

The Geography of Transport Systems

FIFTH EDITION

Jean-Paul Rodrigue

Urban Transportation

CHAPTER 8

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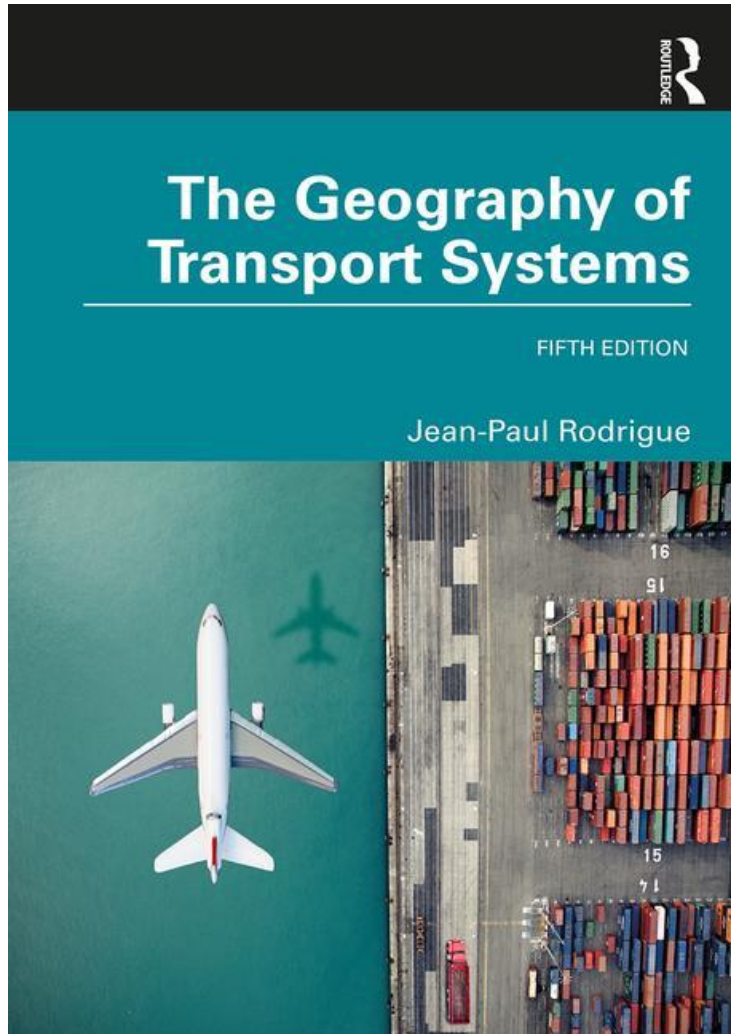
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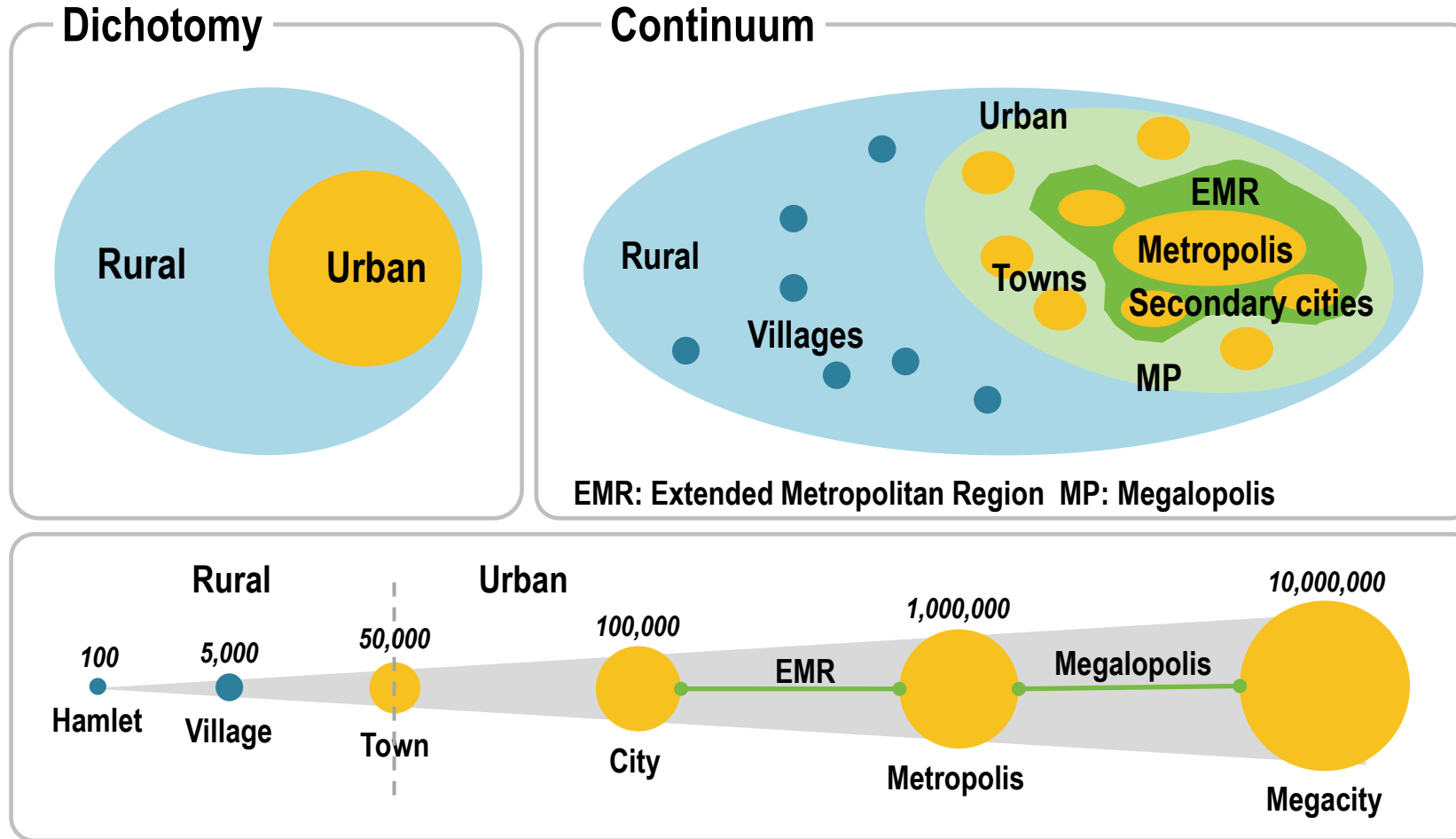


Transportation and Urban Form

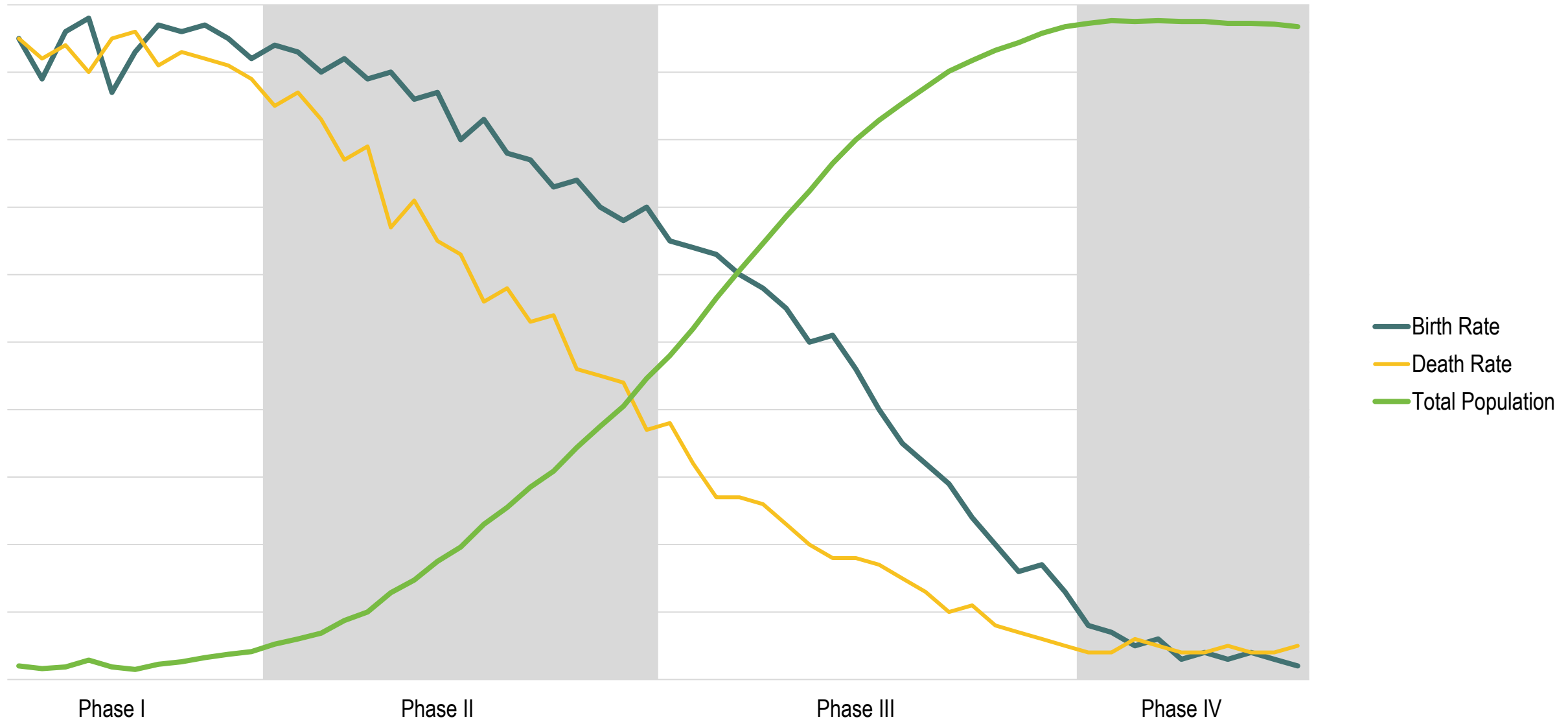
Urban Hierarchy

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'.

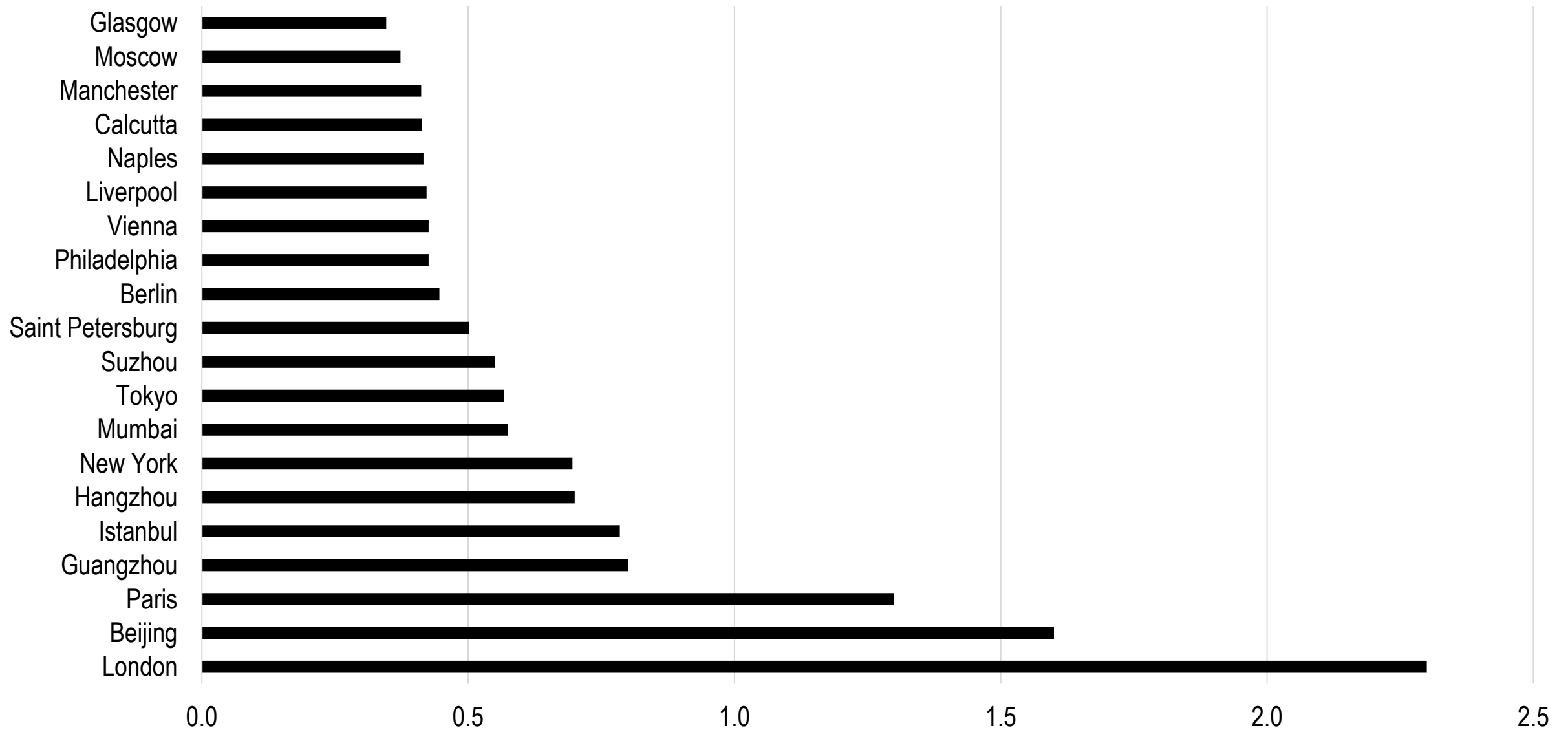
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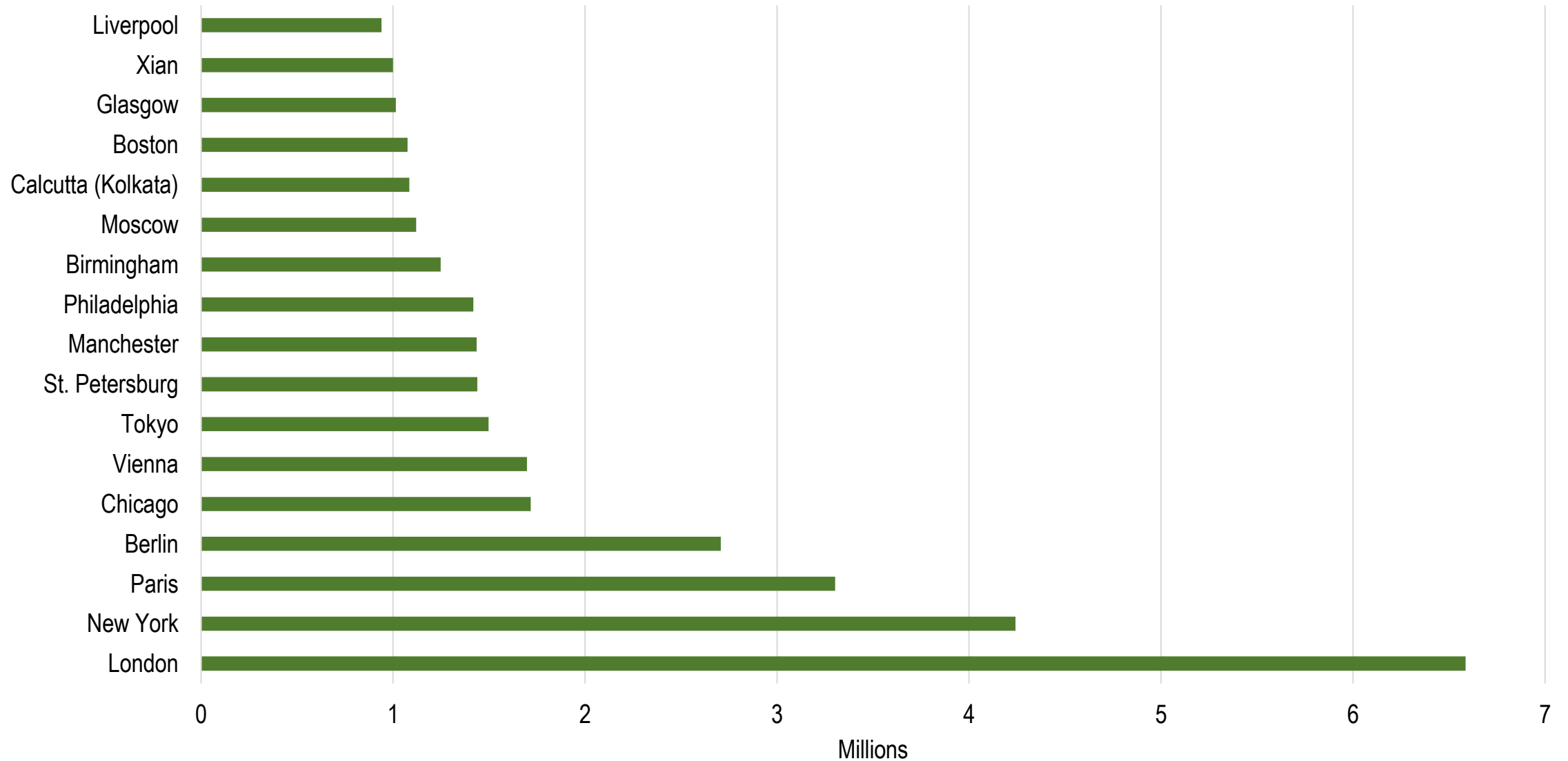
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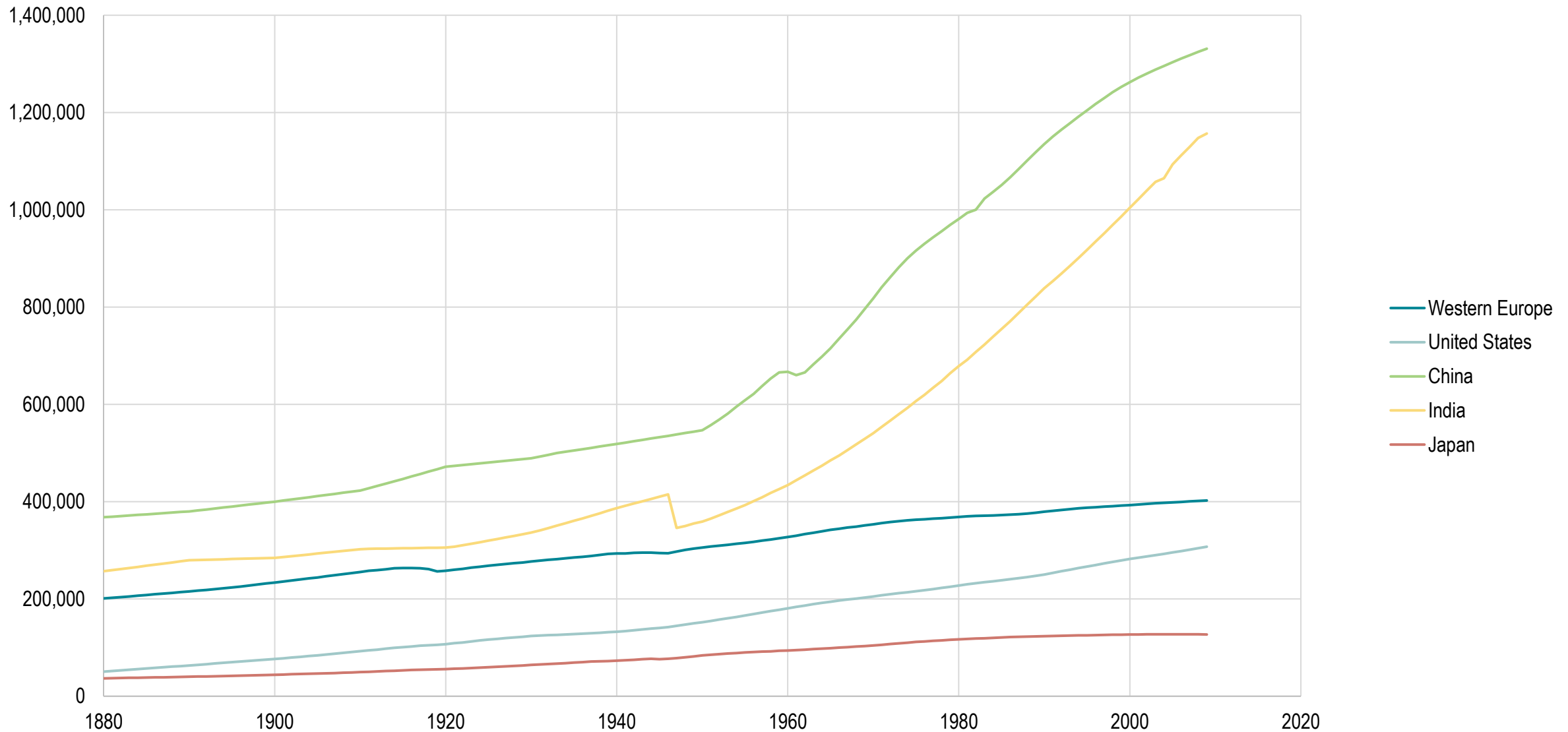
World's Largest Cities, 1850



