

The Geography of Transport Systems

Jean-Paul Rodrigue

Sixth Edition



Urban Transportation

CHAPTER 8

Copyright © 1998-2024, Jean-Paul Rodrigue, Dept. of Global Studies & Geography, Hofstra University, Hempstead, NY, 11549 USA.

Jean-Paul.Rodrigue@hofstra.edu

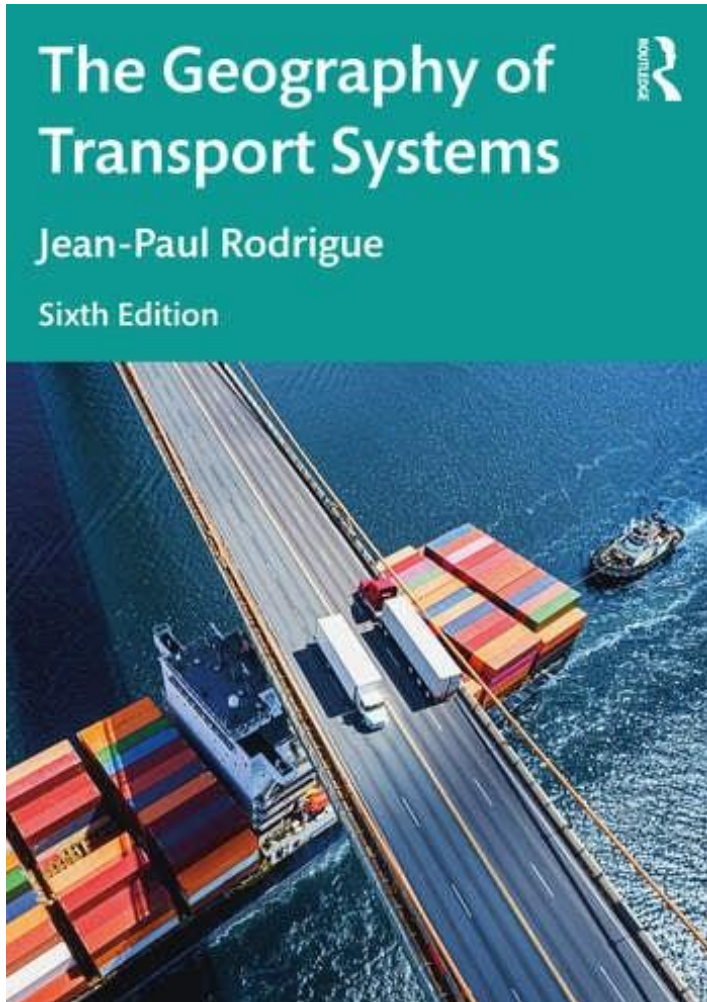
You may use the figures within for educational purposes only. No modification or redistribution permitted.
For more information: <https://transportgeography.org/>

Usage Conditions

- DO NOT COPY, TRANSLATE OR REDISTRIBUTE THIS DOCUMENT.
- The contents of this document can be freely used for personal or classroom use ONLY.
- Although the material contained in this document is freely available, it is not public domain. Its contents, in whole or in part (including graphics and datasets), cannot be copied and published in ANY form (printed or electronic) without consent.
- If you have accessed this document through a third party (such as a content farm), keep in mind that this party is illegally redistributing this content. Please refer to the true source (<https://transportgeography.org/>) instead of the third party.
- Permission to use any graphic material herein in any form of publication, such as an article, a book or a conference presentation, on any media must be requested prior to use.
- Information cited from this document should be referred as: Rodrigue, J-P et al. (2020) The Geography of Transport Systems, Hofstra University, Department of Global Studies & Geography, <https://transportgeography.org/>.

Table of Contents

- 8.1 - Transportation and Urban Form
- 8.2 - Transportation and Land Use
- 8.3 - Urban Mobility
- 8.4 - Urban Transport Challenges



Transportation and Urban Form

Chapter 8.1

Urban Hierarchy

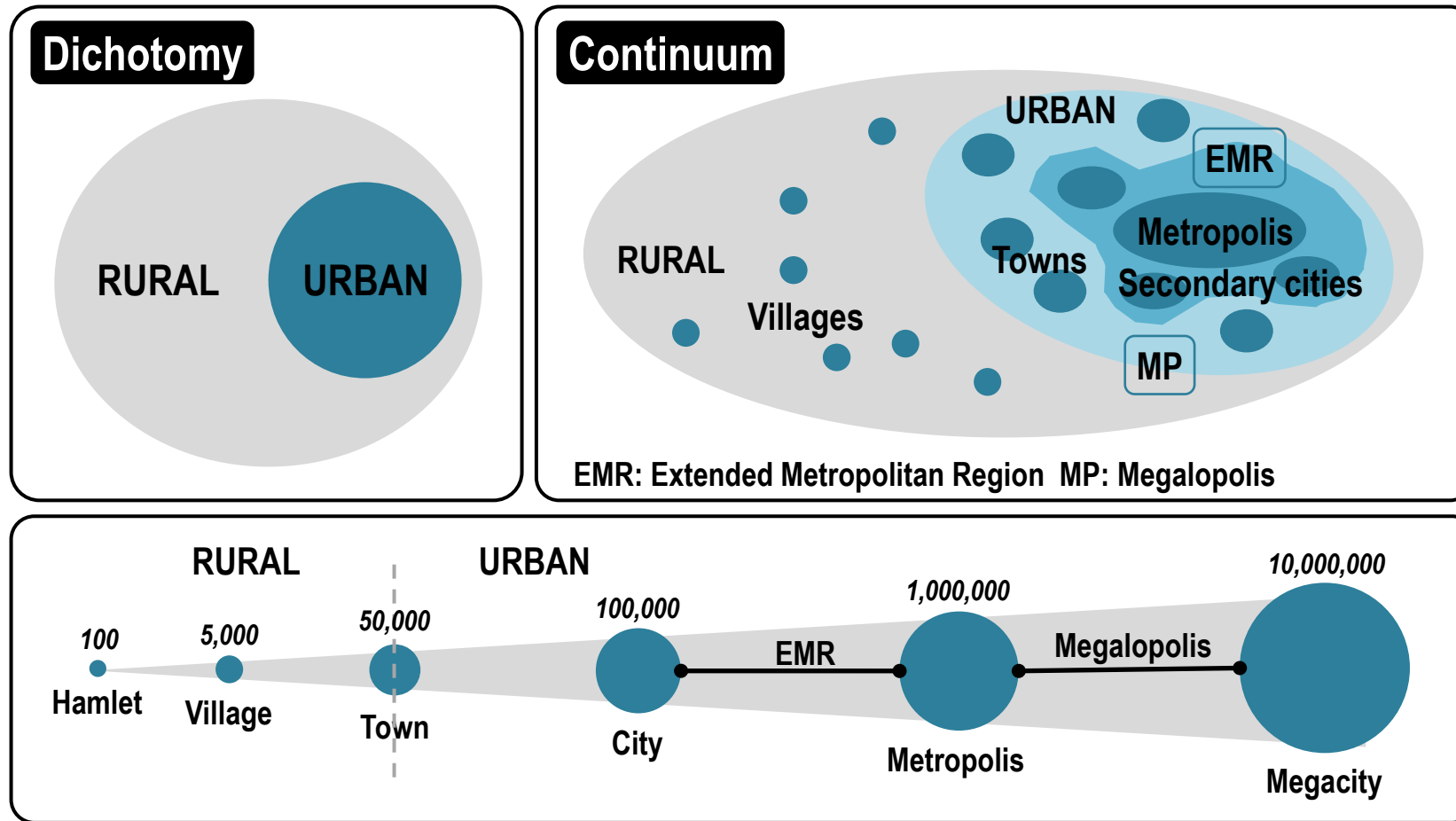
Hamlet	Small collection of homes: population 10-100
Village	Rural in character. Population less than 10,000.
Urban area	Defined by land use? E.g. 75% built up; by function?
Town	Larger than a village but smaller than a city With town charter. Less than 100,000 population.
City	Legal status in some countries. Over 100,000?
Conurbation	Urban area incorporating adjacent centres e.g. former free-standing towns and villages. After Geddes 1915
Metropolis	Large urban agglomeration, usually over 1 million
Megacity	Urban metropolis over 10 million
Megalopolis	Chain of adjacent metropolitan areas.
World or global city	A global centre for finance, culture, political influence.
Eperopolis	‘Continental city’.

Globalization and Urbanization

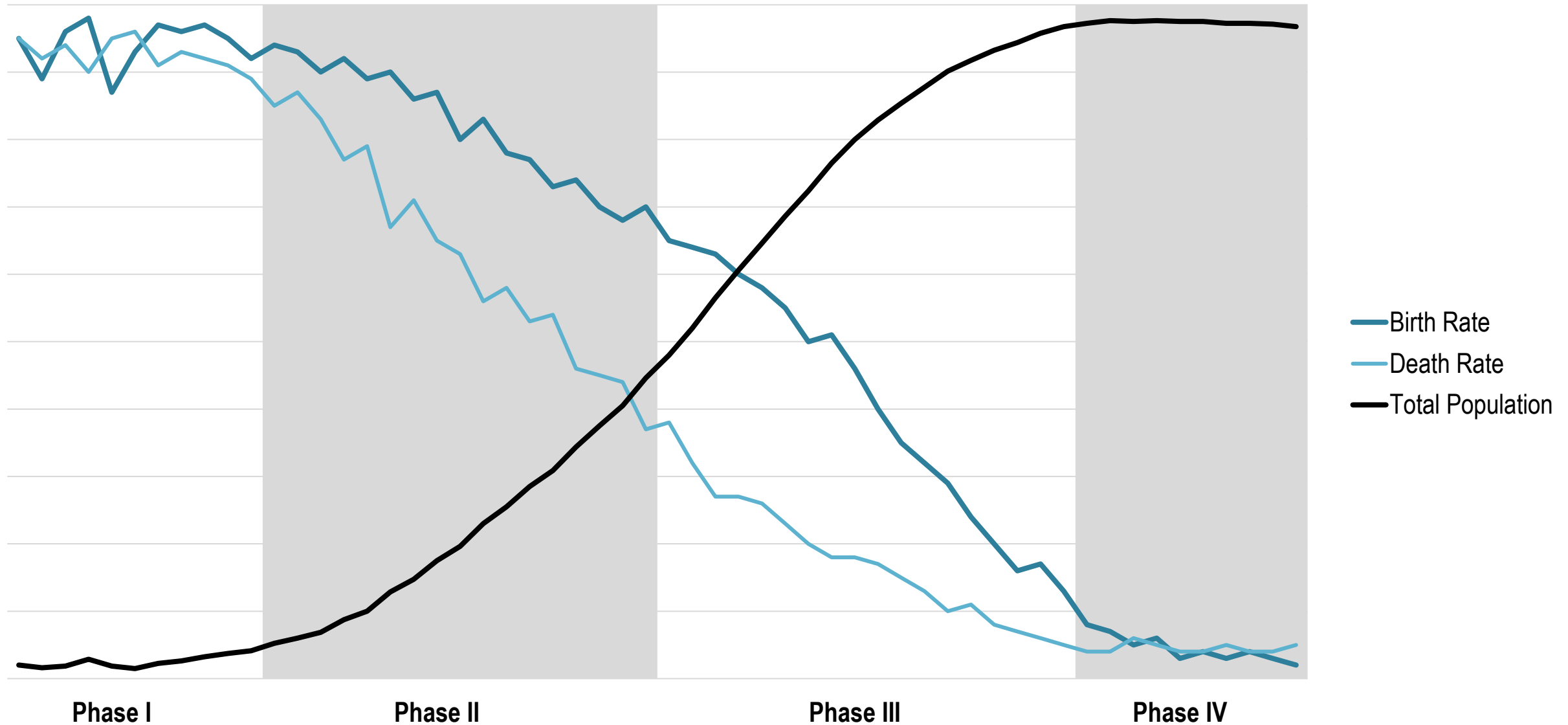
	MERCANTILE ERA	INDUSTRIAL ERA	CONTEMPORARY ERA
Technology	<ul style="list-style-type: none">• Long-distance sailing ships; Cartography (navigation).	<ul style="list-style-type: none">• Steam power; Railroad; Steamships; Machine fabrication.	<ul style="list-style-type: none">• New transport and communication technologies; Advanced production technologies.
Principles	<ul style="list-style-type: none">• New means of payment (credit): precious metals, financial Innovations (accounting & banking).	<ul style="list-style-type: none">• Economies of scale; Vertical integration of production; Factory systems; Assembly line; Labor unions; Property rights; Central banking; Currency; Monetary policies; Compulsory education.	<ul style="list-style-type: none">• Economies of scope; Trade liberalization; Logistical innovations to facilitate flows of goods, services, capital, and information.
Spatial Structure	<ul style="list-style-type: none">• Division of labor brings increasing urbanization; Size of major cities increases.	<ul style="list-style-type: none">• Massive urbanization; Average town size increases; Structural issues (housing, infrastructure, spatial organization); Social issues (unemployment, health, welfare, education).	<ul style="list-style-type: none">• Urban regions competing globally; Relatively fast economic changes causing local dislocations; Rise of large urban regions around major cities connected to the global economy.

© GTS

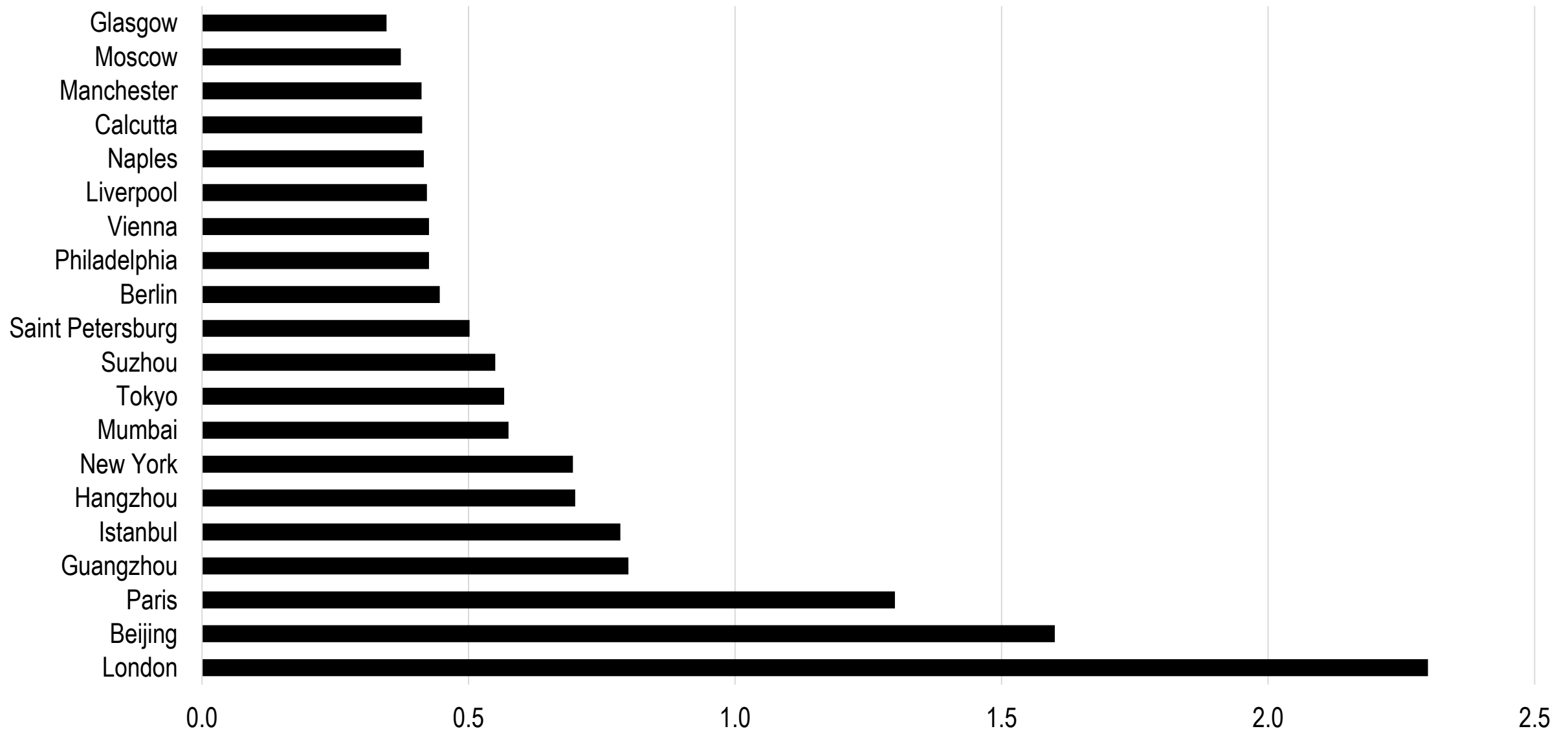
Perspectives about the Urban Spatial Structure: From Dichotomy to Continuum



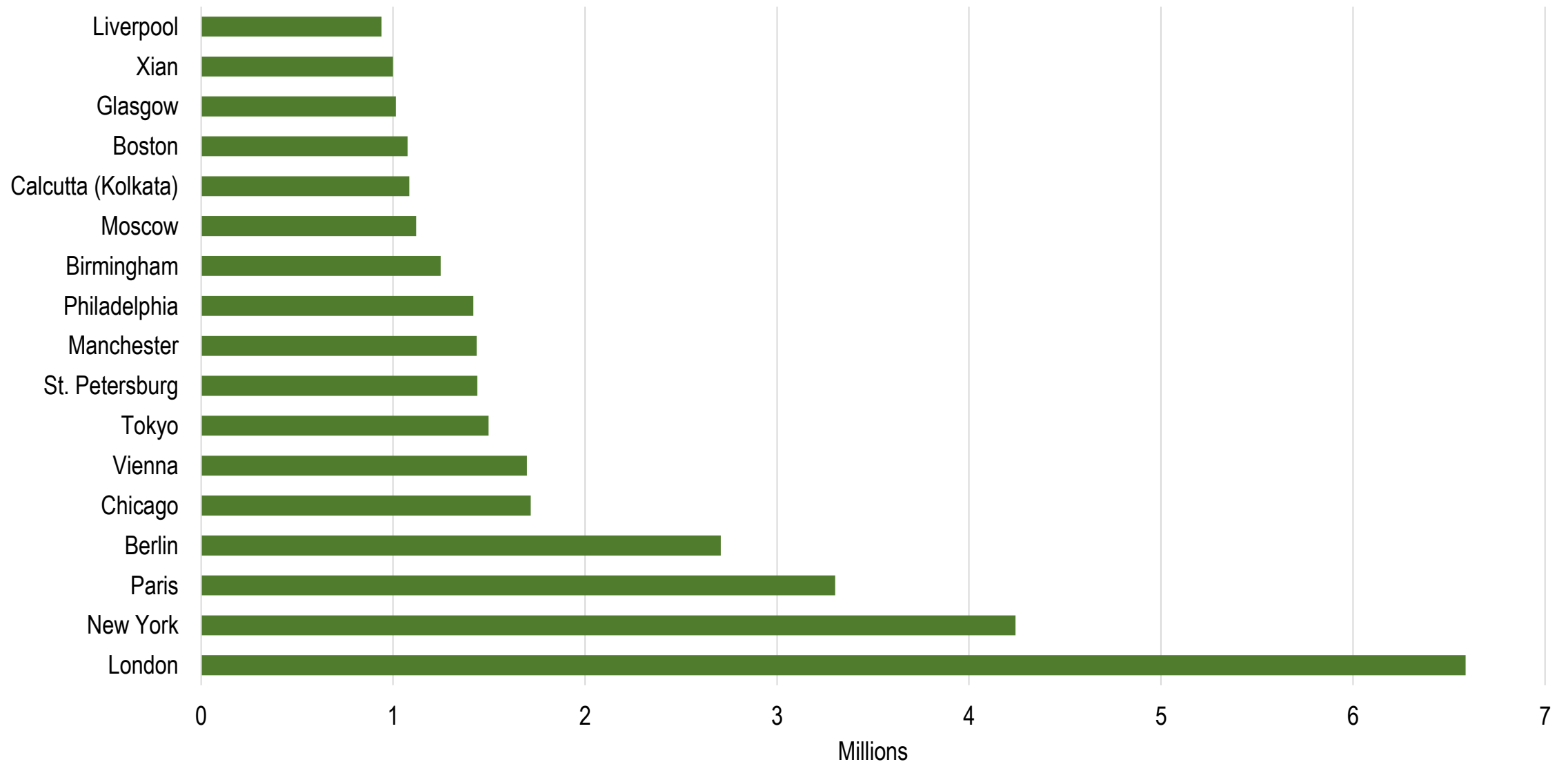
Demographic Transition



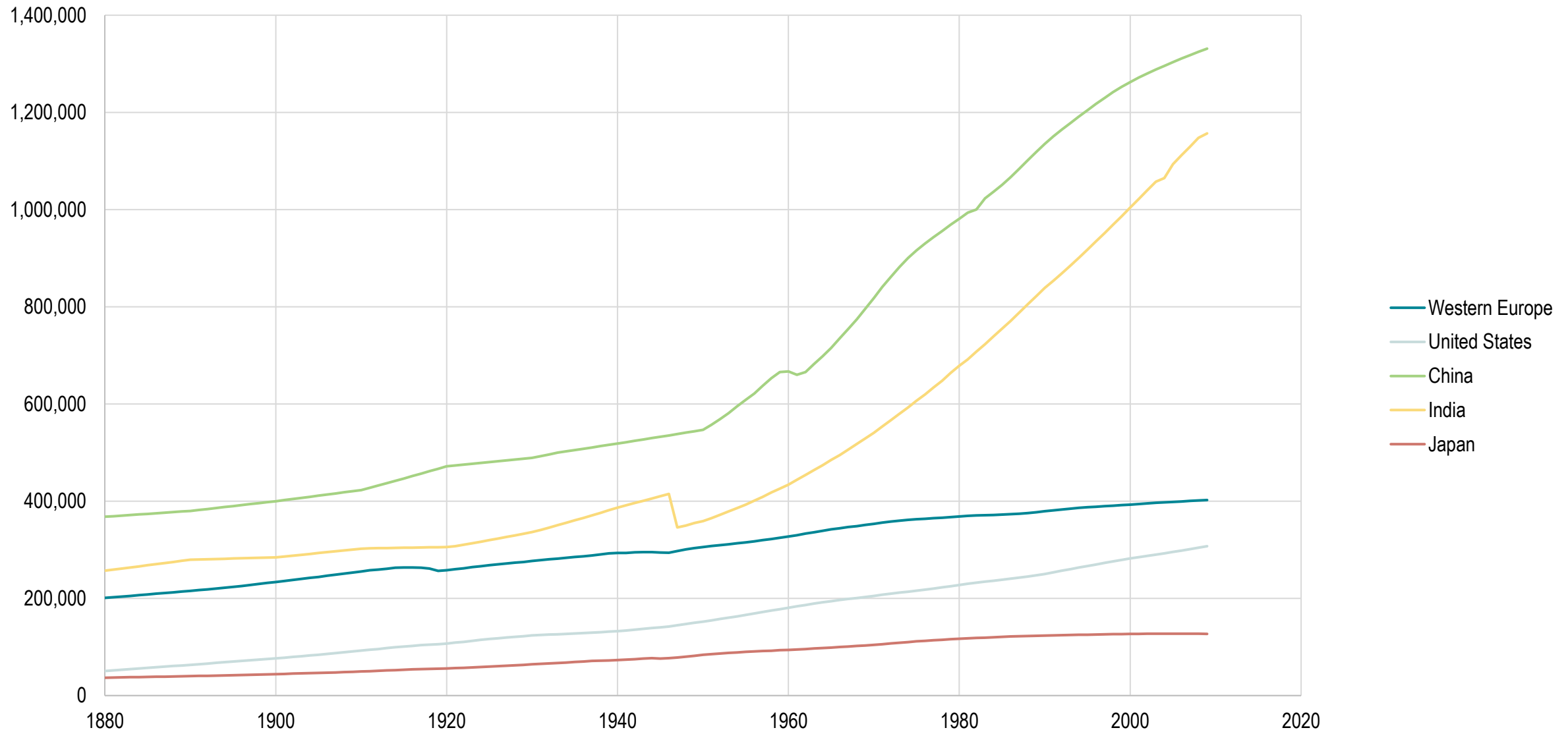
World's Largest Cities, 1850



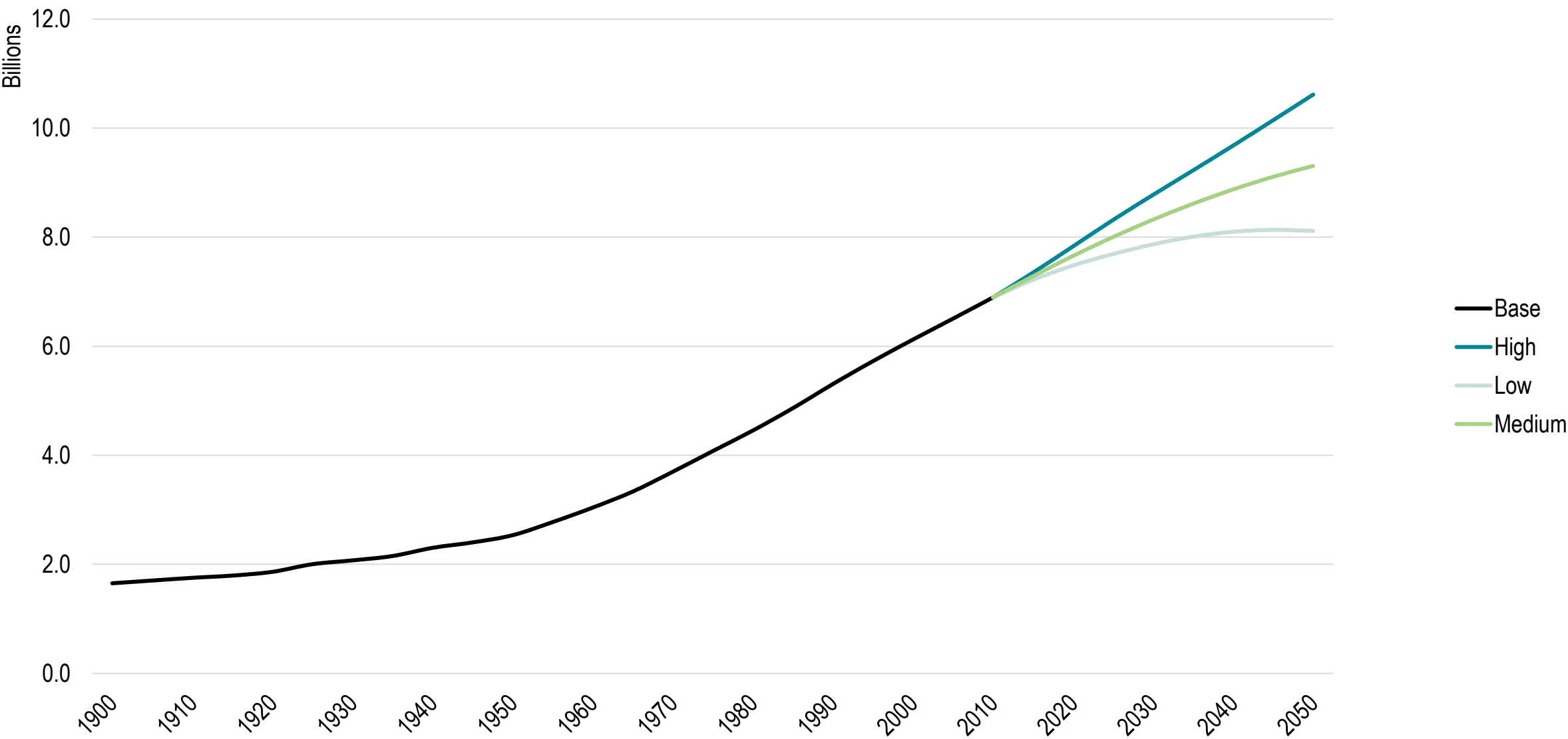
World's Largest Cities, 1900



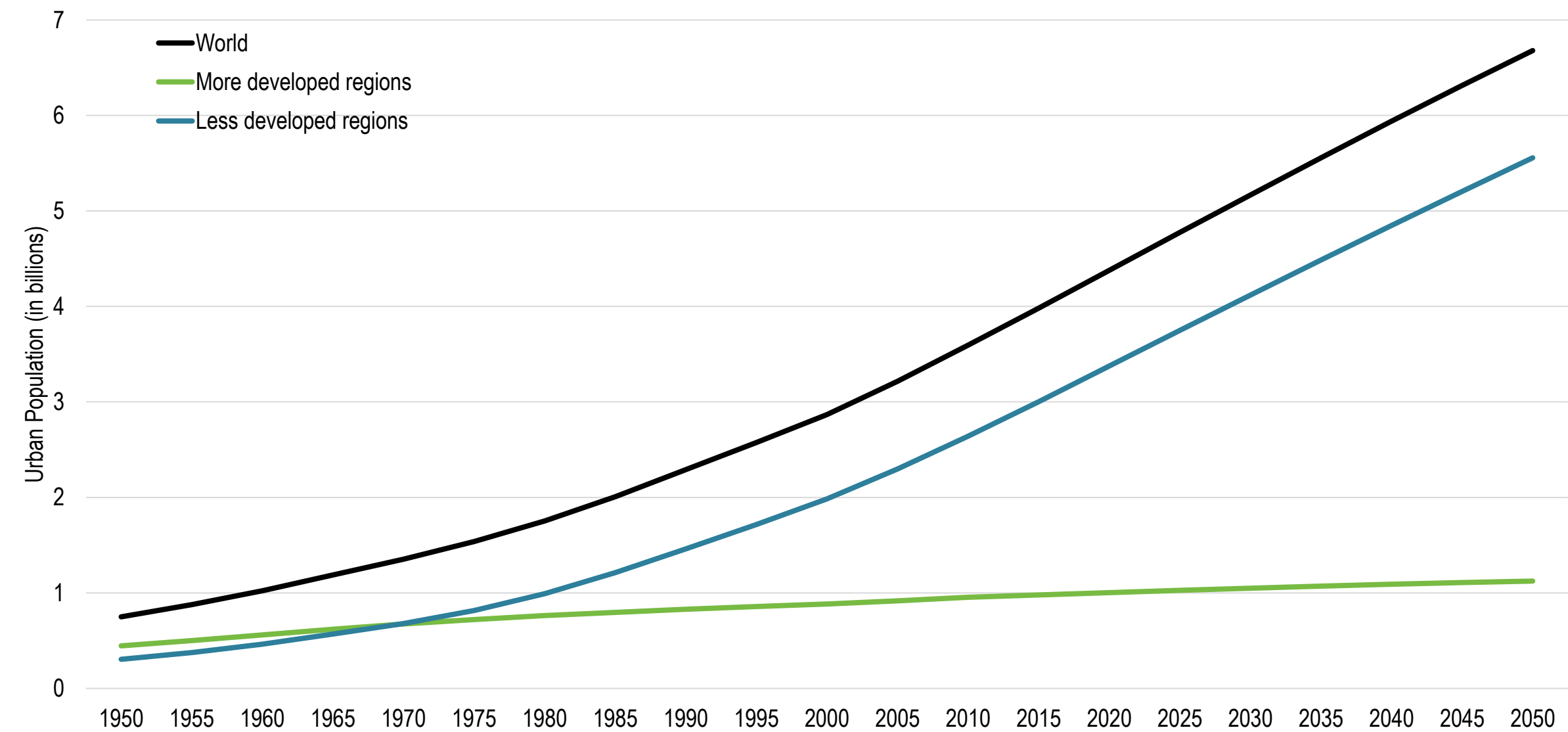
Population, Selected Units, 1880-2009



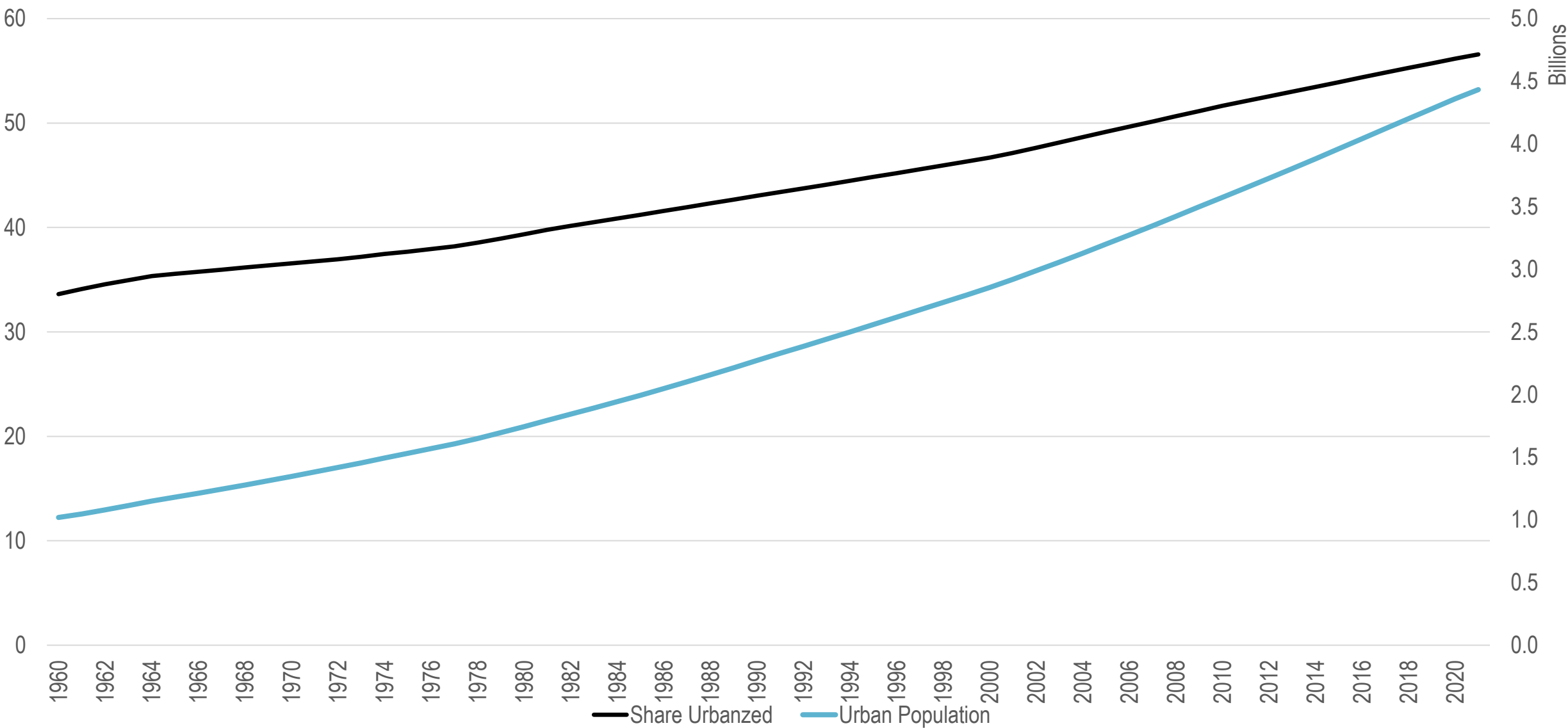
Global Population (1950-2010) and Growth Scenarios, 2010-2050



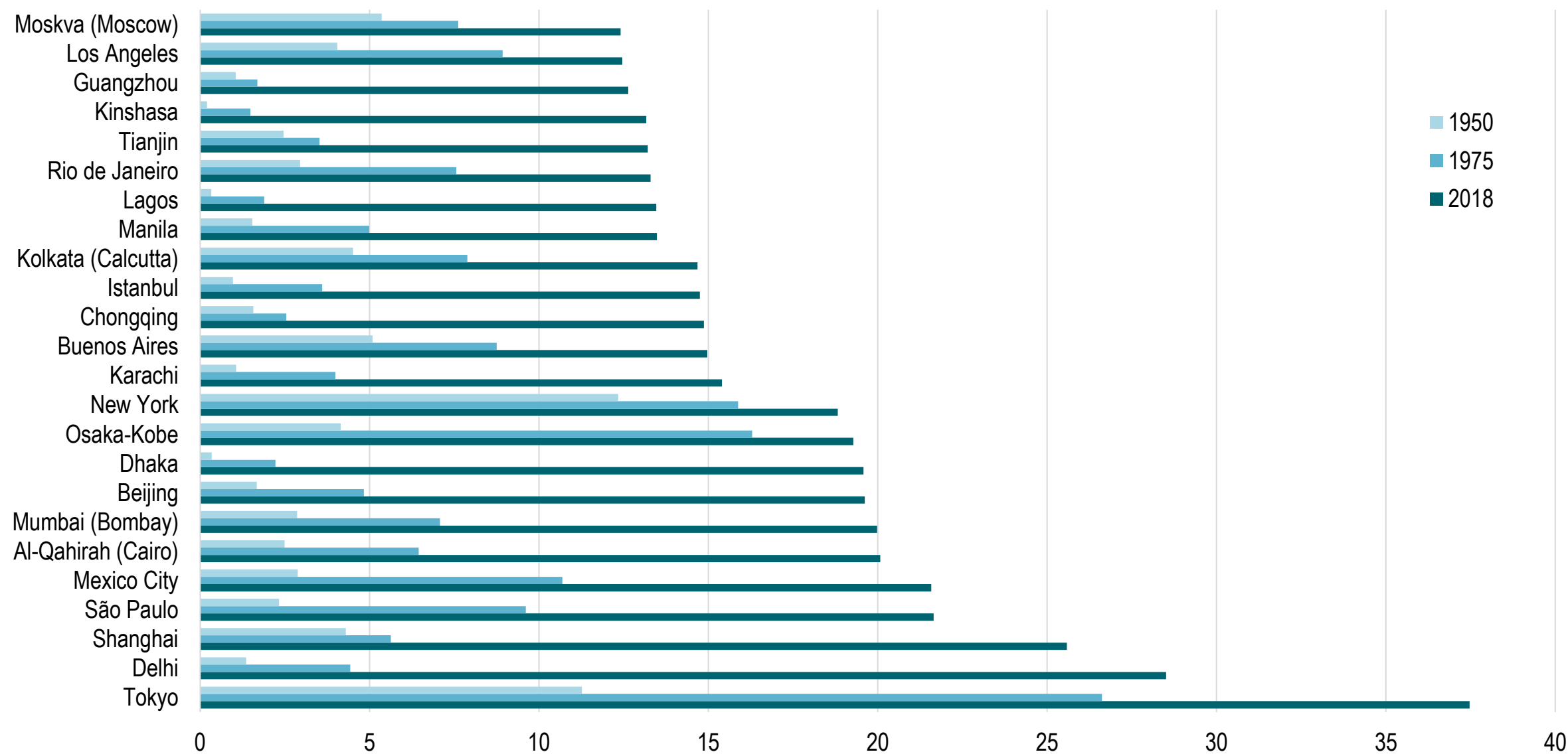
World Urban Population, 1950-2015 with Projections to 2050



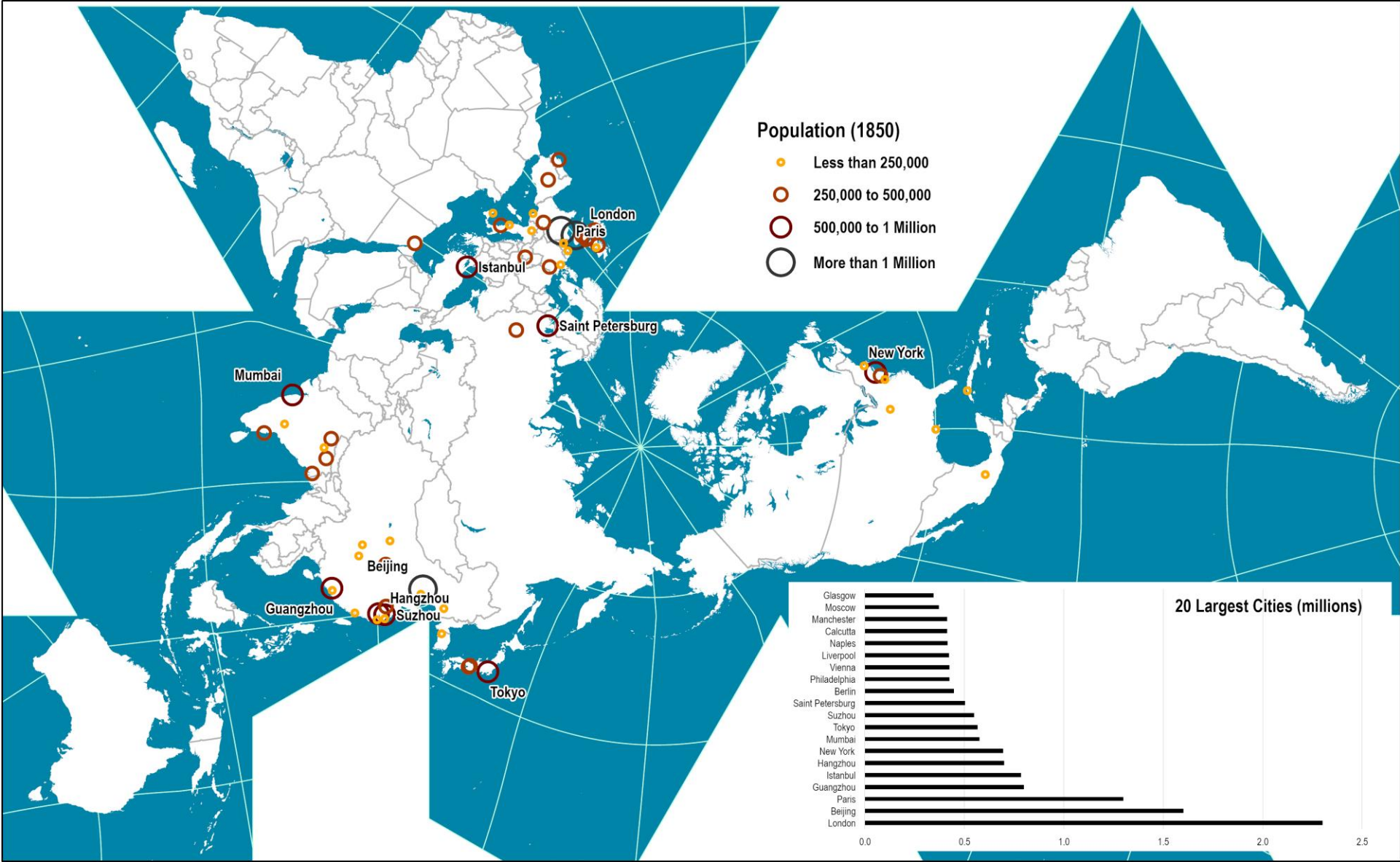
World Urban Population and Share of Population Urbanized



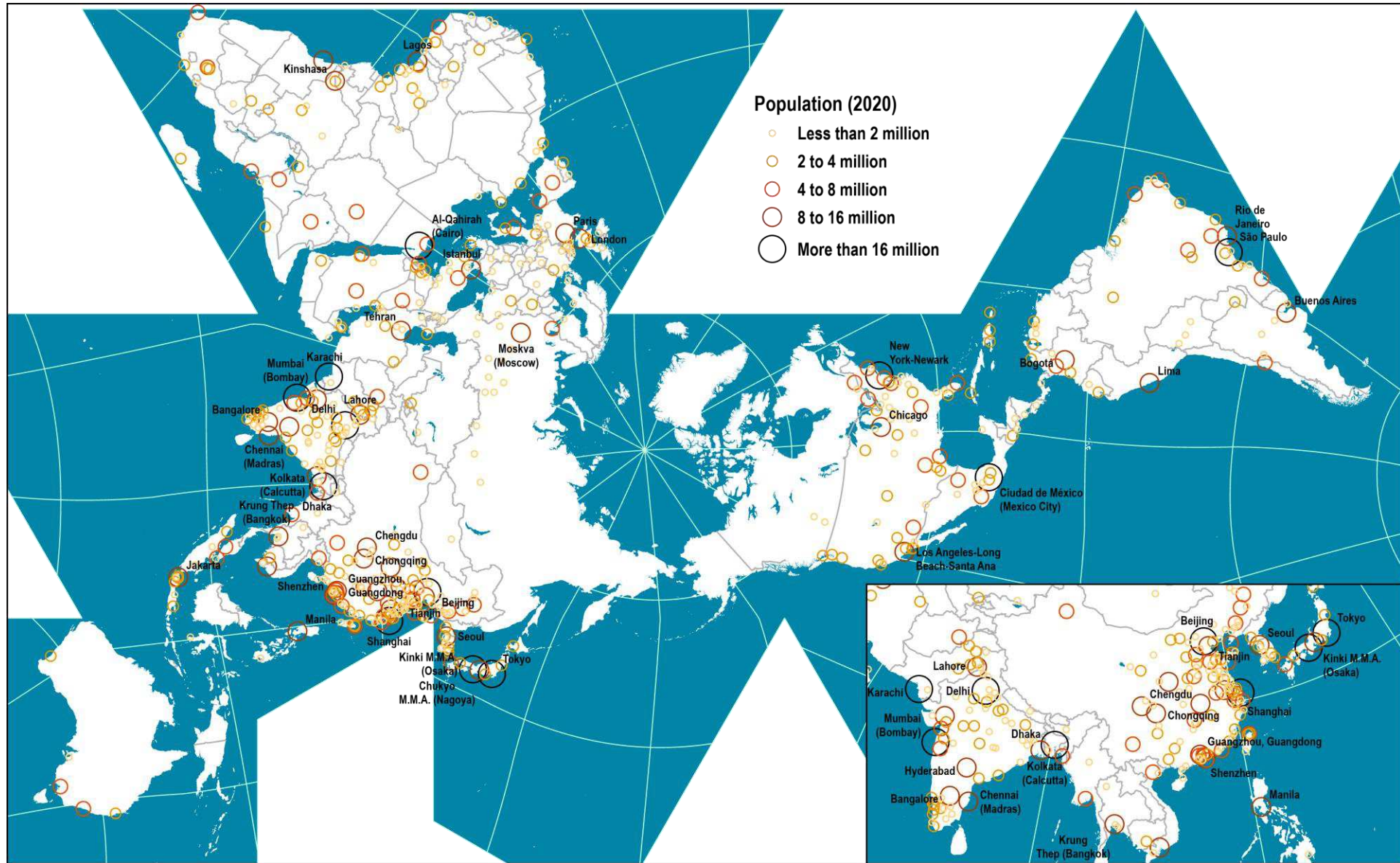
Metropolitan Areas of More than 12 Million Inhabitants, 2018



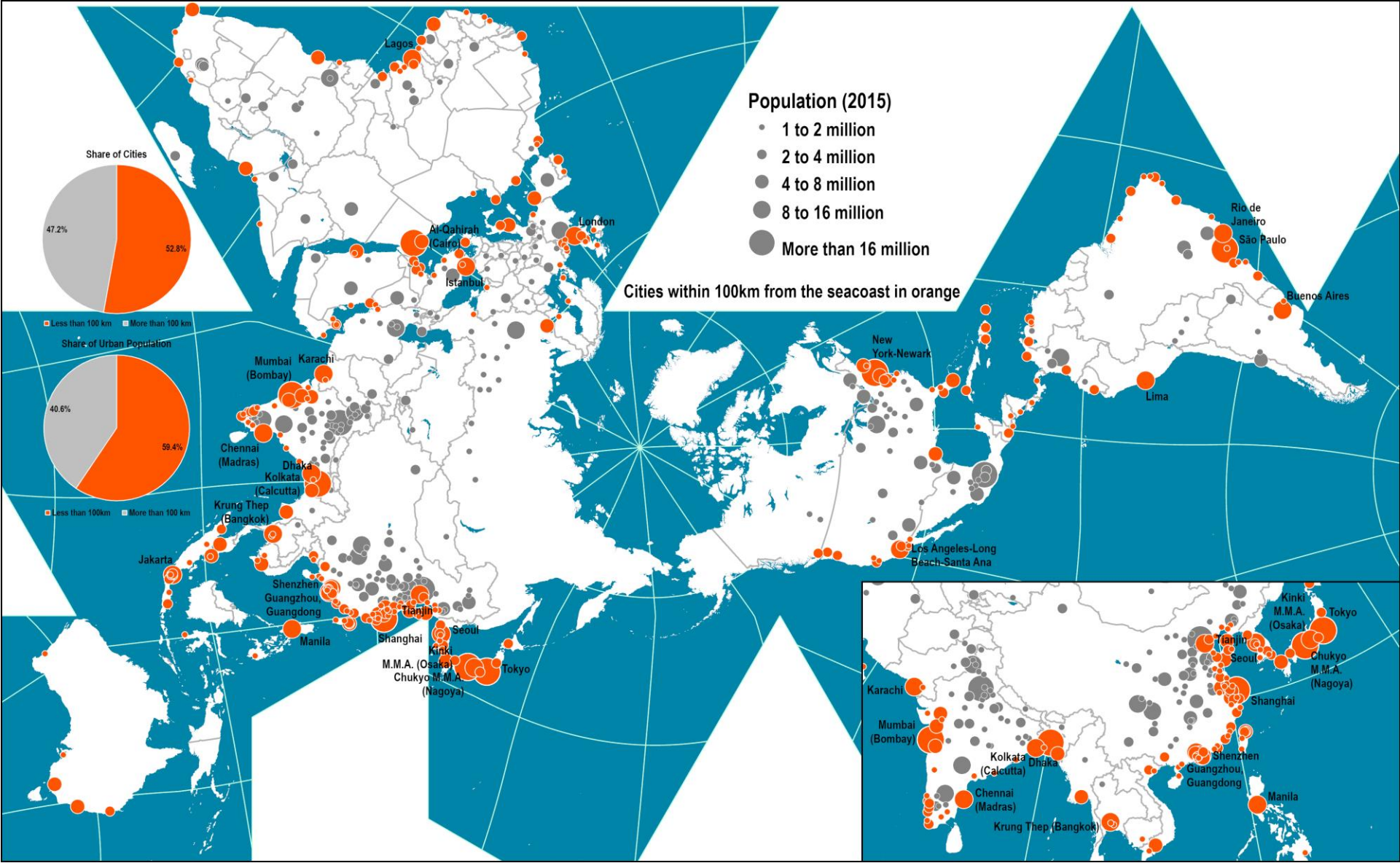
World's Largest Cities, 1850



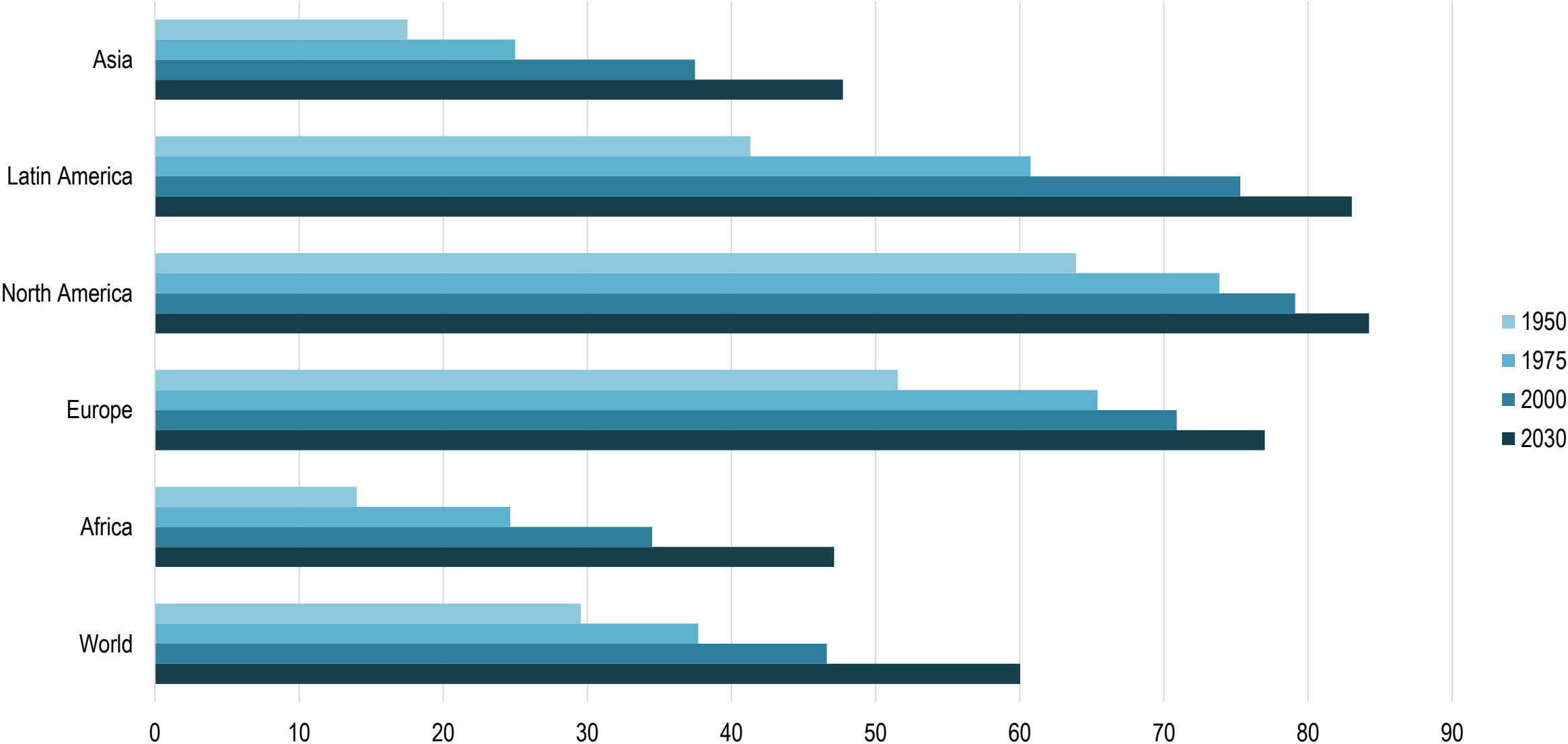
World's Largest Cities, 2020



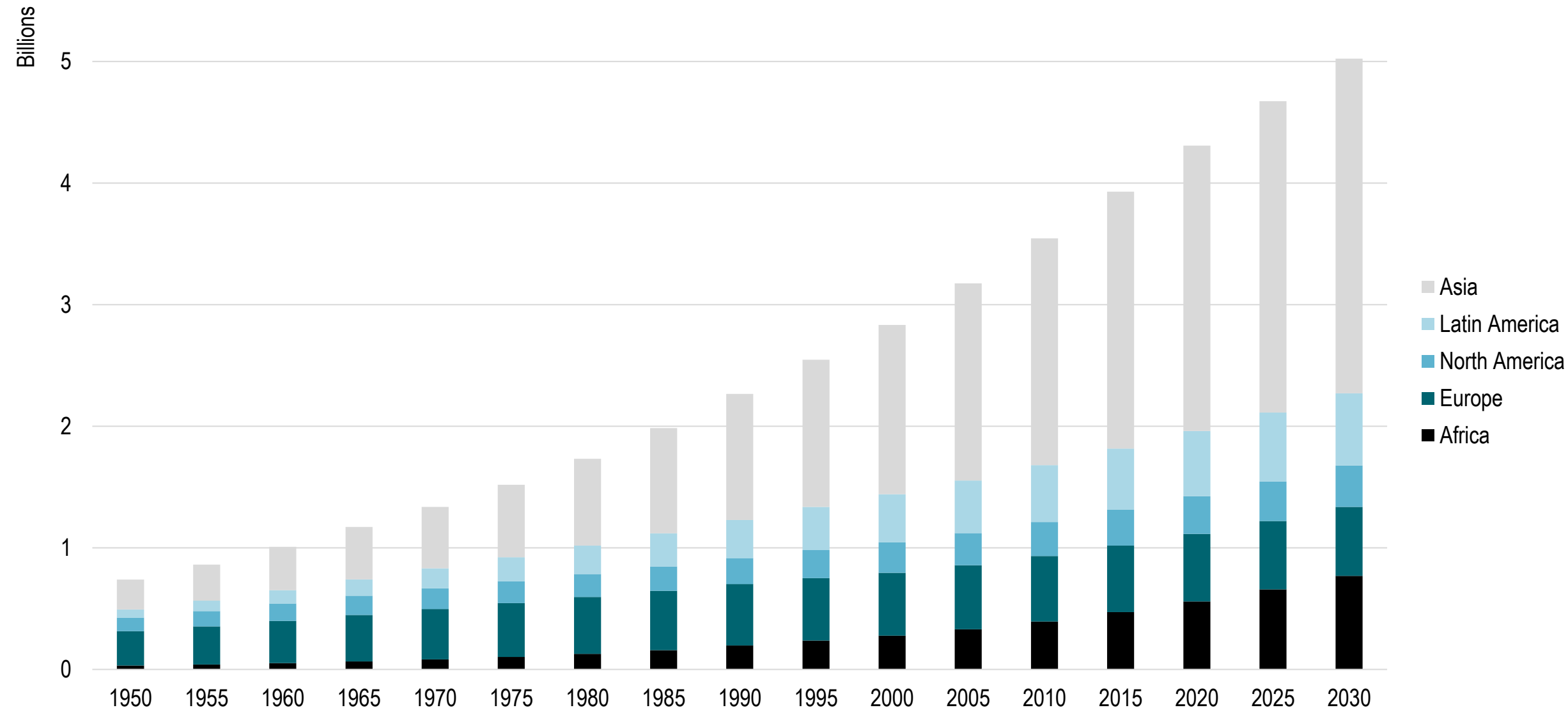
World's Largest Coastal Cities, 2015



Percentage of Urban Population by Region, 1950-2030



Urban Population by Region, 1950-2030



Cities and Connectivity

Function	Main Mode	Nexus
Trade		
Production and Distribution	Water transport. Railways Highways	Port terminals. Heavy industries. Rail terminals and railyards. Manufacturing clusters. Distribution clusters.
Mobility and Accessibility	Highways Transit	Central stations. Shopping districts.
Transactions	Telecommunications Air transport	Financial / management districts.

