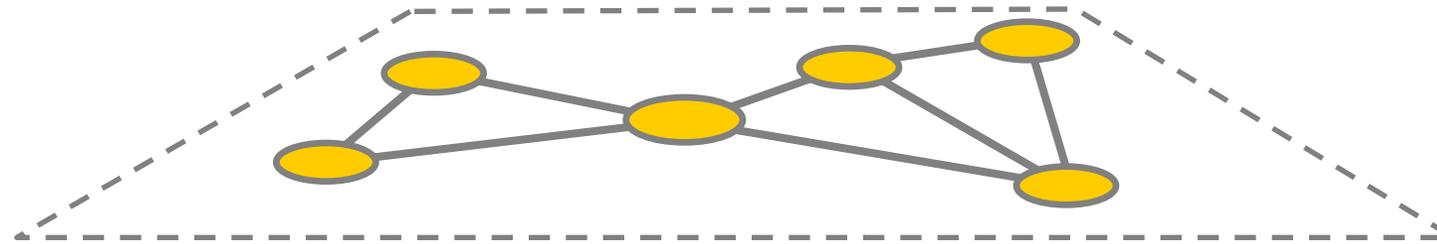
Topology and Network Connectivity



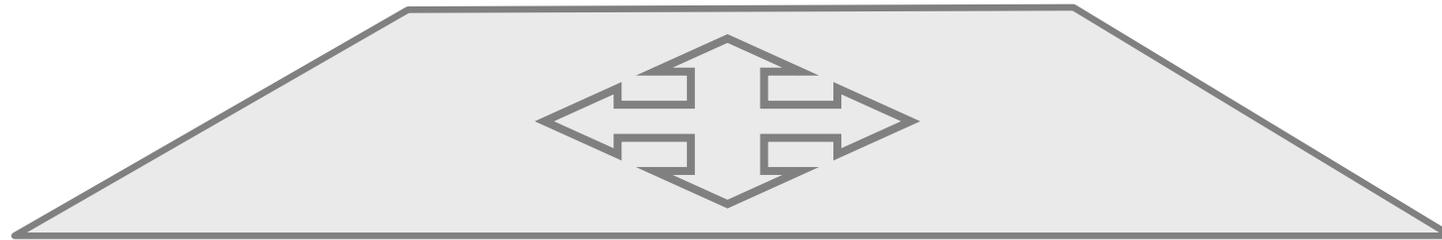
Typology of Transportation Networks



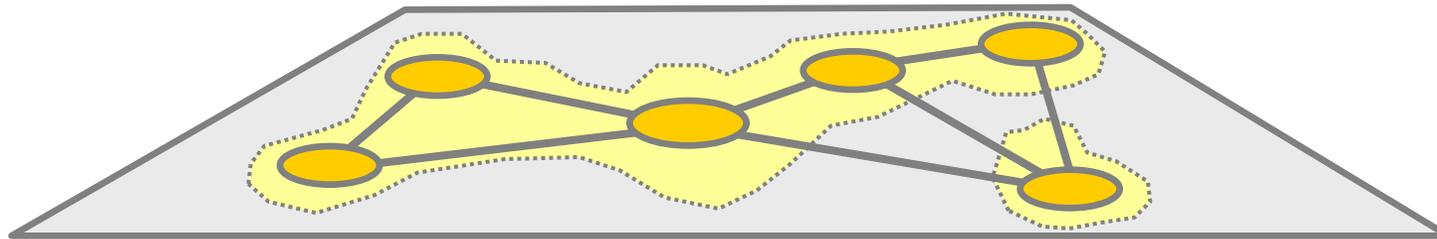
Transport Networks and Space (to be updated)



Transport Network

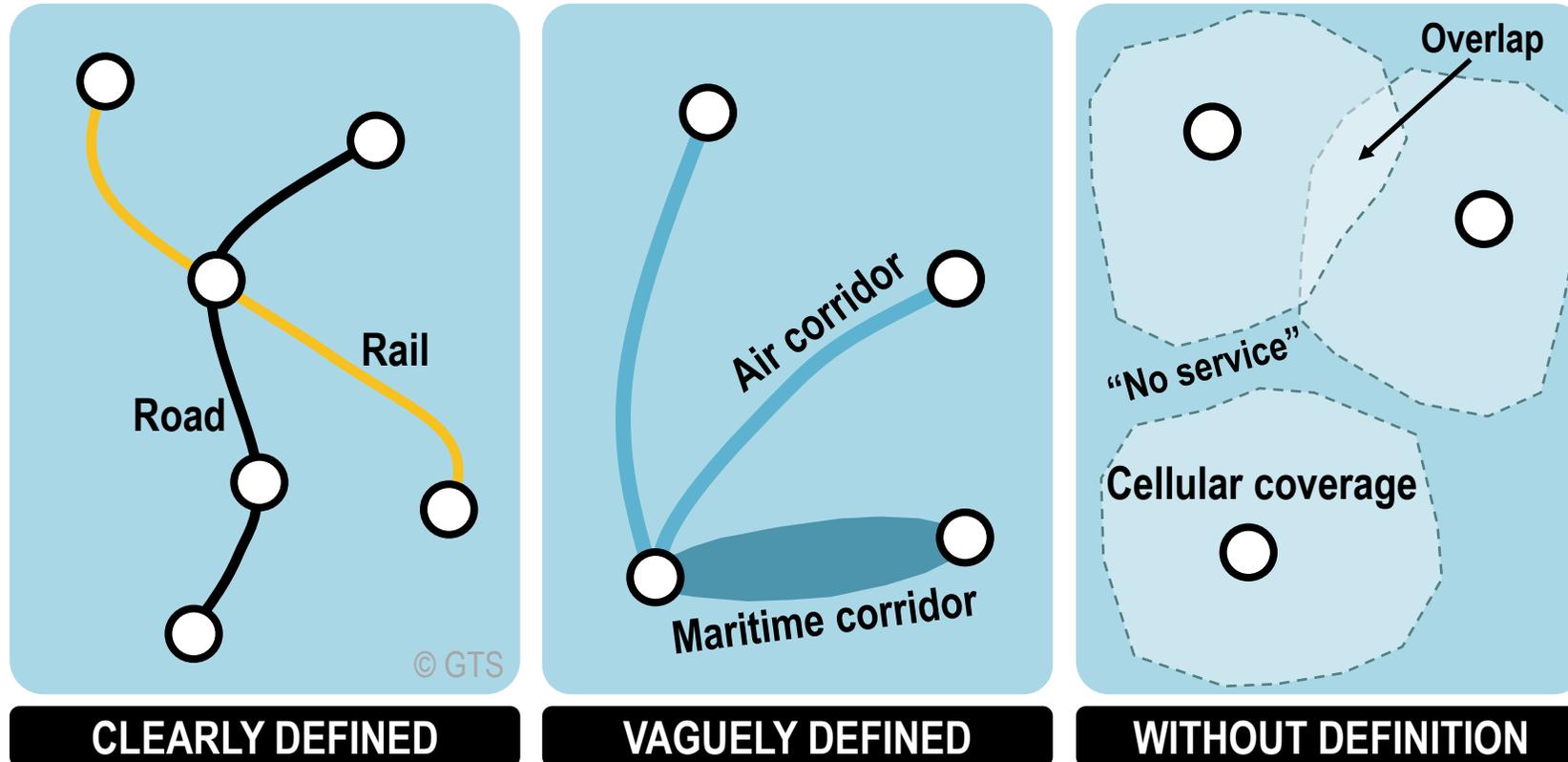


Space

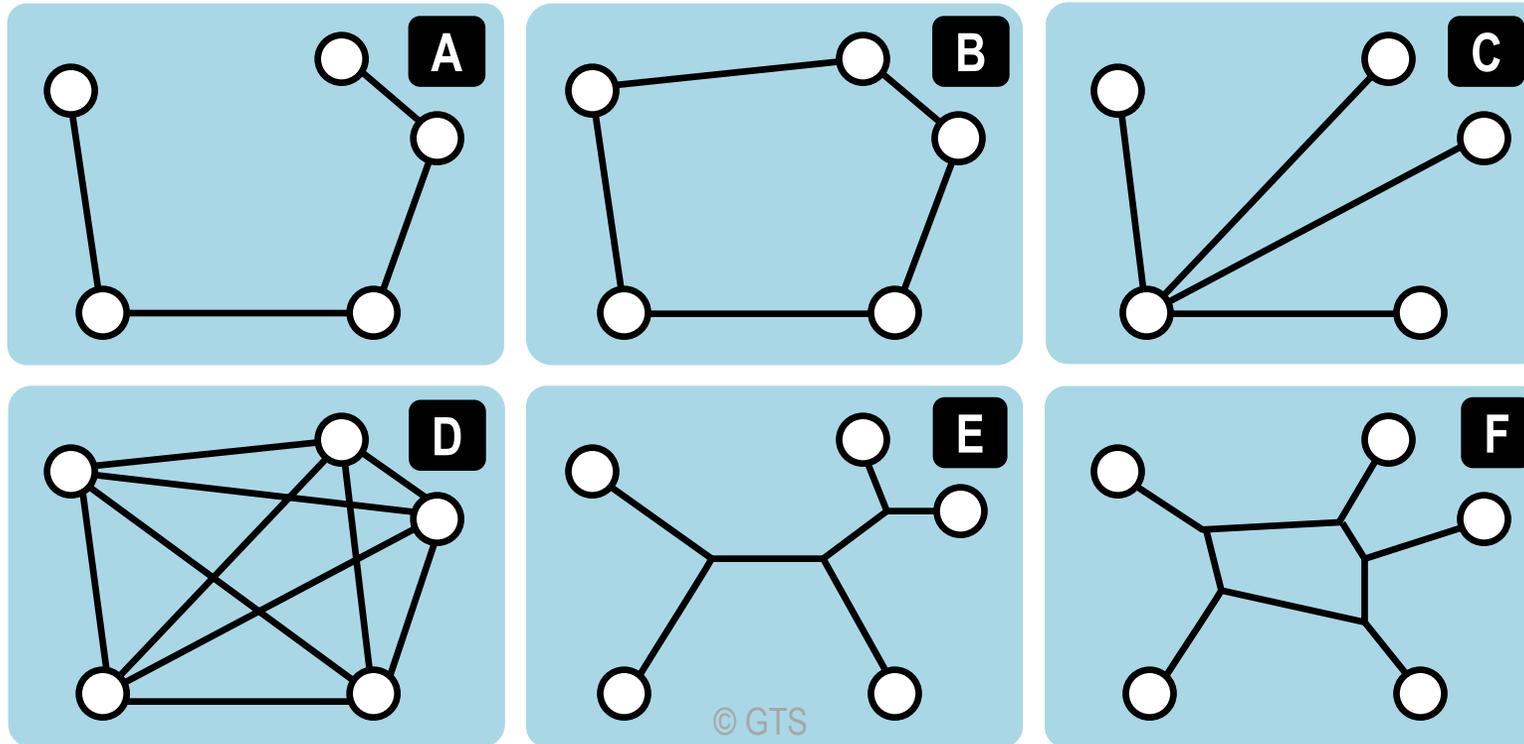


Accessibility

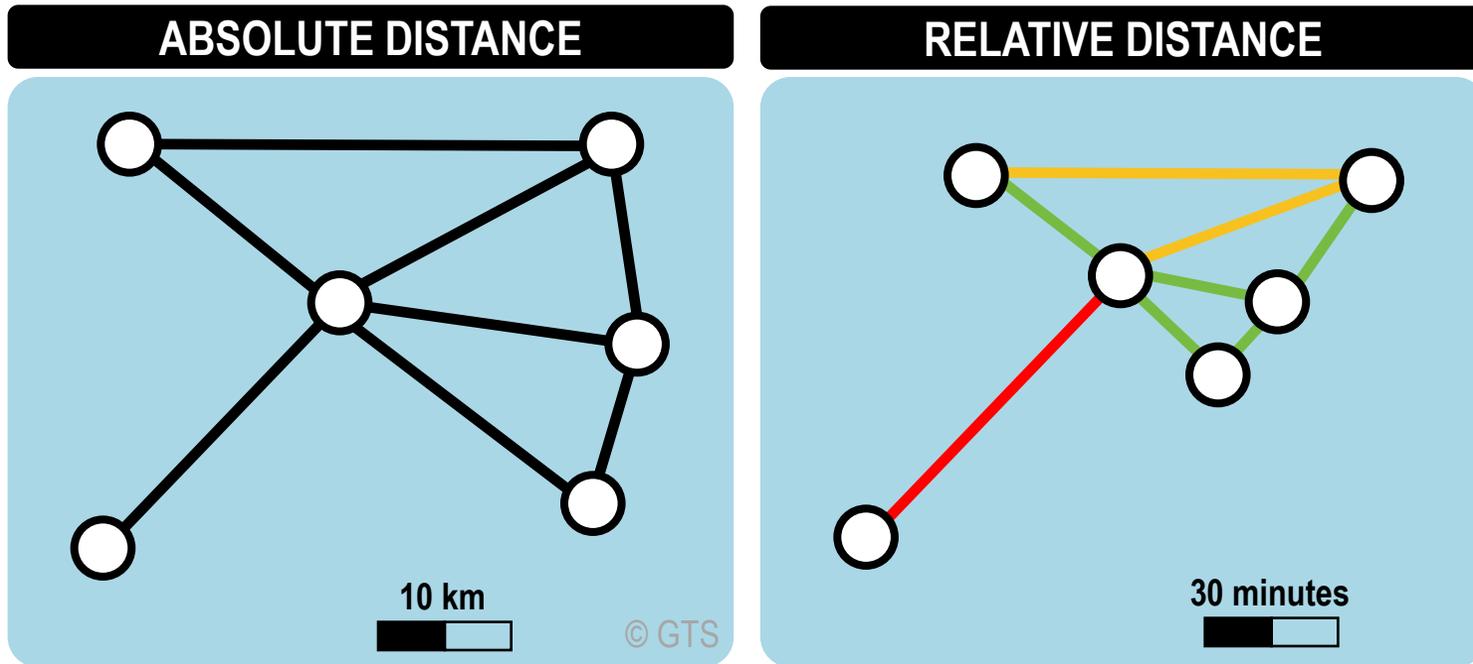
Mode of Territorial Occupation by Transport Networks



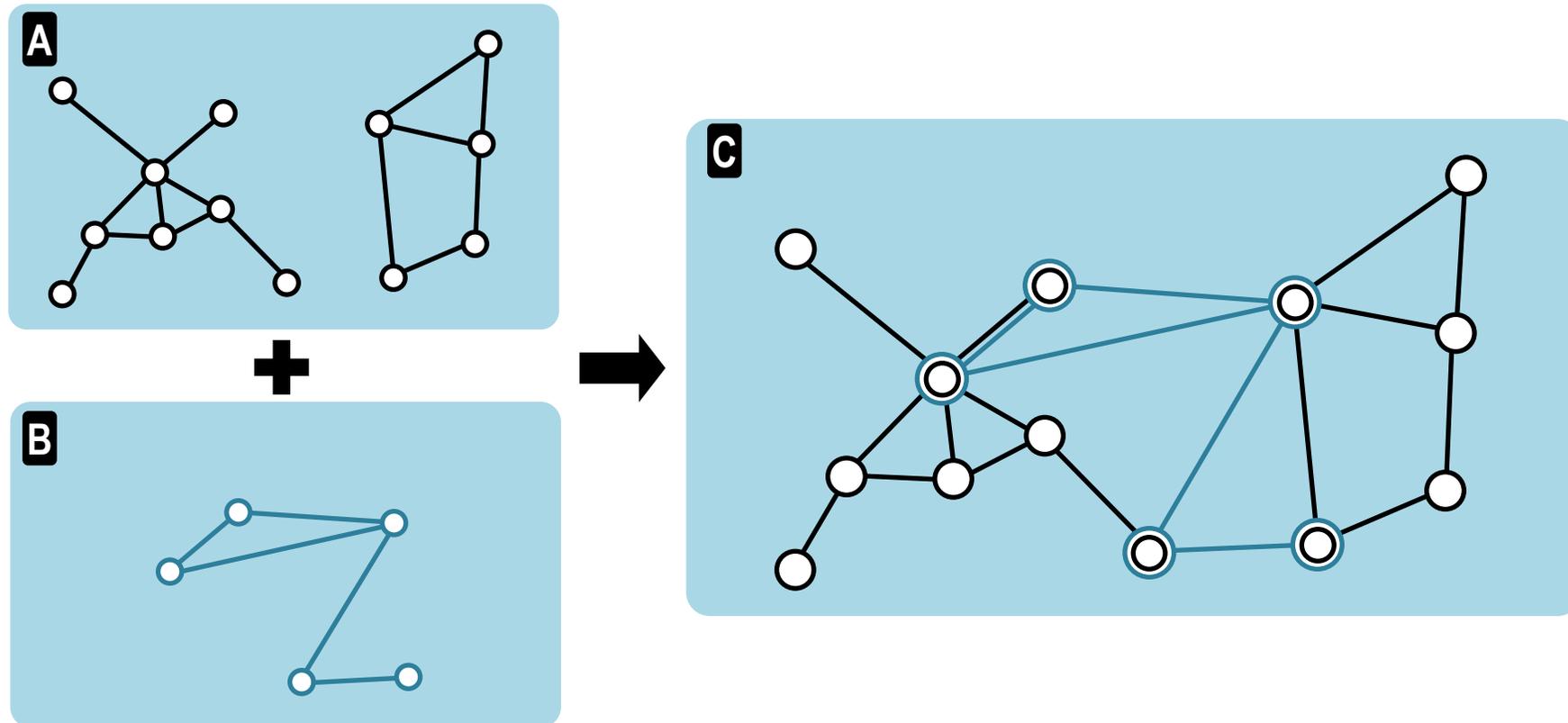
Network Strategies to Service a Set of Locations



Absolute and Relative Distance in a Network



Networks and Spatial Continuity



Spatial Continuity by Transportation Mode

	Ubiquity	Fractionalization	Instantaneity
Automobile	High (road coverage the most extensive)	None (1 passenger = 1 movement)	High (available on demand)
Transit	Average (within metropolitan areas)	Average (bus loads or train loads)	Average to high (fixed high frequency schedules)
Air transport	Limited to airports (common)	Average (plane loads from 50 to 500 passengers)	Average (fixed schedules and connections)
Maritime	Limited to ports (rare)	High (ship loads, reinforced by economies of scale)	Low (fixed schedules and connections)
Rail	Limited to rail terminals (common)	Average (train loads)	Average (fixed schedule)
Pipeline	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 th Century	Canal and rail	Nation building, commerce and political control
20 th Century	Highways and air	National and transnational integration
21 st Century	Telecommunication	Global supply chains

The Geography of Transport Systems



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Transport and Spatial Organization

Chapter 2.2

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.

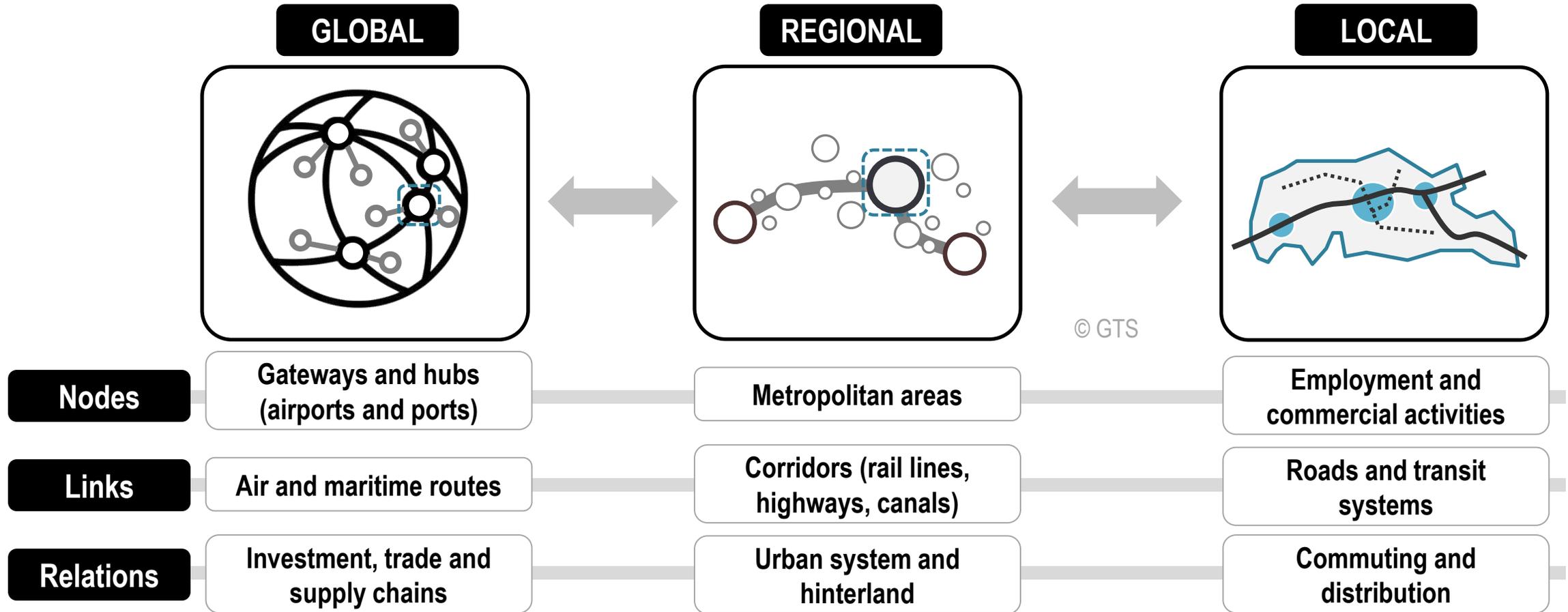


Regulations

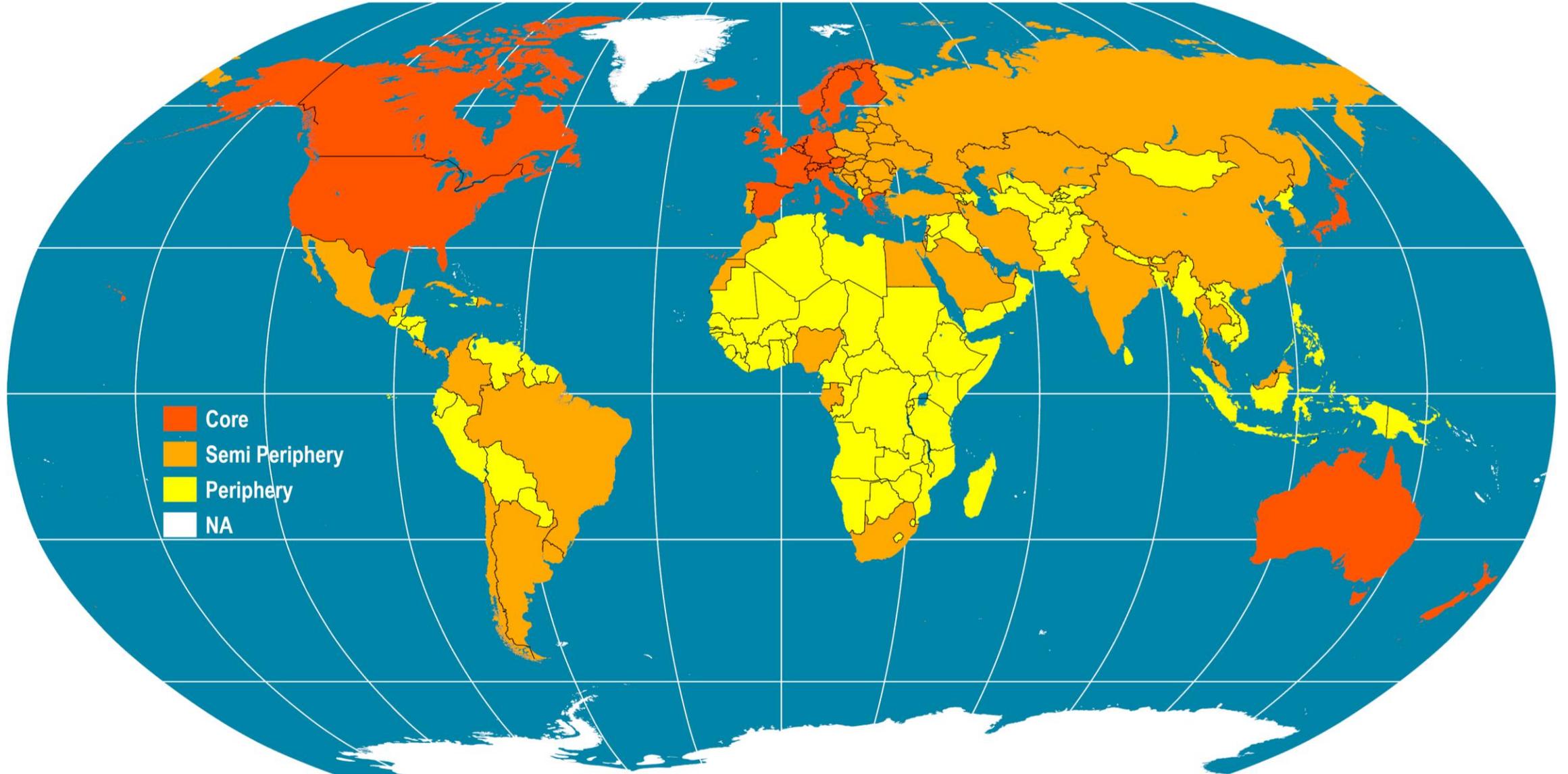
- Restrictions about how transport infrastructure can be developed, owned and operated.
- Pressures from advocacy groups.

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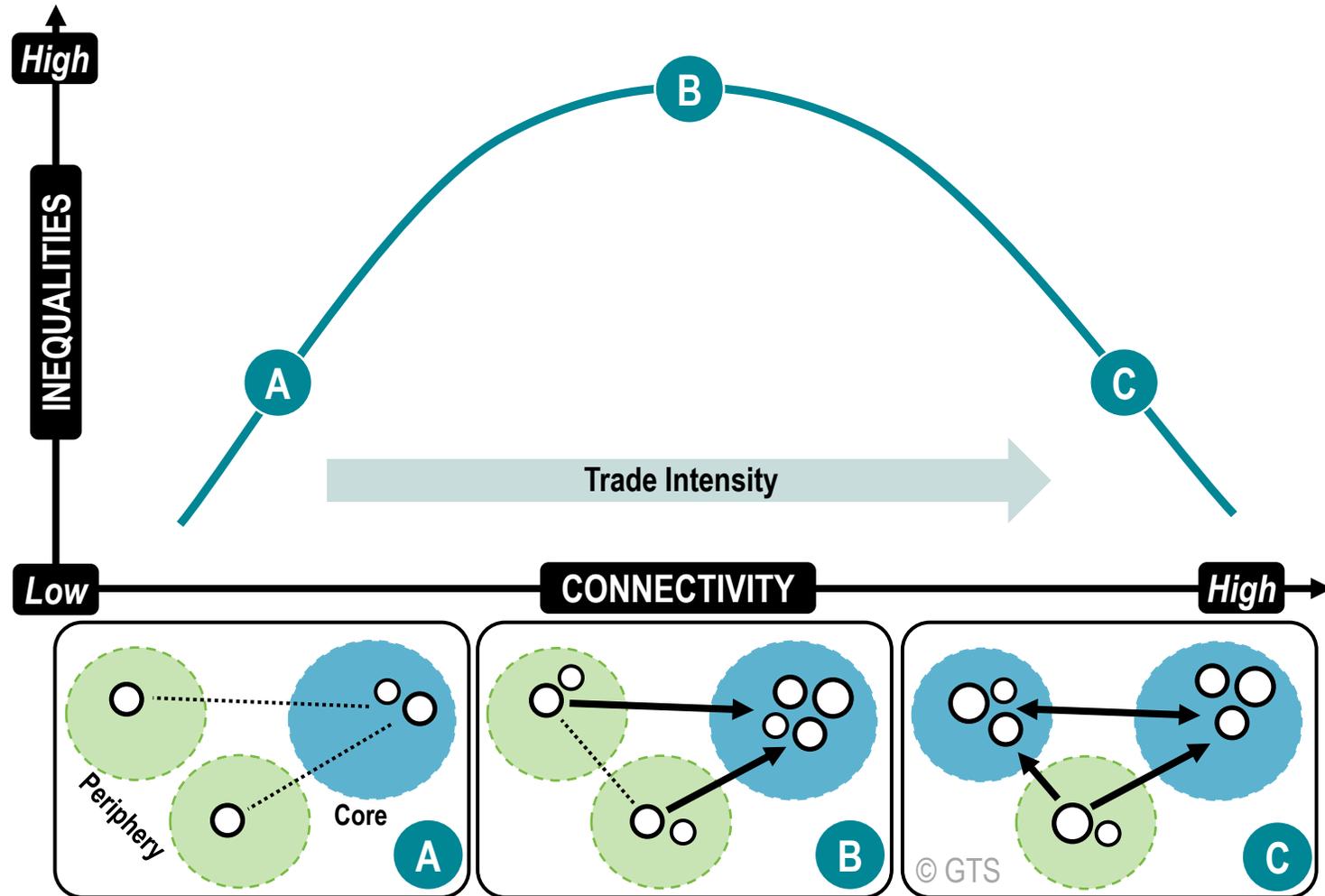
Scales of Spatial Organization for Transportation



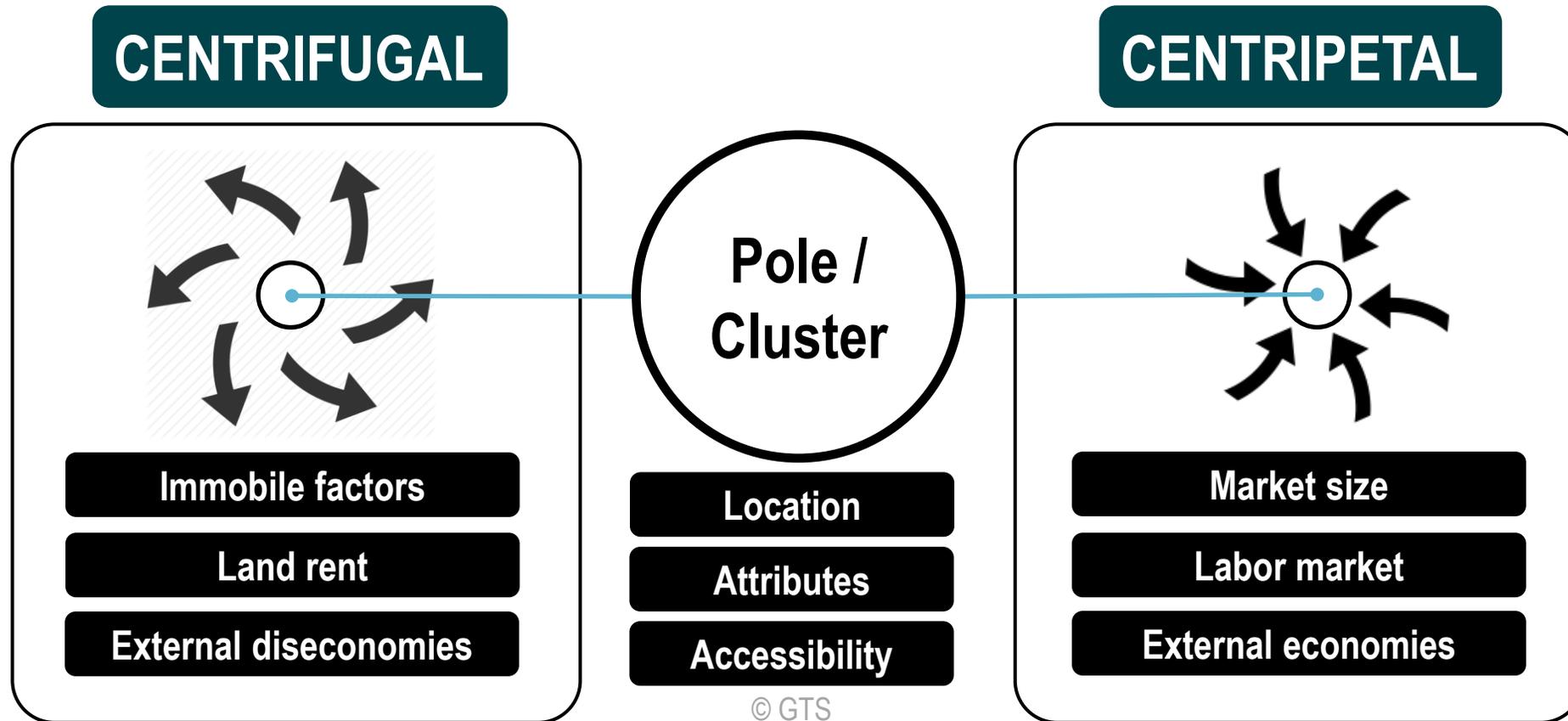
Core / Periphery Division of the World



Trade, Connectivity and Spatial Inequalities



Forces of Geographical Concentration and Dispersion



Factors of Polarization (under construction)