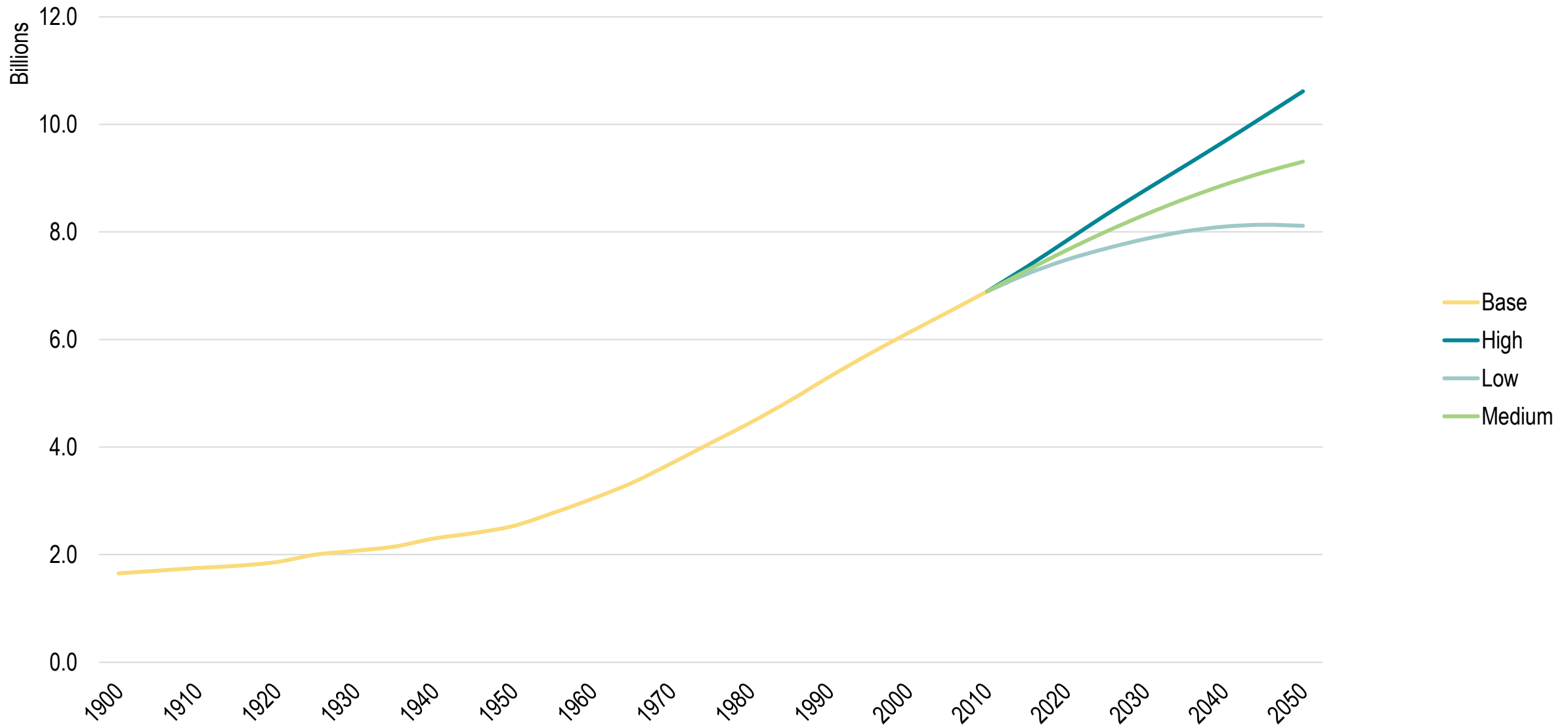
World's Largest Cities, 1900



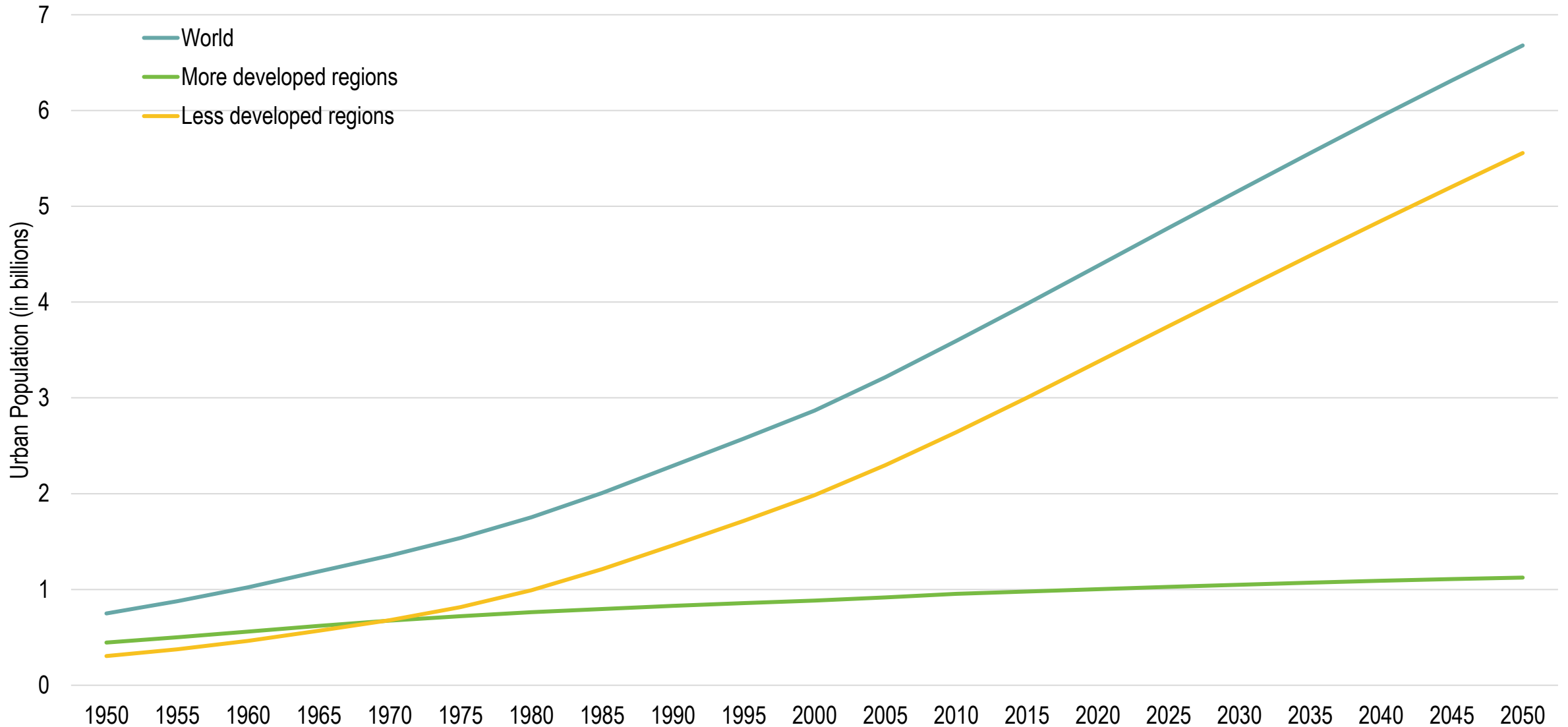
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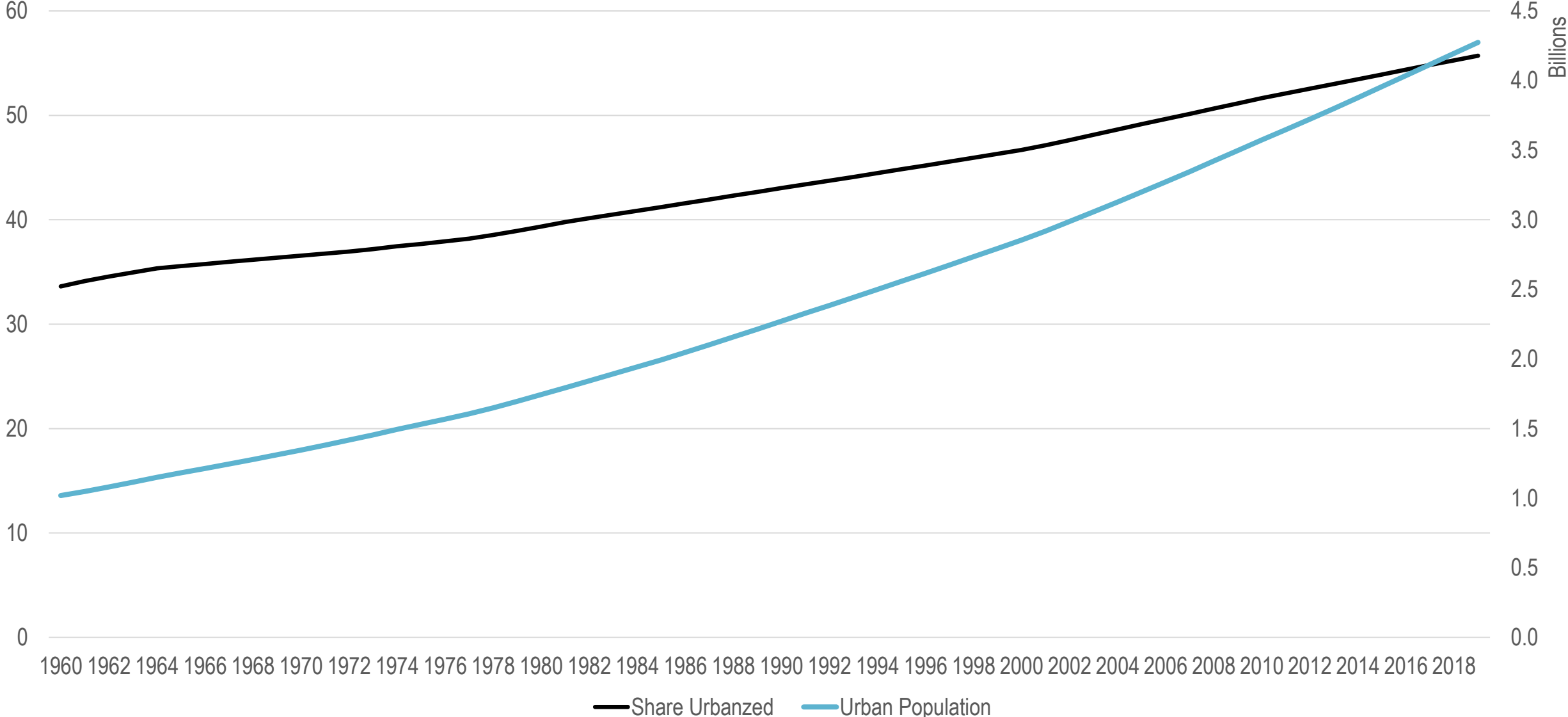
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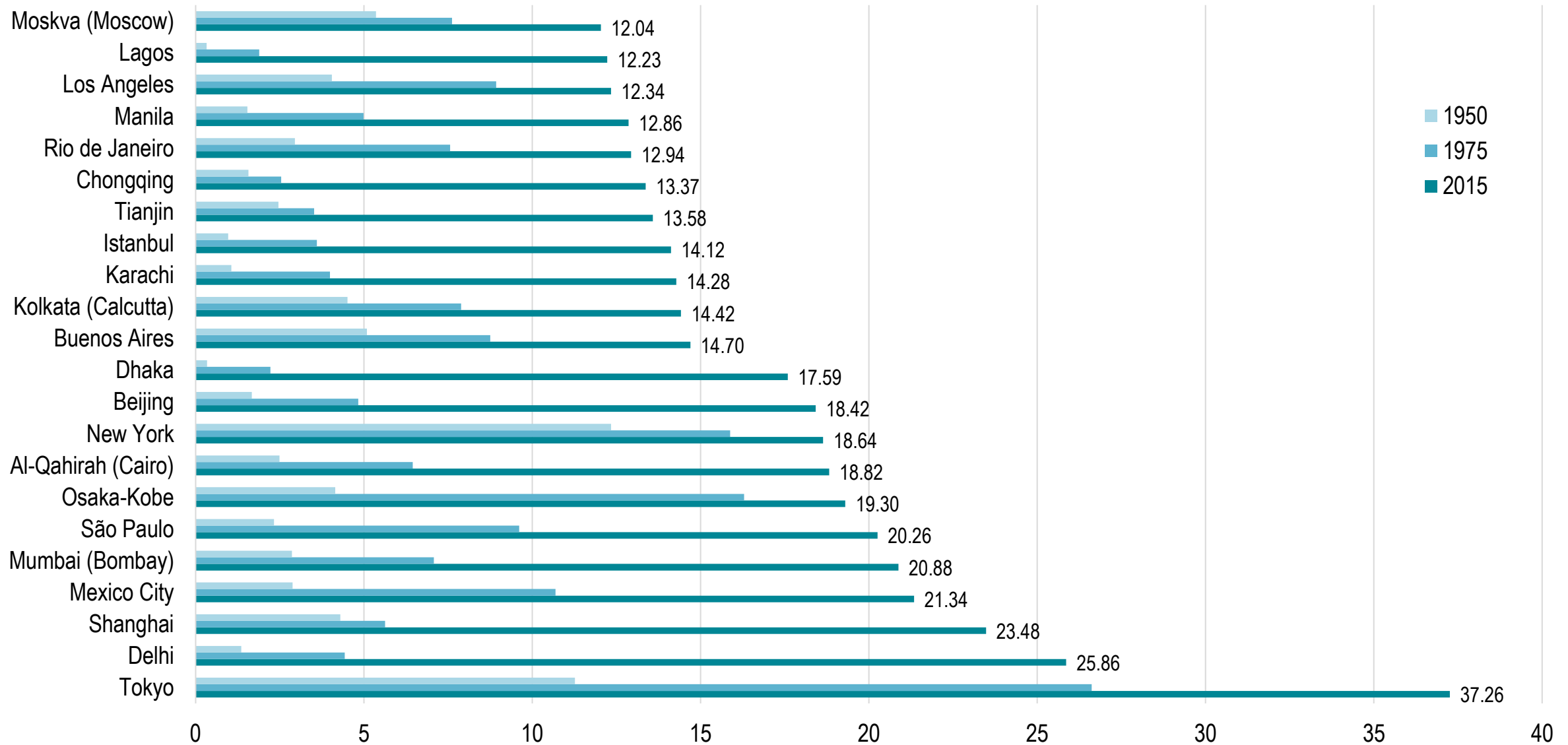
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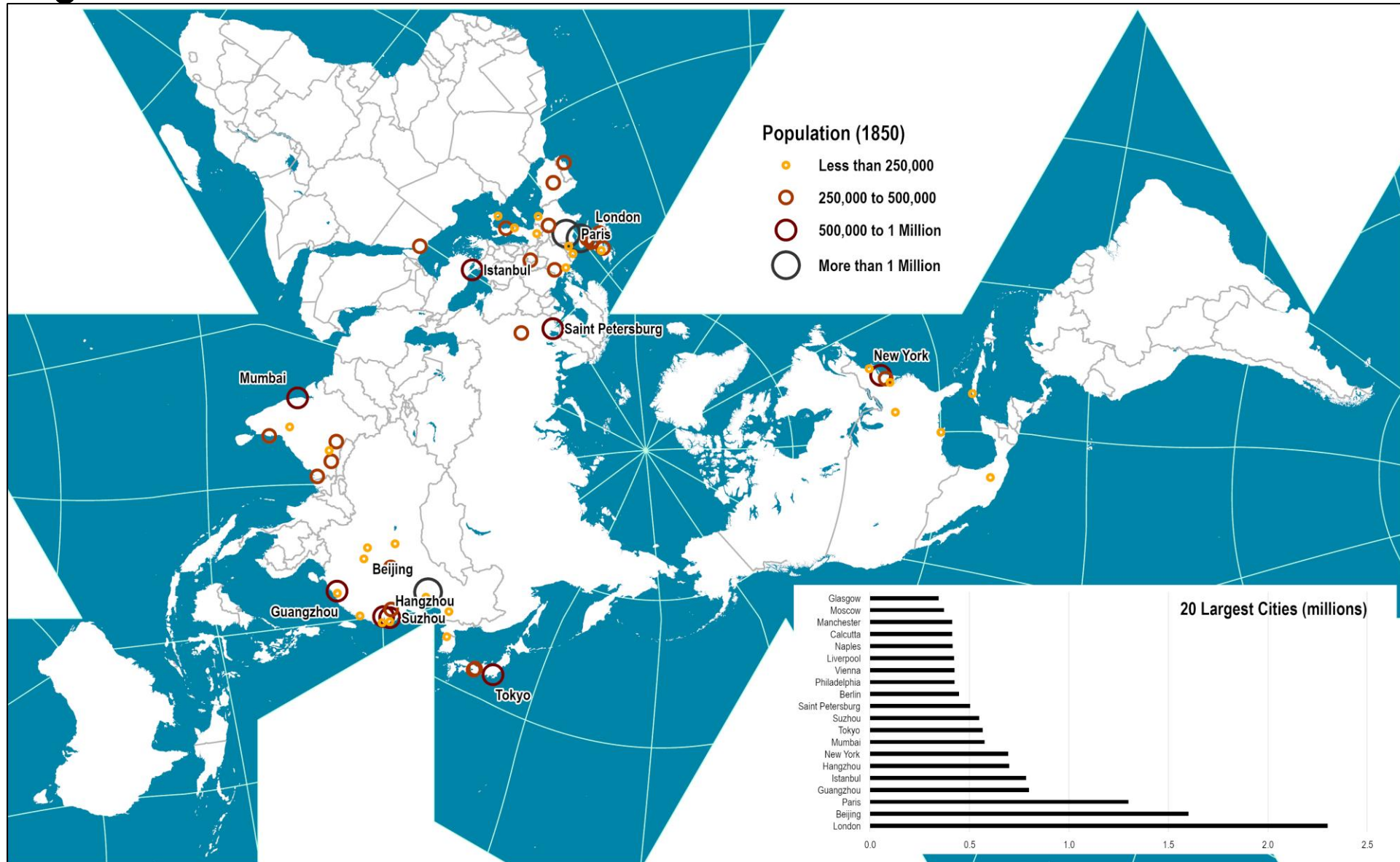
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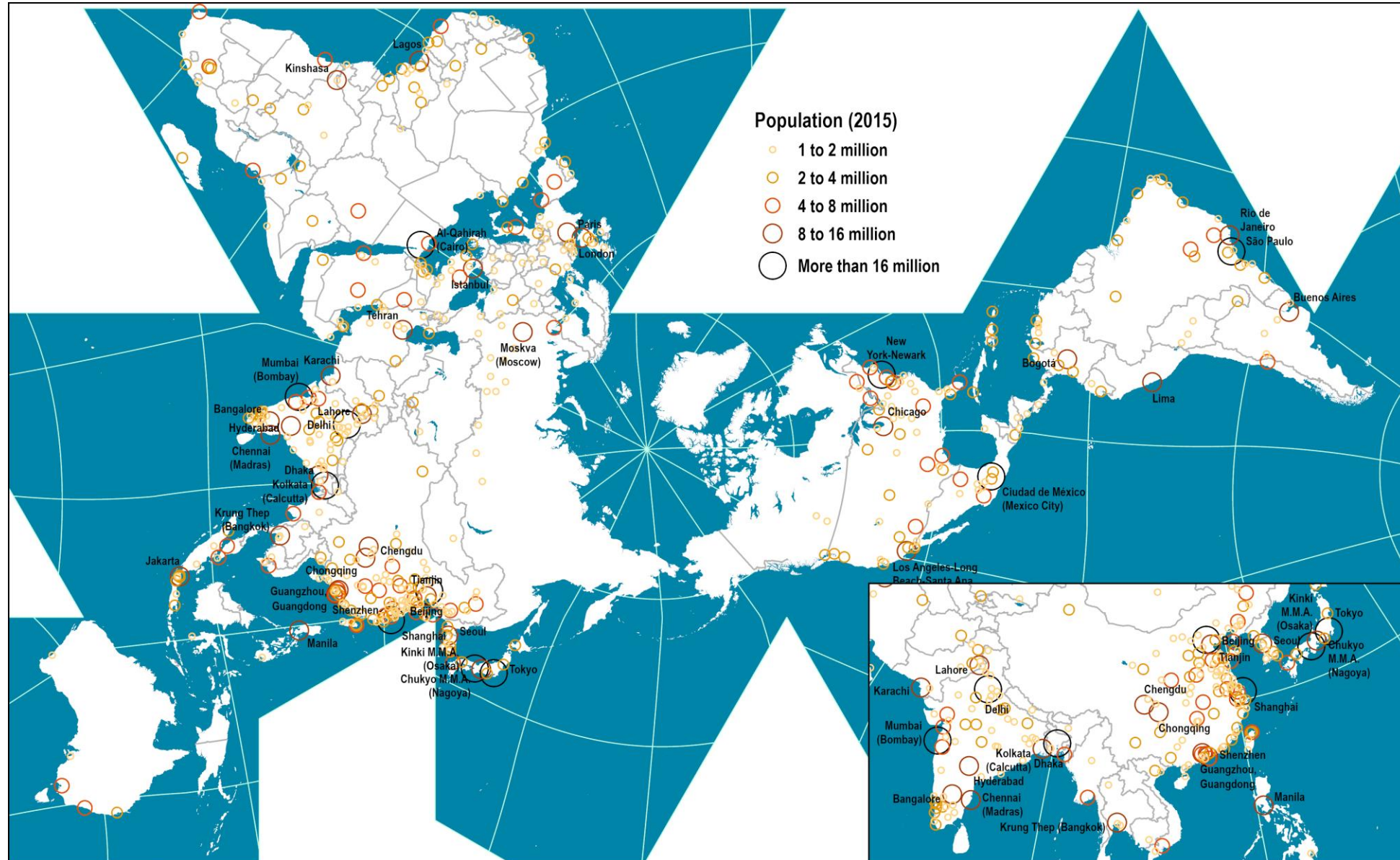
Cities of more than 8 million, 1950-2010