Cities and Connectivity

PRODUCTION AND DISTRIBUTION

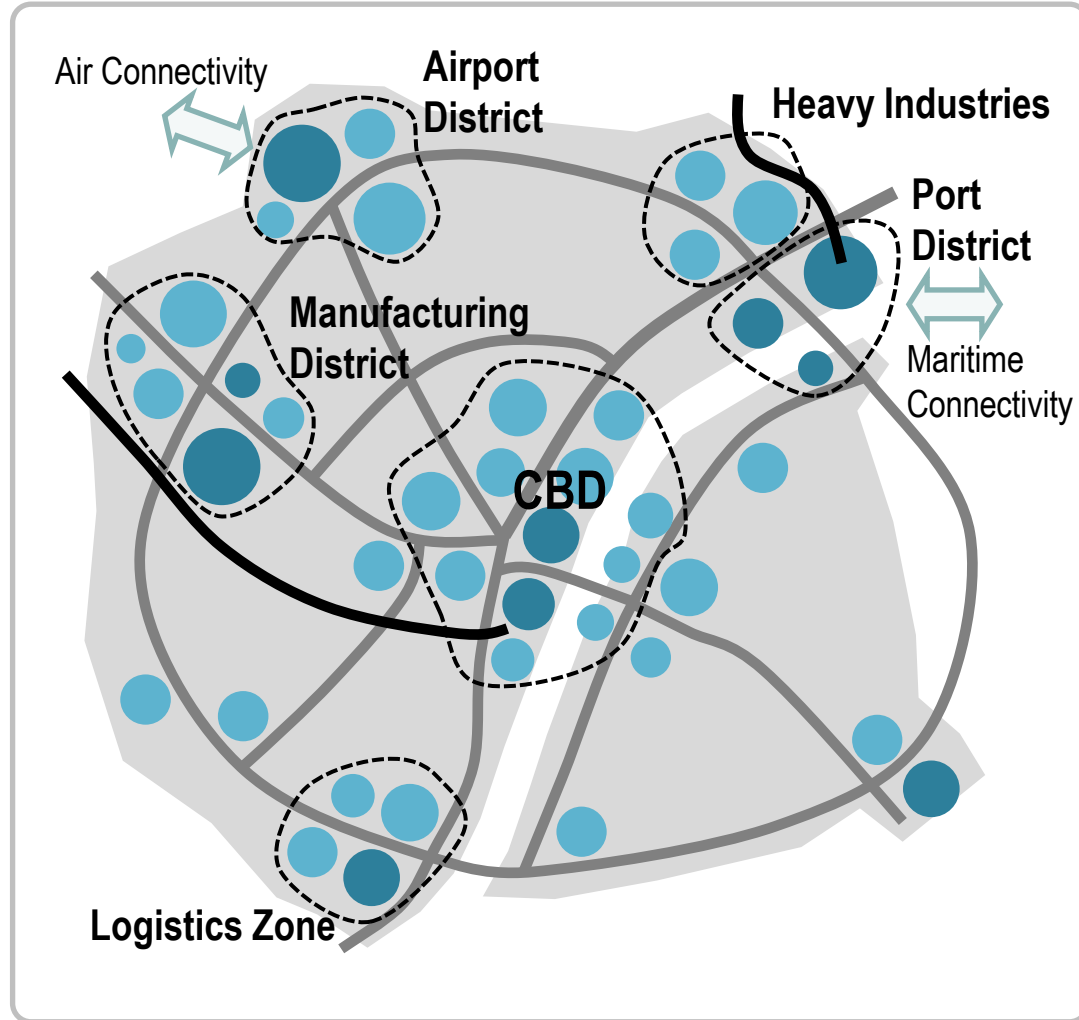
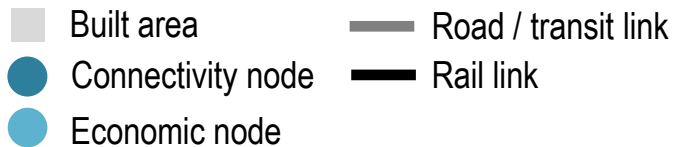
Port districts.
Heavy industries.
Railyards.
Manufacturing clusters.
Distribution clusters.

MOBILITY AND ACCESSIBILITY

Central / transit stations.
Shopping districts.
Airport districts.

TRANSACTIONS

Financial / management districts.



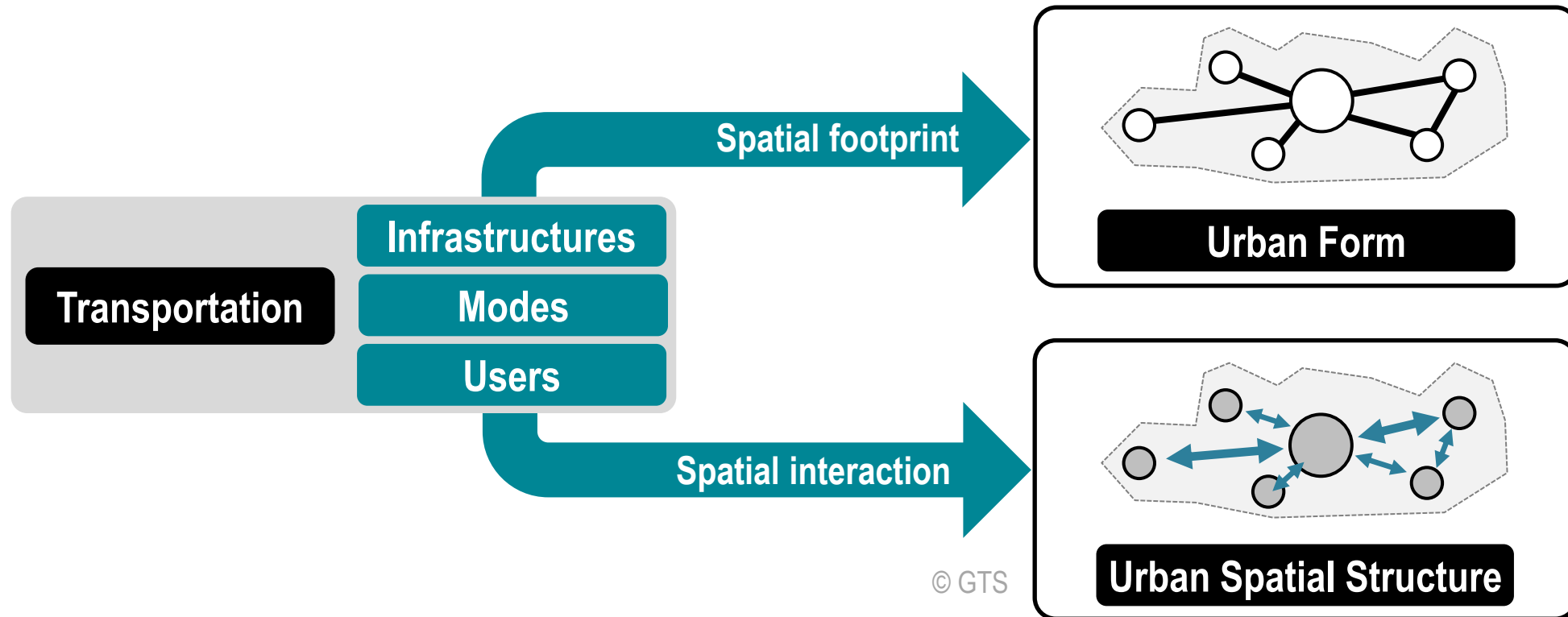
Box 1.4 Most influential urban forms from the early 20th century

The most influential urban forms have been:

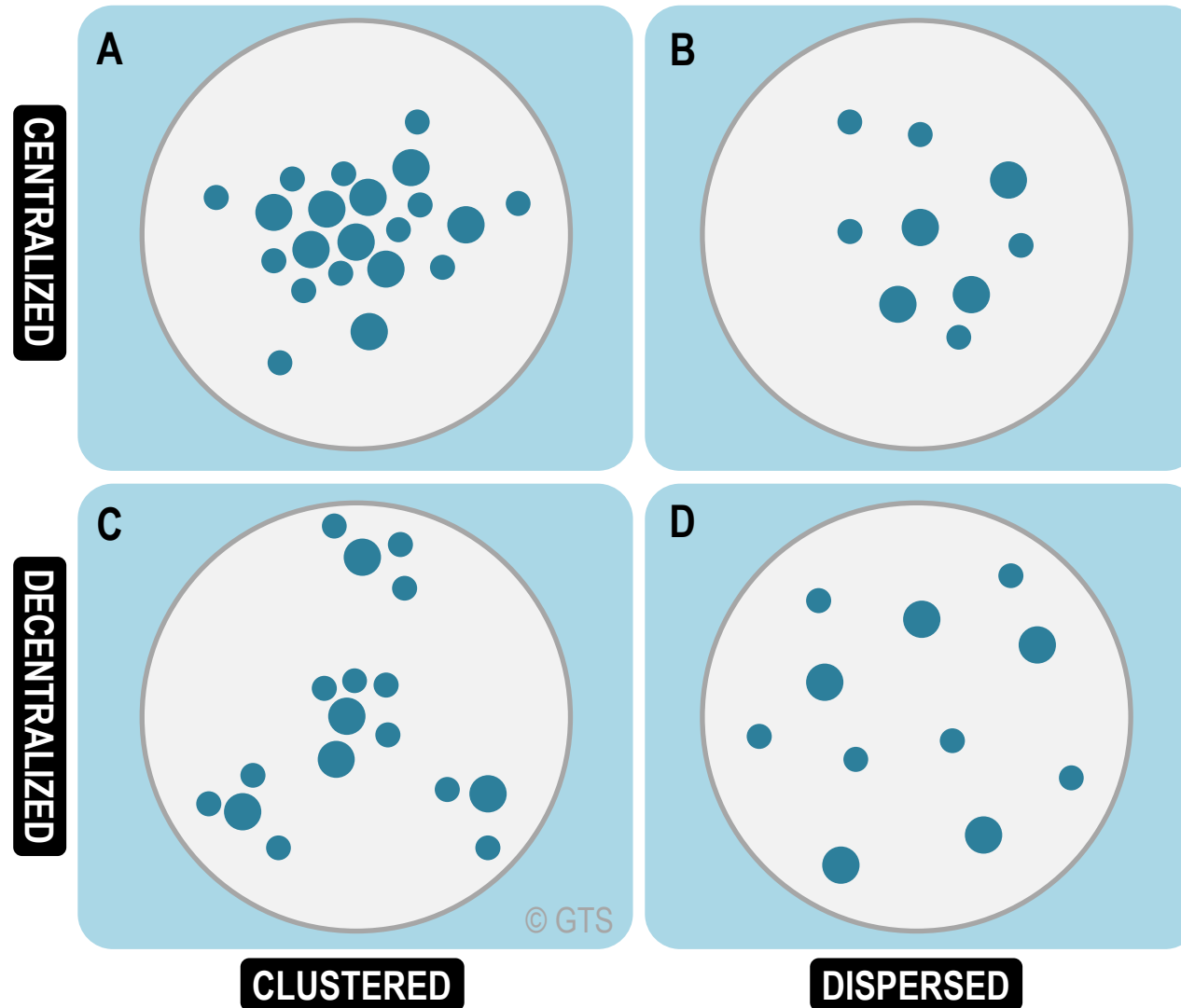
- *The garden city*, circa 1900 (UK): small, self-contained satellite towns, detached dwellings, large plots of land, low densities, separation of incompatible land uses, radial road networks and aesthetic, curving routes.
- *Greenbelts*, circa 1900 (UK): wide buffers of open space surrounding a town or city to prevent it from expanding outwards, and to separate it from new satellite towns (garden cities or new towns) beyond the belt.
- *The neighbourhood unit*, 1920s (US): low-density expanses of open space, focused on community facilities, minimizing conflict between cars and pedestrians by confining arterial routes to the periphery and discouraging through-traffic; assumption that this layout will create social communities.
- *Radburn layout*, 1928 (US): closely related to garden cities, this layout is characterized by cul-de-sacs and superblocks free of traffic; cars and pedestrians are separated from each other; public facilities and shops are located on pedestrian networks and embedded in open space.
- *Urban modernism*: new urban developments following Le Corbusian ideas of tower-blocks 'floating' in open space and connected by parkways.
- *Urban renewal* (1930s onwards): 'slum' clearance and rehousing projects following Radburn or neighbourhood unit layouts, and urban modernism.
- *Road hierarchies*, 1960s (UK): informed by the 1963 report by Colin Buchanan (traffic in towns). Provides a rationale for urban traffic management and the problems of traffic congestion by creating a hierarchy of roads with different functions. At the lowest level of the hierarchy an environmental cell (or residential area) carries only local traffic on 'local distributors'. At higher levels, district and primary distributors (freeways) carry passing and longer-distance traffic. The assumption is that every household will eventually own a car and all urban movement will be car based. These ideas fitted well with urban modernism and the two strands became closely interlinked.
- *New towns*, (war and post-war UK): as a regional response to a perception of problems of growth in major cities (de-concentration), but also seen as a tool of development in lagging regions.
- *Suburbia*, 1920s onwards: undefined and extensive areas of residential development on the urban periphery, single-family units, low densities and large plots of land, structured around car movement systems; serviced with community facilities and shopping malls. Assumes very high levels of car ownership and affluence.

Sources: Hall, 1988; Taylor, 1998

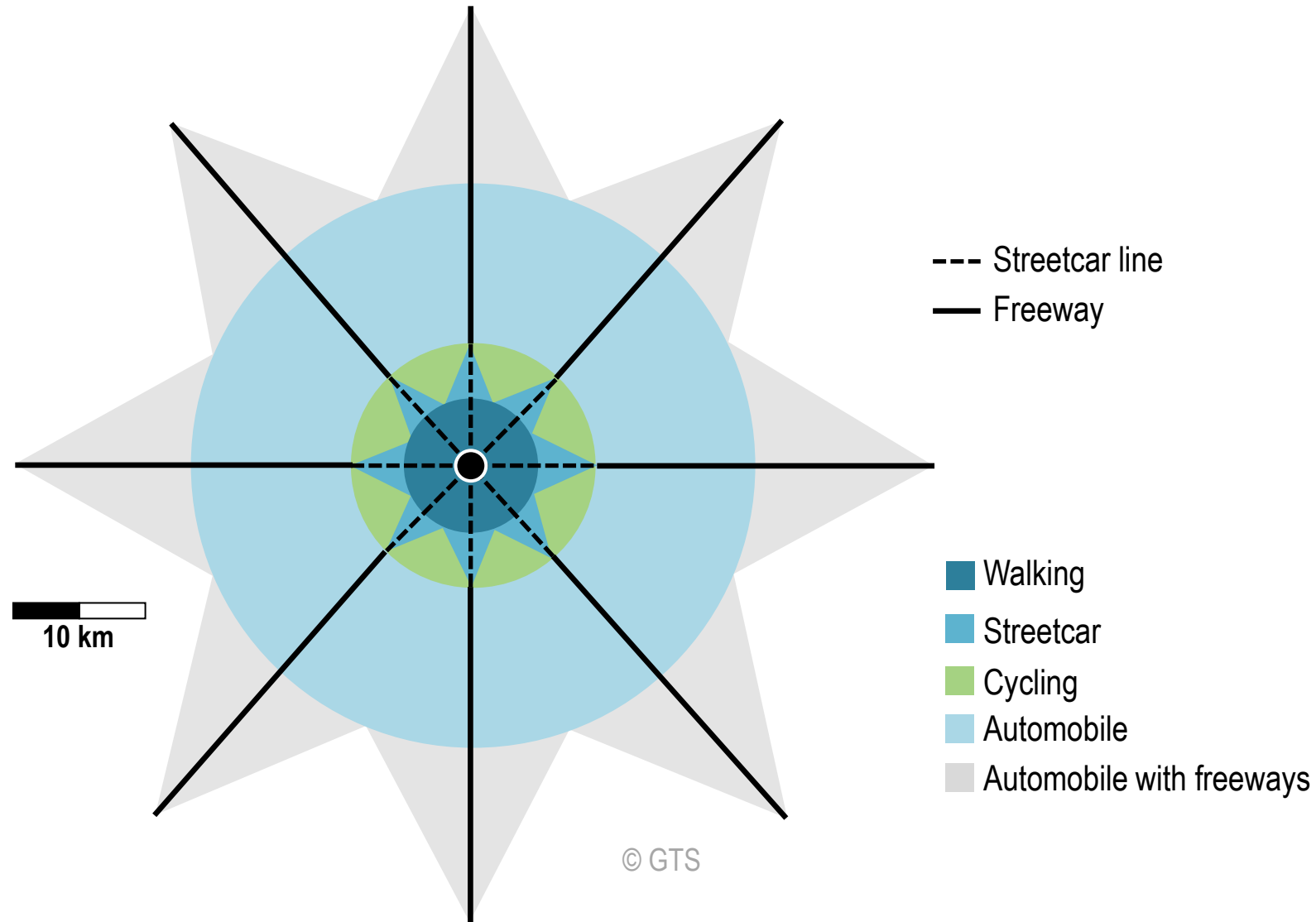
Transportation, Urban Form and Spatial Structure



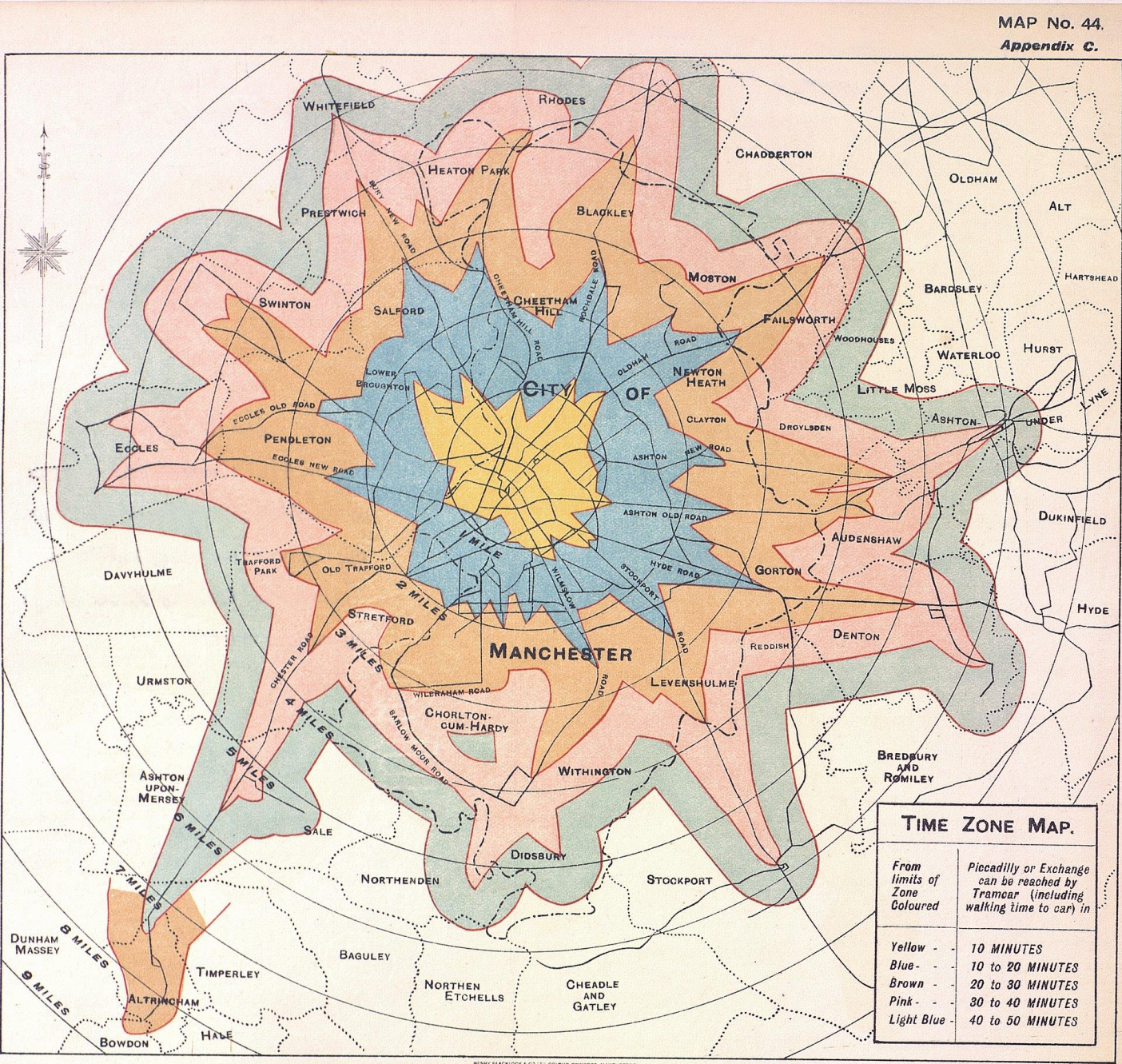
Types of Urban Spatial Structures



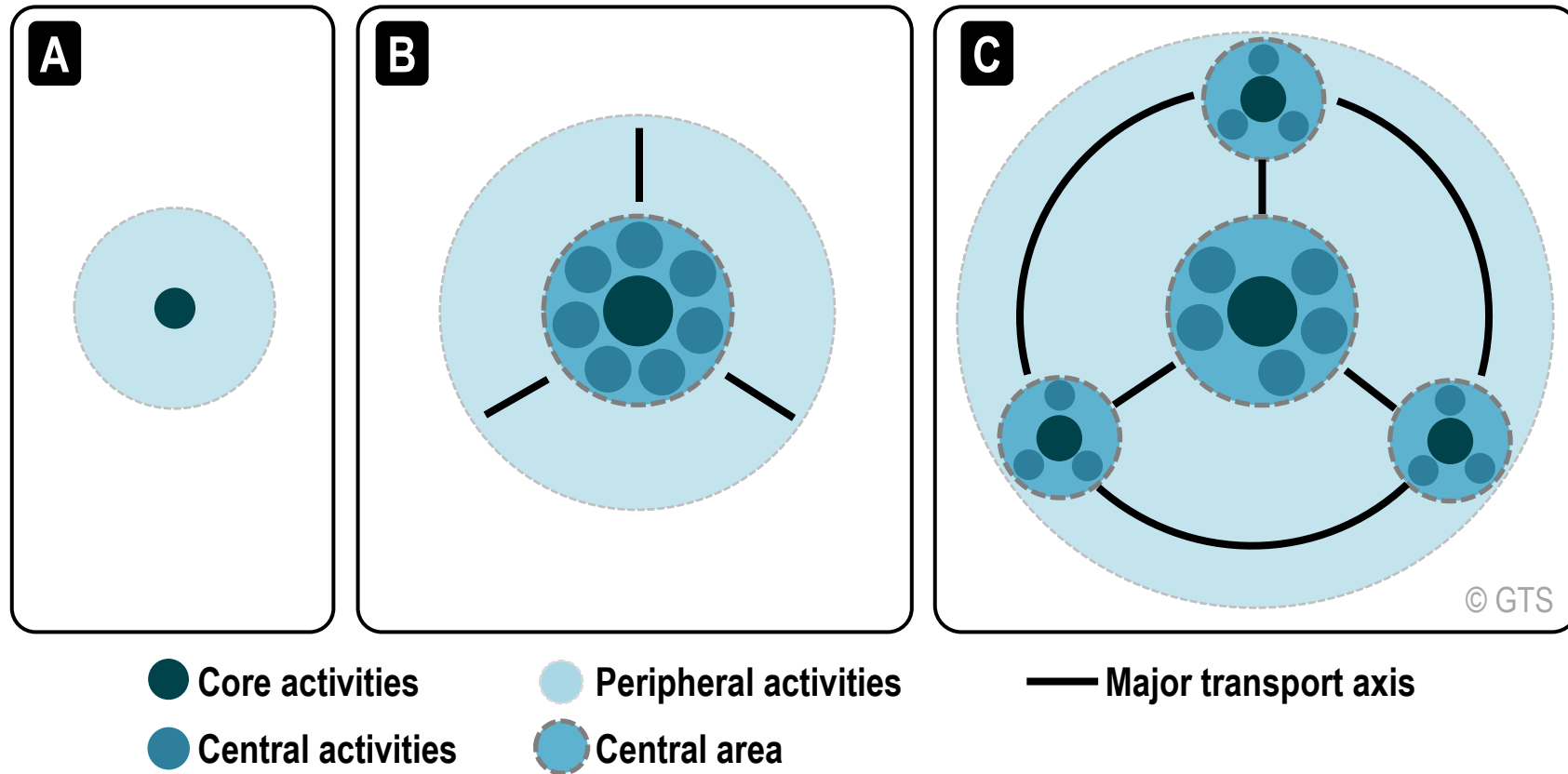
One Hour Commuting According to Different Urban Transportation Modes



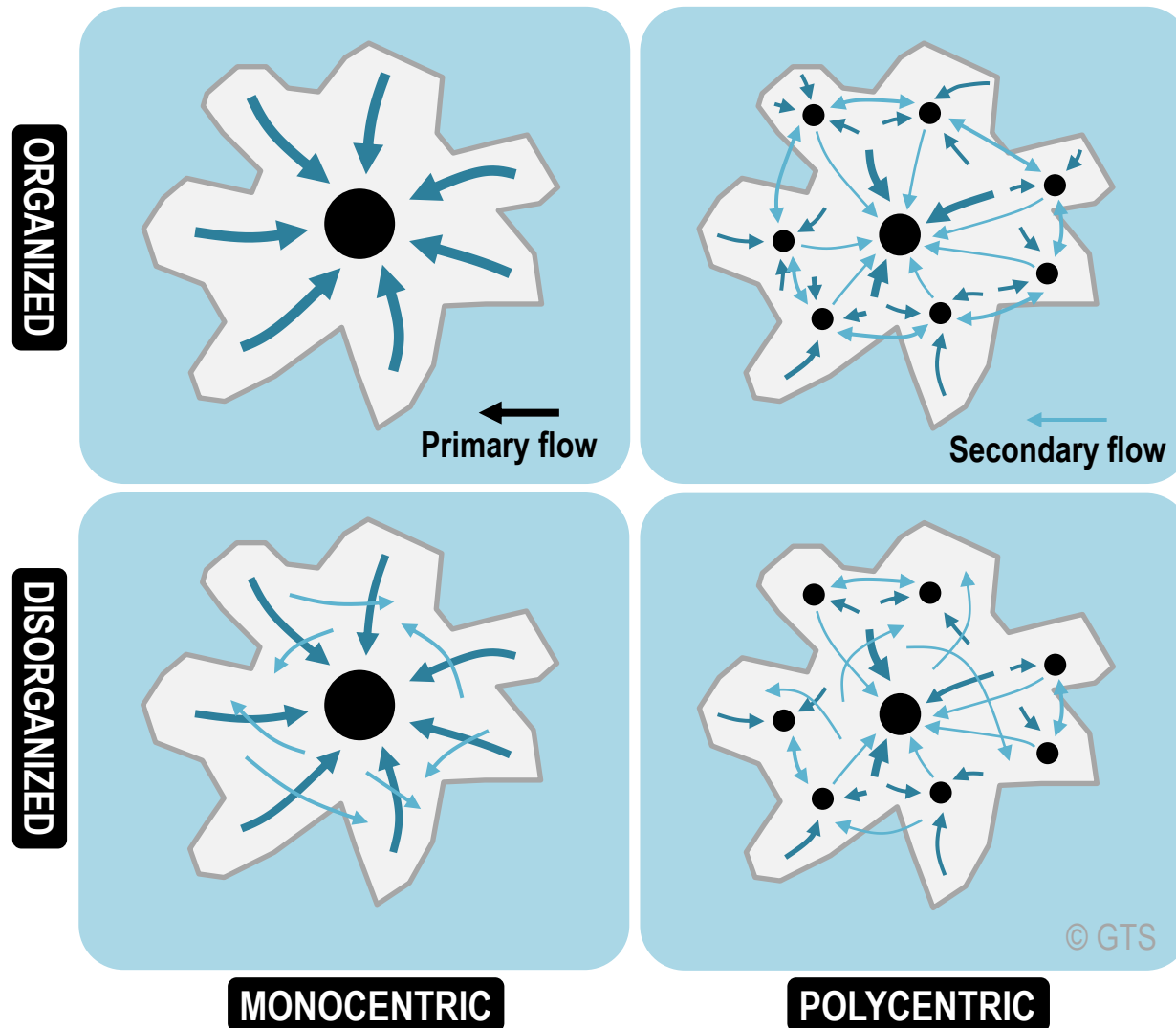
Isochrone Map of Manchester 19



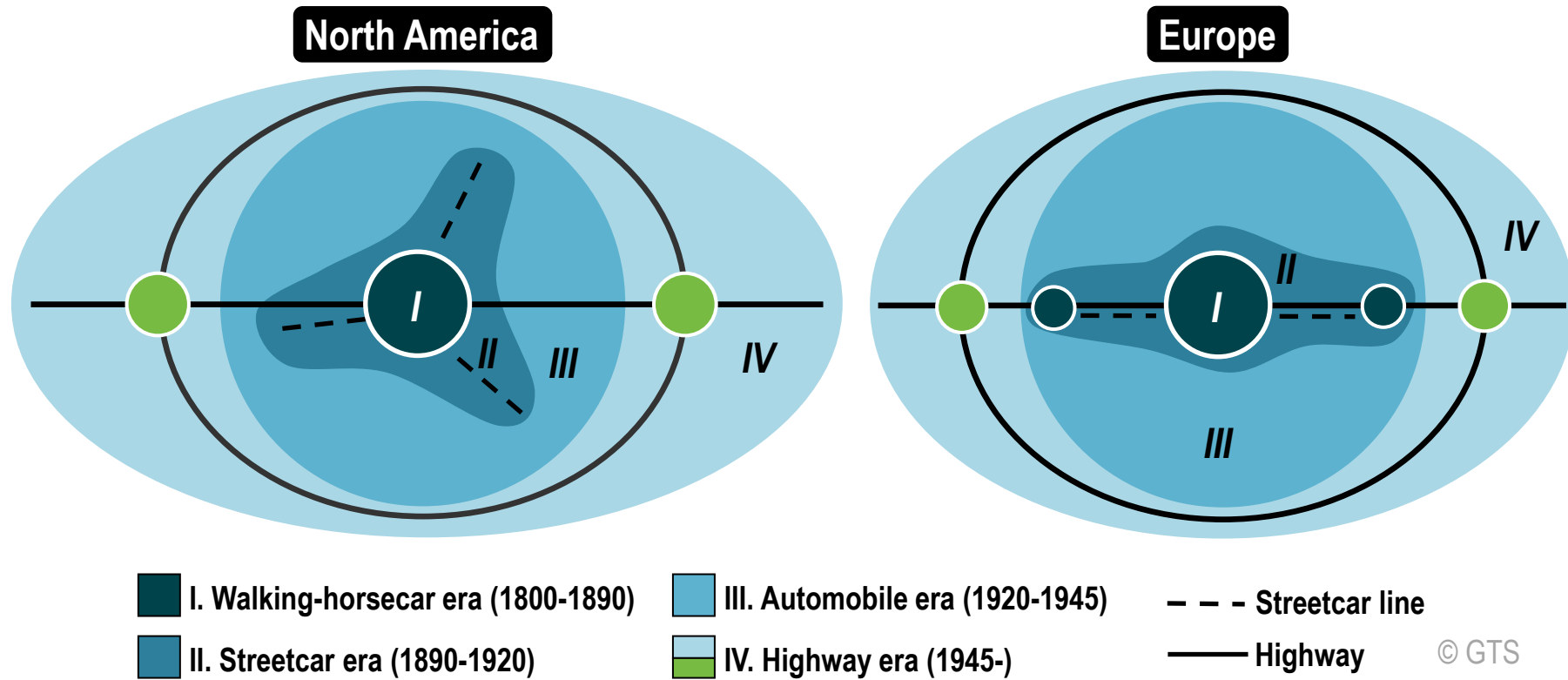
Evolution of the Spatial Structure of a City



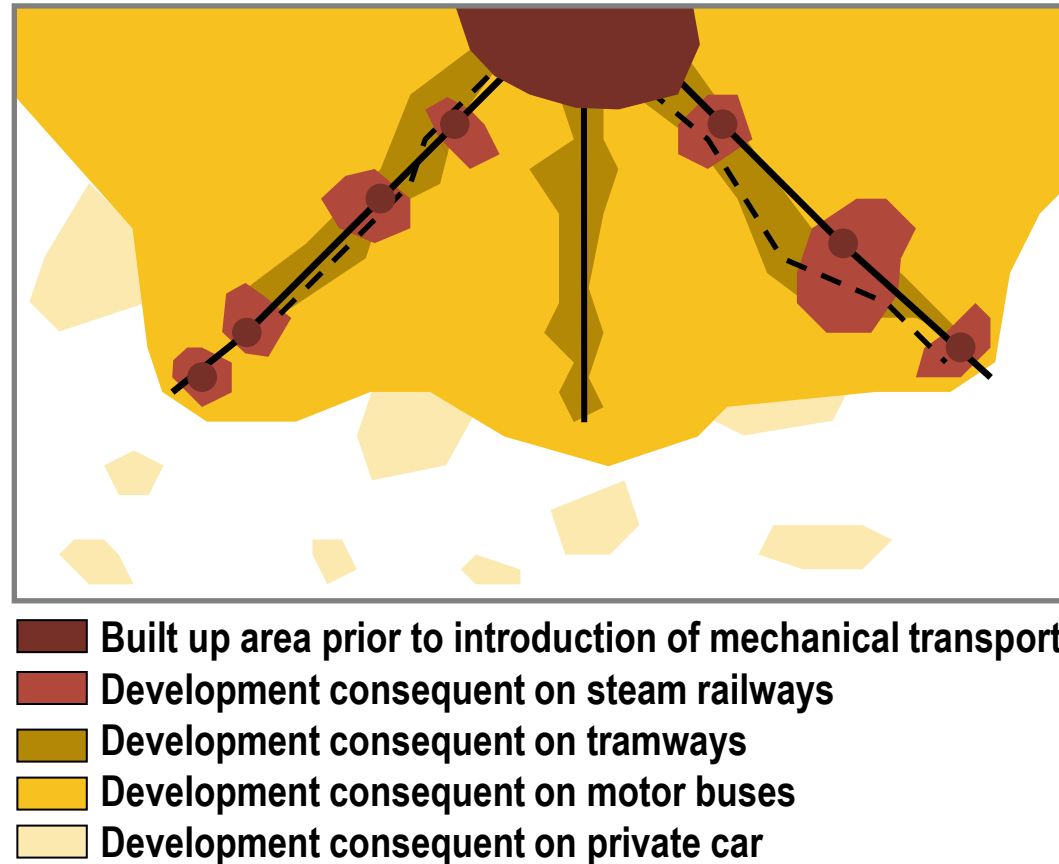
Possible Urban Mobility Patterns



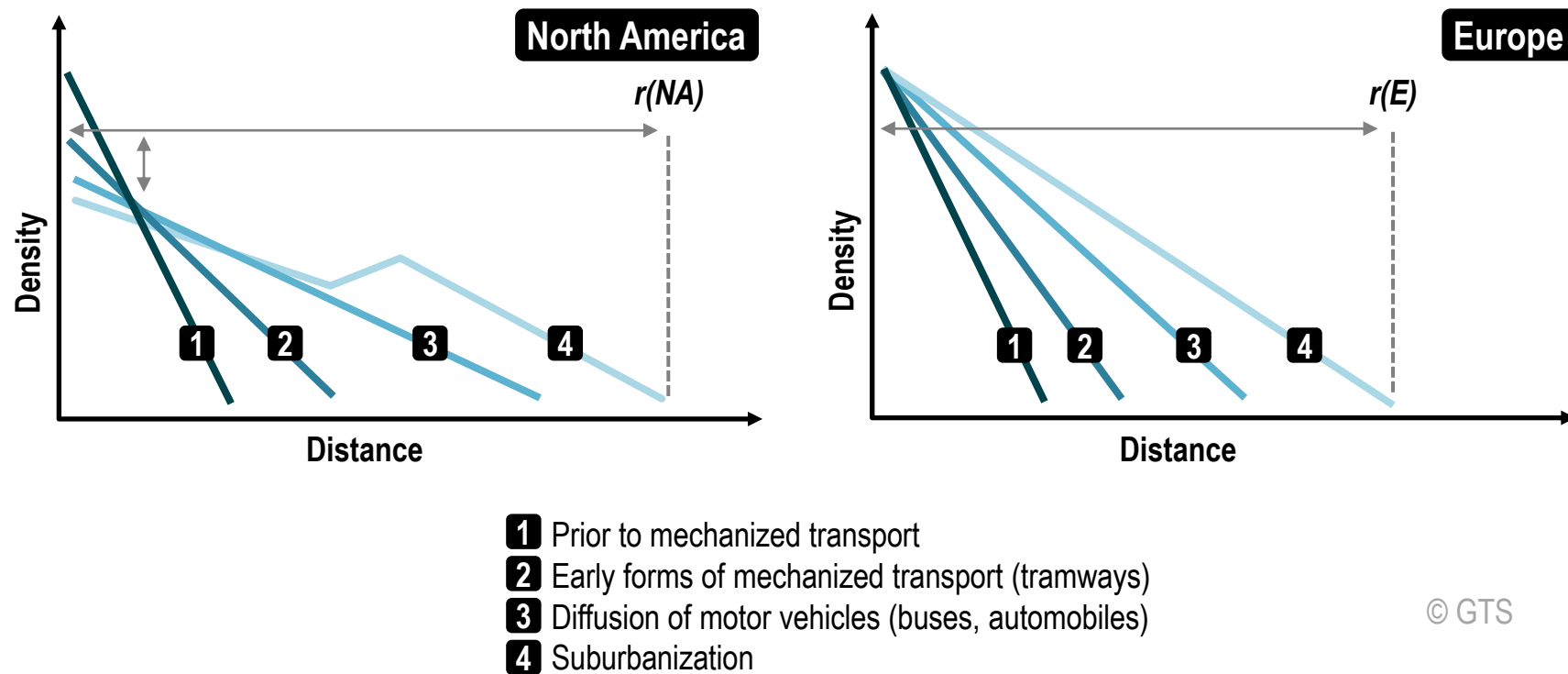
Evolution of Transportation and Urban Form in North American and European Cities



Evolution of Transportation and Urban Form in European Cities (to be redesigned)

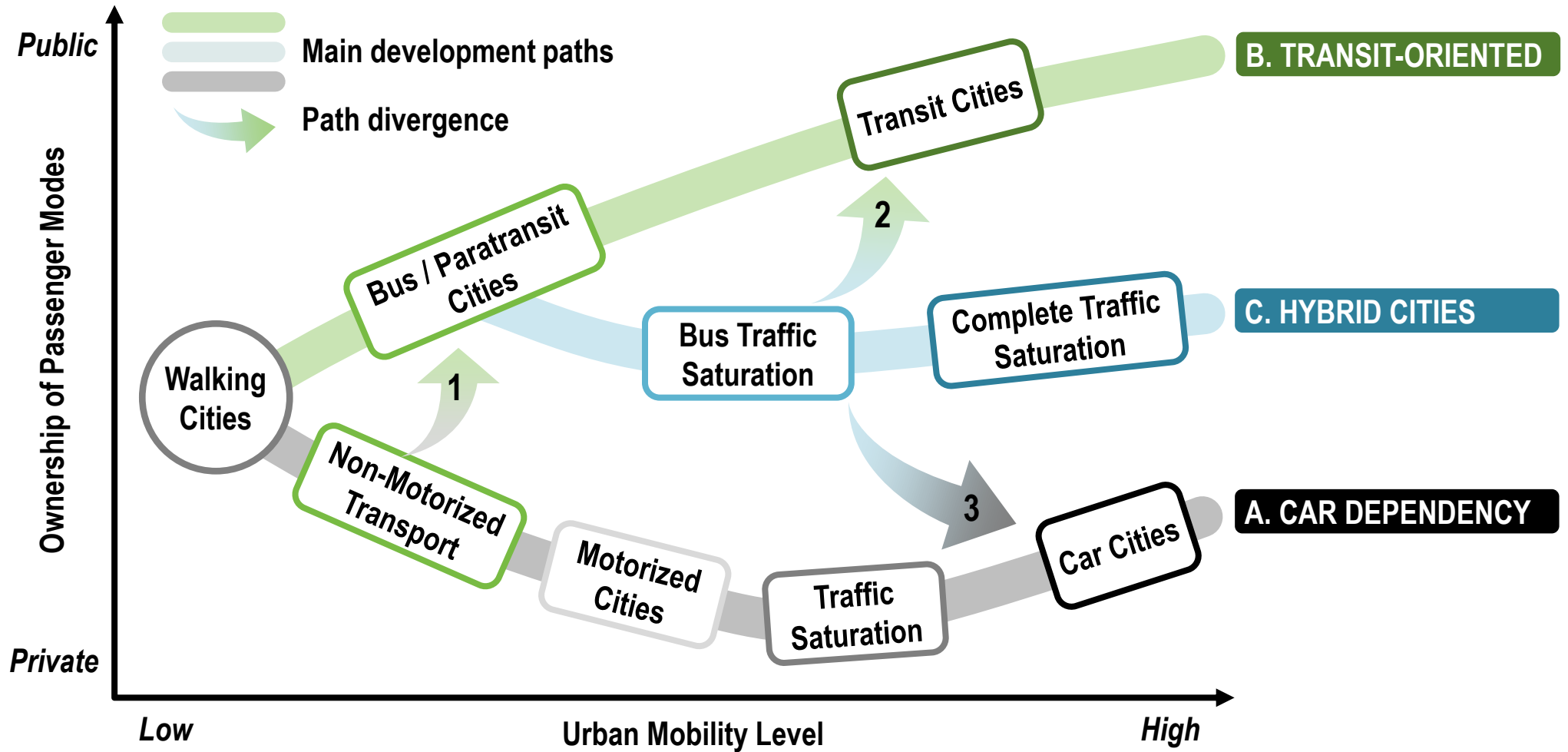


Evolution of Urban Densities in North America and Europe

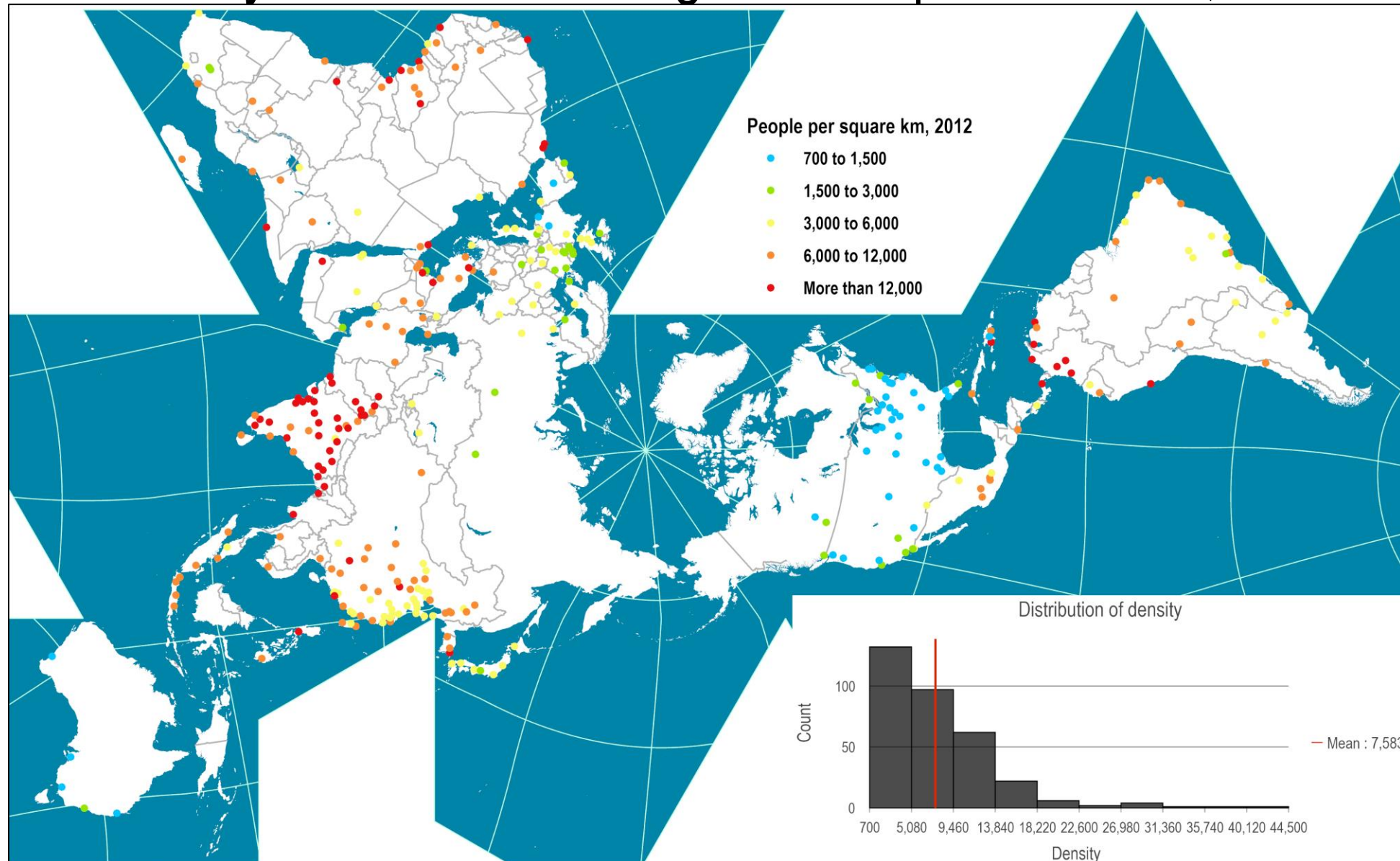


© GTS

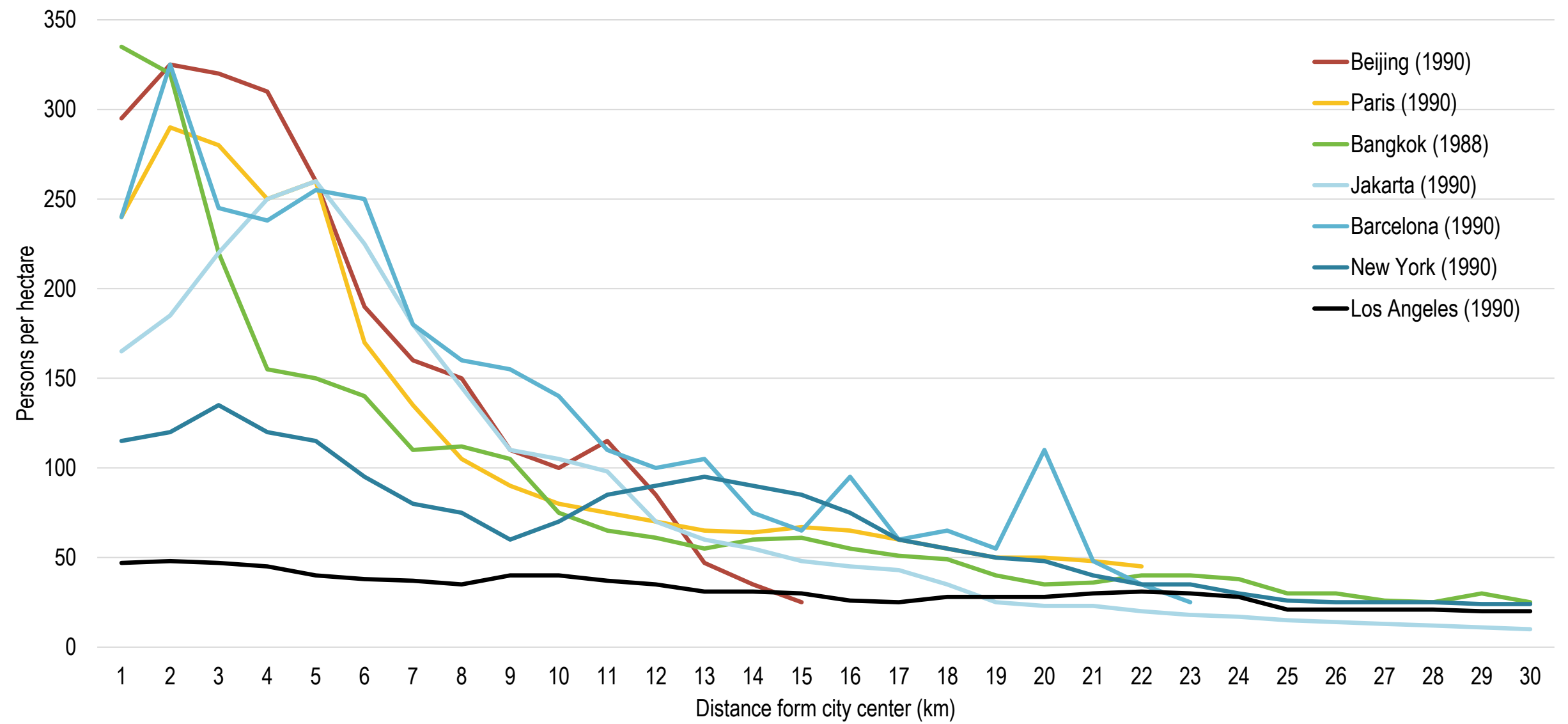
Urban Transport Development Paths



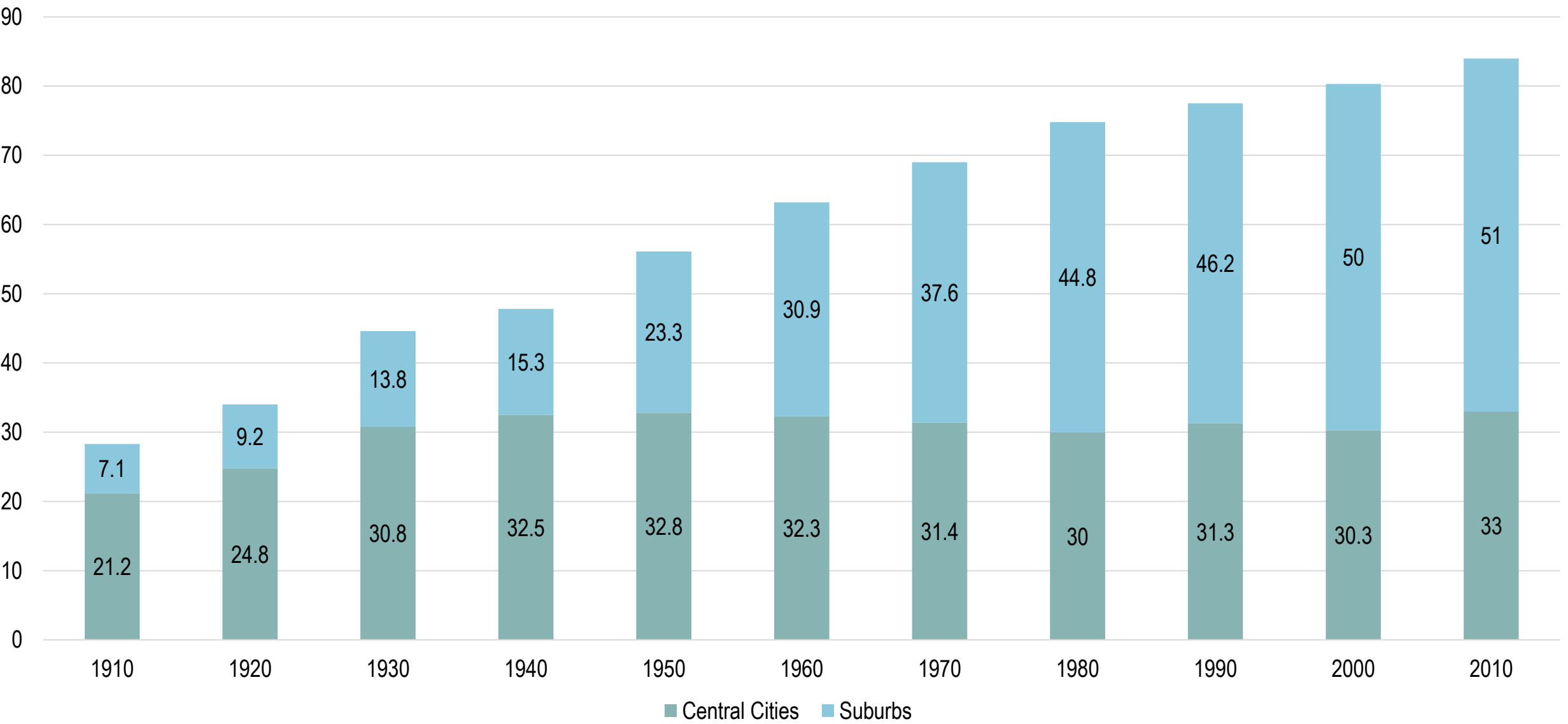
Population Density of the World's Largest Metropolitan Areas, 2012



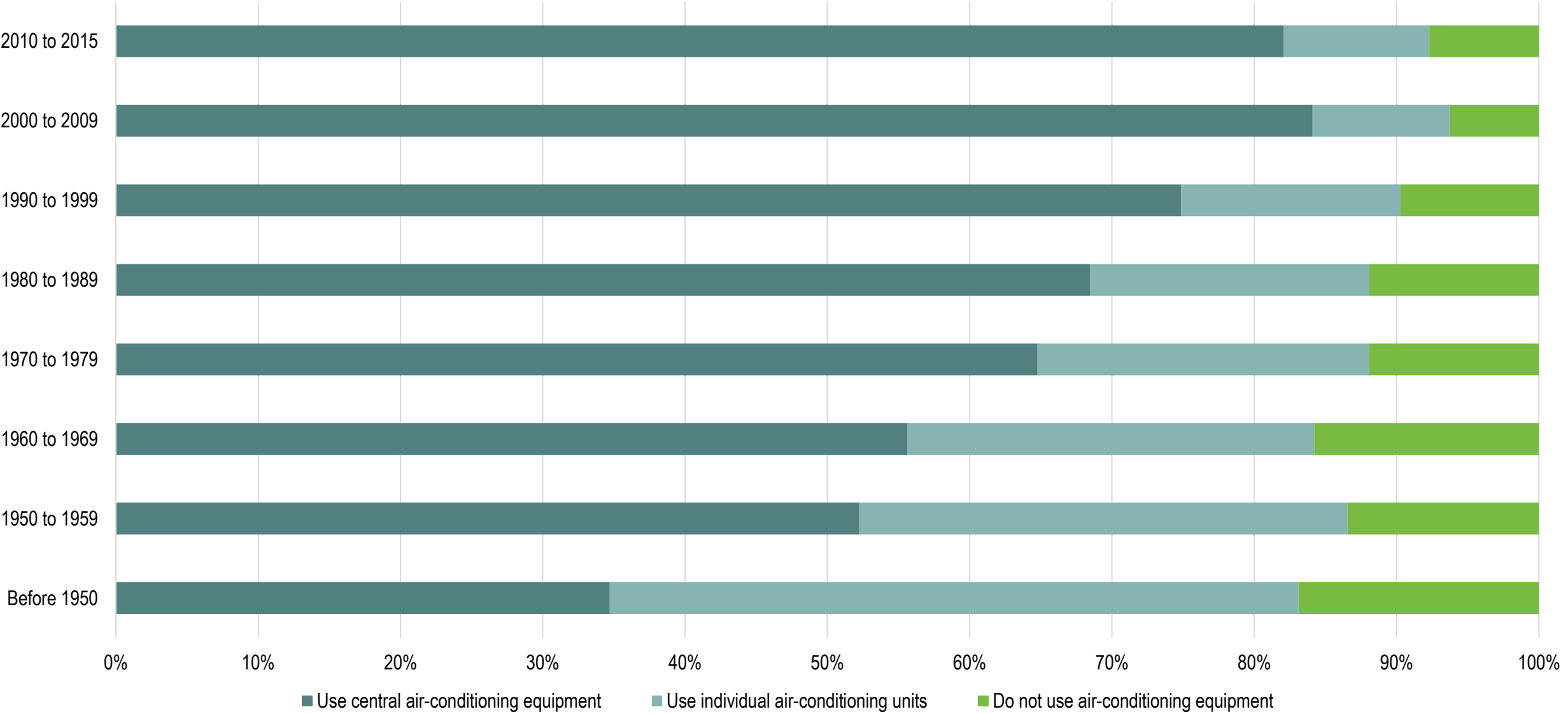
Population Density by Distance from City Center, Selected Cities



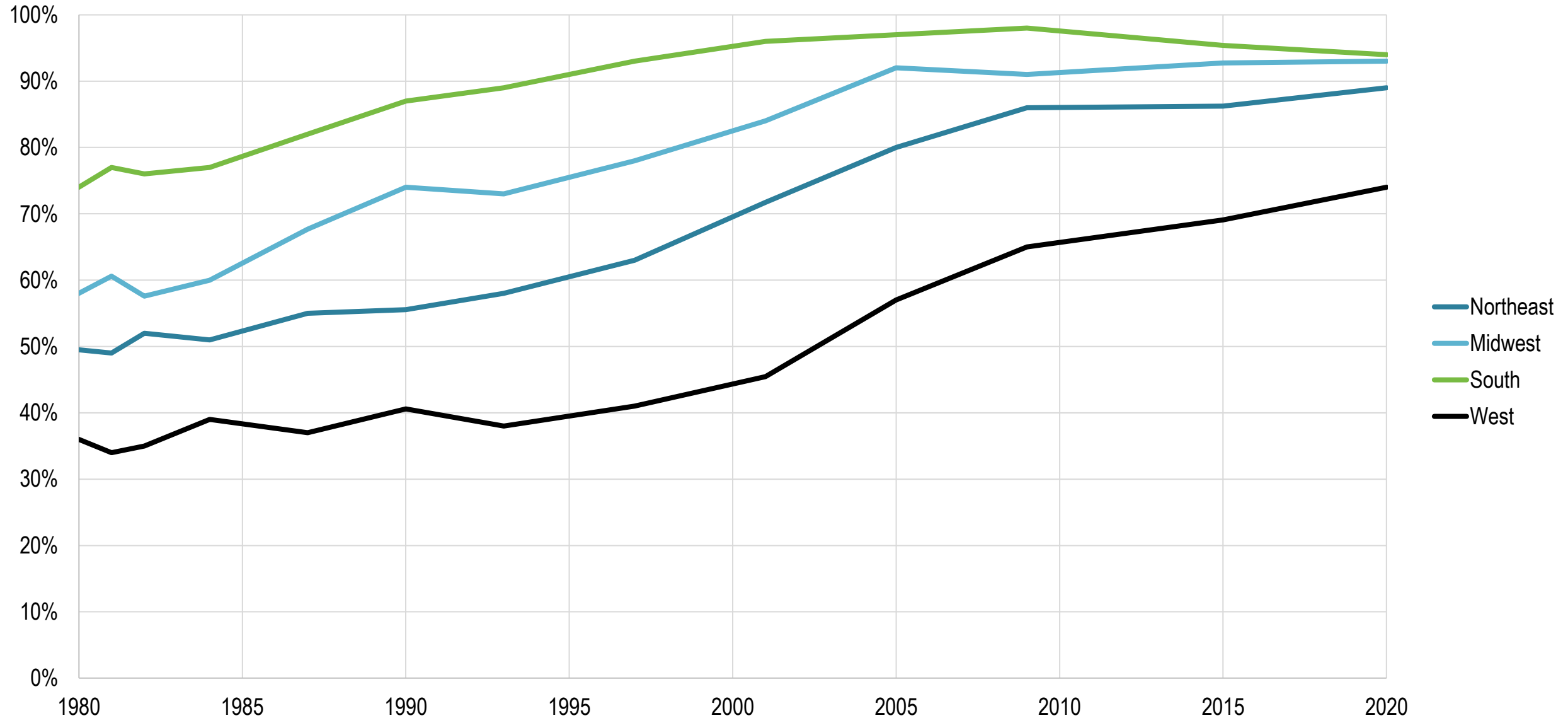
American Population Living in Metropolitan Areas and Their Central Cities and Suburbs, 1910-2010 (%)