Network

Load break

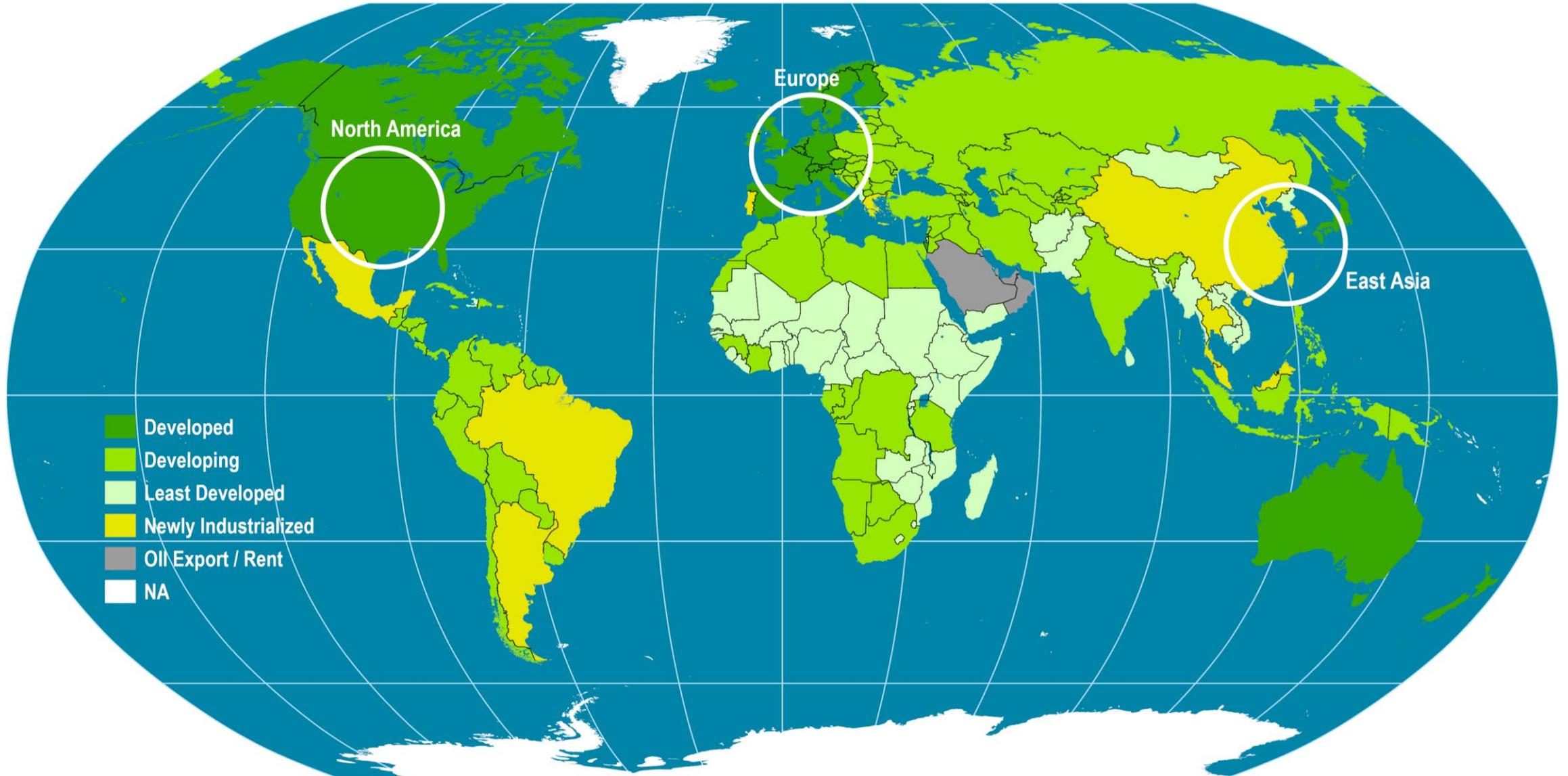
Competition

Services

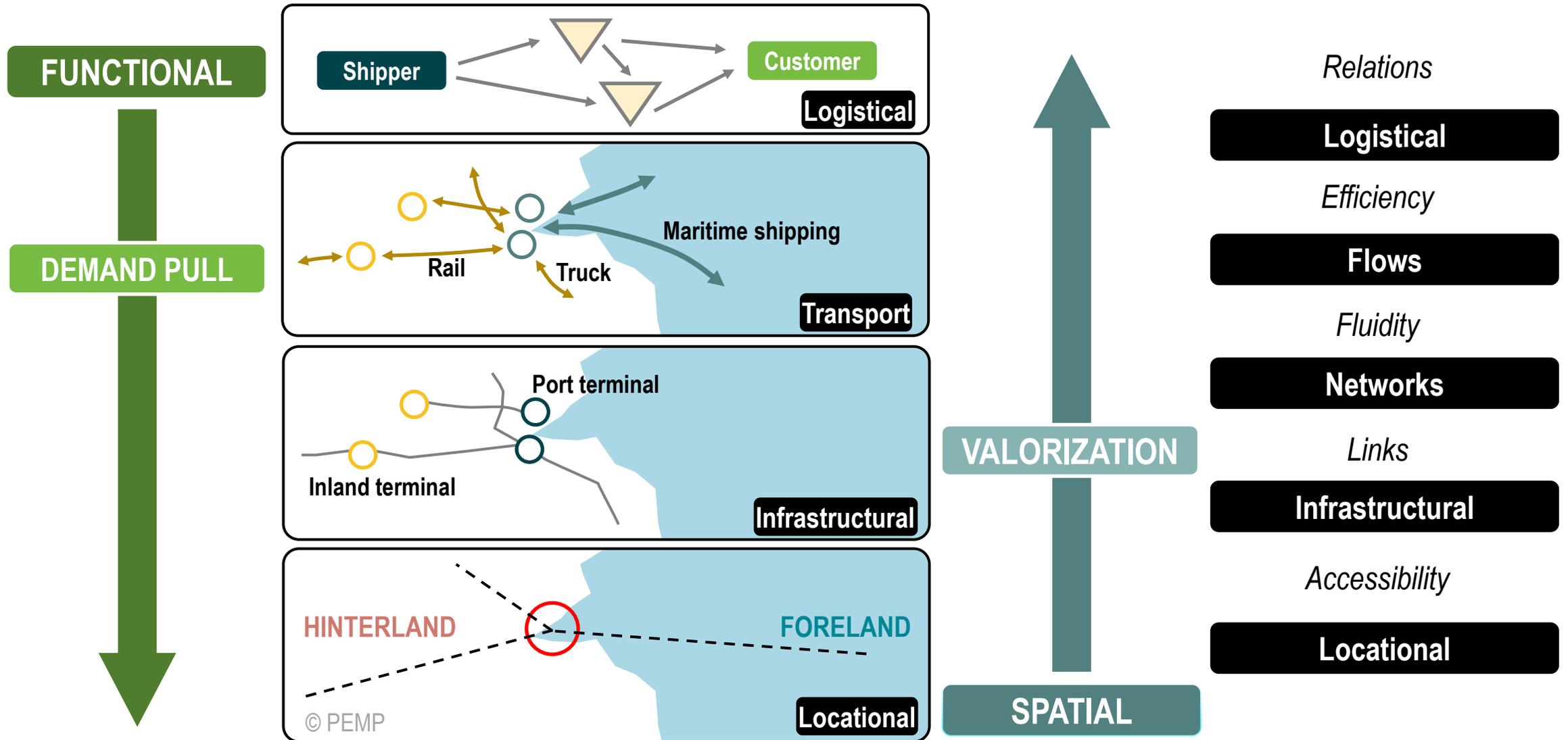
Agglomeration economies



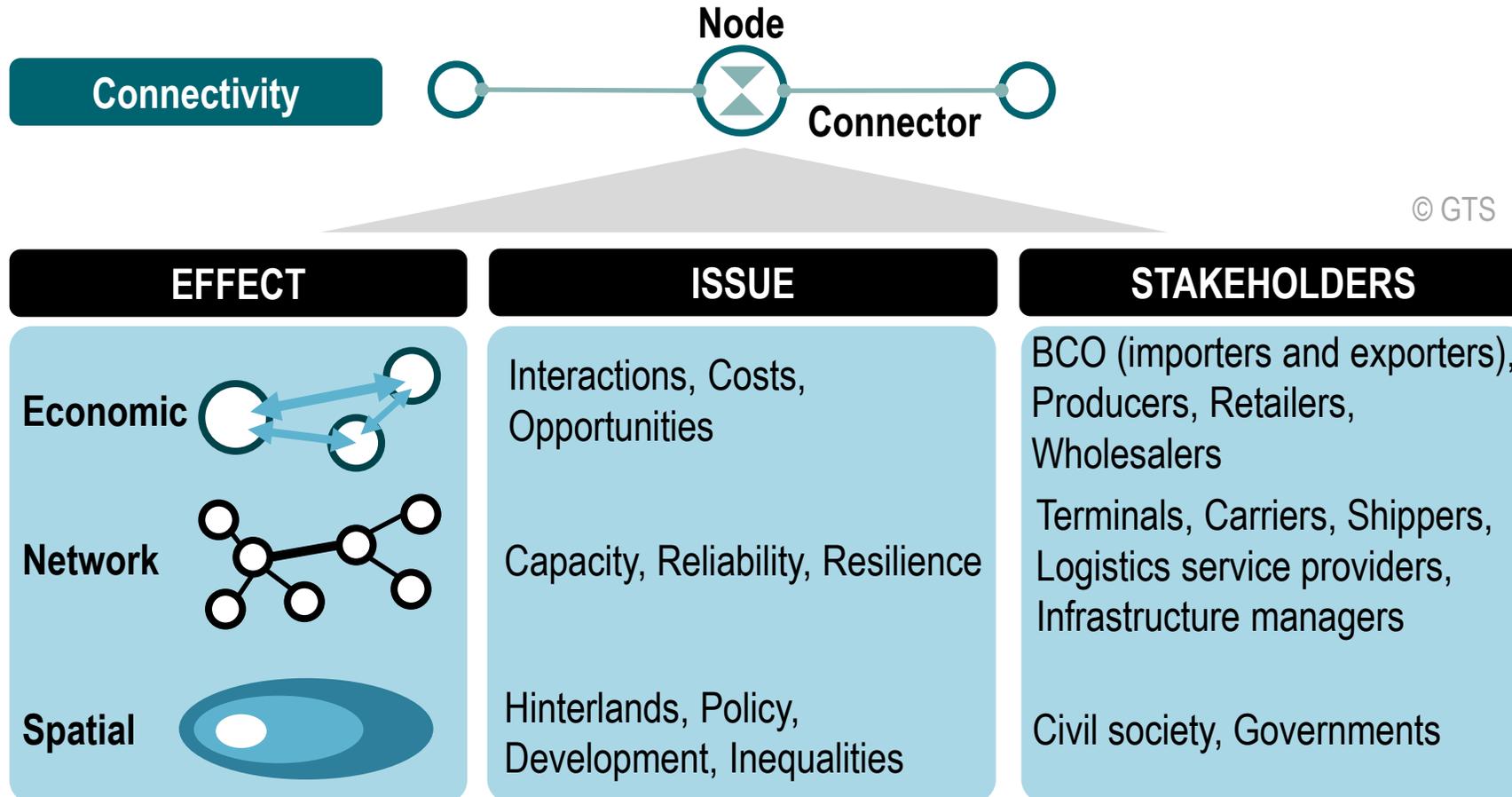
Poles of the Global Economy



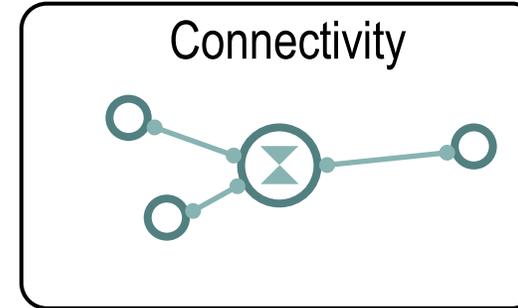
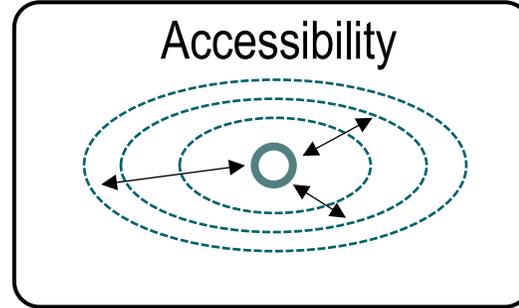
The Layers of Connectivity



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

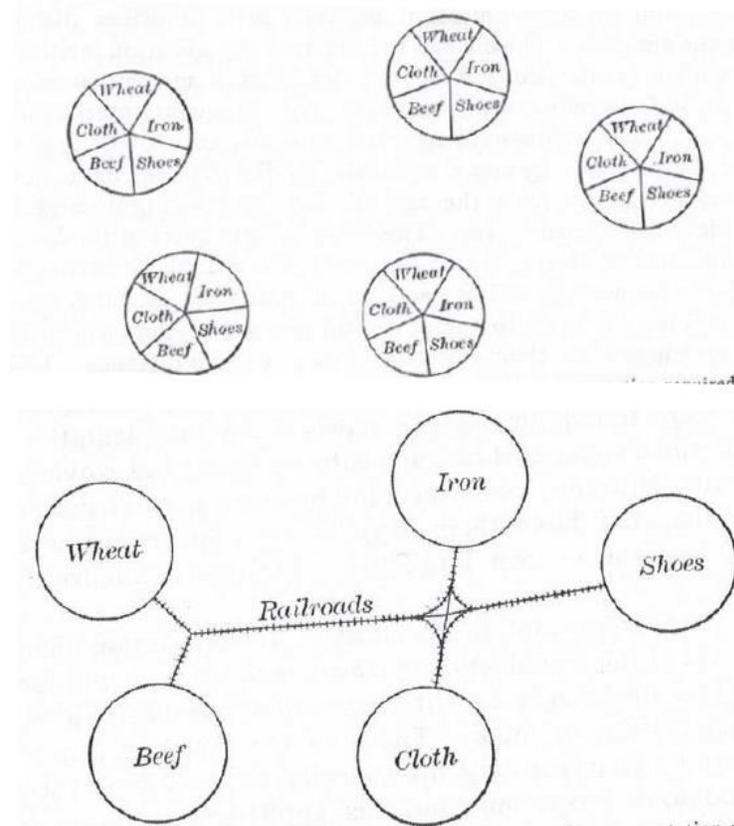
GOVERNANCE

— Trade or commercial policy

— Logistics (transport) policy

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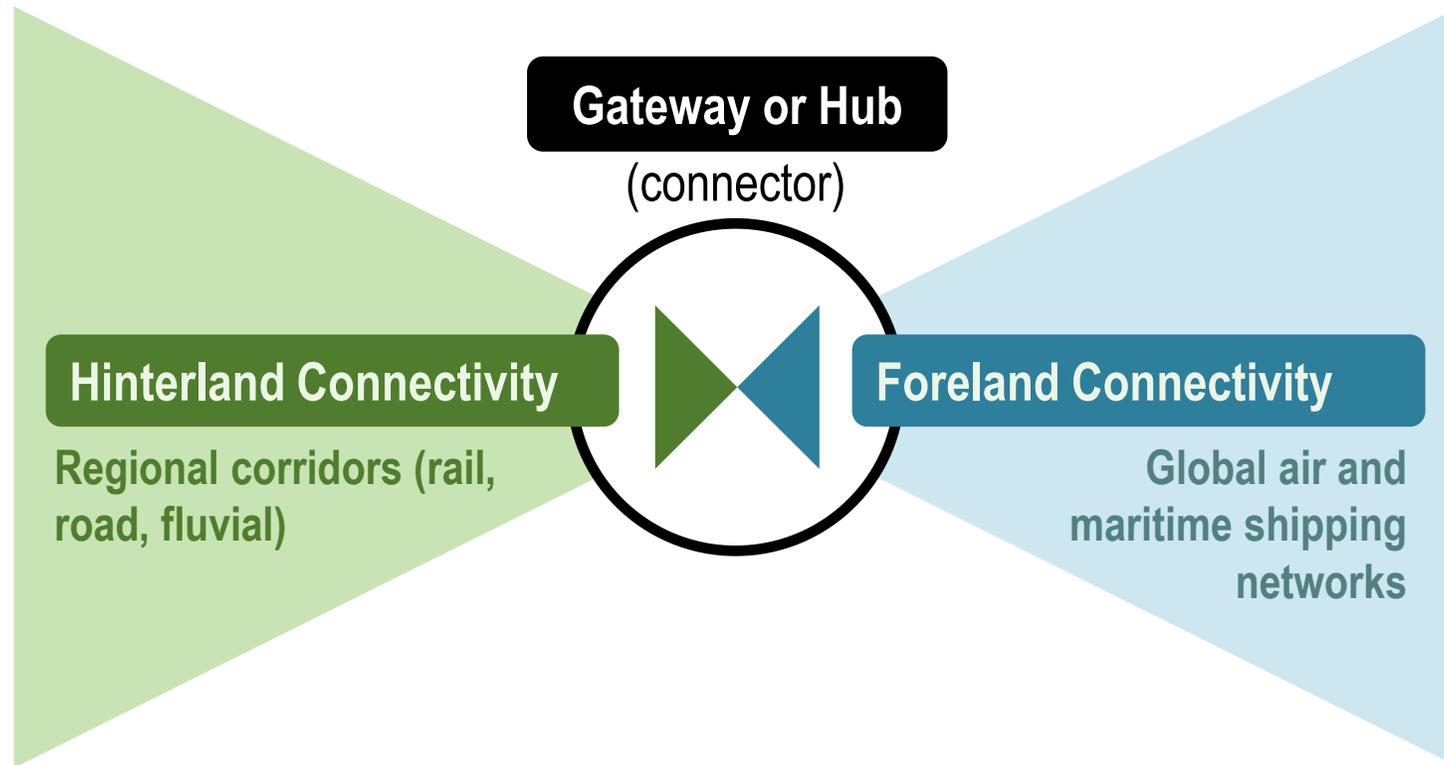
Transportation and the Regional Division of Labor



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

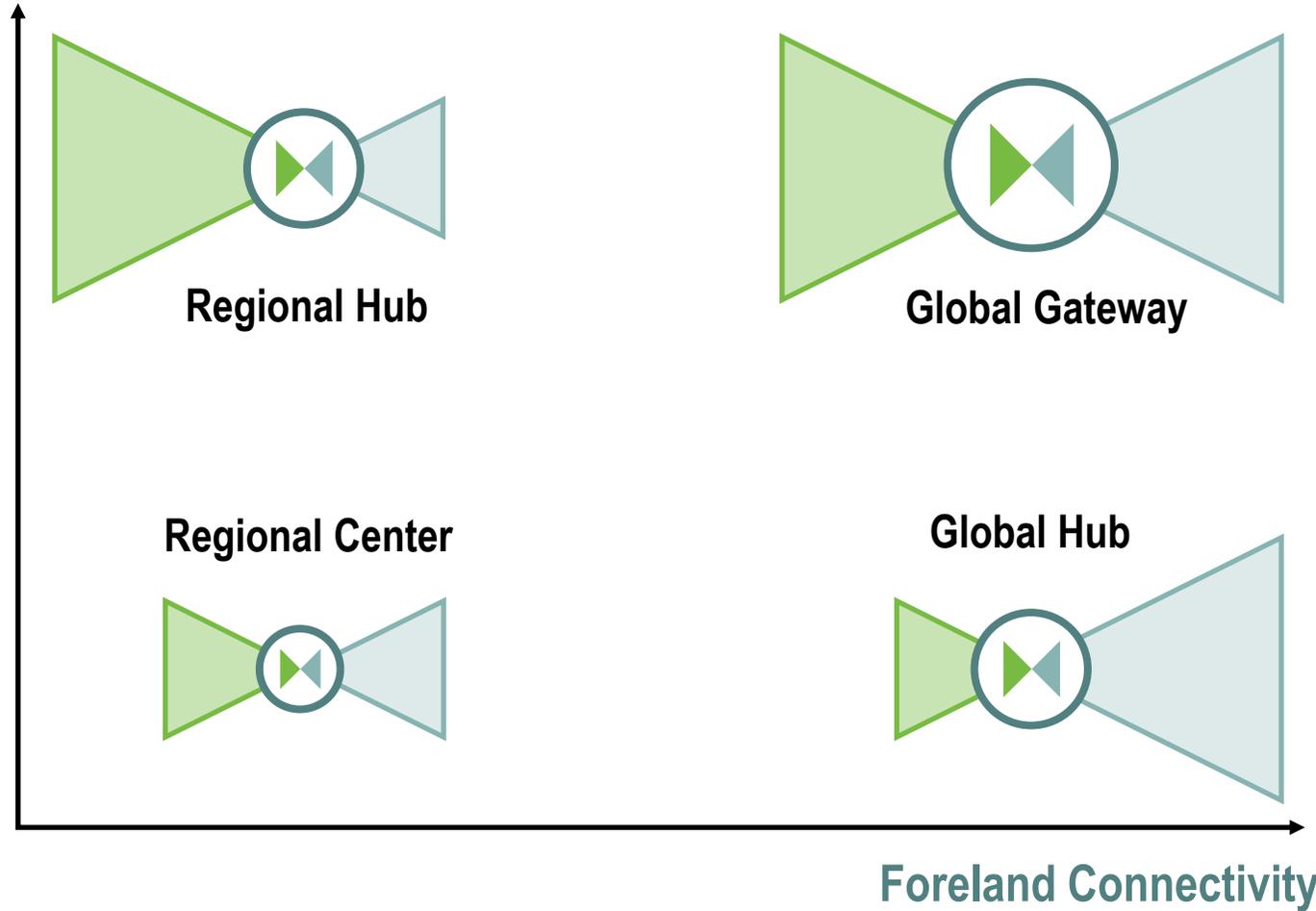
Source : Cooley & Cooley, 1894.

The Components of Nodal Connectivity

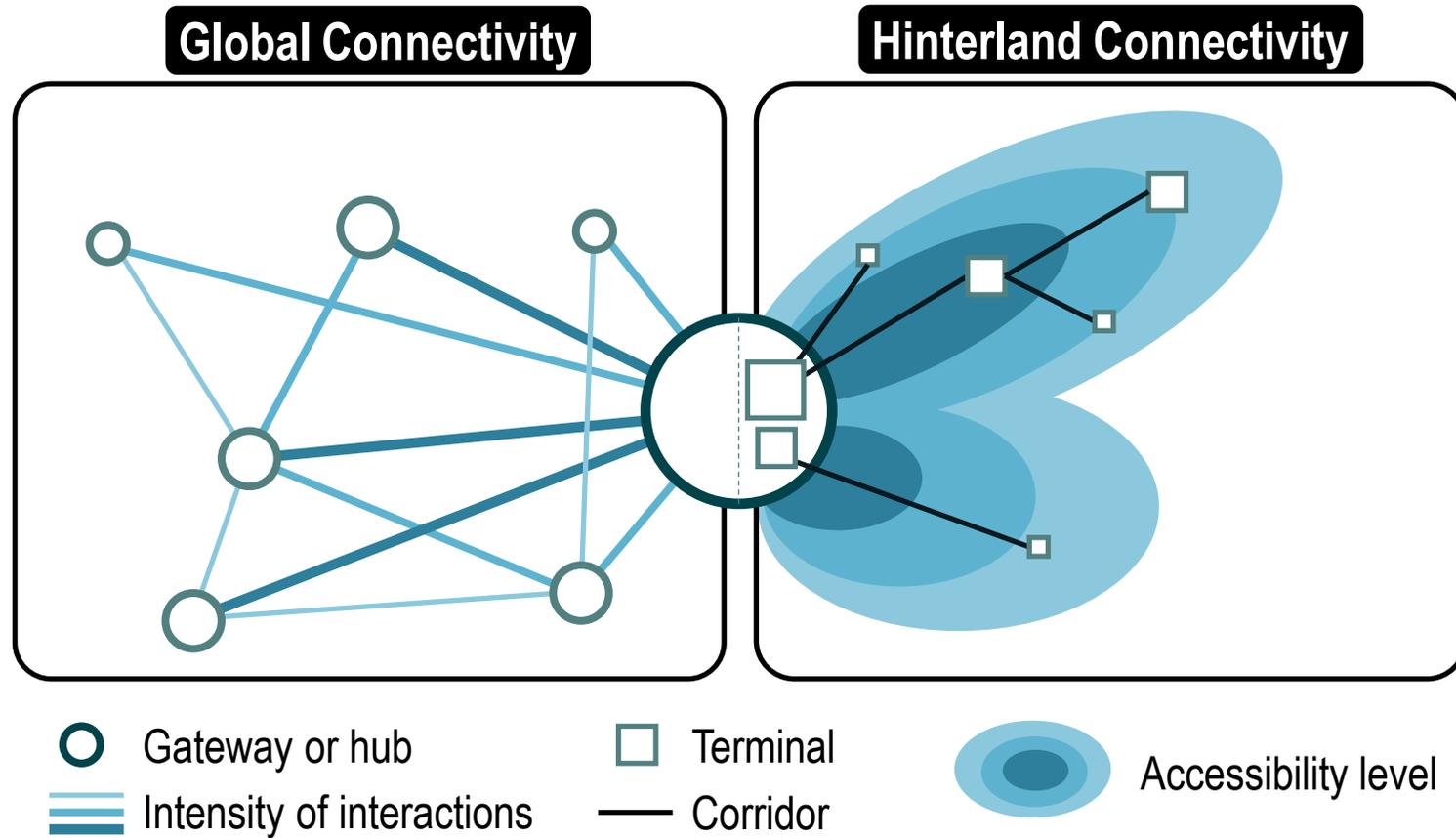


Functional Variations in Connectivity

Hinterland Connectivity



Global and Hinterland Connectivity



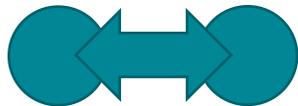
The Three Tiers of Connectivity



Terminals (networks)

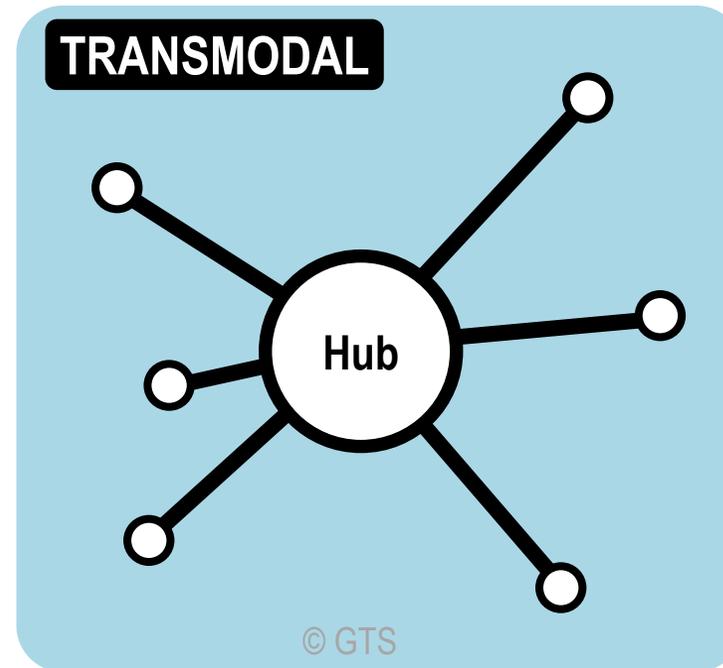
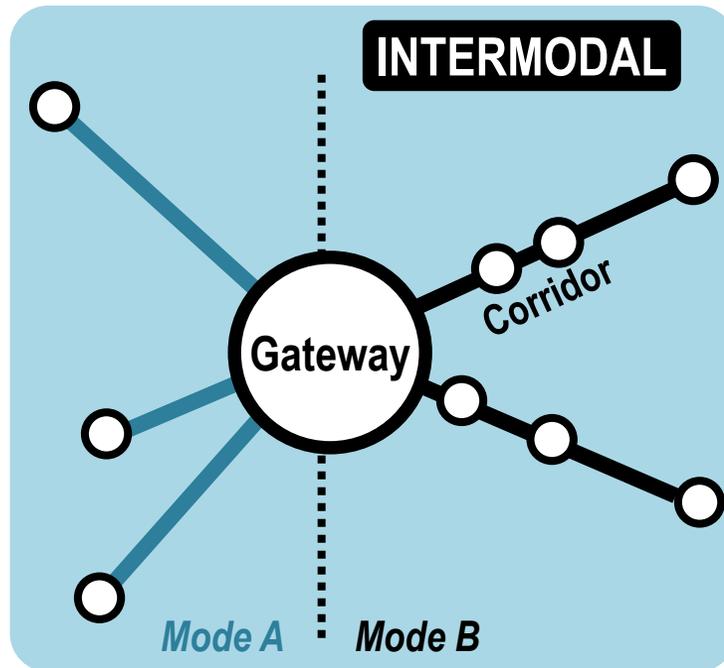


Distribution (supply chains)