1950	1970	1990	2000	2010
Developed countries				
New York London	New York London Tokyo Los Angeles Paris	Tokyo New York Los Angeles Moscow Osaka Paris	Tokyo New York Los Angeles Moscow Osaka Paris	
Developing countries				
None	Shanghai Mexico City Buenos Aires Beijing Sao Paulo	Mexico City Sao Paulo Shanghai Calcutta Buenos Aires Bombay Seoul Beijing Rio de Janeiro Tianjin Jakarta Cairo Delhi Manila	Mexico City Sao Paulo Shanghai Calcutta Bombay Beijing Jakarta Delhi Buenos Aires Lagos Tianjin Seoul Rio de Janeiro Dhaka Cairo Manila Karachi Bangkok Istanbul Teheran Bangalore Lima	

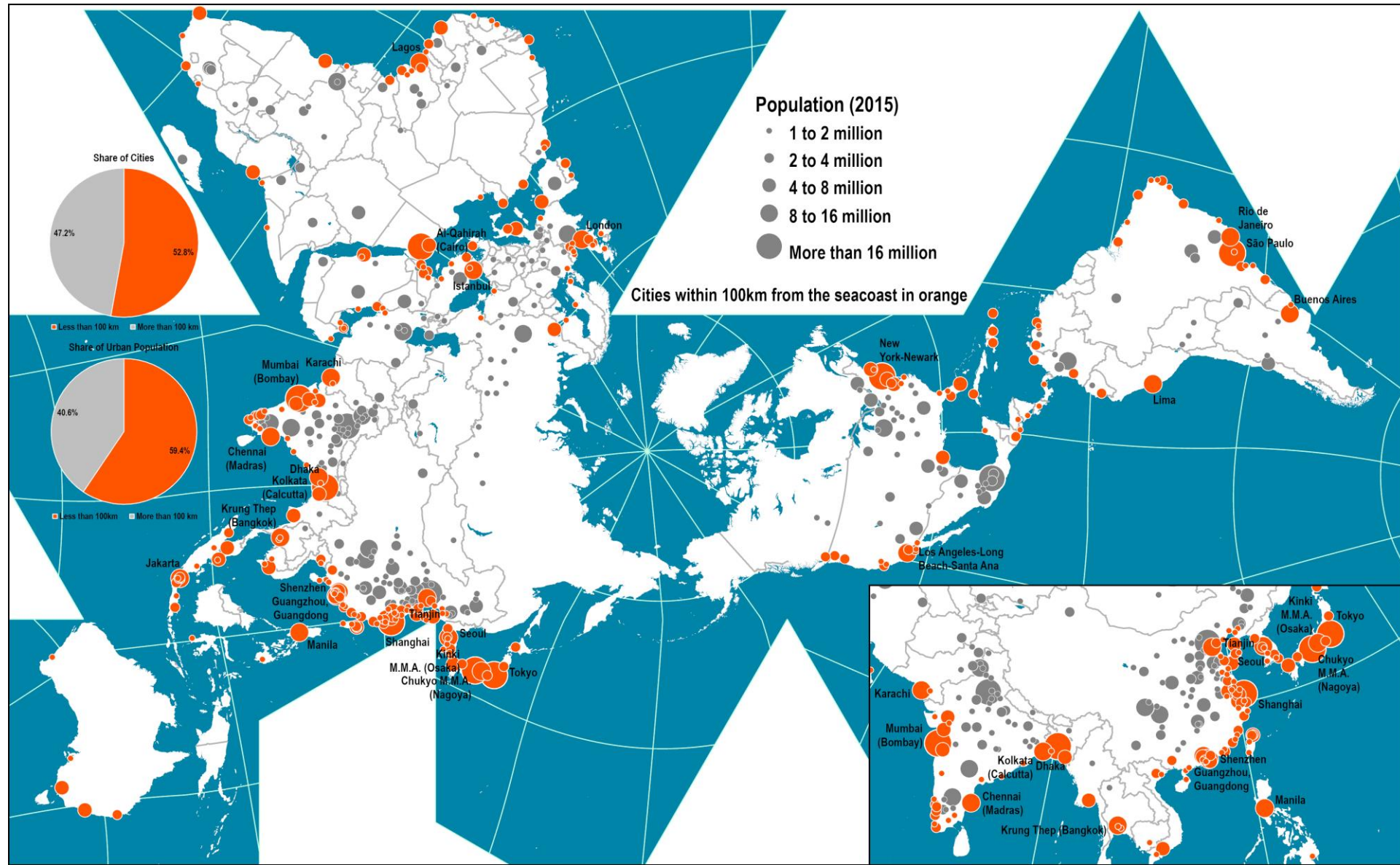
World's Largest Cities, 1850



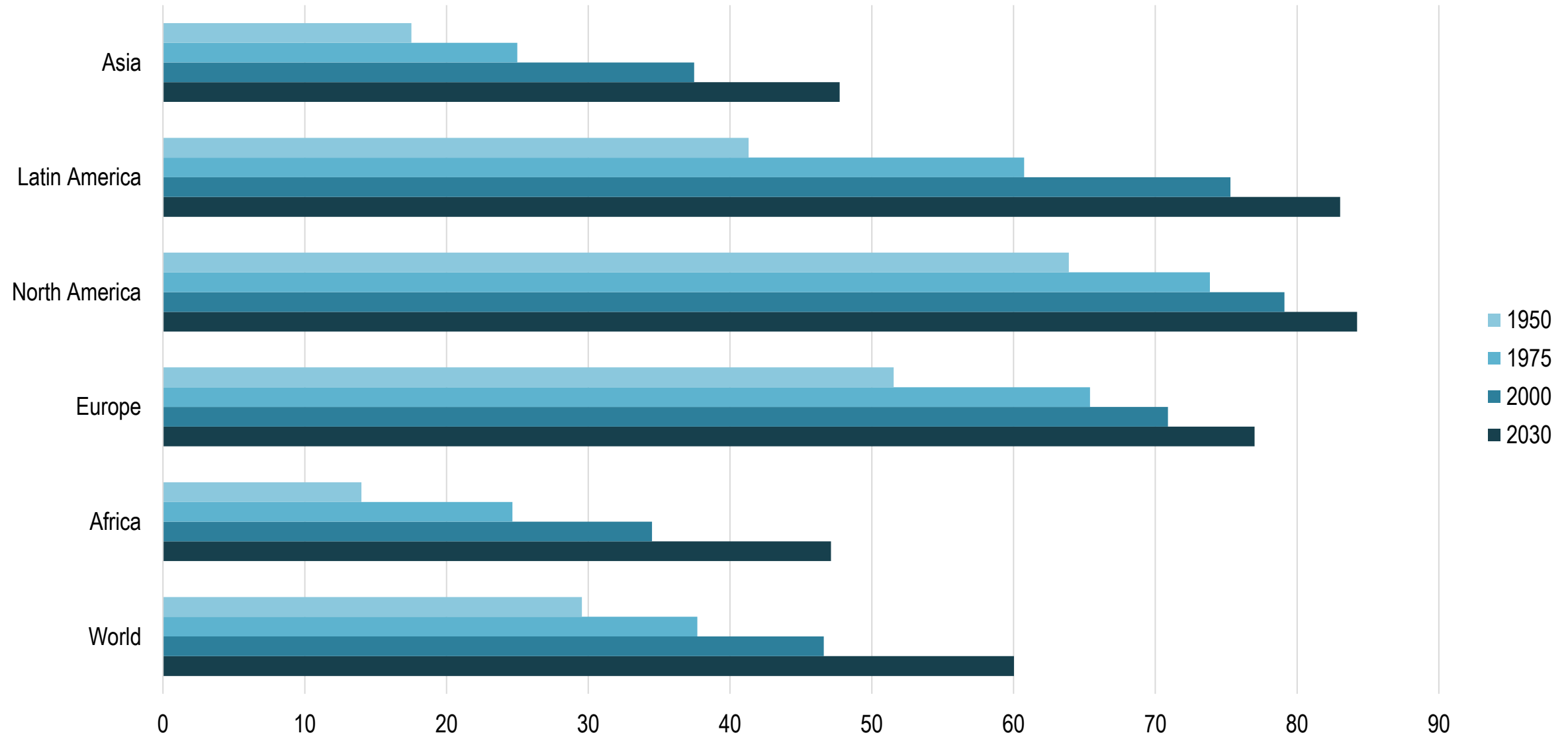
World's Largest Cities, 2015



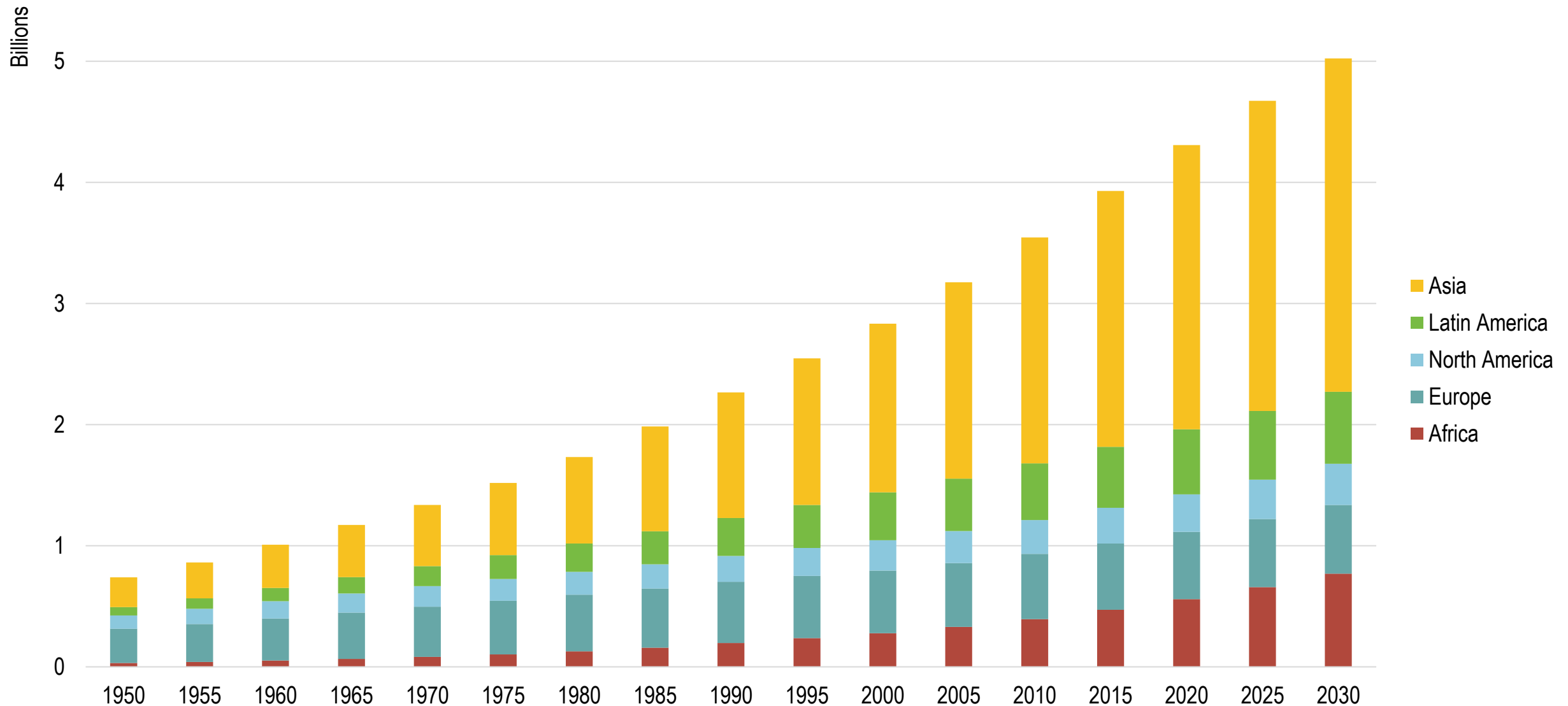
World's Largest Coastal Cities, 2015



Percentage of Urban Population by Region, 1950-2030



Urban Population by Region, 1950-2030 (in millions)