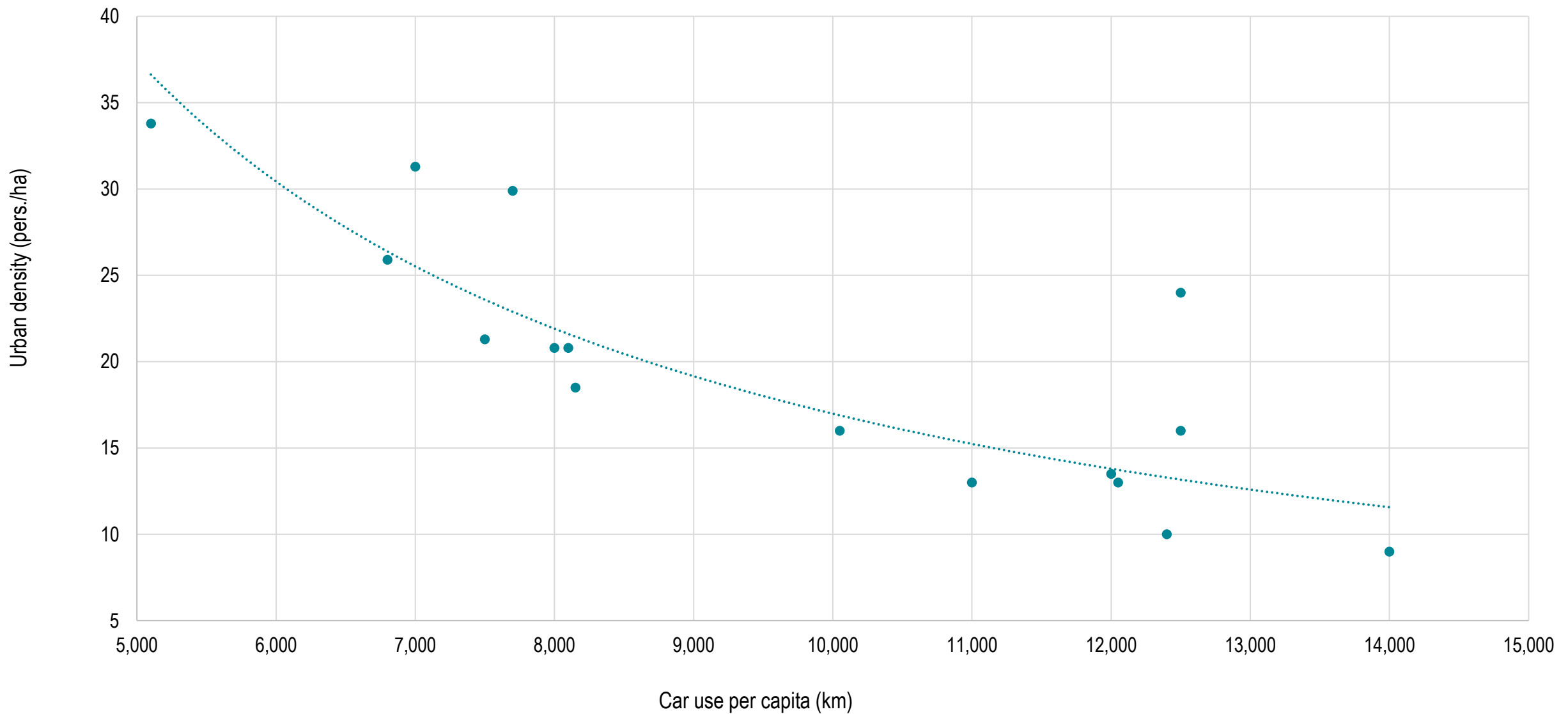
Share of Housing Units Equipped with Air Conditioning by Year of Construction, United States, 2015



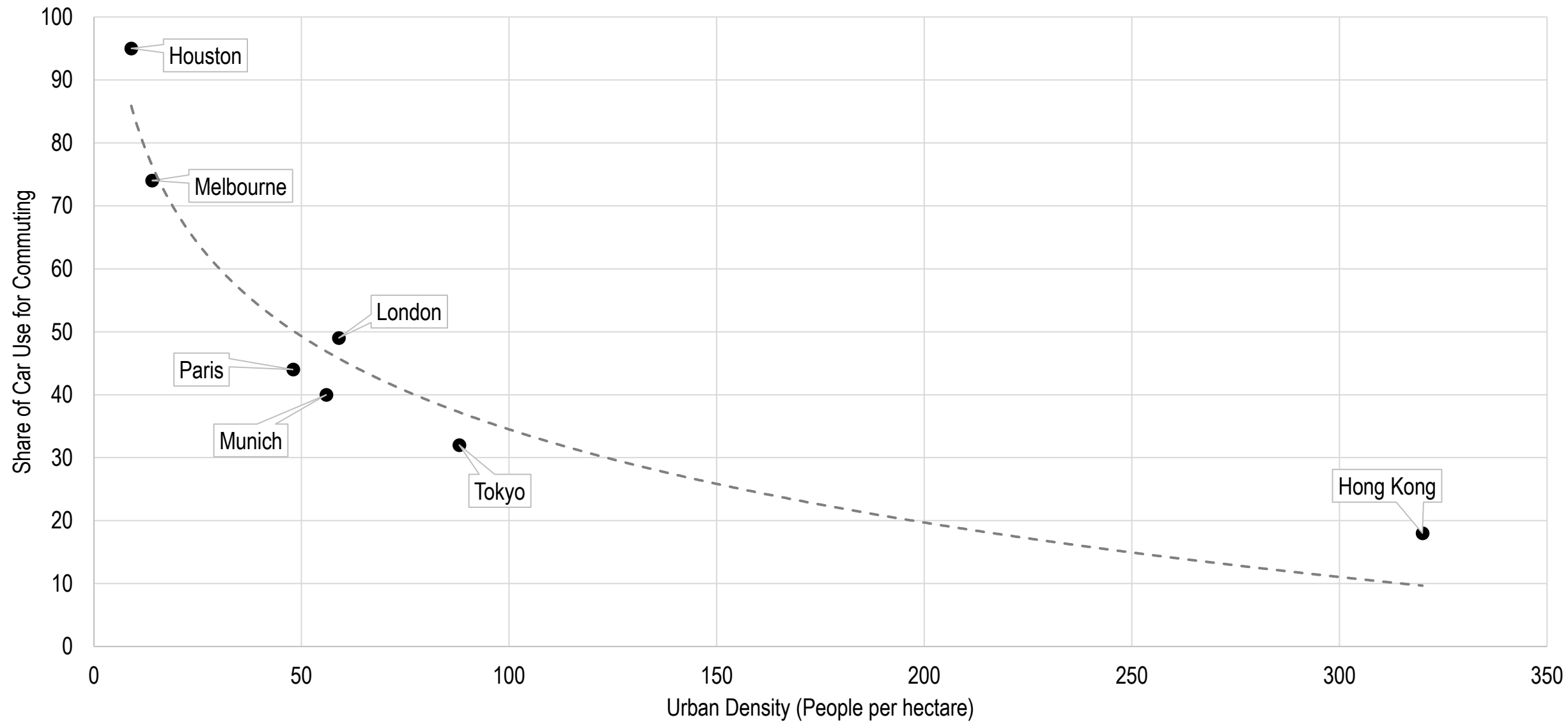
Share of Housing Units Equipped with Air Conditioning by Region in the United States, 1980-2020



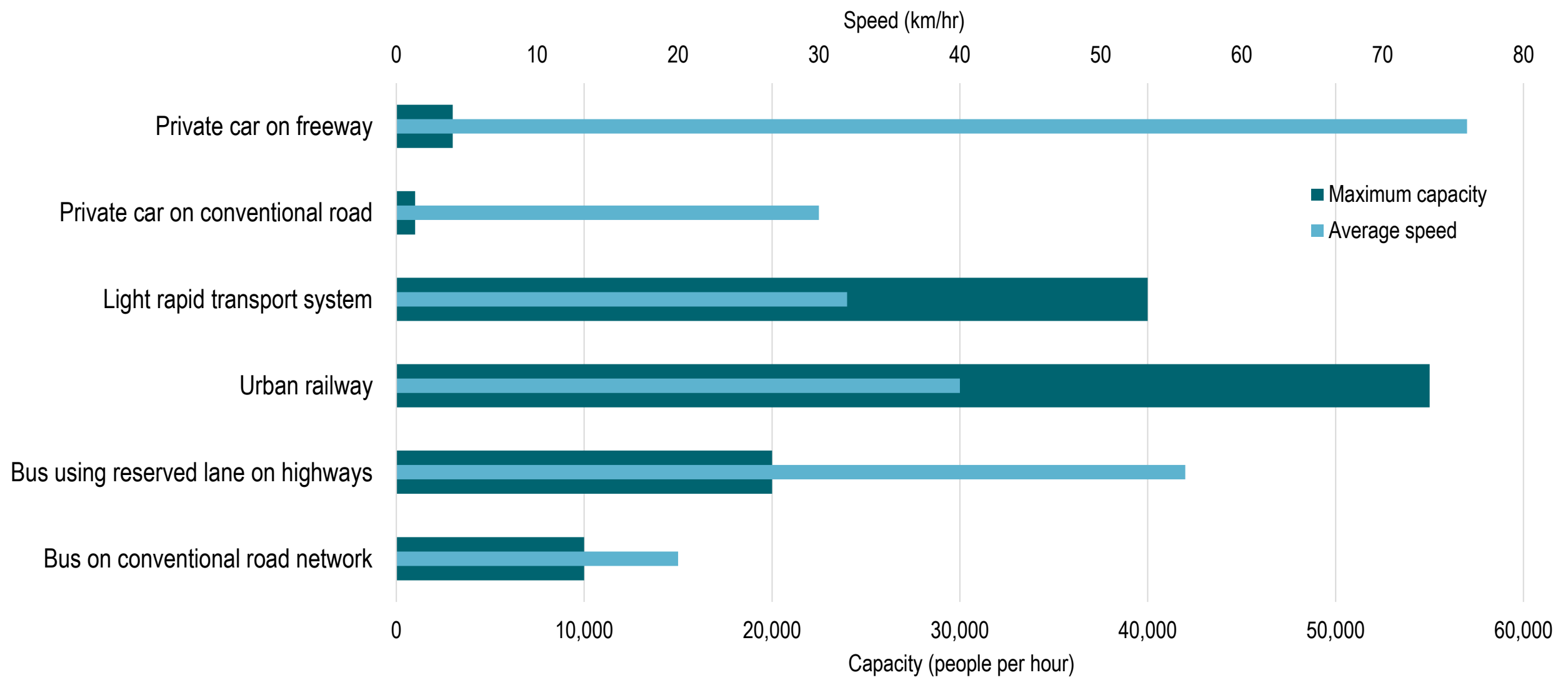
Density and Car Use in North American Cities, 1991



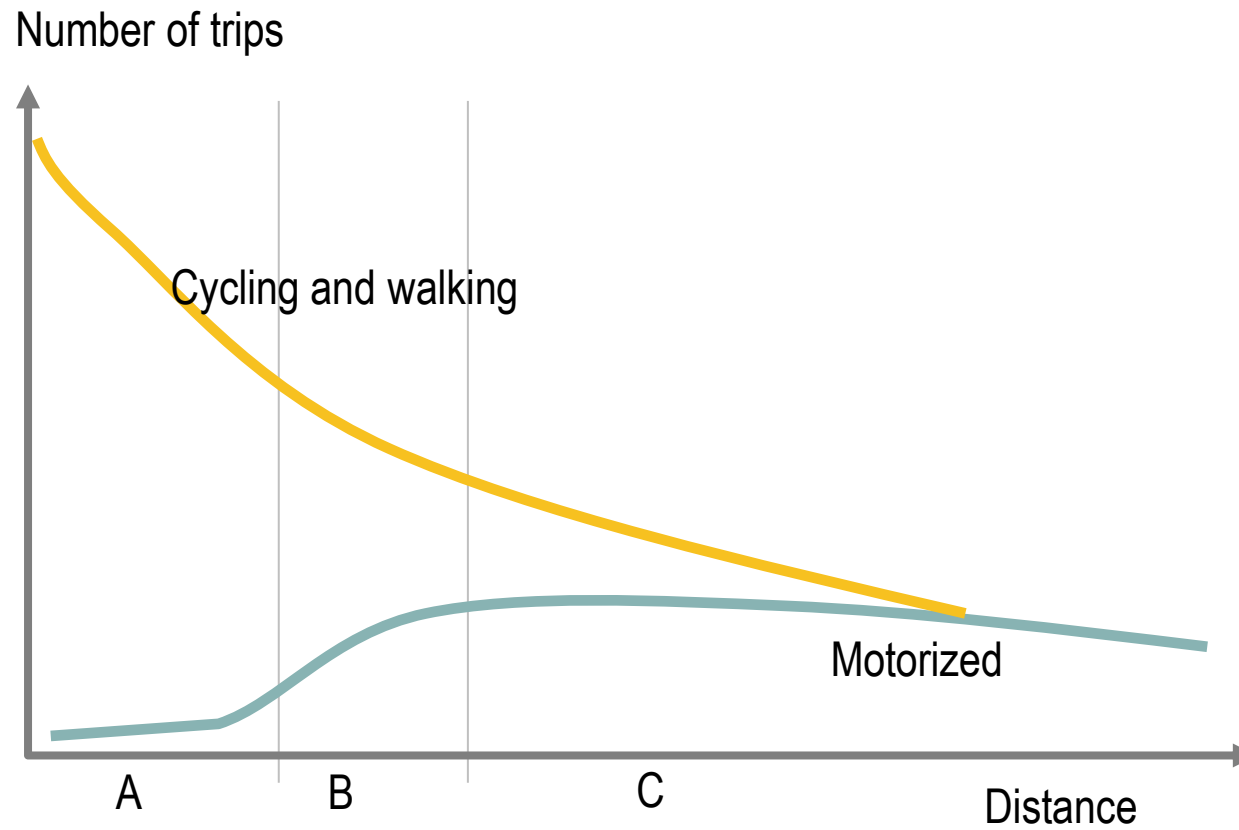
Density and Car Use in Selected Global Cities, 2000s



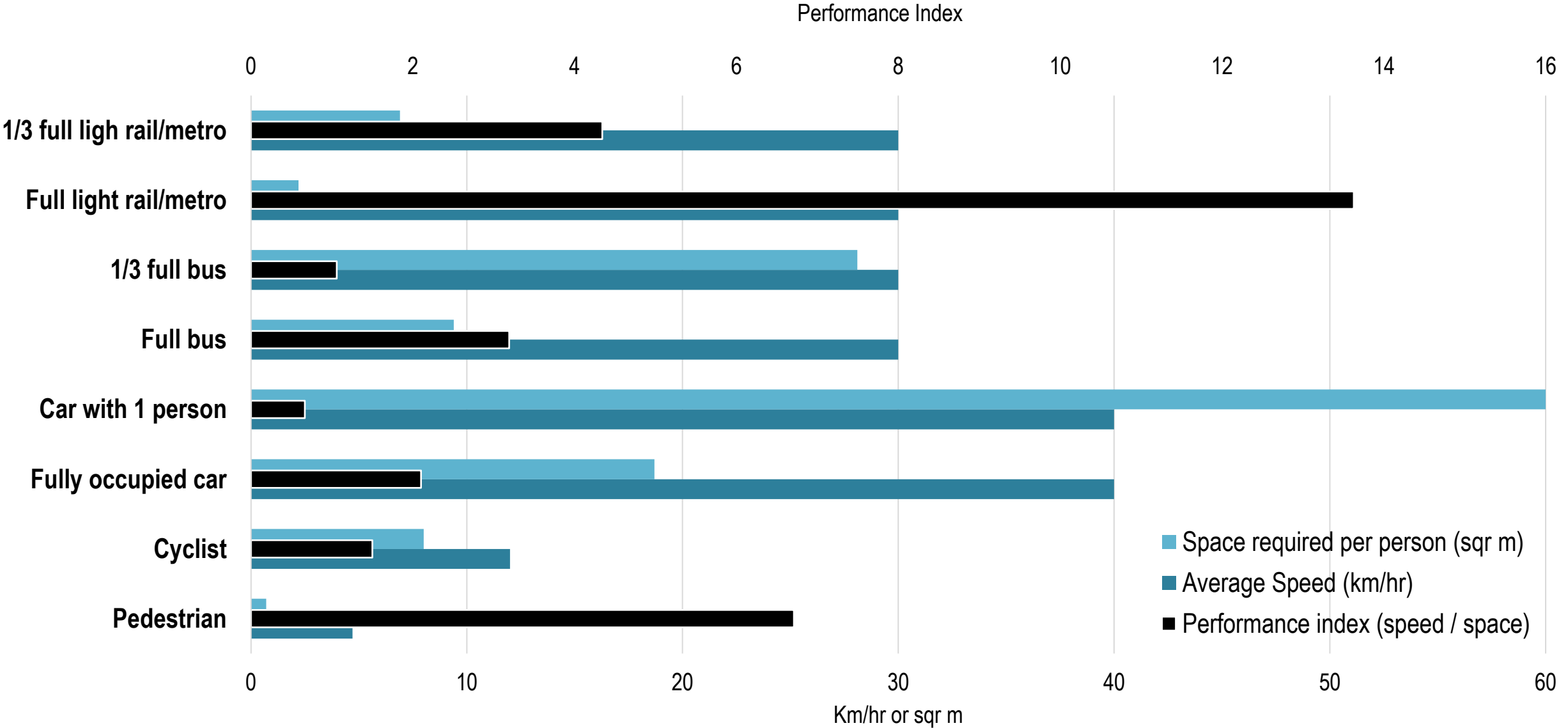
Service Attributes of Urban Transportation Modes



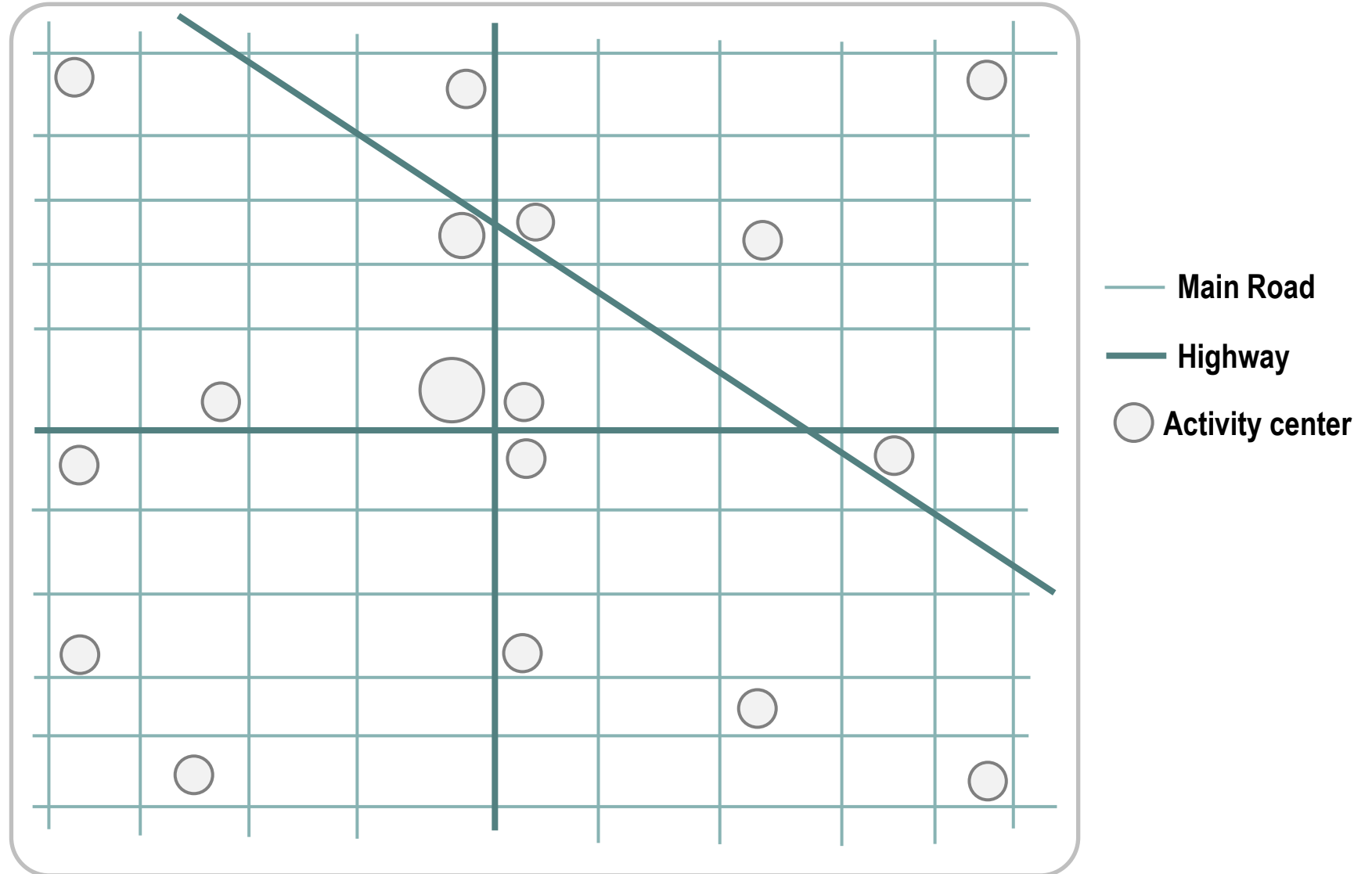
Urban Modes and Distance Decay



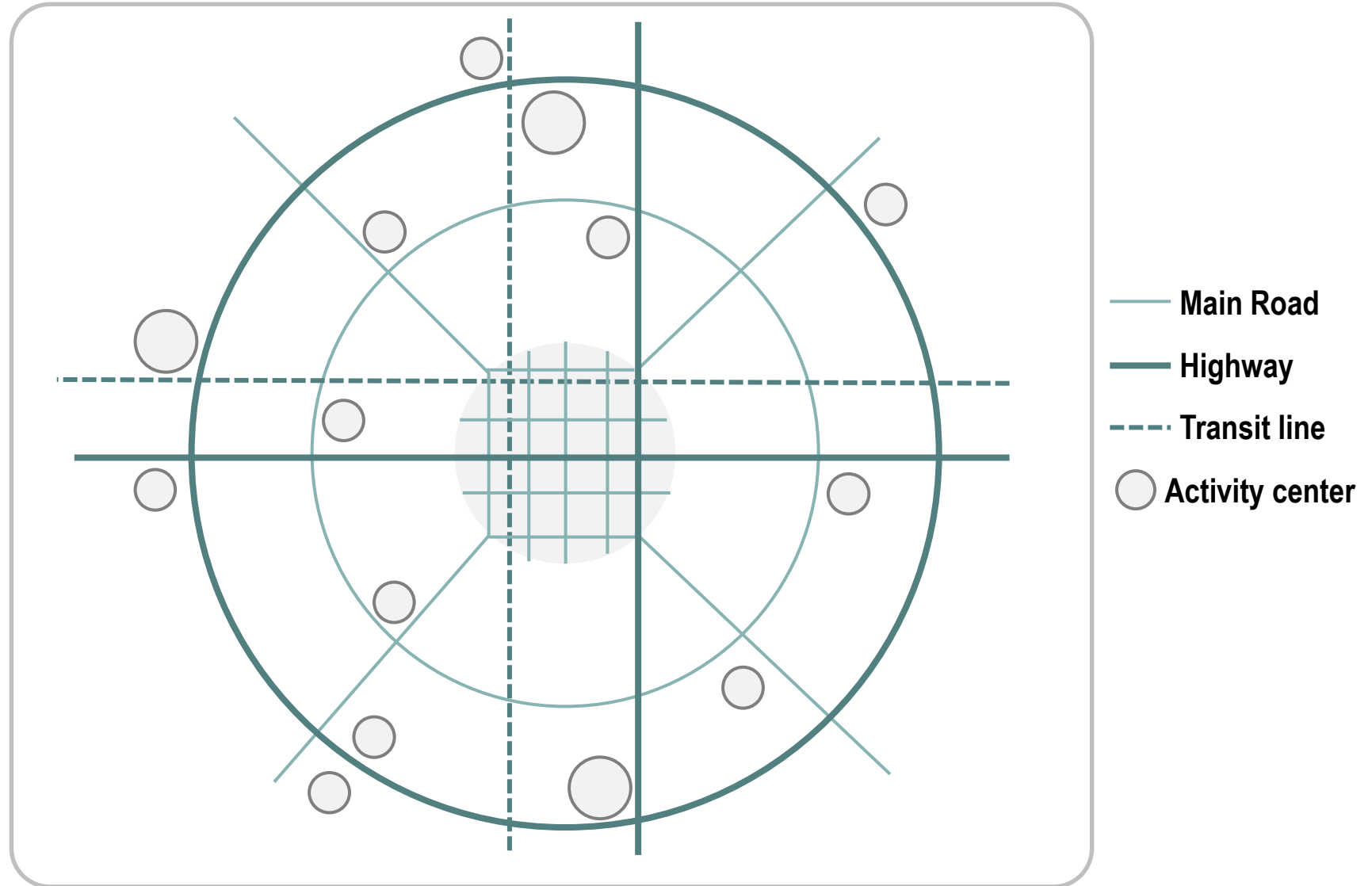
Performance by Urban Transport Mode



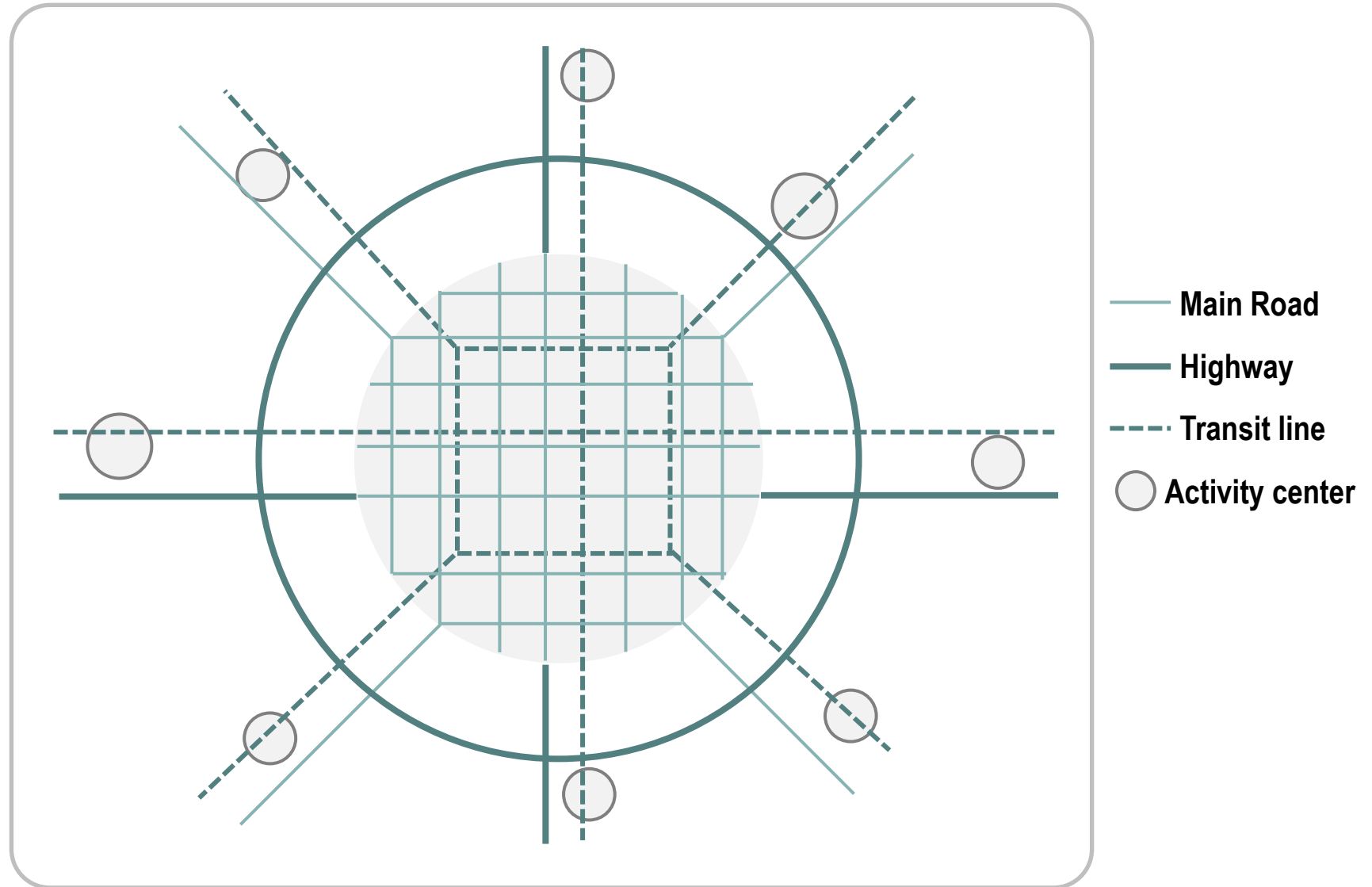
Type I - Completely Motorized Network



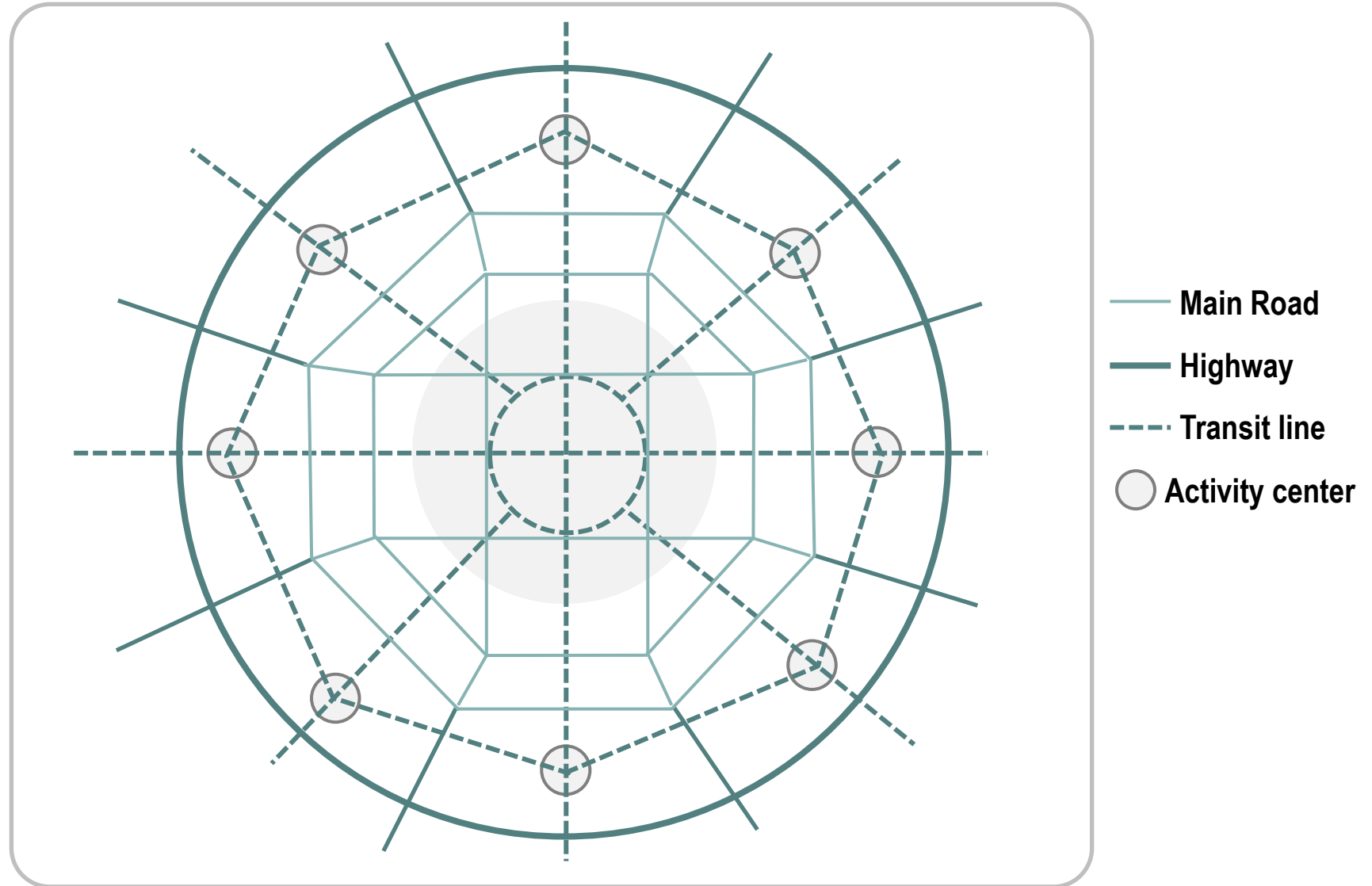
Type II - Weak Center



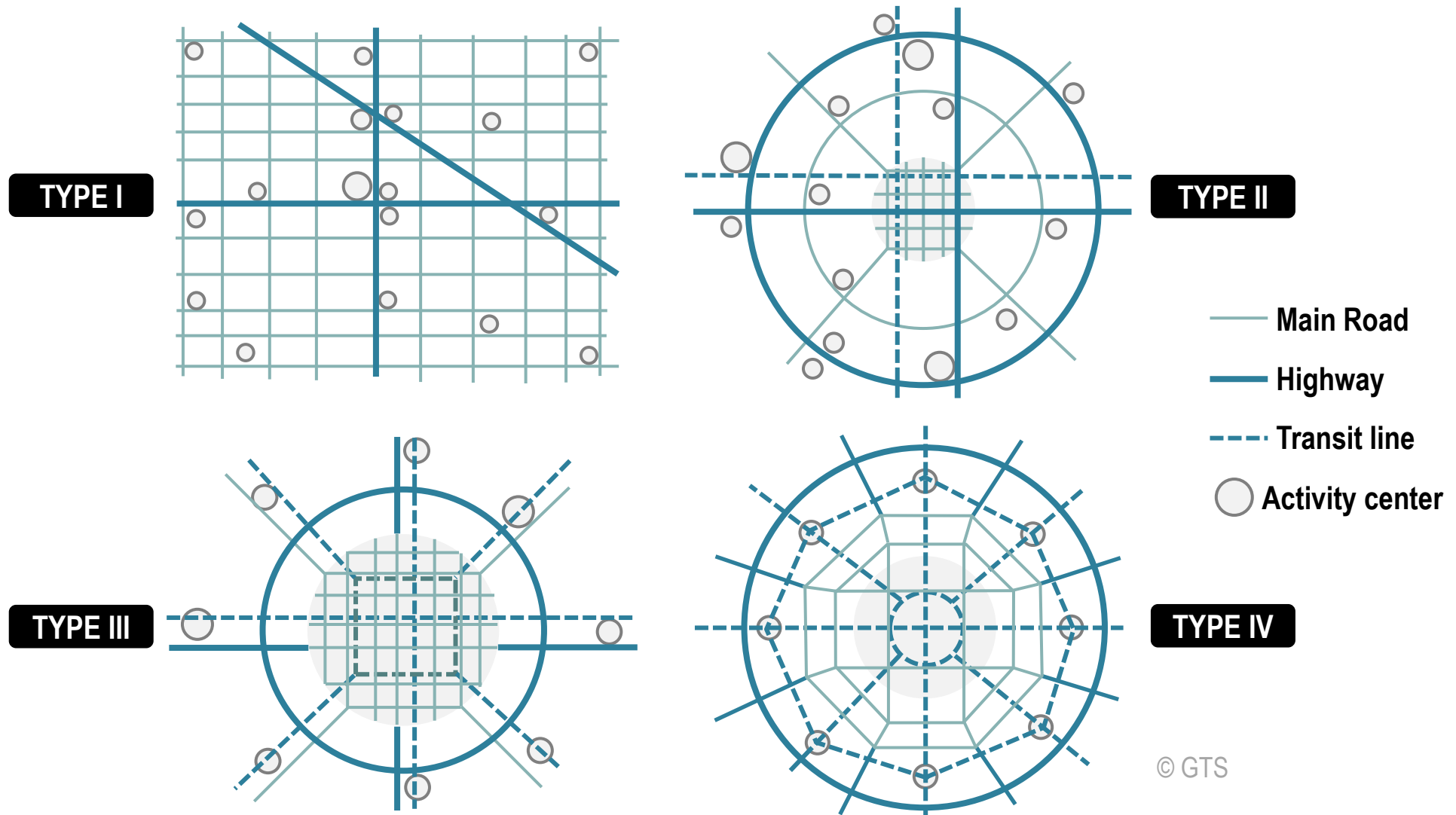
Type III - Strong Center



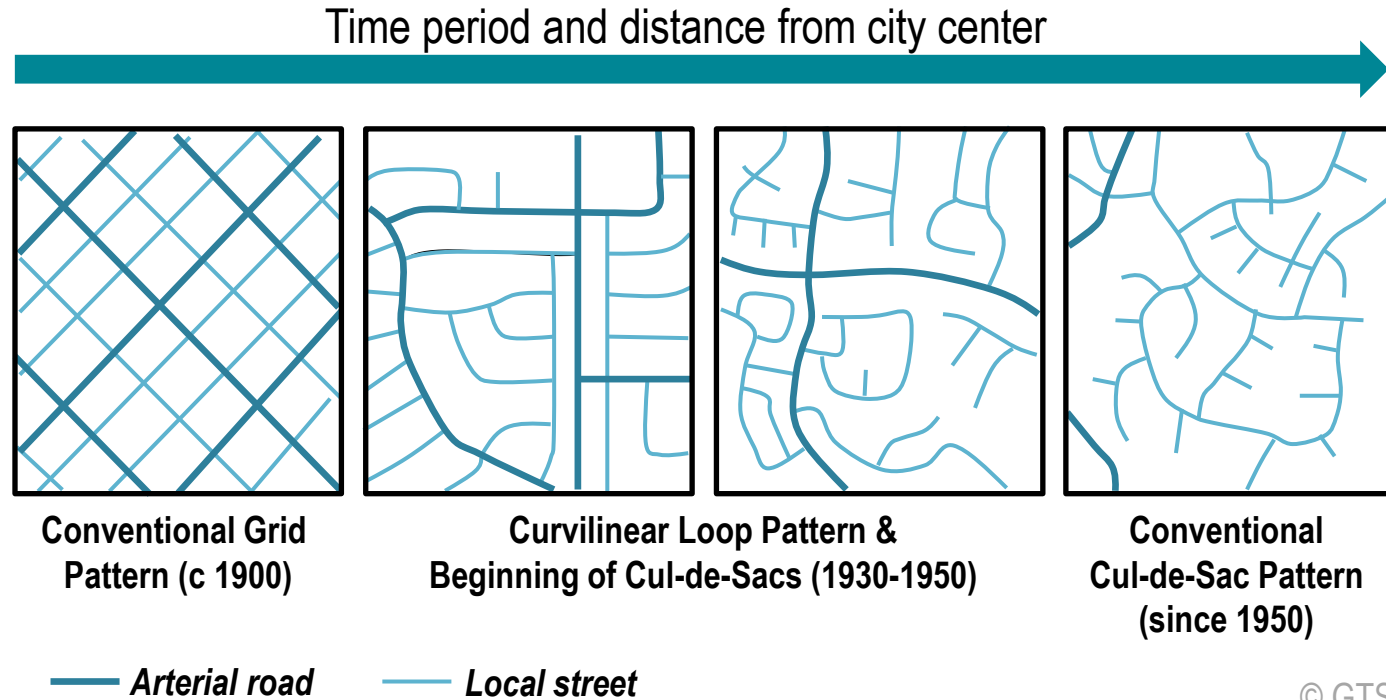
Type IV - Traffic Limitation



Transportation and the Urban Spatial Structure

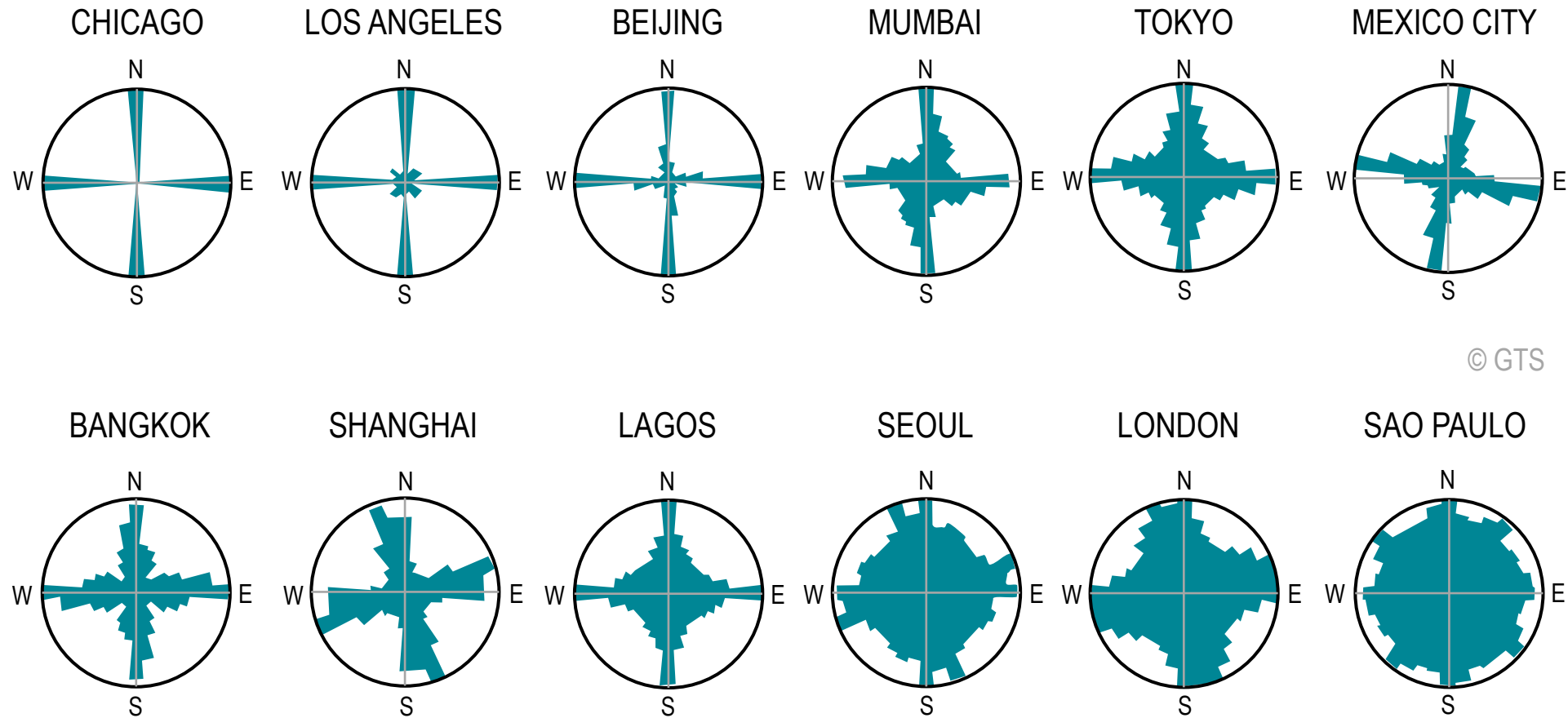


Street Network Types

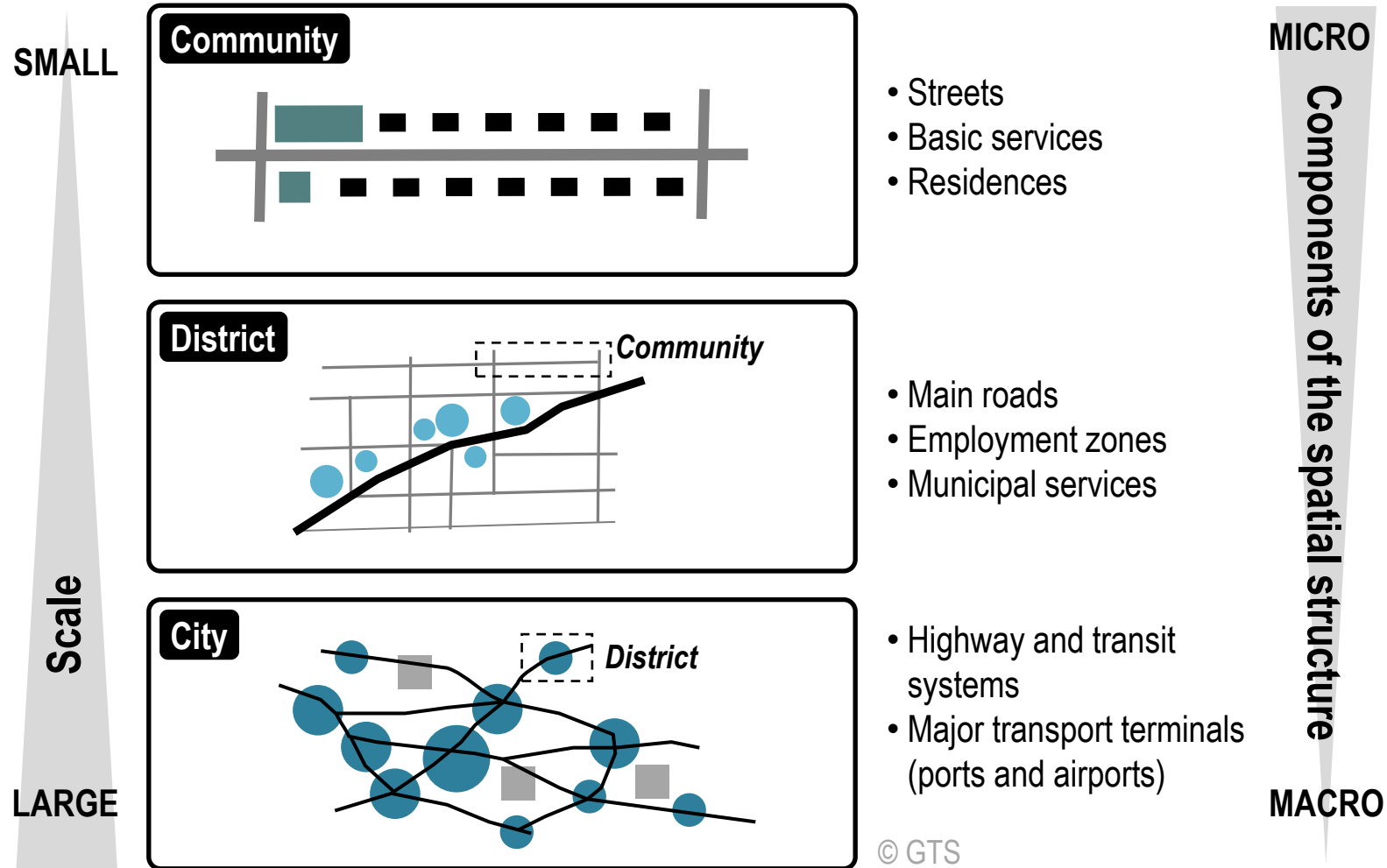


© GTS

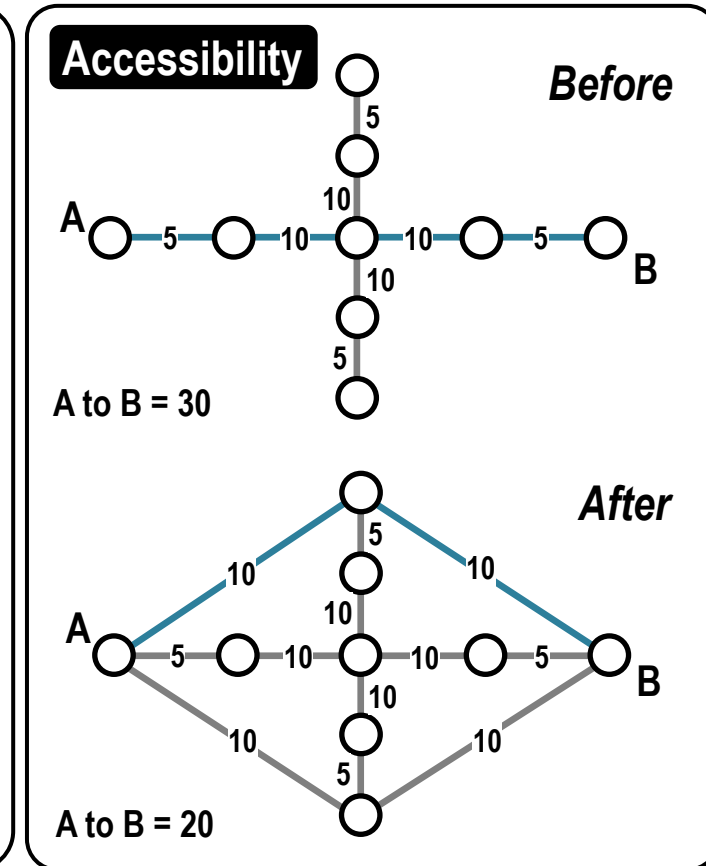
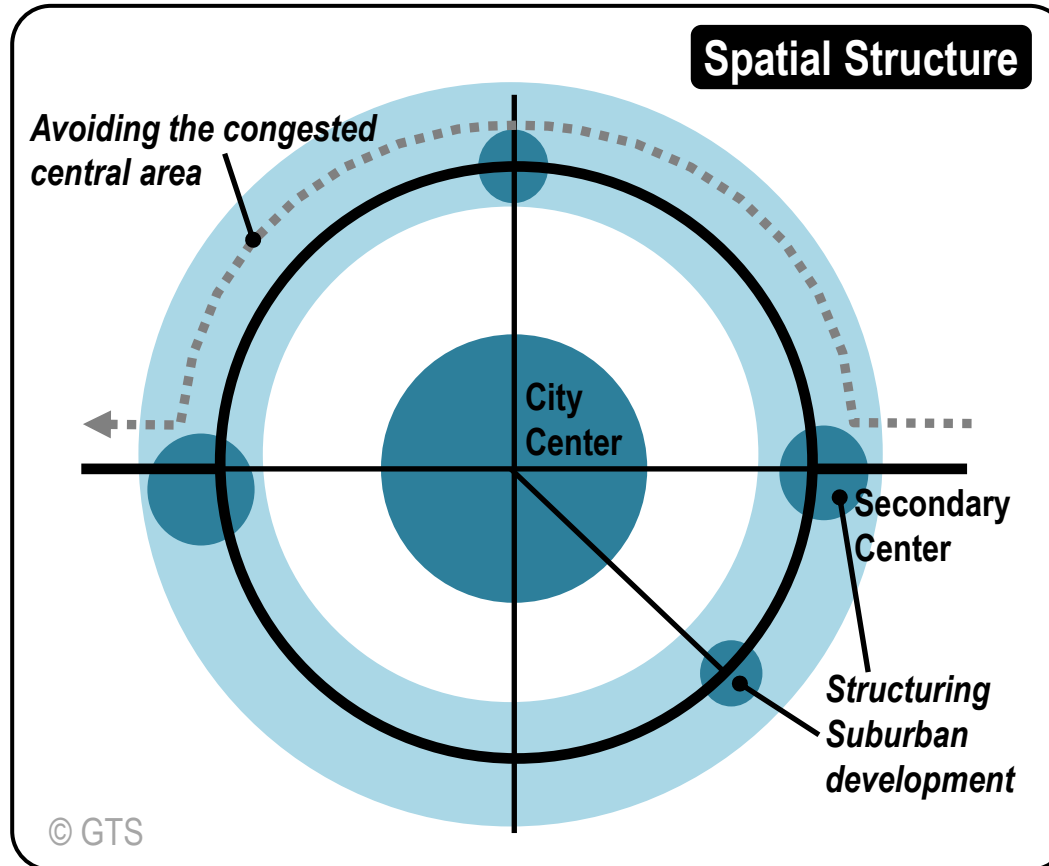
Street Network Orientation, Selected Cities



Scale and Urban Spatial Structure

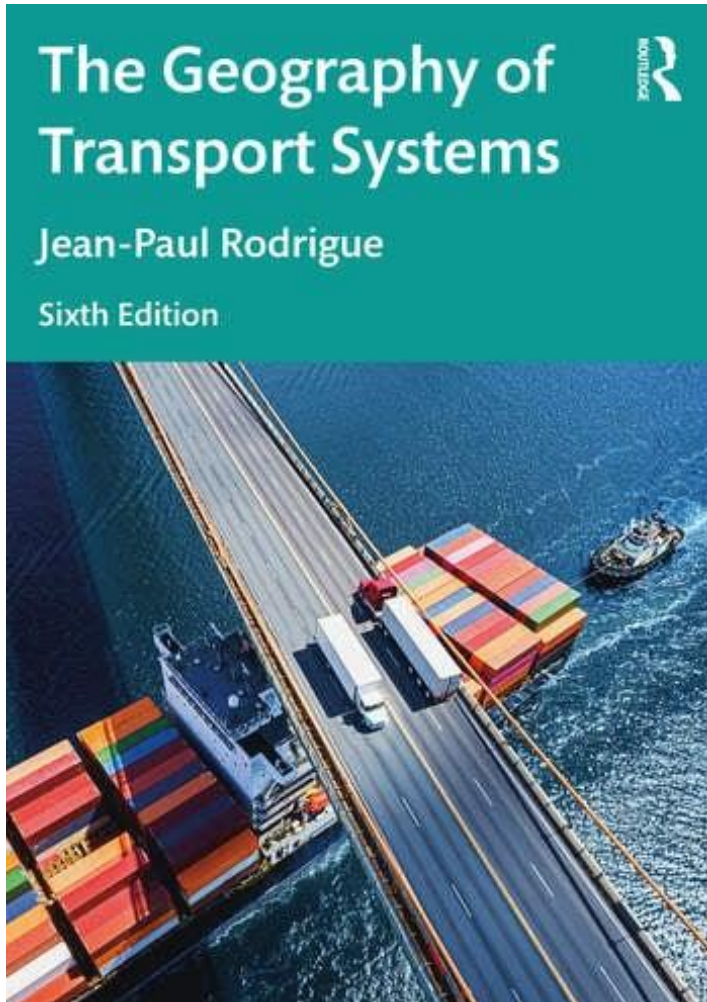


The Rationale of a Ring Road



Suburban Development along a Highway Interchange

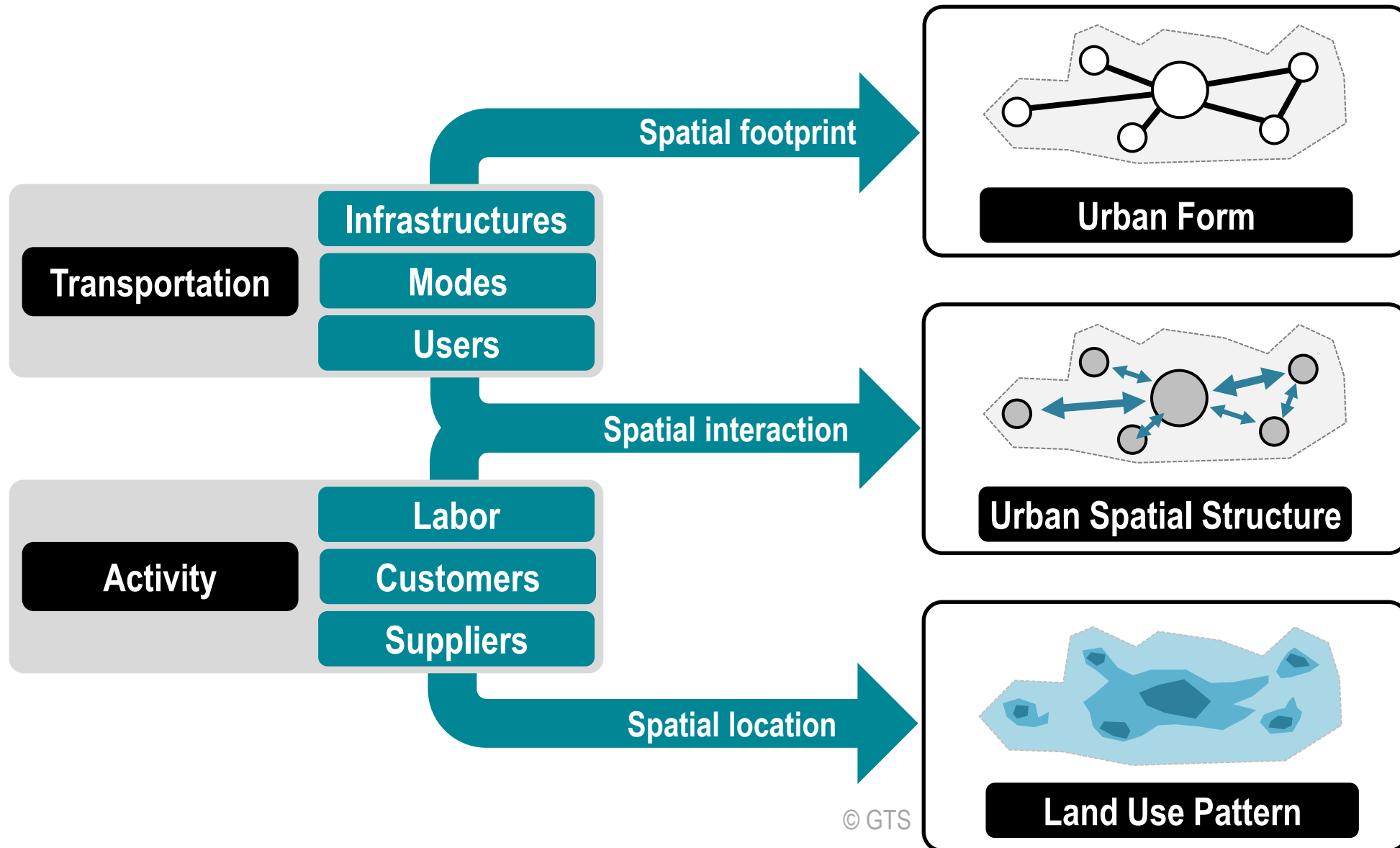




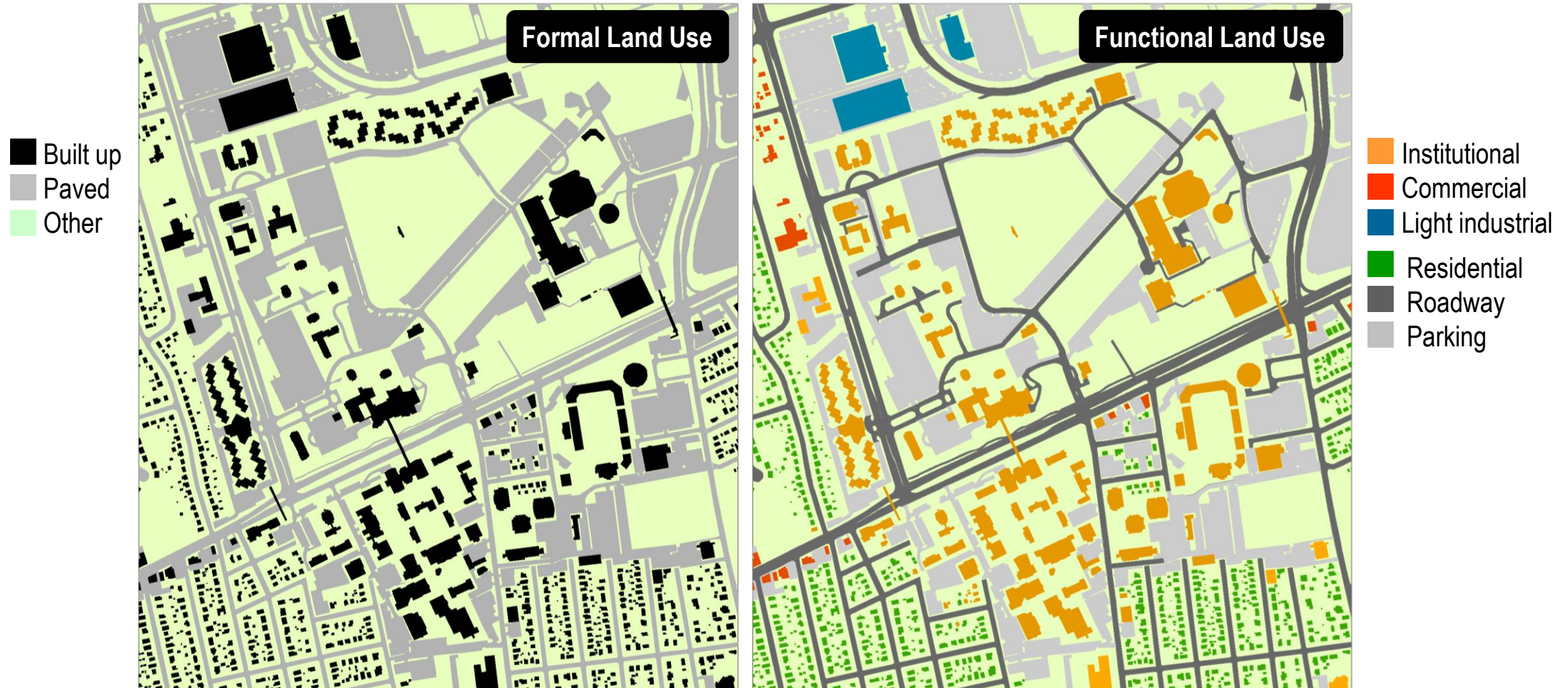
Transportation and Land Use

Chapter 8.2

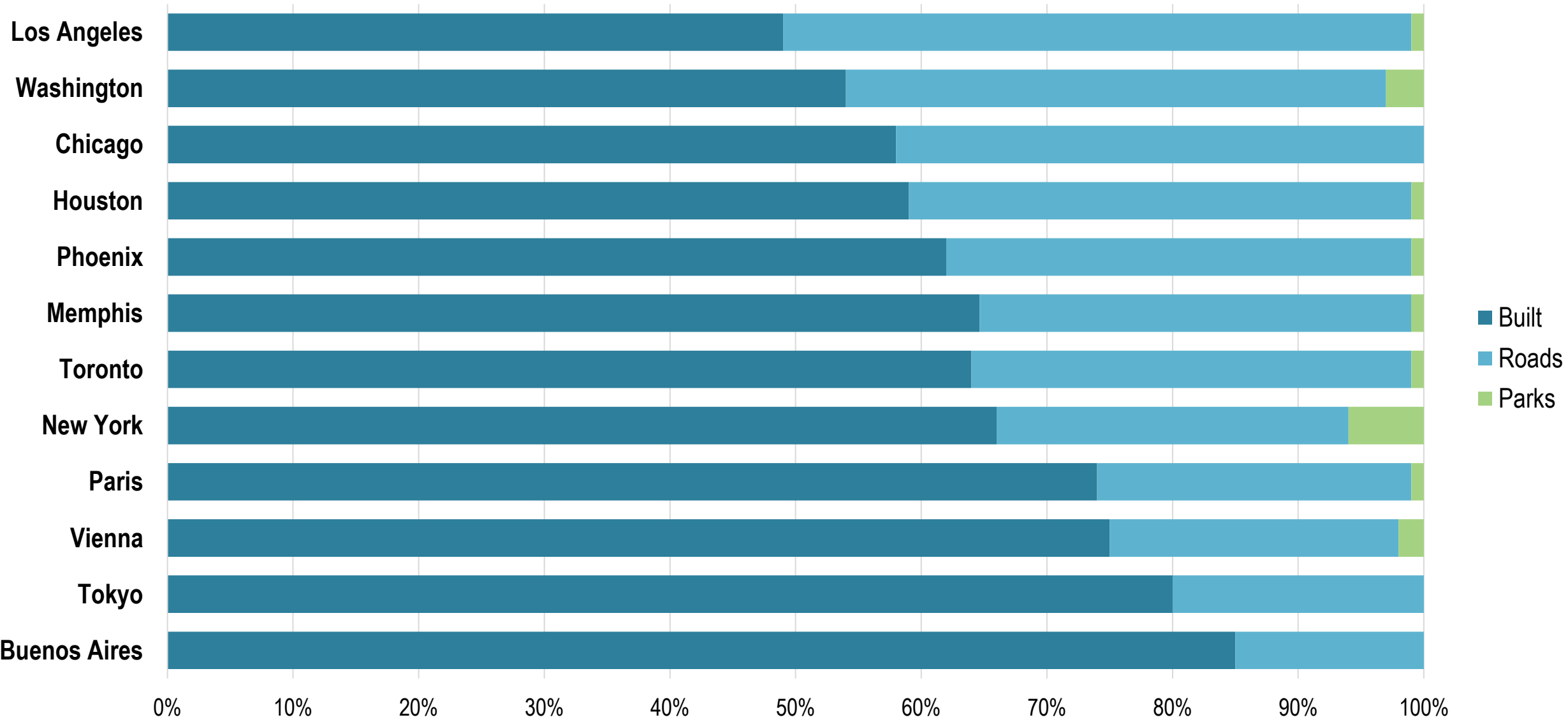
Transportation, Activity Systems and Land Use