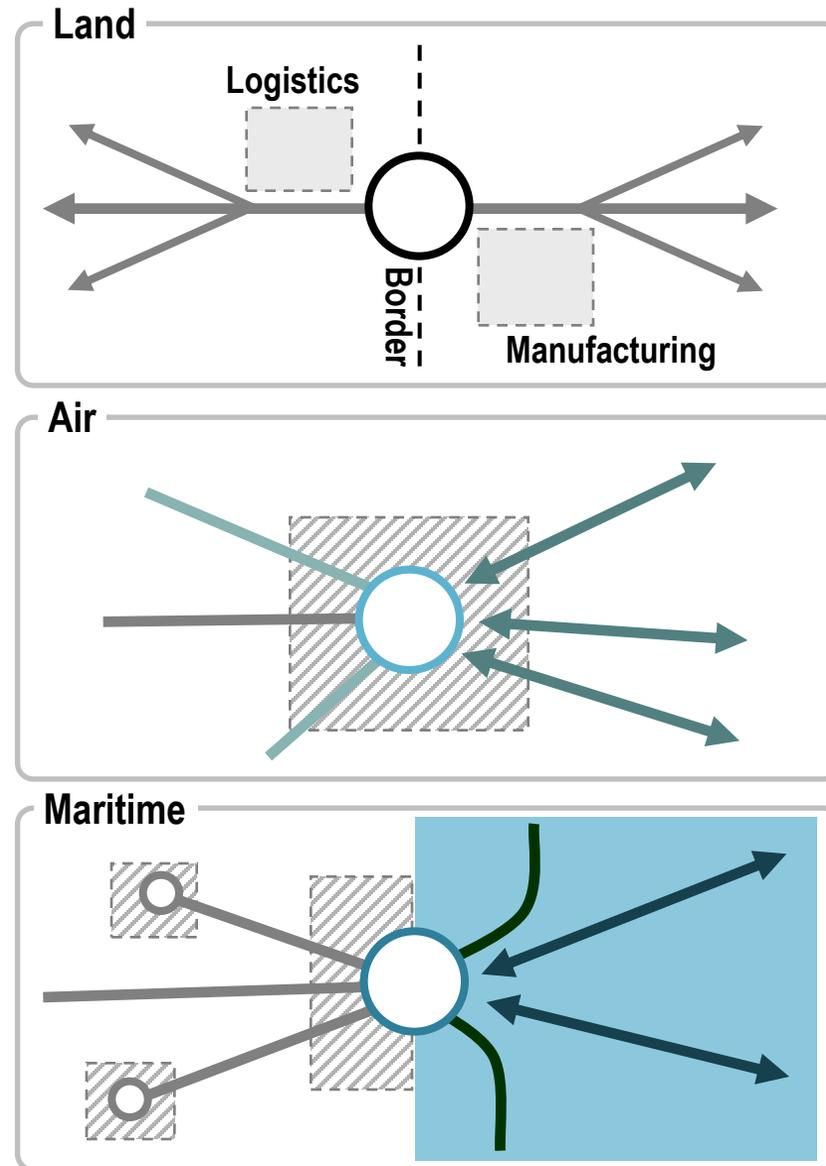


Production and consumption (trade)

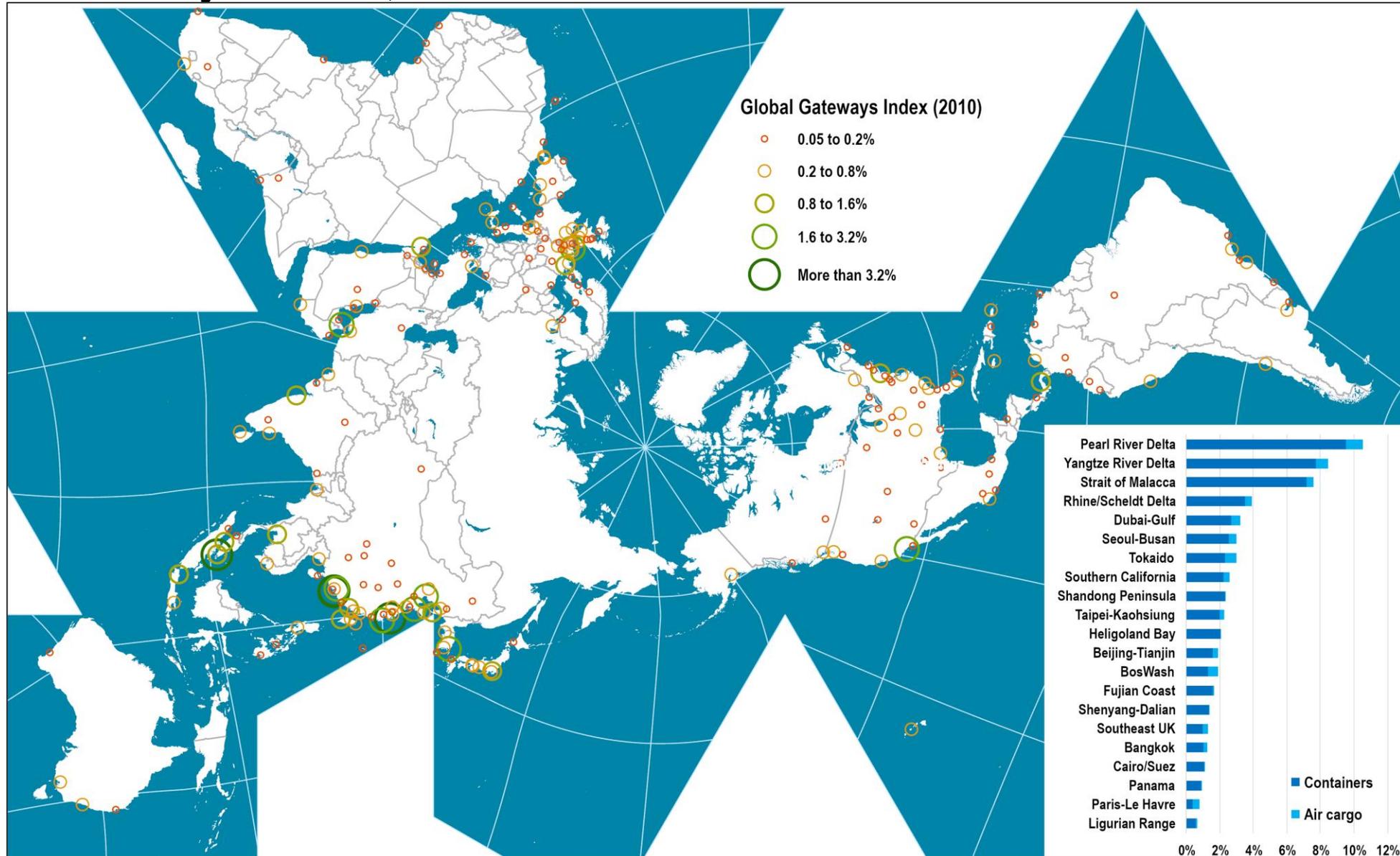
Gateways and Hubs



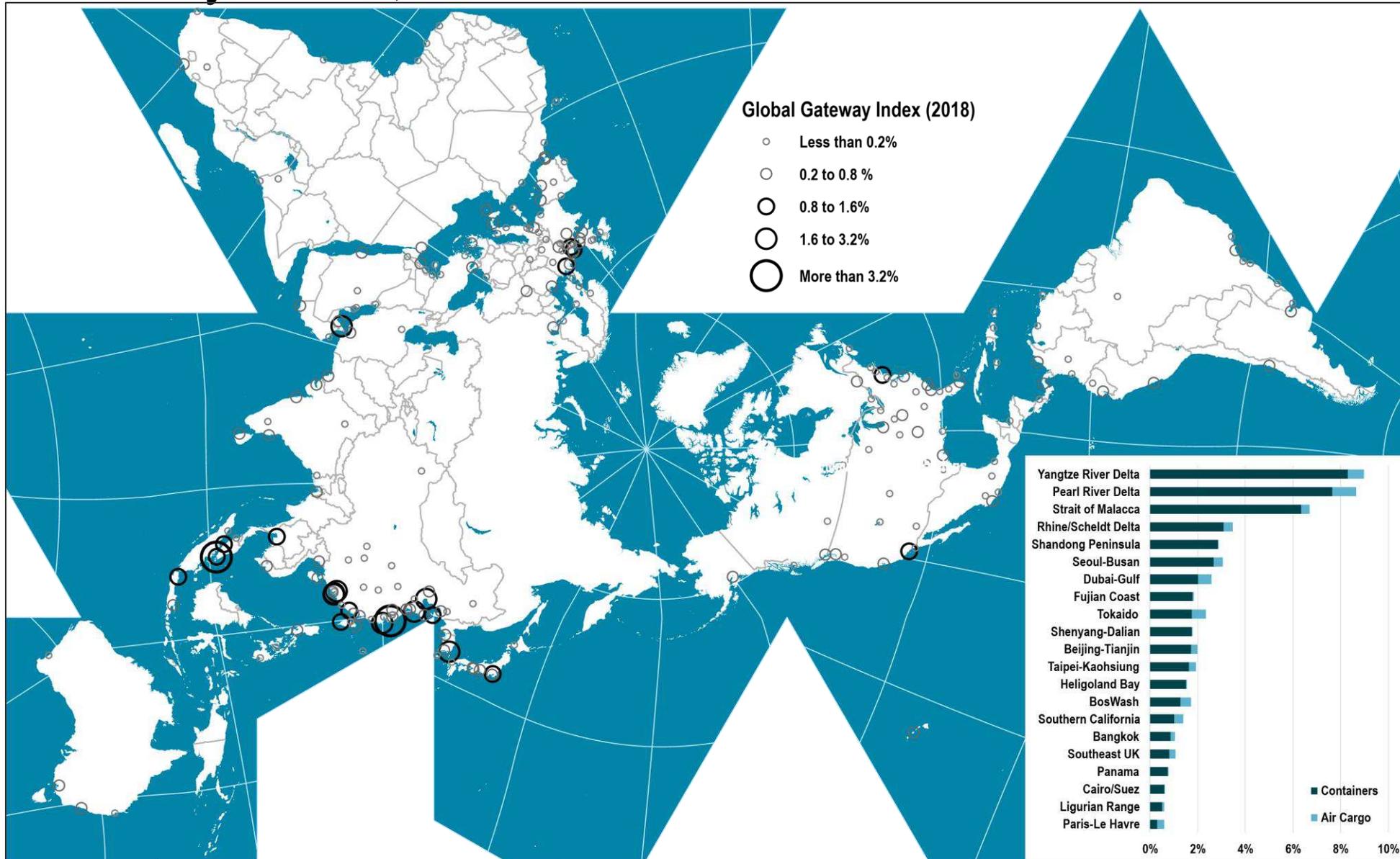
Modal Gateways



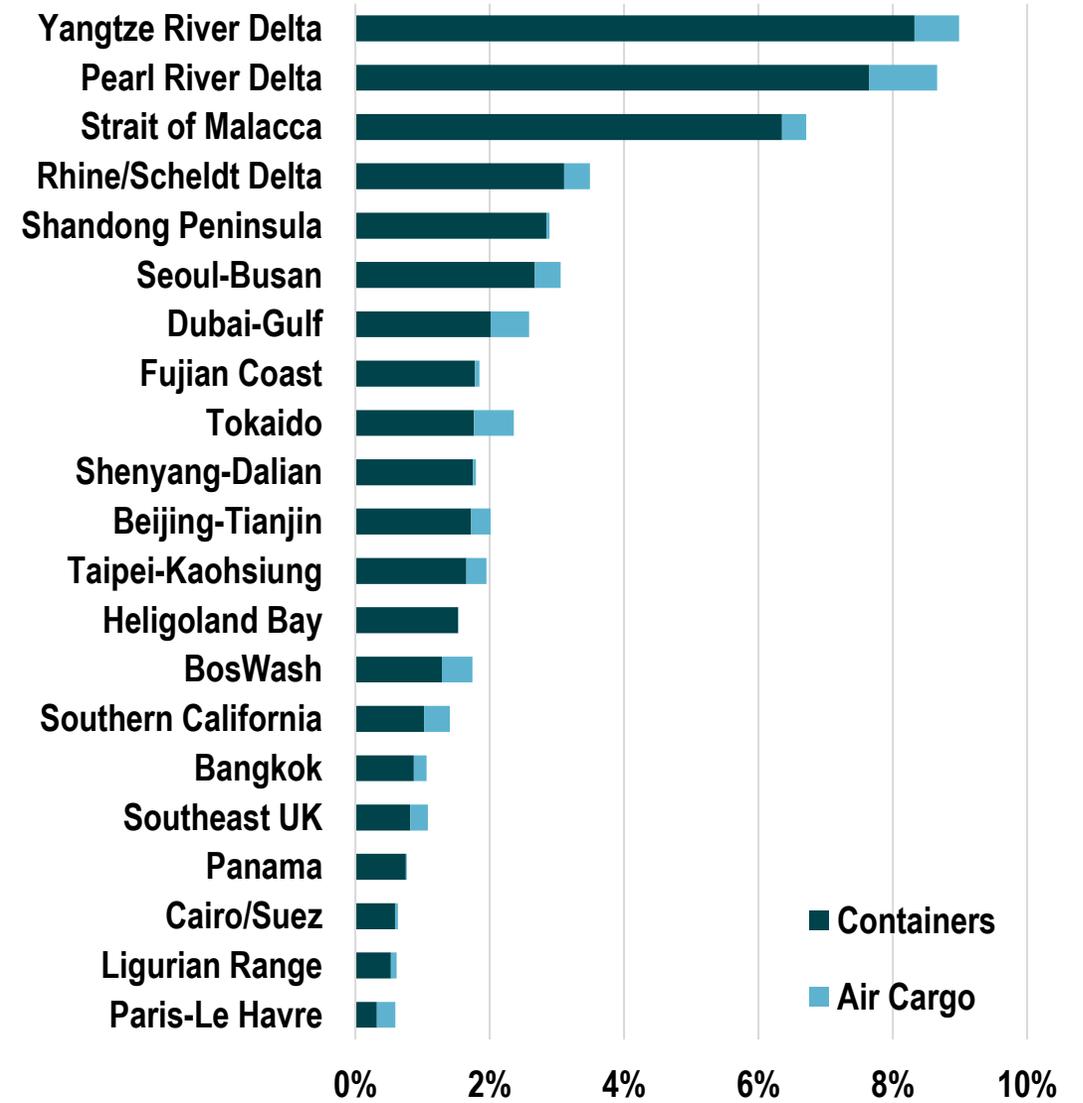
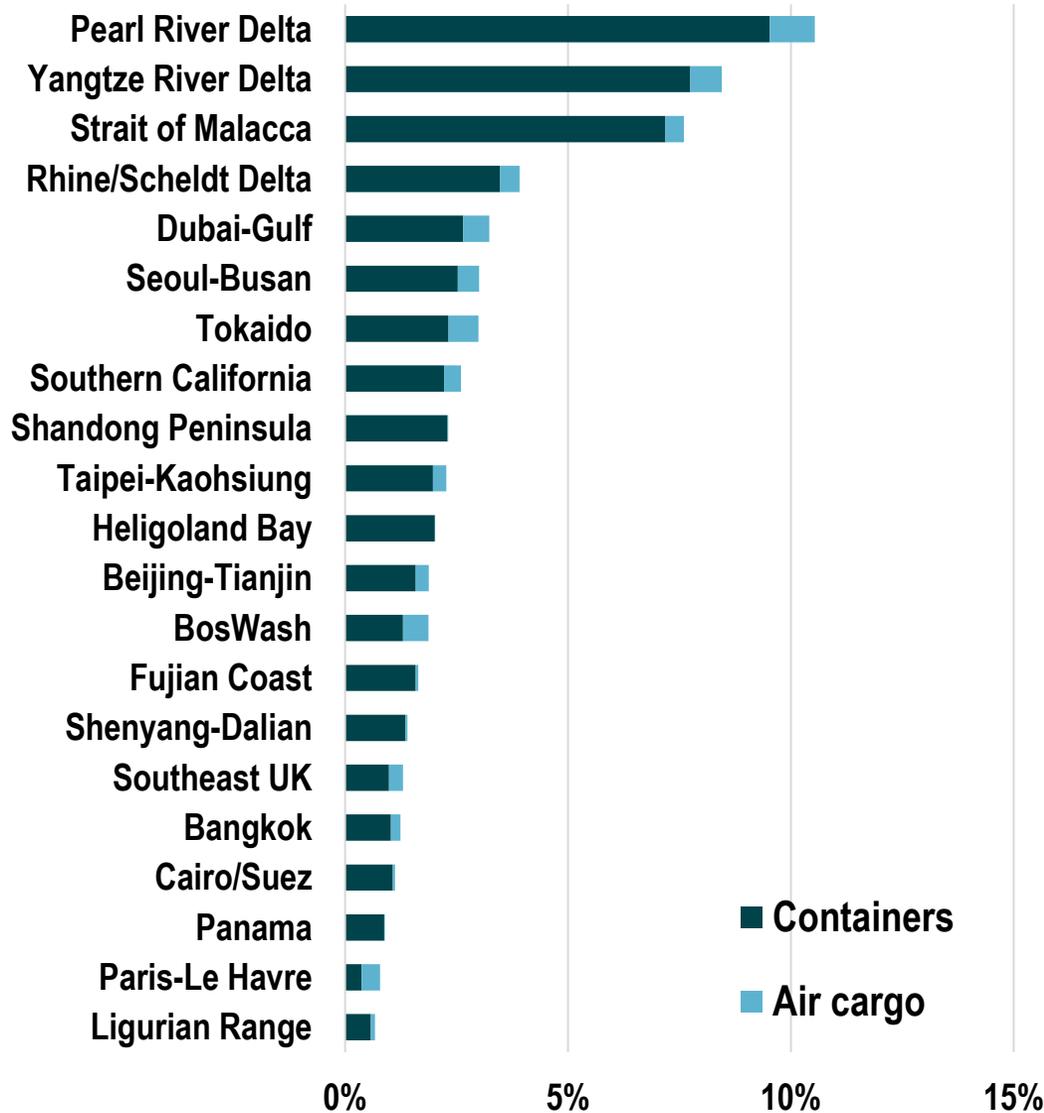
Global Gateways Index, 2010



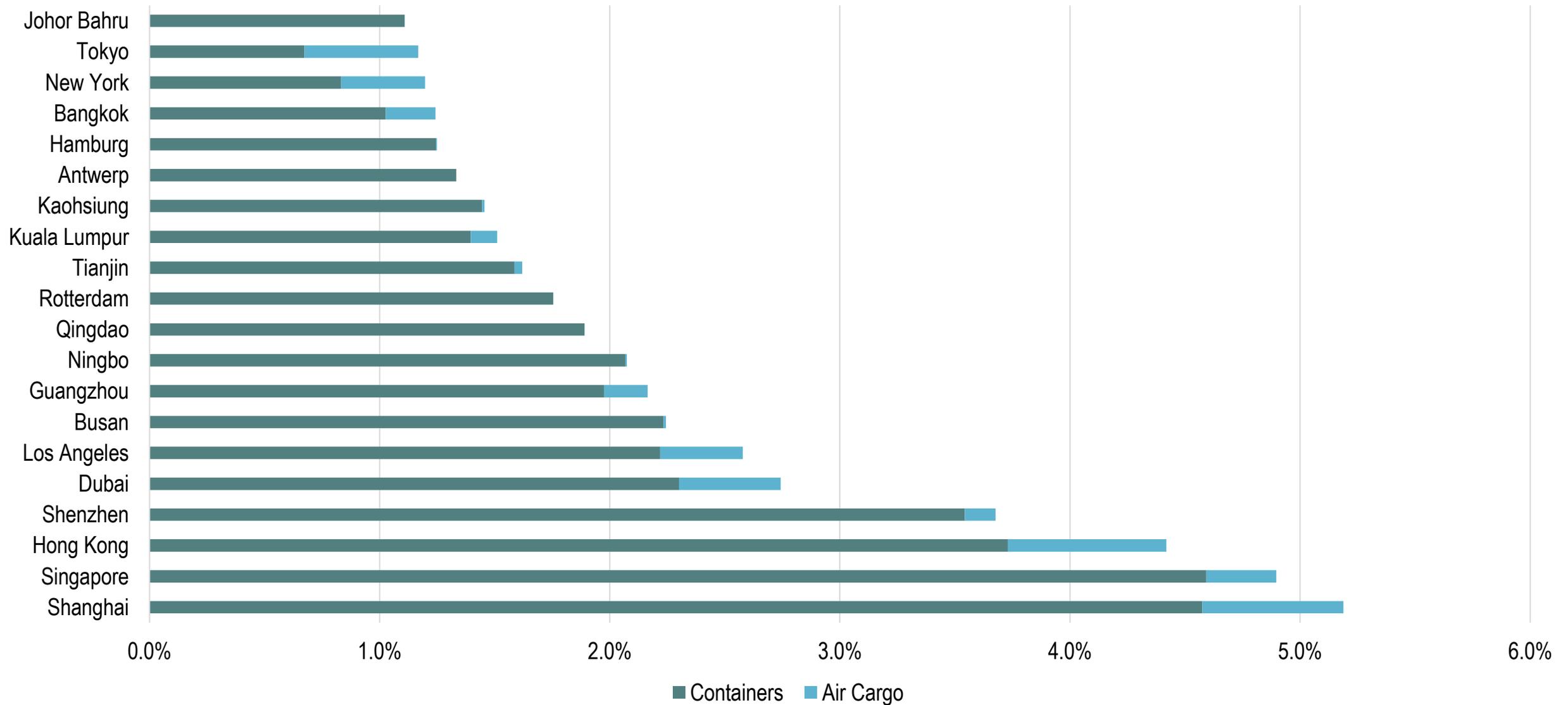
Global Gateways Index, 2018



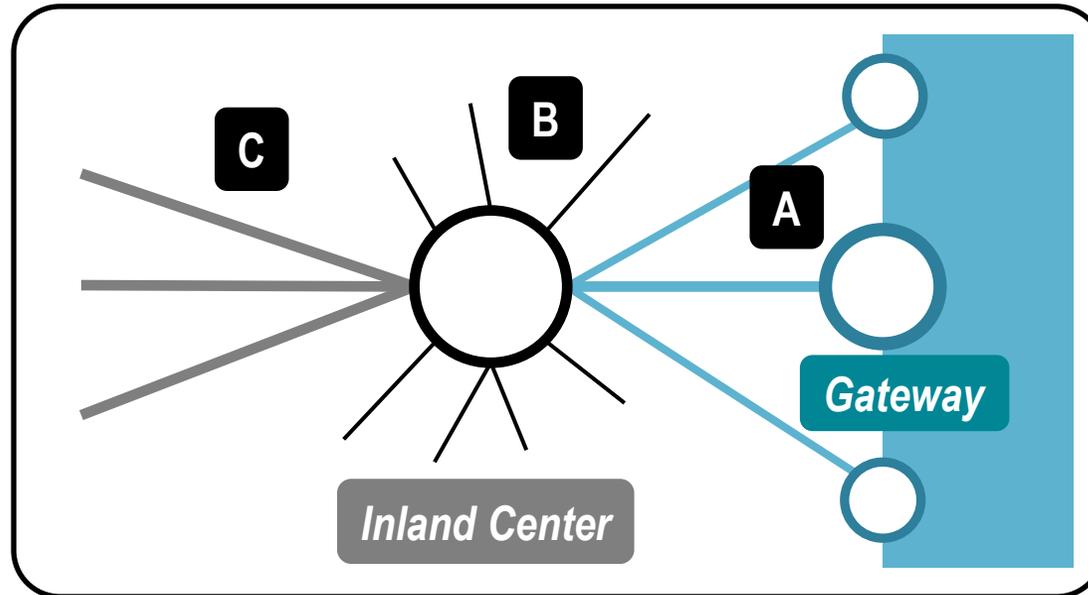
Global Gateways Index by Gateway Region, 2010-2018



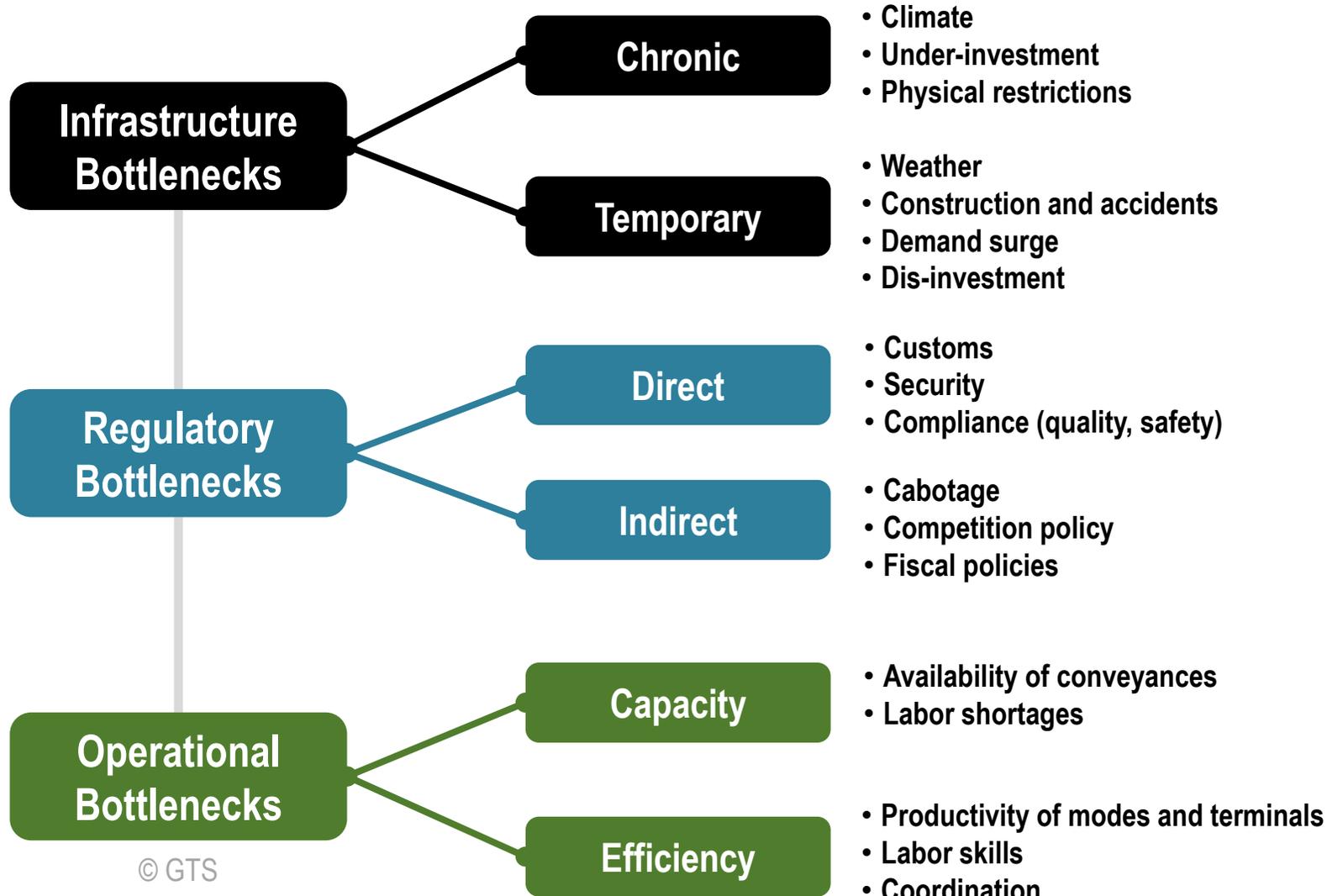
Top 25 Gateways, Global Gateways Index, 2010



Types of Hinterland Connectivity

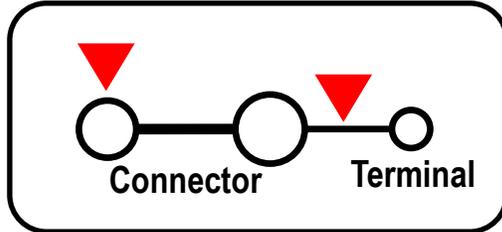


Types of Bottlenecks



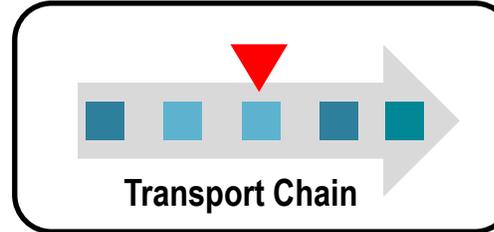
Main Transportation Bottlenecks

Infrastructure Bottlenecks



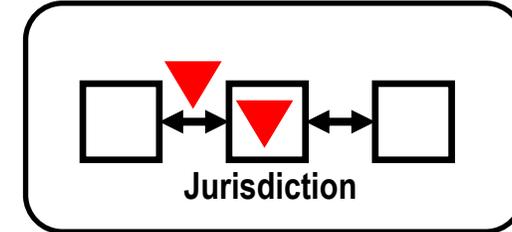
- Lack of terminal or connector capacity.
- Availability of conveyances.
- Natural or anthropogenic disruptions.
- Lack of investment and maintenance.

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

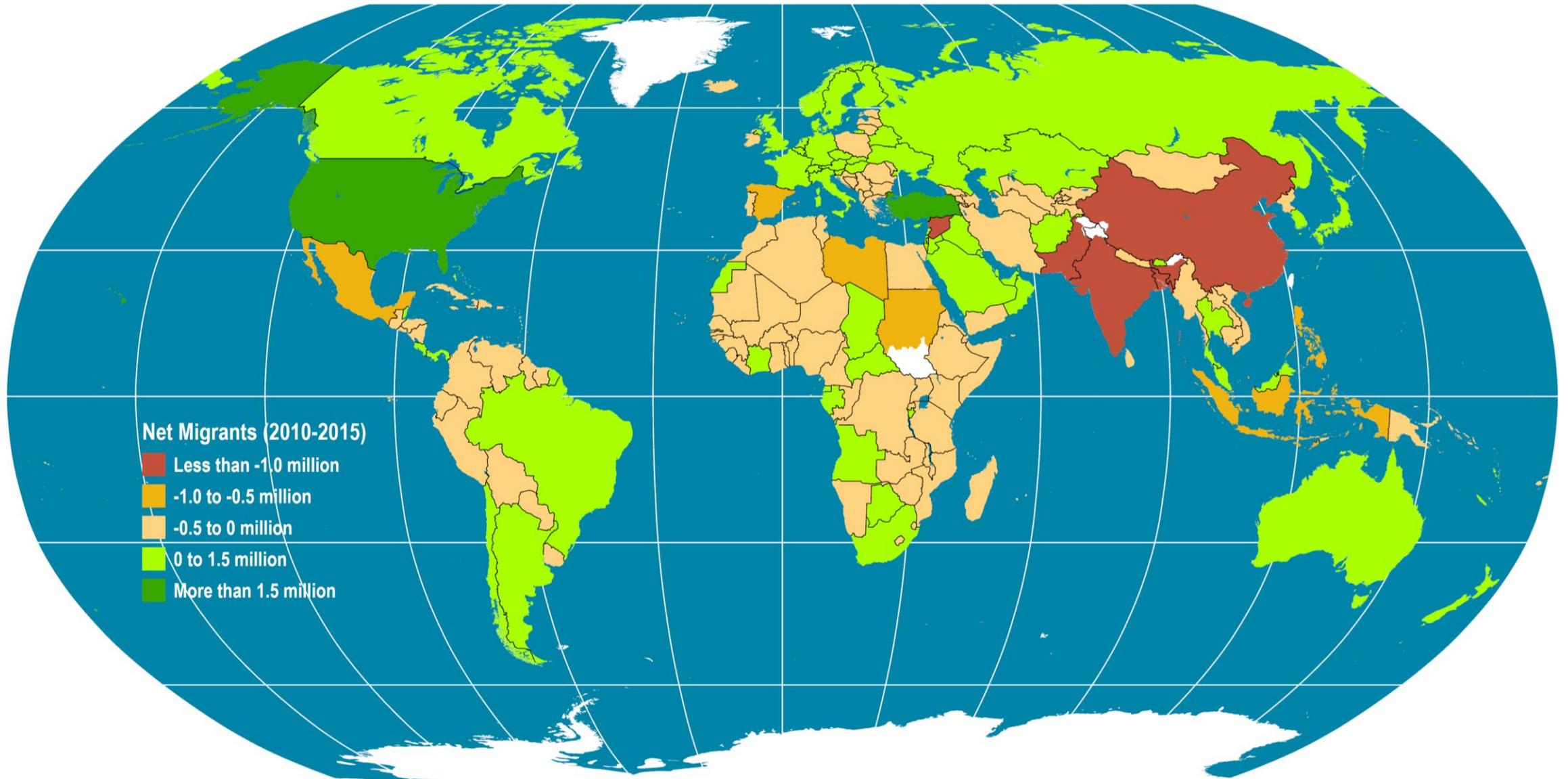
Temporary

Extent

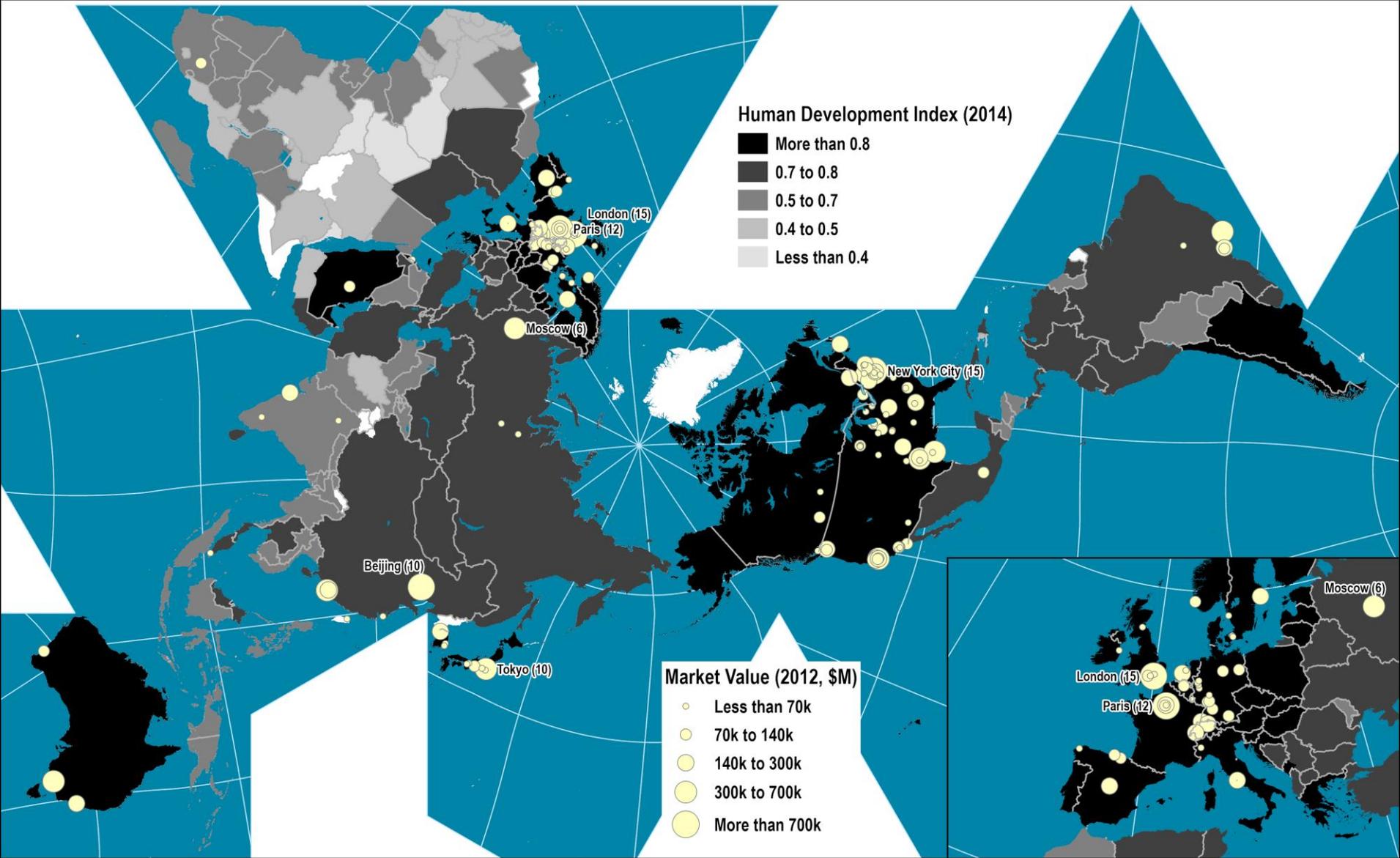
Direct

Indirect

Global Net Migration (2010-2015)



World's 250 Largest Corporations by Head Office City



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Criteria to be a World City (Foreign Policy)

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

Business activity

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.