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

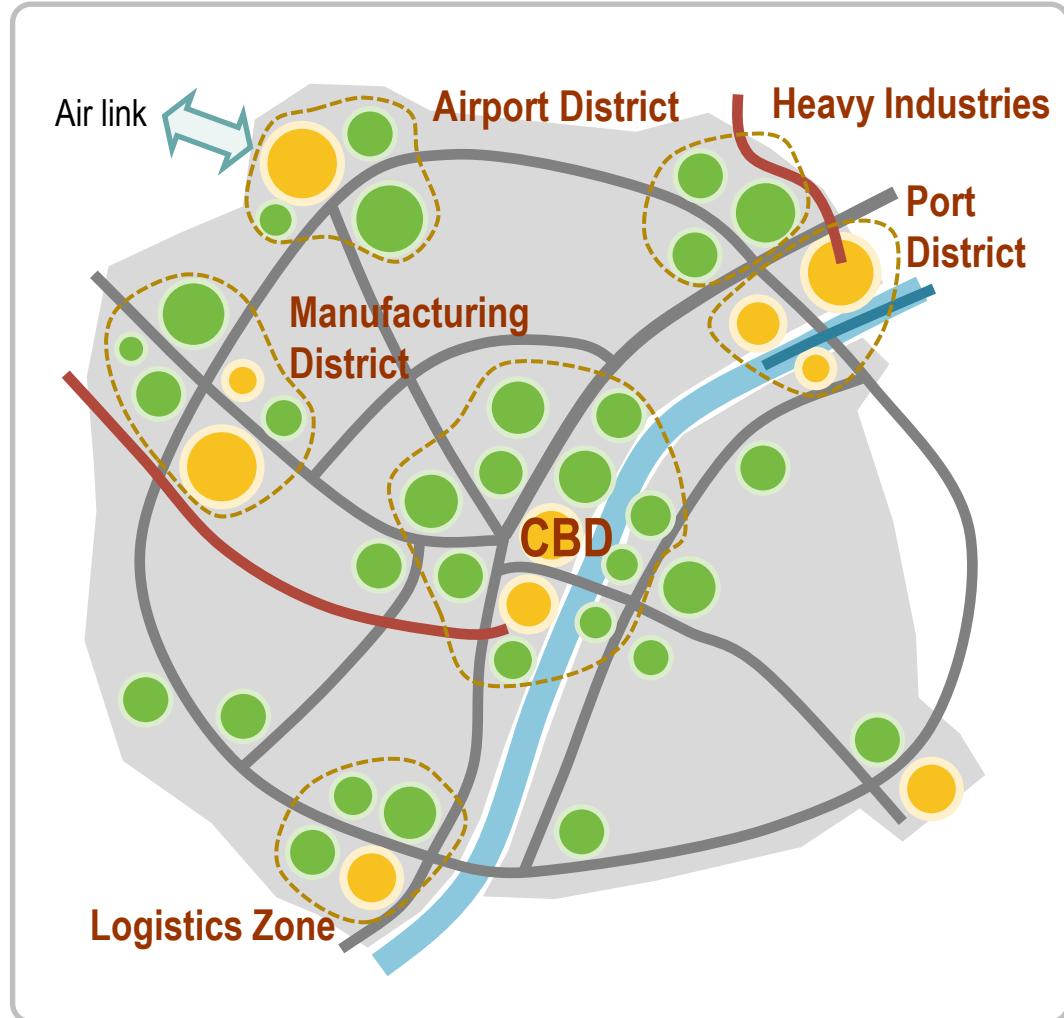
Port districts.
Heavy industries.
Railyards.
Manufacturing clusters.
Distribution clusters.

Mobility and Accessibility

Central / transit stations.
Shopping districts.
Airport districts.

Transactions

Financial / management districts.



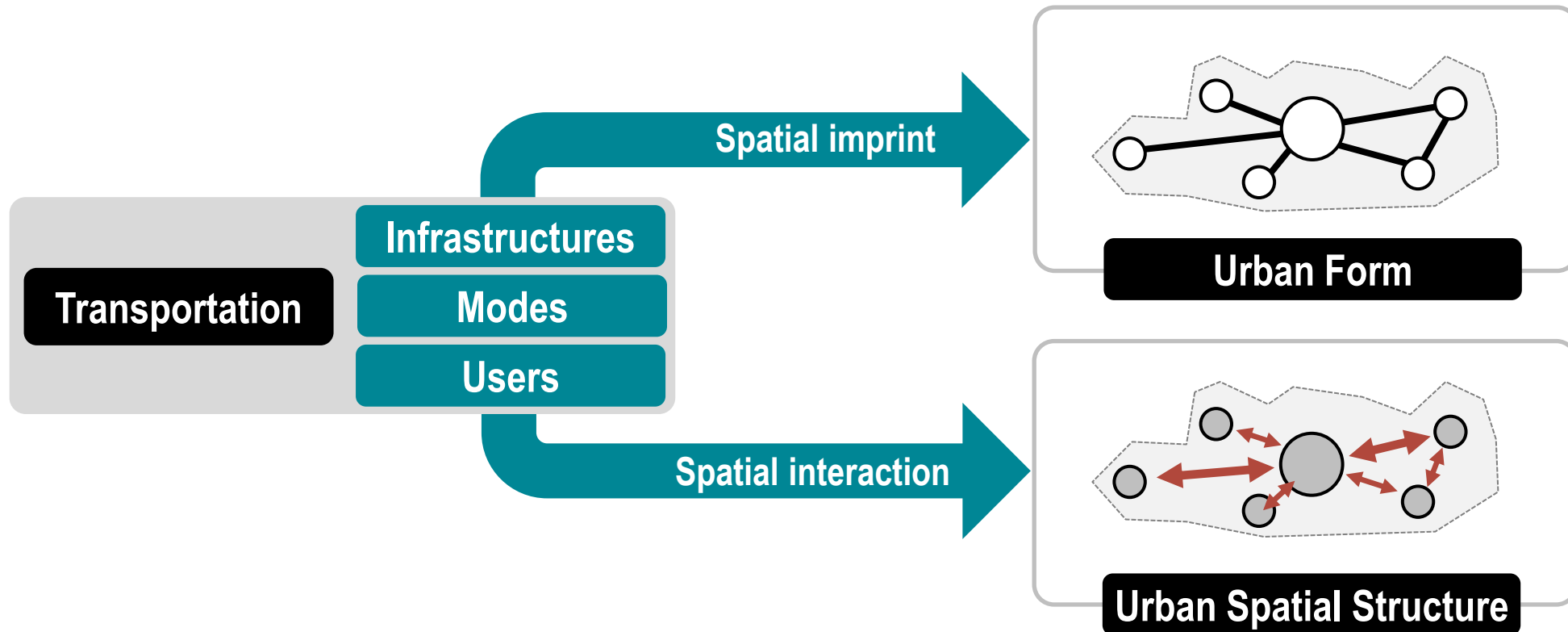
Box 1.4 Most influential urban forms from the early 20th century

The most influential urban forms have been:

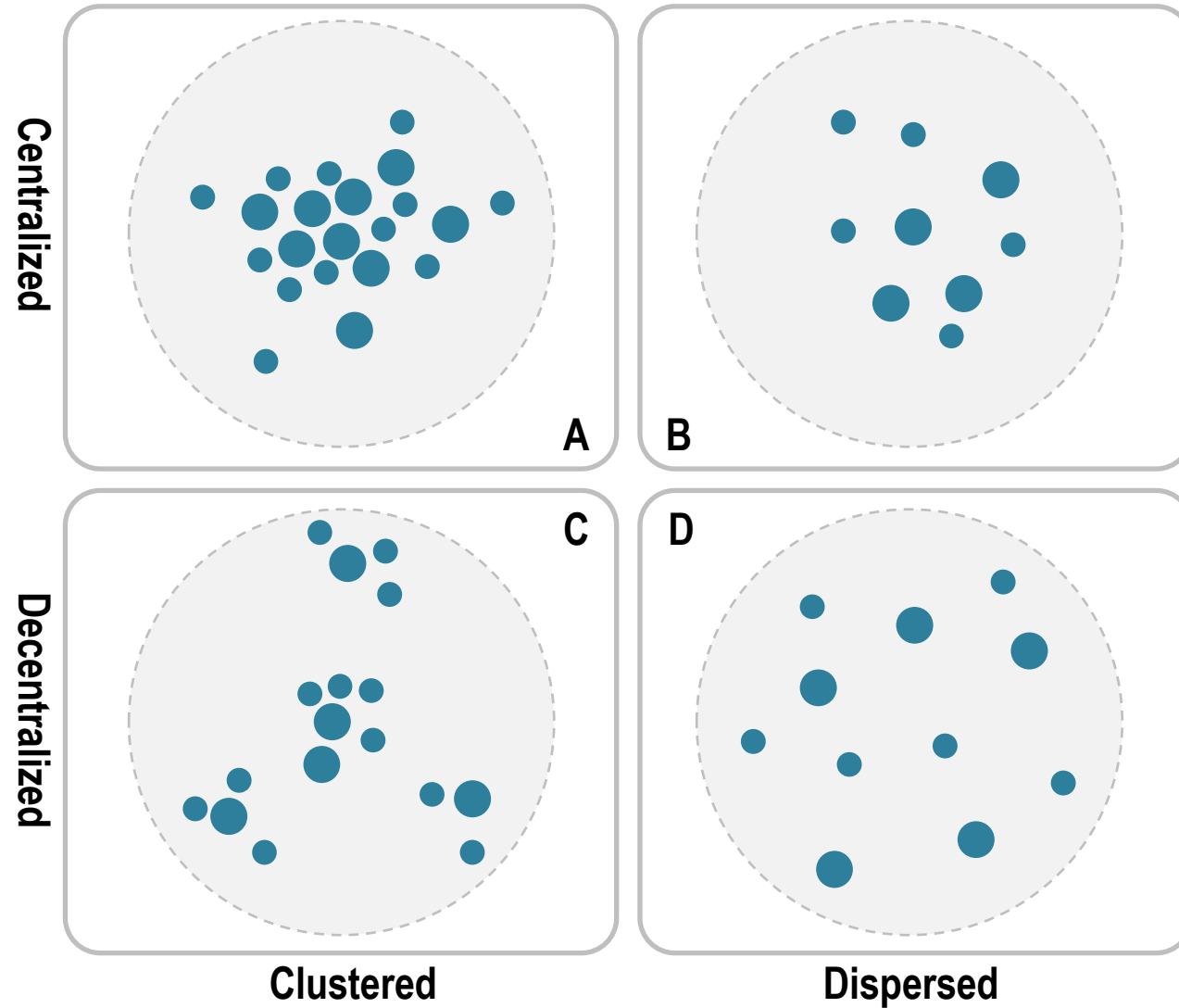
- *The garden city*, circa 1900 (UK): small, self-contained satellite towns, detached dwellings, large plots of land, low densities, separation of incompatible land uses, radial road networks and aesthetic, curving routes.
- *Greenbelts*, circa 1900 (UK): wide buffers of open space surrounding a town 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

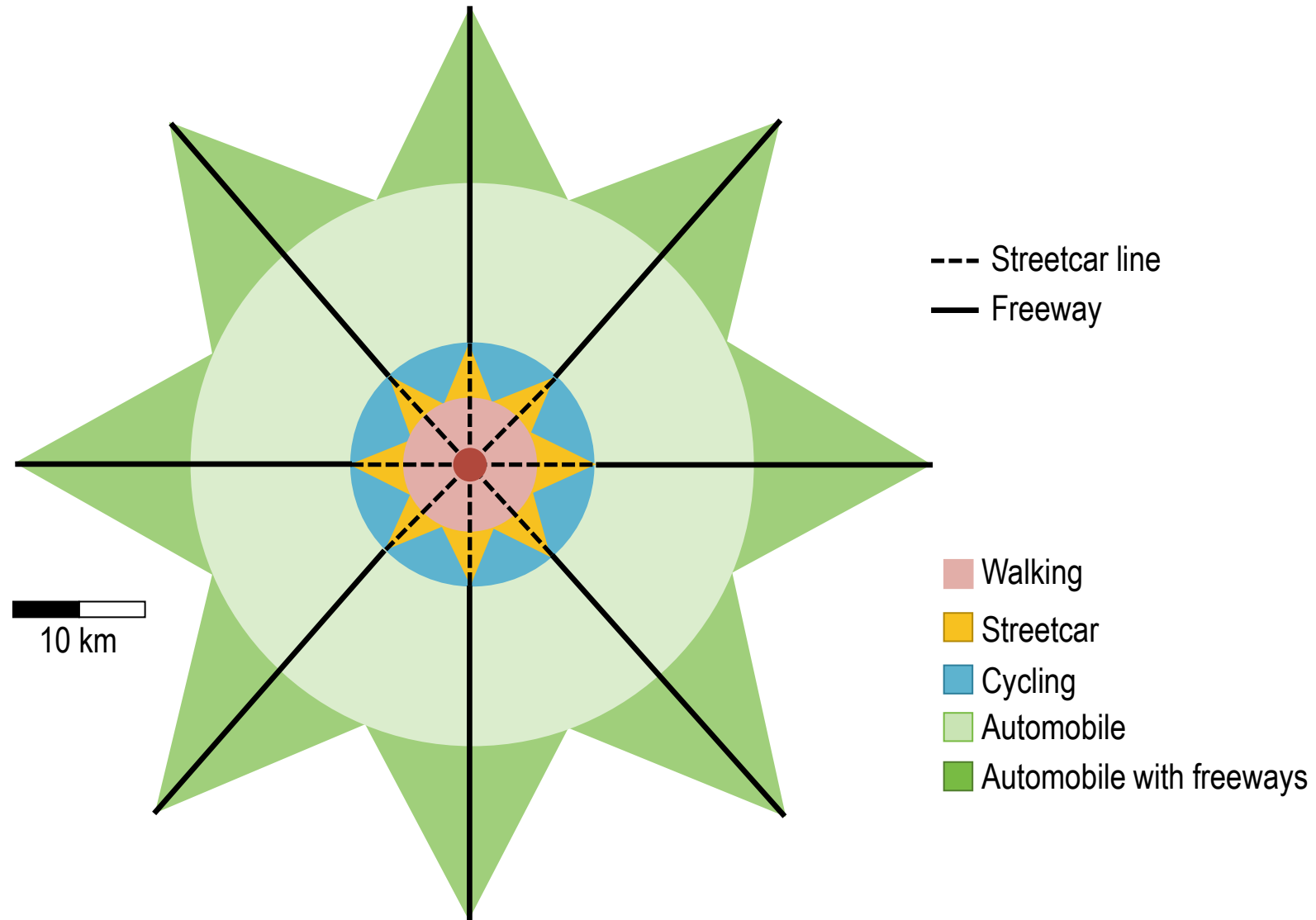
Transportation, Urban Form and Spatial Structure