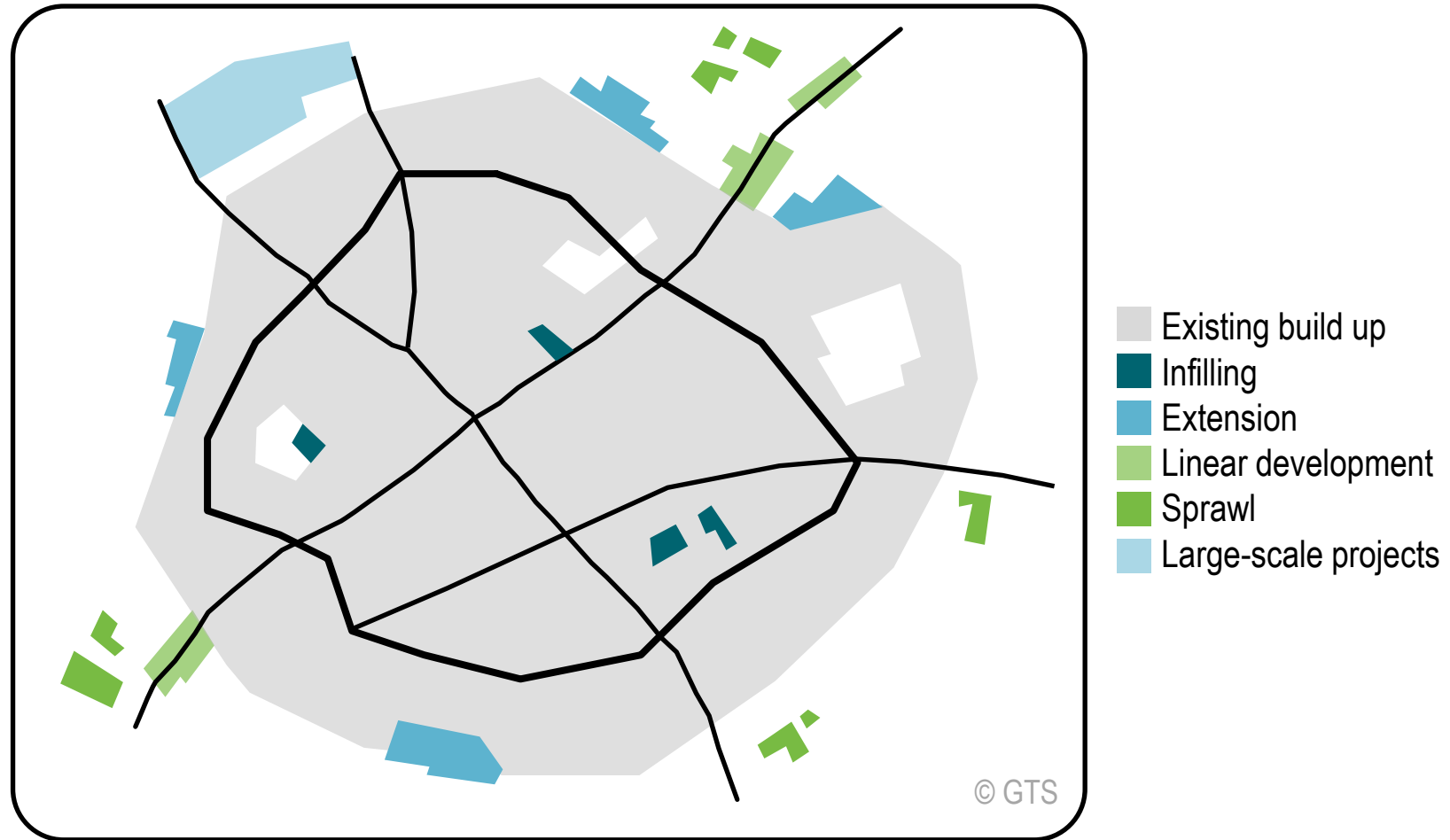
Formal and Functional Land Use



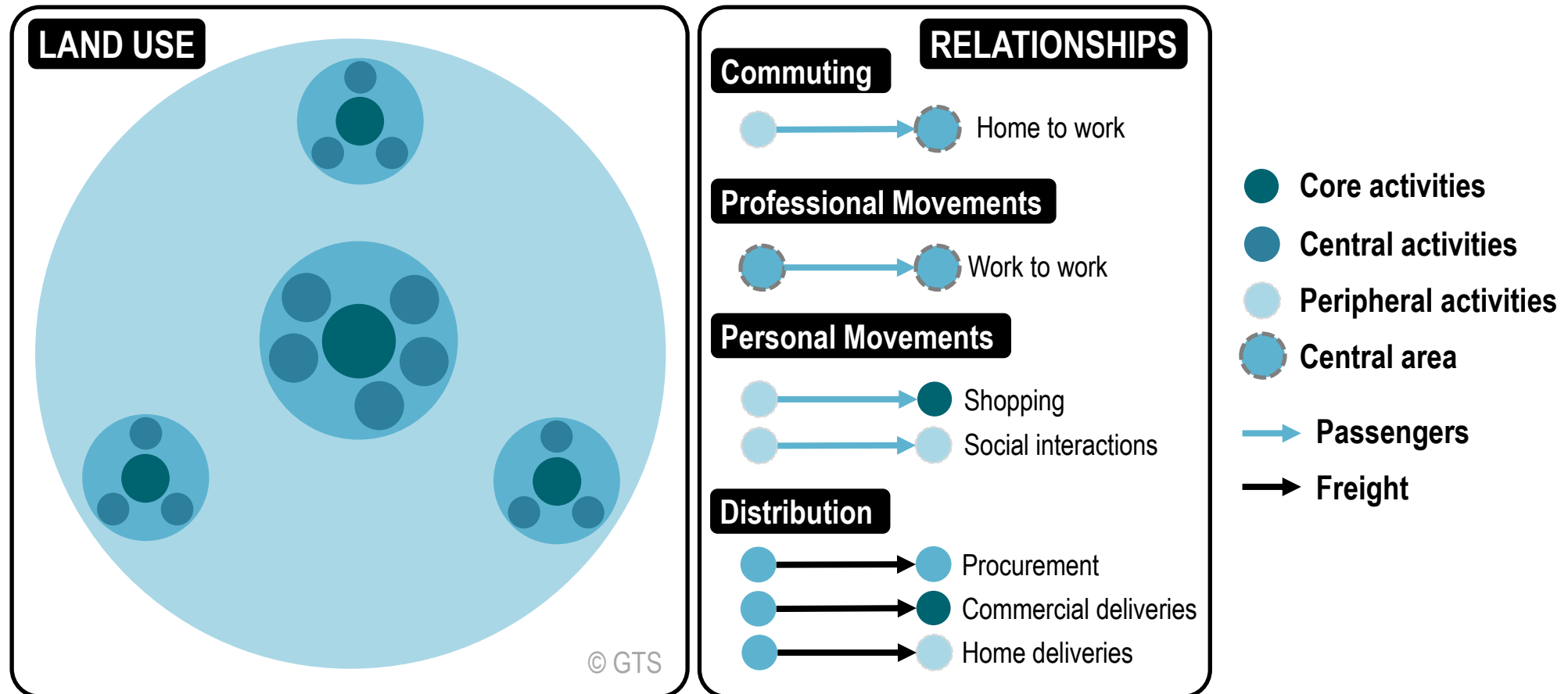
Land Use Footprint in Selected Central Areas



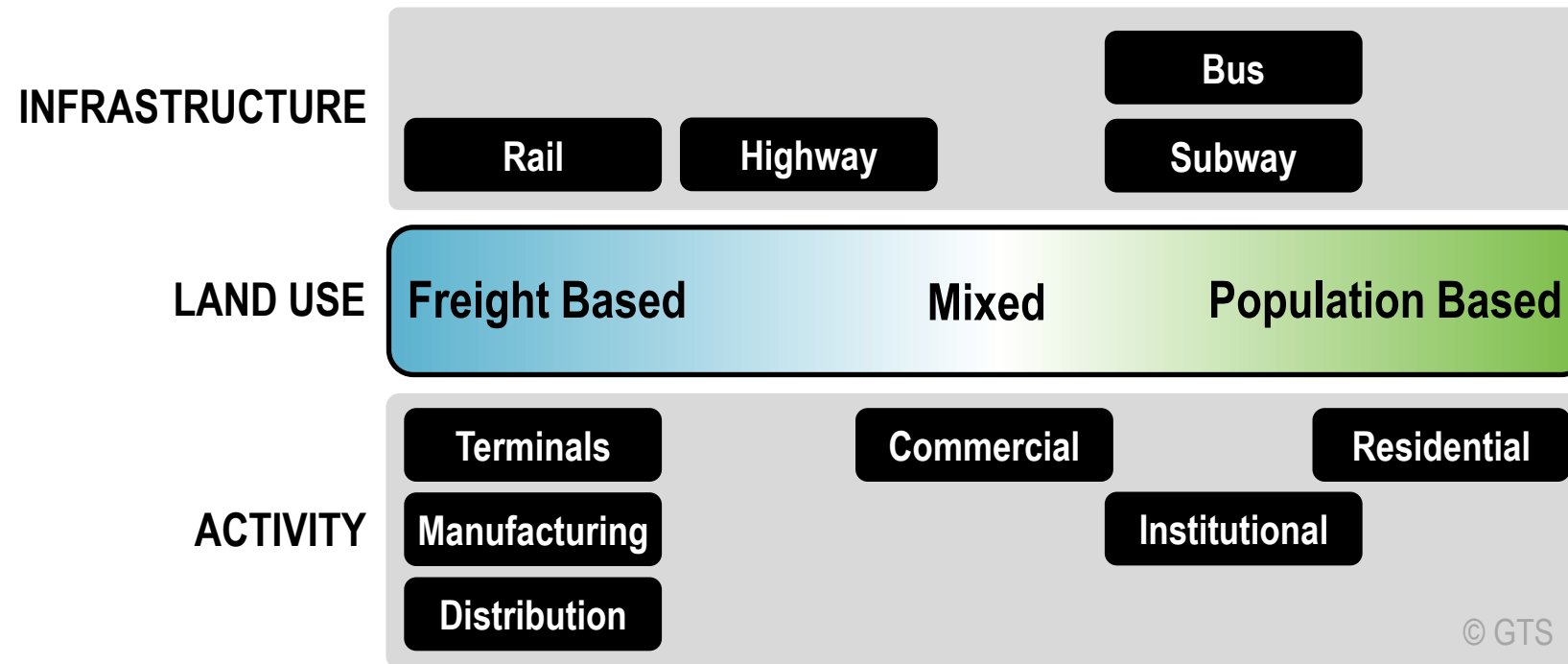
Types of Urban Expansion



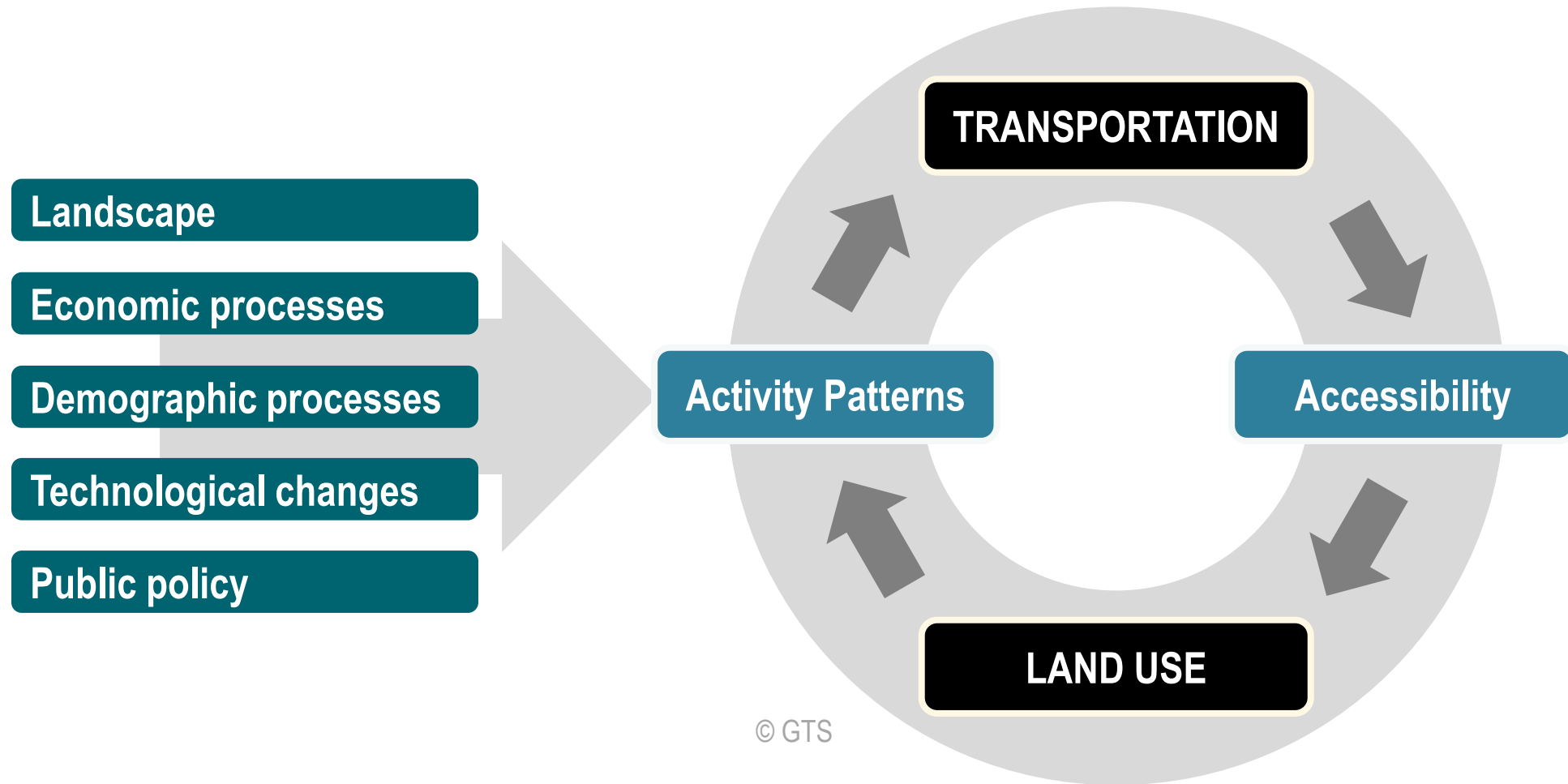
Relationships between Land Uses



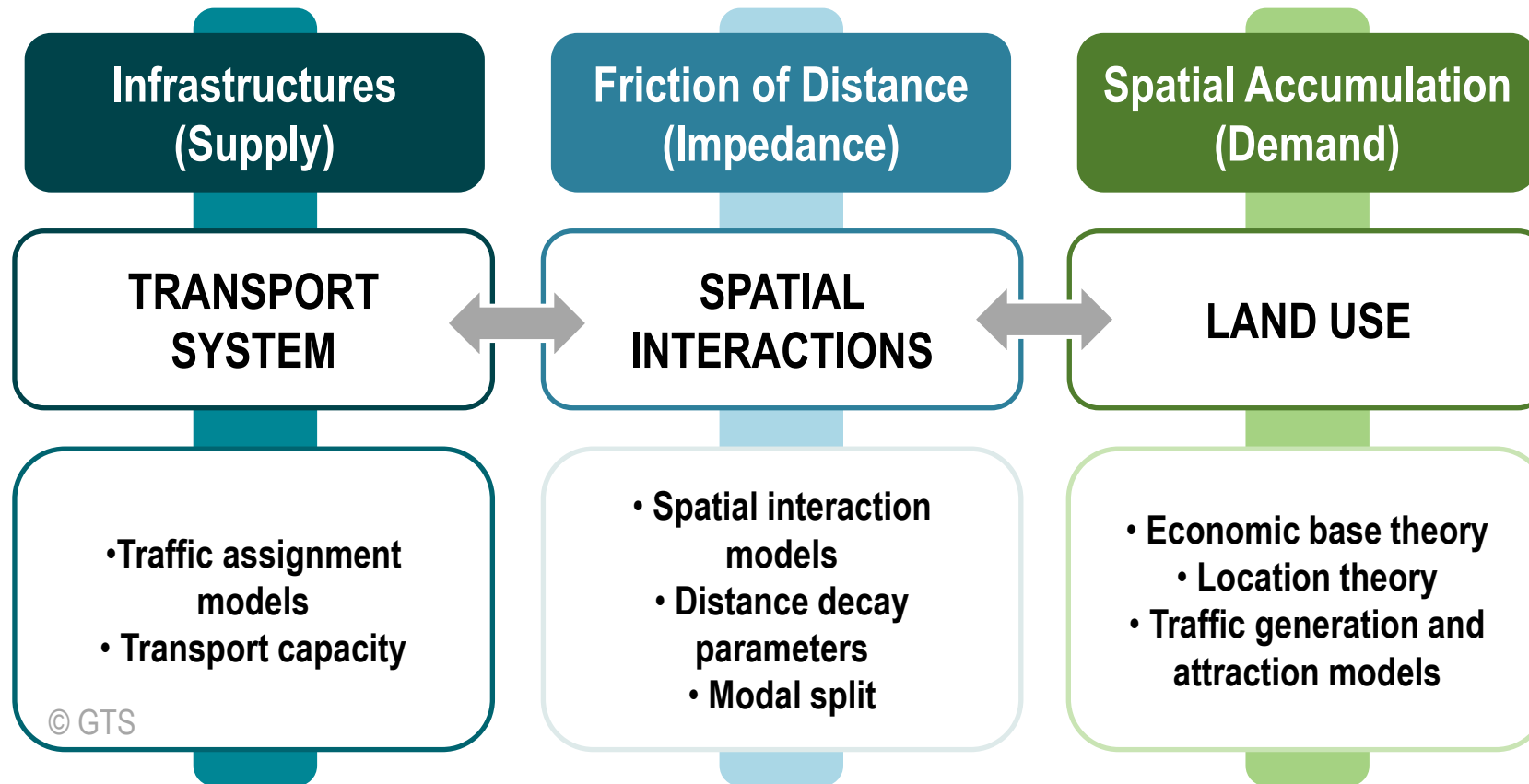
Transport Infrastructure and Activity Location



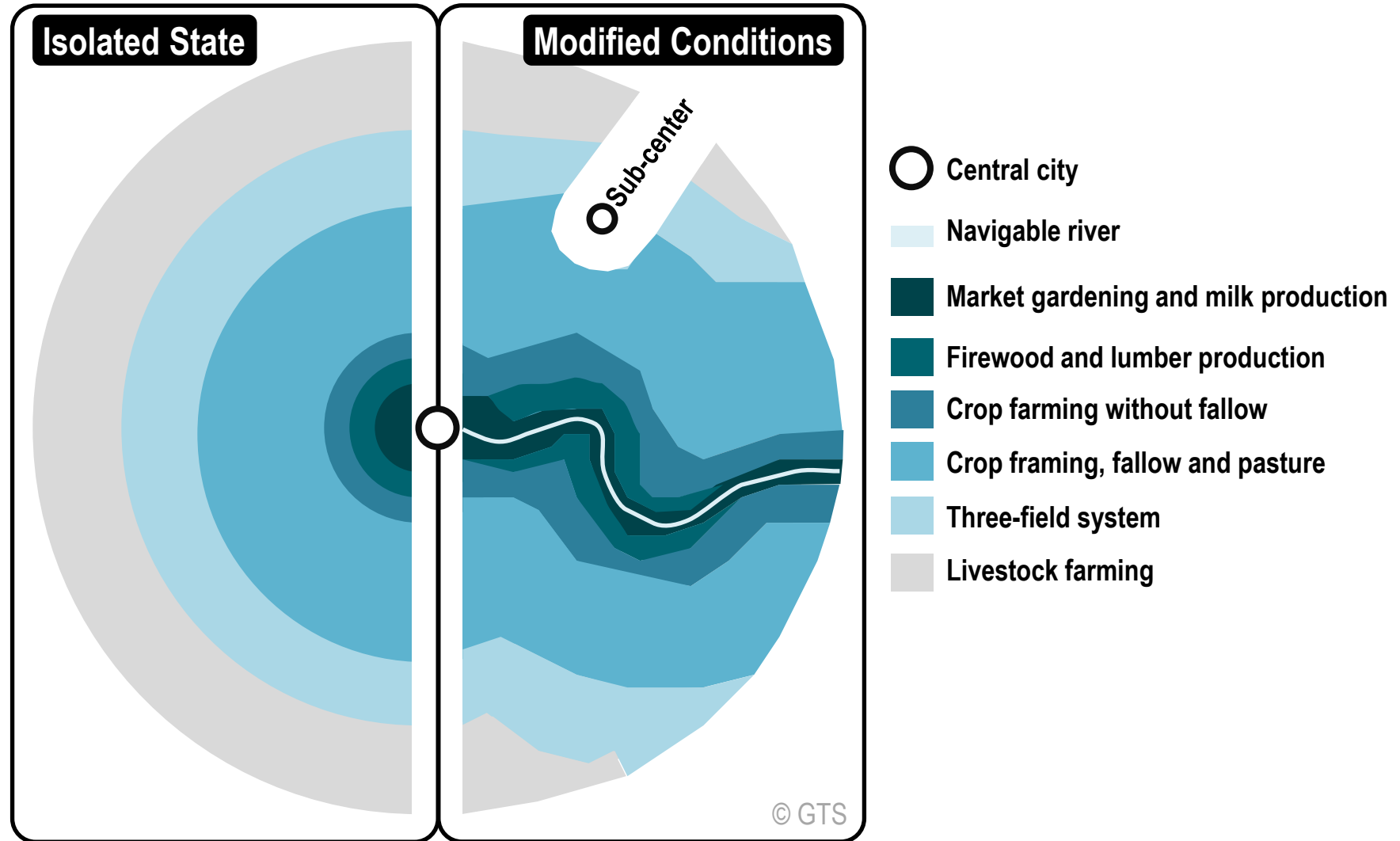
Transportation / Land Use Interactions



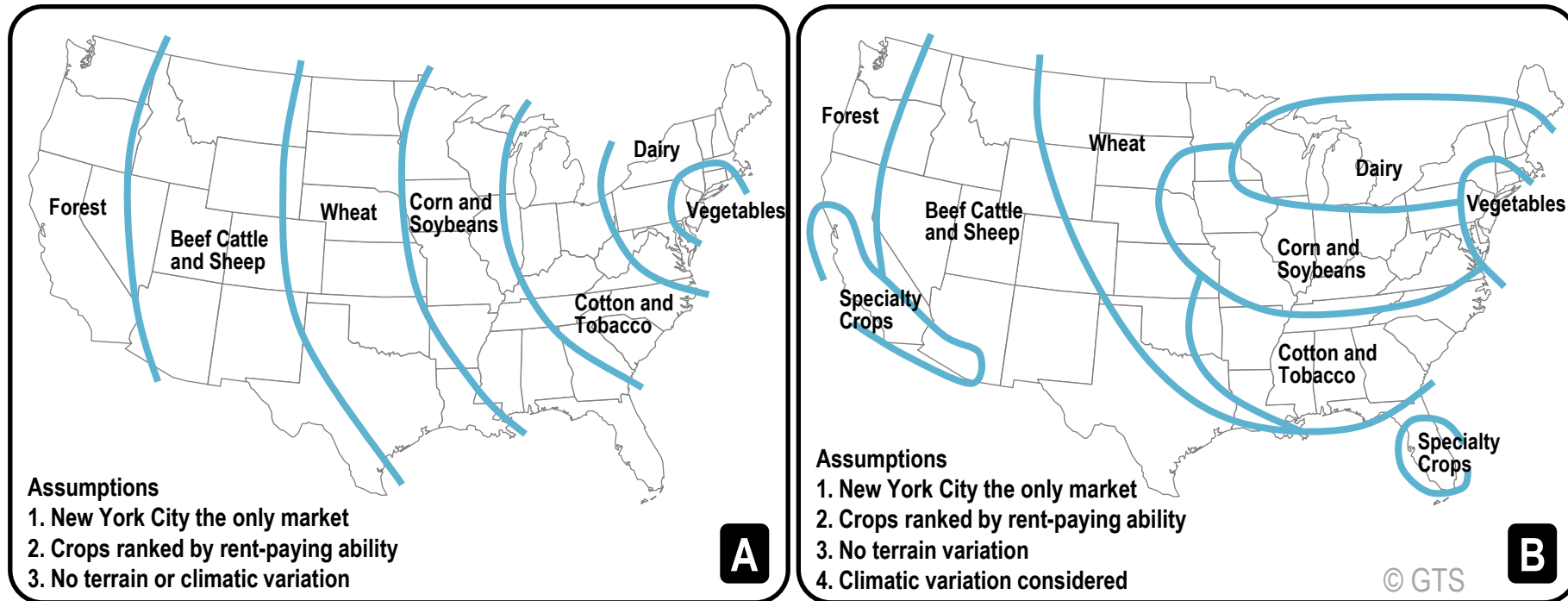
The Transport / Land Use System



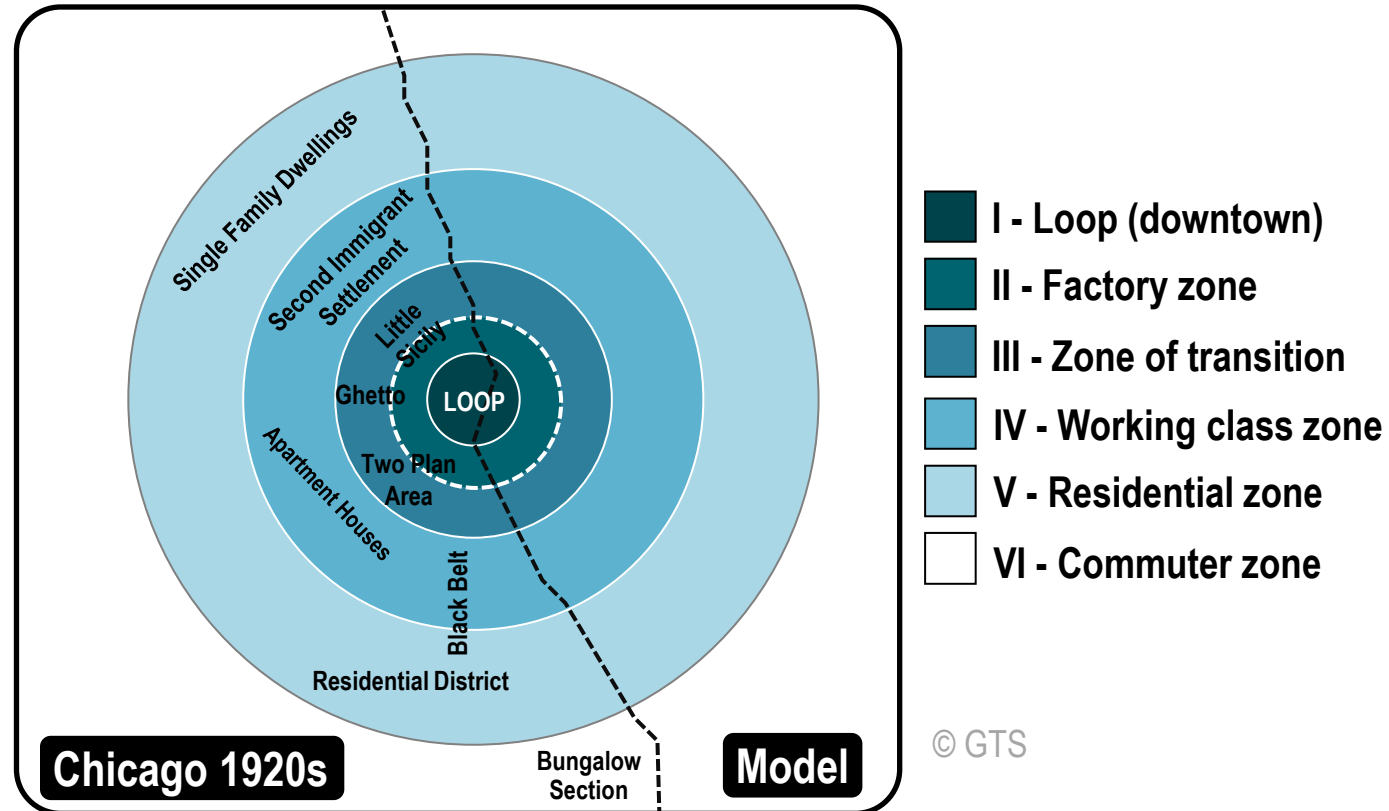
Von Thunen's Regional Land Use Model



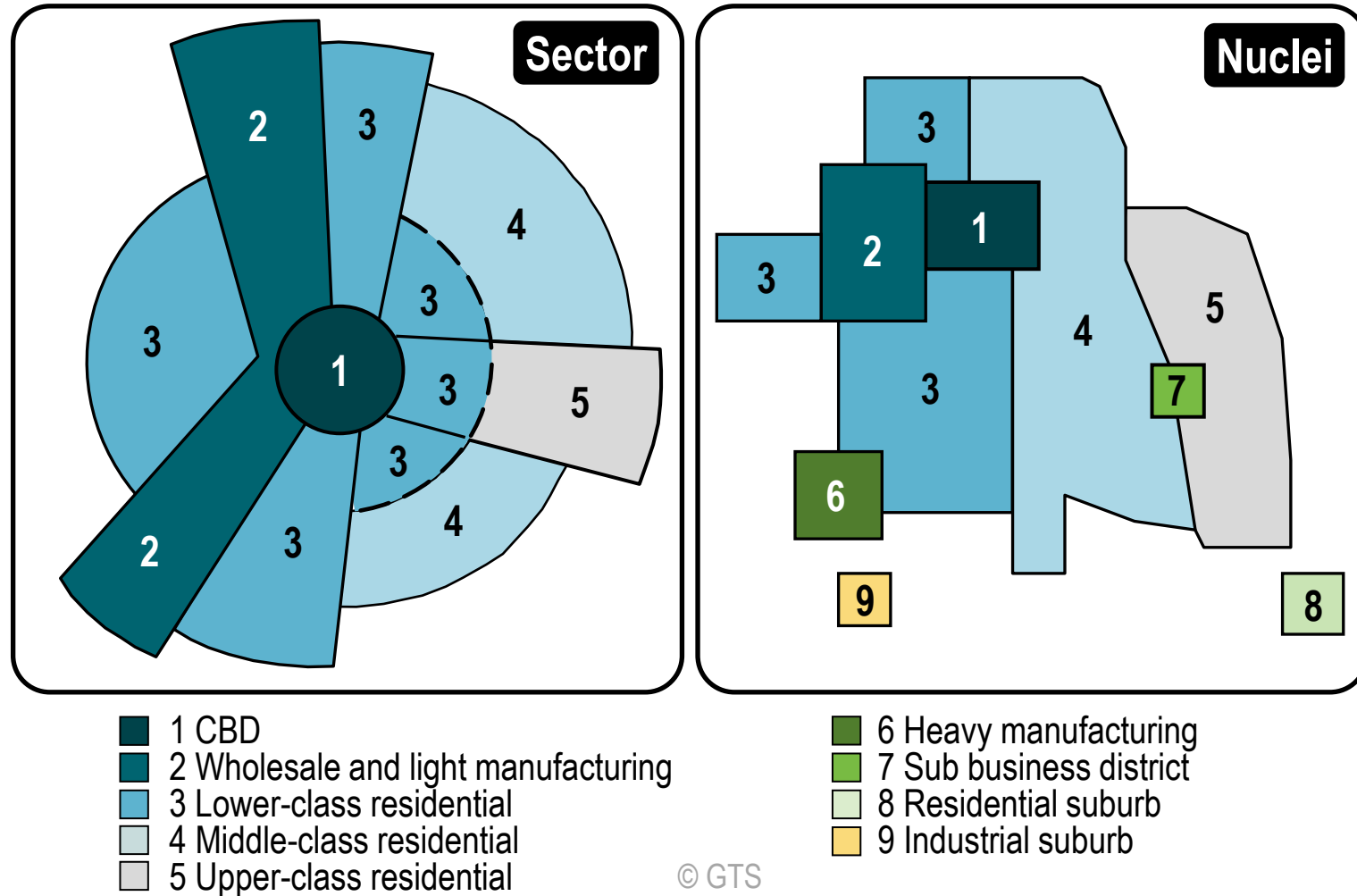
Inference of Von Thunen's Model to the Continental United States



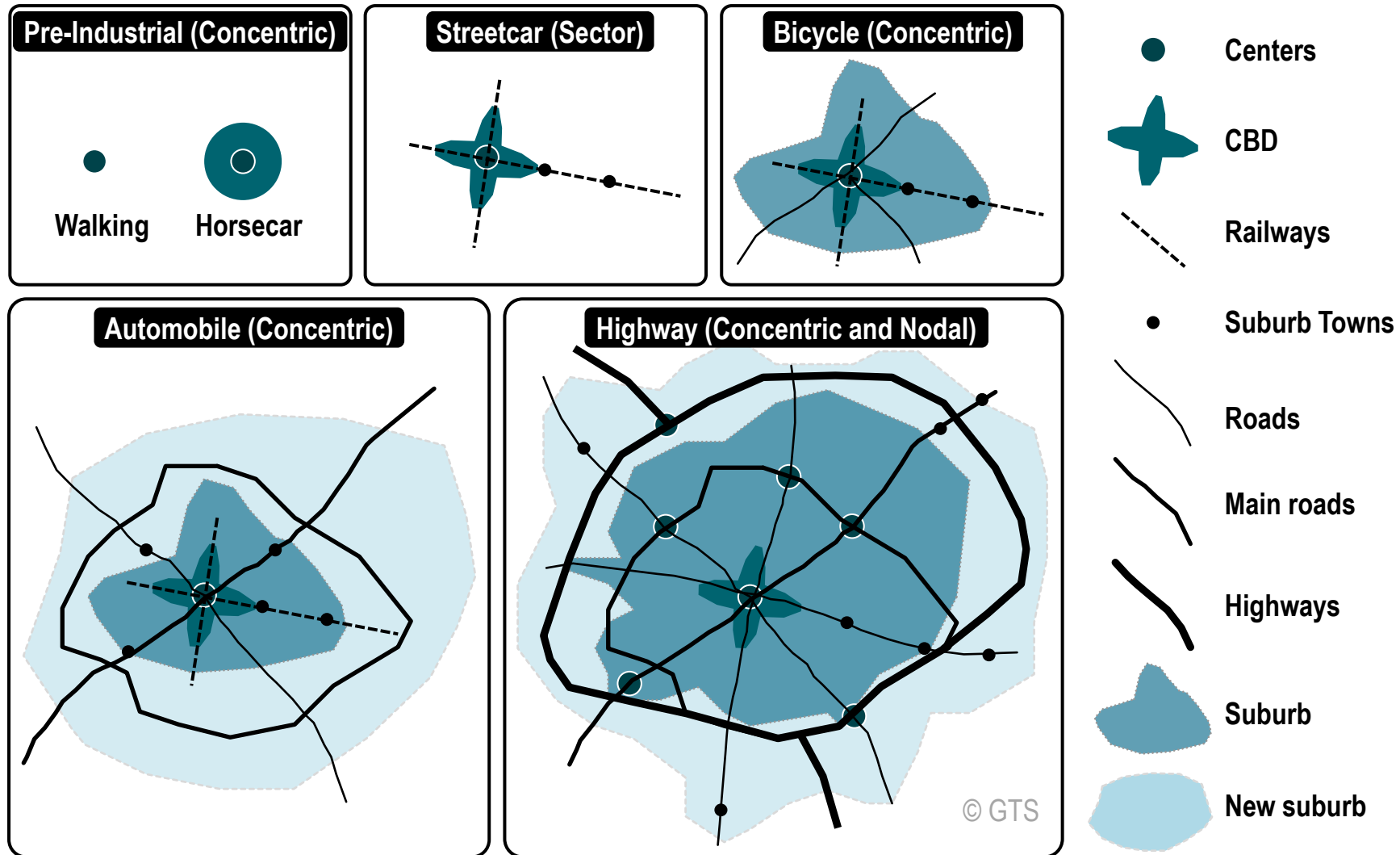
The Burgess Urban Land Use Model



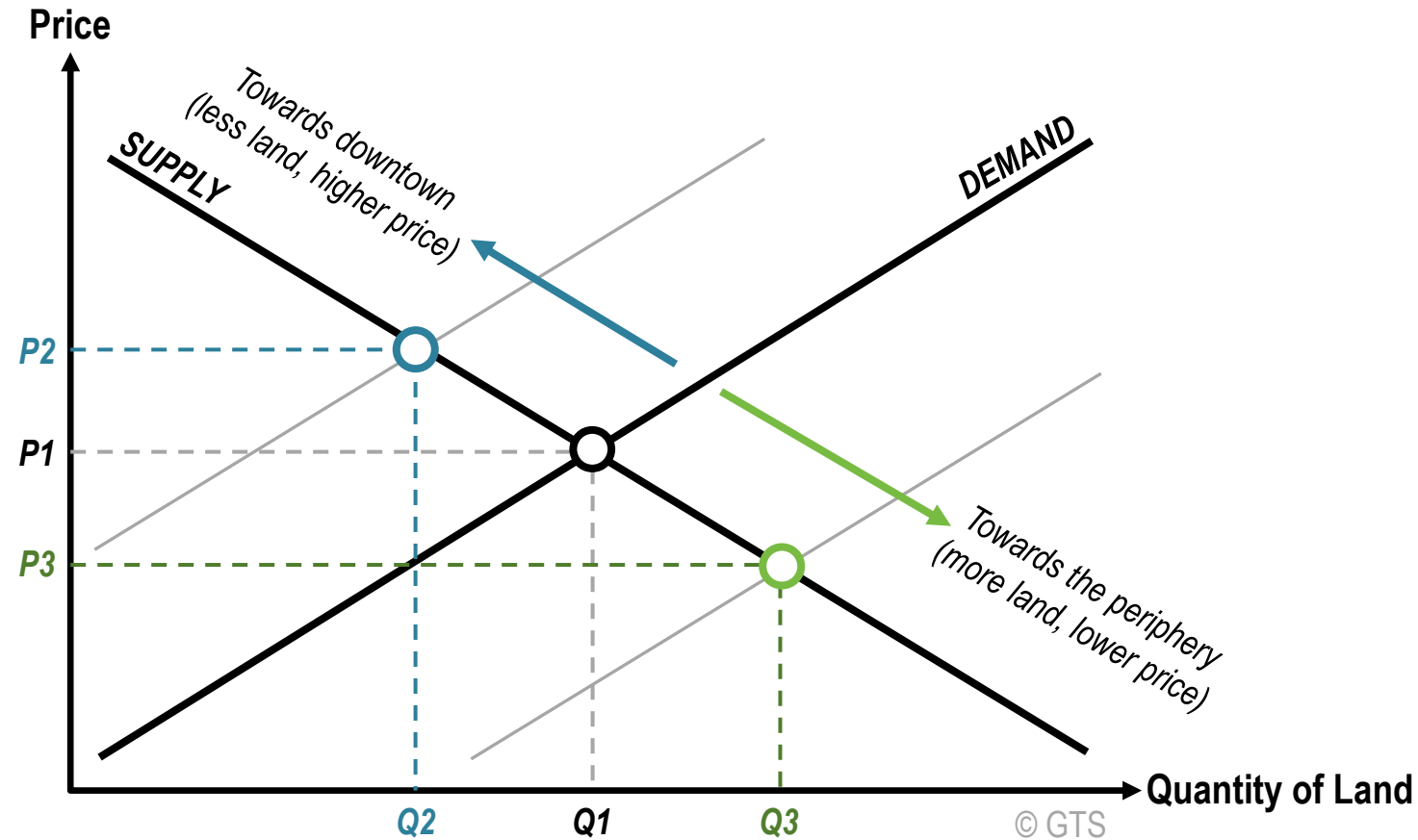
Sector and Nuclei Urban Land Use Models



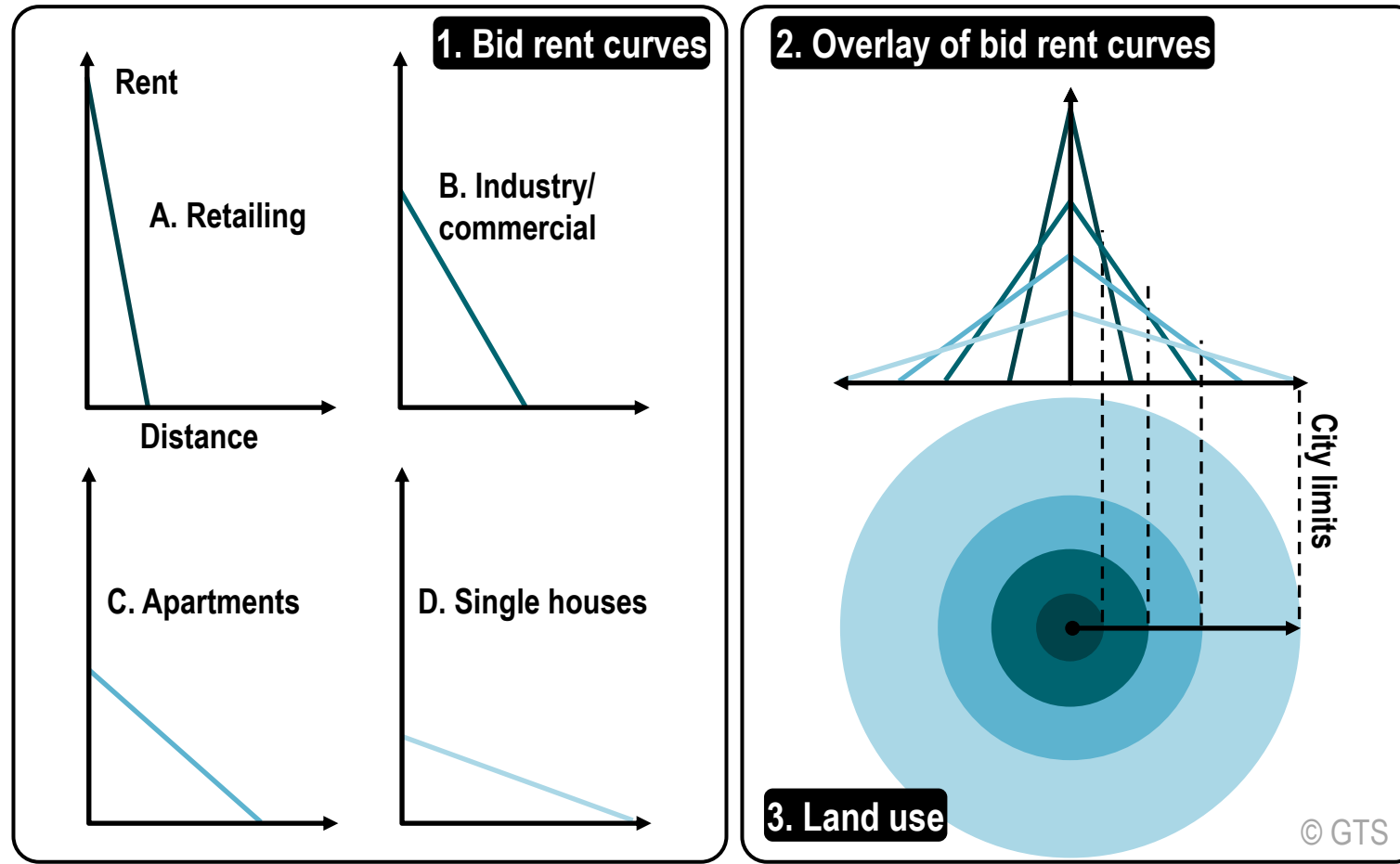
The Hybrid Land Use Model: Transportation and the Formation of Urban Landscapes



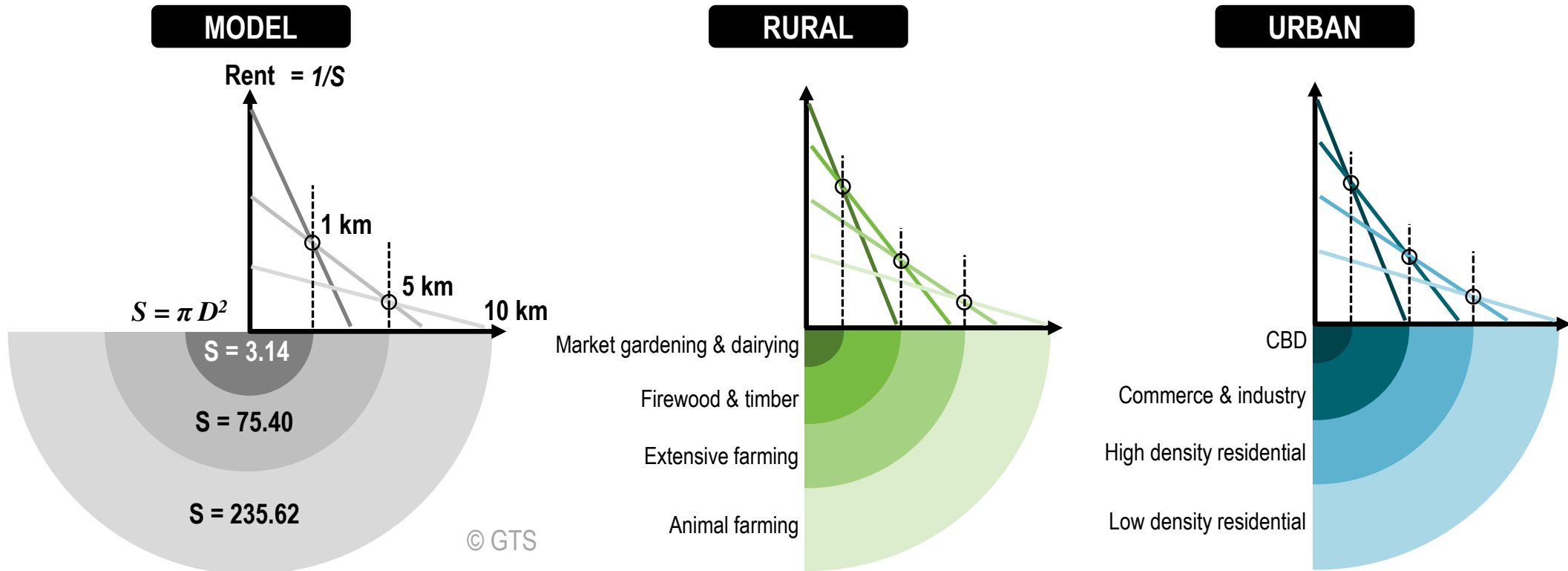
Basic Land Economics



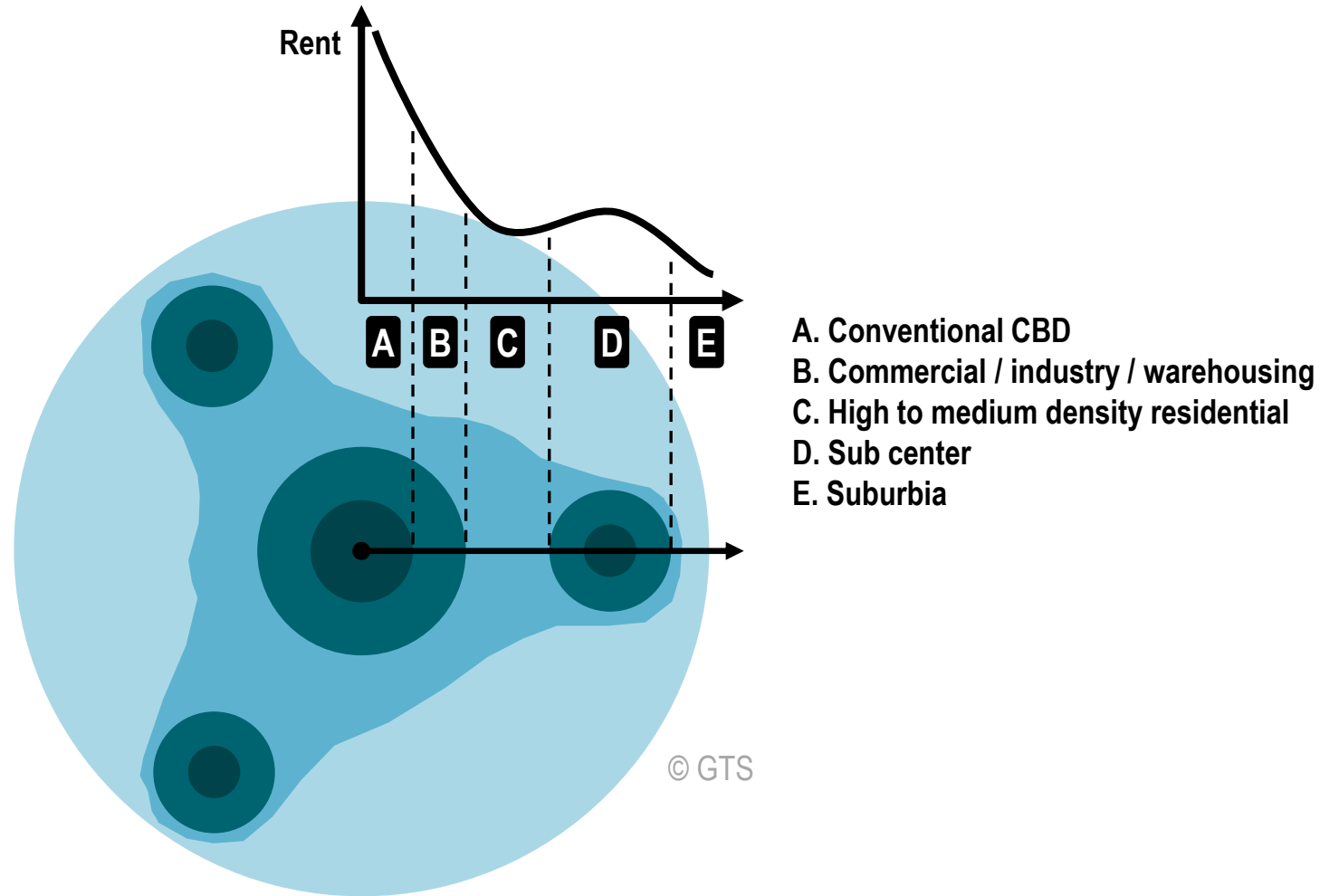
Land Rent and Land Use



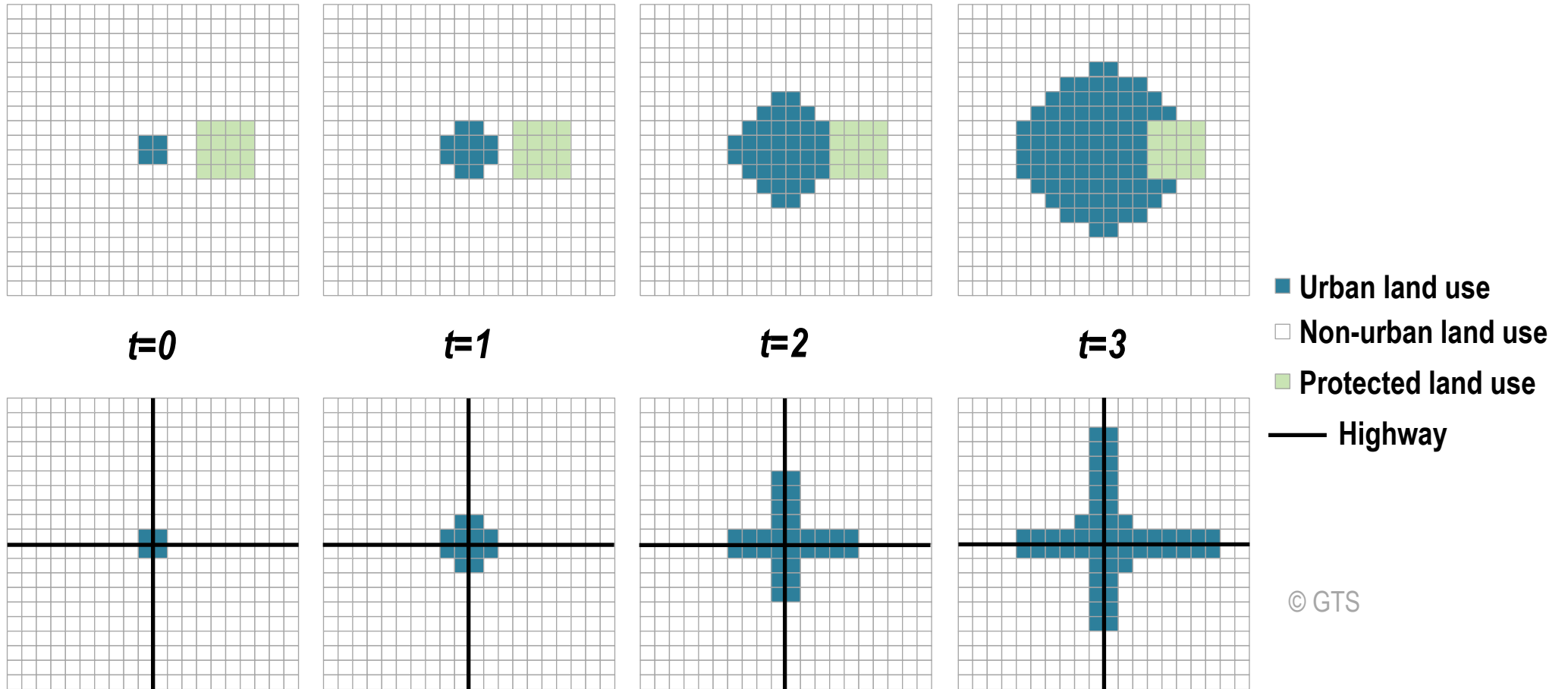
Land Rent Theory and Rent Curve



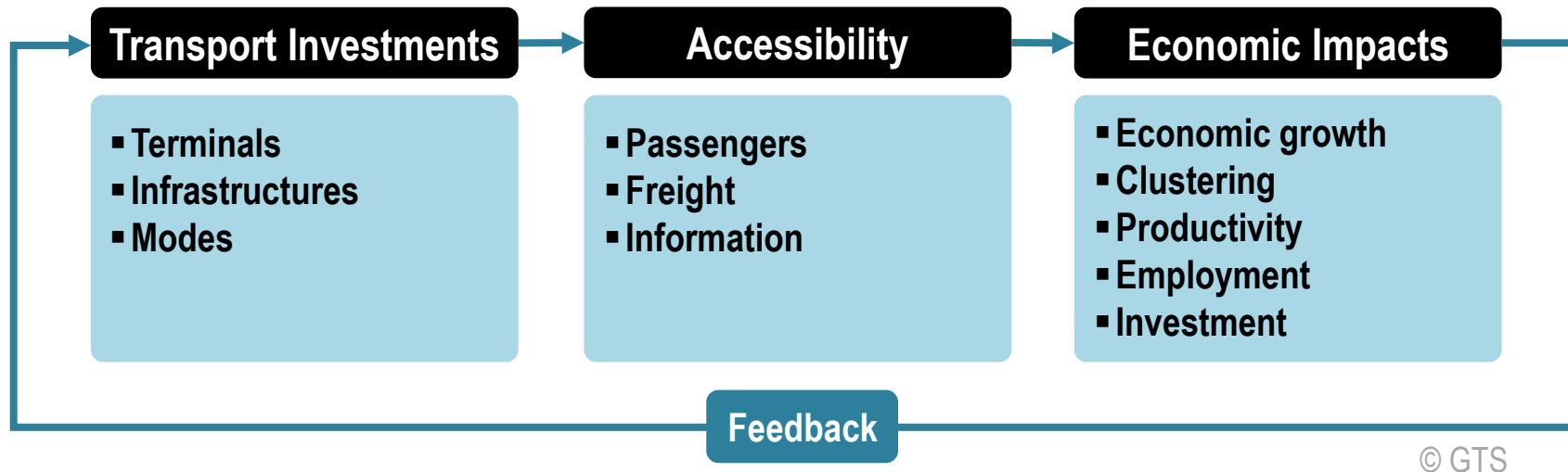
Contemporary Modifications of the Land Rent Theory