Human capital

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.

Information exchange

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.

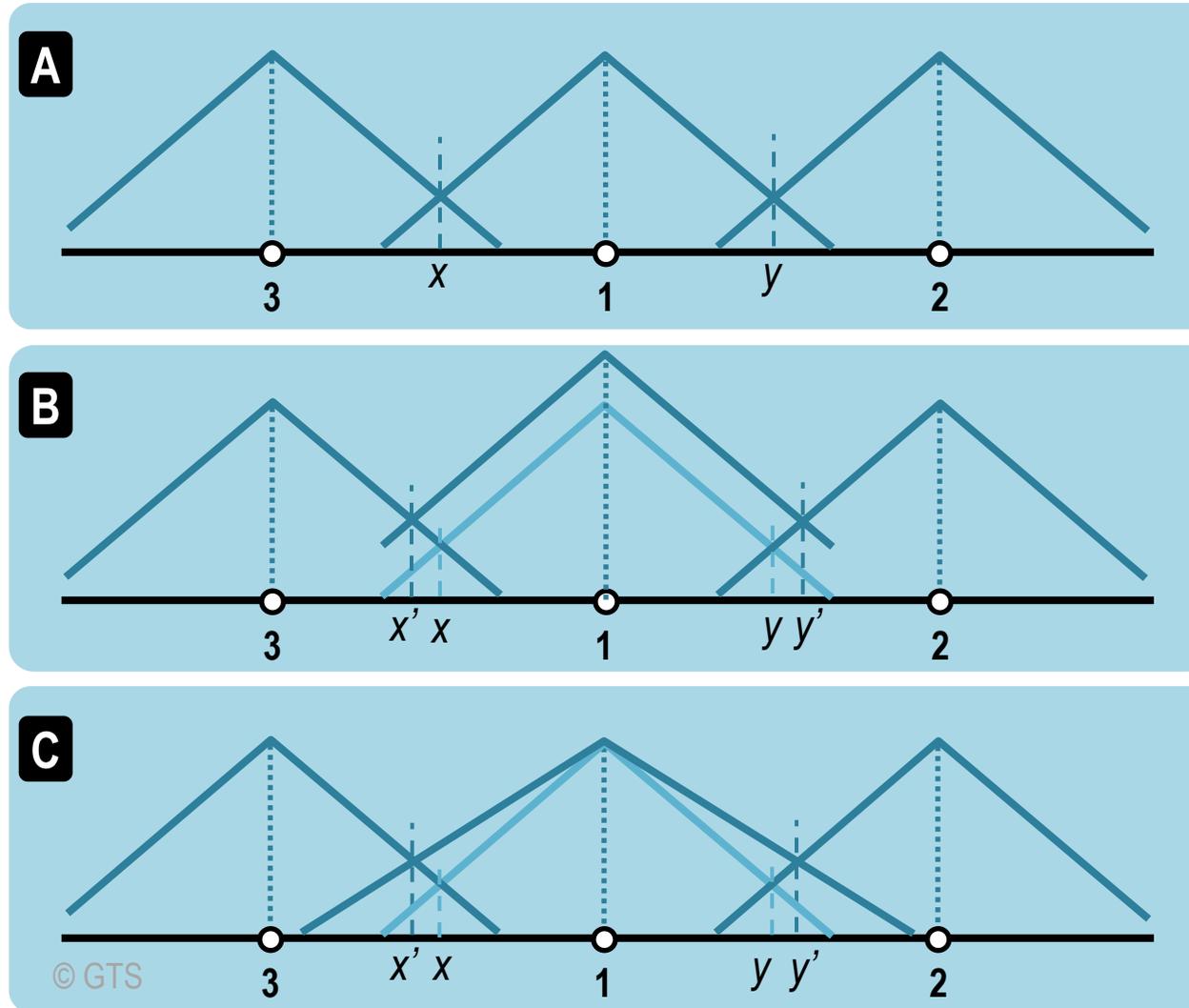
Cultural influence

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.

Political engagement

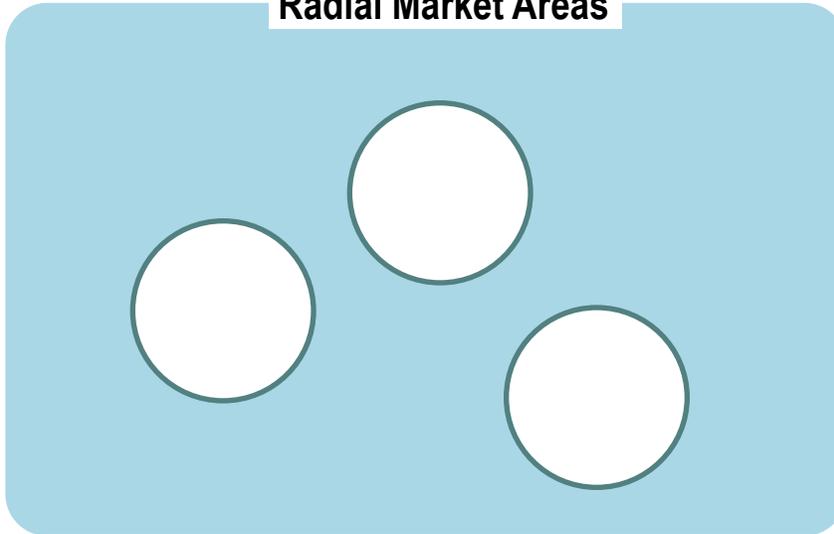
The level of influence on global politics; number of embassies and consulates, major think tanks, international organizations and local institutions with international reach, and the number of political conferences.

Delimitation and Variations in Market Areas

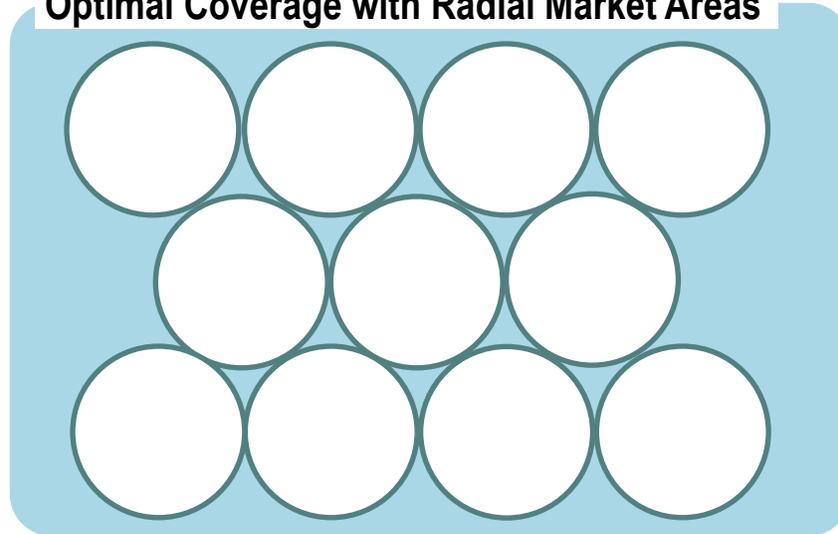


The Spatial Setting of Market Areas

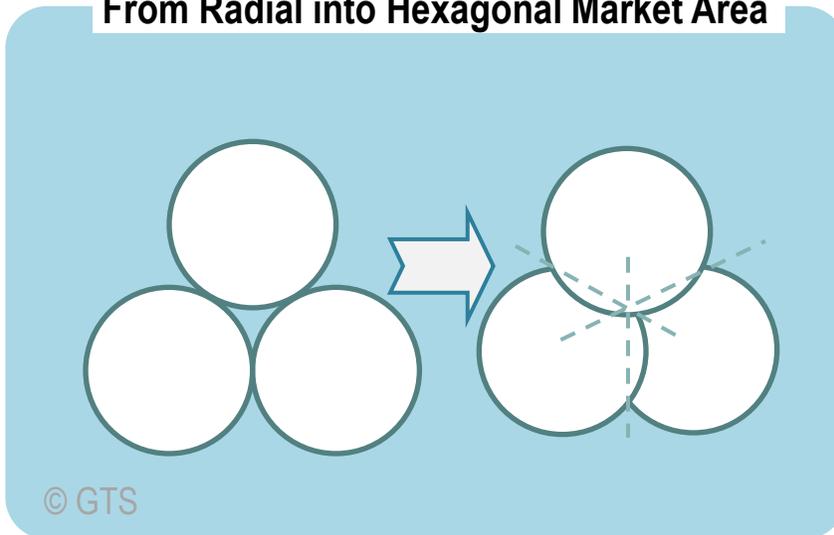
Radial Market Areas



Optimal Coverage with Radial Market Areas

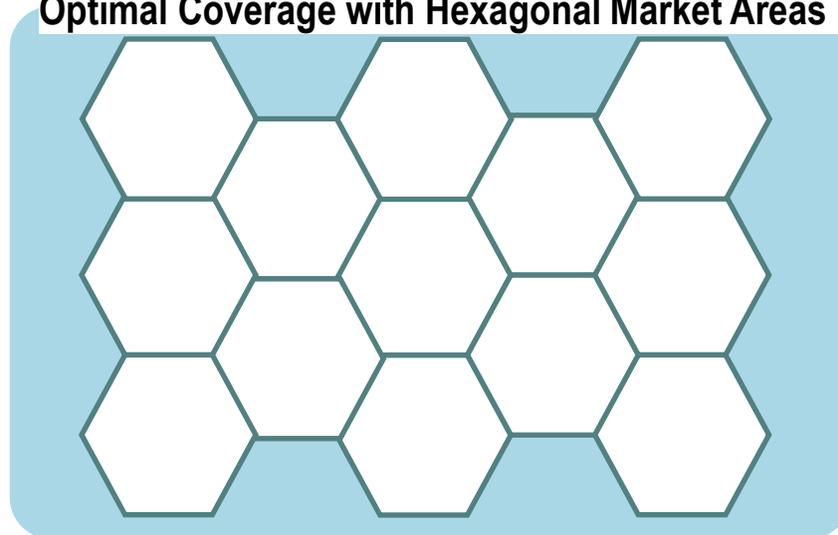


From Radial into Hexagonal Market Area

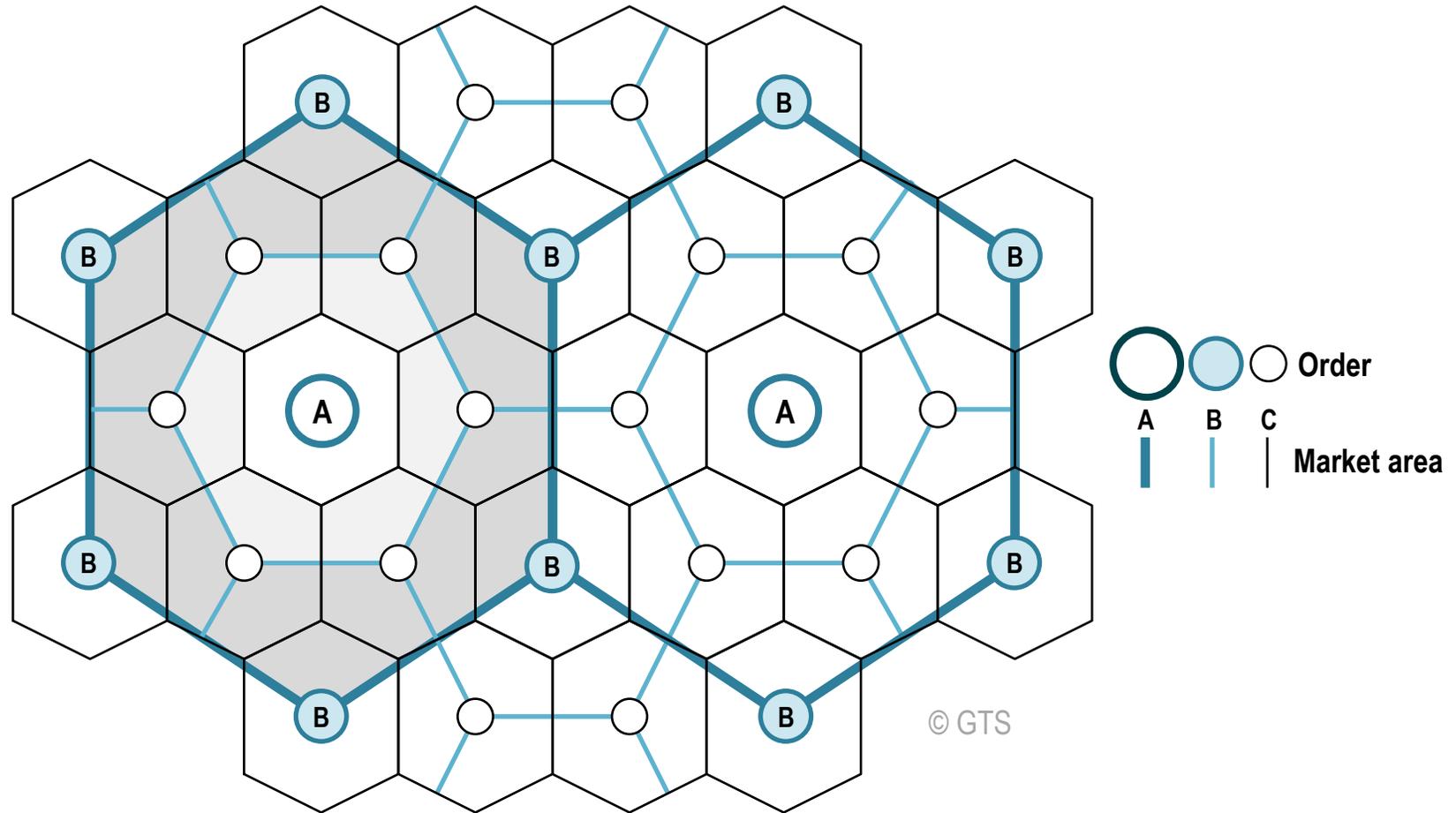


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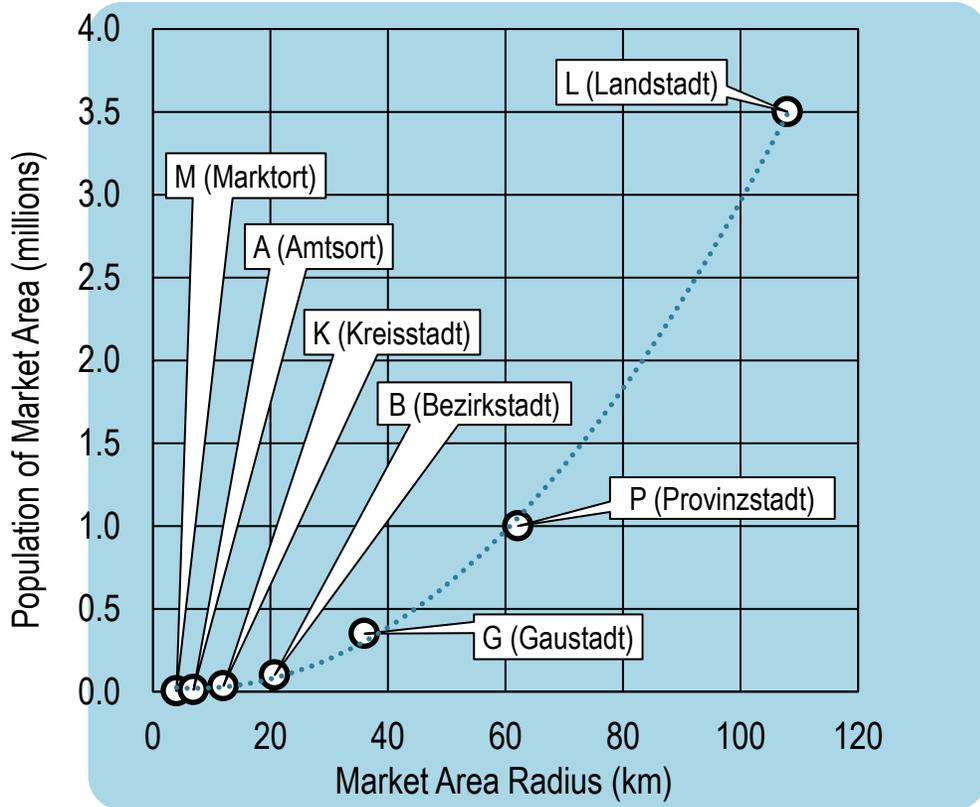
Optimal Coverage with Hexagonal Market Areas



Central Places Theory (k=3)

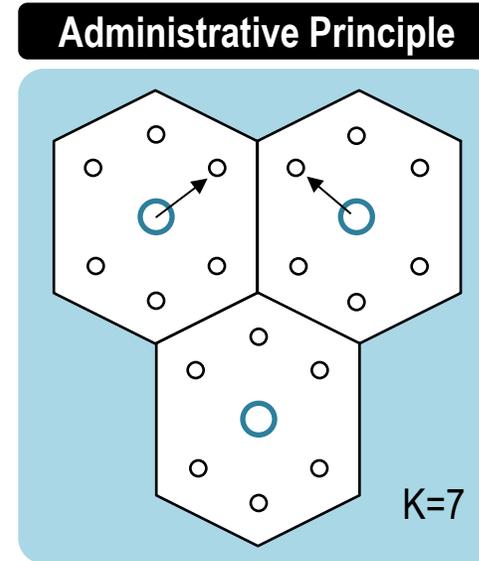
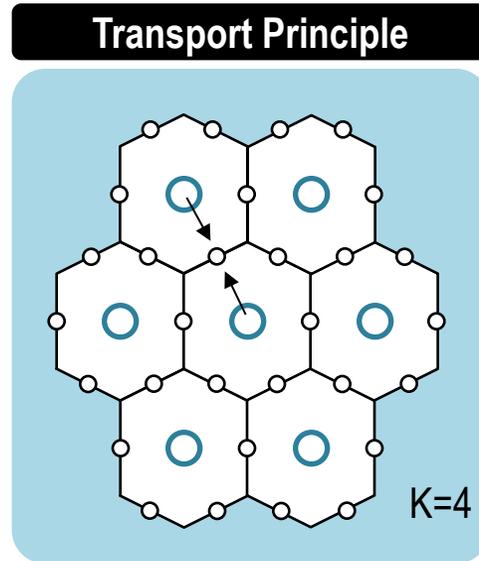
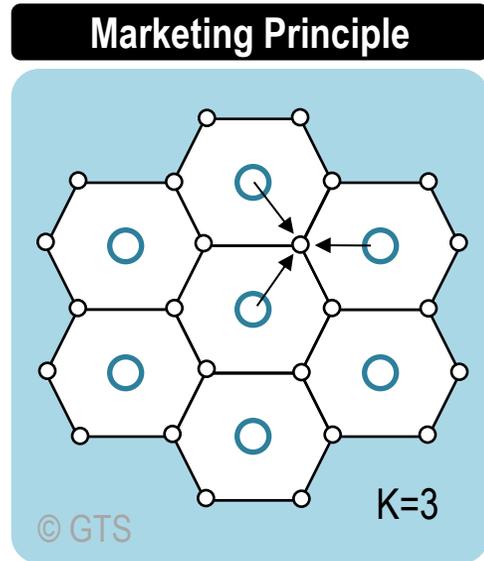


Market Size / Area Relationships in the Central Places Theory

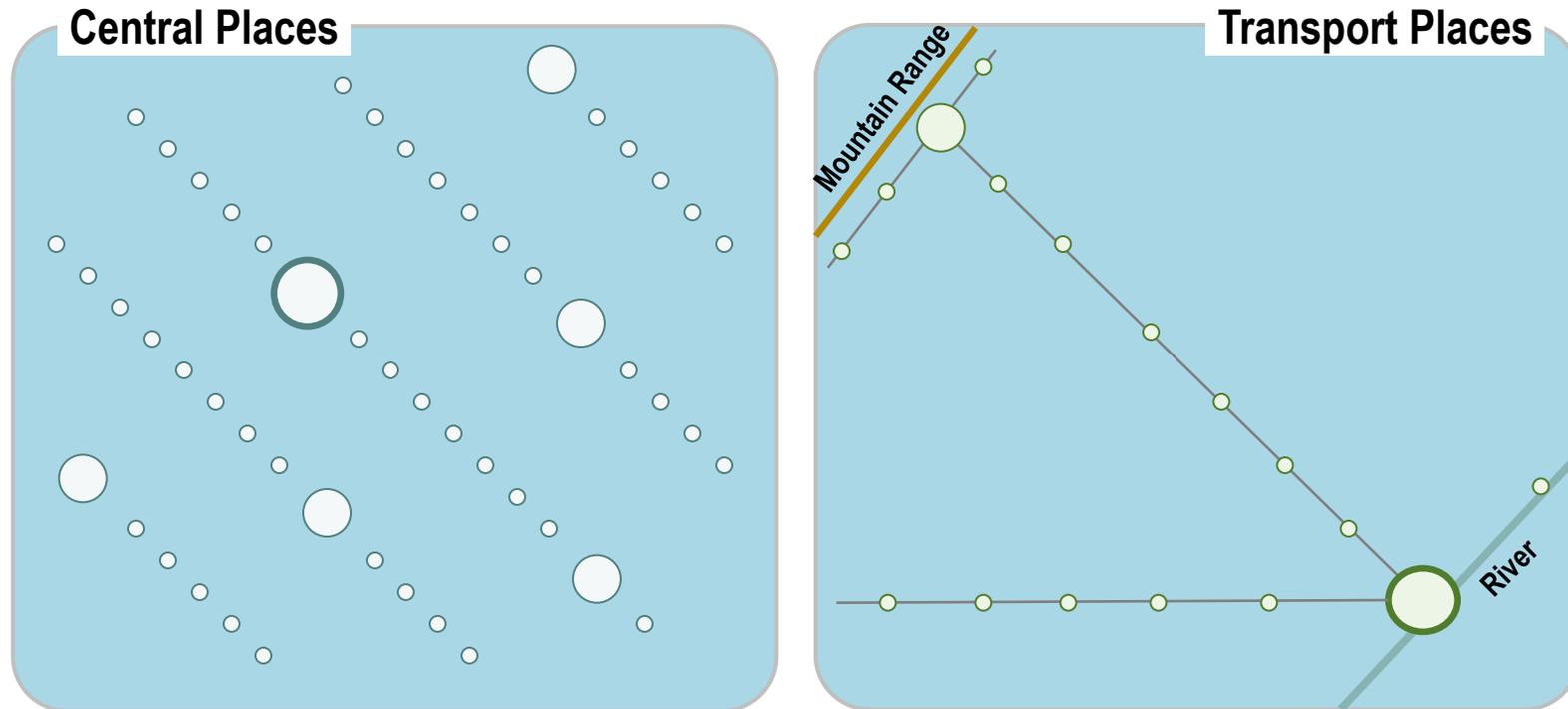


Order	Radius (km)	Town Population	Market Population
M (Marktort)	4	1,000	3,500
A (Amtsort)	6.9	2,000	11,000
K (Kreisstadt)	12	4,000	35,000
B (Bezirkstadt)	20.7	10,000	100,000
G (Gaustadt)	36	30,000	350,000
P (Provinzstadt)	62.1	100,000	1,000,000
L (Landstadt)	108	500,000	3,500,000

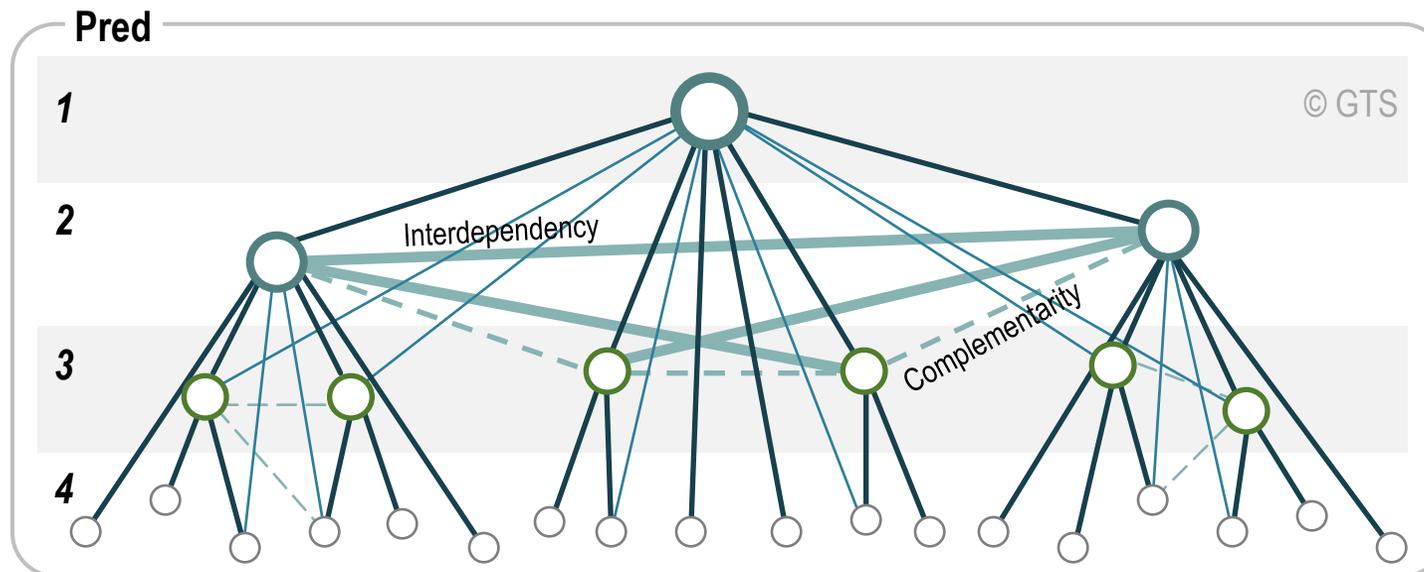
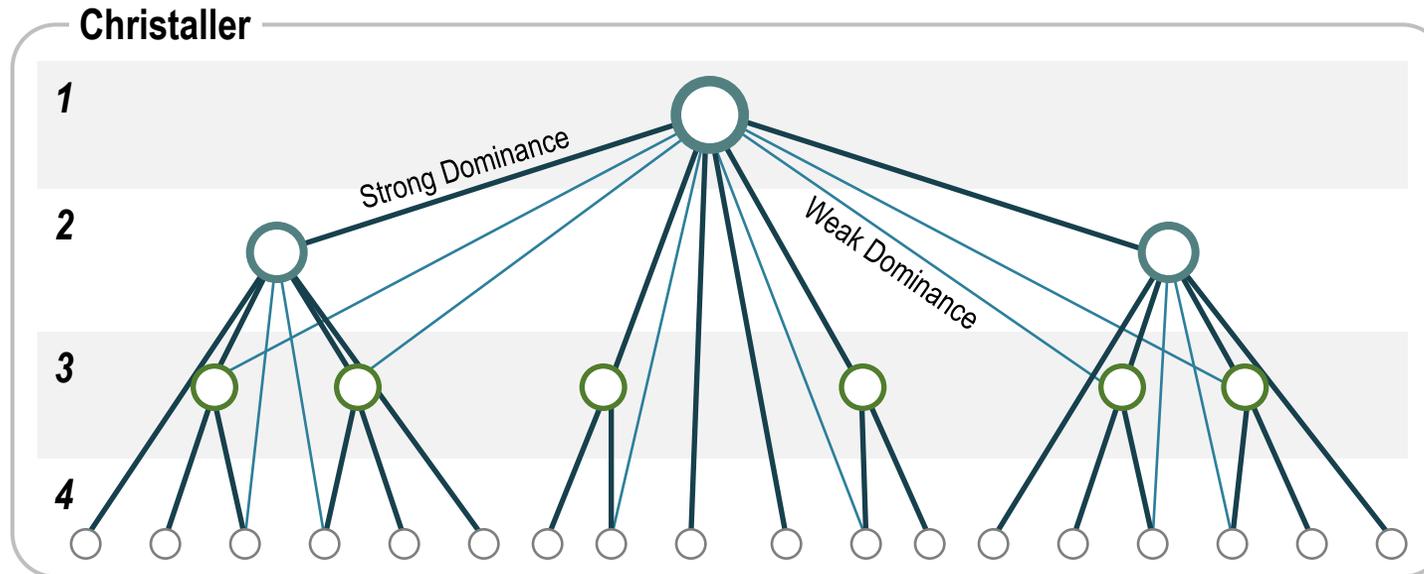
Variations of the Central Places Theory