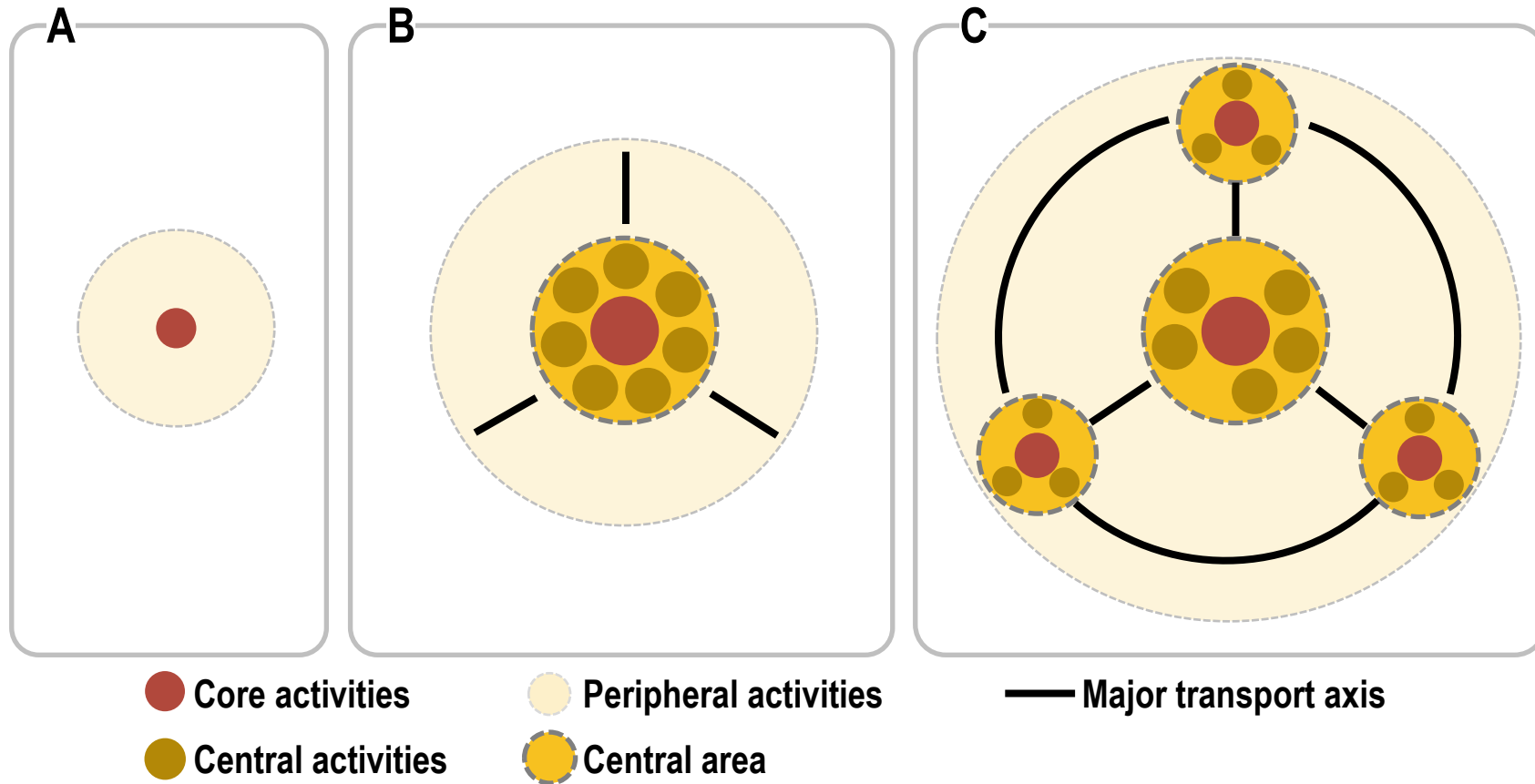
Types of Urban Spatial Structures



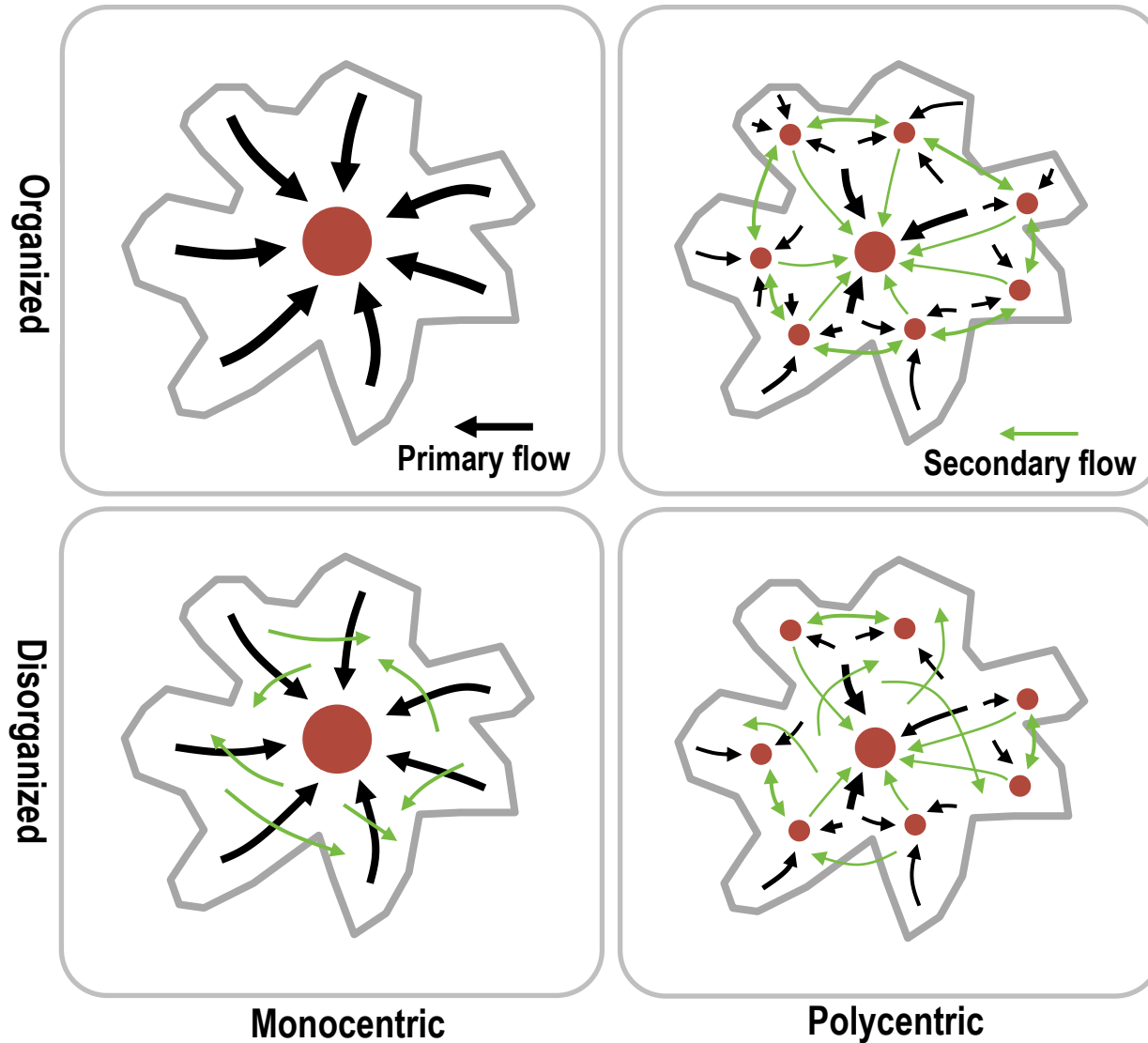
One Hour Commuting According to Different Urban Transportation Modes



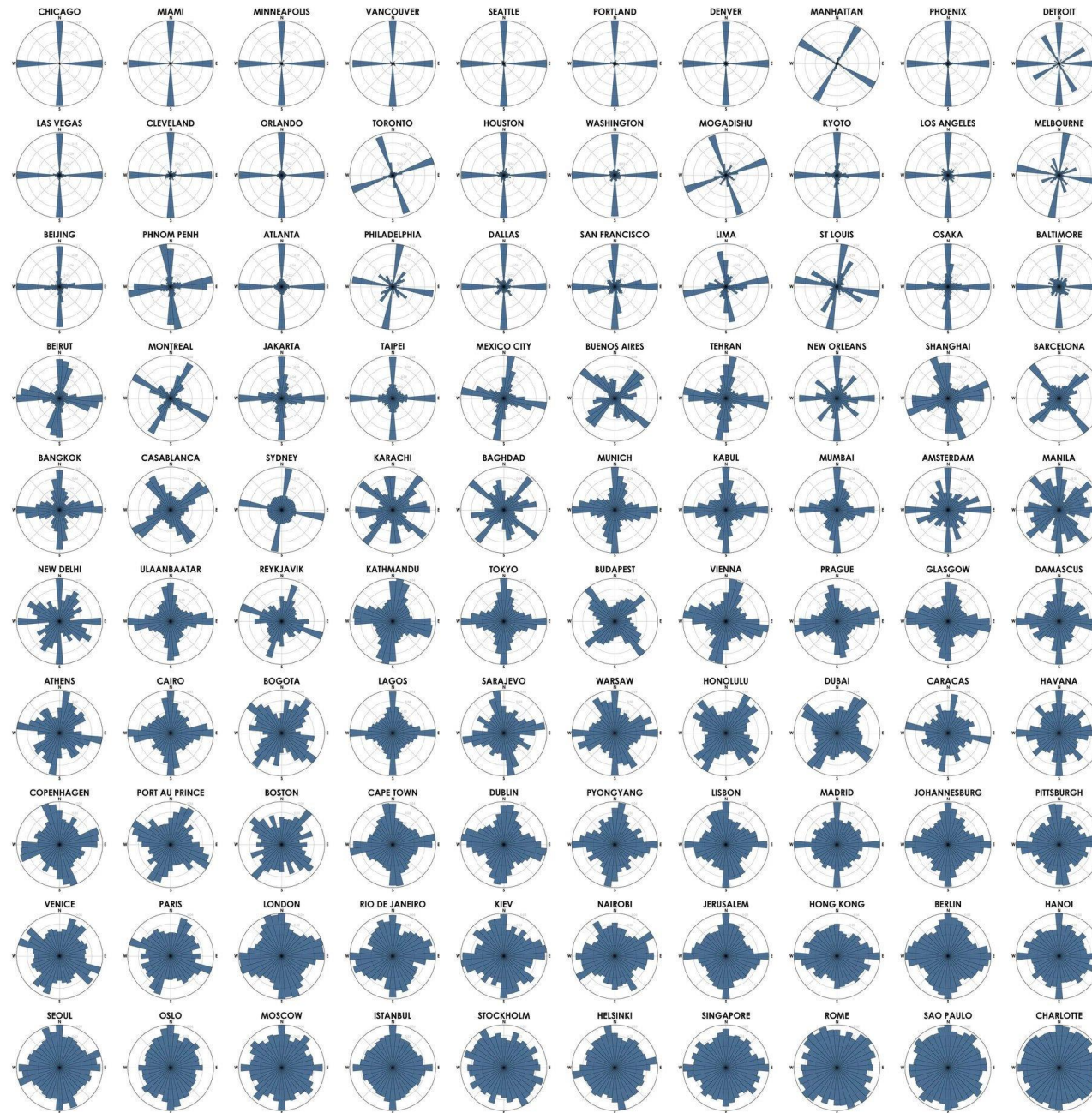
Evolution of the Spatial Structure of a City