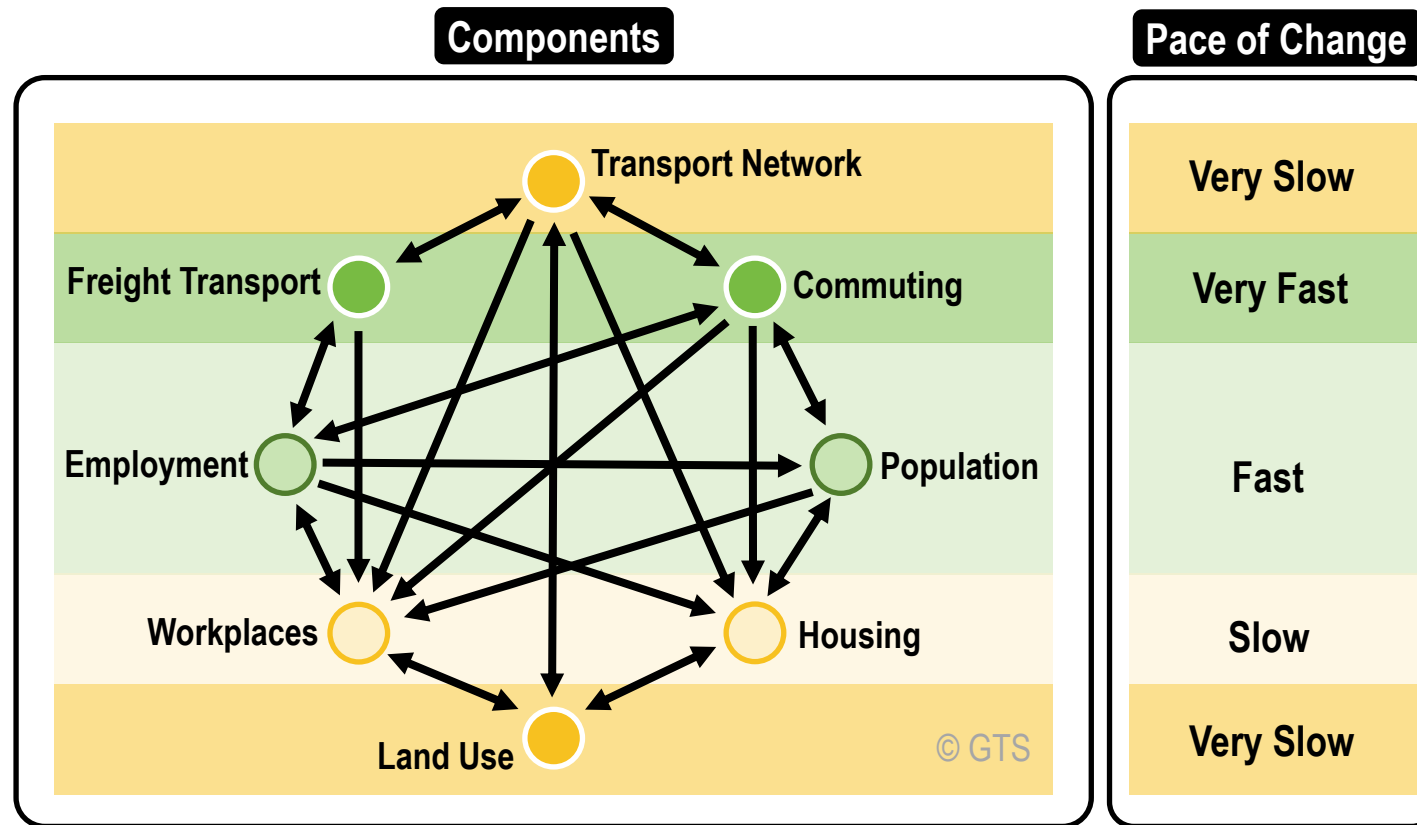
Cellular Automata Land Use Dynamics

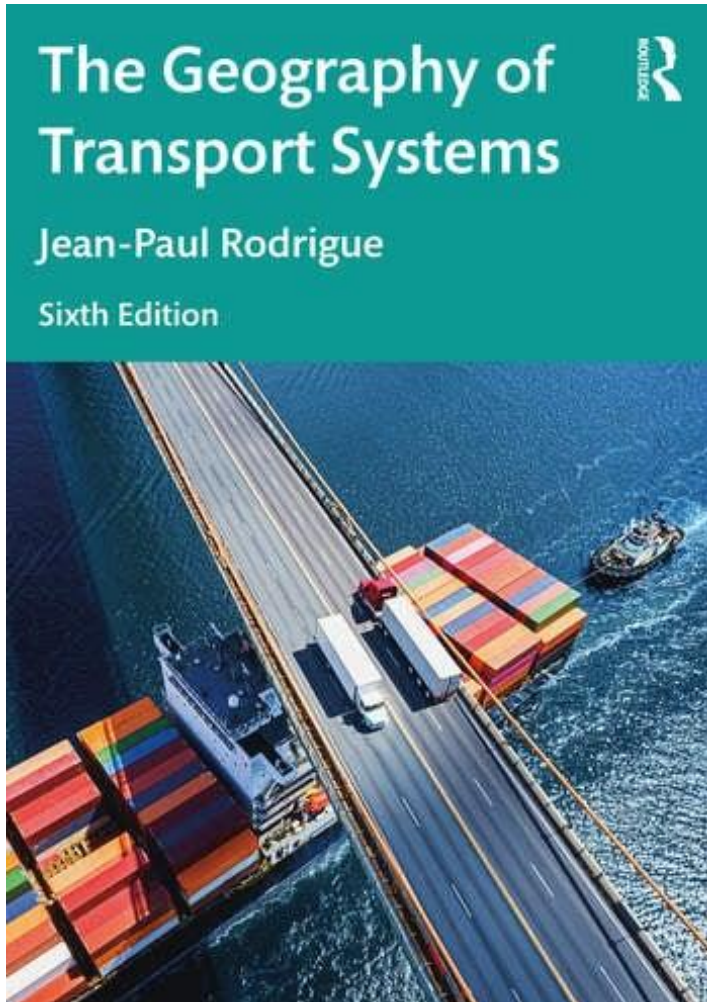


Basic Urban Dynamics



Dynamics of Urban Change

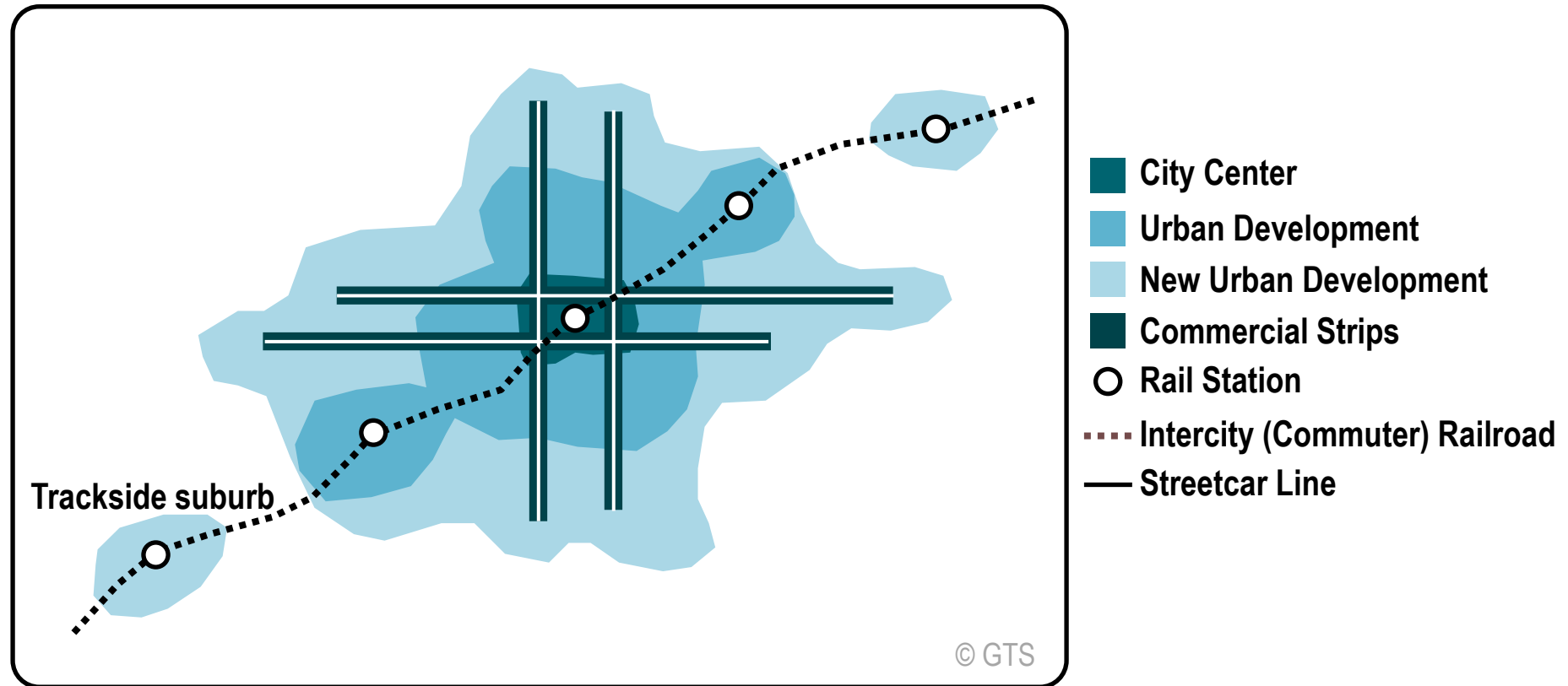




Urban Mobility

Chapter 8.3

Transit Technology and Urban Development, Late 19th – Early 20th Century



Suitability of Travel Modes

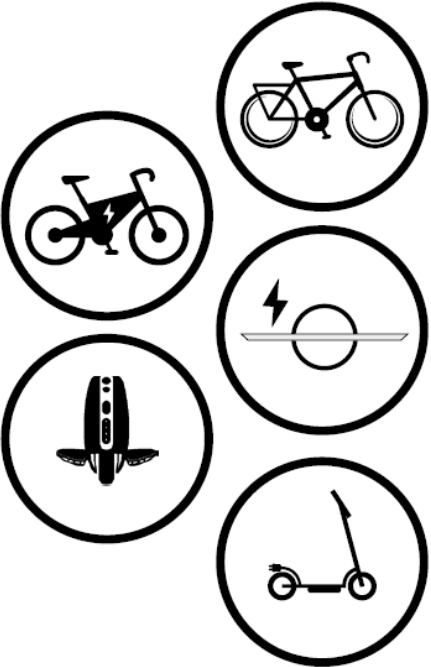
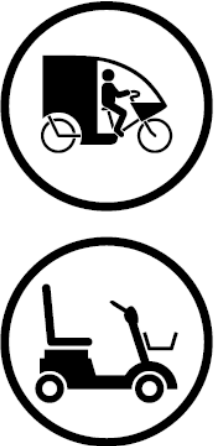
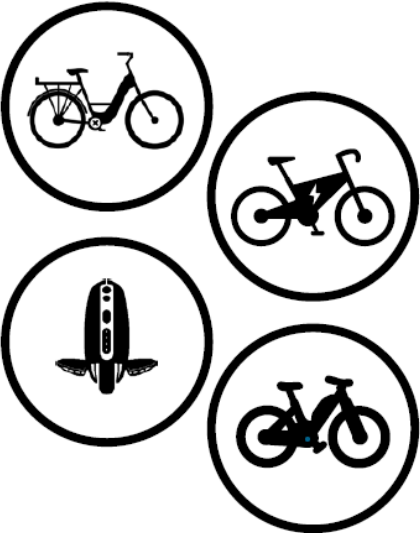

Mode	Limitations	Most Appropriate Uses
Walking	Requires physical ability. Limited distance and carrying capacity. Difficult or unsafe in some areas.	Short trips by physically able people.
Micromobility (Bicycle, ebike, scooter)	Requires physical ability. Limited distance and carrying capacity.	Short to medium length trips by physically able people on suitable routes.
Taxi	Relatively high cost per mile.	Infrequent trips over short and medium distance.
Fixed Route Transit	Destinations and times limited.	Short to medium-distance trips along corridors.
Paratransit	High cost and limited service.	Travel for disabled people.
Automobile	Requires driving ability and automobile. High fixed costs.	Travel by people who can drive and afford an automobile.
Ridesharing	Requires cooperative automobile driver. Consumes driver's time for deviations.	Trips that the driver would take anyway (commuting).
Vehicle Rentals	Requires convenient and affordable vehicle rentals services.	Occasional use by drivers for specific purposes.
Motorcycle	Requires riding ability and motorcycle. Average fixed costs.	Travel by people who can ride and afford a motorcycle.
Teleworking	Requires IT equipment and skills.	Alternative to some work and professional.

Suitability of Passenger Mobility Modes

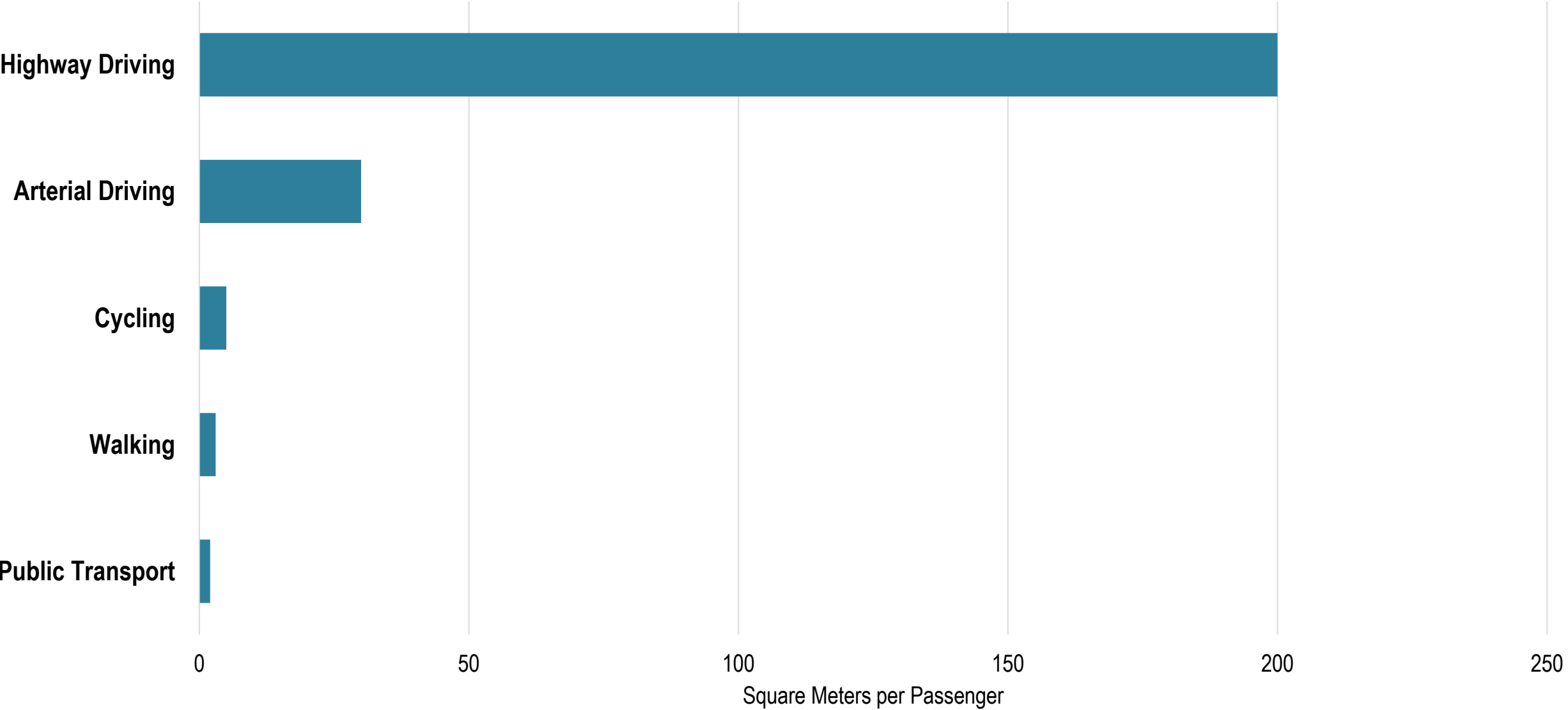
MODE	USES	LIMITATIONS
Walking	<ul style="list-style-type: none"> • Short trips by physically able people. 	<ul style="list-style-type: none"> • Requires physical ability. • Limited distance and carrying capacity. • Difficult or unsafe in some areas.
Micromobility	<ul style="list-style-type: none"> • Short to medium-length trips by physically able people on suitable routes. 	<ul style="list-style-type: none"> • Requires physical ability. • Limited distance and carrying capacity.
Motorcycle	<ul style="list-style-type: none"> • Travel by people who can ride and afford a motorcycle. 	<ul style="list-style-type: none"> • Requires riding ability and motorcycle. • Average fixed costs.
Transit	<ul style="list-style-type: none"> • Short to medium-distance trips along corridors. 	<ul style="list-style-type: none"> • Destinations and times limited.
Paratransit	<ul style="list-style-type: none"> • Travel for people with disabilities. 	<ul style="list-style-type: none"> • High cost and limited service.
Taxi	<ul style="list-style-type: none"> • Infrequent trips over short and medium distances. 	<ul style="list-style-type: none"> • Relatively high cost per mile.
Automobile	<ul style="list-style-type: none"> • Travel by people who can drive and afford an automobile. 	<ul style="list-style-type: none"> • Requires driving ability and automobile. • High fixed costs.
Ridesharing	<ul style="list-style-type: none"> • Trips that the driver would take anyway (commuting). 	<ul style="list-style-type: none"> • Requires cooperative automobile driver. • Consumes driver's time for deviations.
Vehicle rental	<ul style="list-style-type: none"> • Occasional use by drivers for specific purposes. 	<ul style="list-style-type: none"> • Requires convenient and affordable vehicle rental services.
Teleworking	<ul style="list-style-type: none"> • Alternative to some work and professional services. 	<ul style="list-style-type: none"> • Requires IT equipment and skills.

© GTS

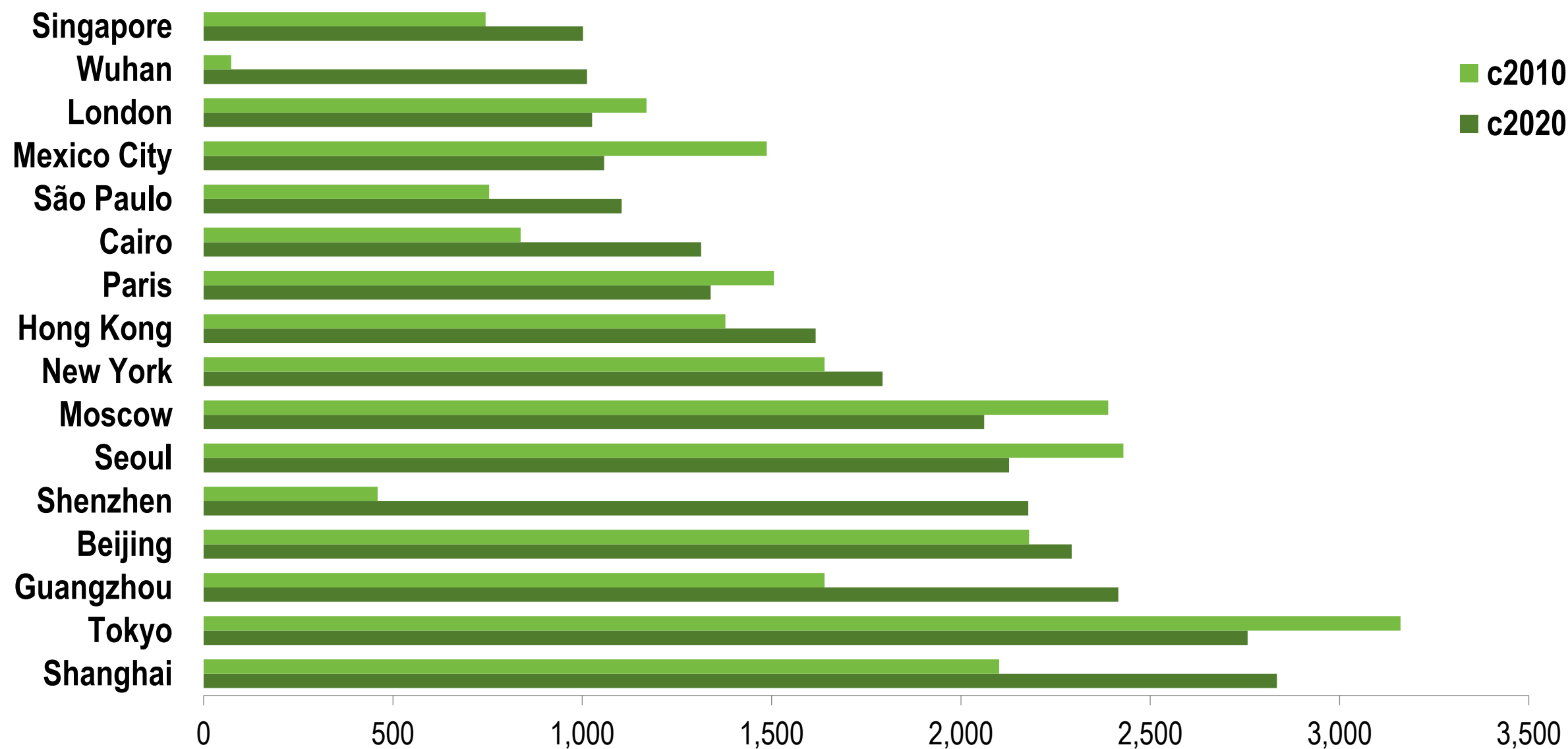
FIGURE IX PROPOSED MICROMOBILITY DEFINITION AND CLASSIFICATION

Type A	Type B	Type C	Type D
"unpowered or powered up to 25 km/h (16 mph)"		"powered with top speed between 25-45 km/h (16-28 mph)"	
"< 35 kg (77 lb)"	"35-350 kg (77-770 lb)"	"< 35 kg (77 lb)"	"35-350 kg (77-770 lb)"
			

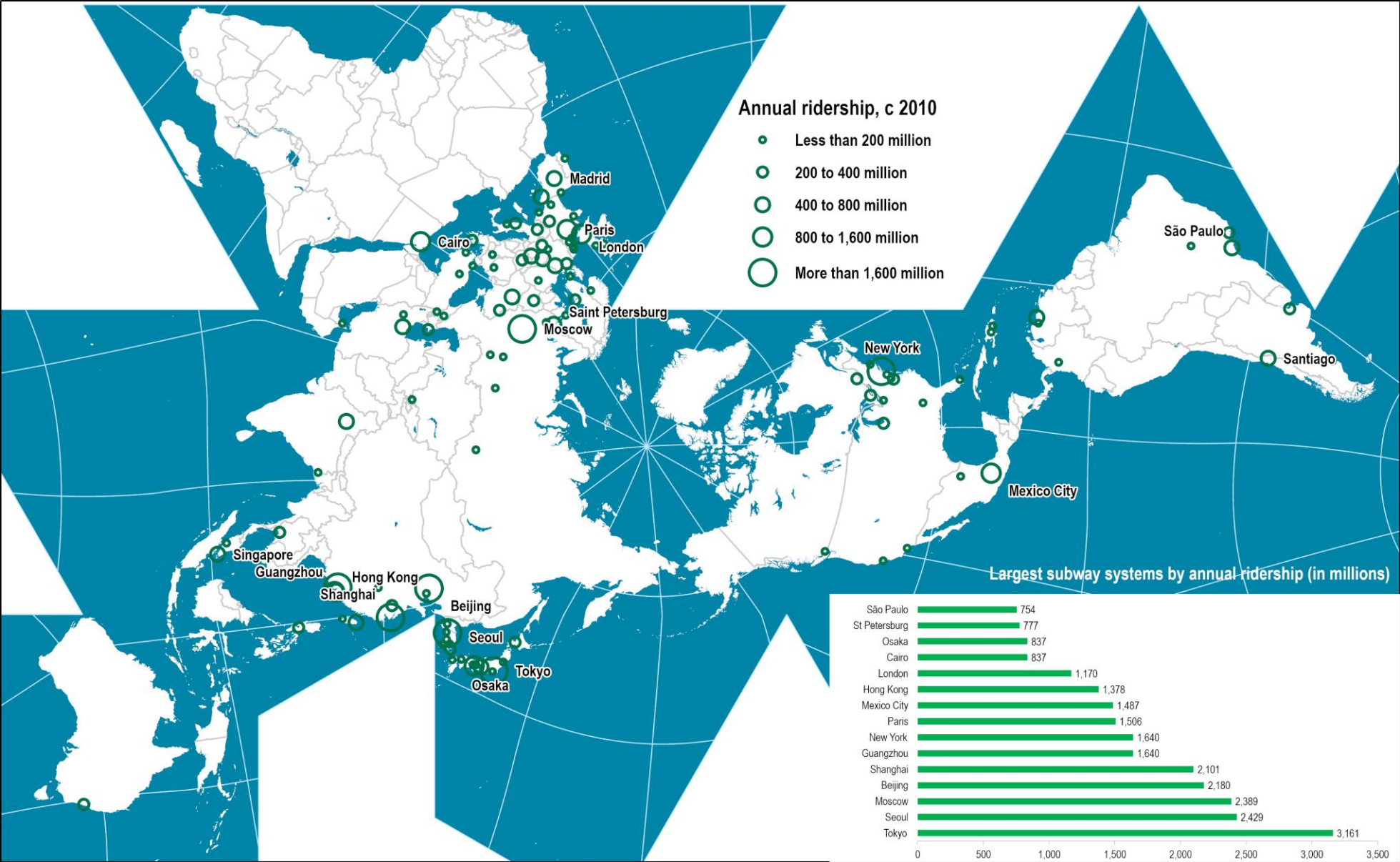
Space Required per Passenger on Road Transport Modes



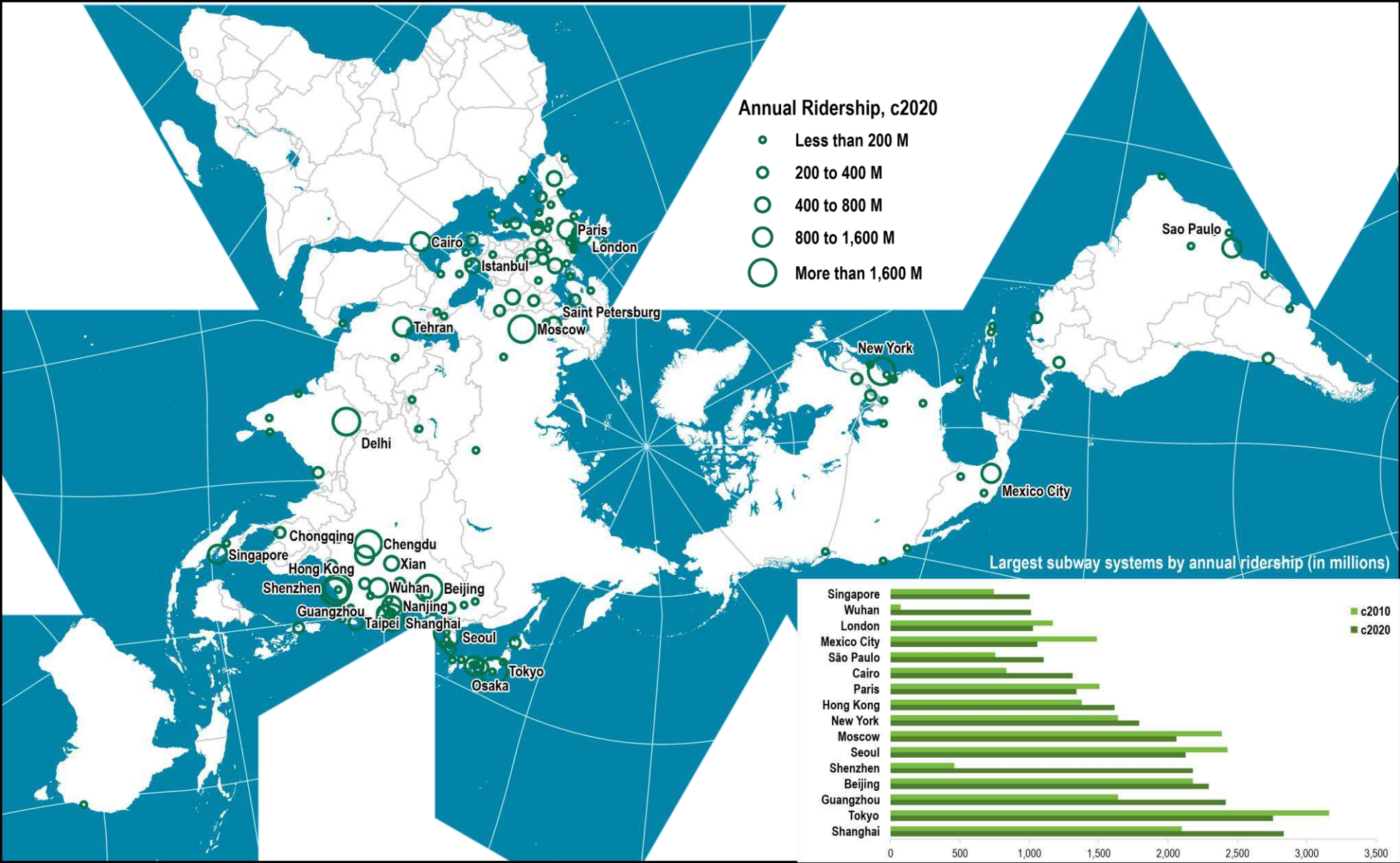
Largest Subway Systems in the World by Annual Ridership (in millions)

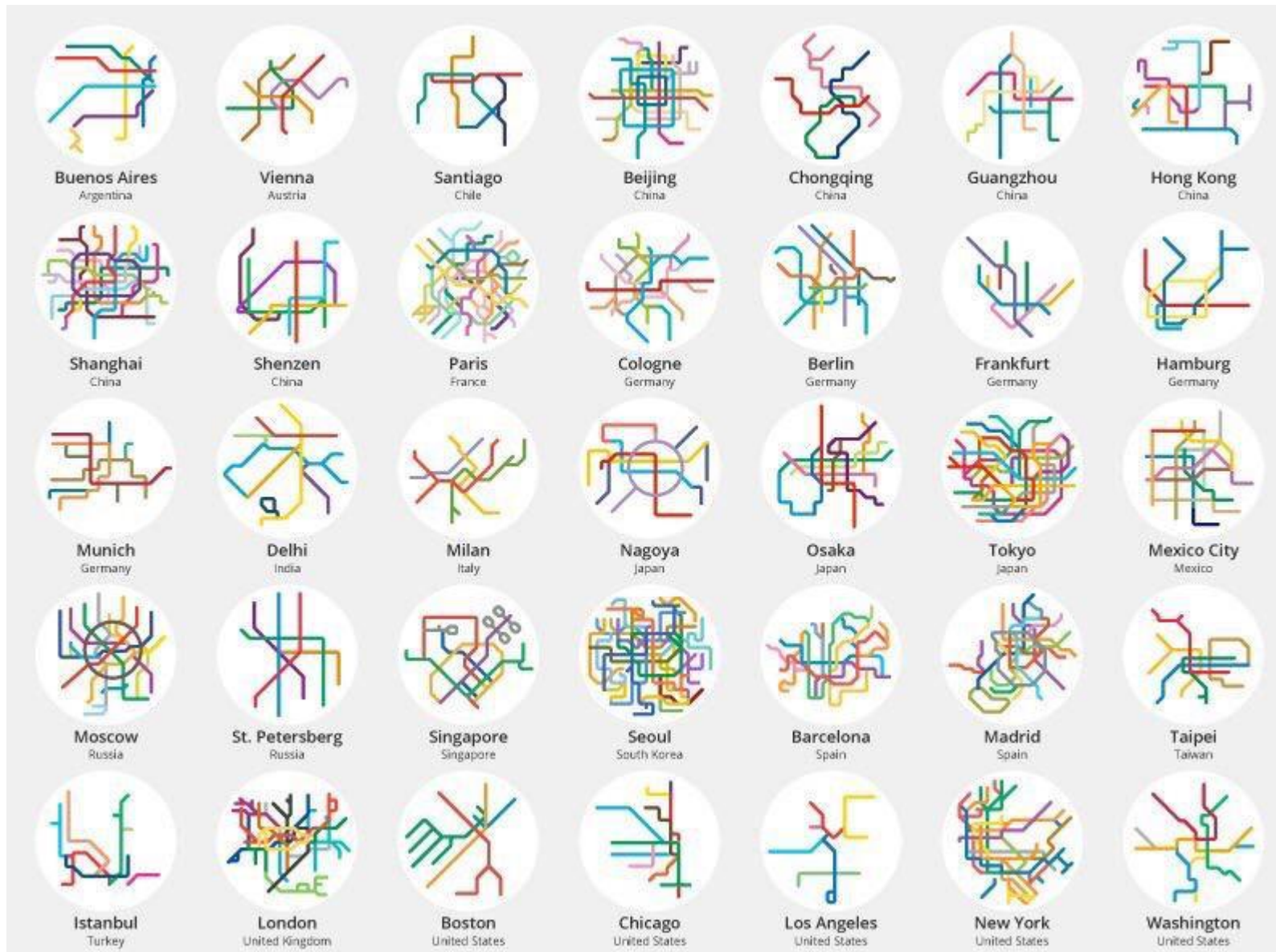


World's Main Subway Systems, c2010

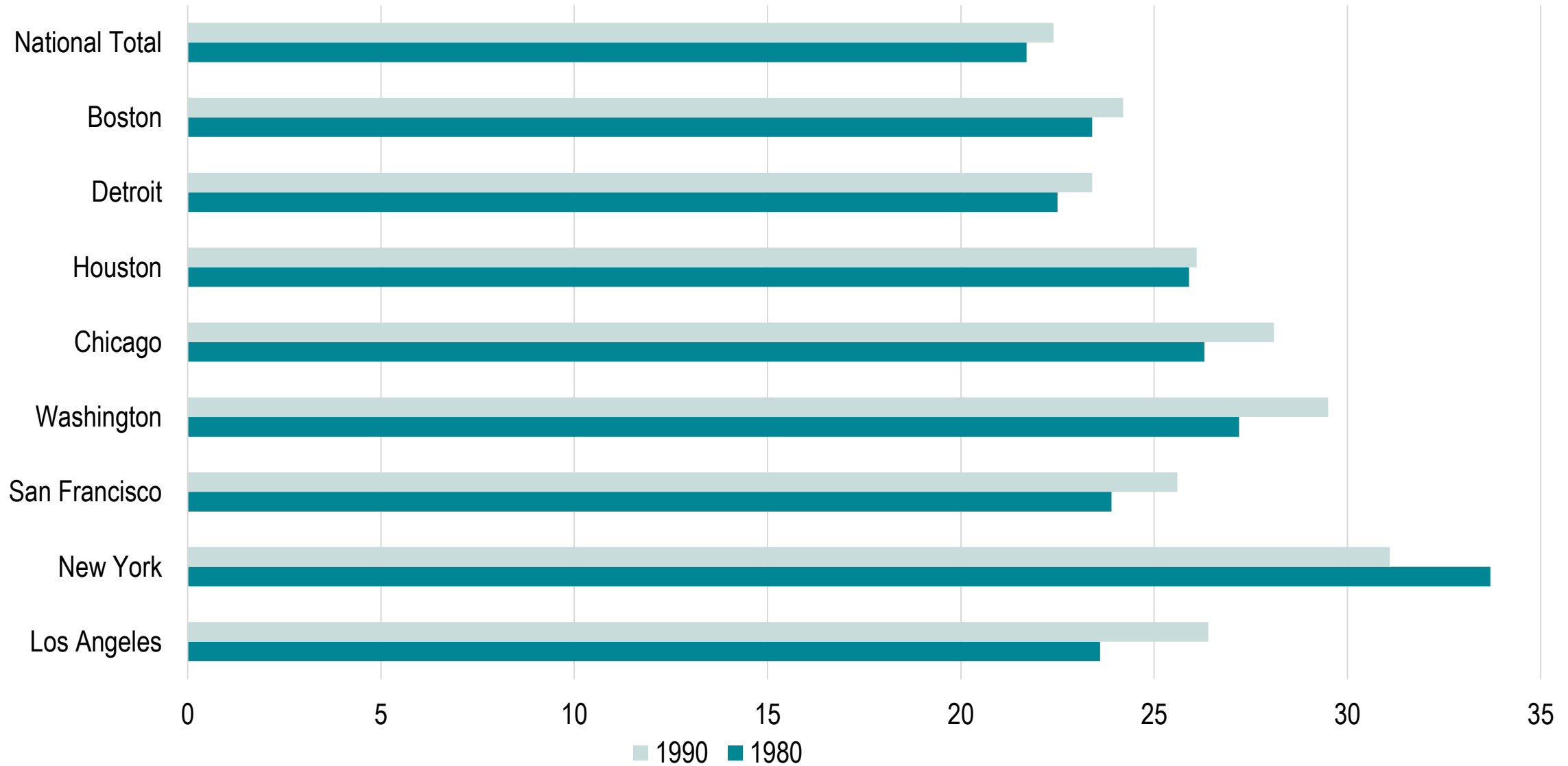


World's Main Subway Systems, c2020

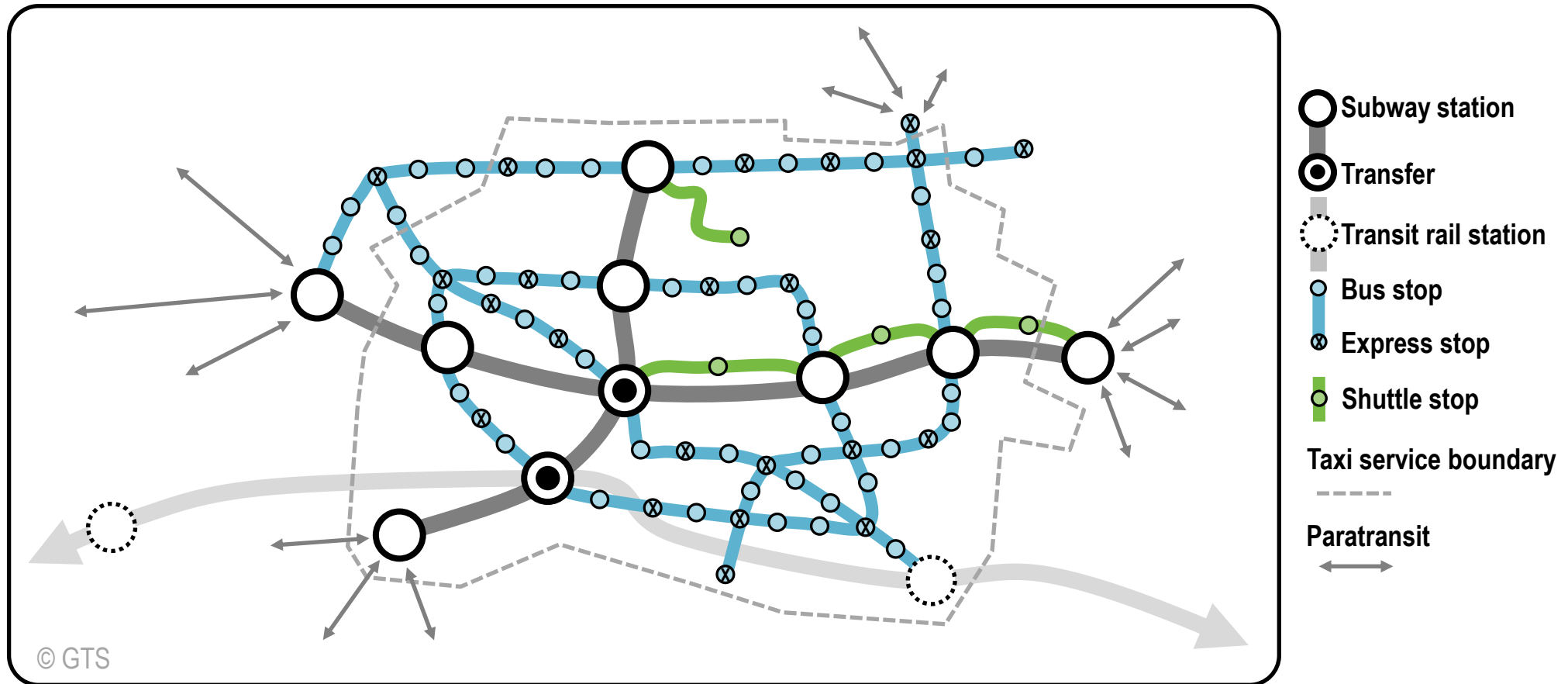




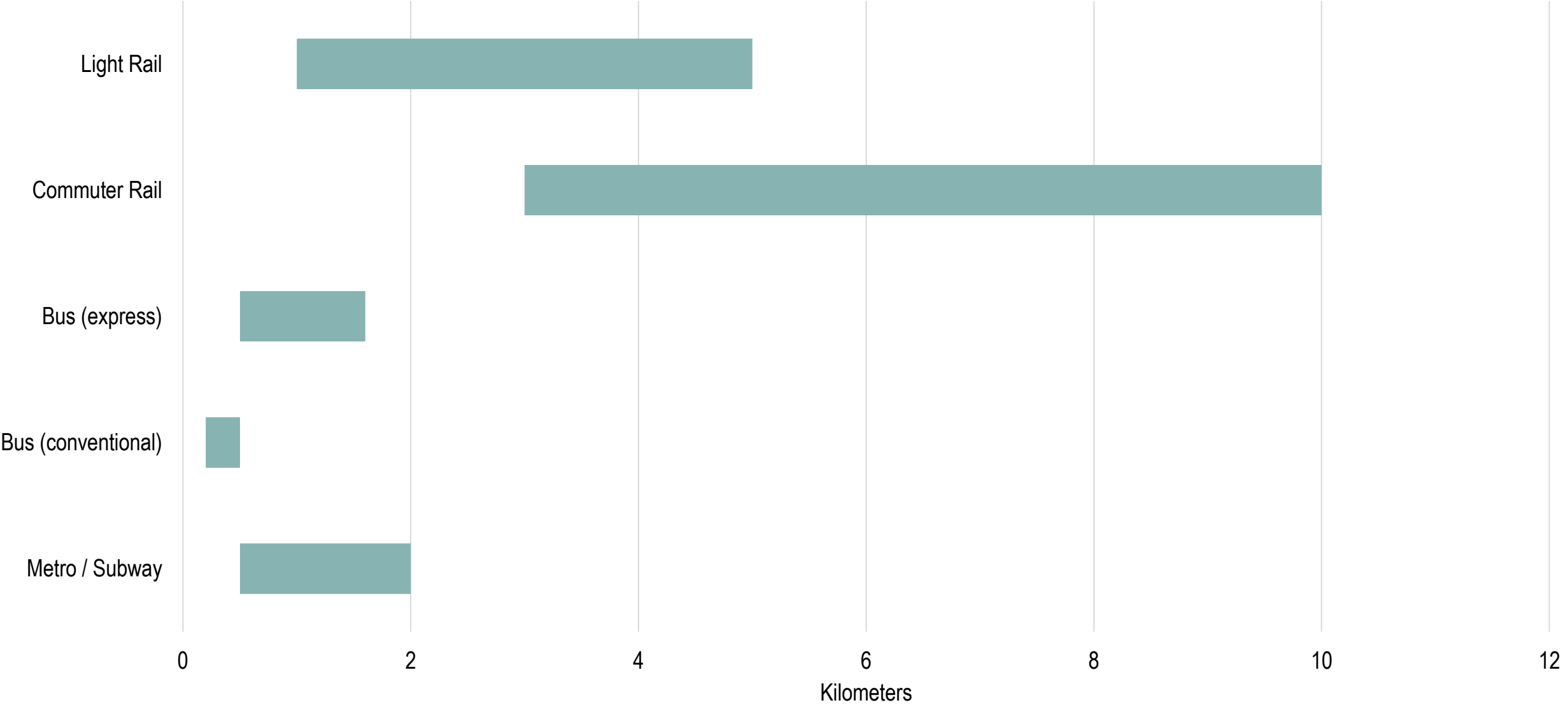
Mean Travel Time to Work for Selected American Cities (in minutes), 1980-1990



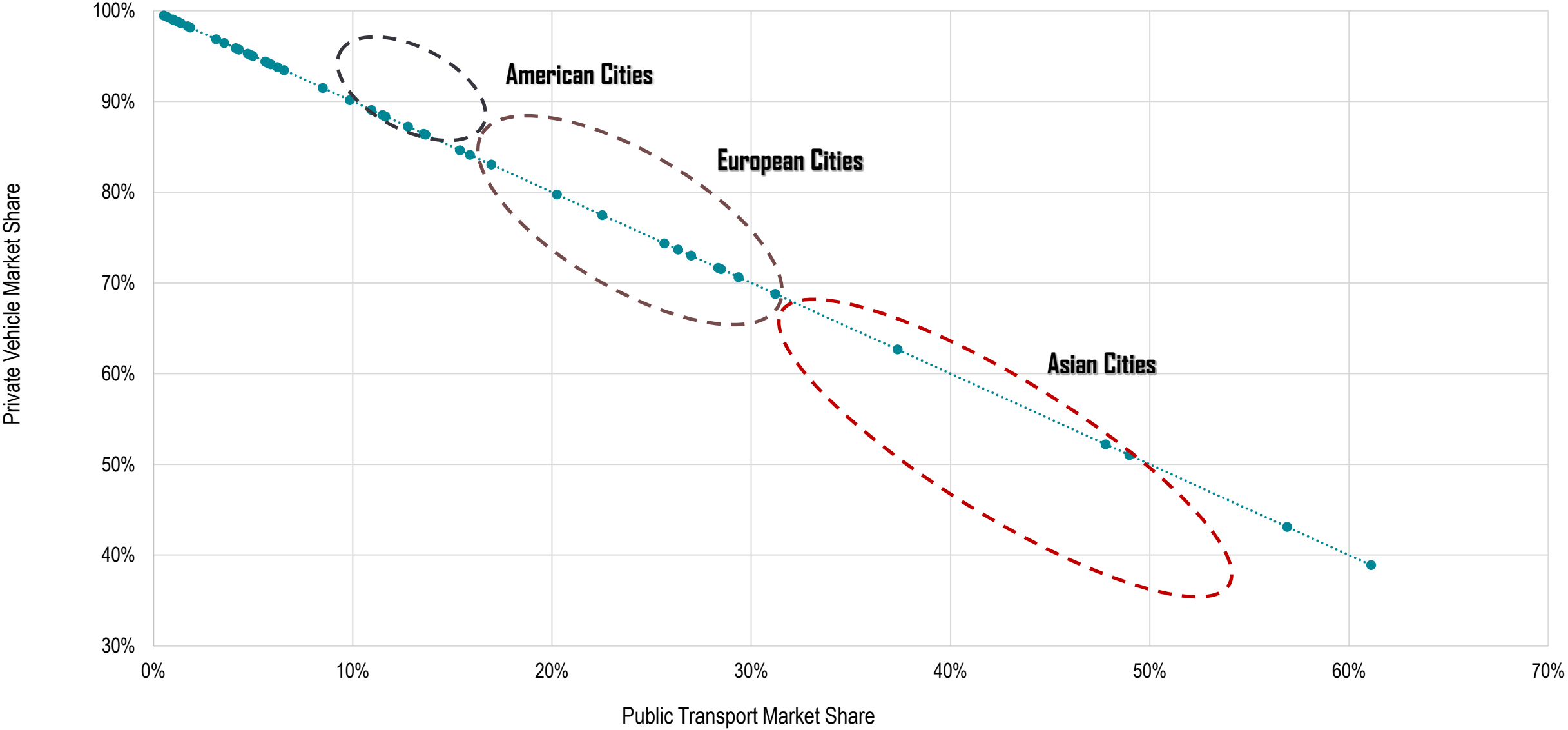
Components of an Urban Transit System



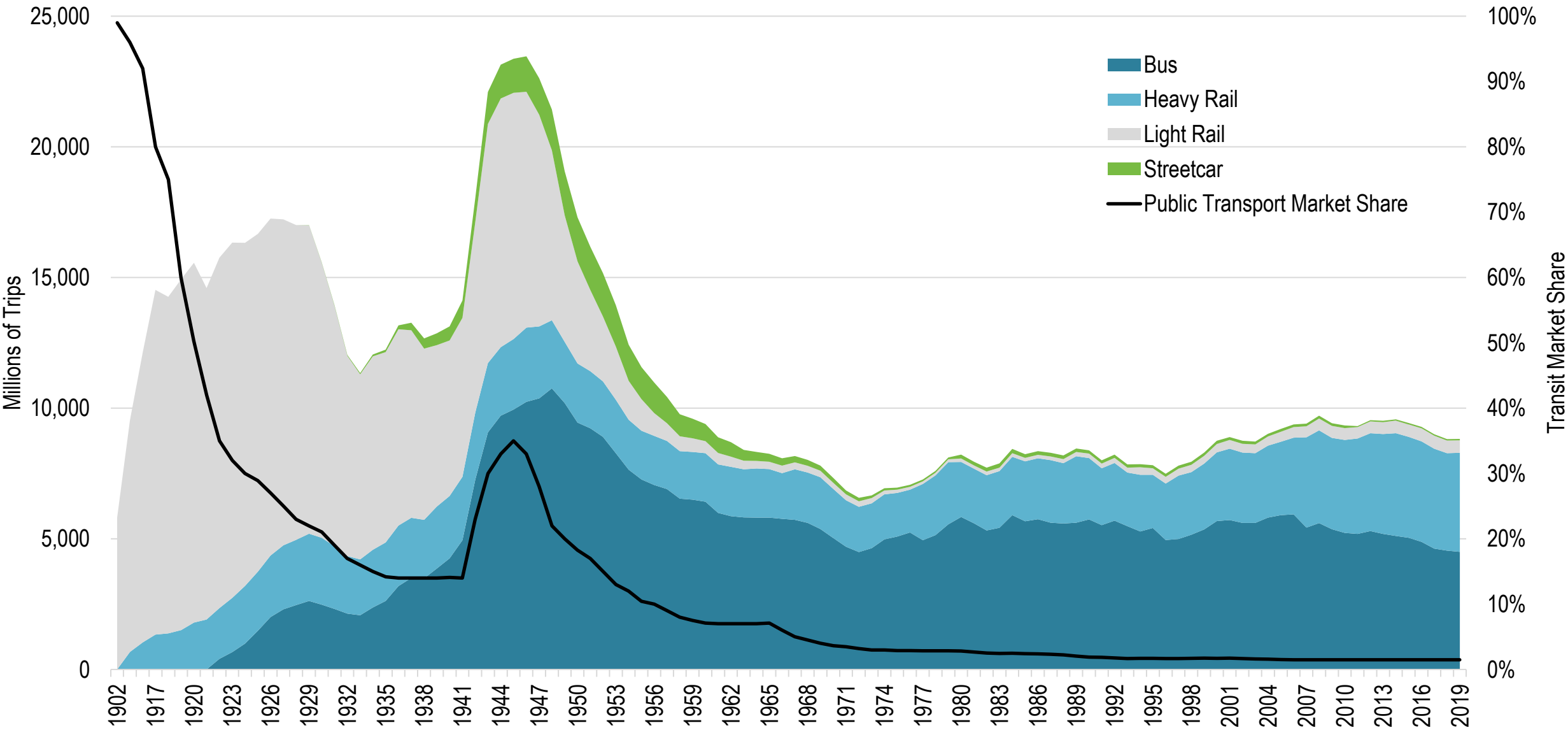
Distance between Access Points to Public Transit



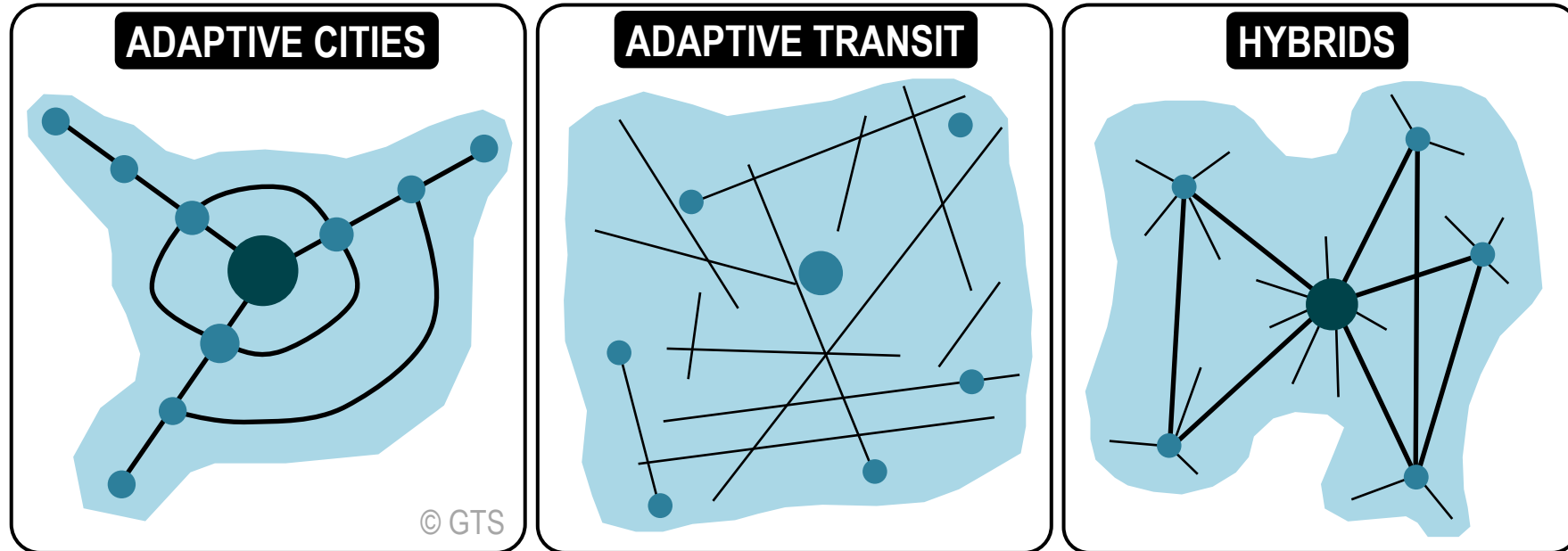
Private Vehicle and Public Transport Market Share, 1990/91



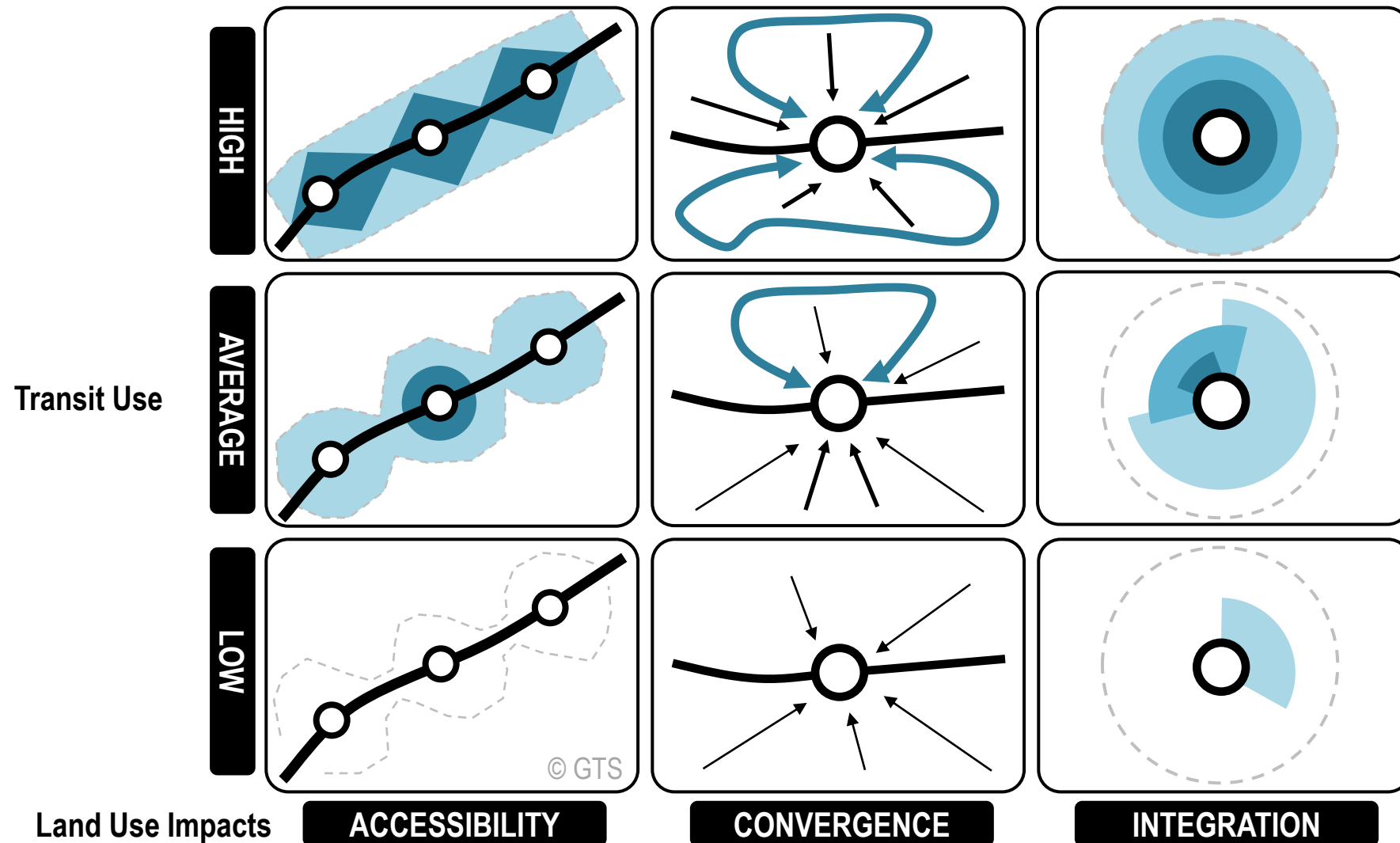
Trips by Public Transport in the United States, 1903-2019