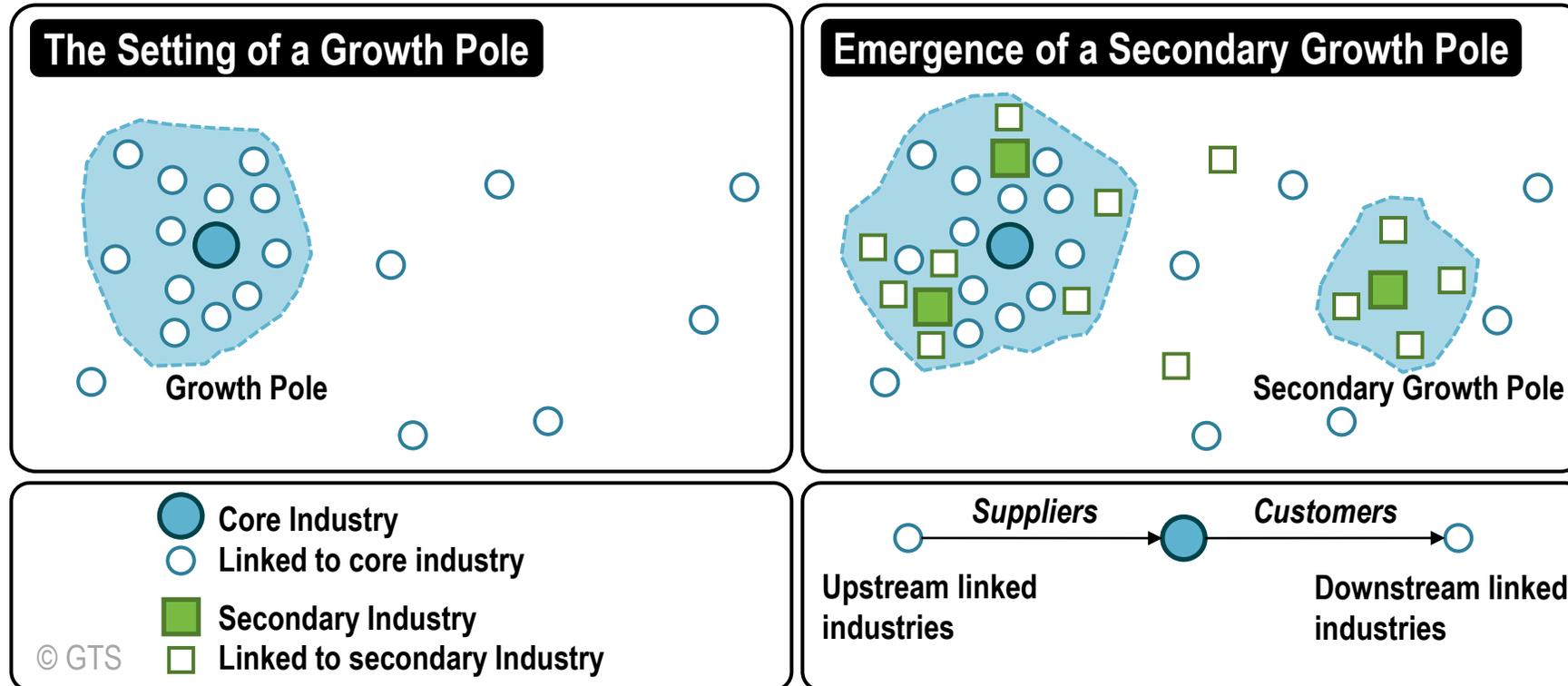
Central Places and Transport Places



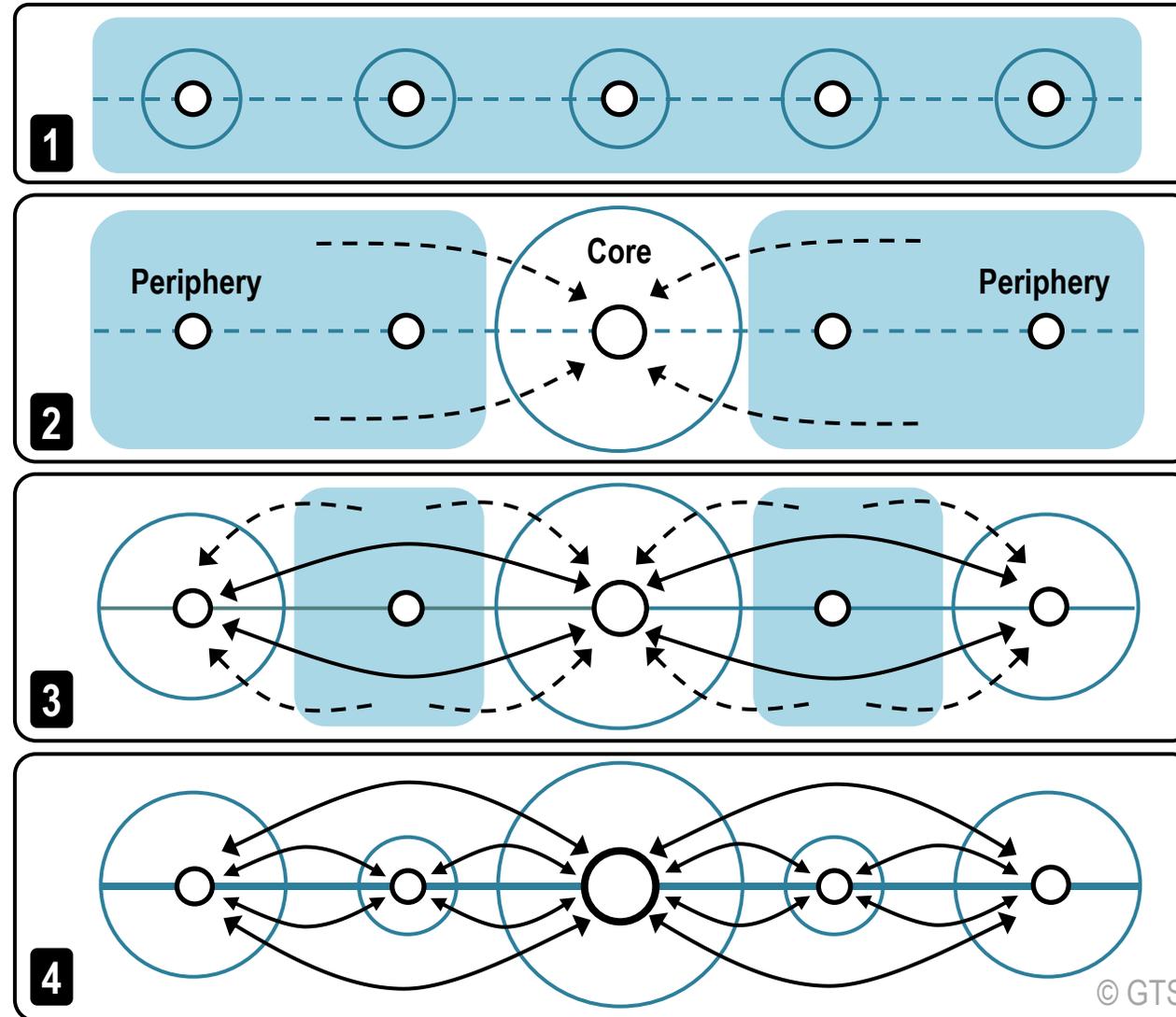
Urban Hierarchy



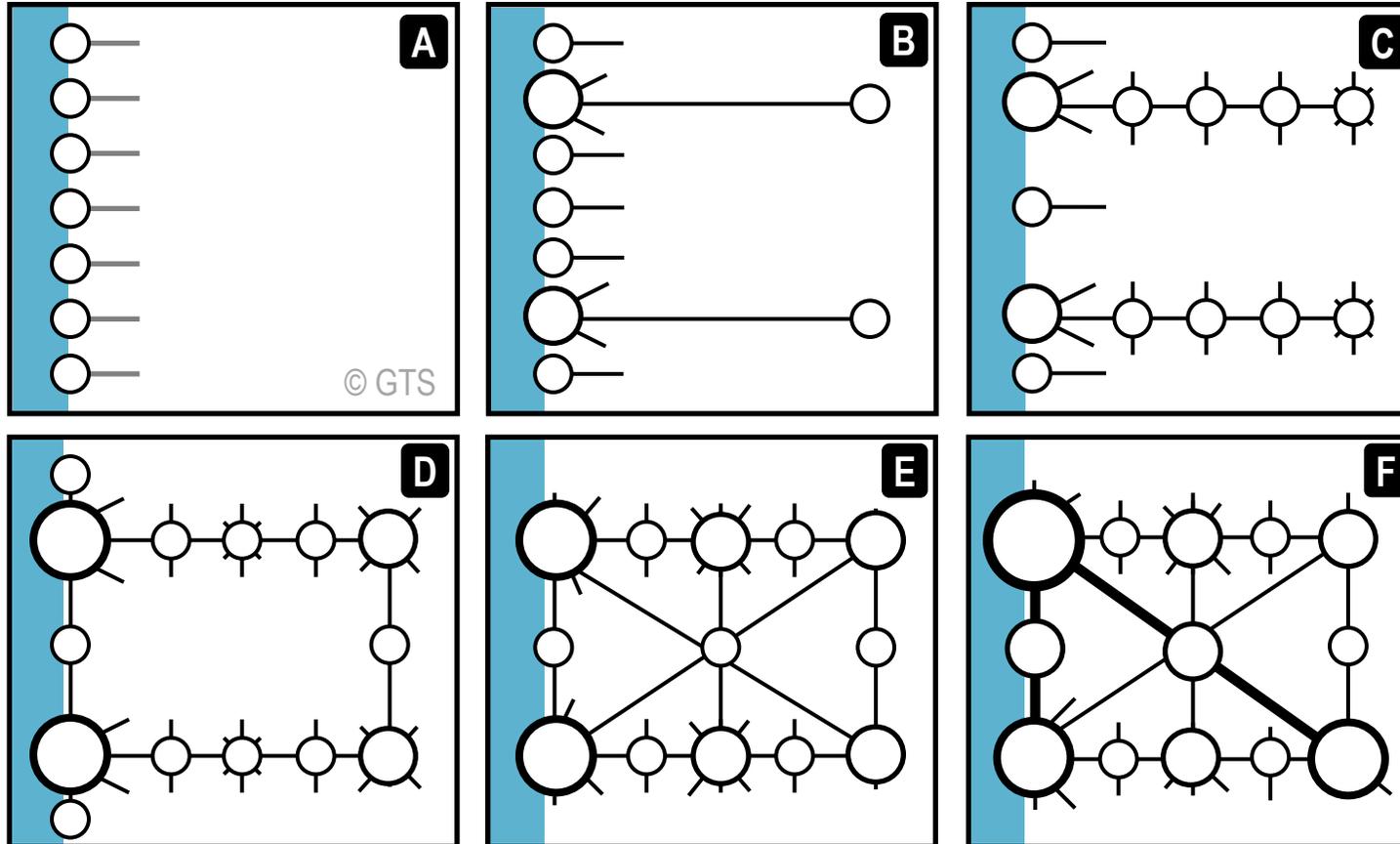
Growth Poles Theory



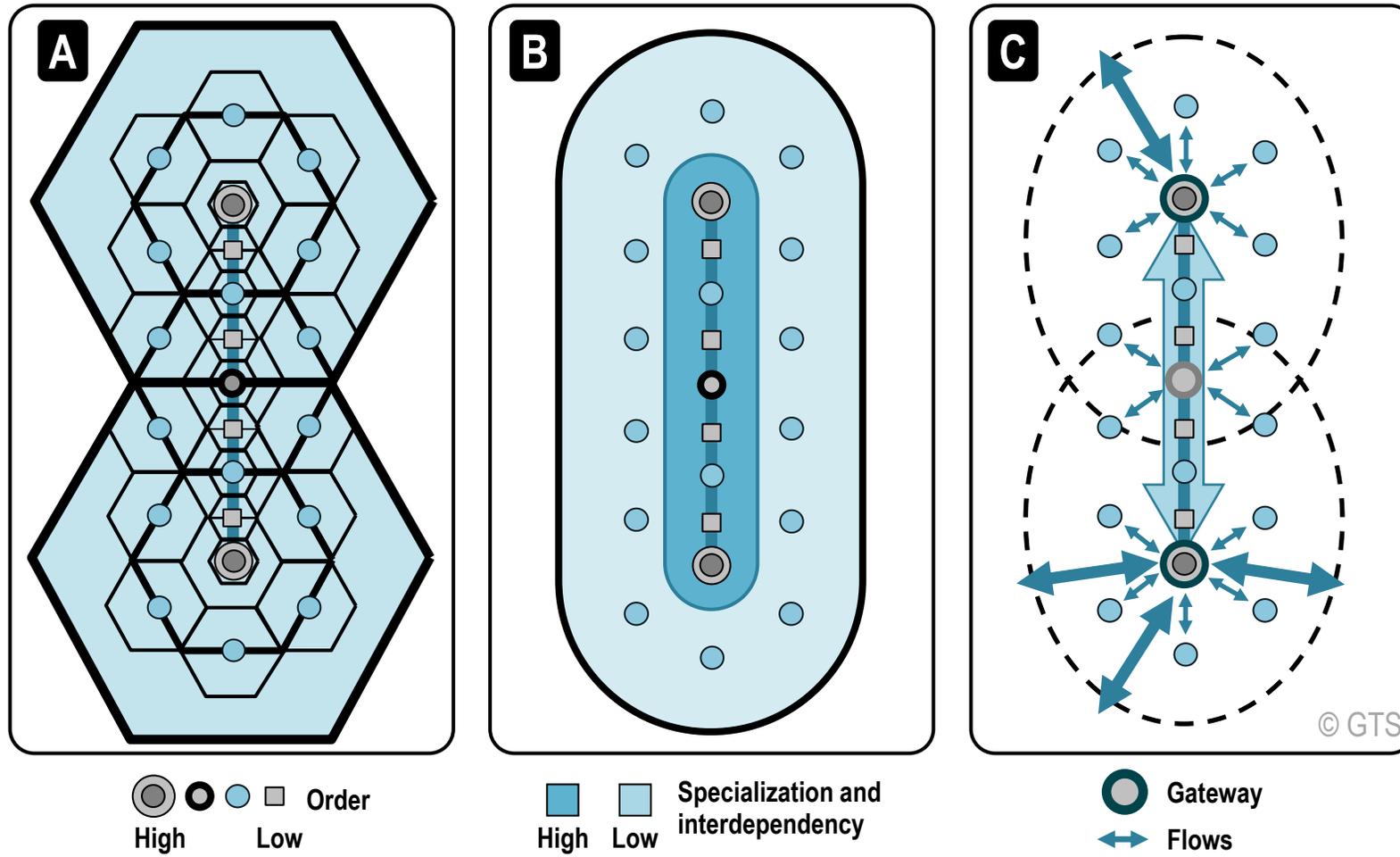
Core-Periphery Stages of Development in an Urban System



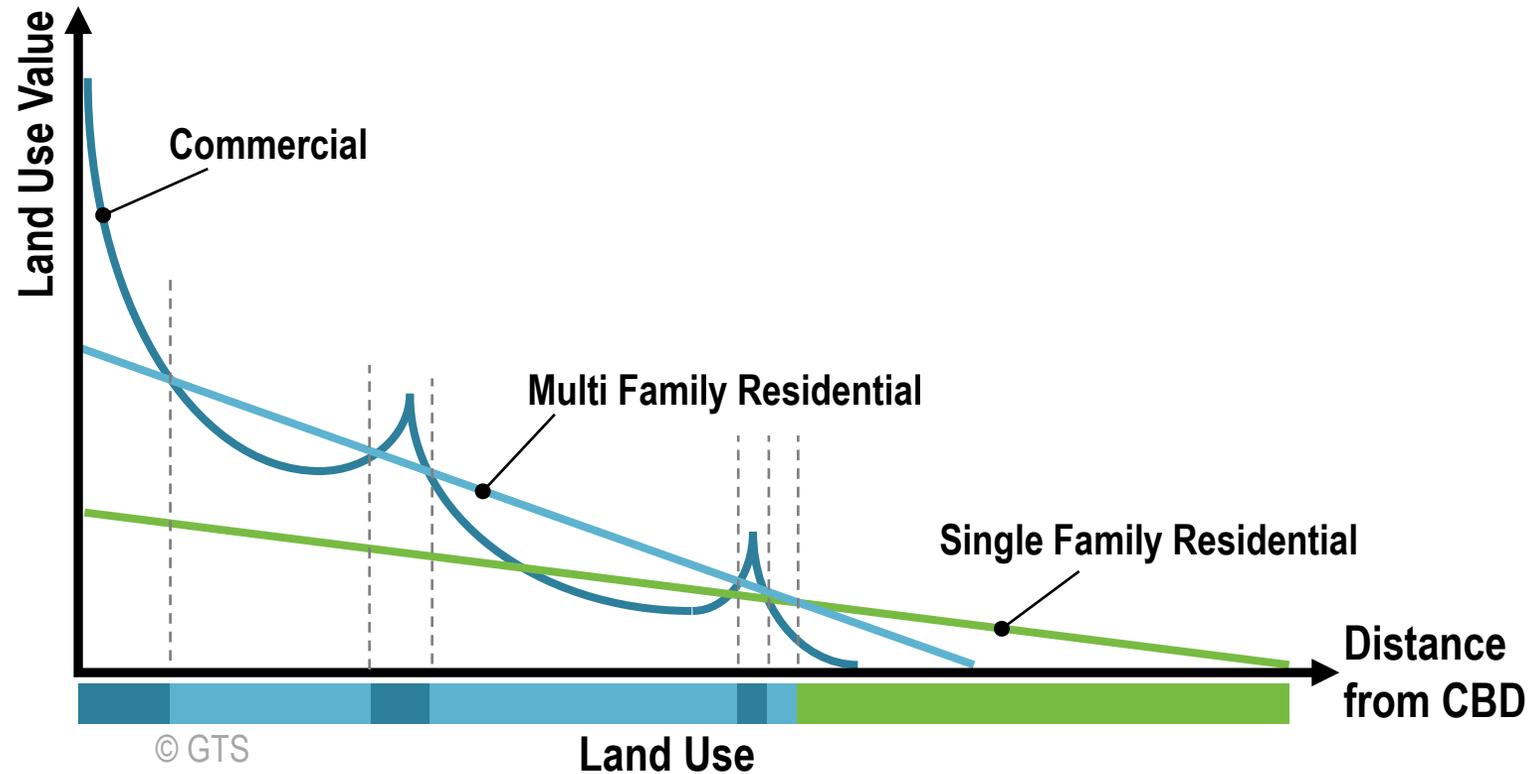
Conceptual Corridor Development



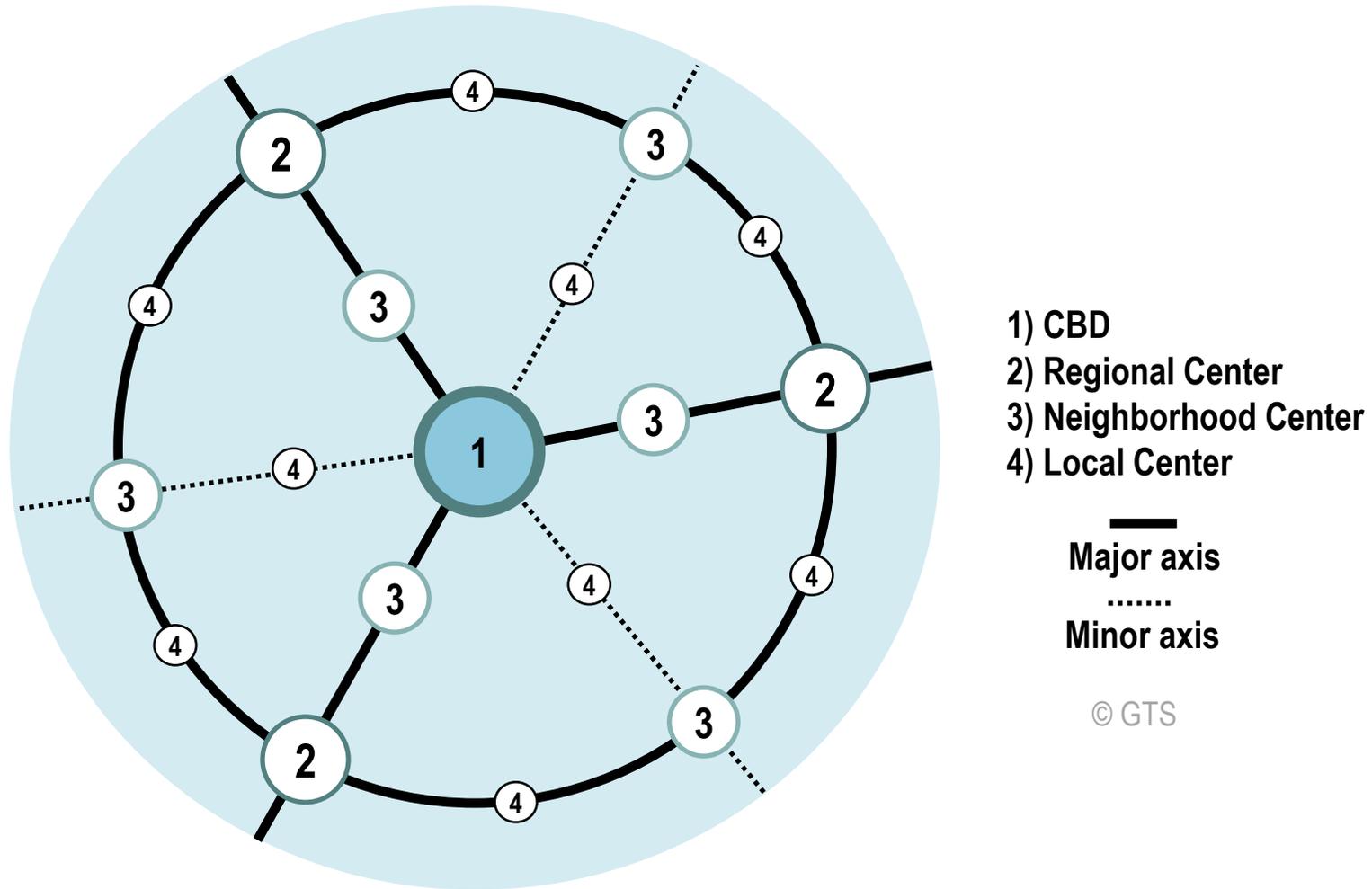
Transport Corridors and the Regional Spatial Structure