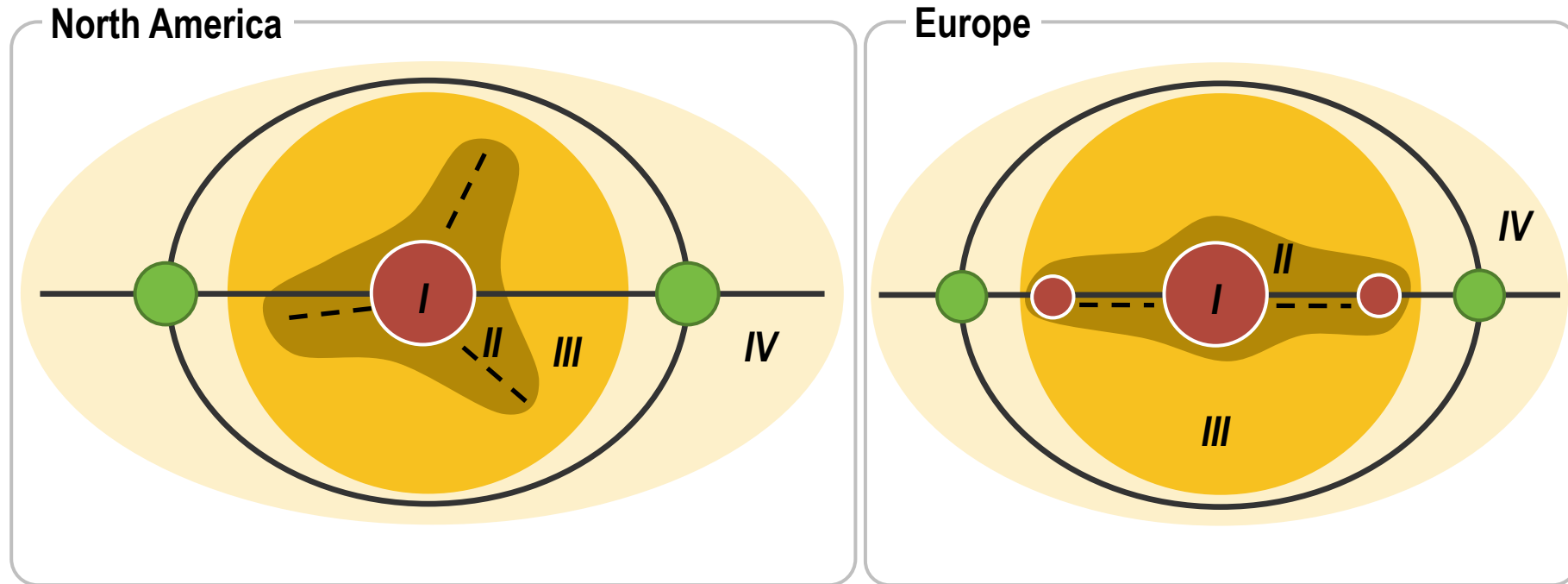
Possible Urban Mobility Patterns



City Street Network Orientation

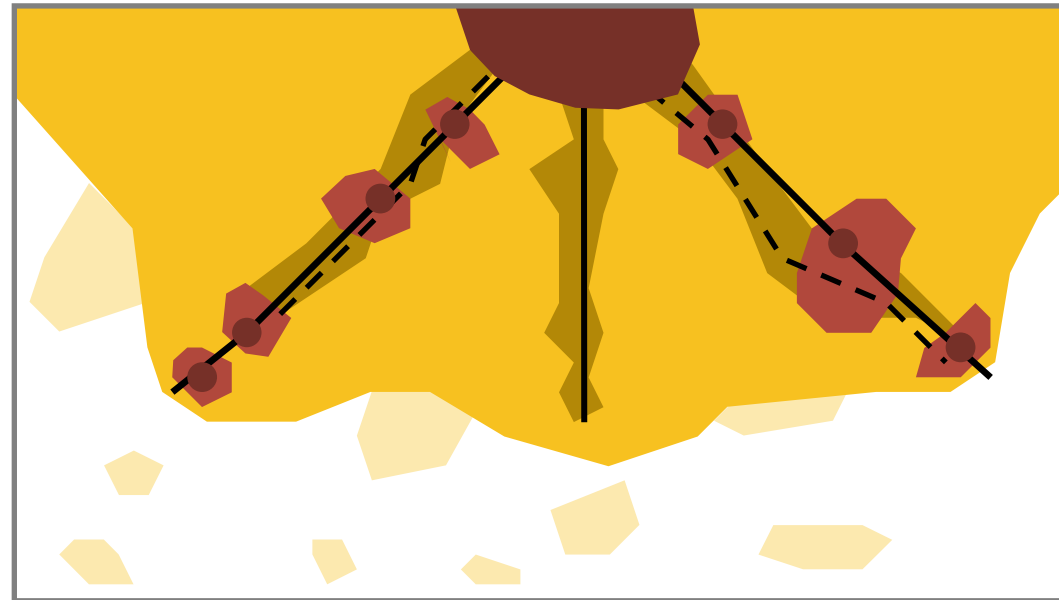


Evolution of Transportation and Urban Form in North American and European Cities



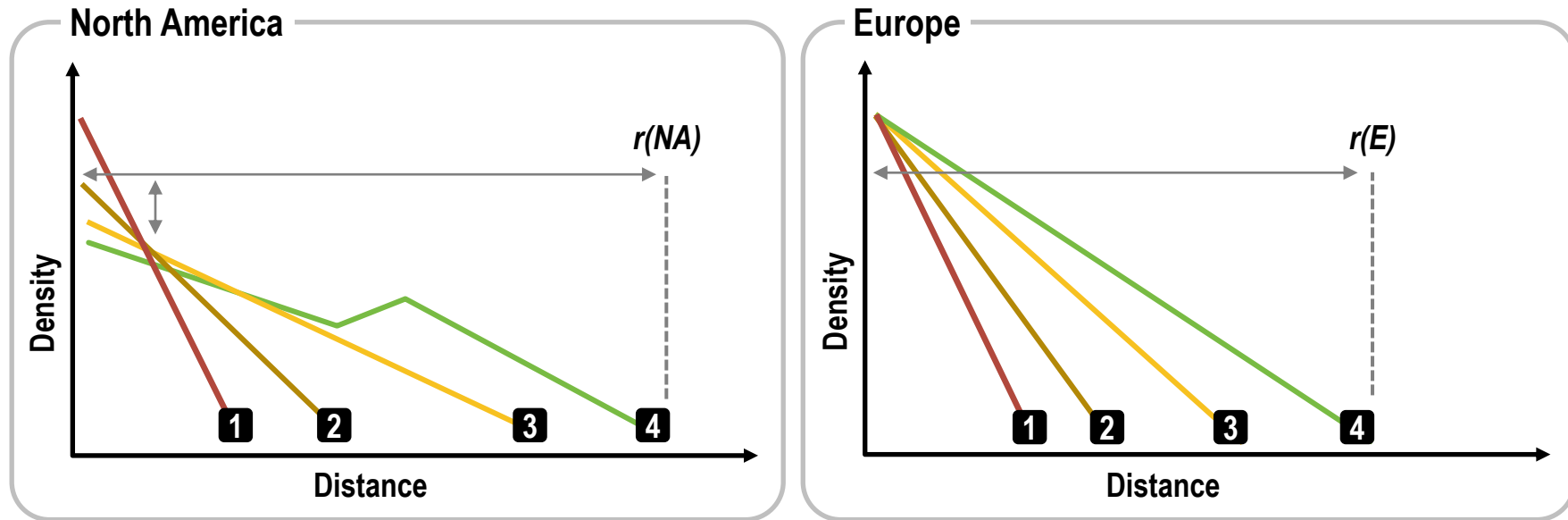
- I - Walking-horsecar era (1800-1890)
- II - Streetcar era (1890-1920)
- III - Automobile era (1920-1945)
- IV - Highway era (1945-)
- - - Streetcar line
- Highway

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



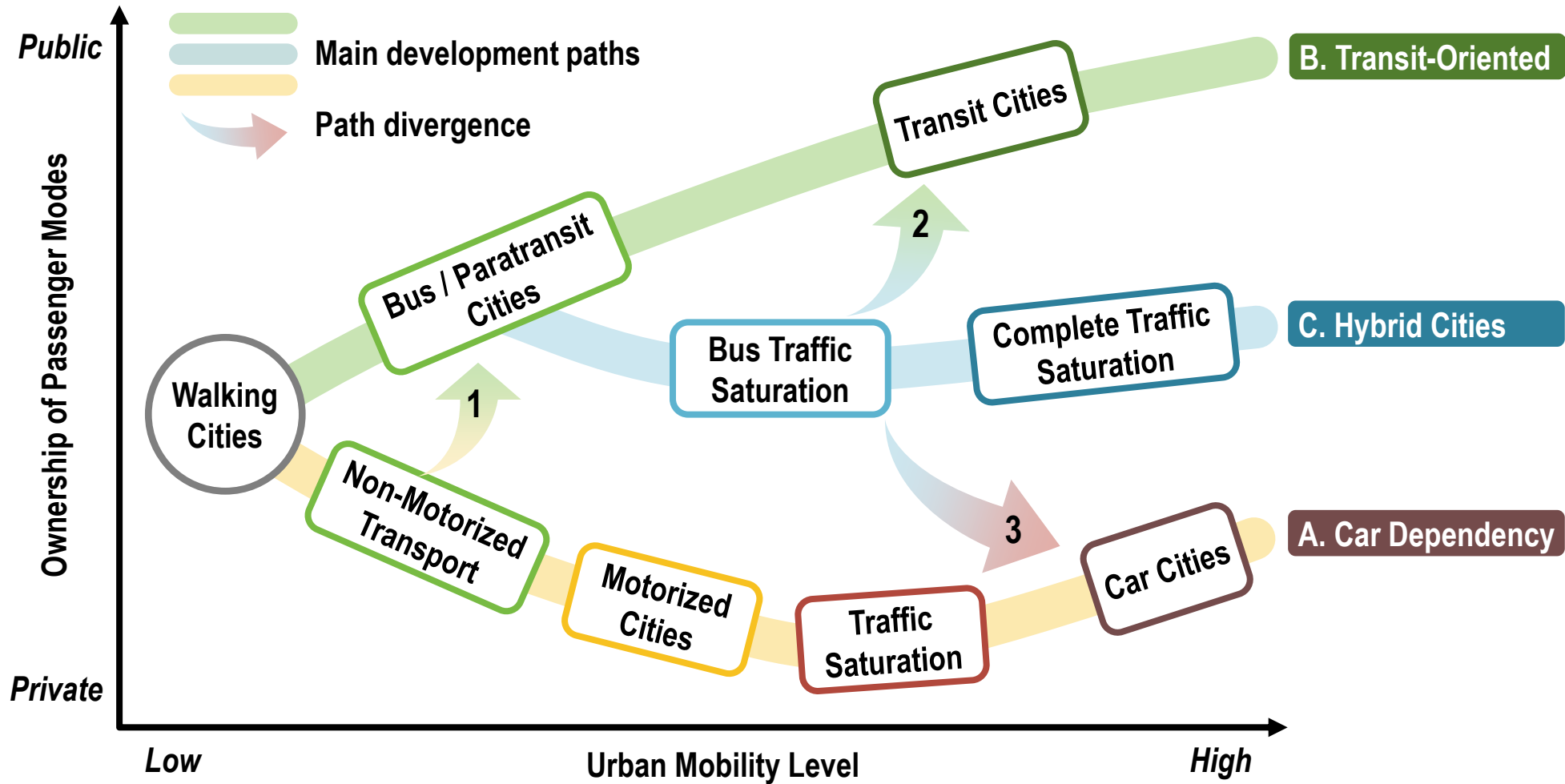
- Dark brown** Built up area prior to introduction of mechanical transport
- Red** Development consequent on steam railways
- Brown** Development consequent on tramways
- Yellow** Development consequent on motor buses
- Light yellow** Development consequent on private car

Evolution of Urban Densities in North America and Europe

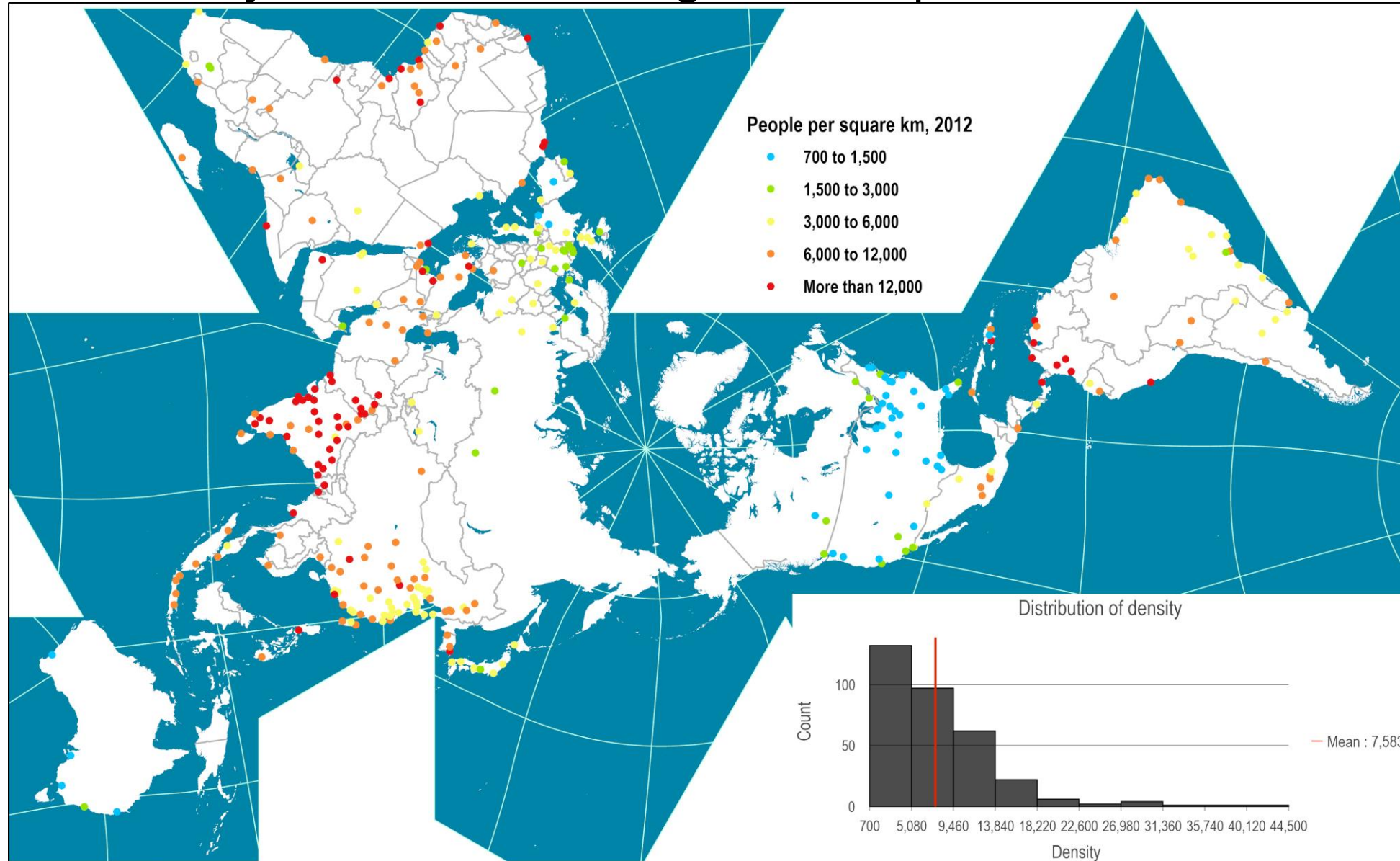


- 1 Prior to mechanized transport
- 2 Early forms of mechanized transport (tramways)
- 3 Diffusion of motor vehicles (buses, automobiles)
- 4 Suburbanization

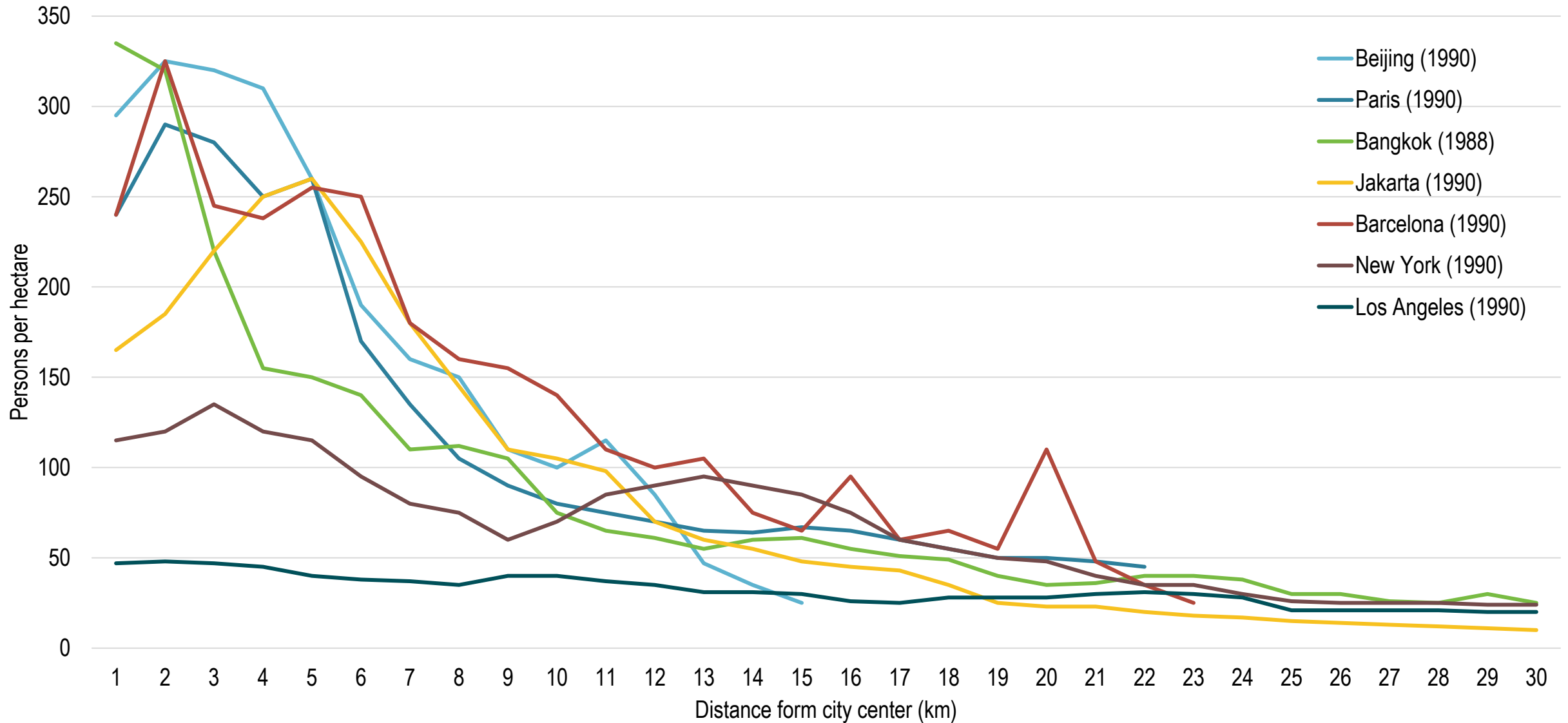
Urban Transport Development Paths



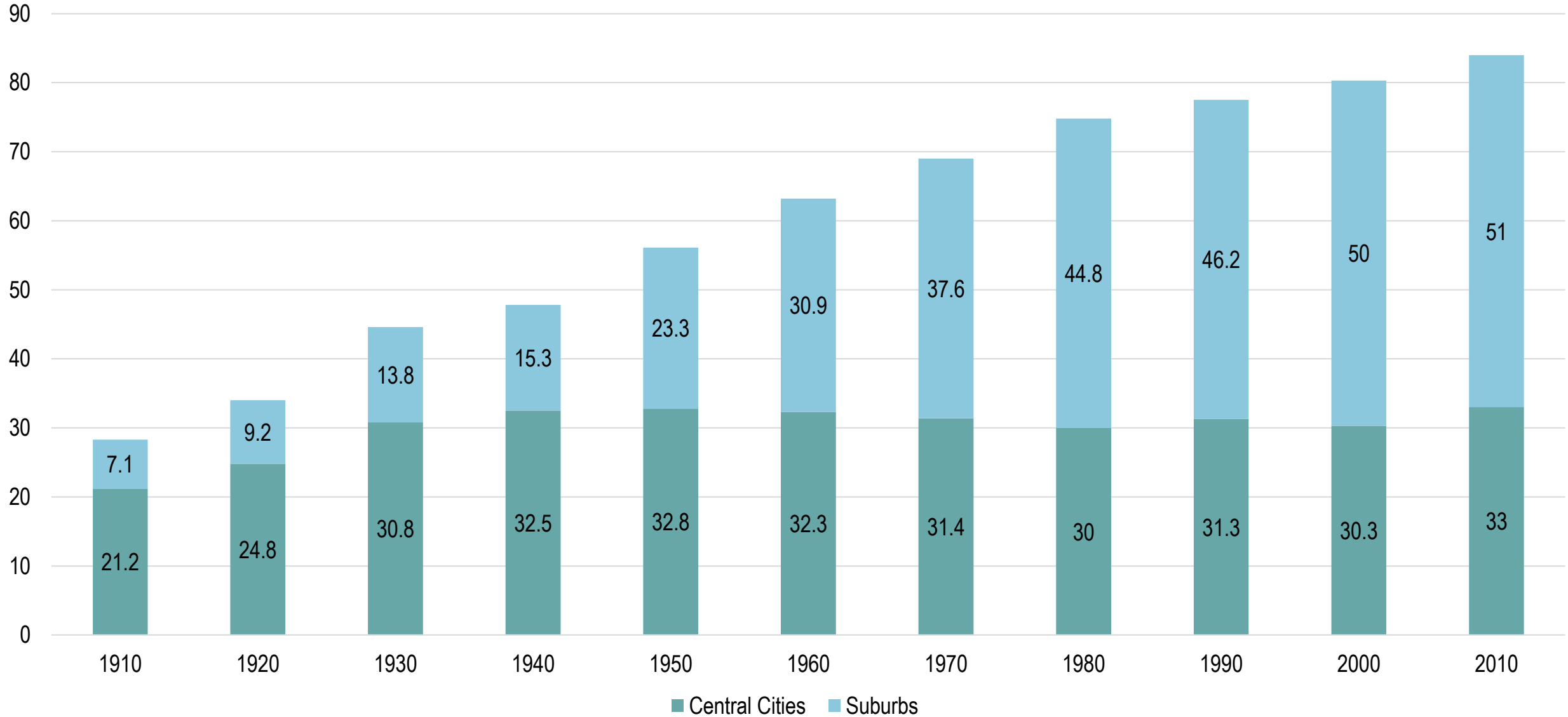
Population Density of the World's Largest Metropolitan Areas, 2012