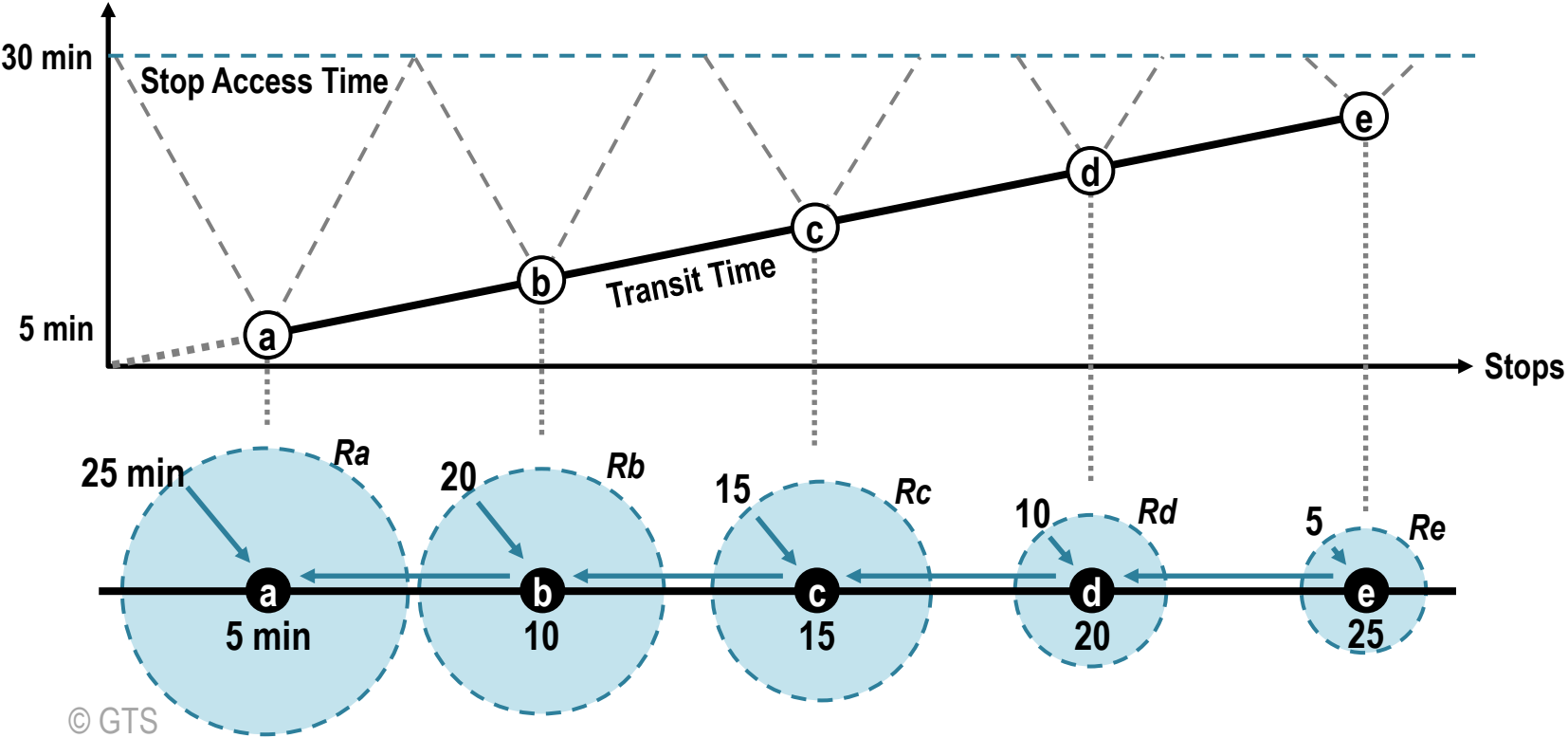
Transit and Urban Form



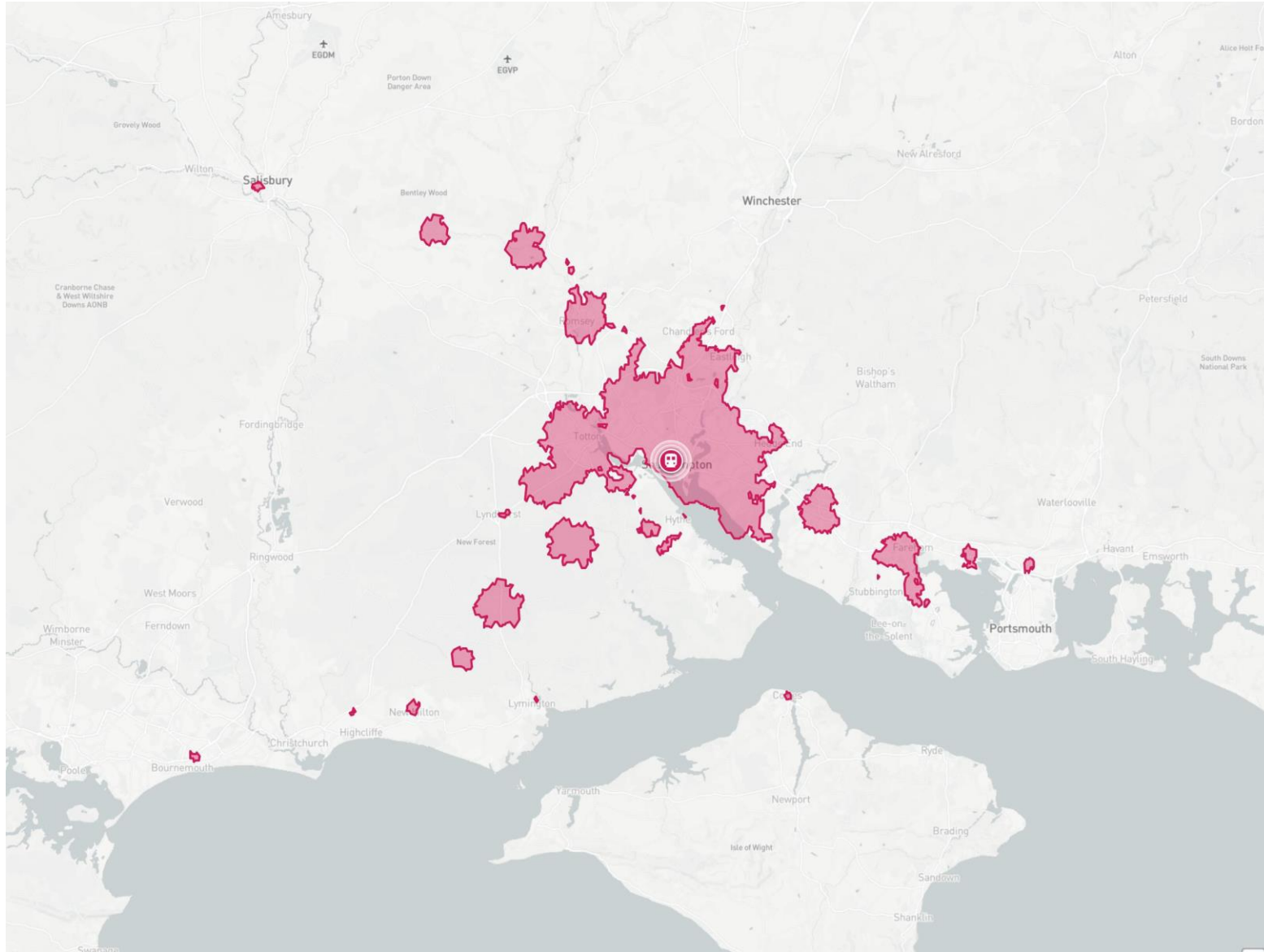
Transit and Urban Land Use Impacts



Accessibility along a Transit Line



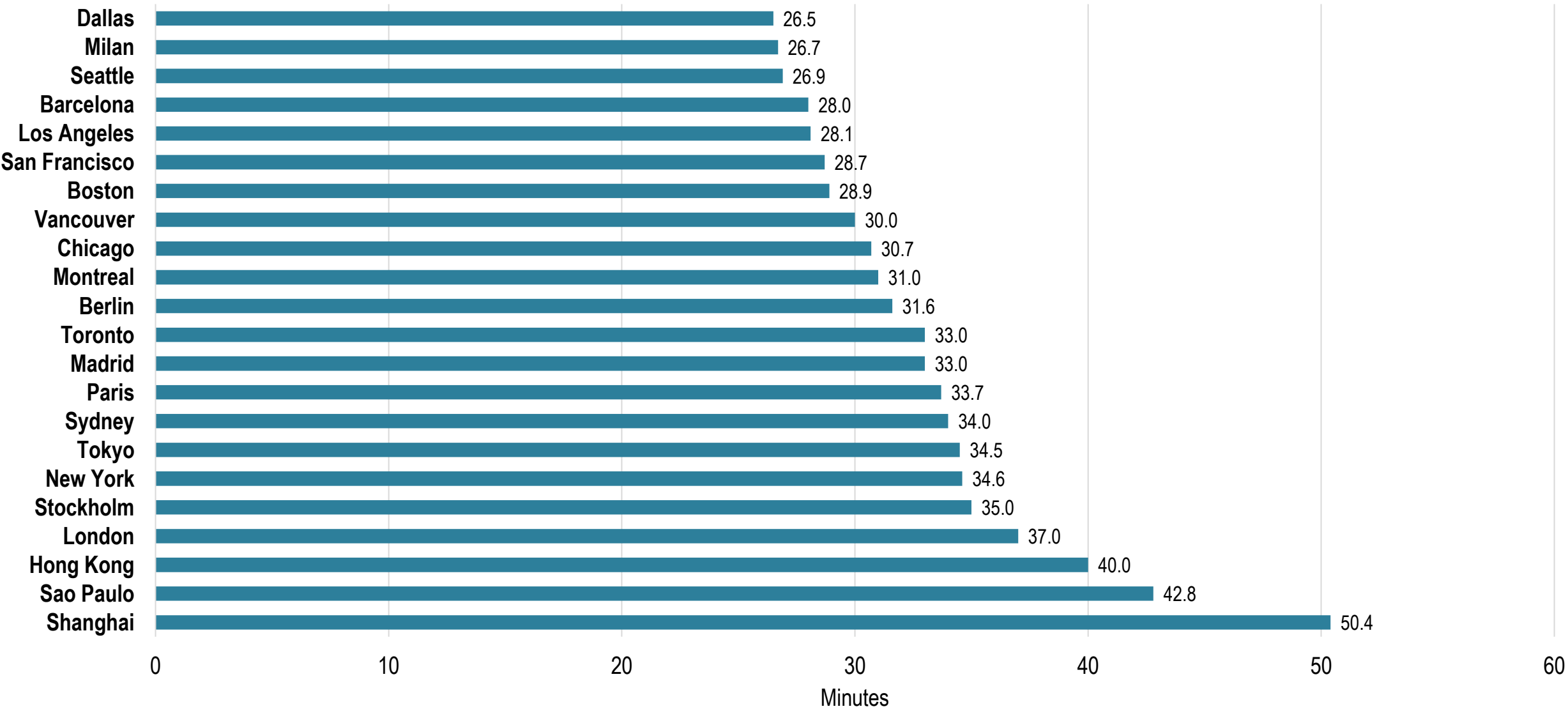
Areas Accessible to Southampton Central Station in less than 45 Minutes



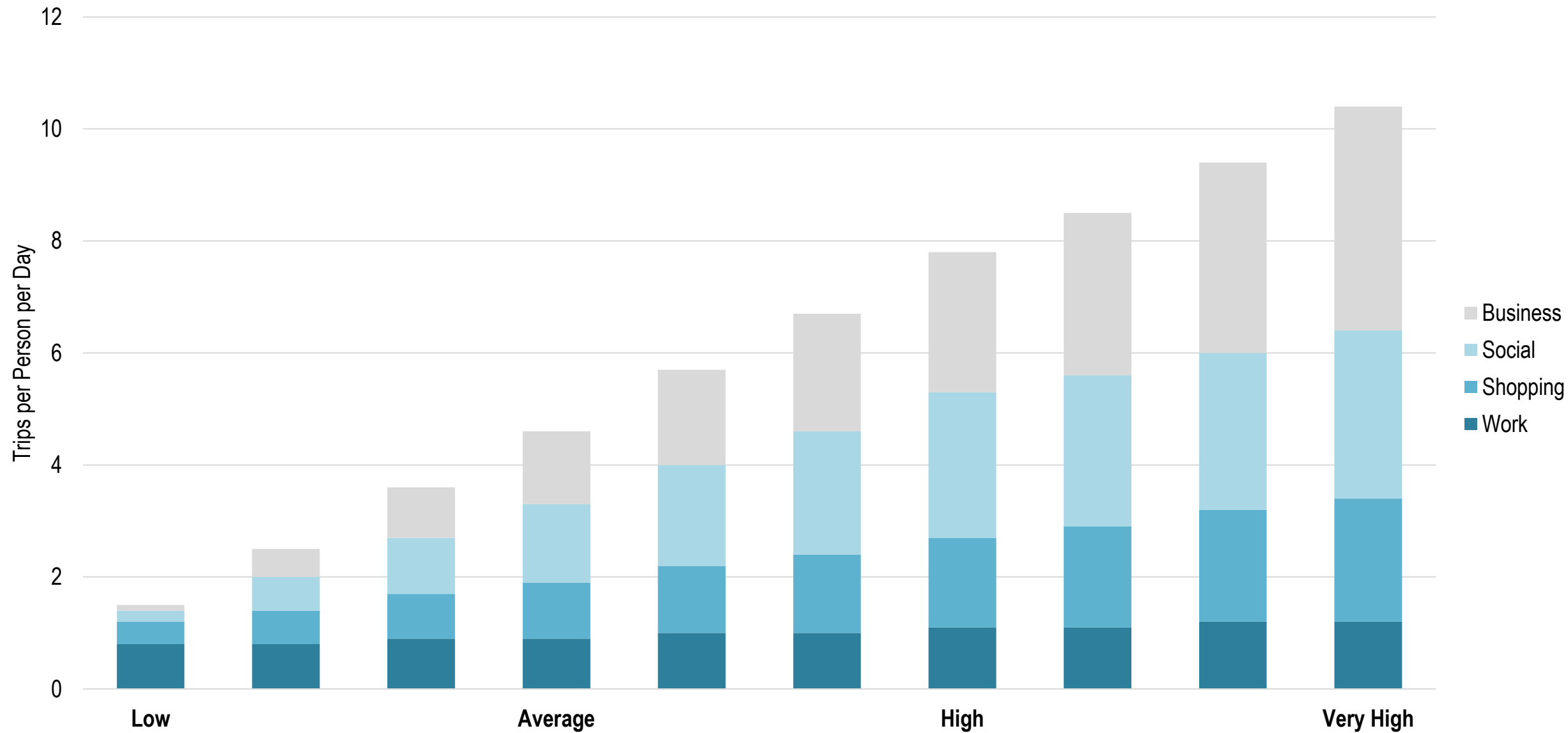
Types of Urban Movements

Movement Type	Pattern	Dominant Time	Destination
Pendular	Structured	Morning and afternoon	Localized (employment)
Professional	Varied	Workdays	Localized
Personal	Structured	Evening	Varied with some foci
Touristic	Seasonal	Day	Highly localized
Distribution	Structured	Nighttime / Early morning	Localized

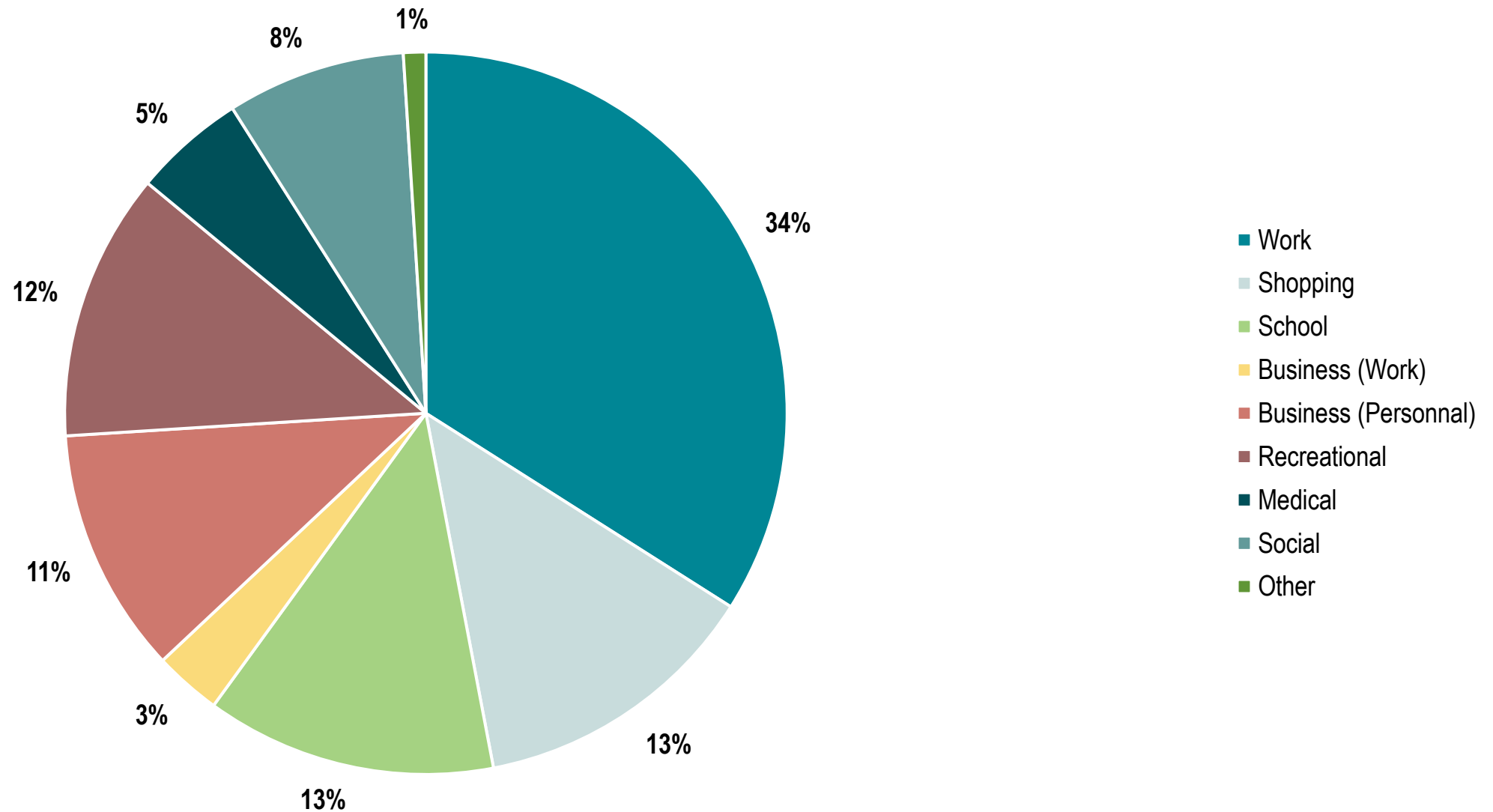
Average Commuting Time (One Way), Selected Metropolitan Areas



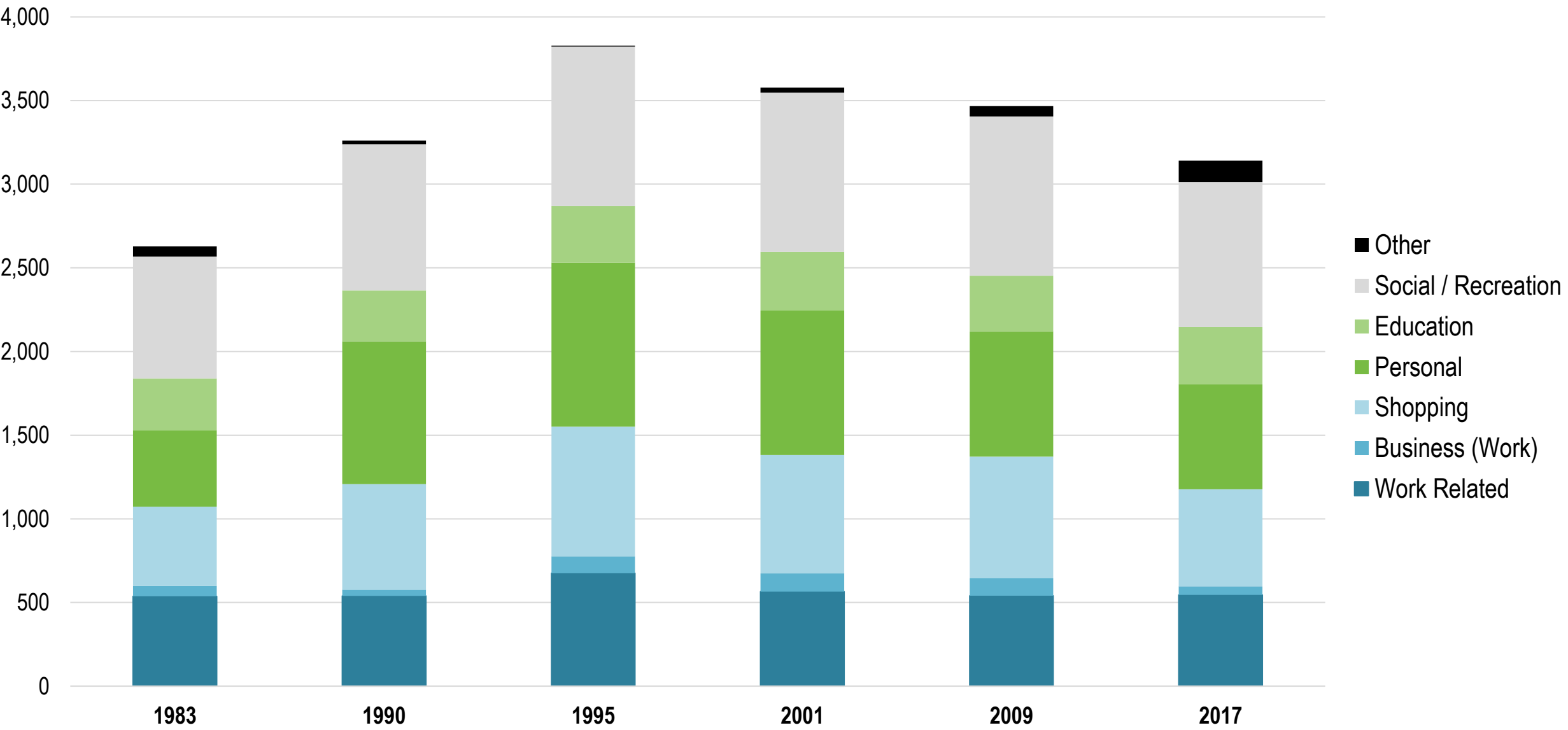
Income and Urban Transport Demand



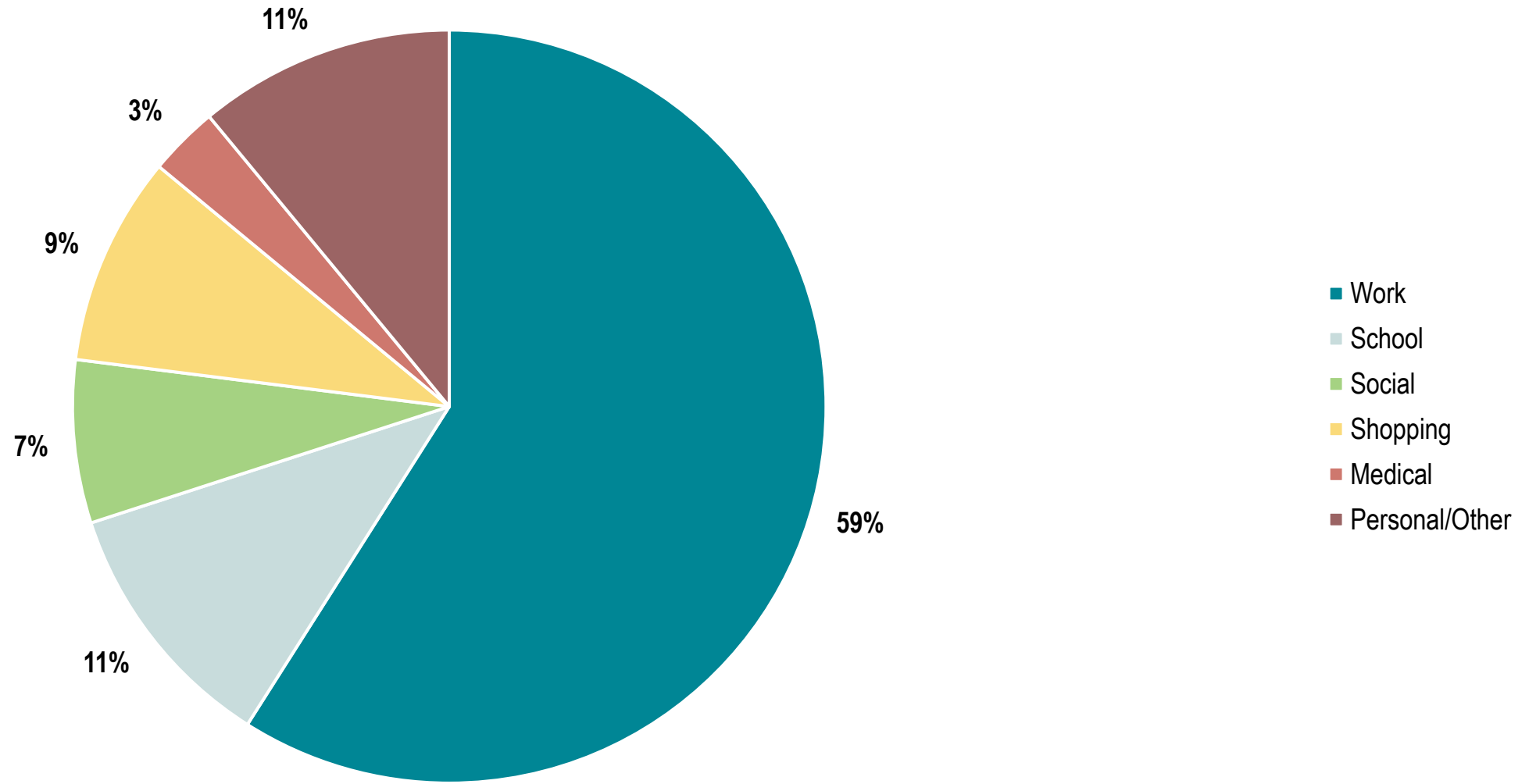
Main Purposes of Passenger Trips in the United States, 2001



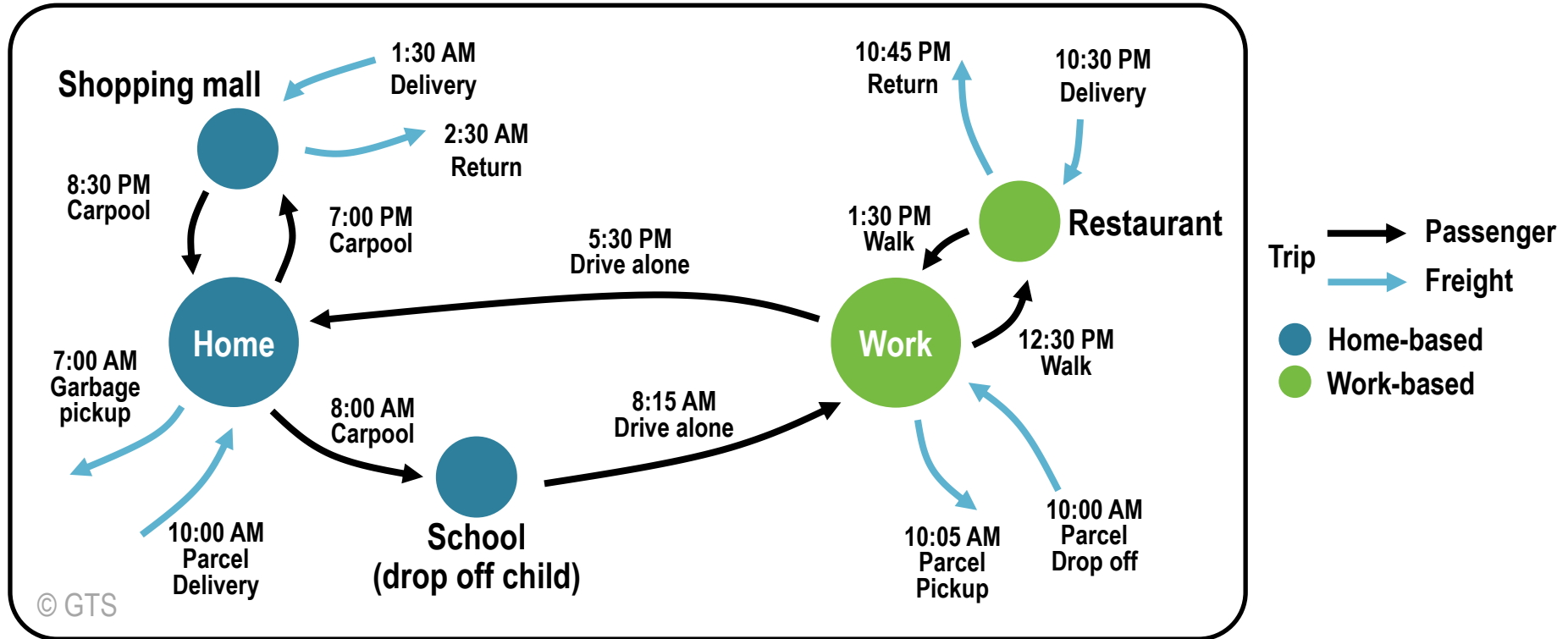
Average Annual Person Trips per Household by Trip Purpose, United States, 1983-2017



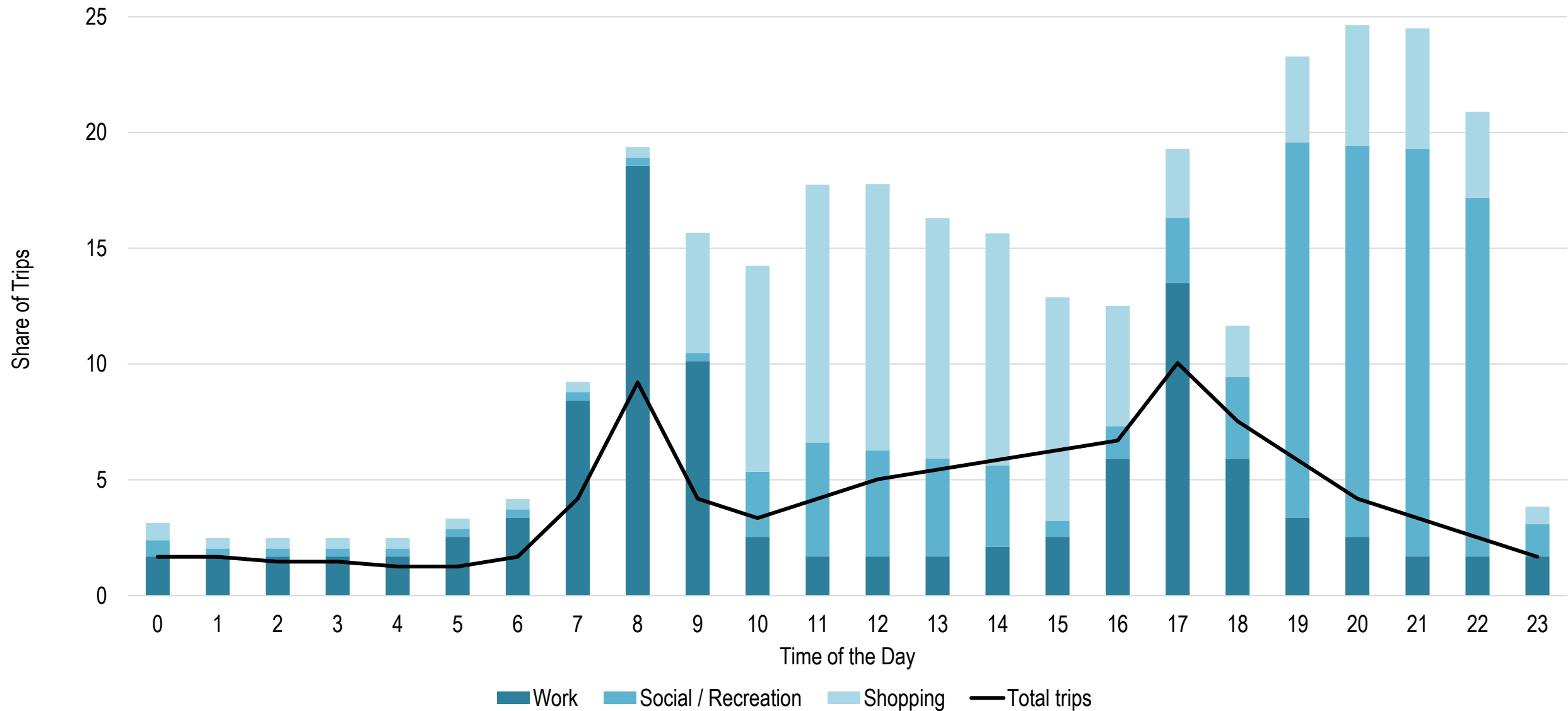
Main Purposes of Transit Trips in the United States, 2007



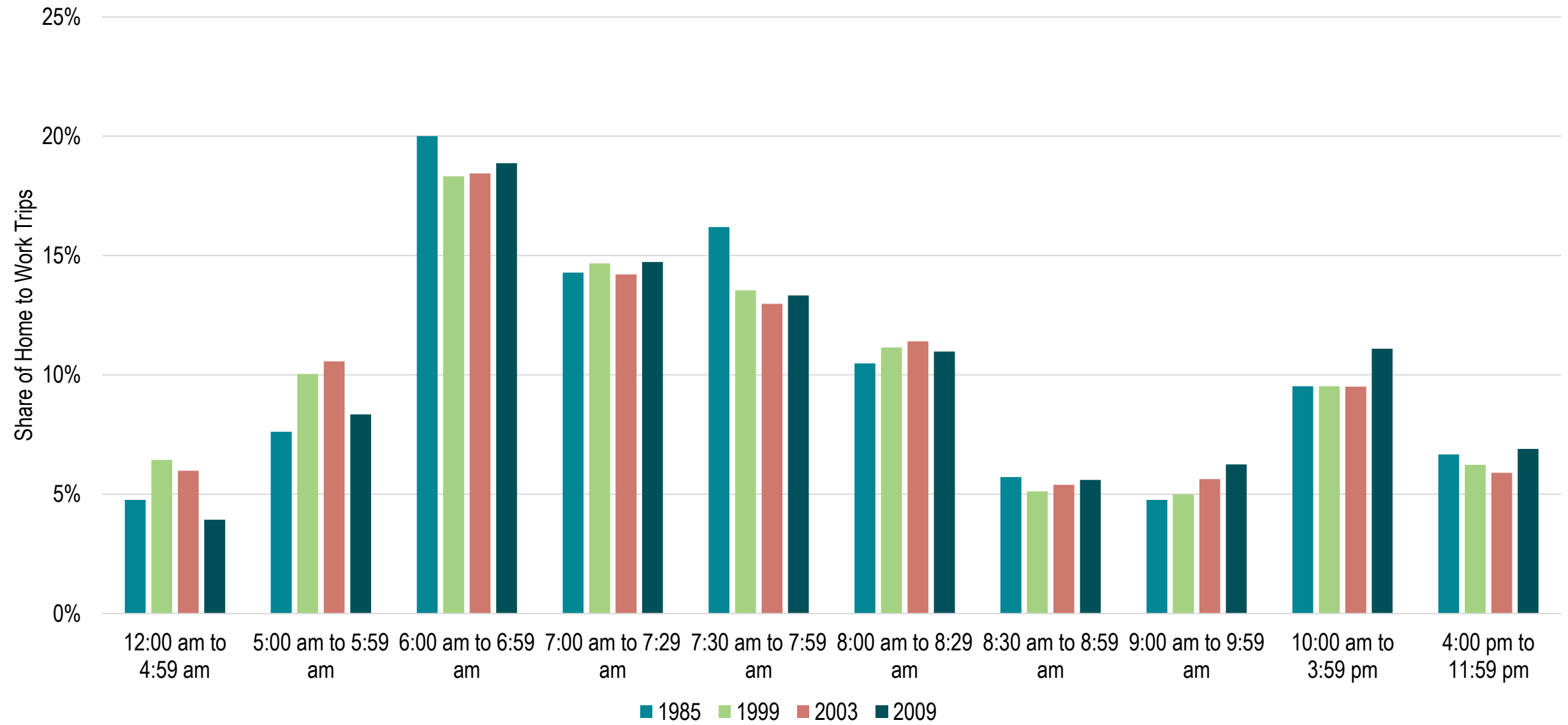
Typical Activity Space of an Urban Working Adult



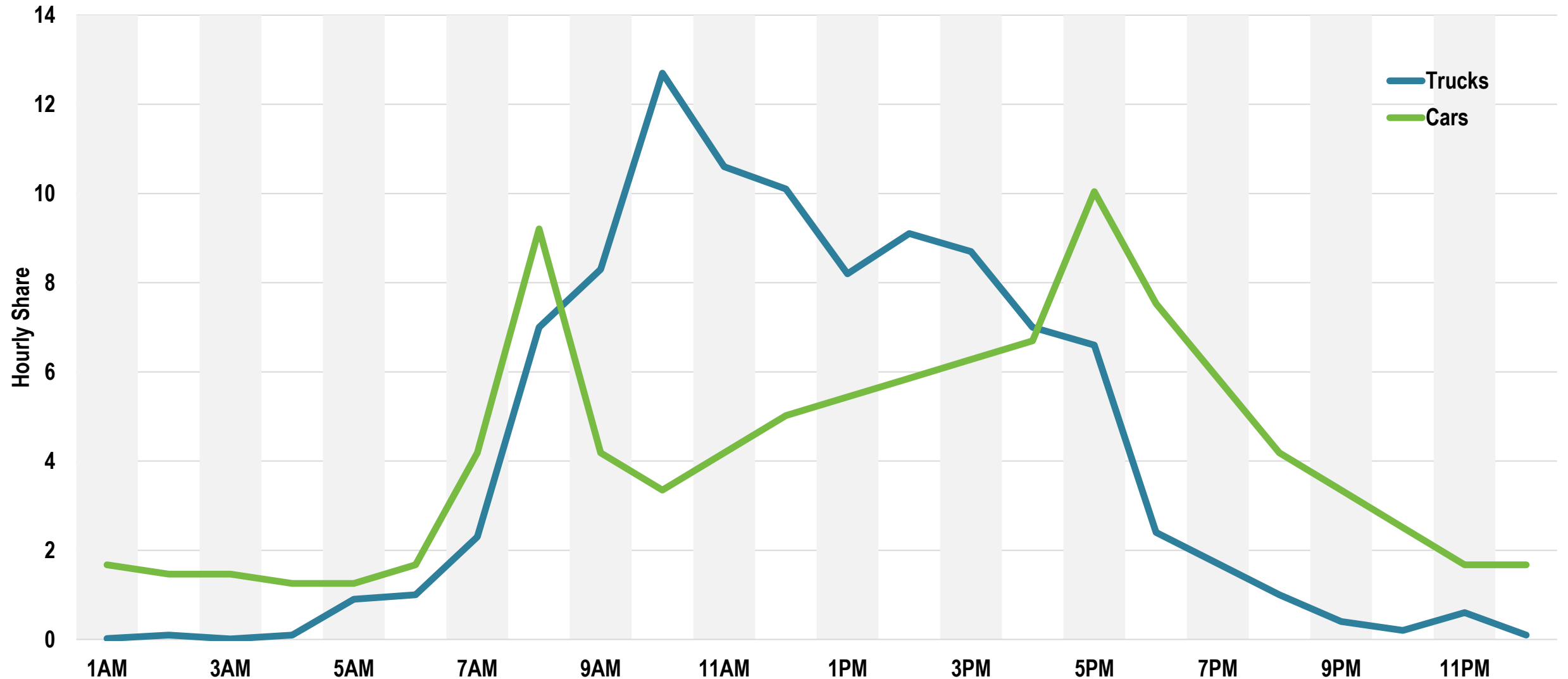
Urban Travel by Purpose and by Time of the Day in Typical City



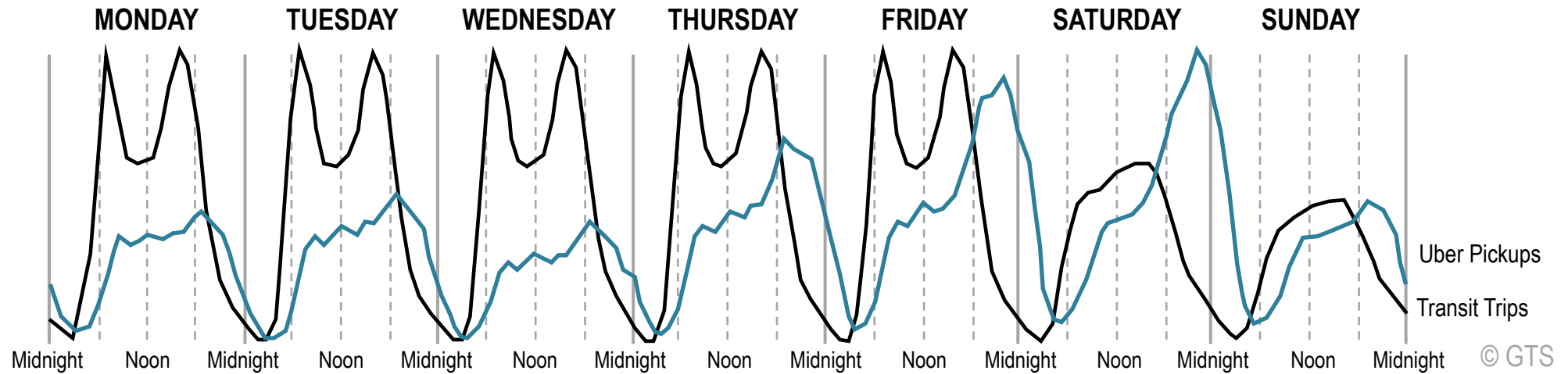
Time of Departure for Home to Work Trips, United States



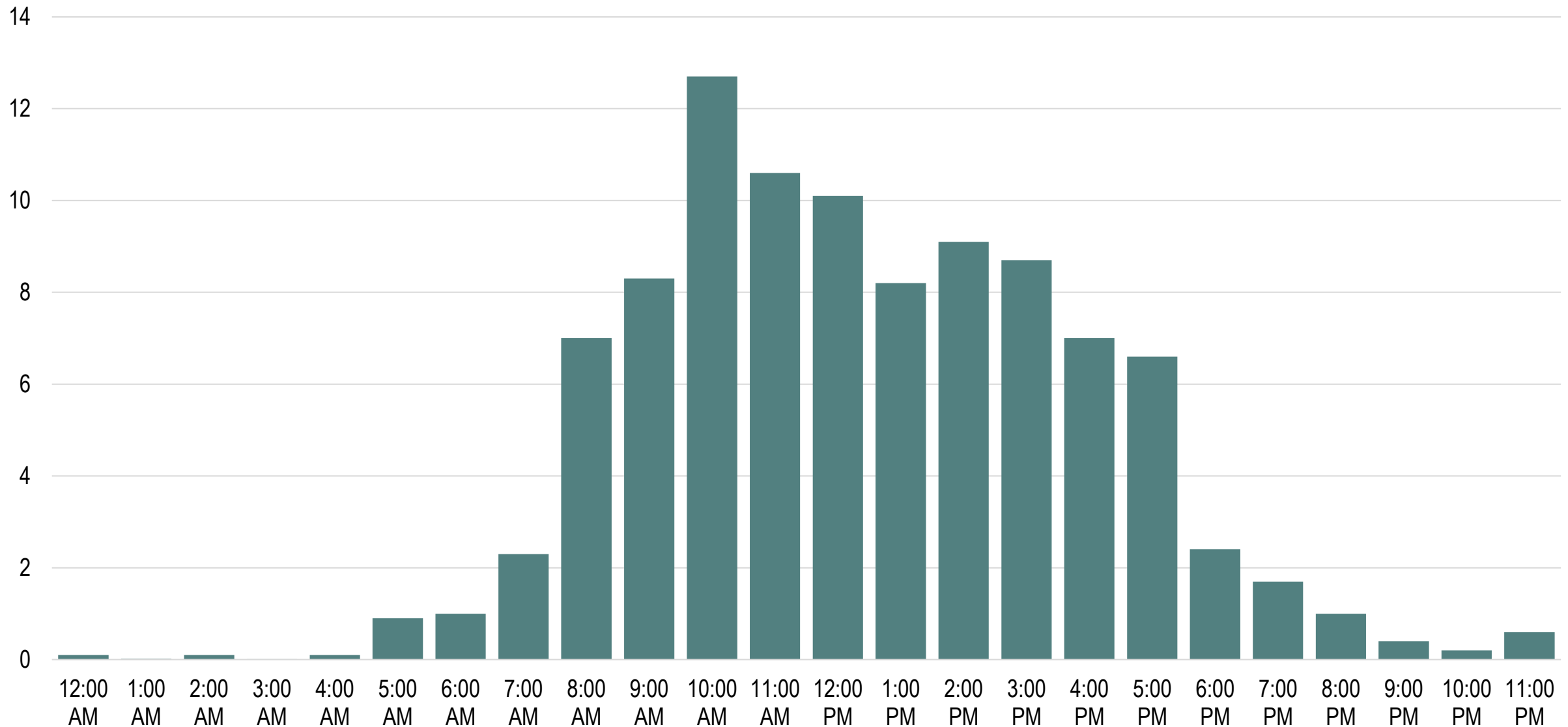
Typical Car and Truck Trips Distribution by Time of the Day



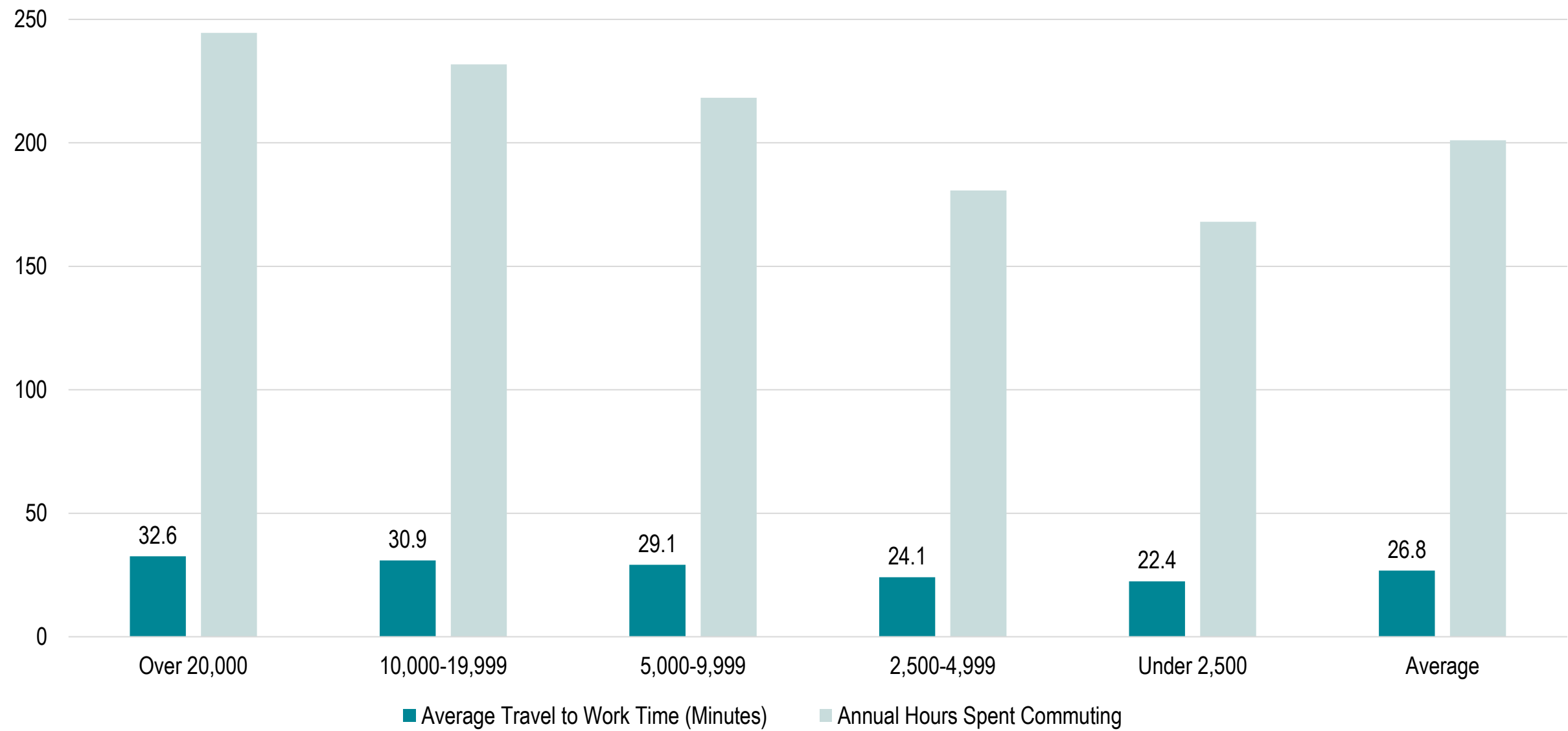
Weekly Distribution of Transit Scheduled Trips and Uber Pickups, Los Angeles



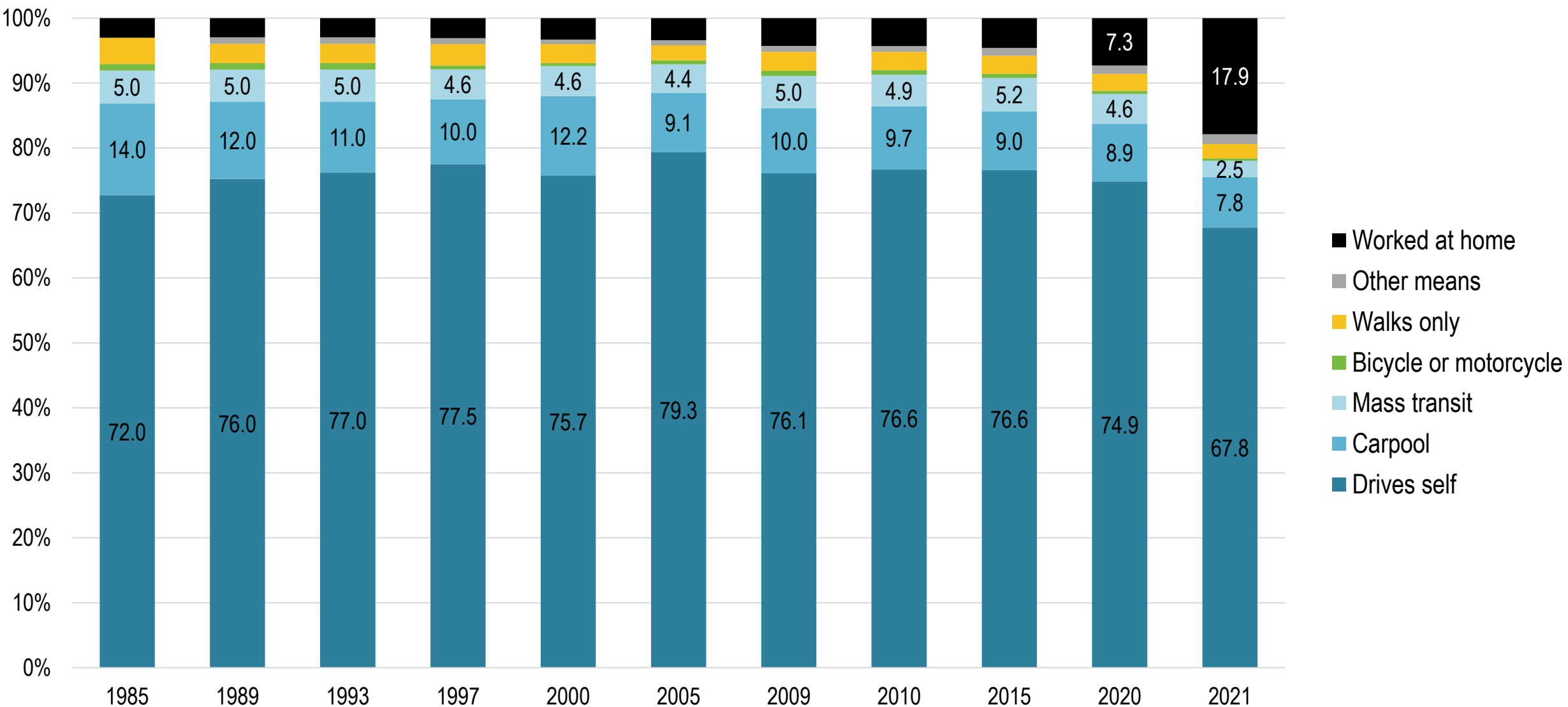
Typical Truck Trips Distribution by Time of the Day



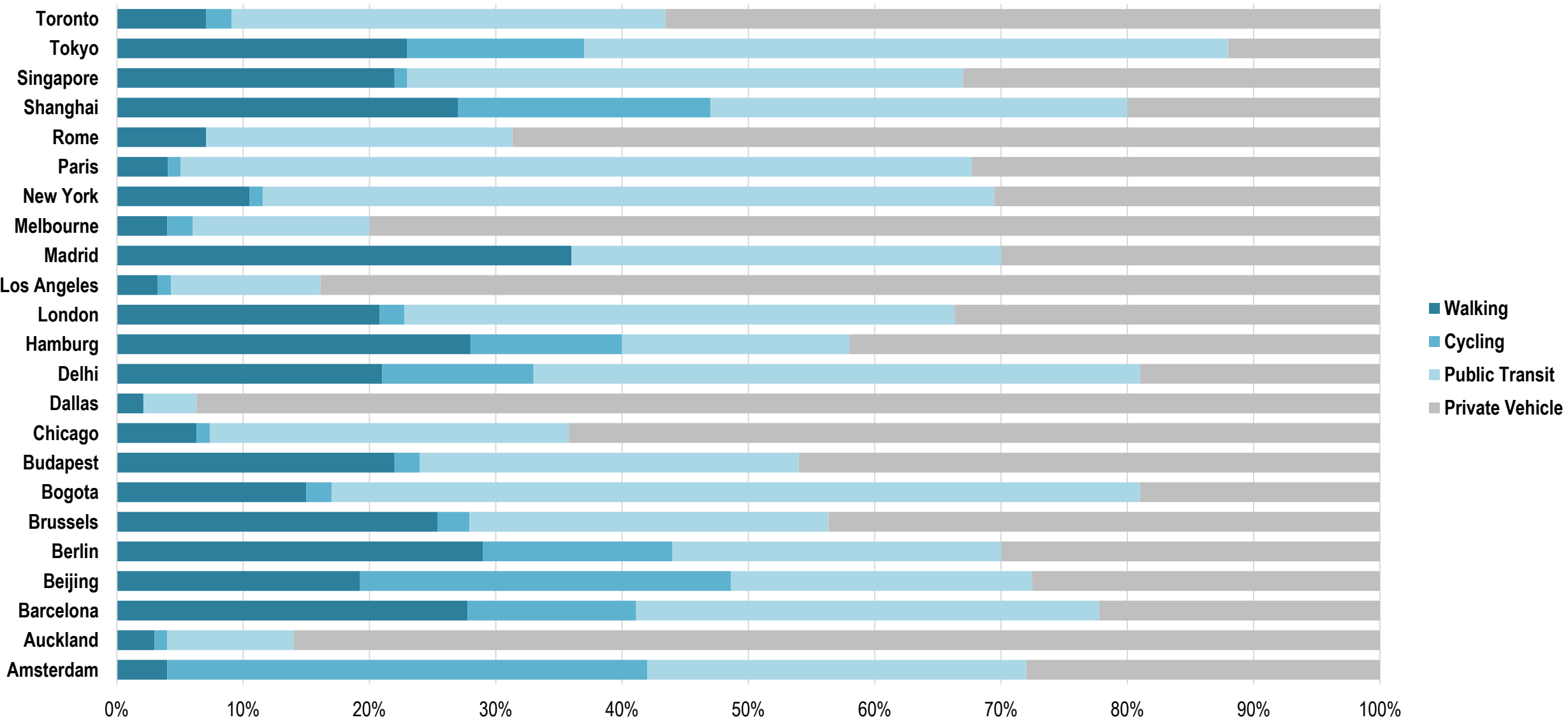
International Journey to Work Travel Times by Population Density, 1990