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



Central Places in Urban Areas



The Geography of Transport Systems



Jean-Paul Rodrigue

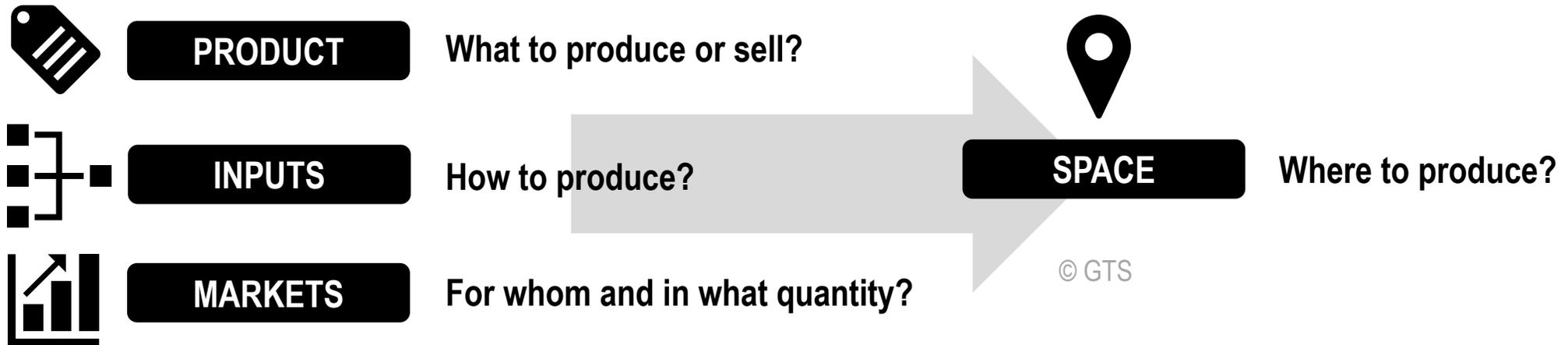
Sixth Edition



Transportation and Location

Chapter 2.3

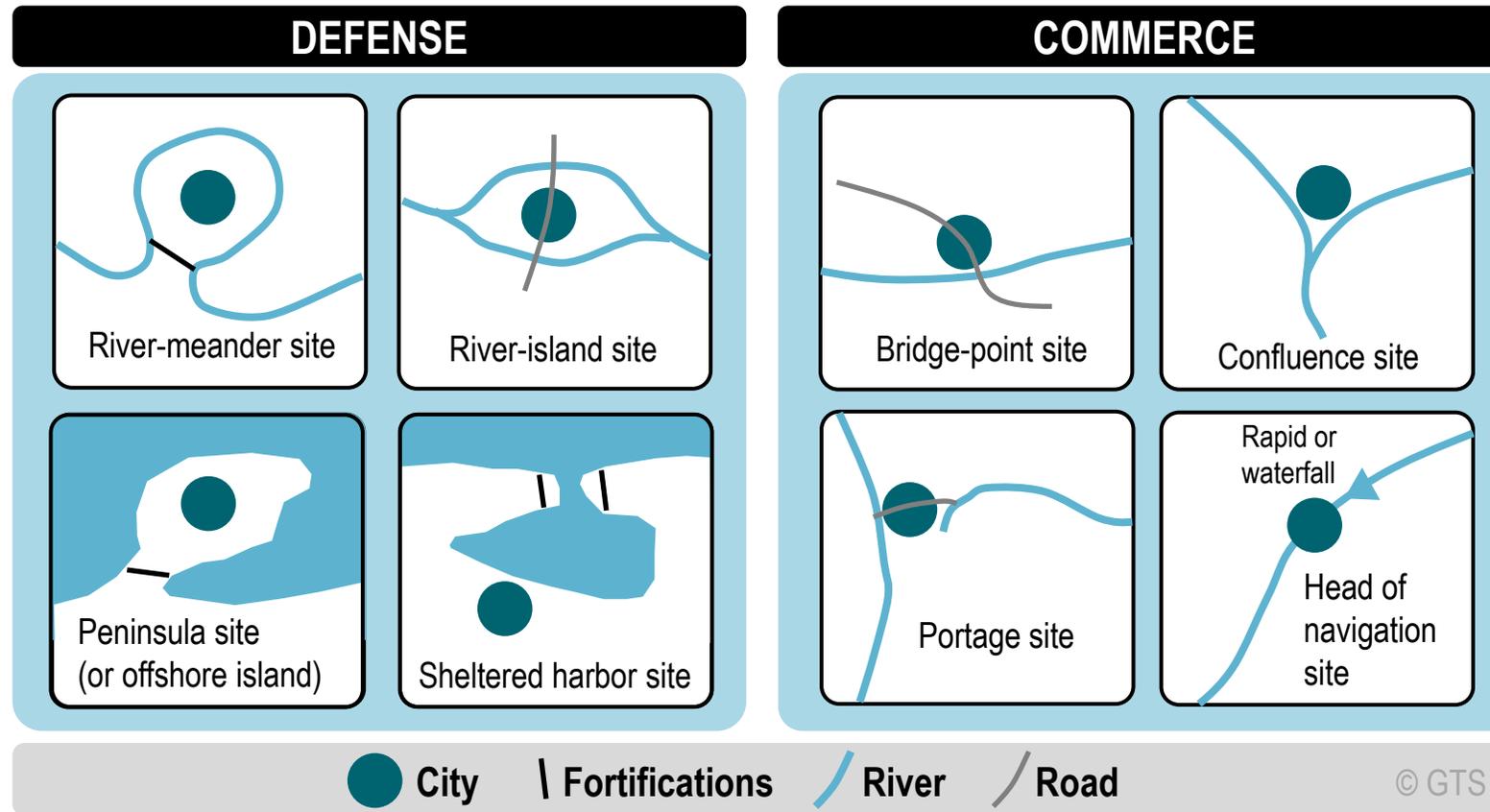
Strategic Decision Making in Location



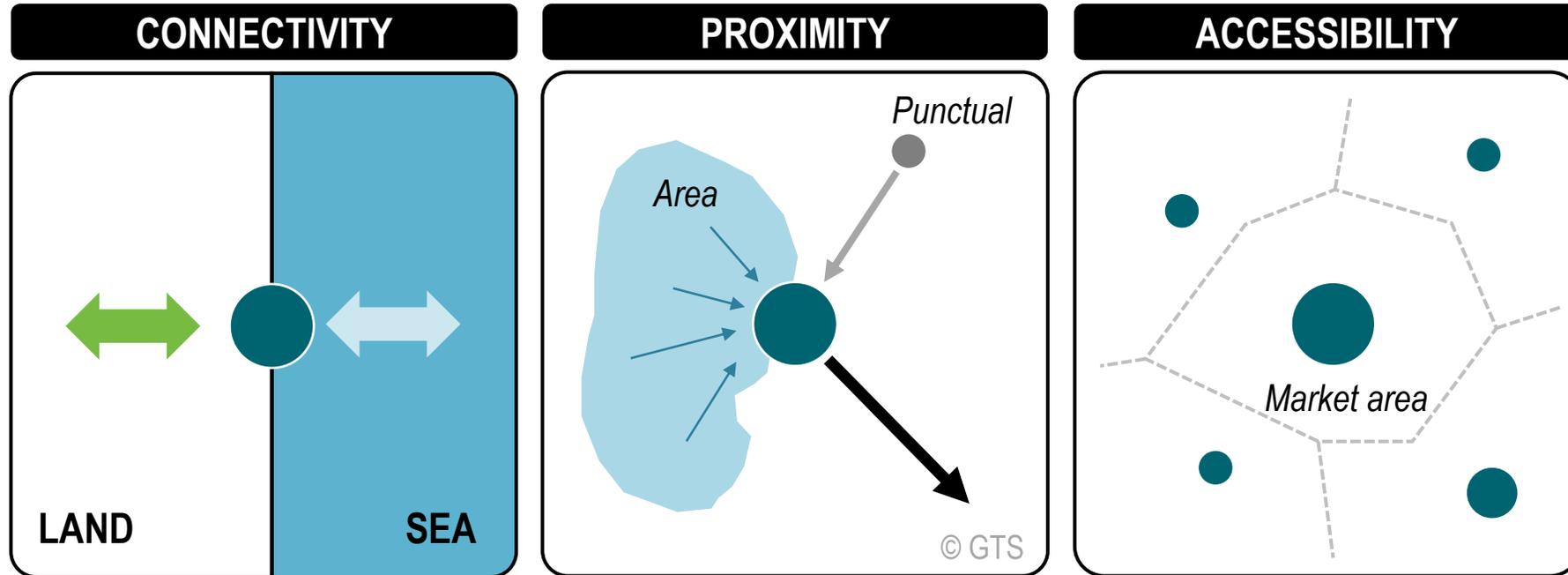
Traditions in Location Theories

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

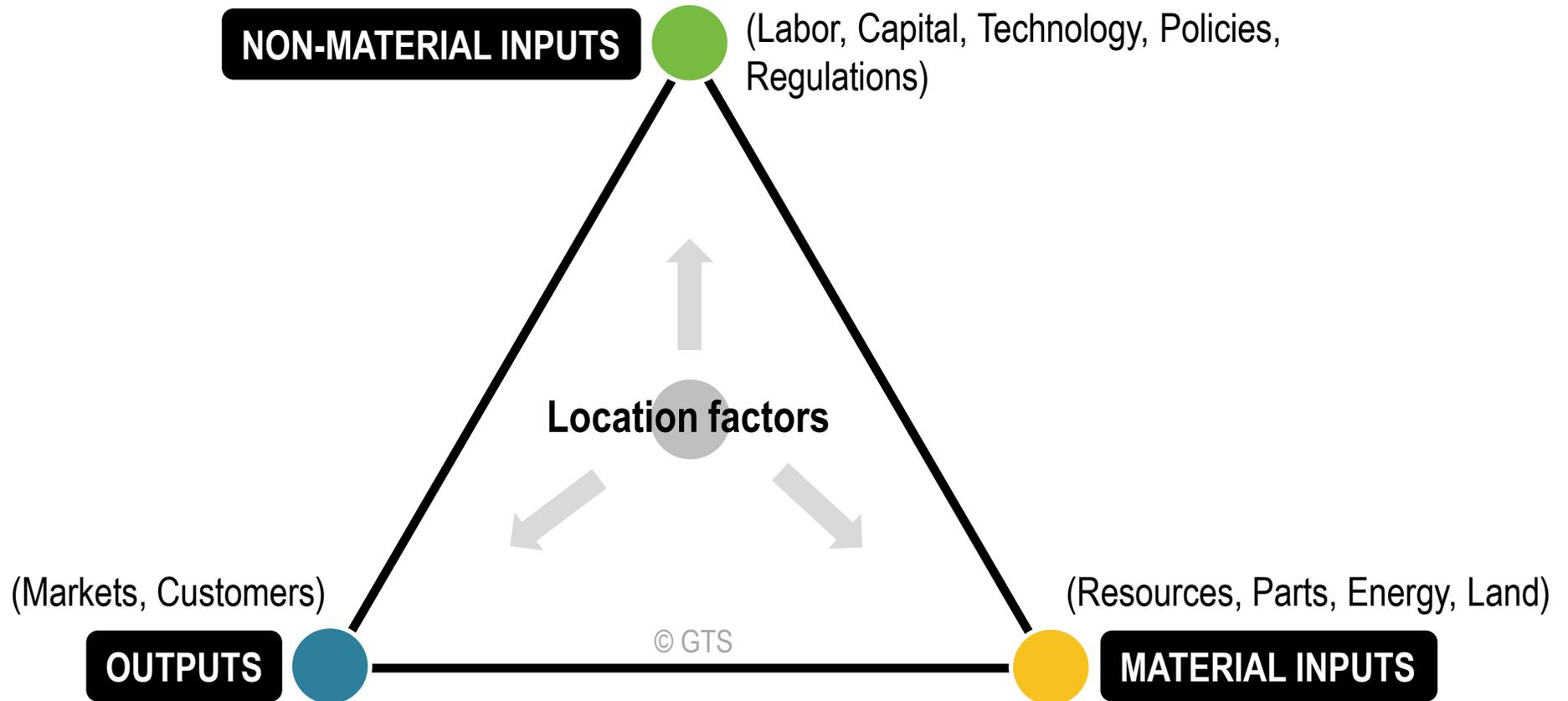
Historical Urban Location Factors



Factors in Urban Location

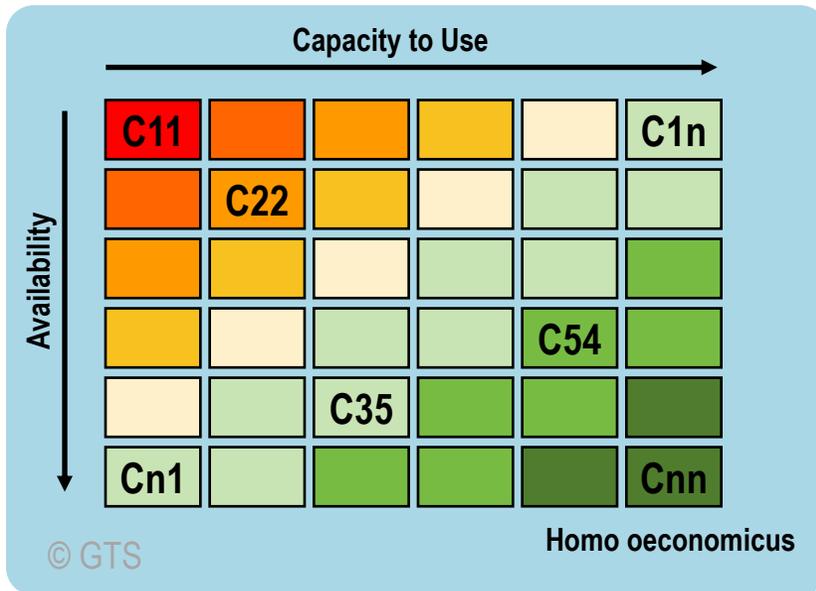


The Location Spectrum

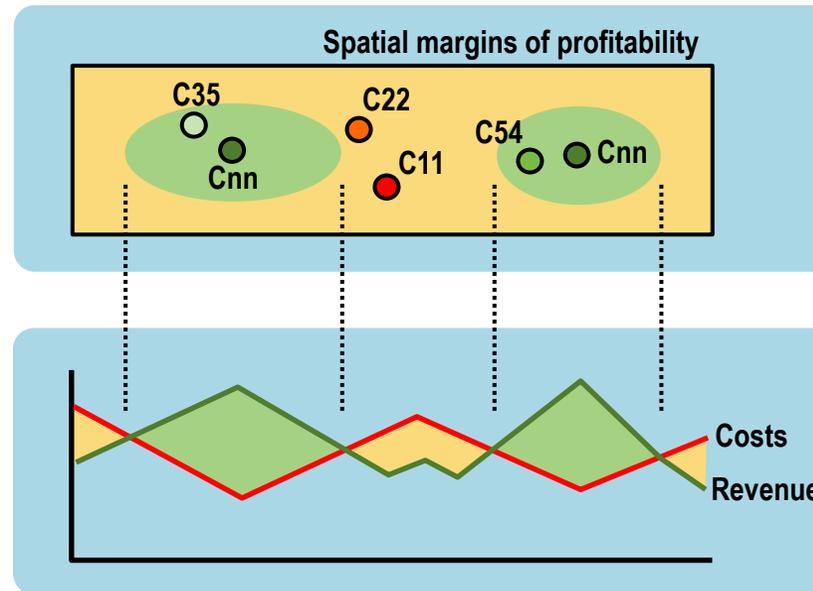


Behavioral Approach to Location

INFORMATION

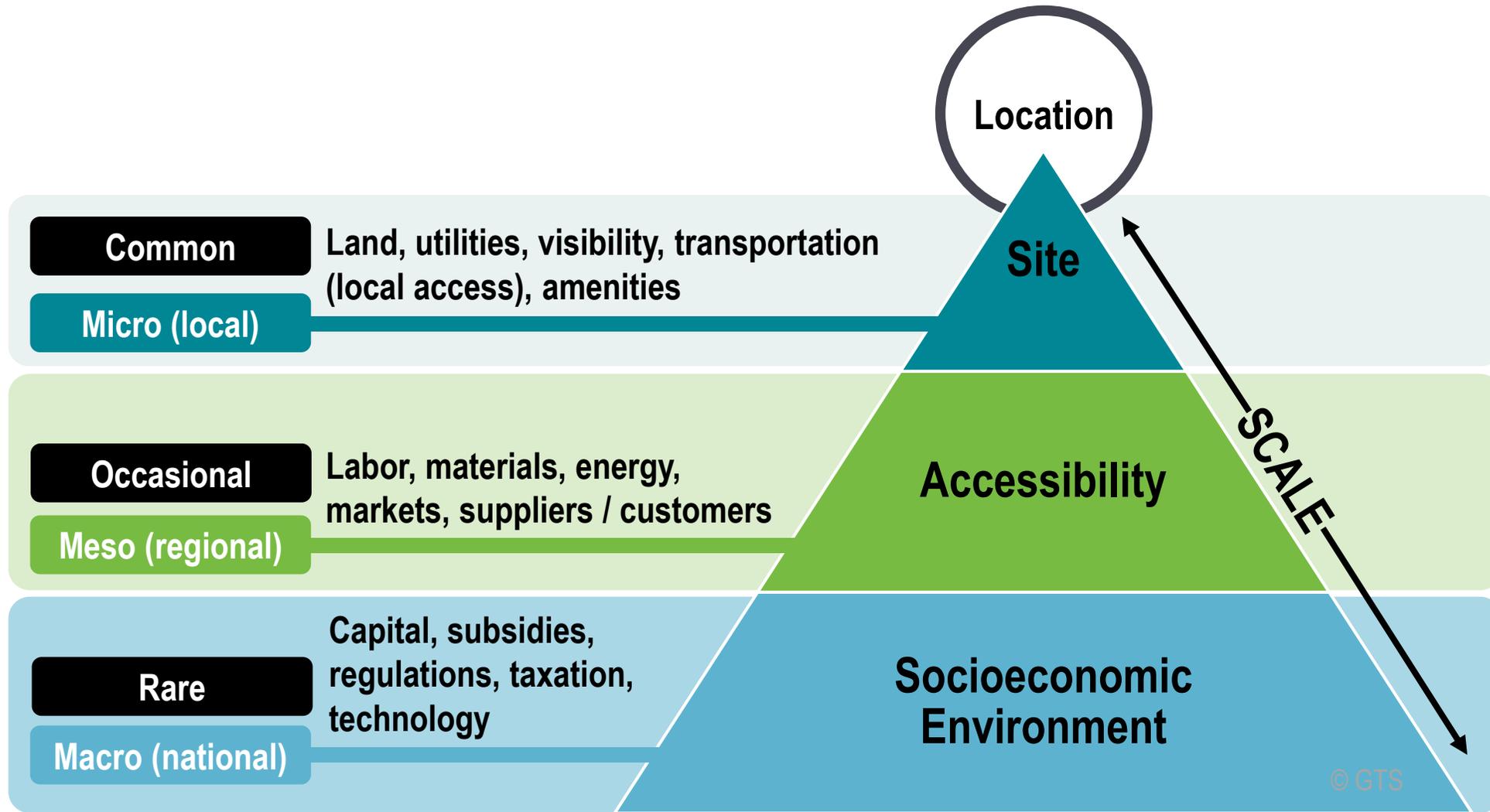


TERRITORY

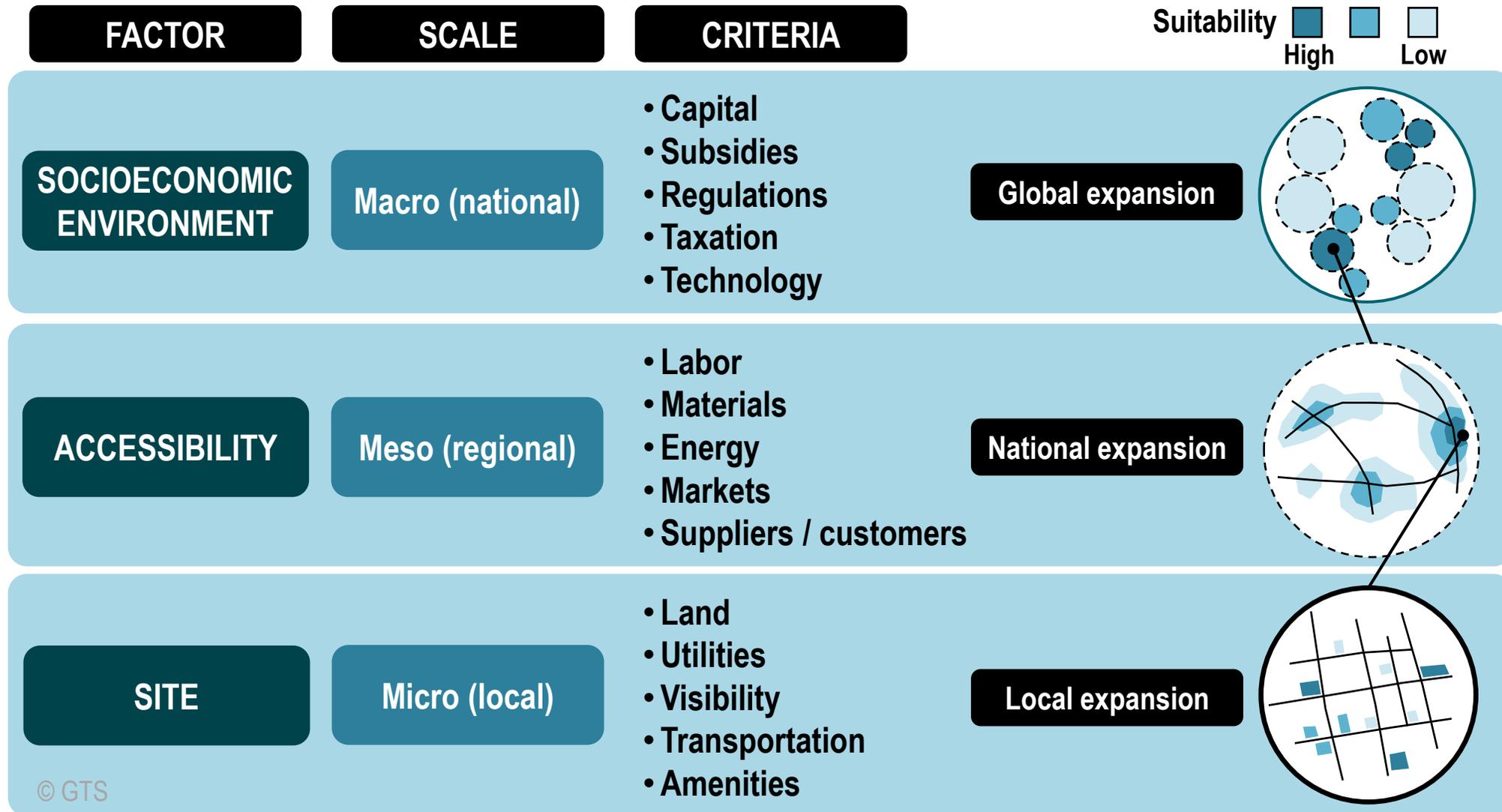


PROFITABILITY

Basic Location Factors



Basic Location Factors



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Factors Affecting Location Decisions (To be updated)

Country Factors

- Government rules, attitudes, political risk, incentives
- Culture & economy
- Market location
- Labor availability, attitudes, productivity, and cost
- Availability of supplies, communications, energy
- Exchange rates and currency risks

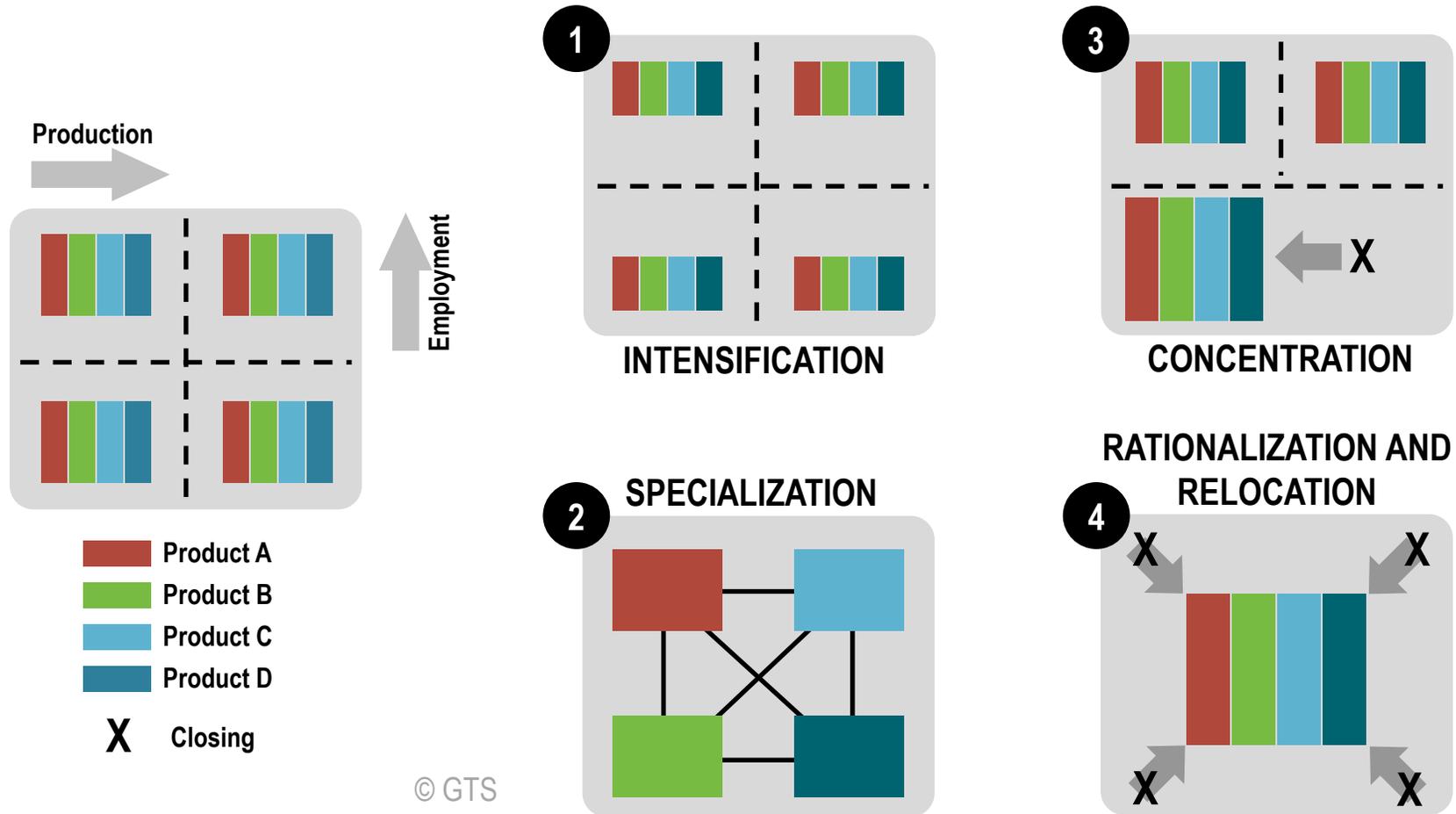
Region Factors

- Attractiveness of region (culture, taxes, climate, etc.)
- Labor, availability & costs
- Costs and availability of utilities
- Environmental regulations of state and town
- Government incentives
- Proximity to raw materials & customers
- Land/construction costs

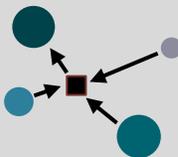
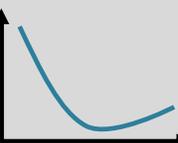
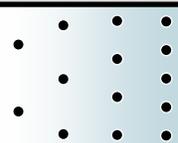
Local Factors

- Site size and cost
- Air, rail, highway, and waterway systems
- Zoning restrictions
- Nearness of services / supplies needed
- Environmental impact issues

Locational Changes in Manufacturing



Main Types of Economies in Production, Distribution and Consumption

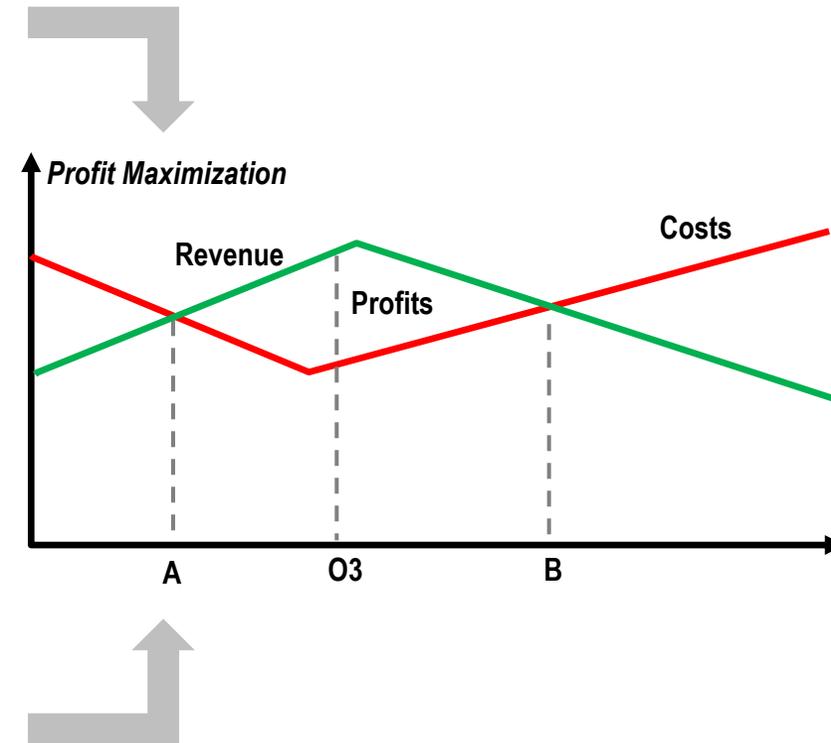
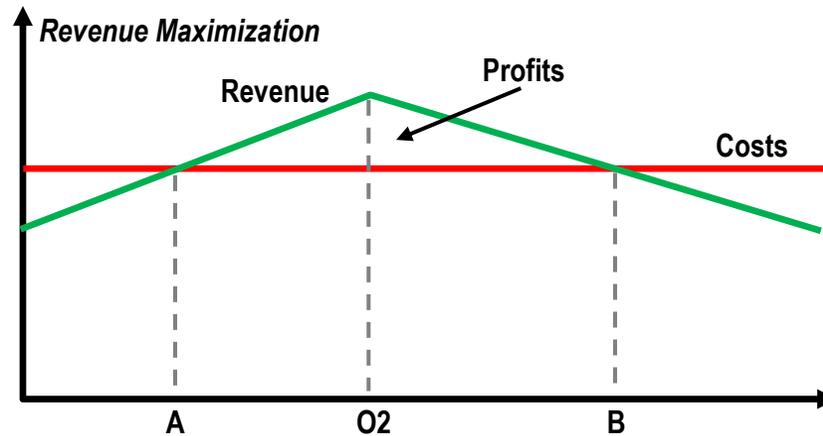
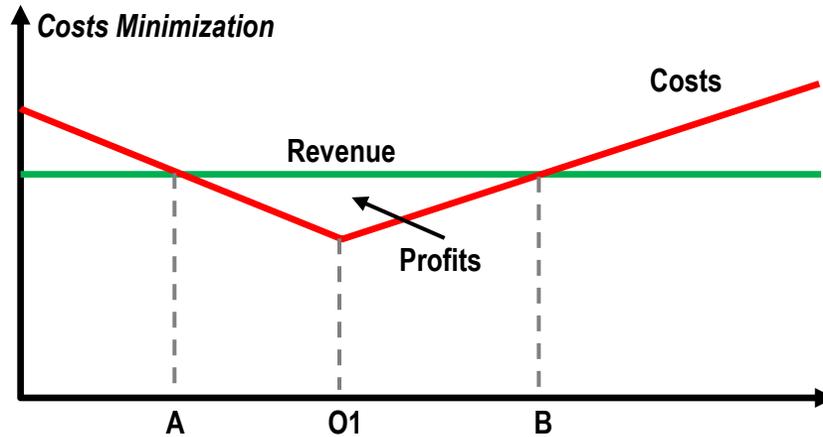
		PRODUCTION	DISTRIBUTION	CONSUMPTION
Economies of transportation		Lower unit costs through accessibility to suppliers and customers	Lower unit distribution costs through transport chains management	Lower unit output costs through accessibility to suppliers and customers
Economies of scale		Lower unit costs with larger plants	Lower unit transport costs through larger modes and terminals	Lower unit costs with larger retail outlets
Economies of scope		Lower unit output costs with more product types	Lower transport costs with bundling of different loads	Product diversification attracts more customers
Economies of agglomeration		Industrial and service linkages with manufacturing clusters	Lower input costs with clustering of distribution activities	Lower input costs with clustering of retail activities
Economies of density		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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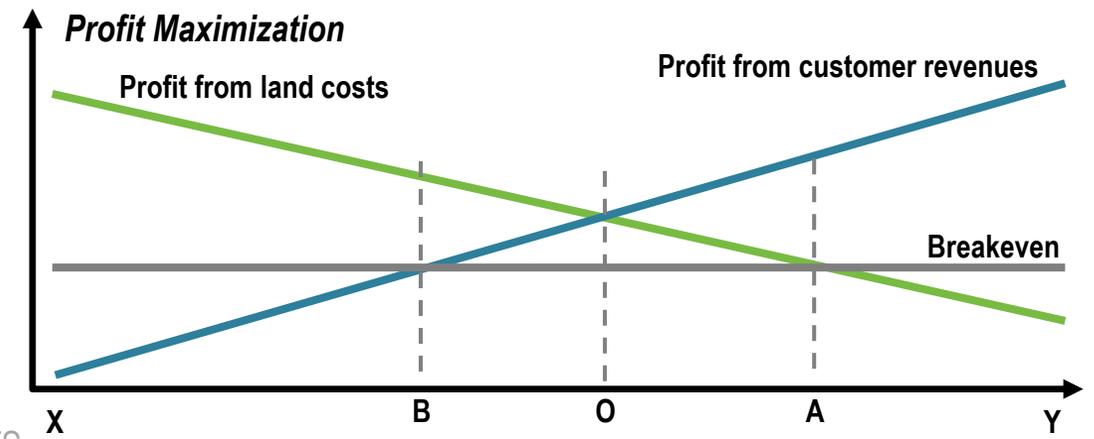
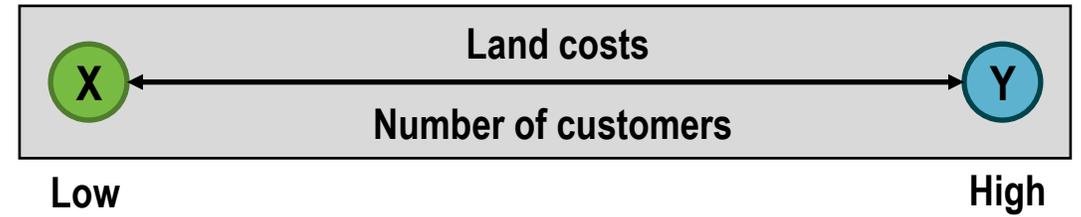
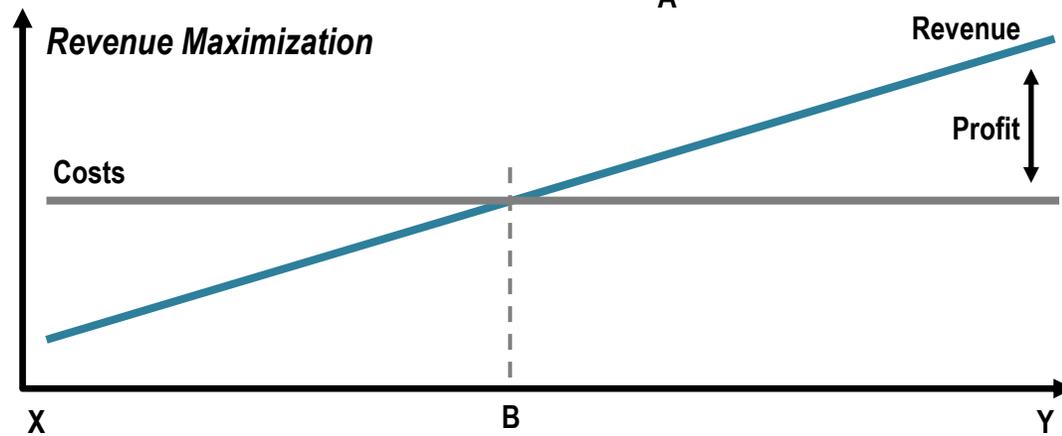
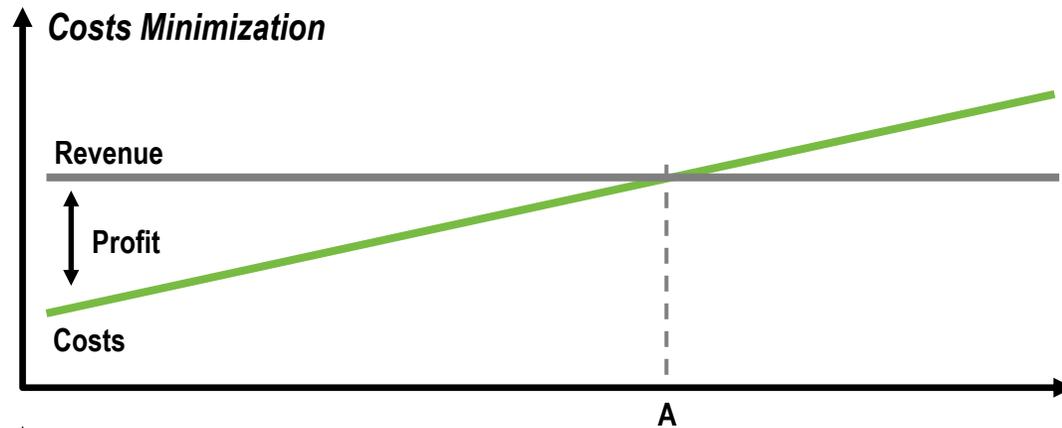
Main Location Factors for Distribution Activities

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

Basic Location Strategies

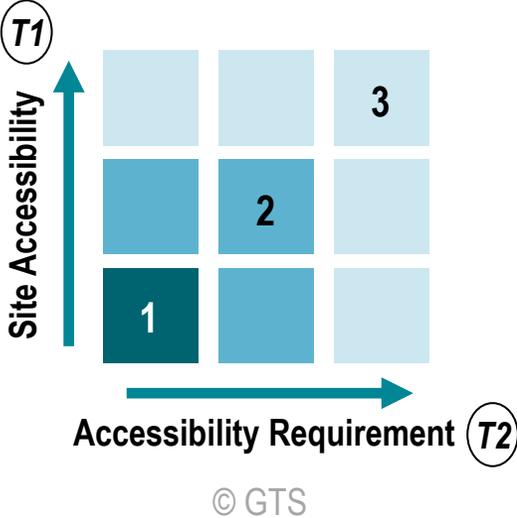
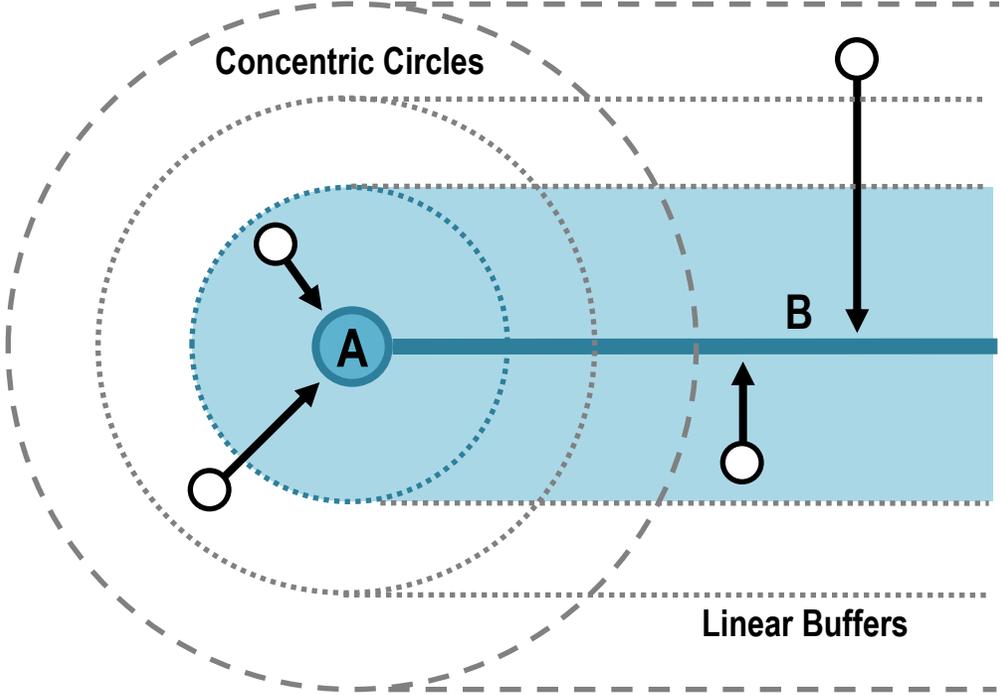