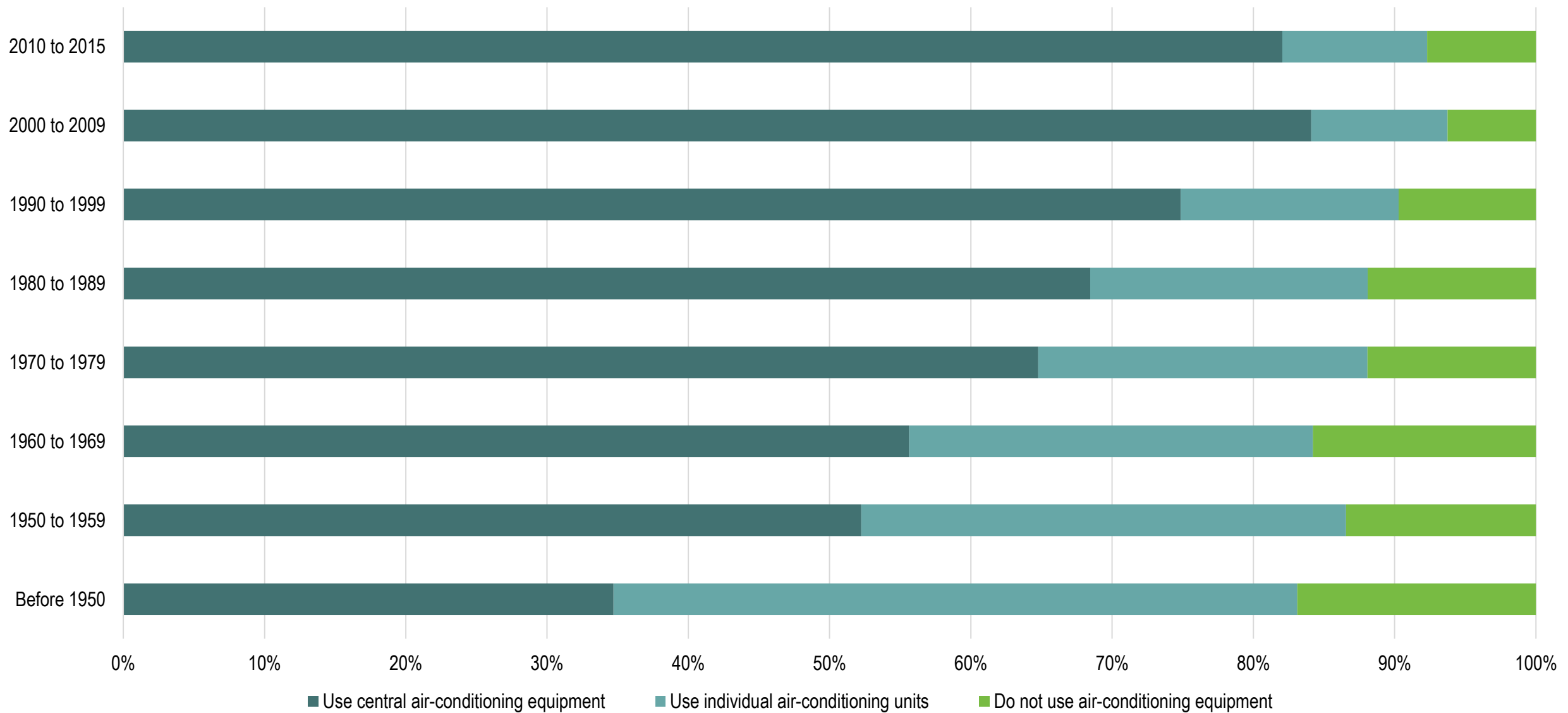
Population Density by Distance from City Center, Selected Cities



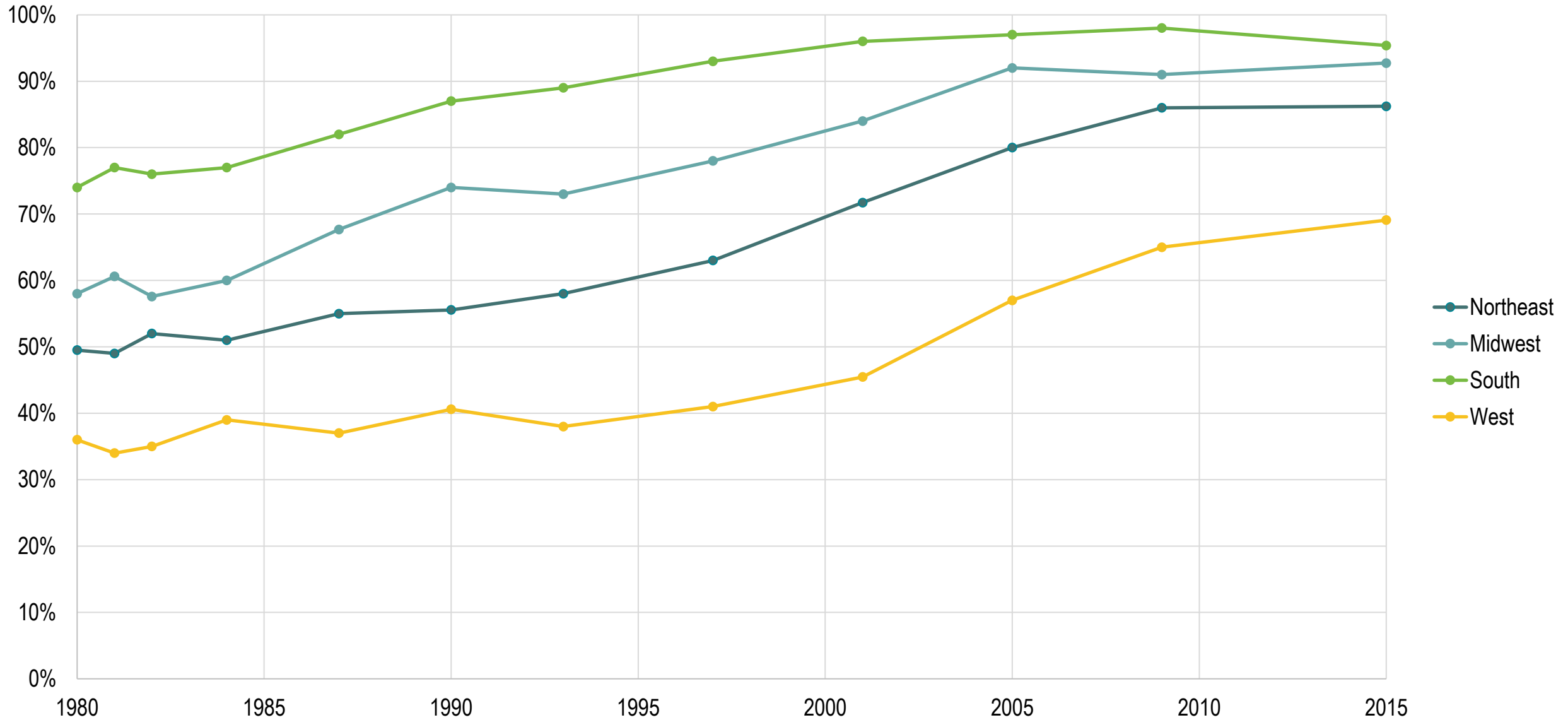
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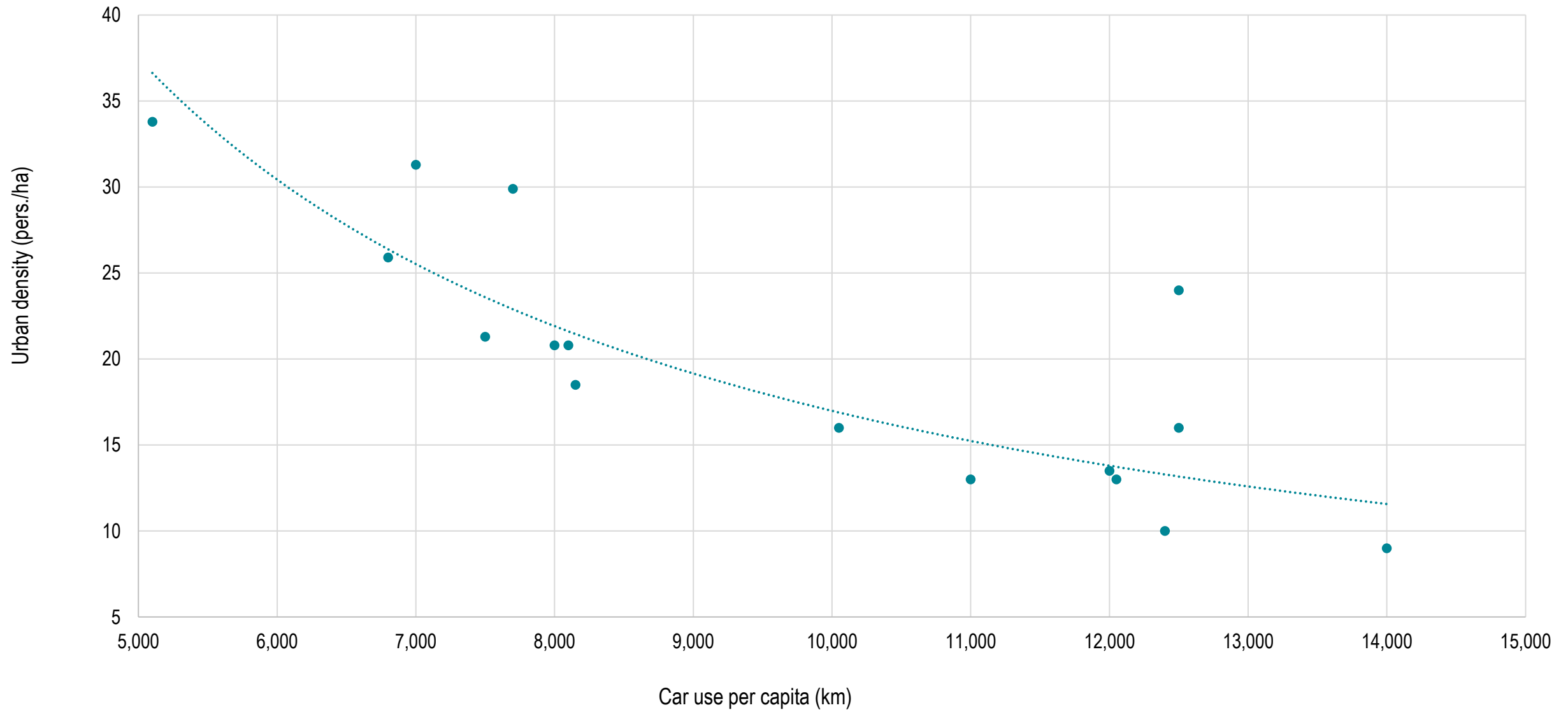
Share of Housing Units Equipped with Air Conditioning by Year of Construction, United States, 2015



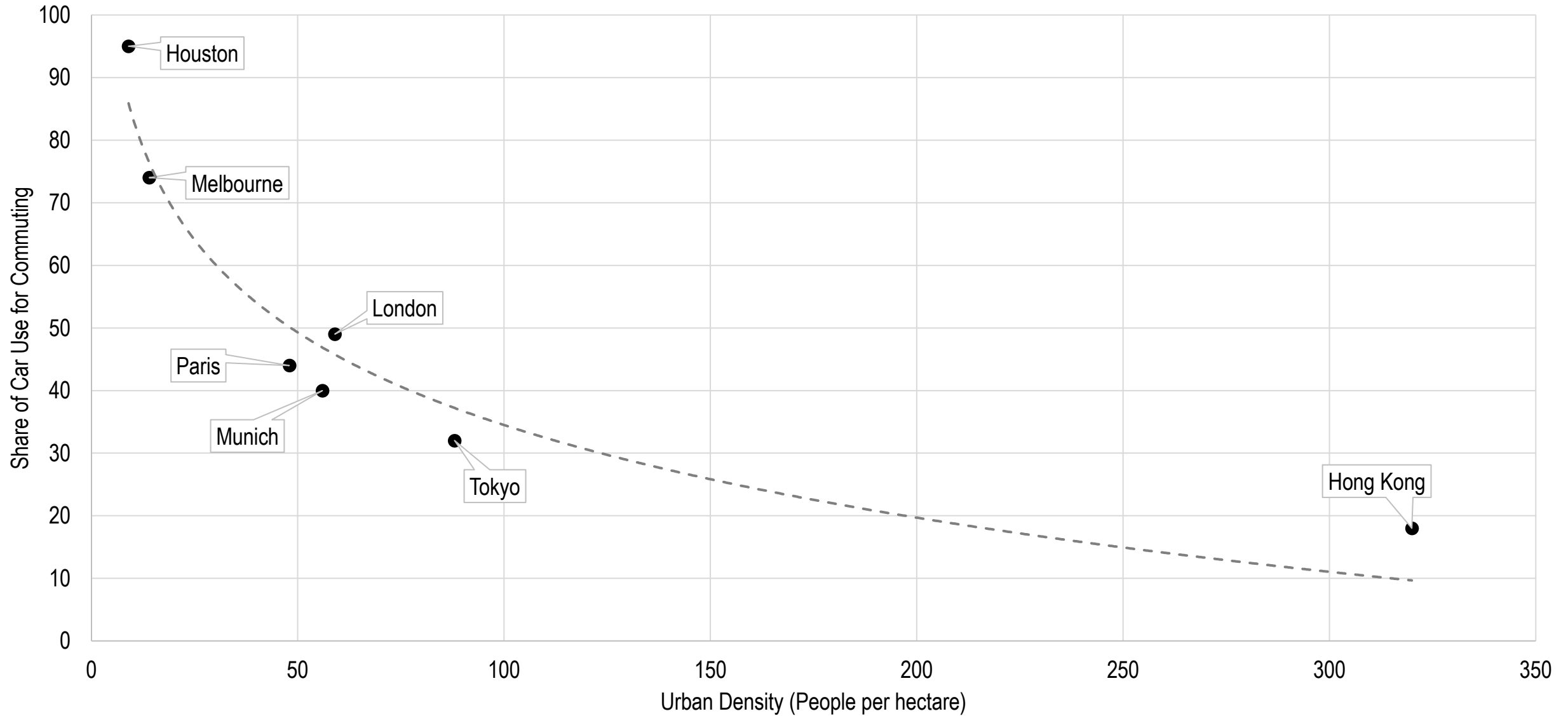
Share of Housing Units Equipped with Air Conditioning by Region in the United States, 1980-2015