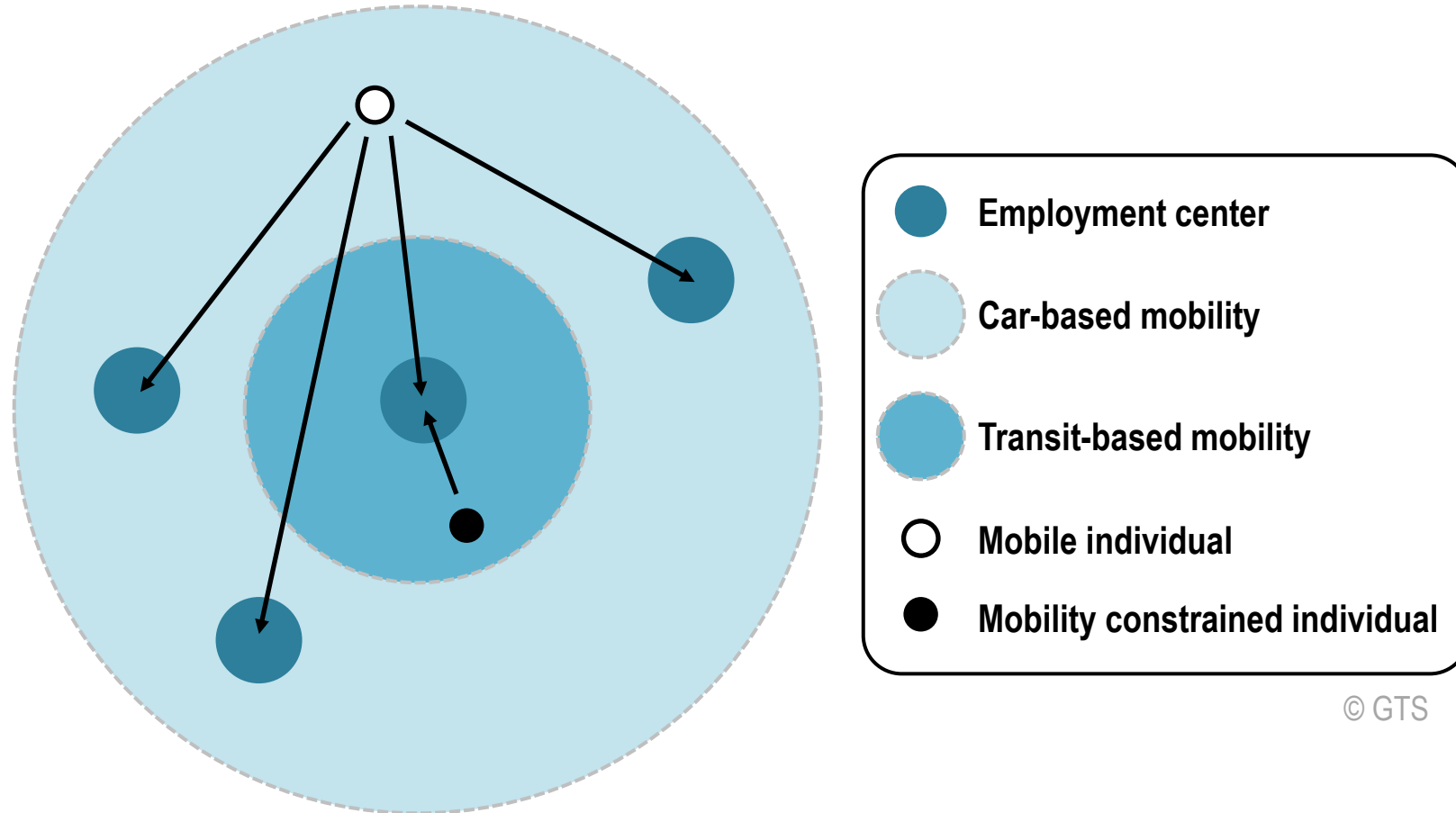
Home-to-Work Trips by Mode, United States, 1985-2021



Modal Split, Journey to Work Trips, Selected Cities

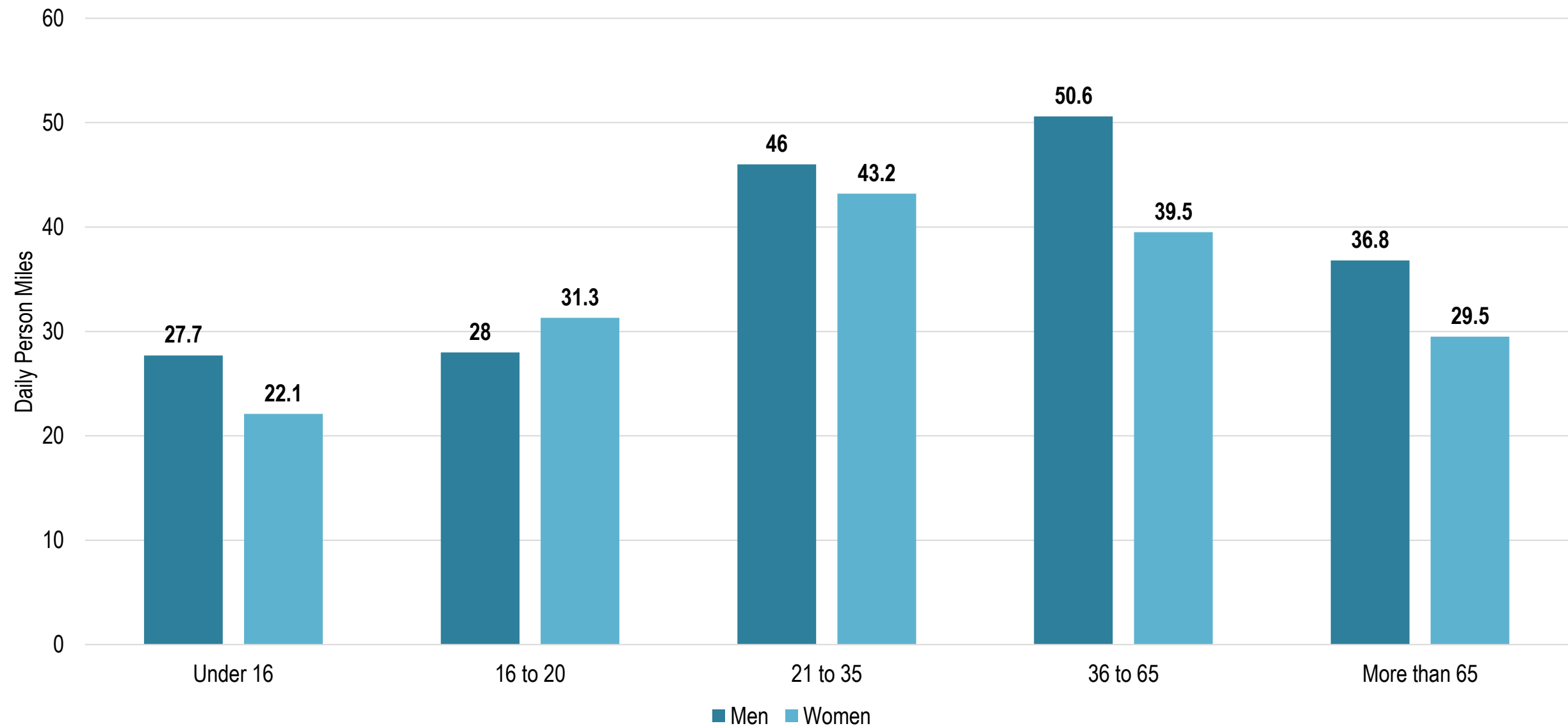


Mobility Gaps in Urban Areas

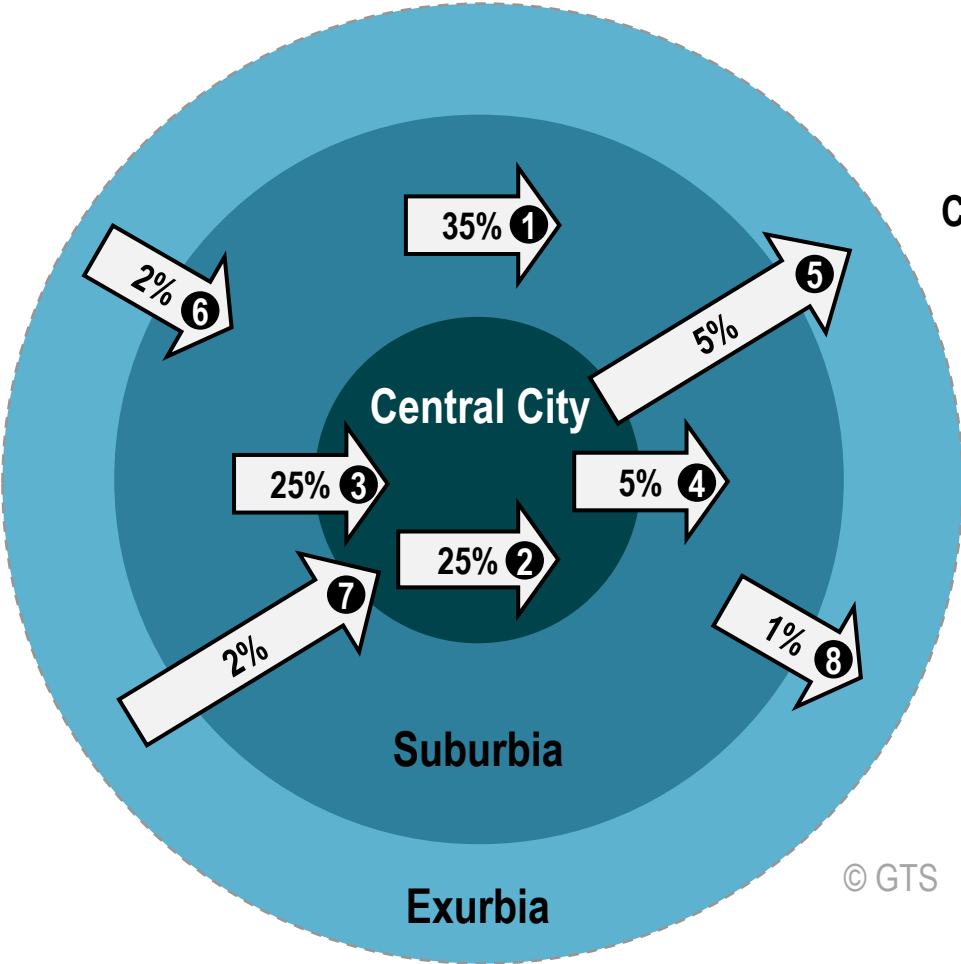


© GTS

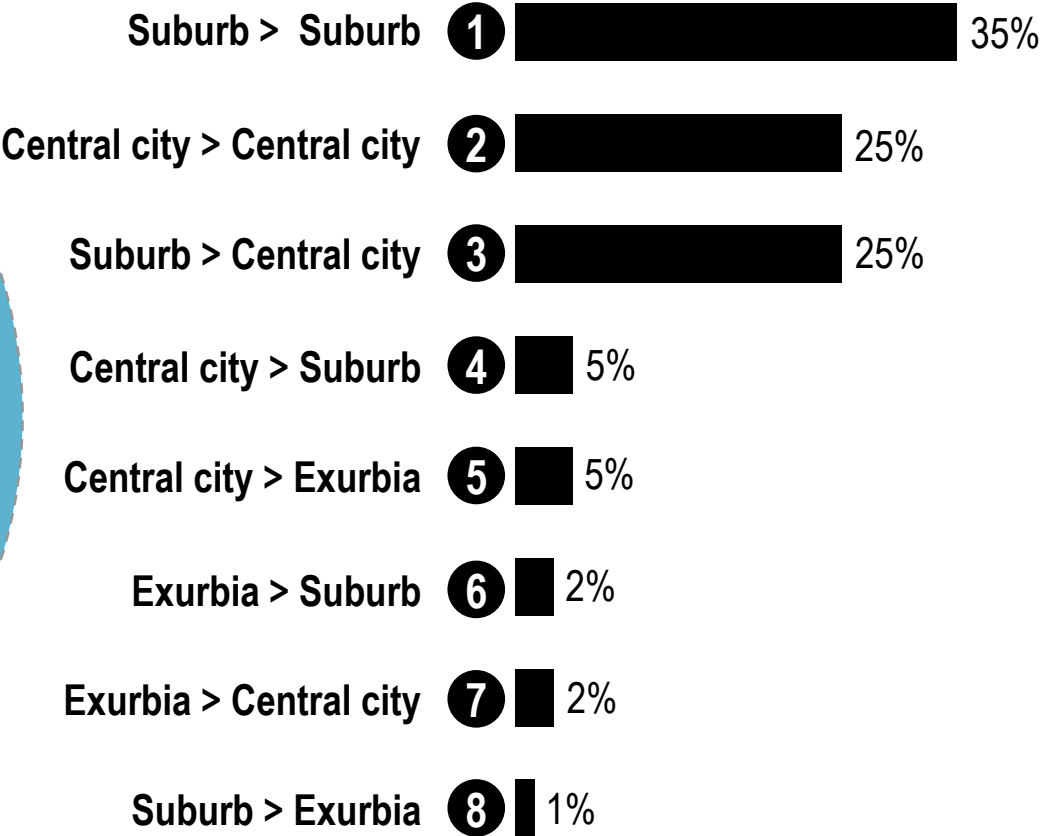
Daily Person Miles of Travel per Person by Age and Gender, 2017



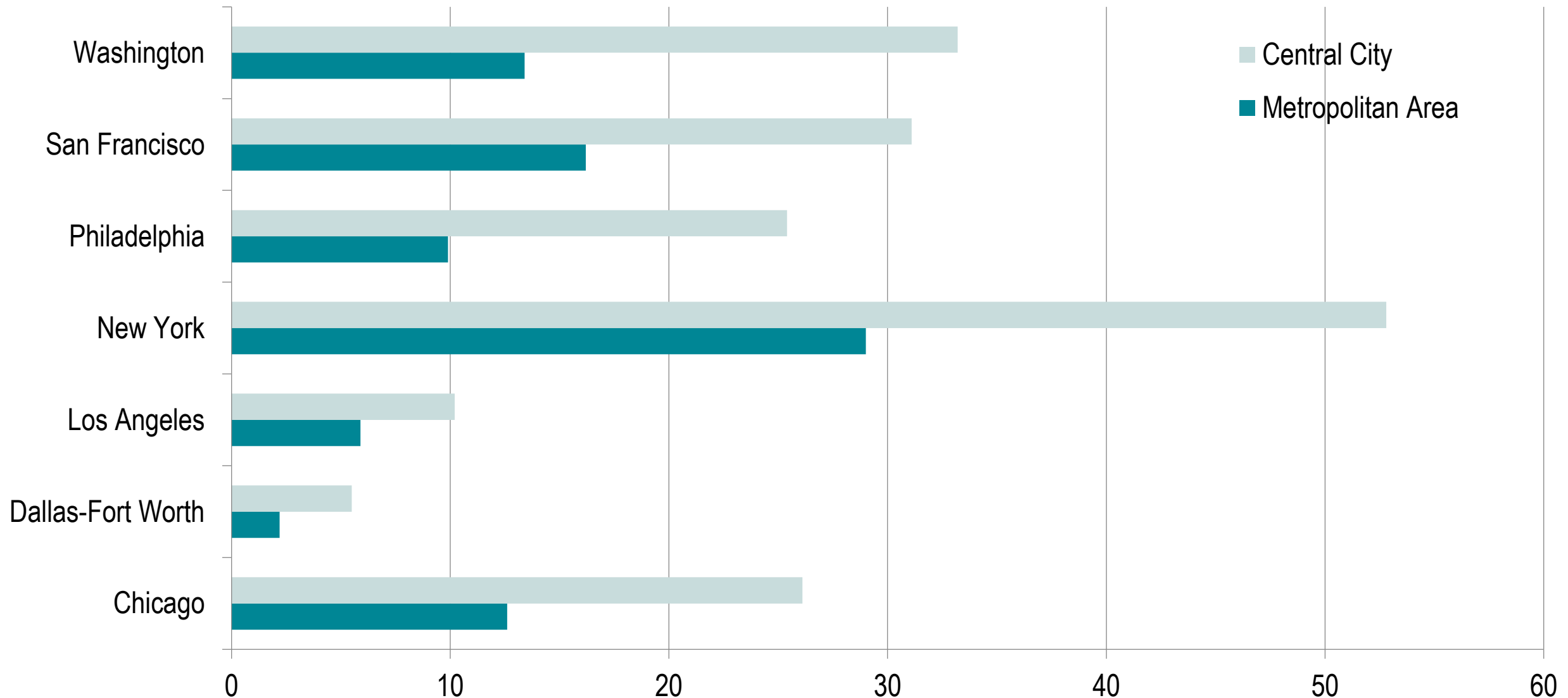
Work-Related Mobility in a Motorized City



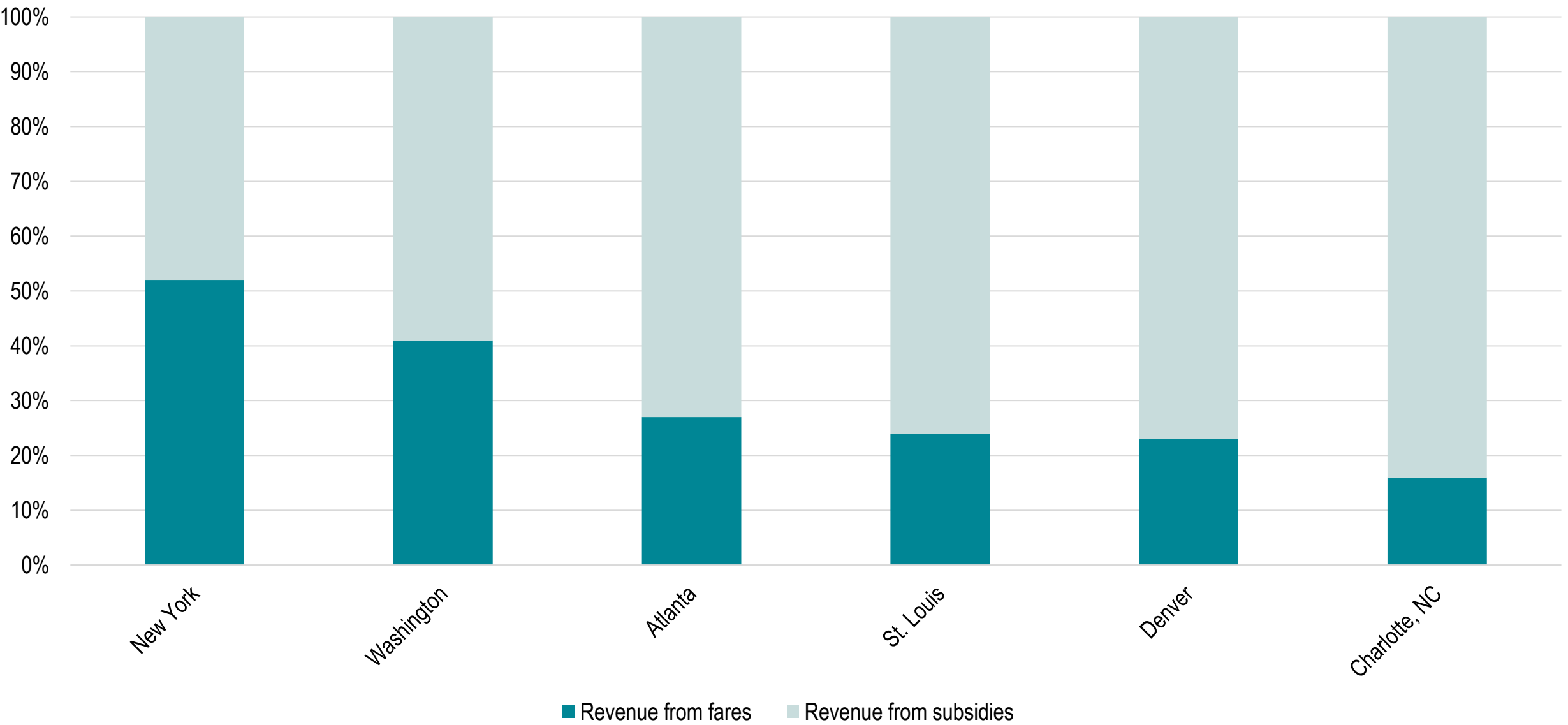
© GTS



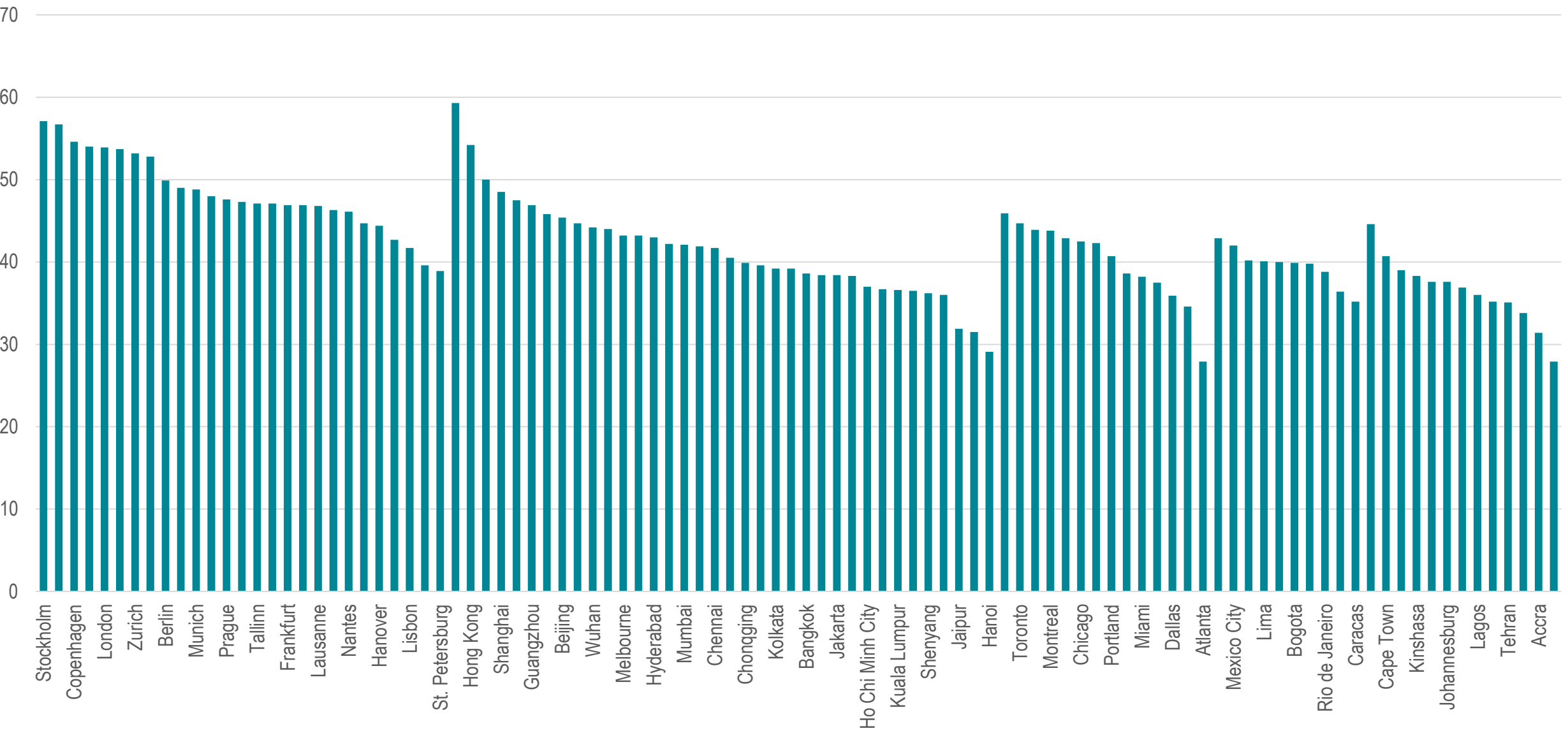
Percentage of Workers Using Public Transportation, Selected Urban Areas, 2000

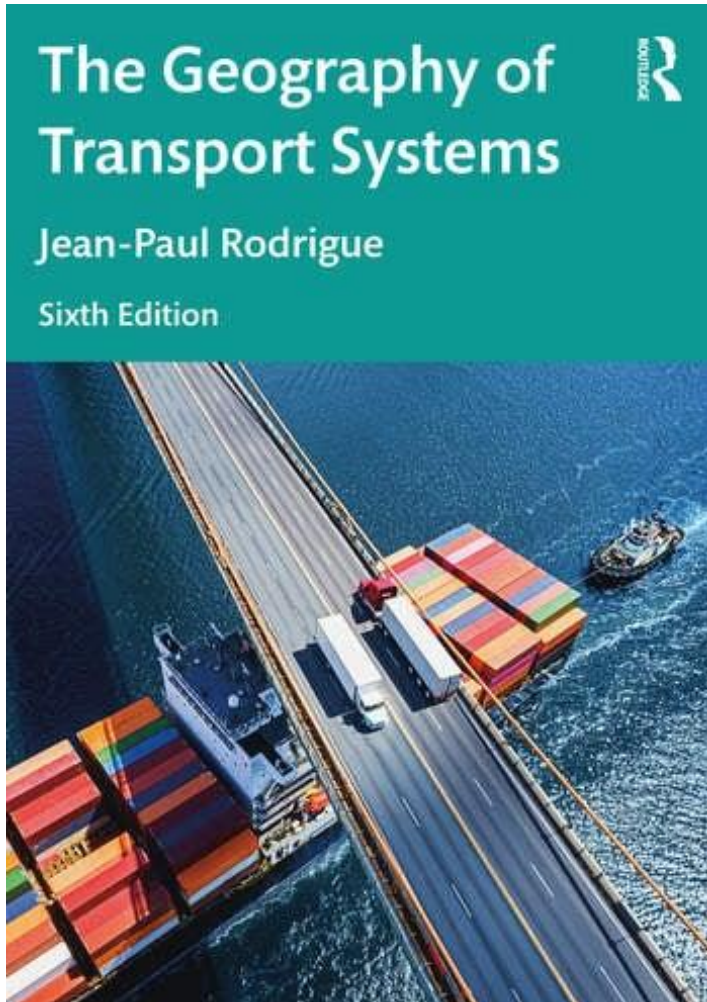


Source of Revenue for Some American Transit Systems, 2008



Urban Mobility Index, 2017





Urban Transport Challenges

Chapter 8.4

Common Tools for Mitigating Urban Road Congestion



Ramp metering



Traffic signal synchronization



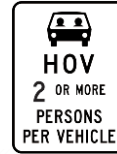
Incident management



Vehicle restrictions



Sharing vehicles



HOV lanes



Congestion pricing



Parking management



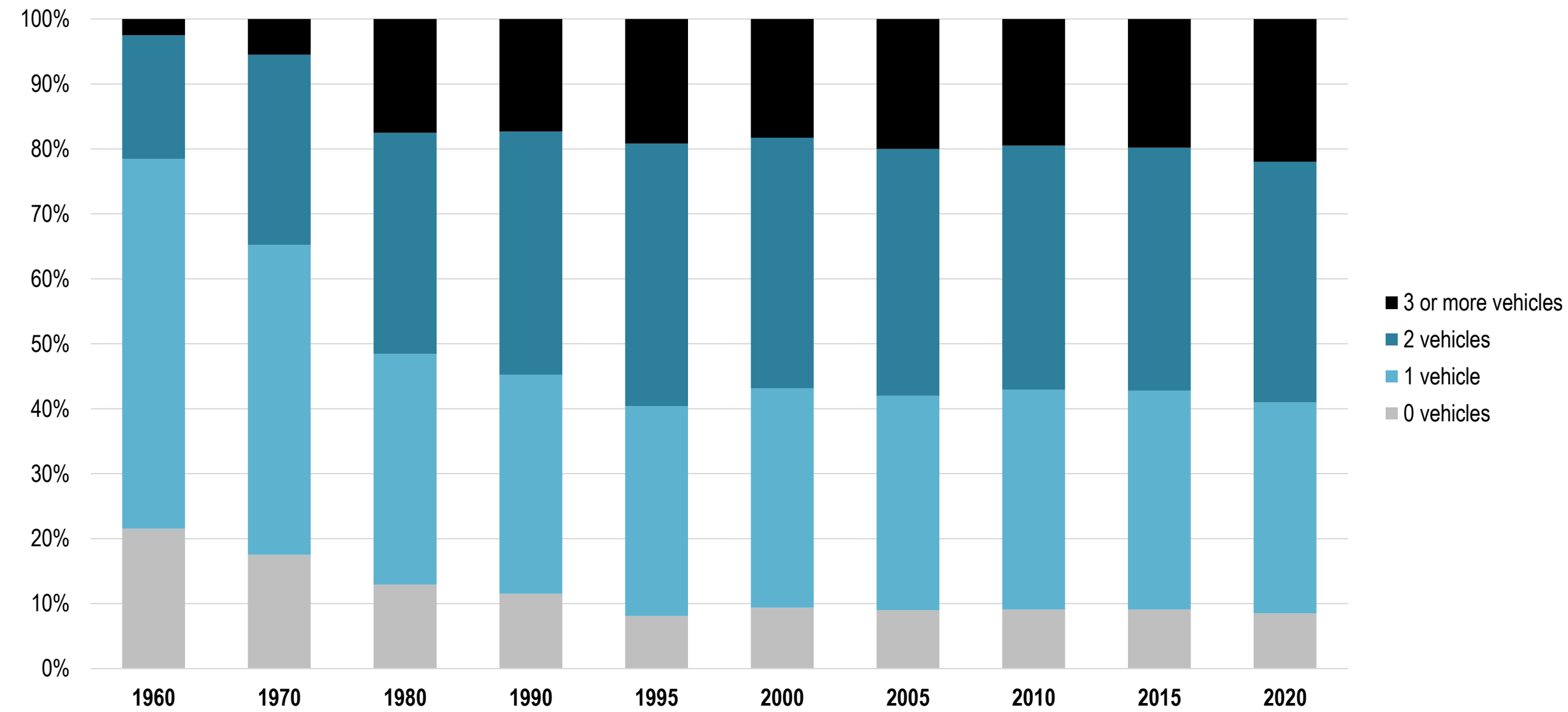
Public transit



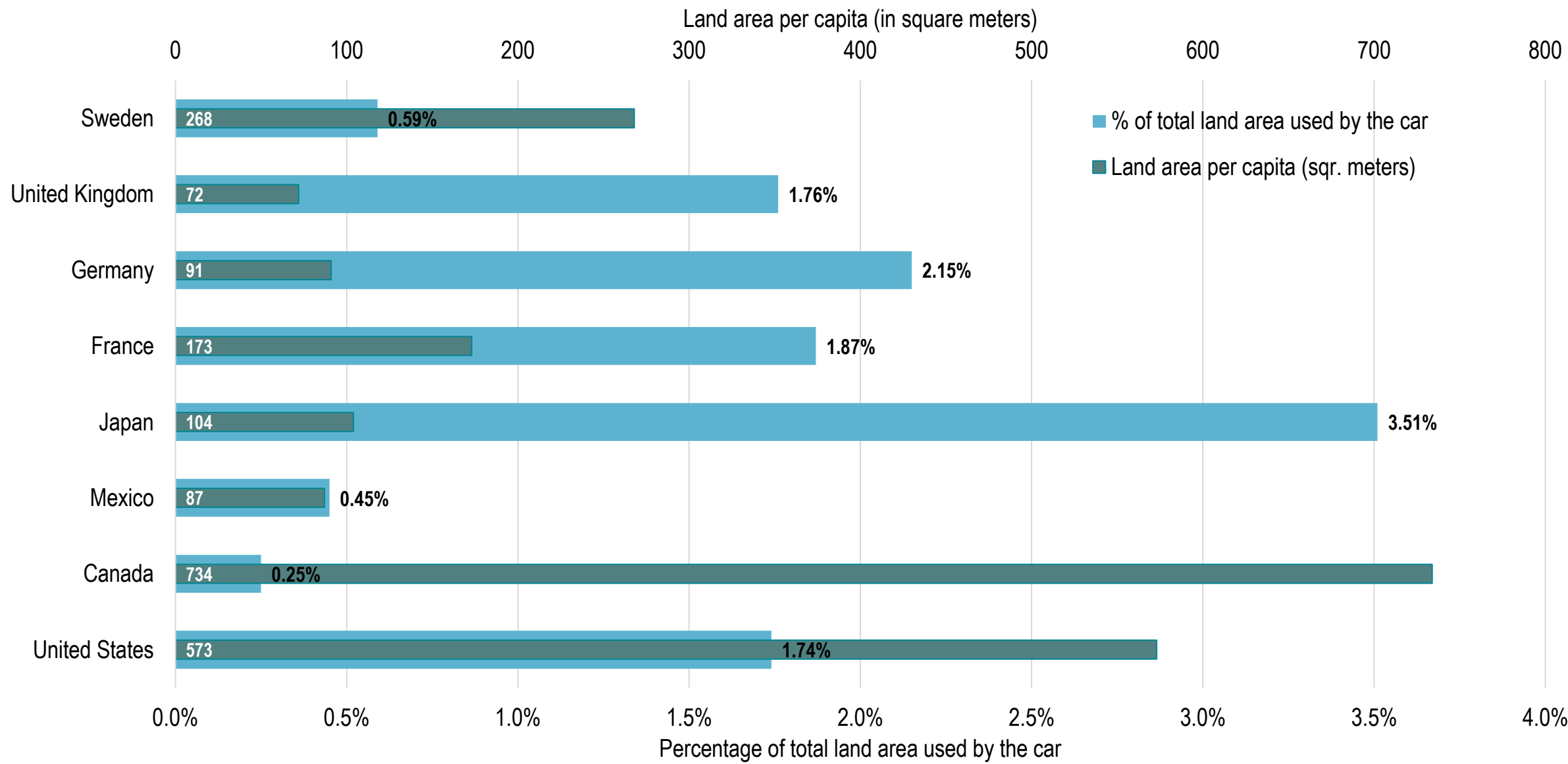
Micro-mobility

© GTS

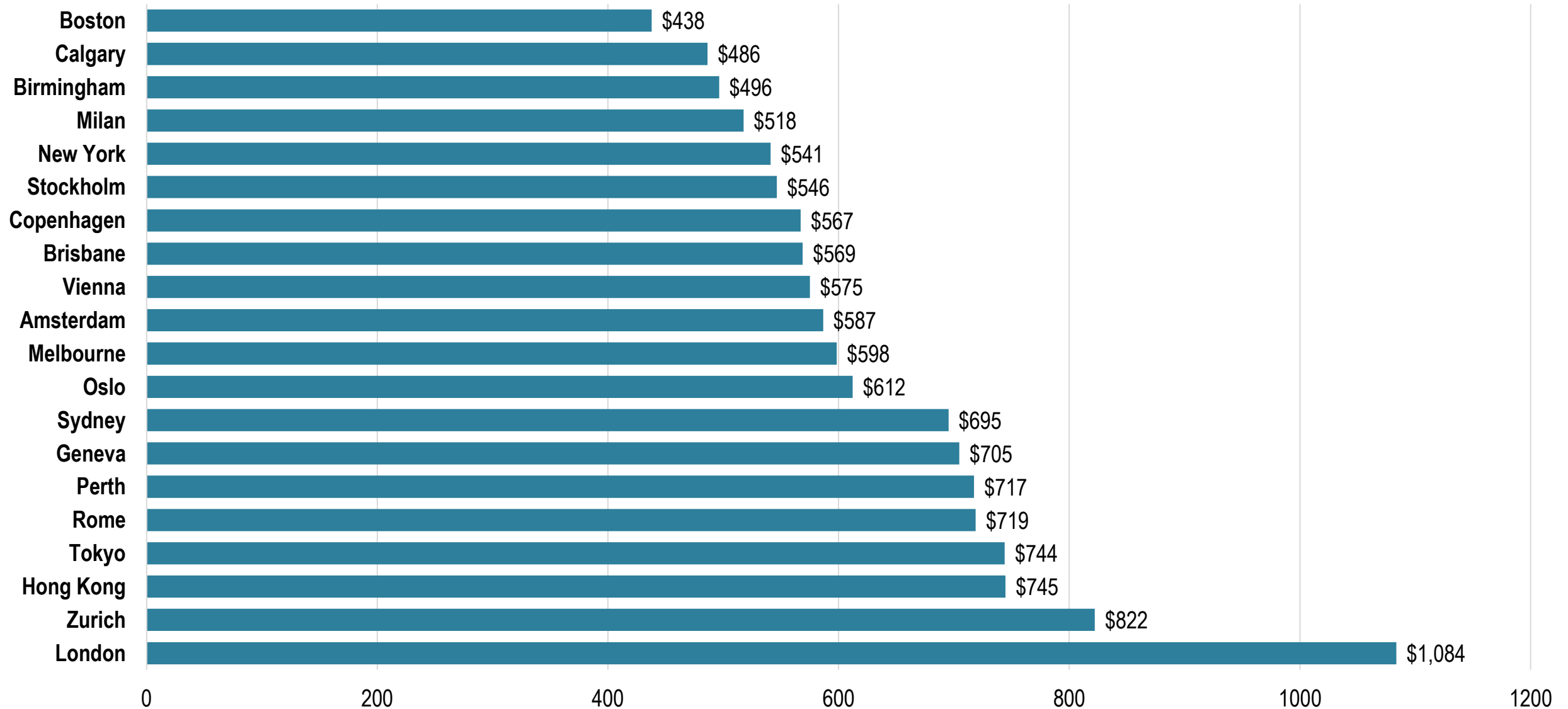
Percentage of Households by Number of Vehicles, 1960-2020



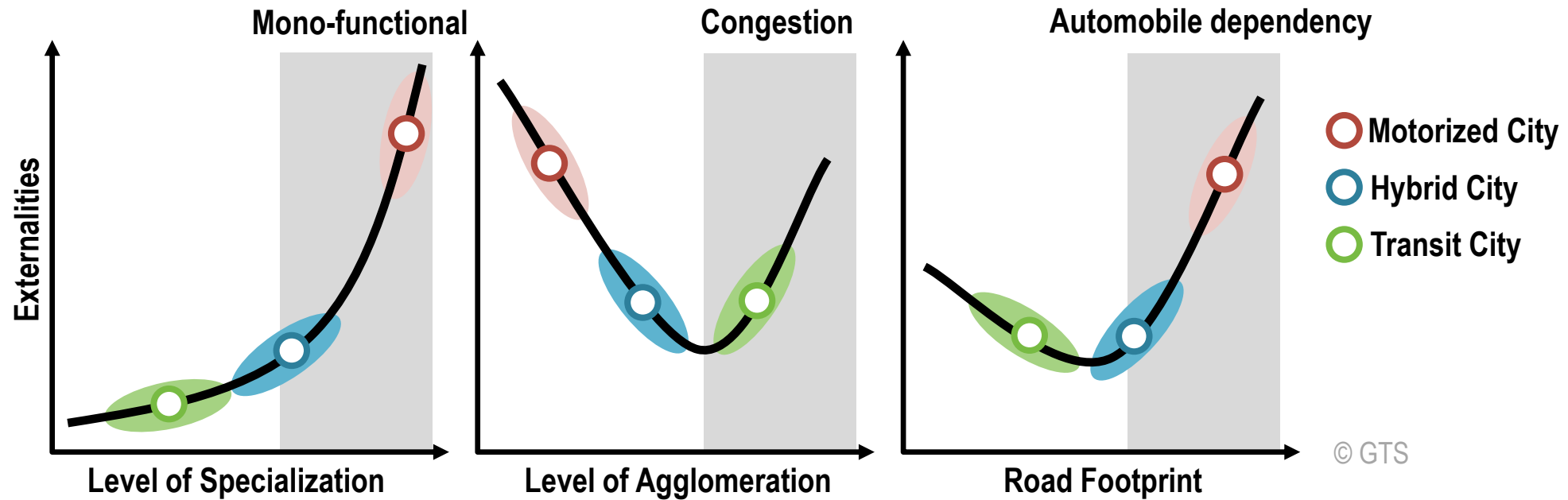
Land Area Consumed by the Car in Selected Countries, 1999



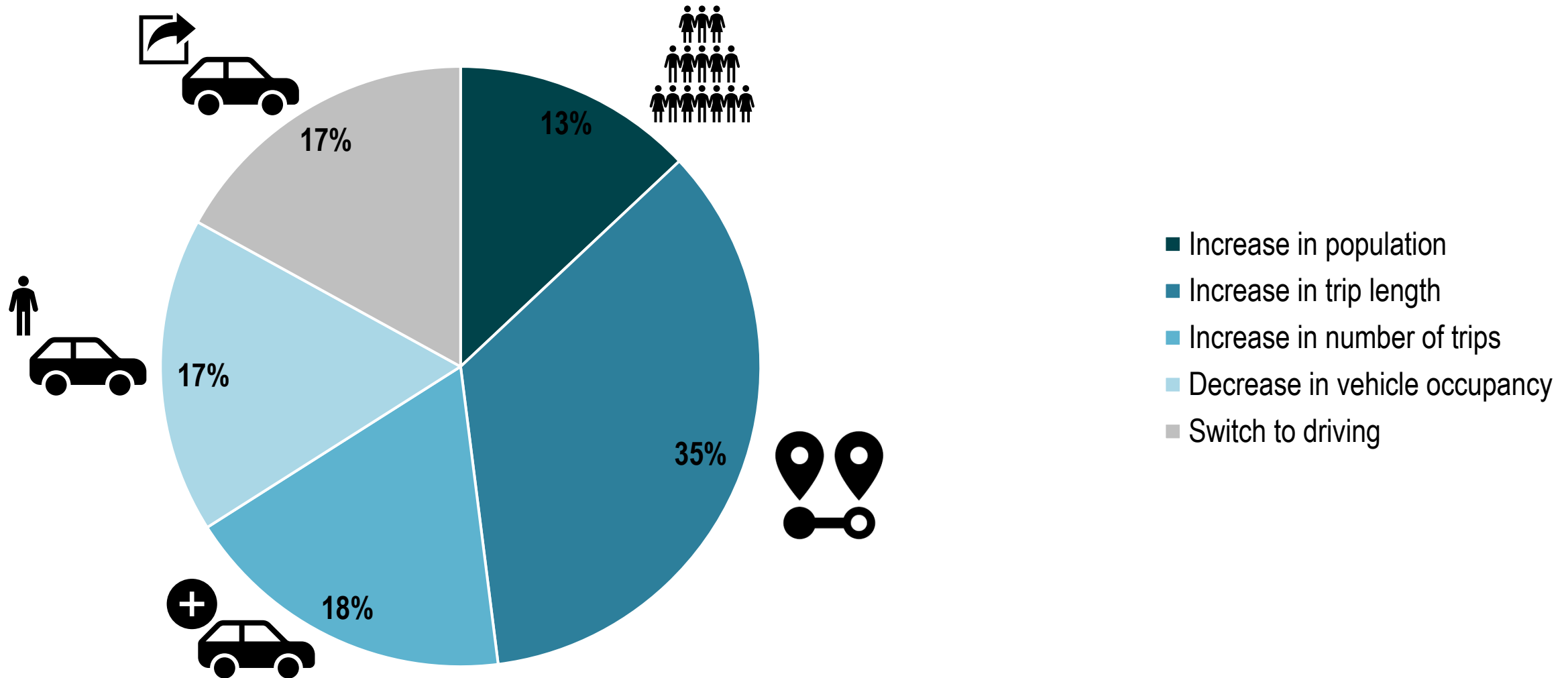
Central Business District Monthly Parking Rate, 2011



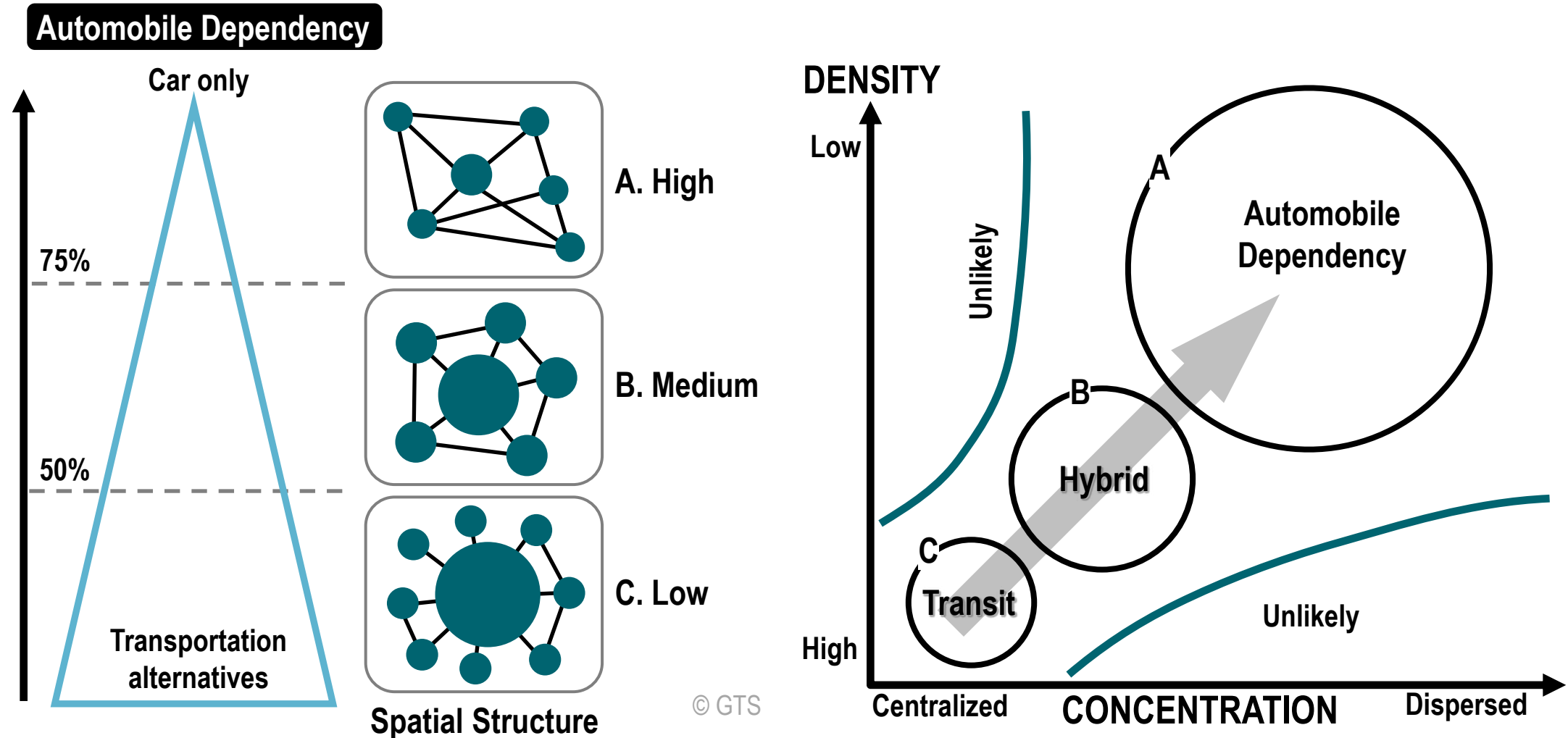
Geographical Paradoxes behind Urban Transport Problems



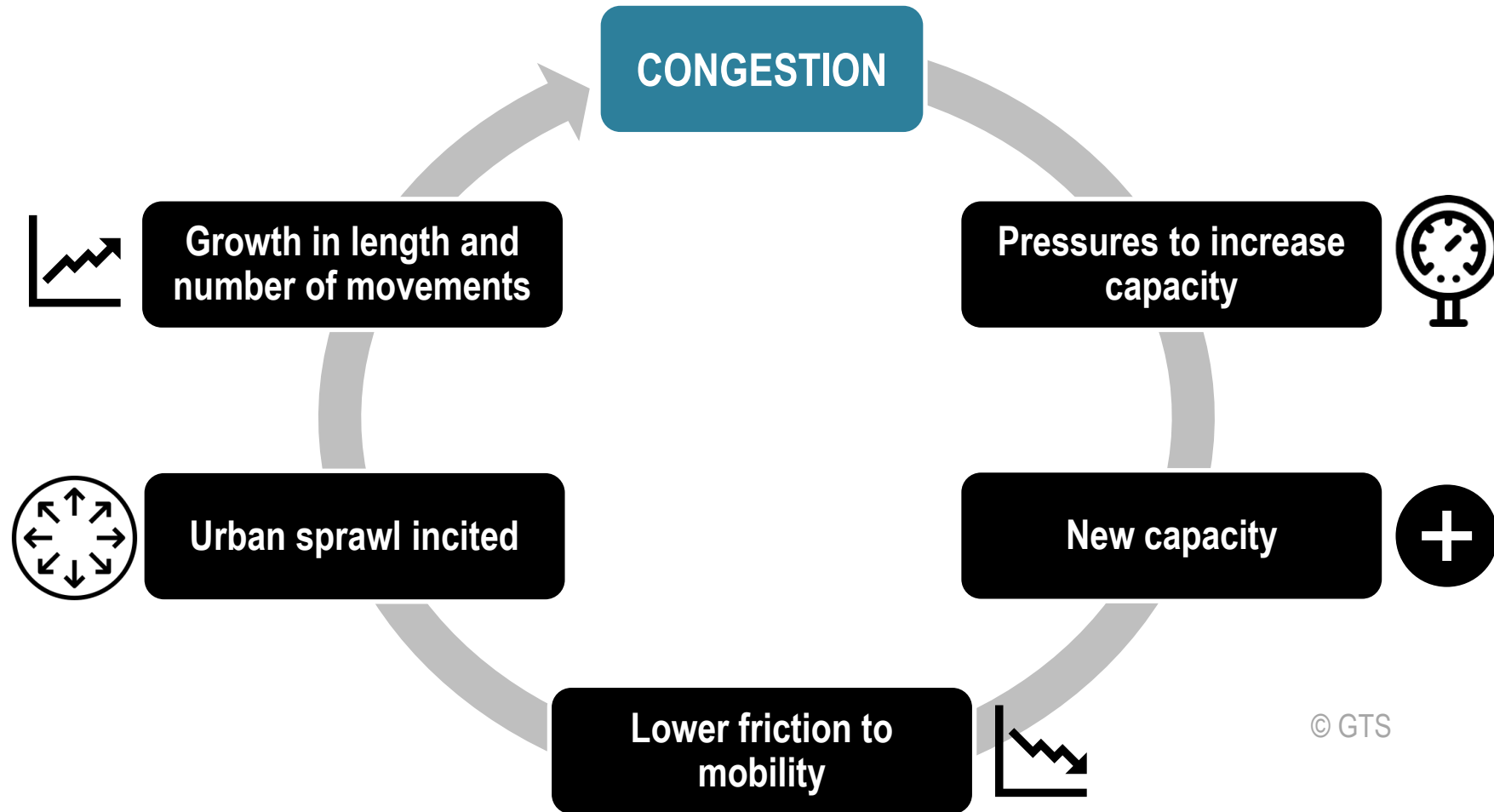
Factors Contributing to the Growth of Driving in the United States



Automobile Dependency and Urban Spatial Structure

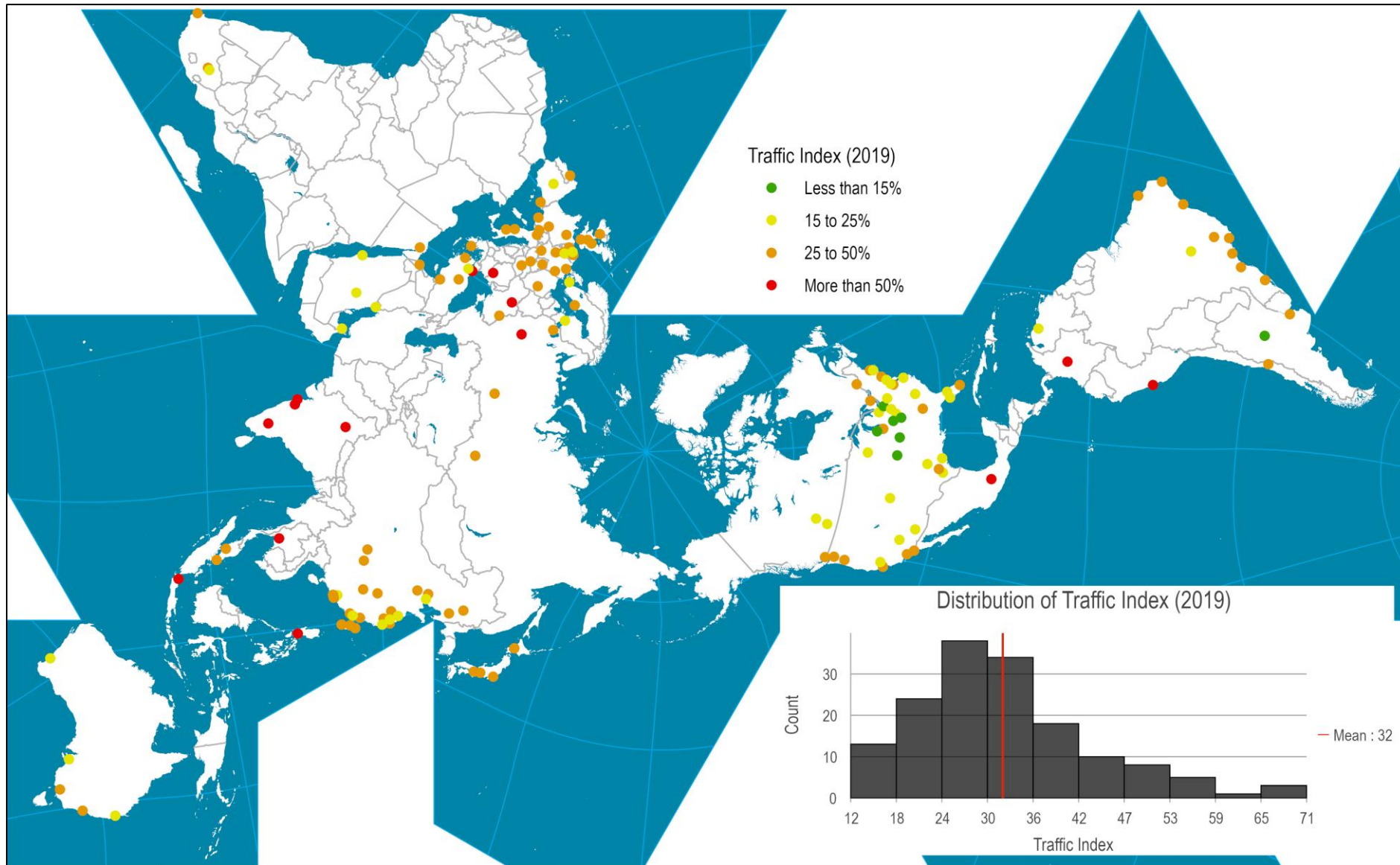


The Vicious Circle of Congestion

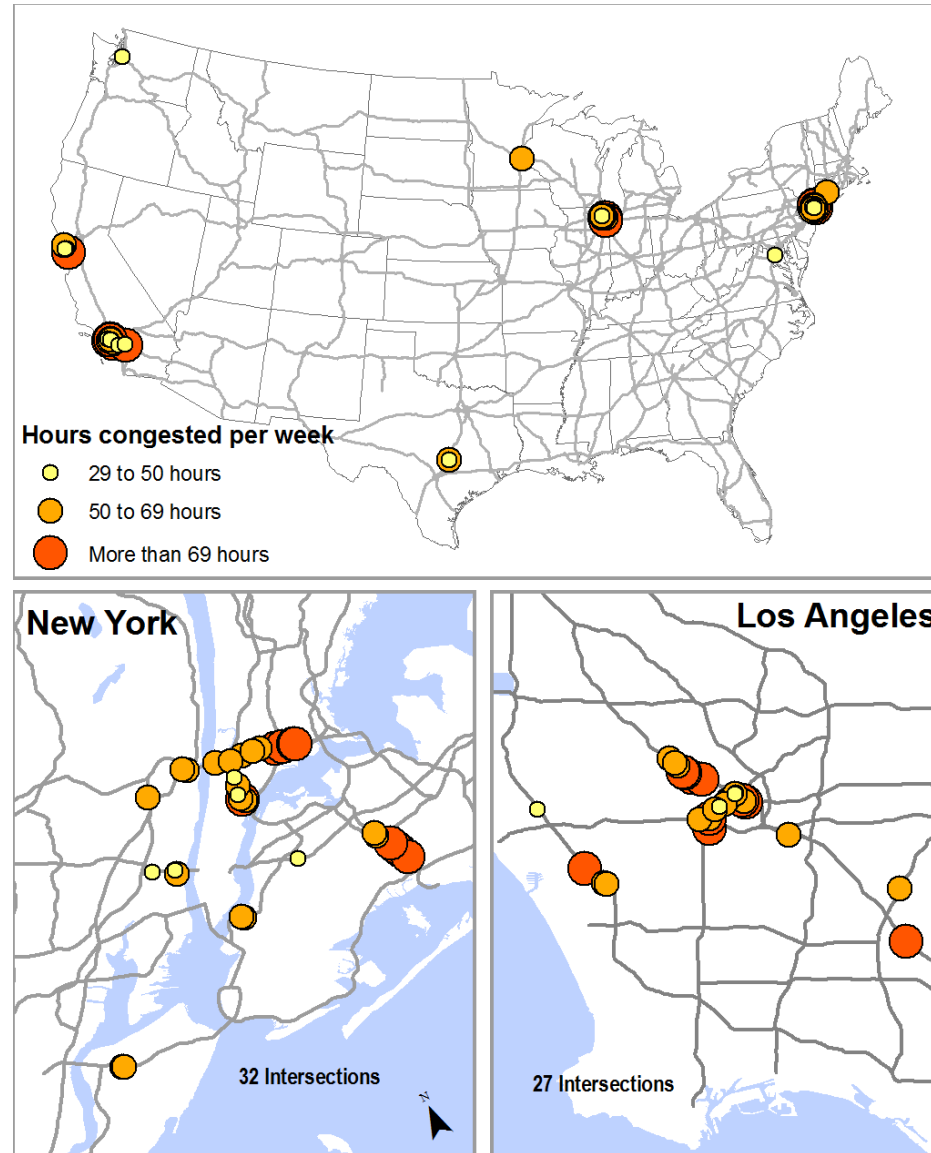


© GTS

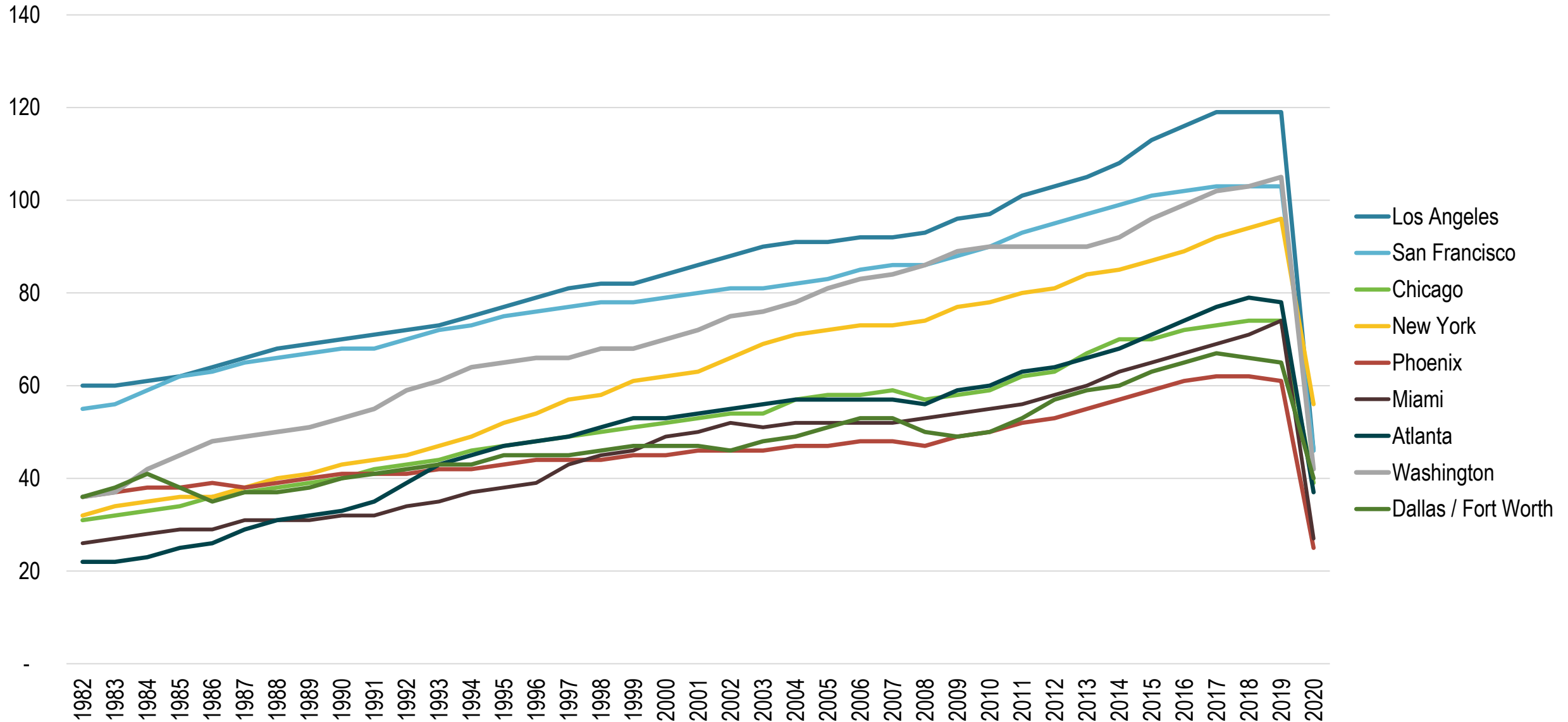
Traffic Index, Selected Metropolitan Areas