Basic Location Strategies

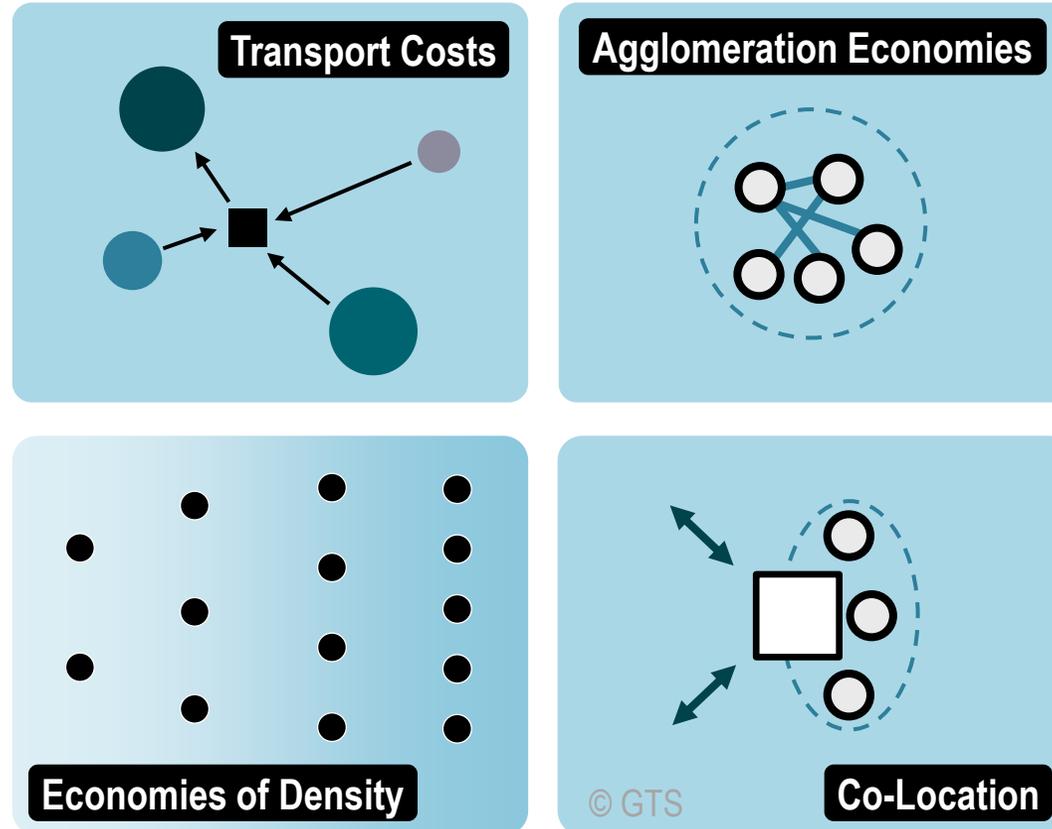


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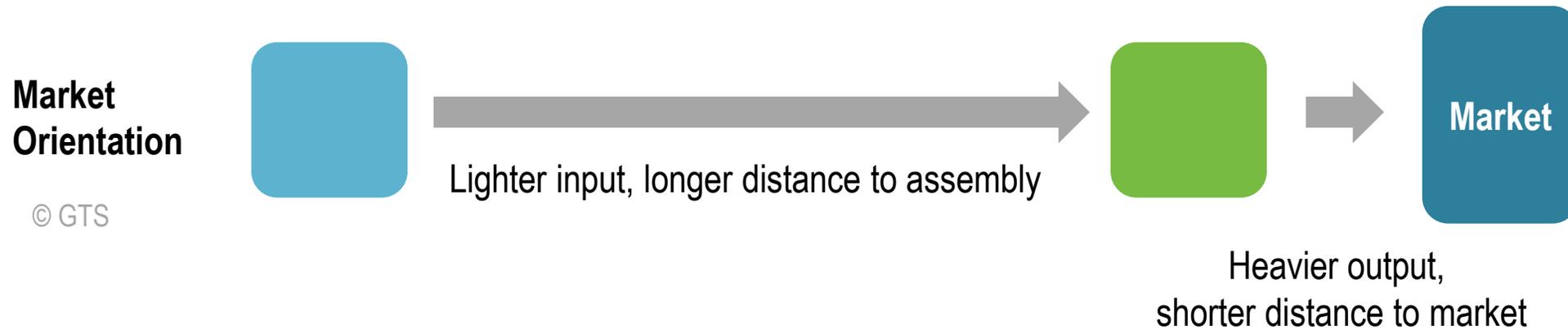
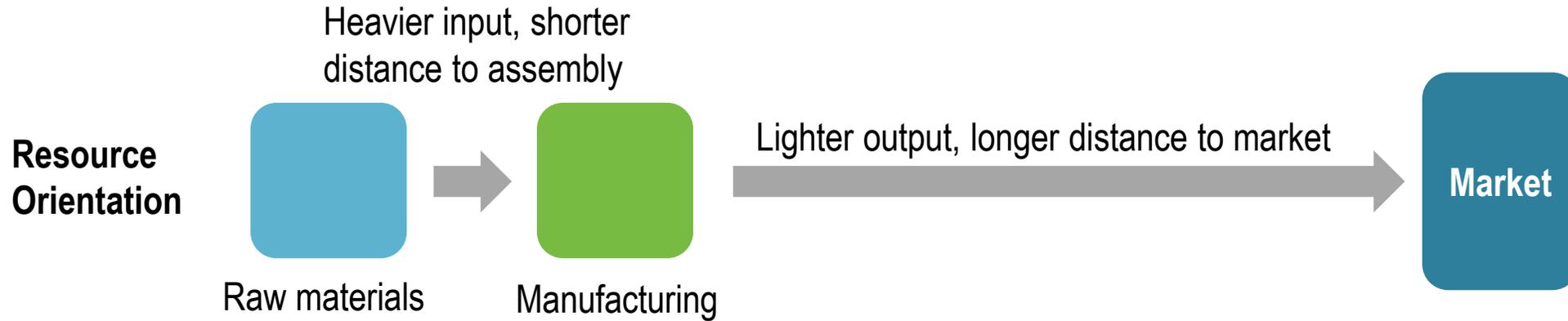
Accessibility and Location



The Four Main Locational Influences of Transportation

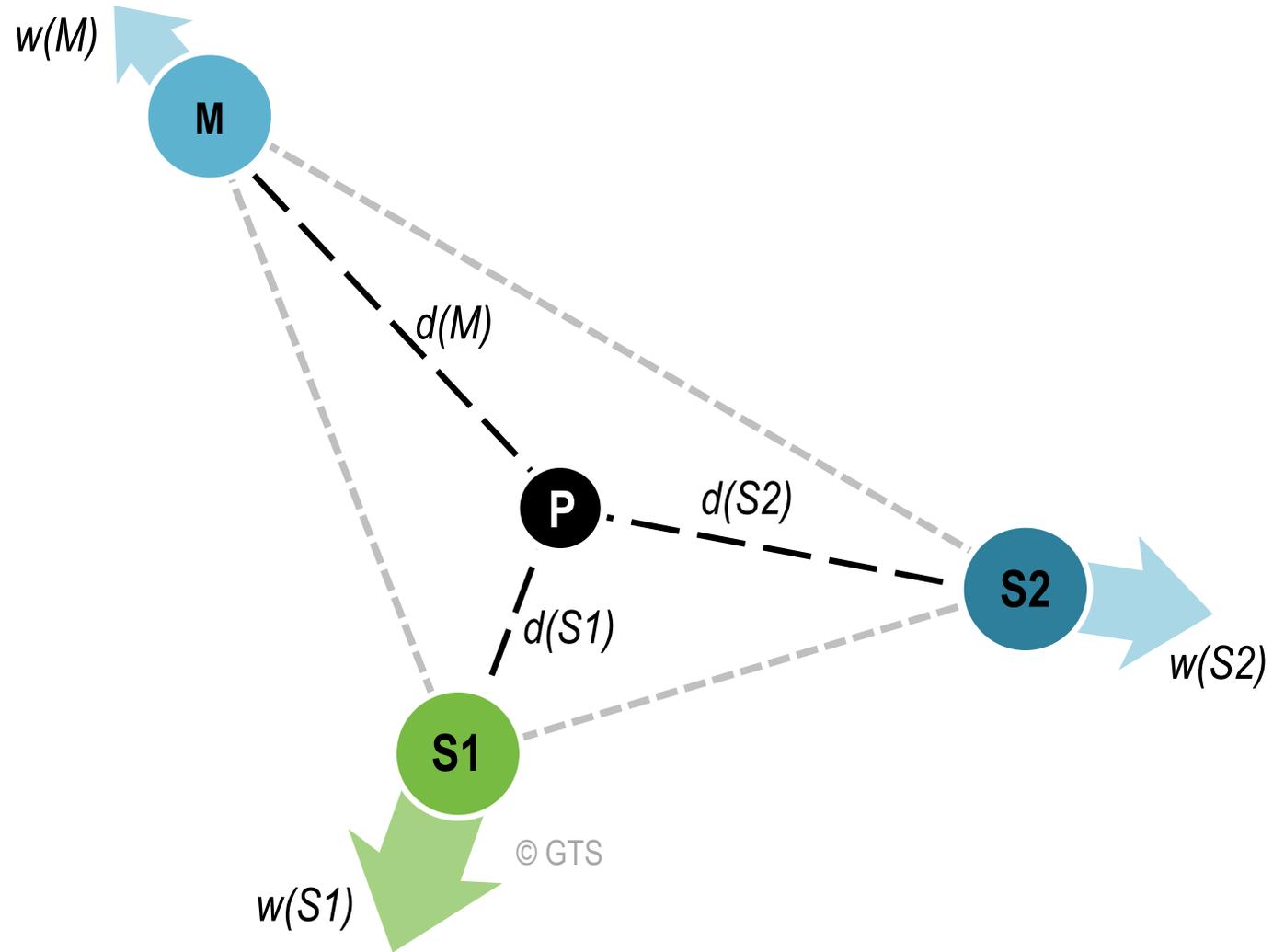


Resource and Market Orientation

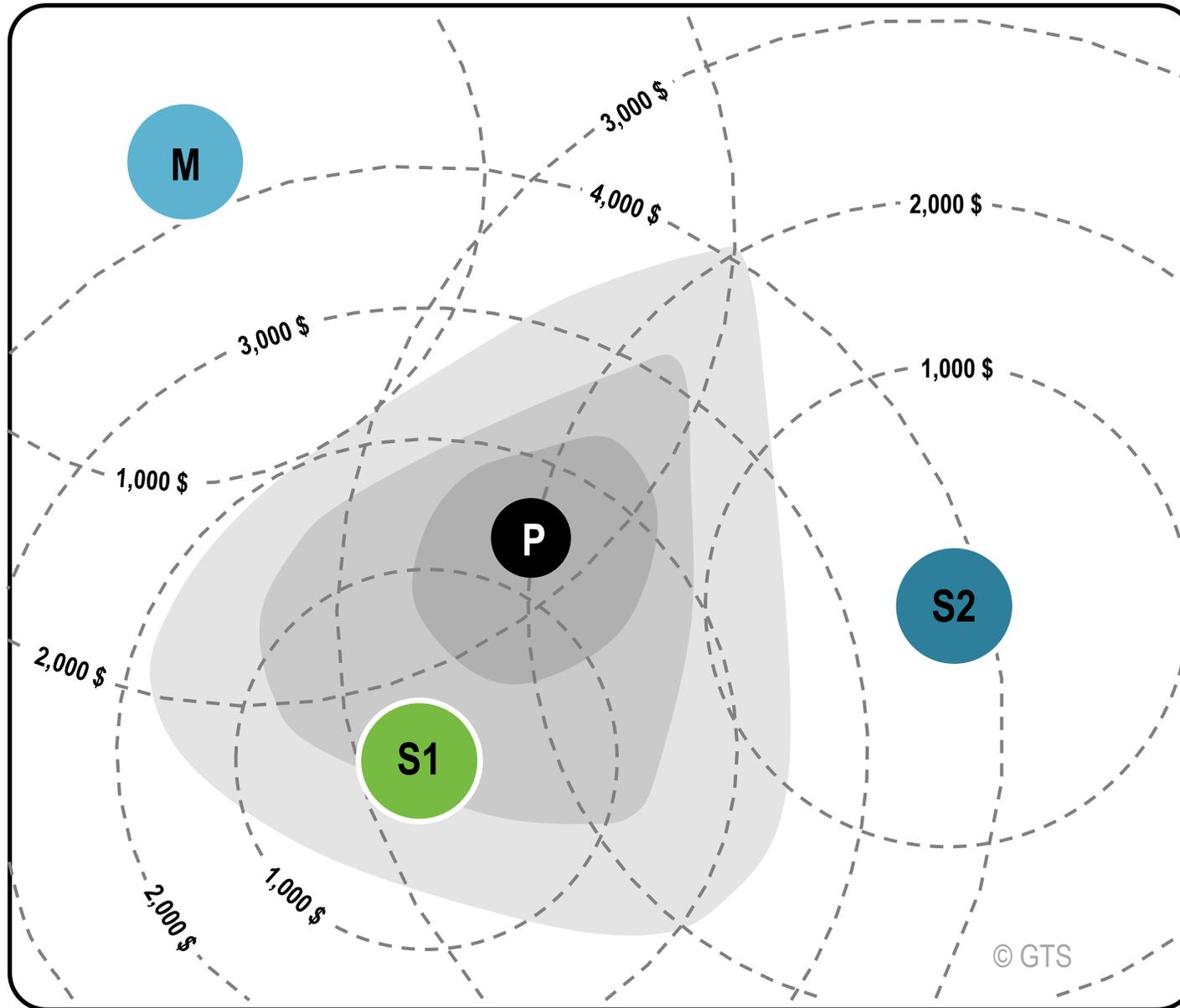


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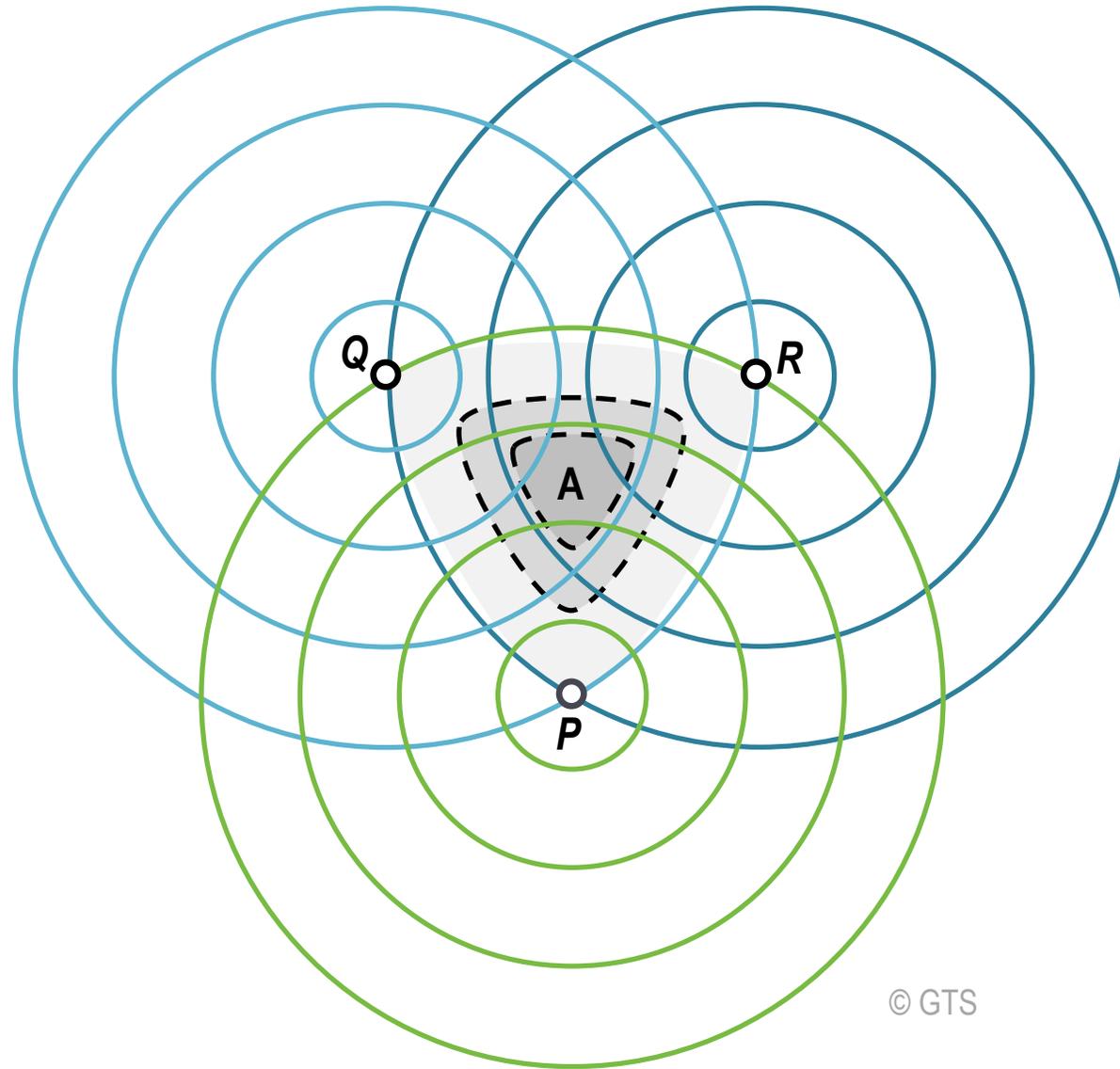
Weber's Location Triangle



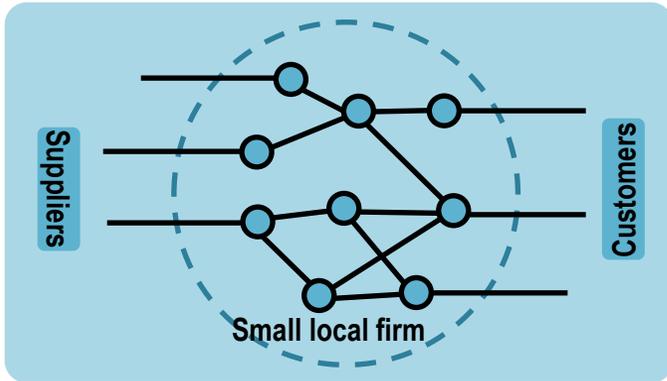
Transport Costs Surfaces and Location



Economies of Agglomeration

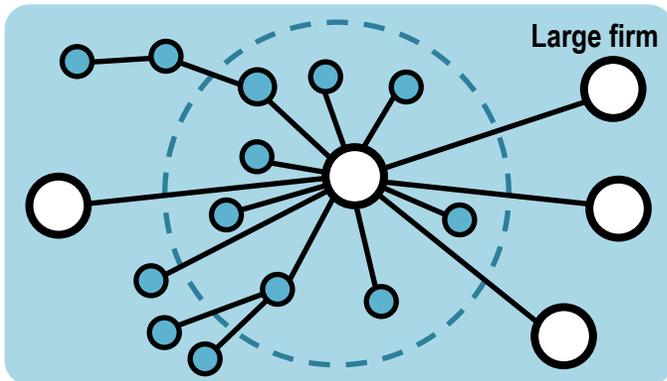


Types of Manufacturing Clusters



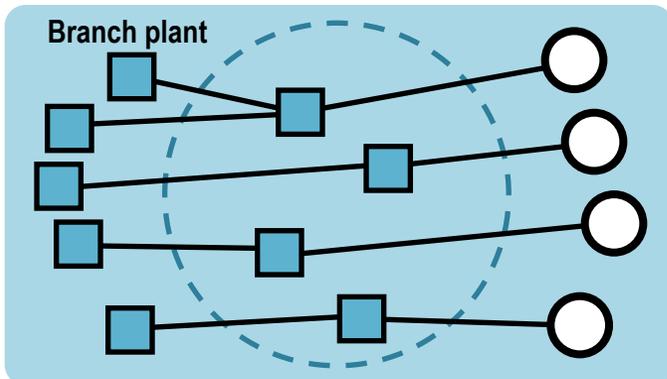
MARSHALLIAN INDUSTRIAL CLUSTER

- 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

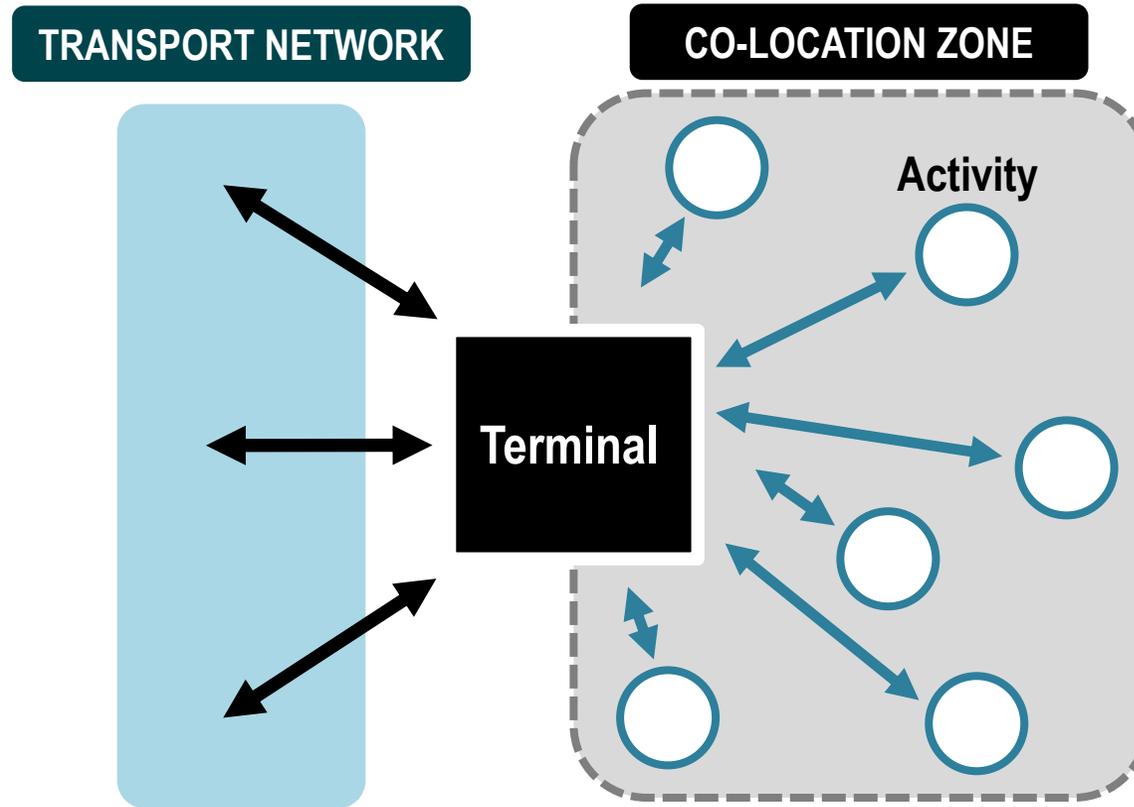
Resource Clusters

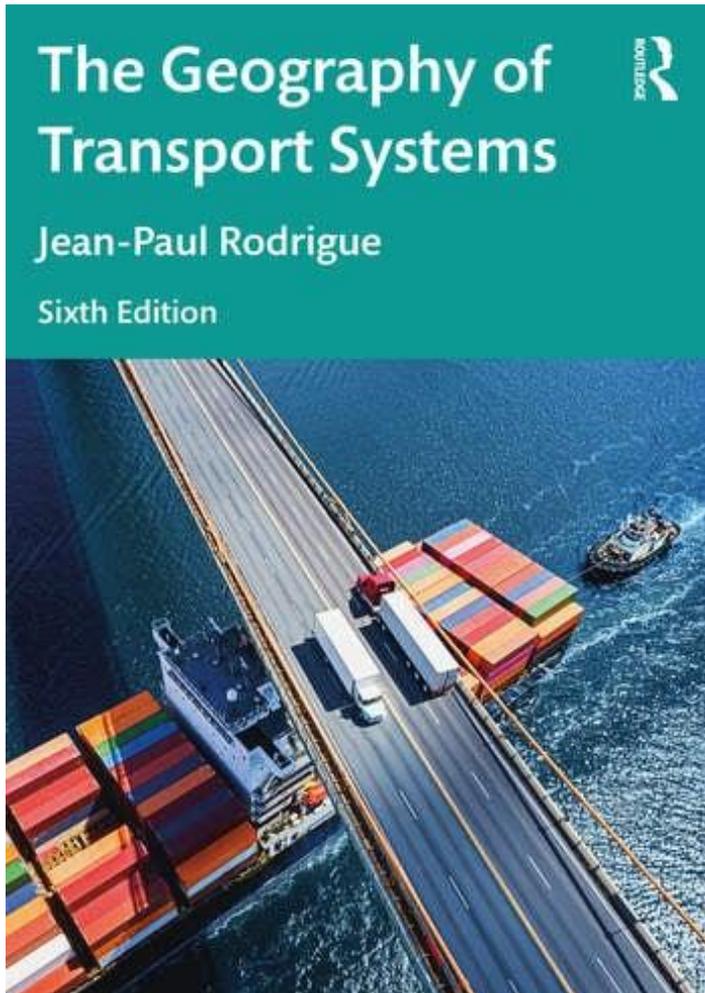
Logistics Clusters

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.



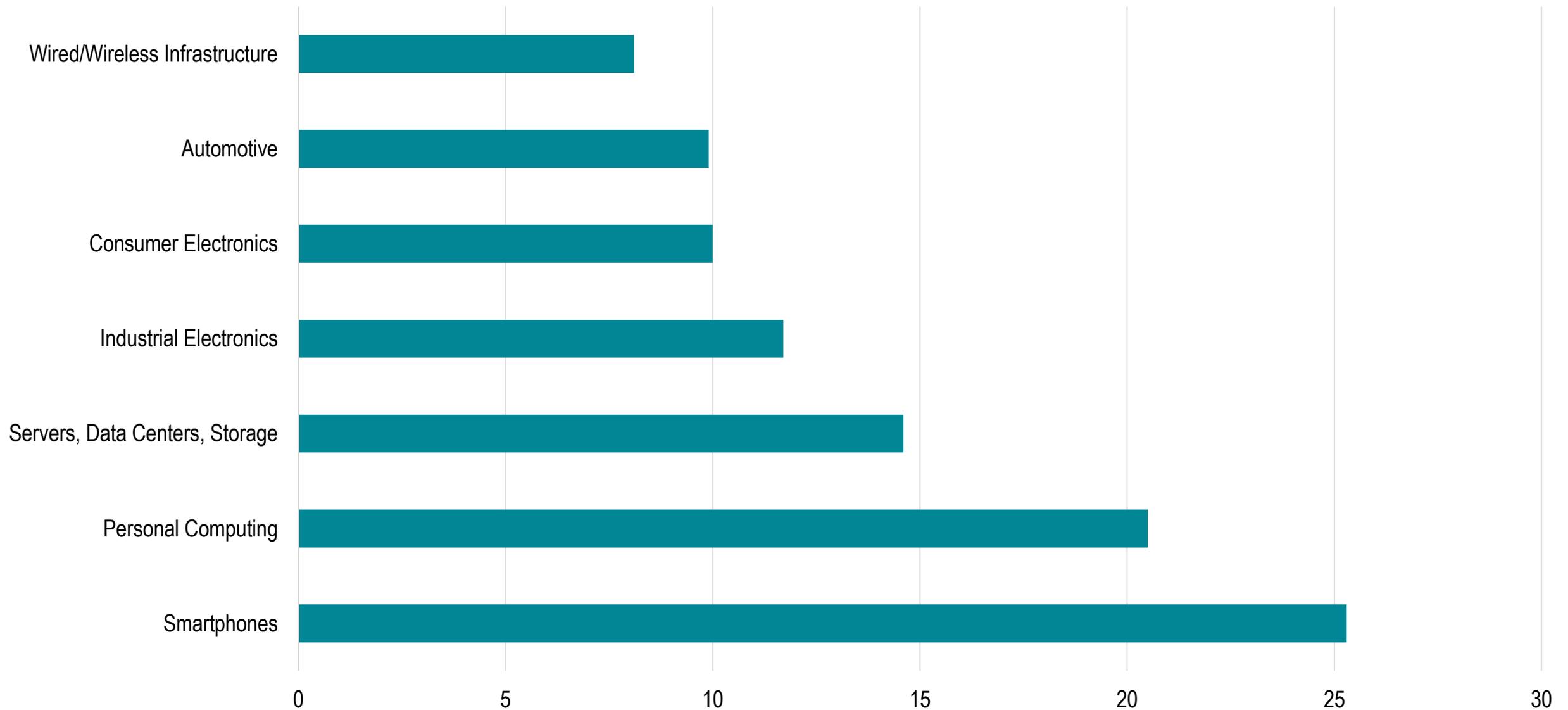
ASSET MANAGEMENT

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

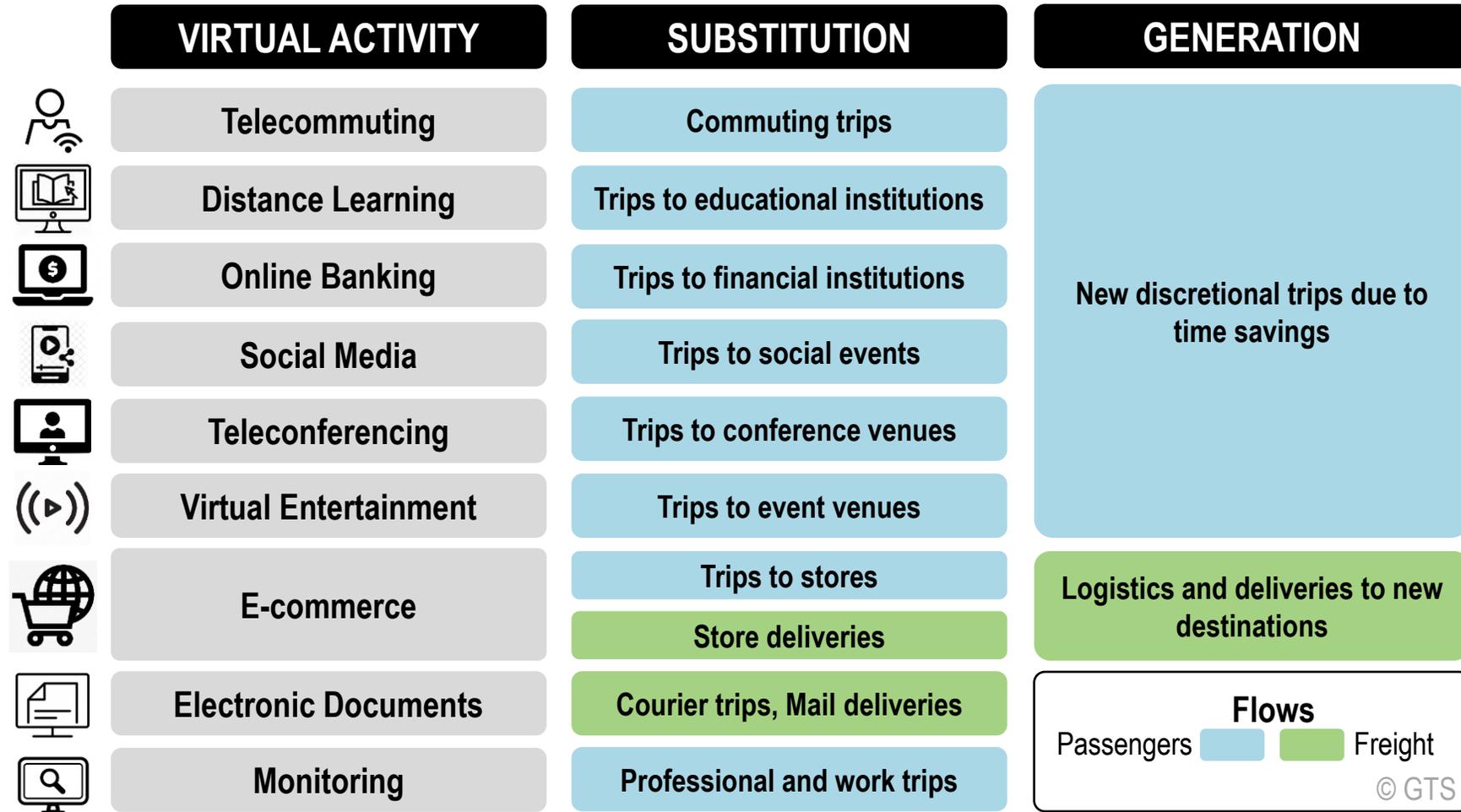
Uber links users with individual car owners willing to provide a taxi service. Airbnb links users with property owners.

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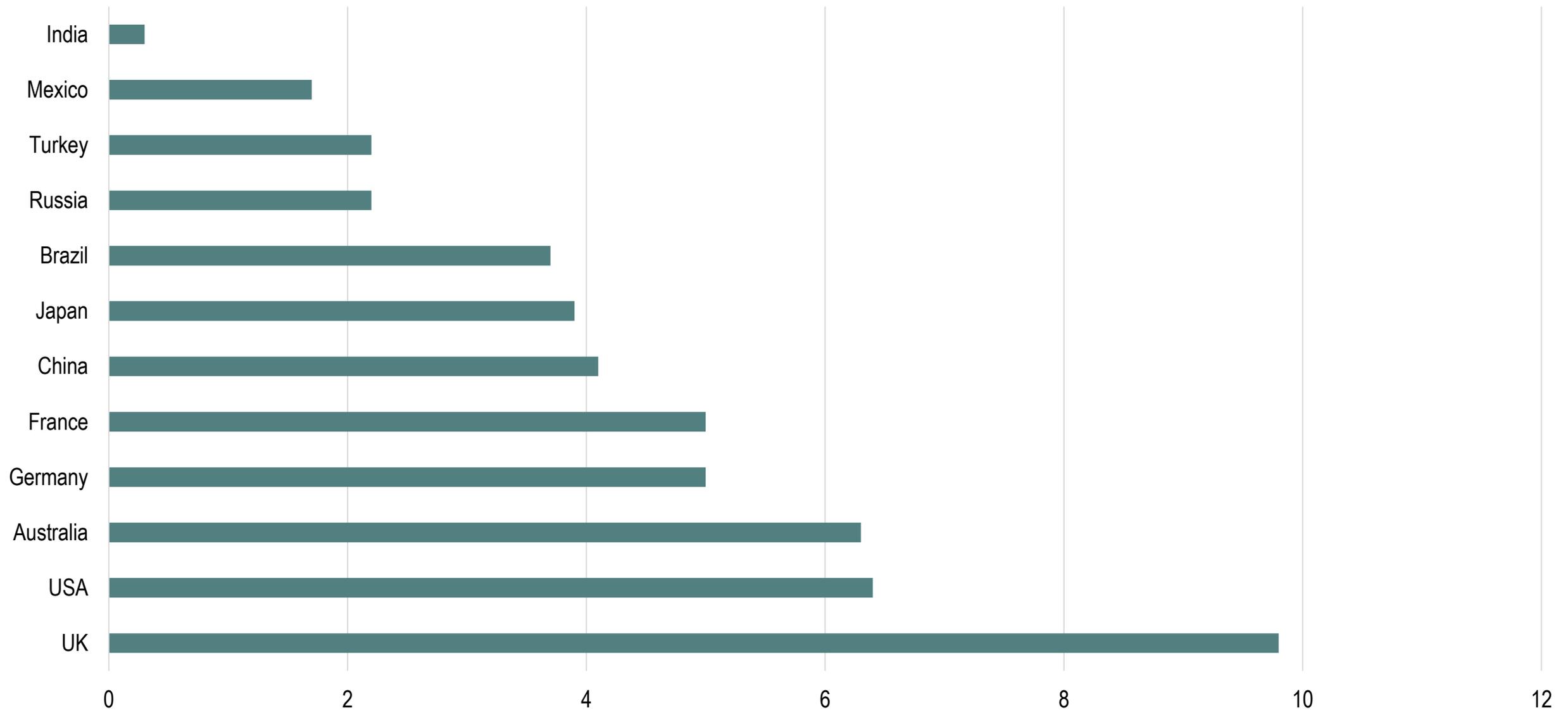
Main Semiconductors Application Markets, 2019



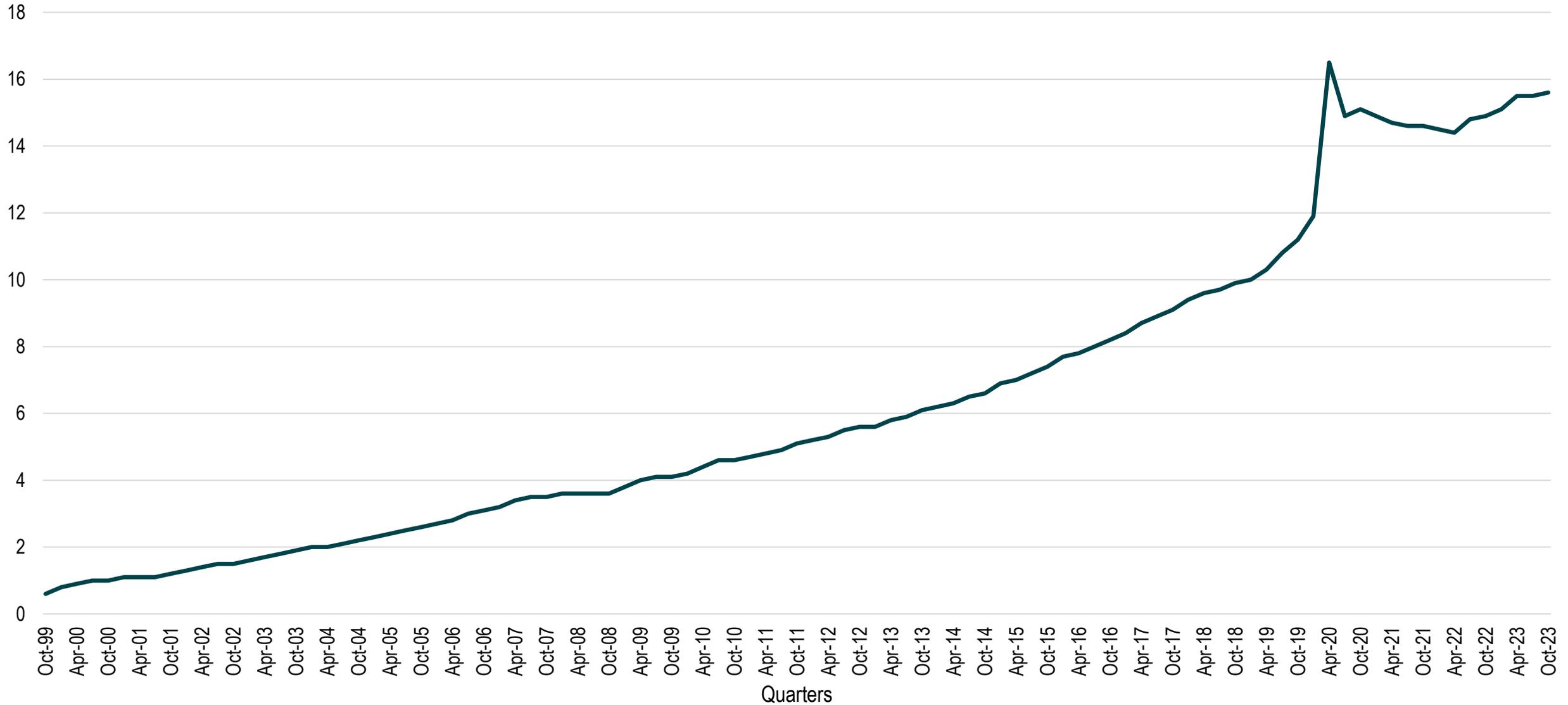
The Substitution and Generation Effects of Information Technologies on Mobility



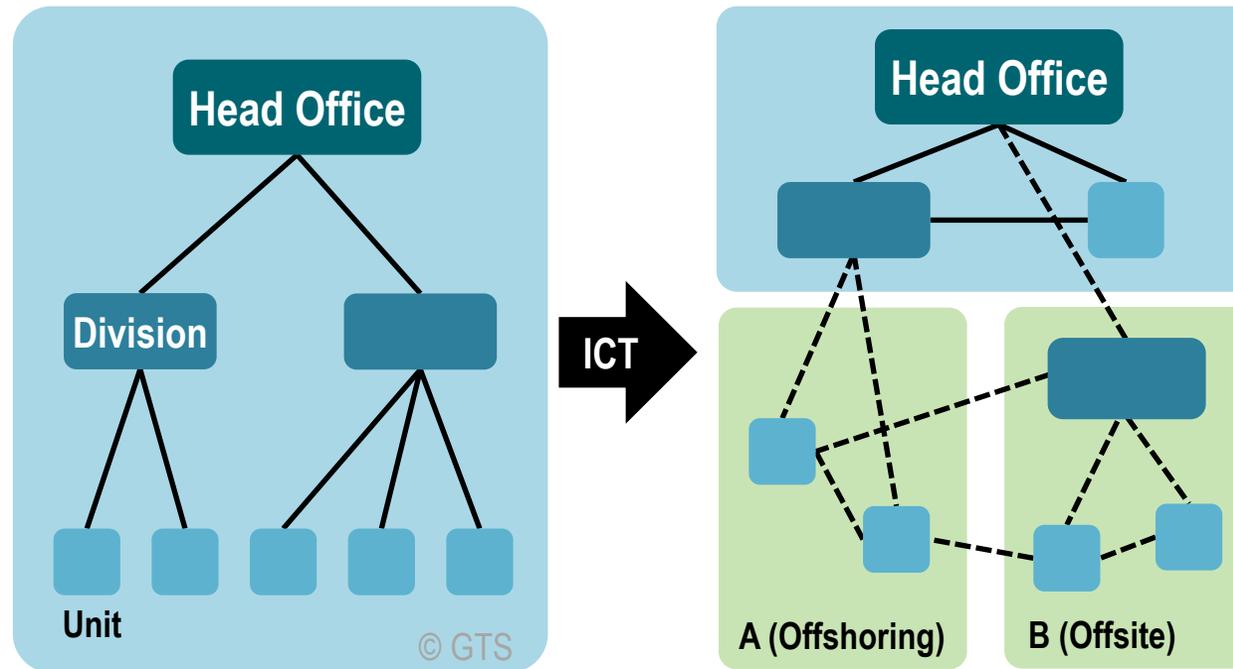
Online Retail Sales as Share of Total Retail Sales, 2012



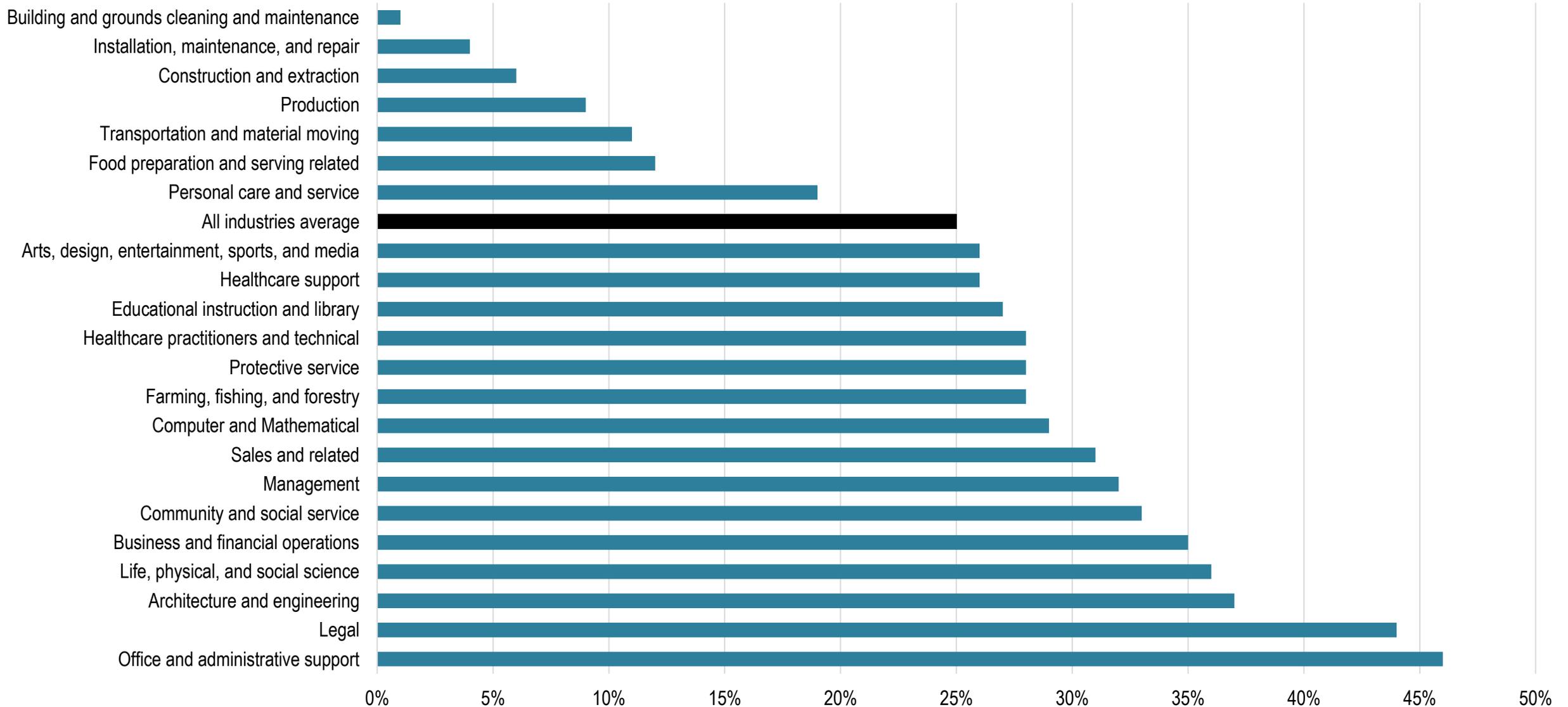
E-Commerce Retail Sales as a Percent of Total Sales, United States



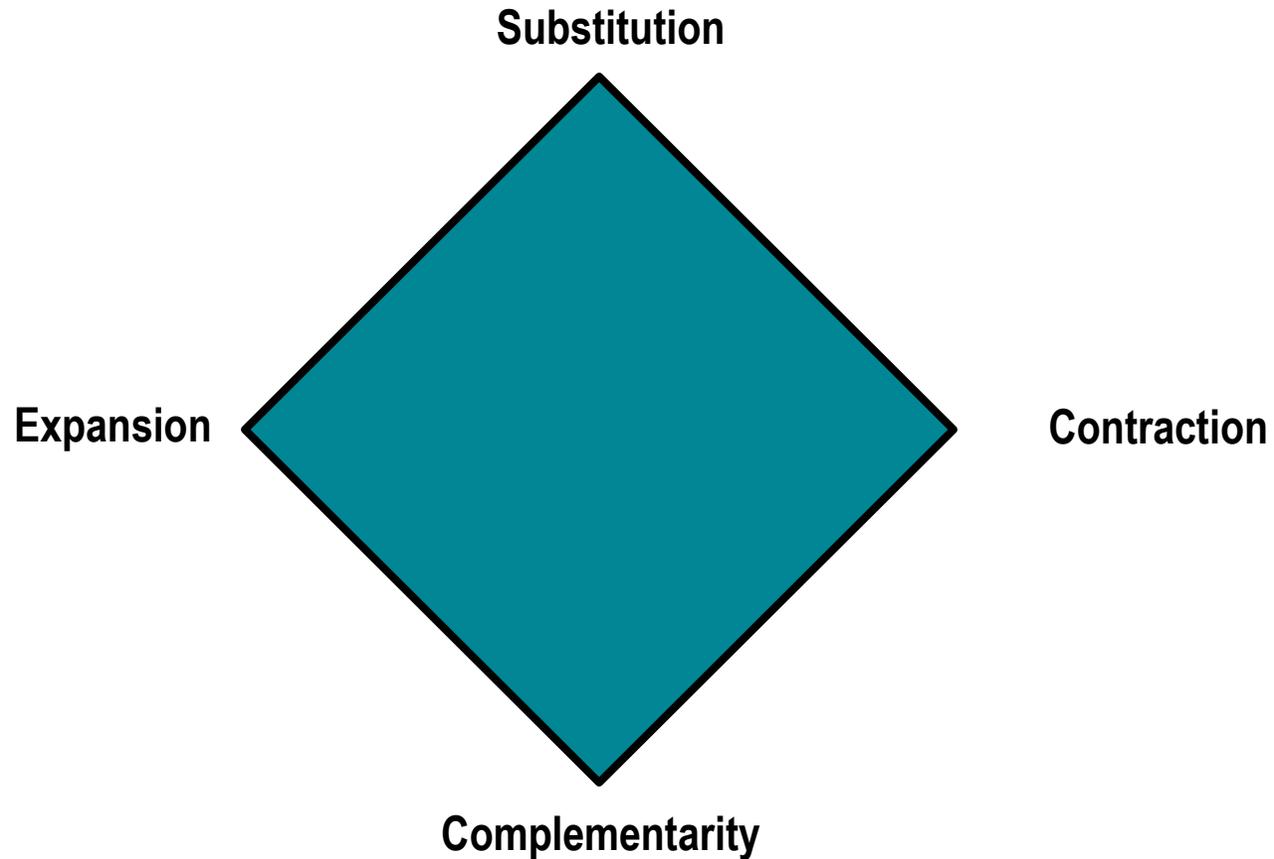
Information Technologies and the Corporate Structure



Estimated Share of U.S. Employment Exposed to AI



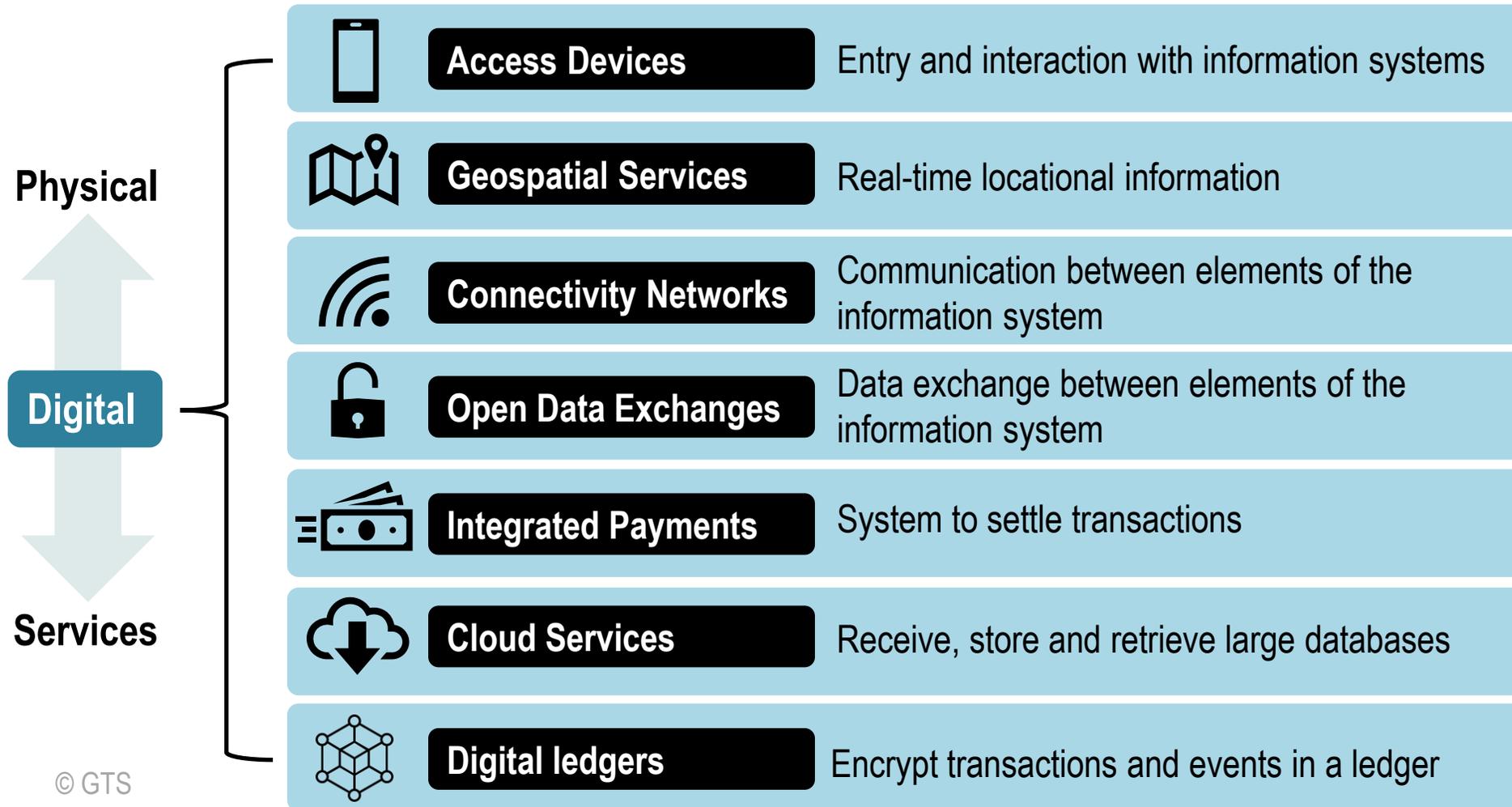
Possible Impacts of ICT on Mobility (under construction)



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	

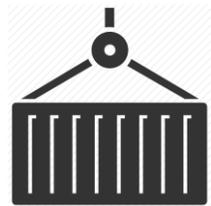
The Digitalization of Mobility



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"X-pooling"		"X-hailing"		"X-sharing"	
Bus-pooling	Vanpooling	Ride-hailing/ Ride-sourcing	e-hailing	Sharing of vehicles	Ride sharing
		  		   	 
<p>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.</p>		<p>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>		<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.



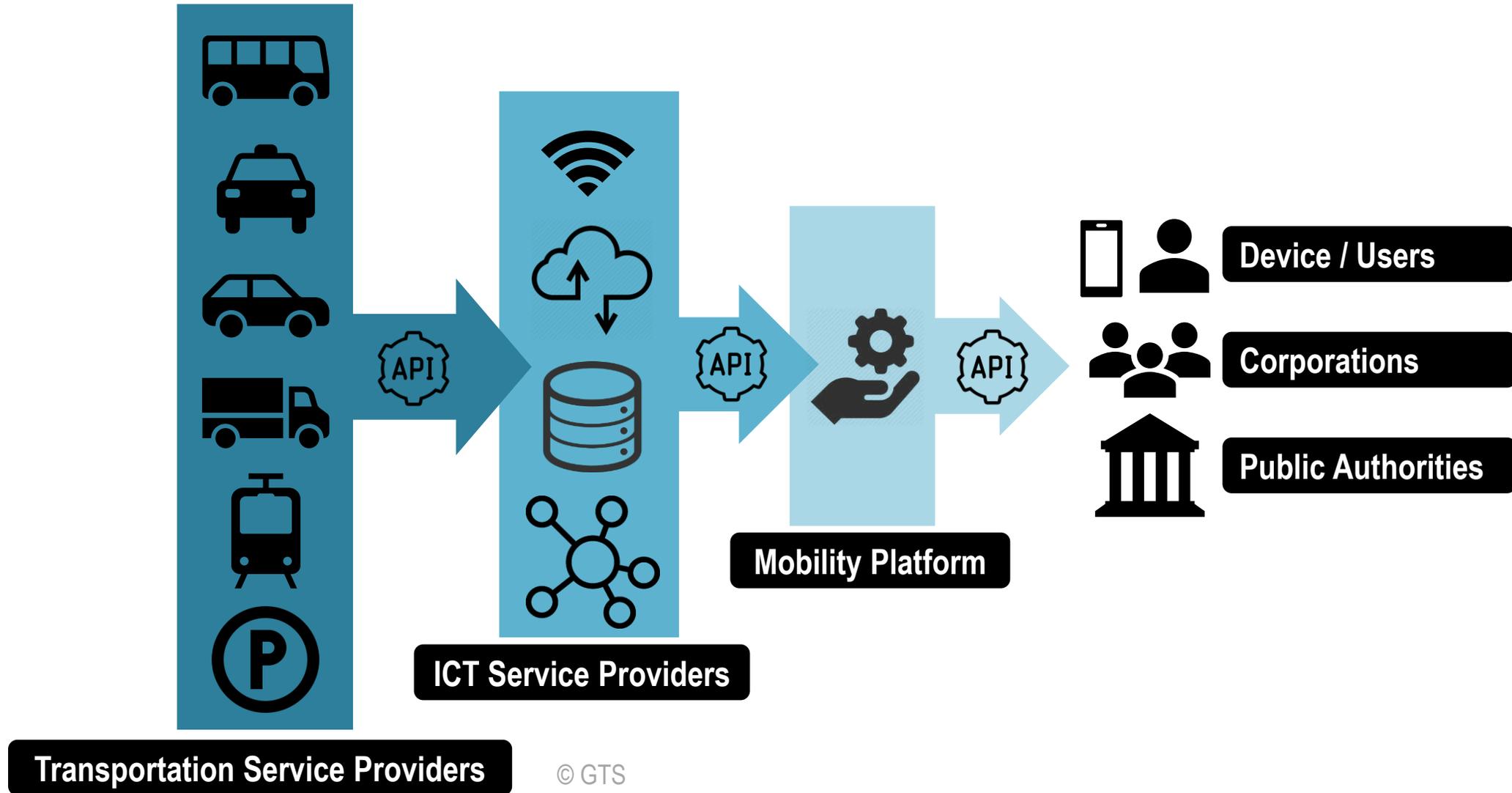
BUSINESS PROCESS

- Electronic data exchange.
- Blockchain.

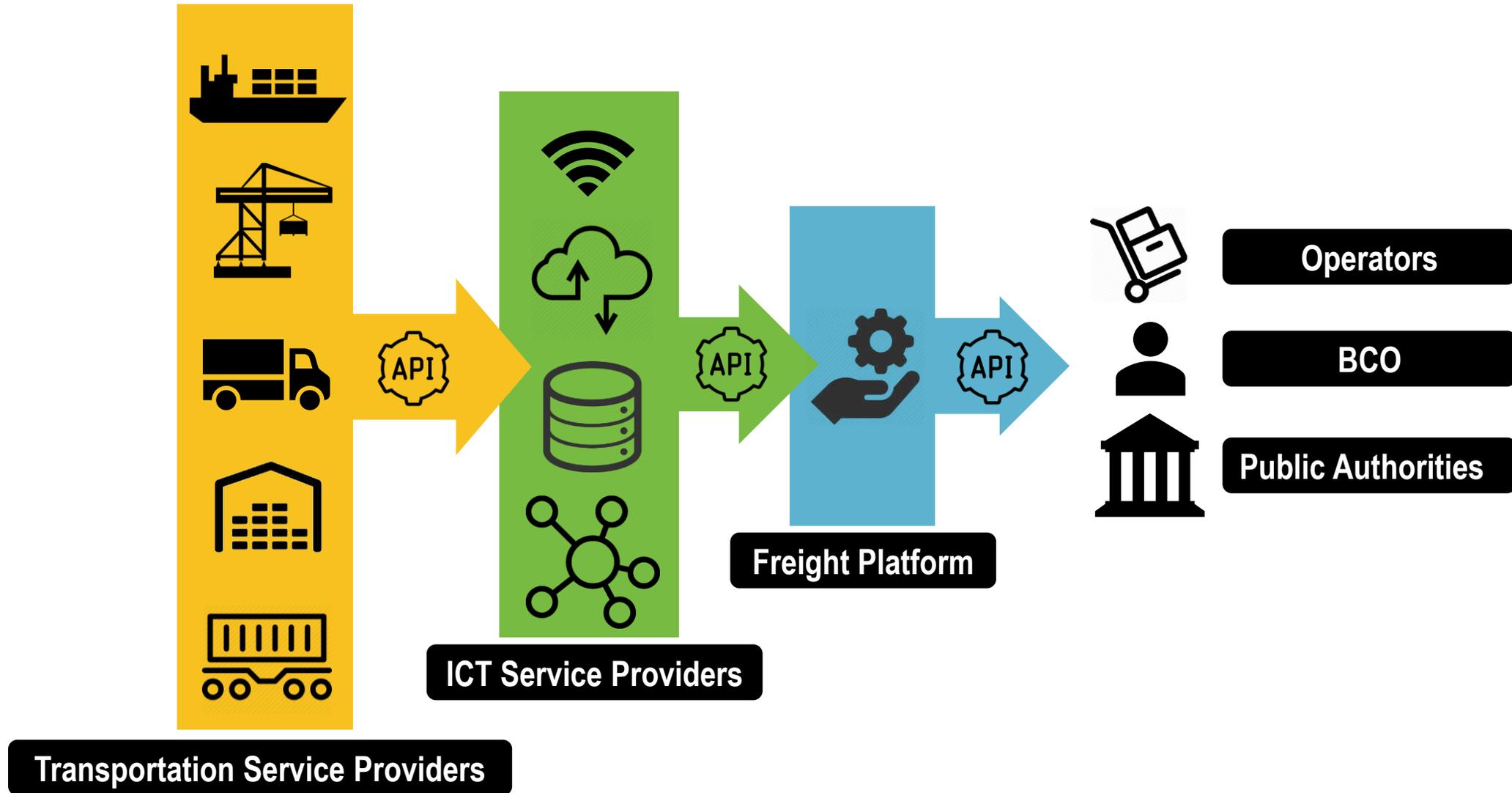


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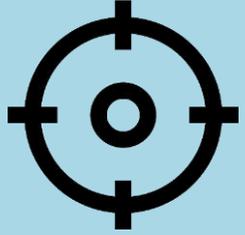
Mobility as a Service (Digitalization)



Digital Freight Platform

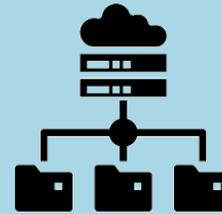


Key Information Technology Drivers in Freight Distribution



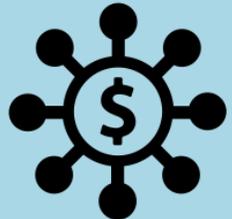
FREIGHT VISIBILITY/TRACKING

- 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.



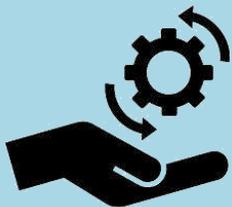
ASSET MANAGEMENT

- 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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