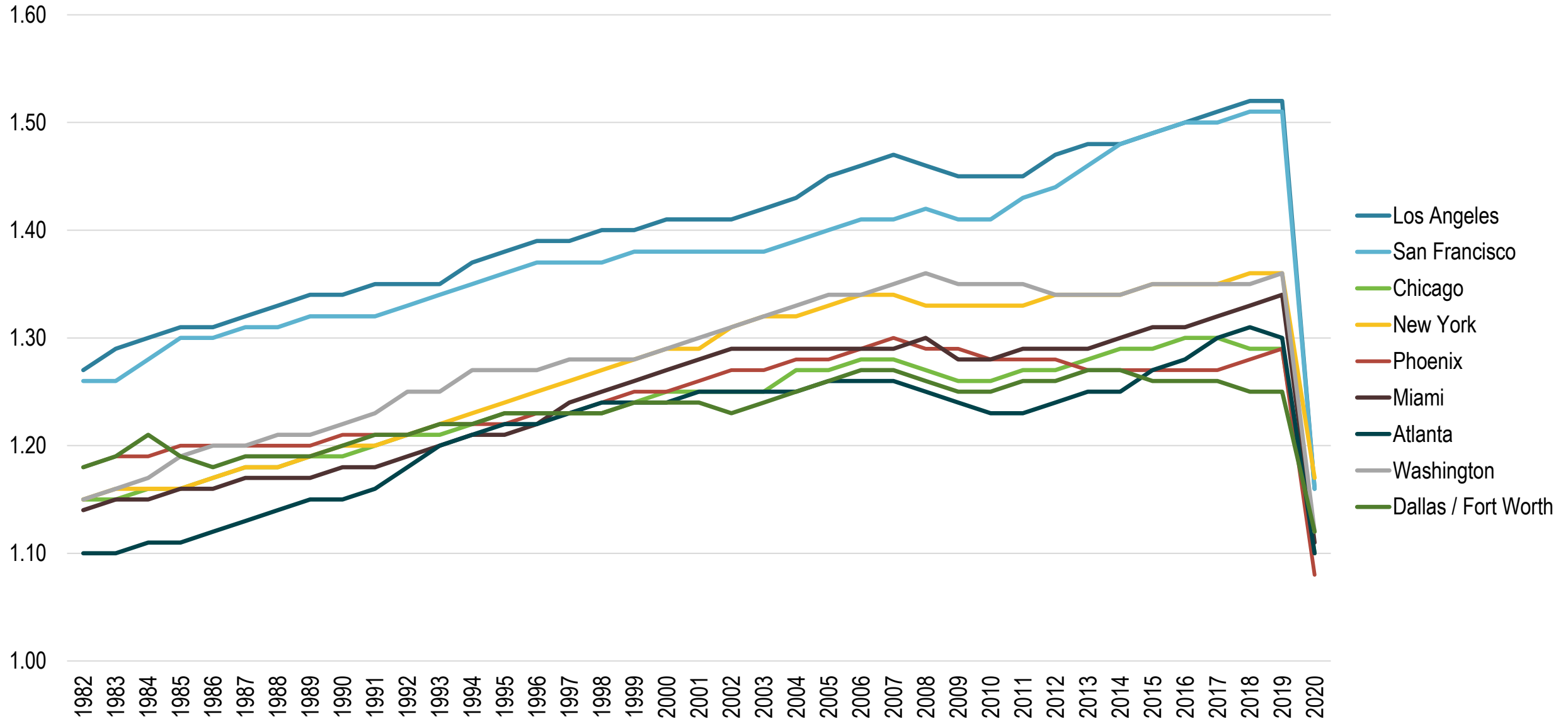
100 Most Congested Highway Intersections in the United States, 2006



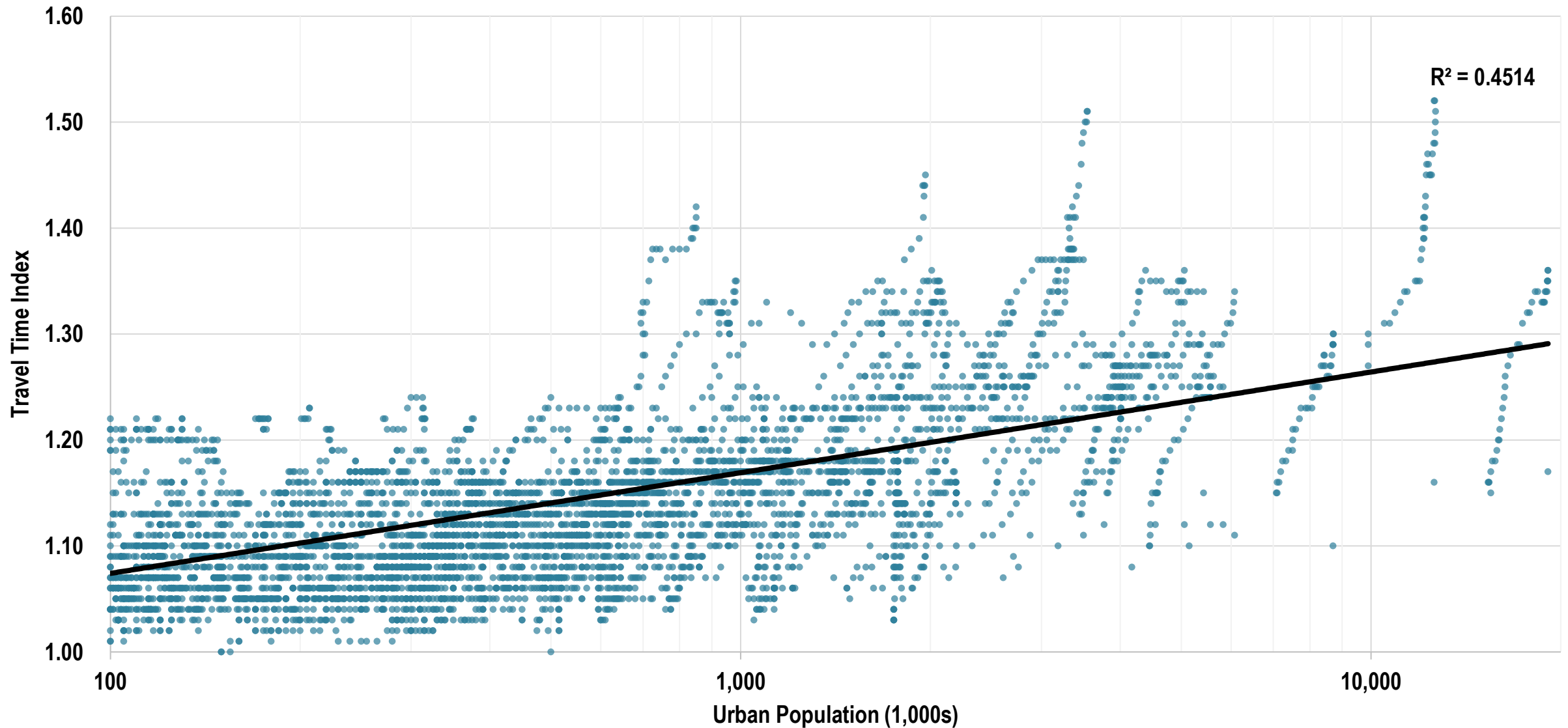
Average Number of Hours of Delay per Auto Commuter per Year, Selected American Cities, 1982-2020



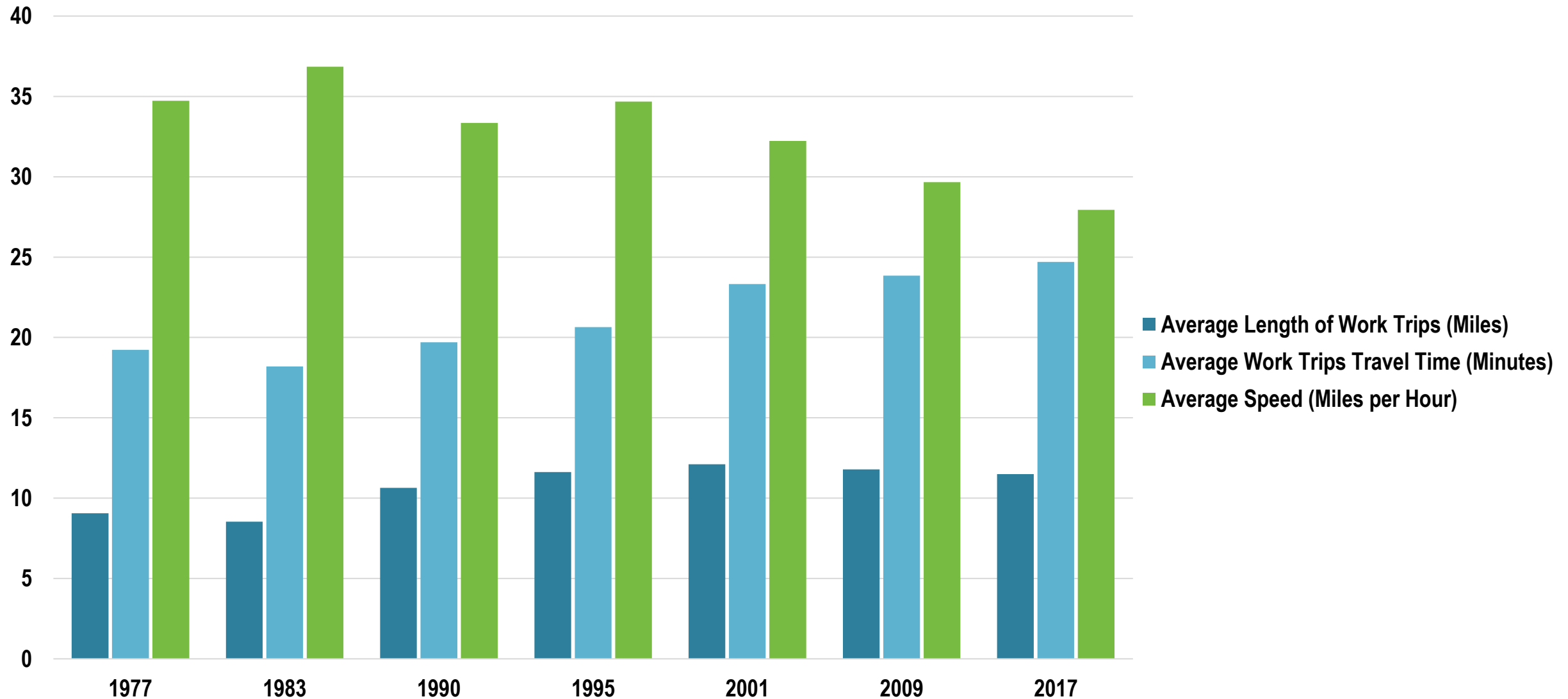
Travel Time Index per Year, Selected American Cities, 1982-2020



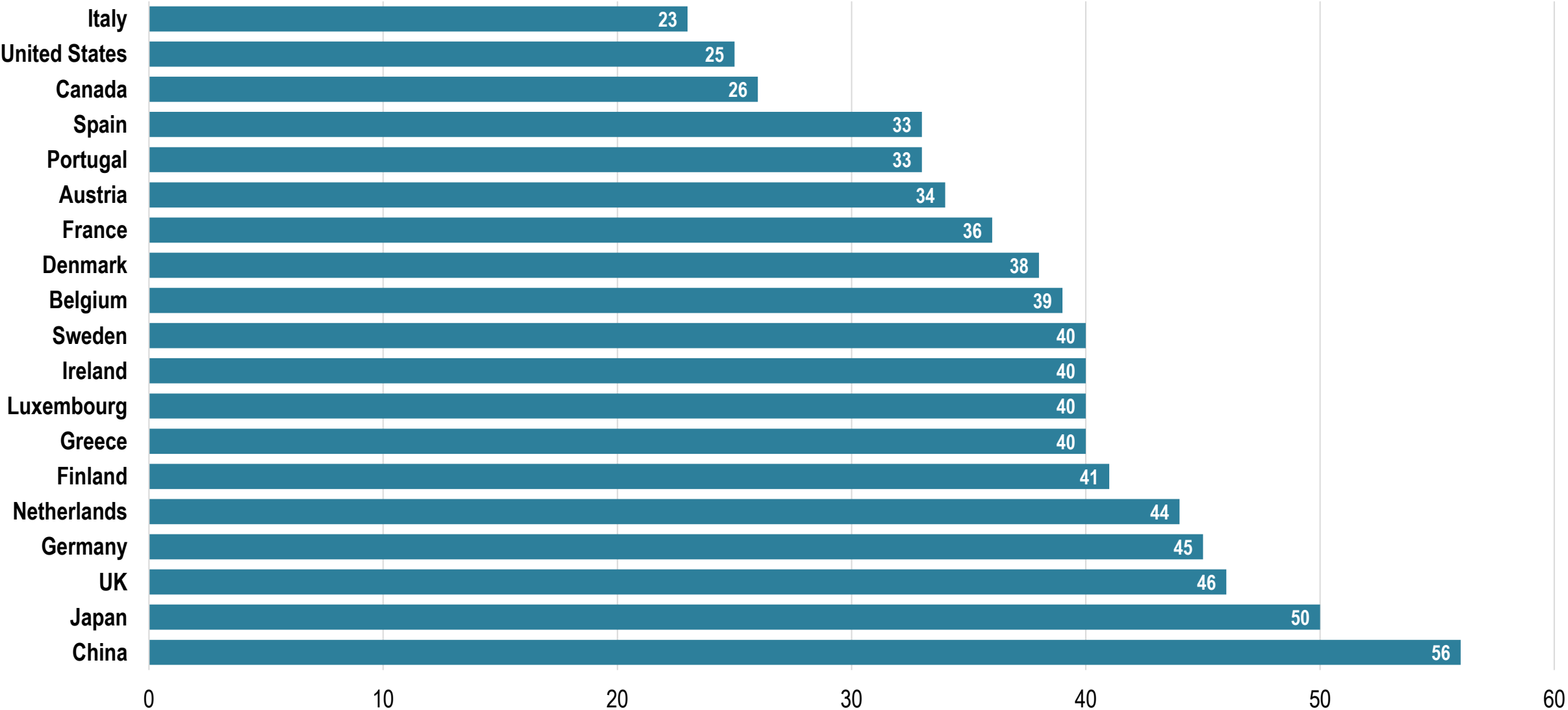
City Size and Travel Time Index, United States, 1982-2020



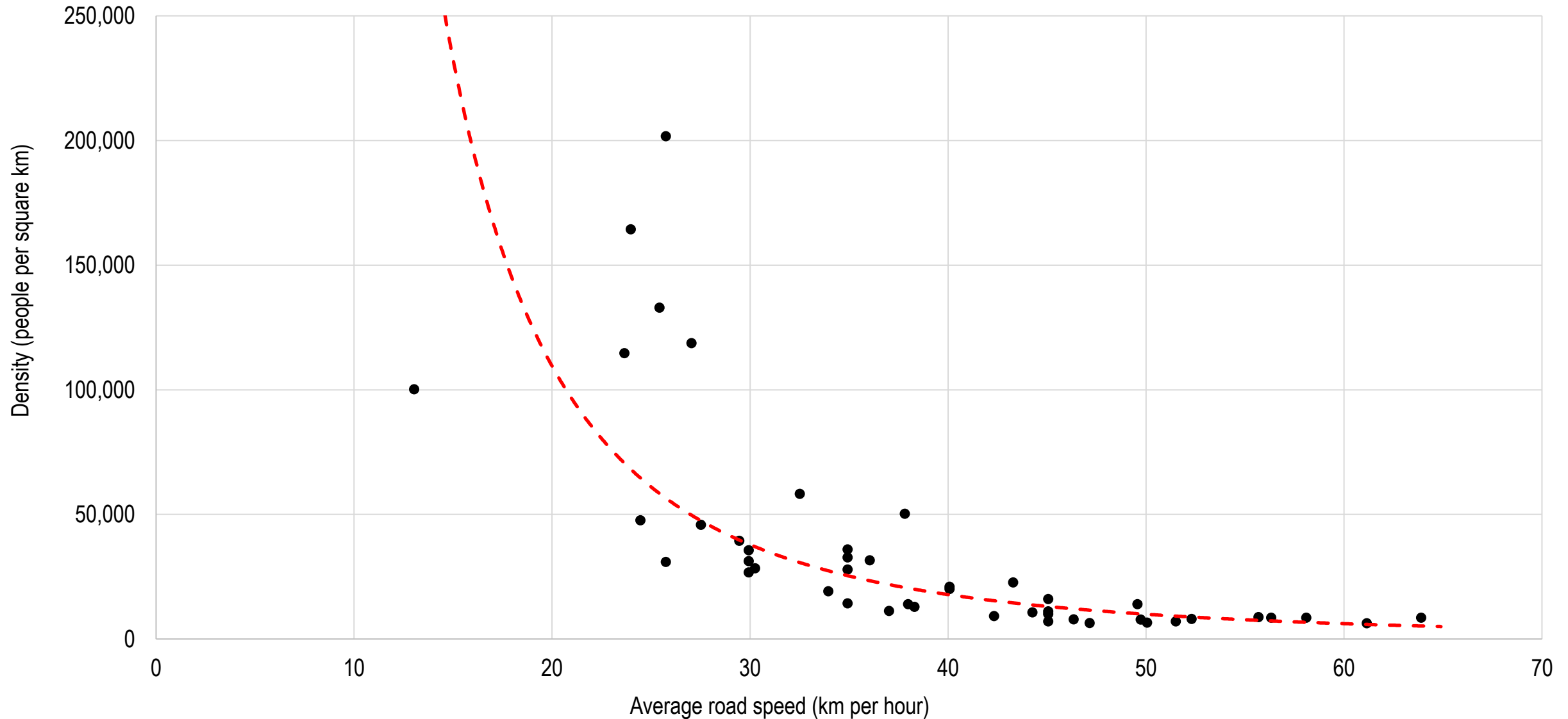
Home-to-Work Commute Profile, United States, 1977-2017



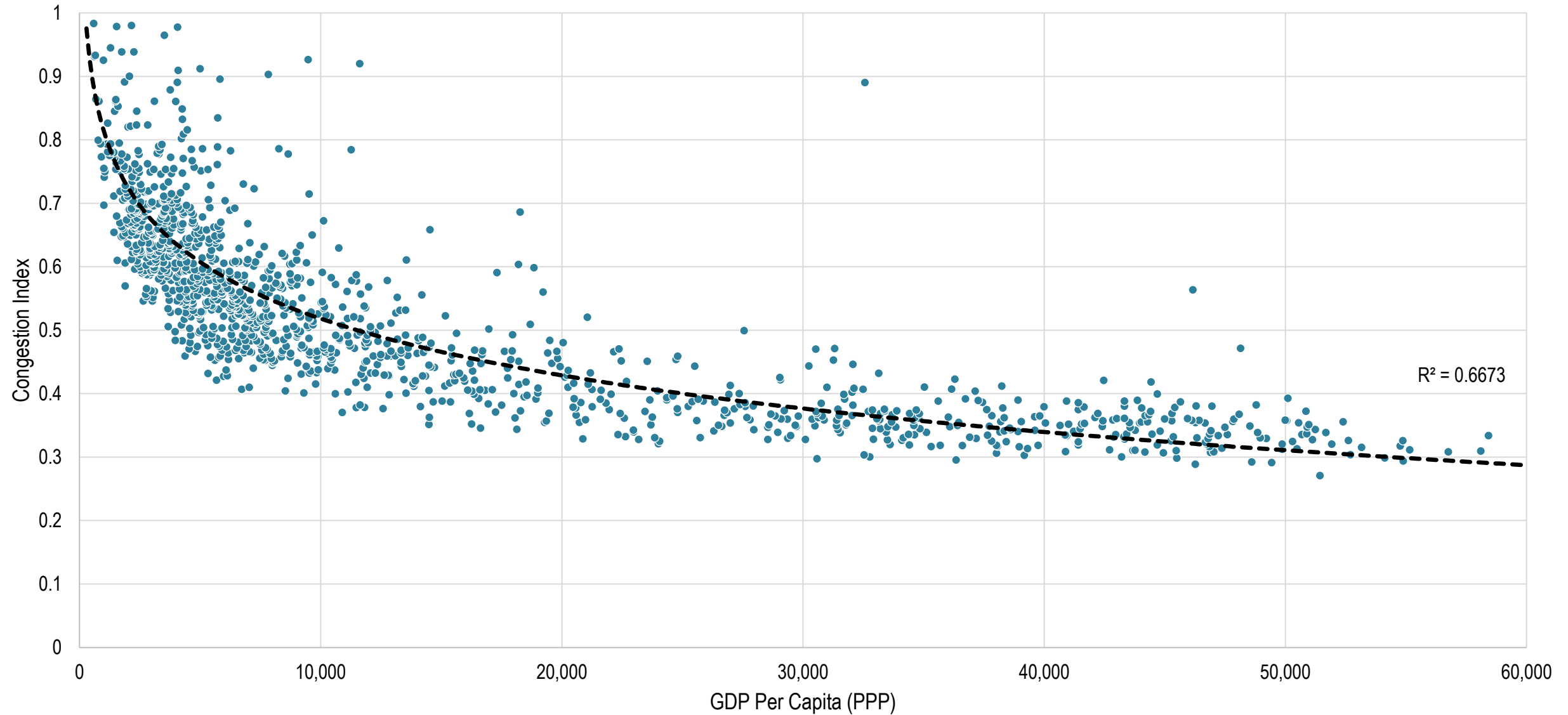
Average Daily Commuting Time, selected Countries, 2015 (in minutes)



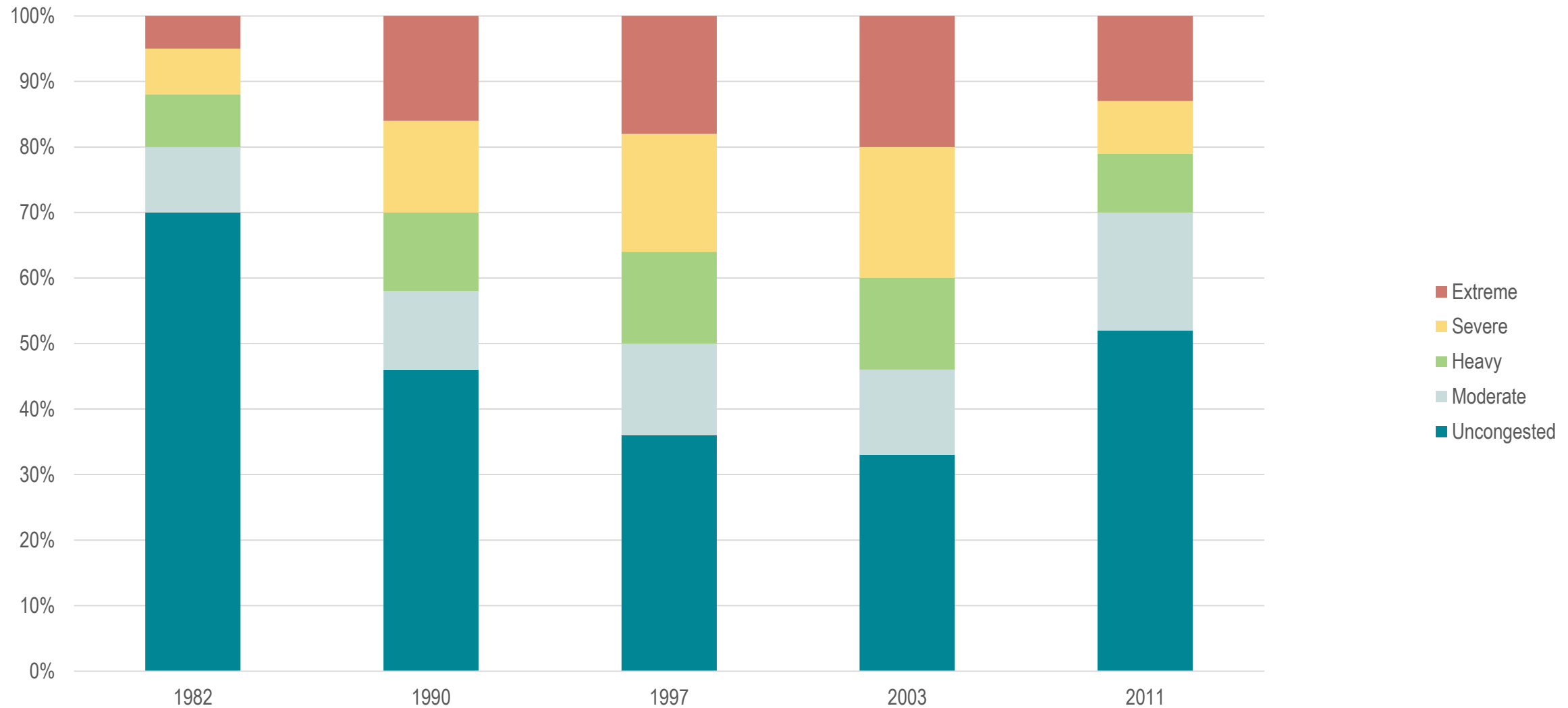
Urban Density and Driving Speed, Selected Global Cities



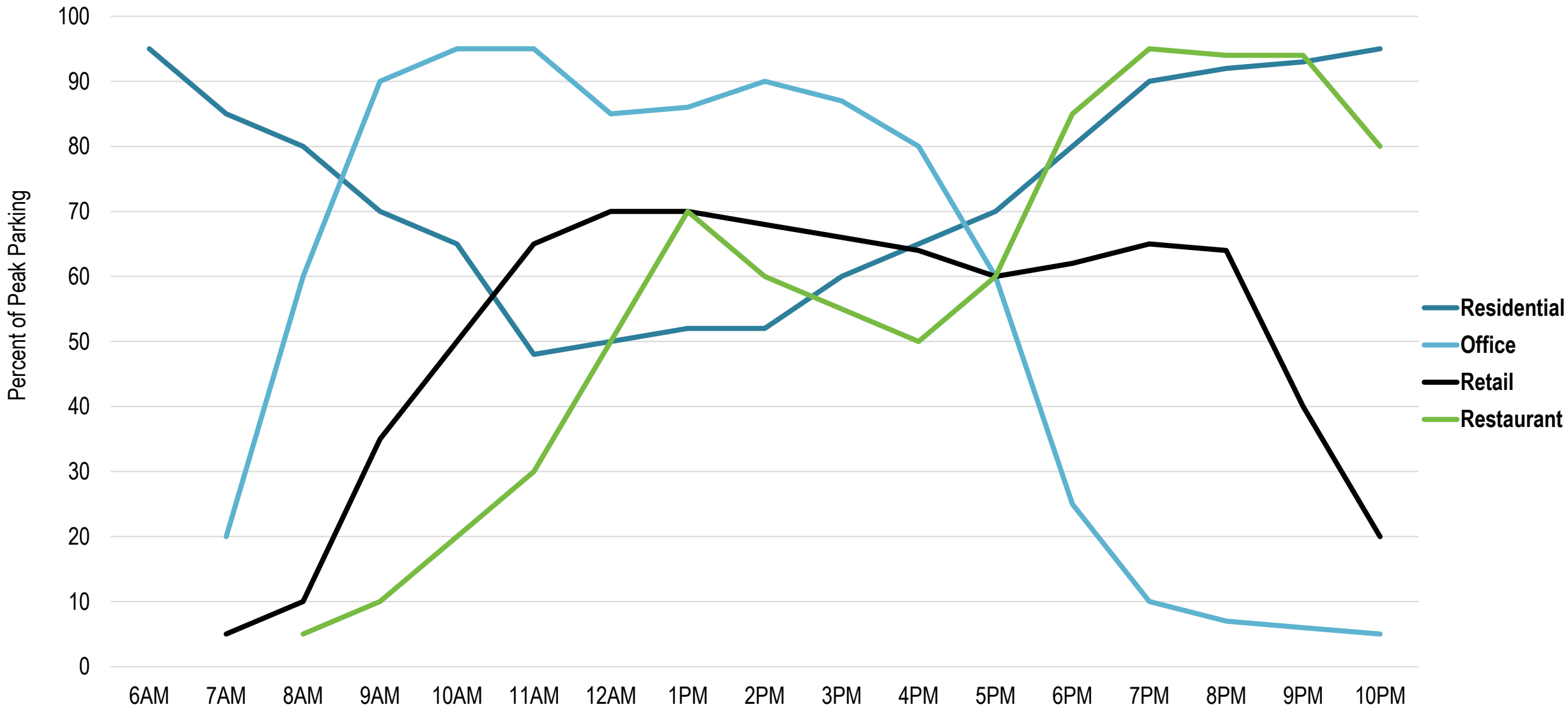
GDP Per Capita and Congestion Index, Selected Cities



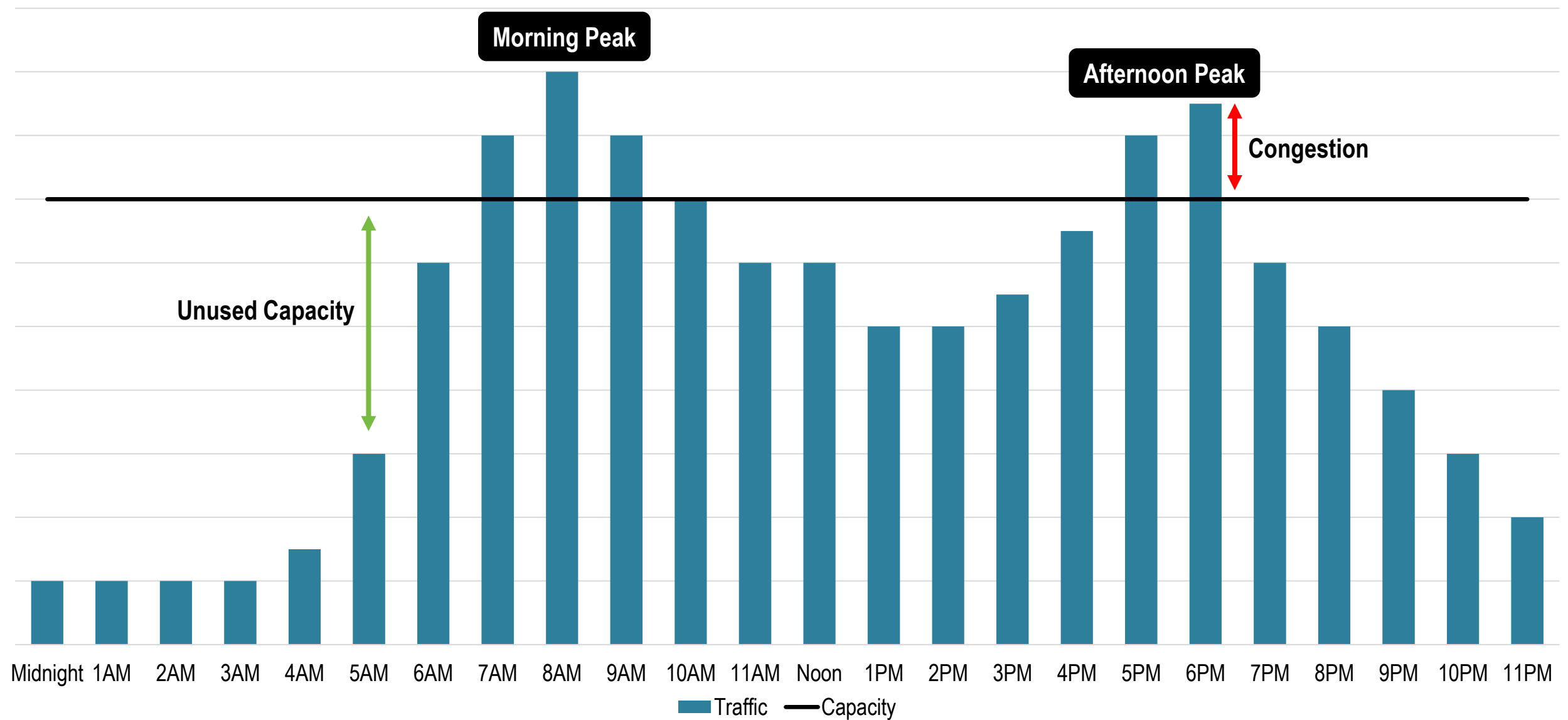
Traffic Conditions in Major American Cities, 1982-2003 (2011 data inconsistent)



Parking Accumulation by Land Use by Time of the Day

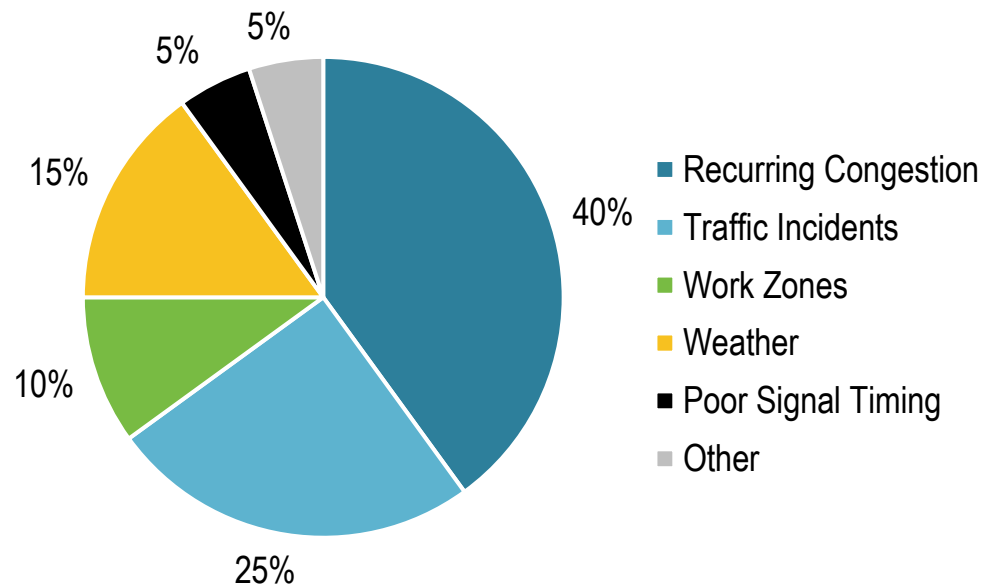


Recurring Congestion

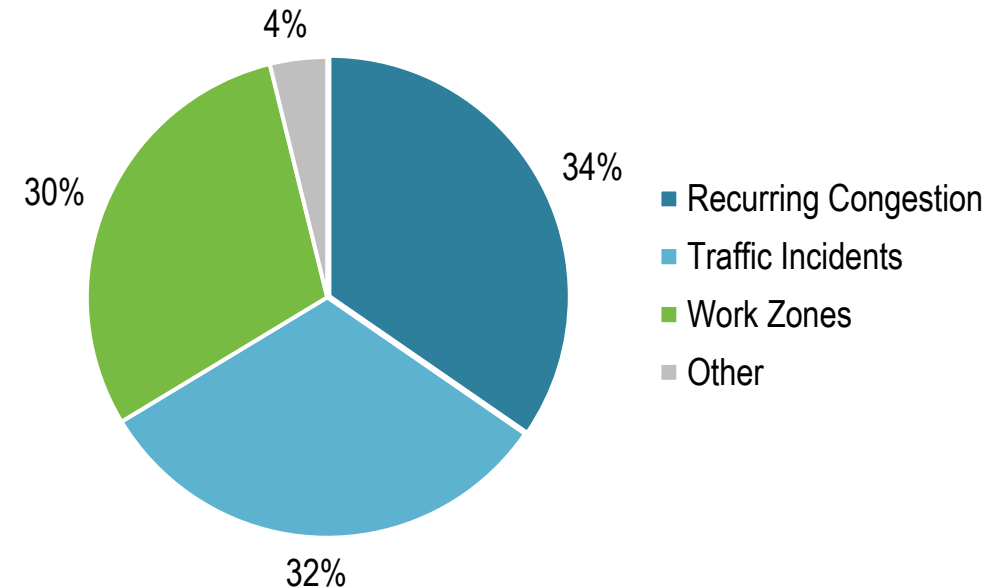


Major Sources of Recurring and Non-Recurring Congestion

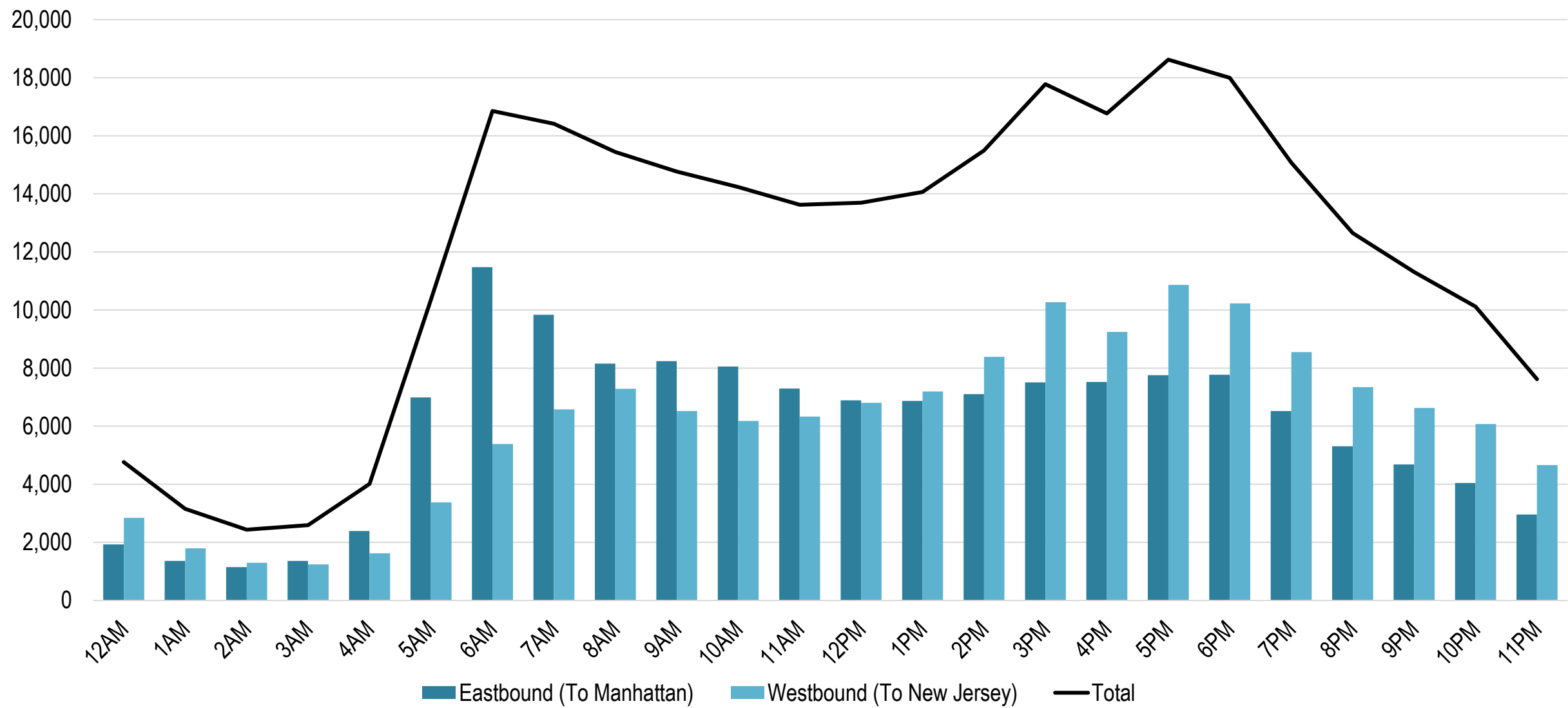
Congestion in the United States (hours by Cause)



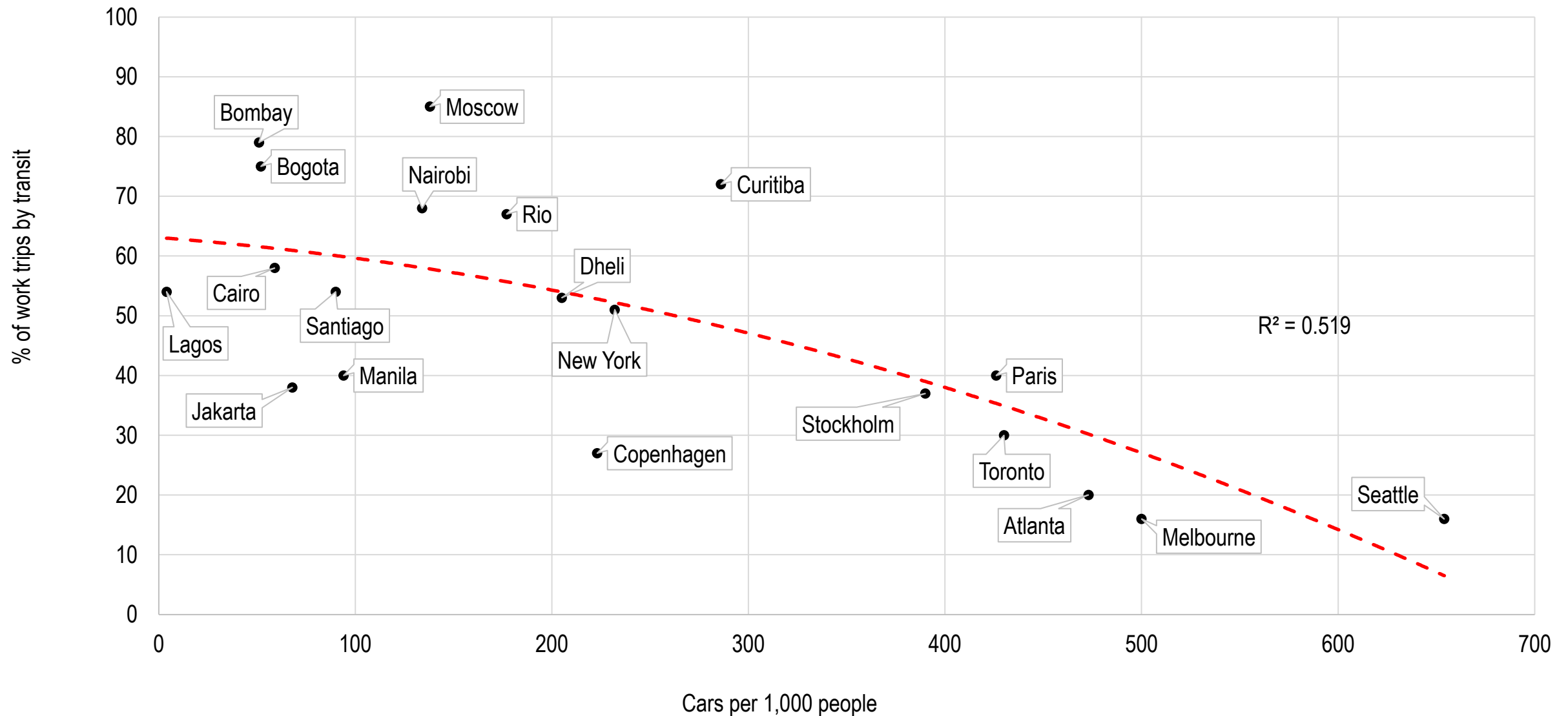
Congestion in Germany (hours by Cause)



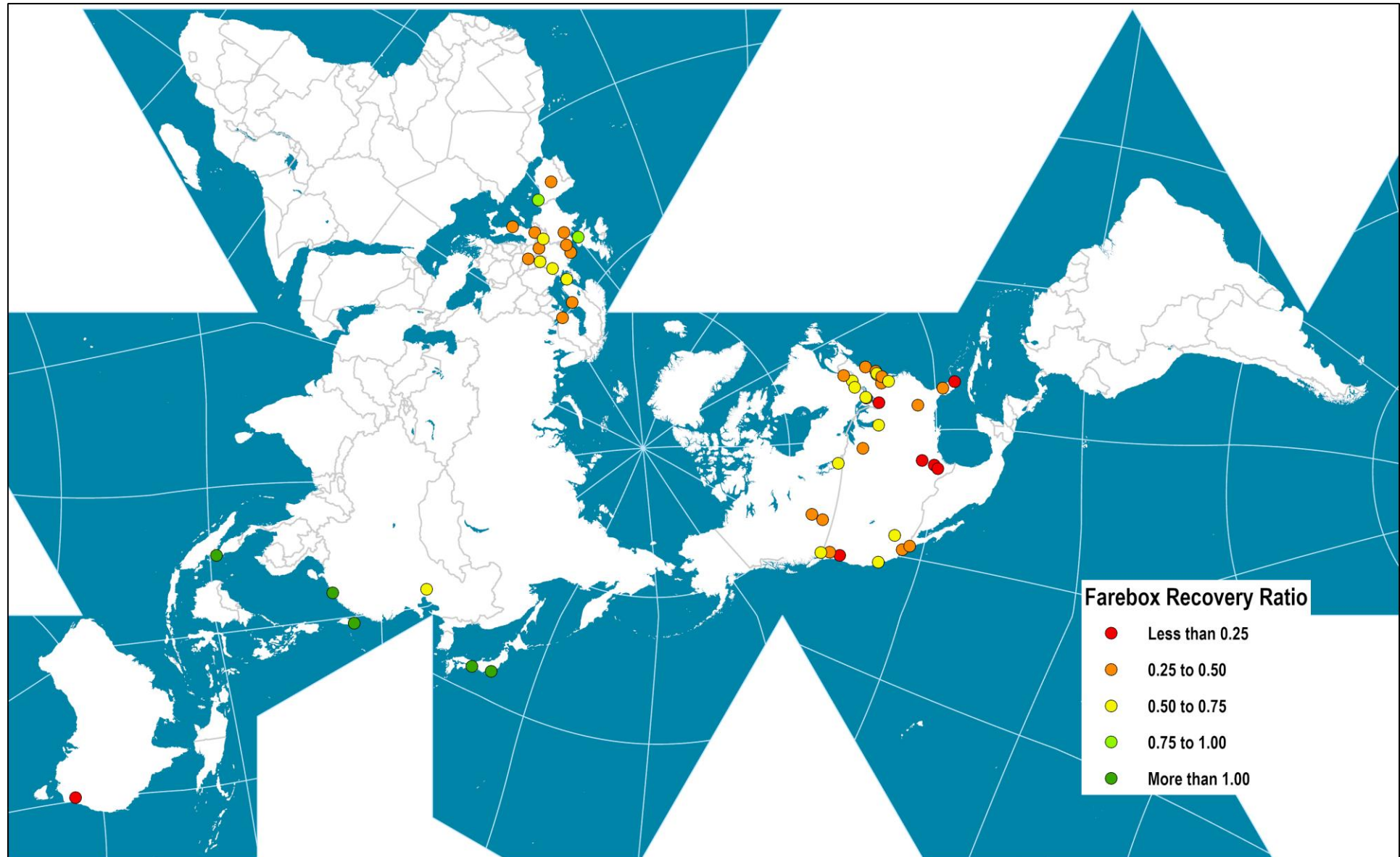
Average Hourly Traffic on George Washington Bridge, 2016



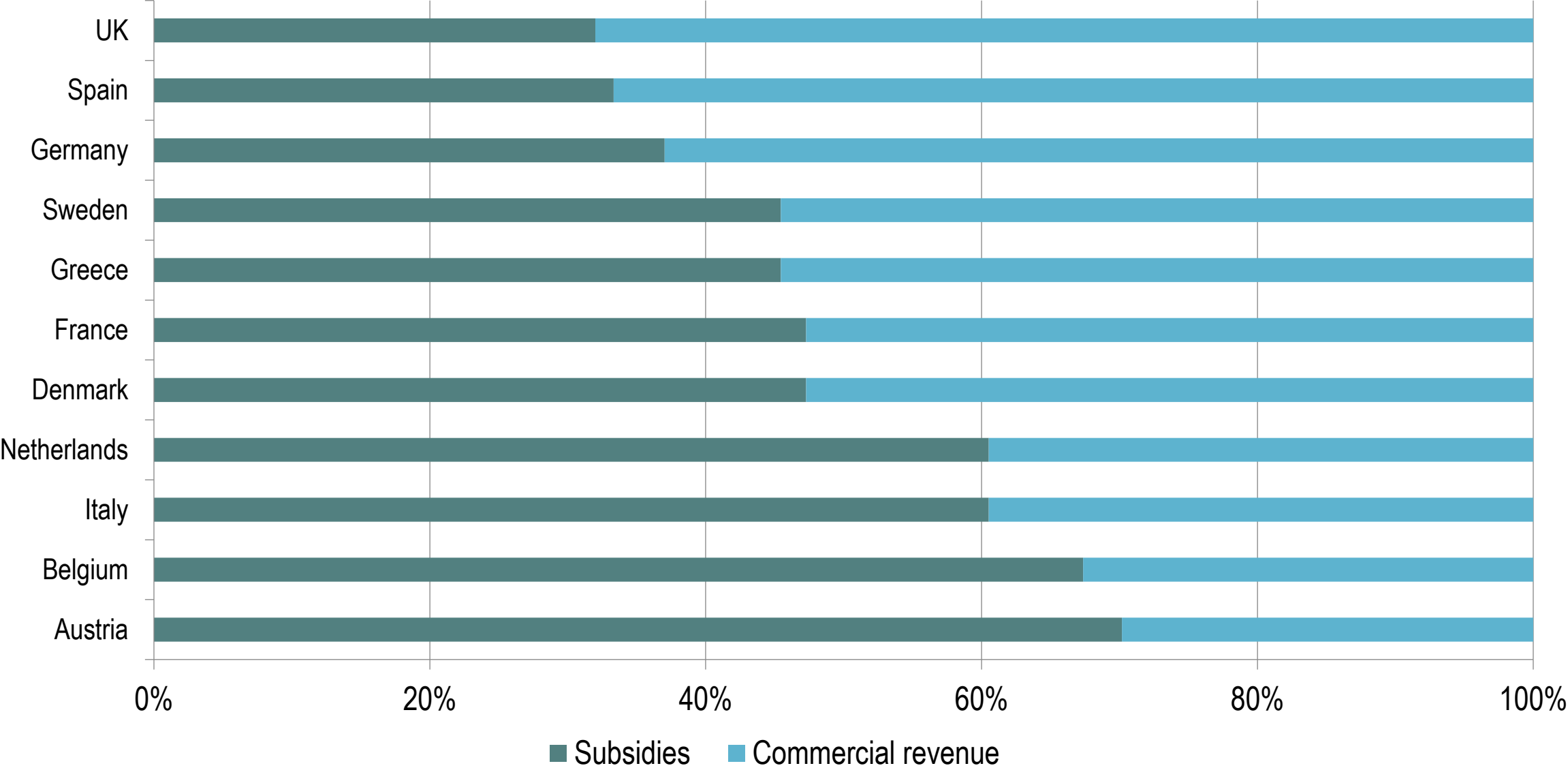
Transit Use and Car Ownership in Selected Cities, 1993



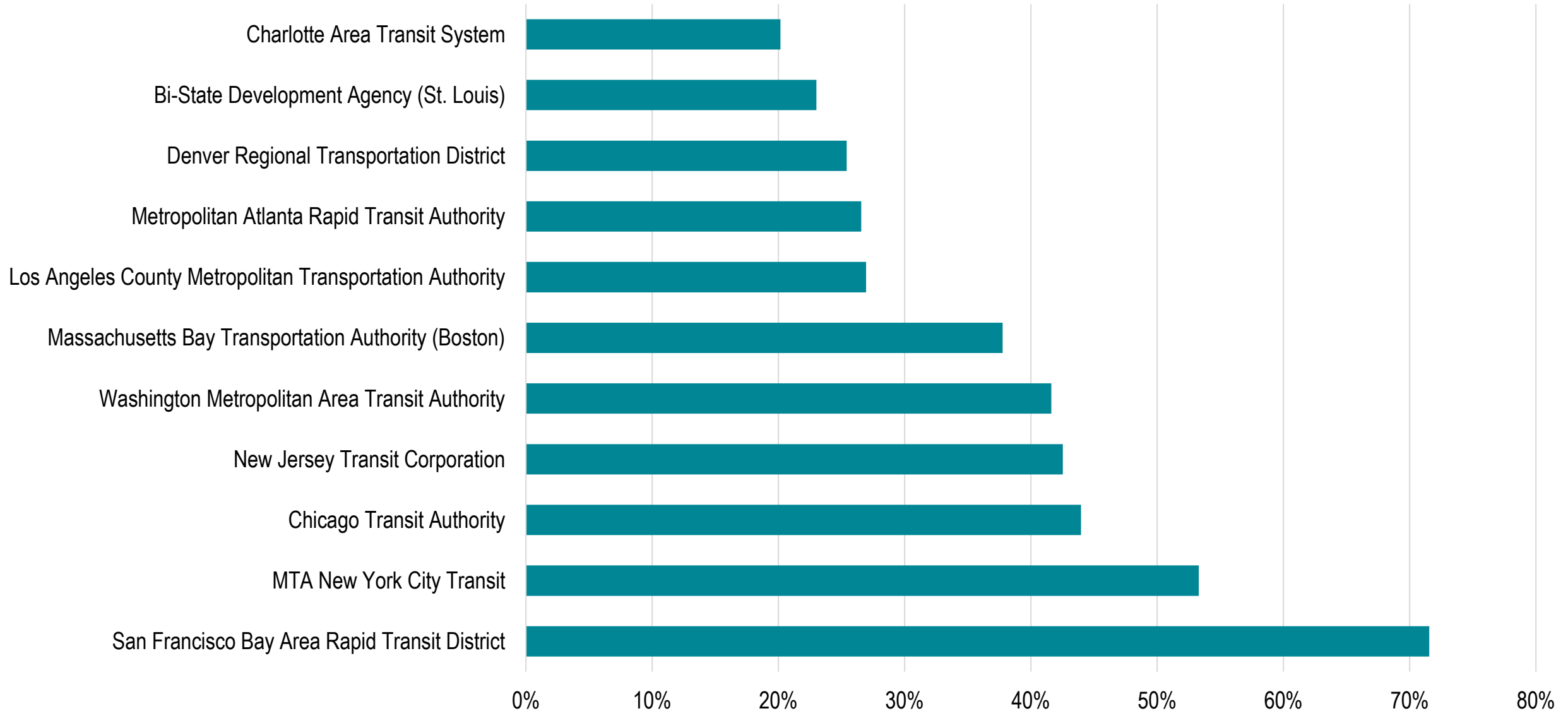
Farebox Recovery Ratio, Selected Transit Systems



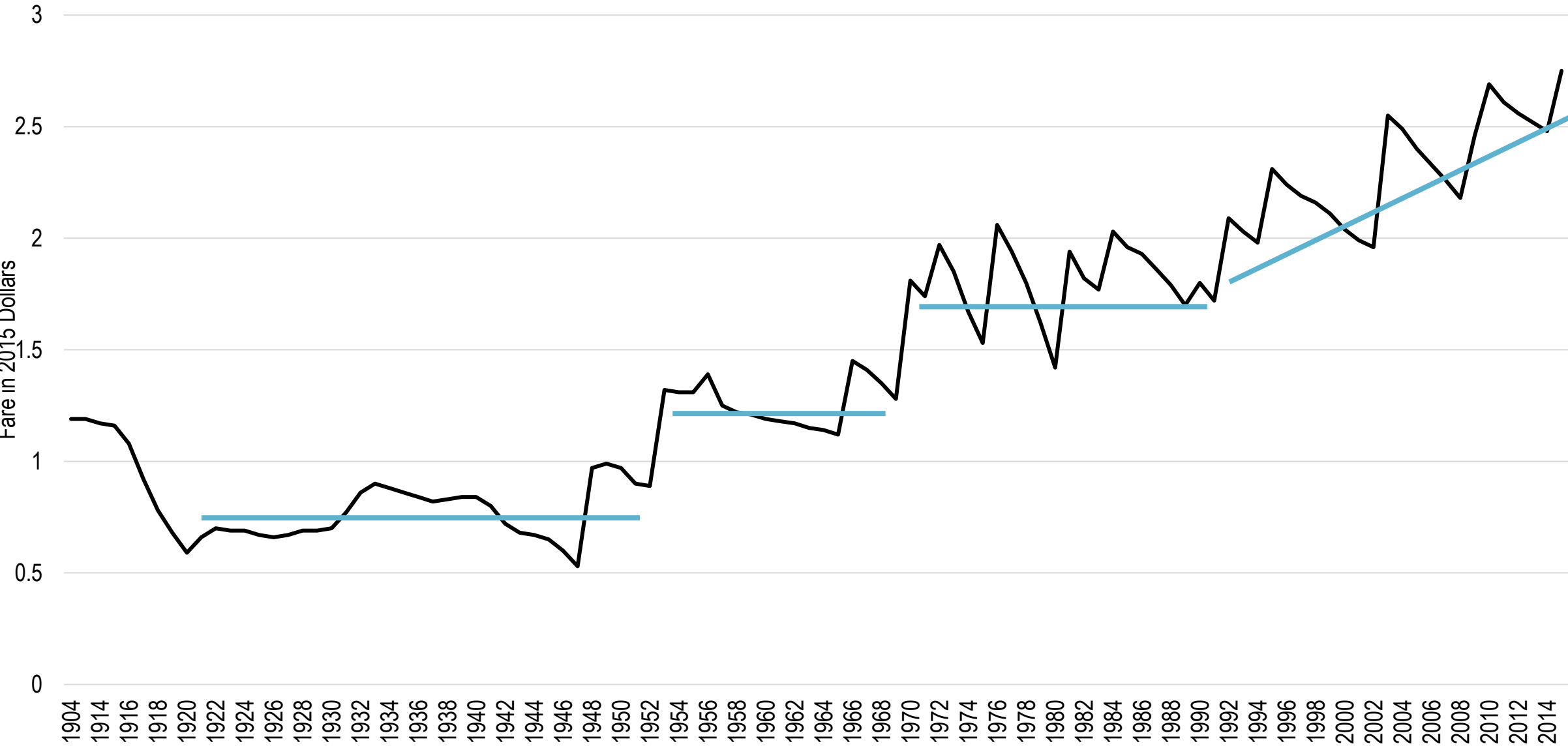
Source of Revenue for Bus Operations, Europe, 2002



Fare Recovery Ratio of Selected Public Transit Systems, United States, 2010



Transit Fare for the New York Subway, 1904-2015 (inflation-adjusted)



Challenges of Urban Transit