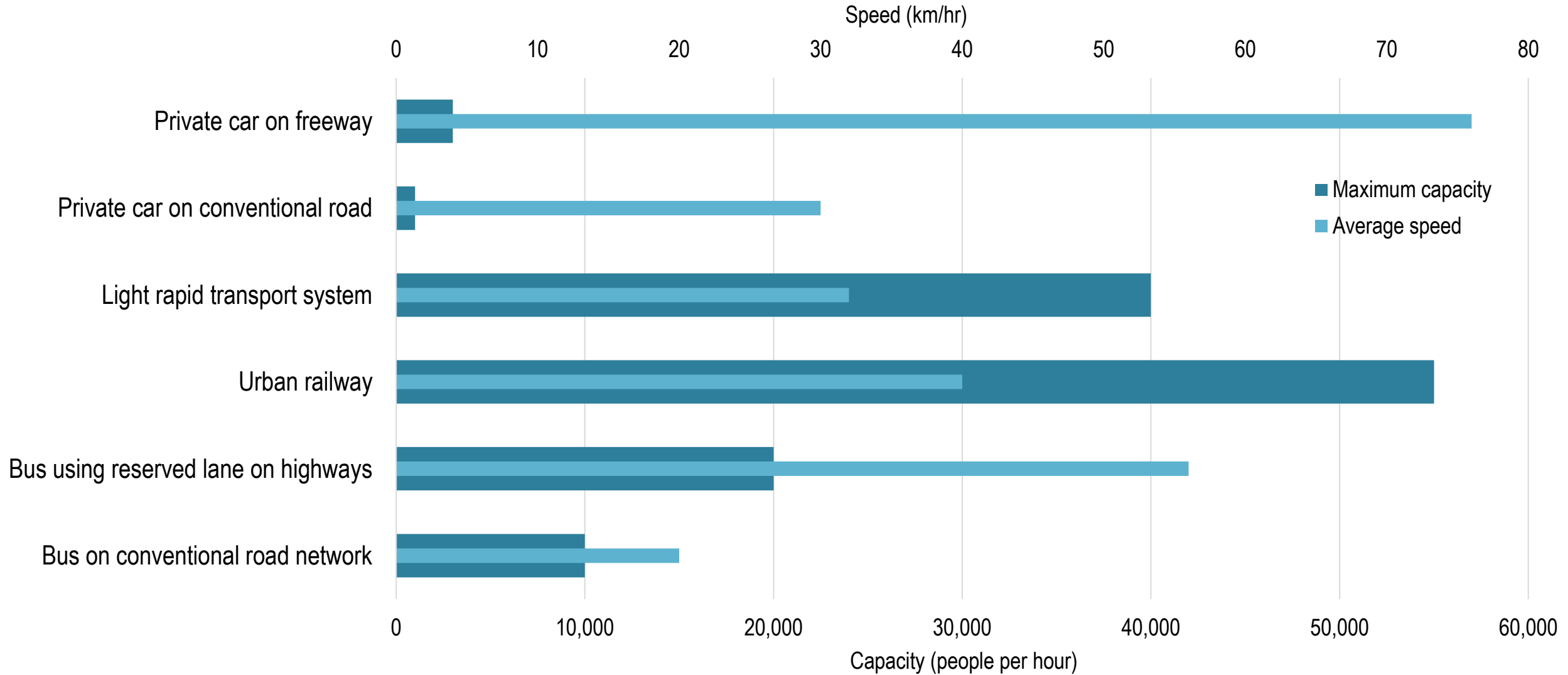
Density and Car Use in North American Cities, 1991



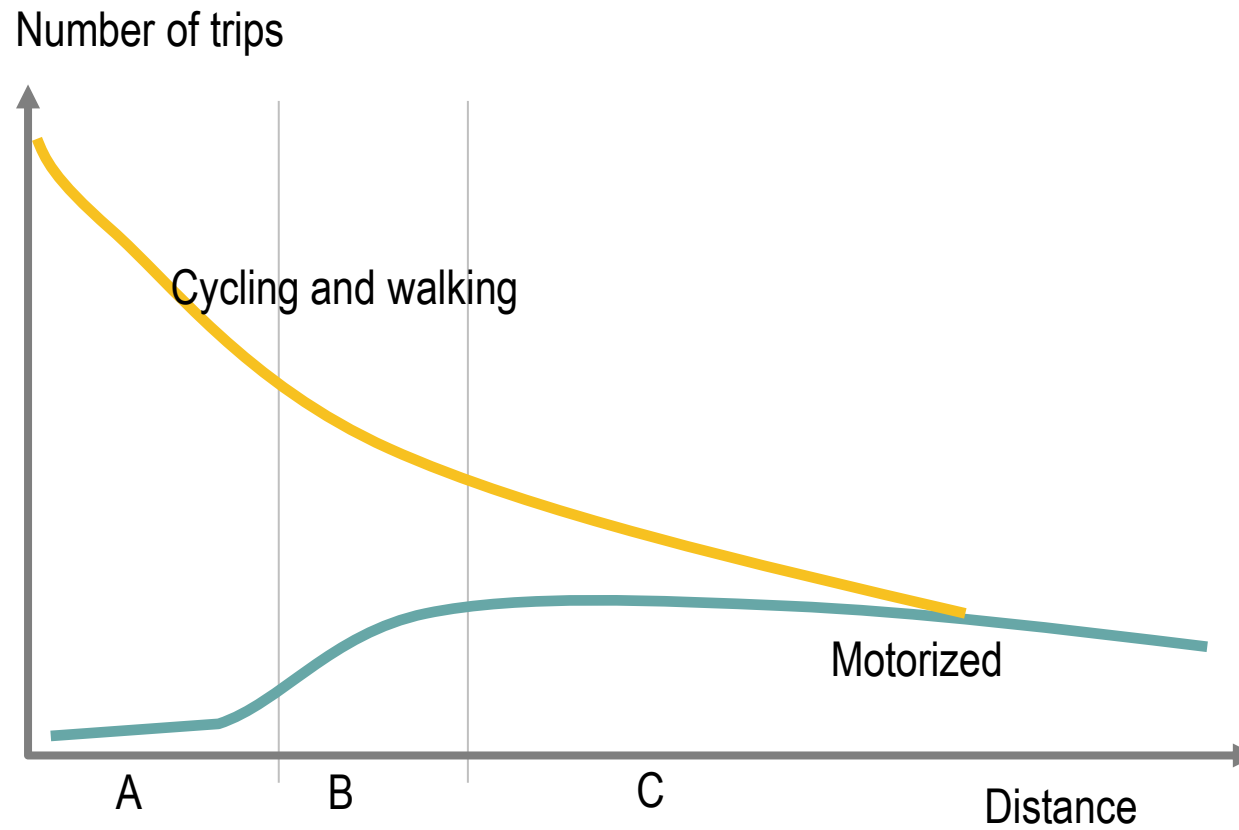
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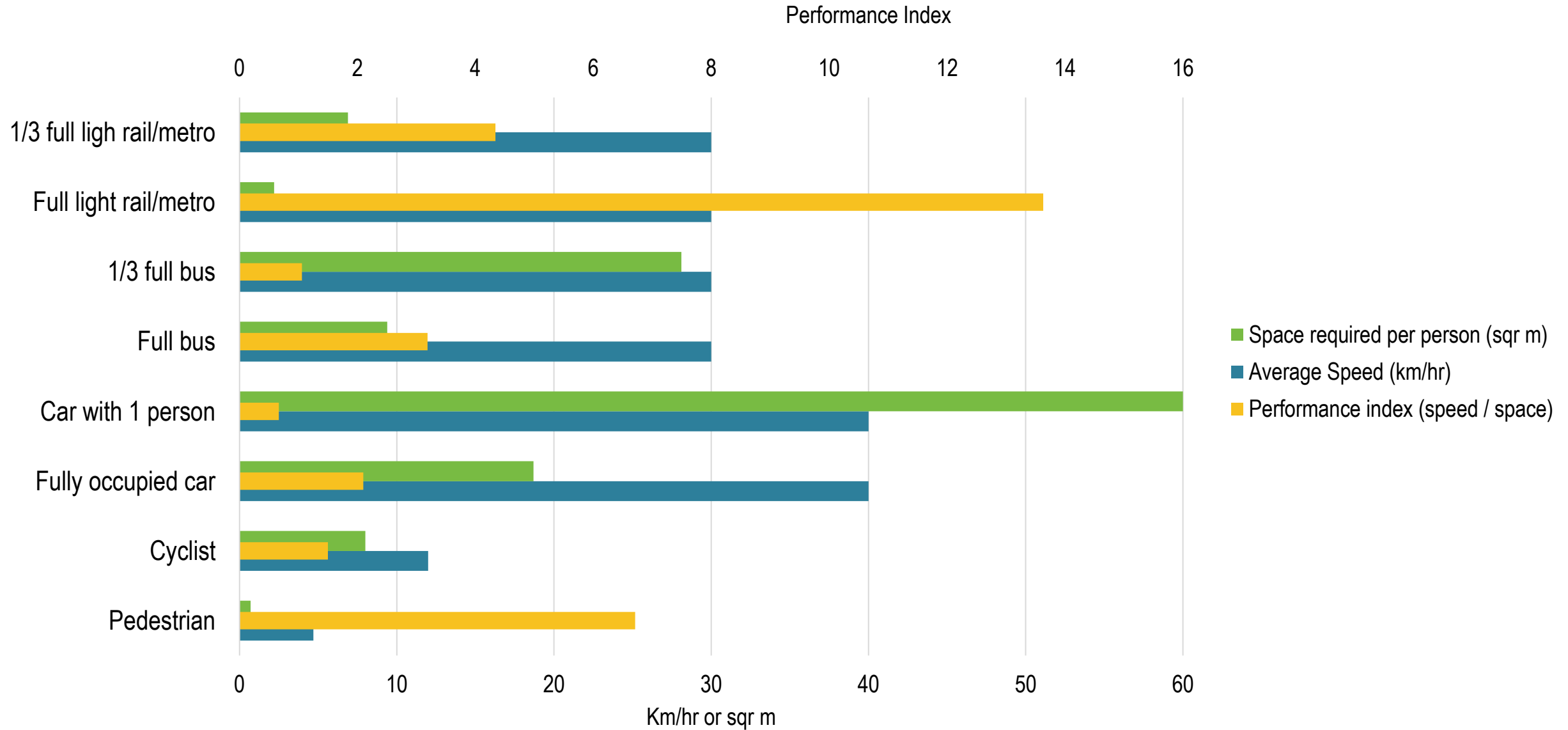
Service Attributes of Urban Transportation Modes



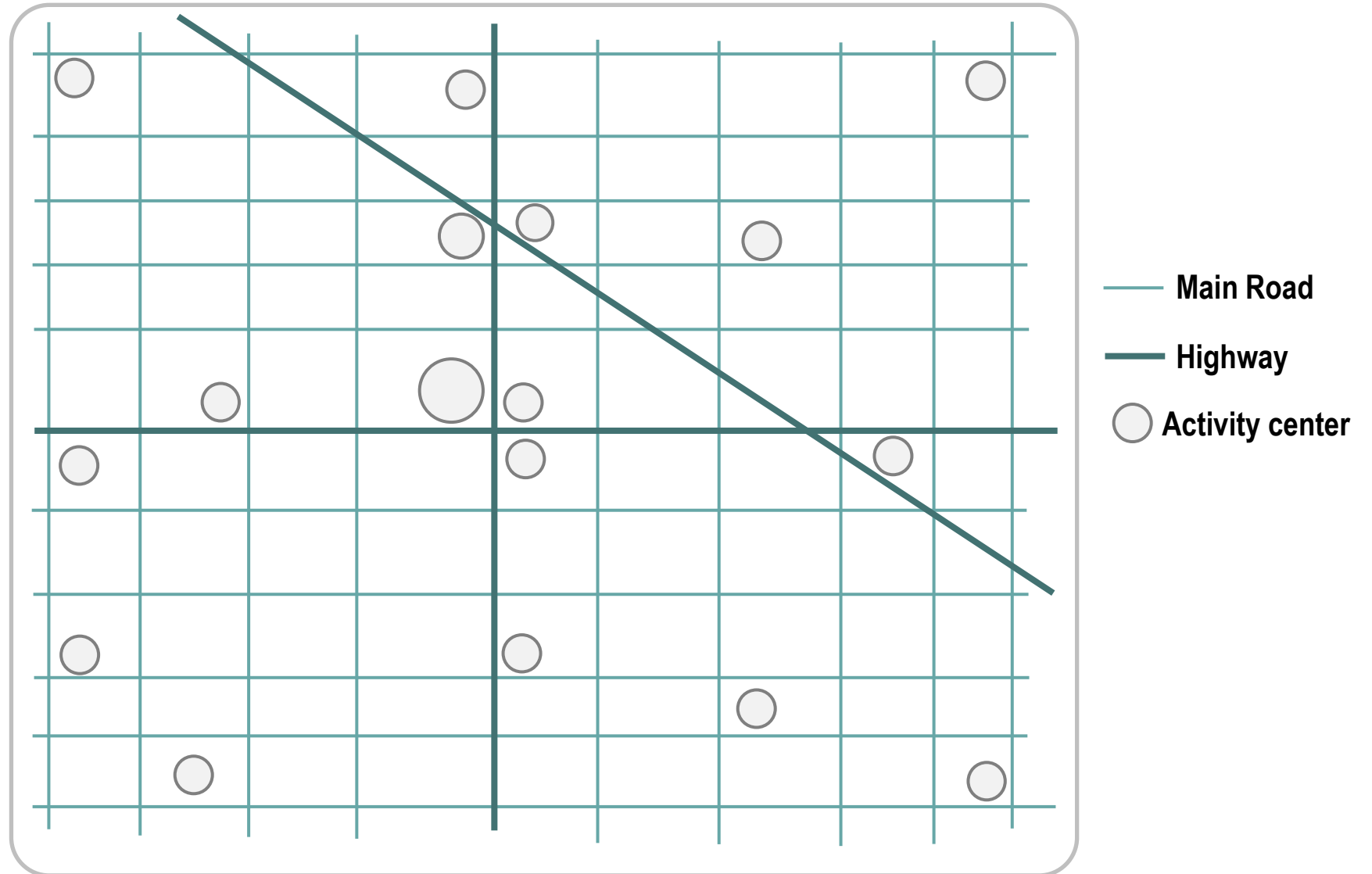
Urban Modes and Distance Decay



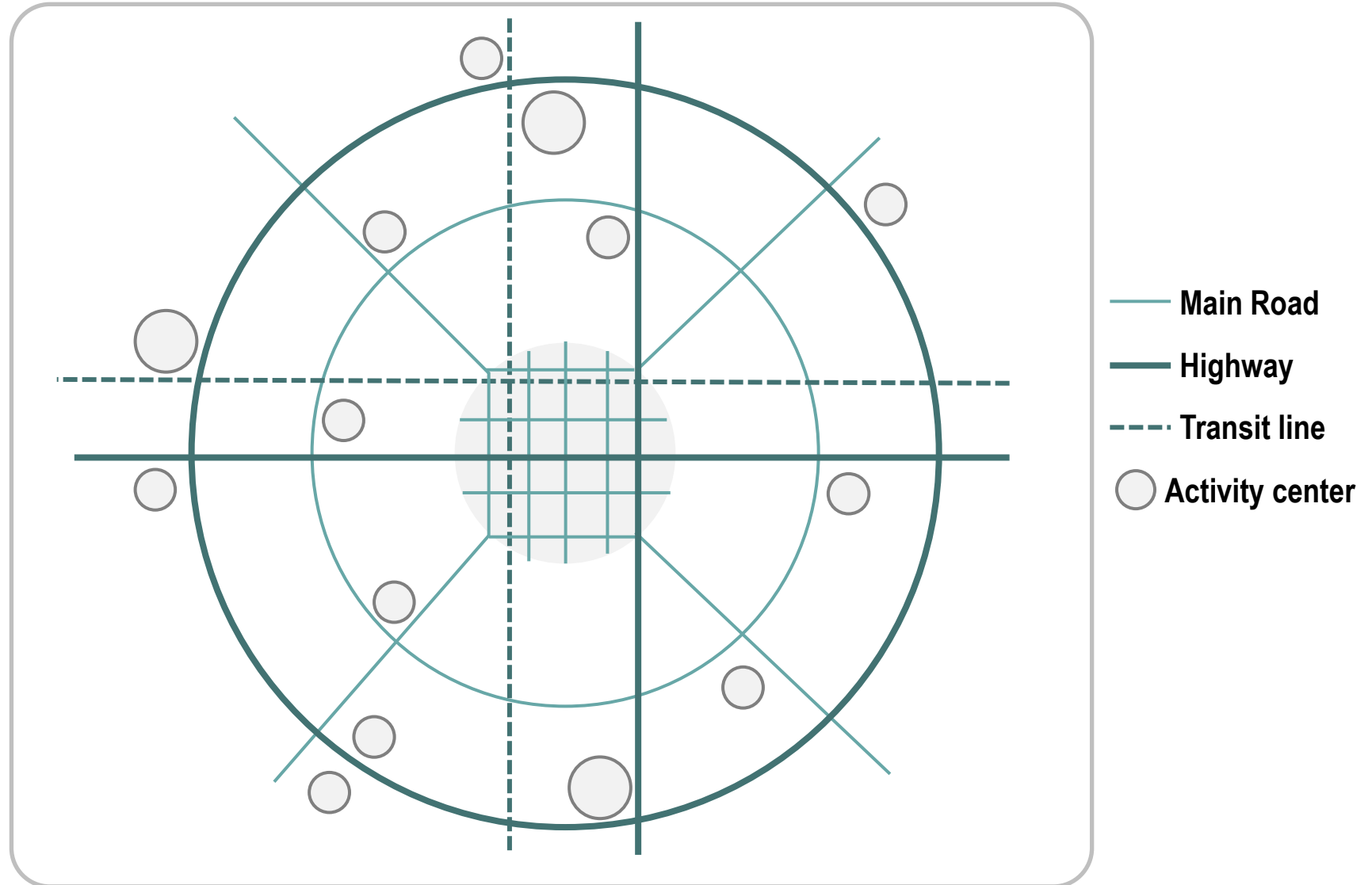
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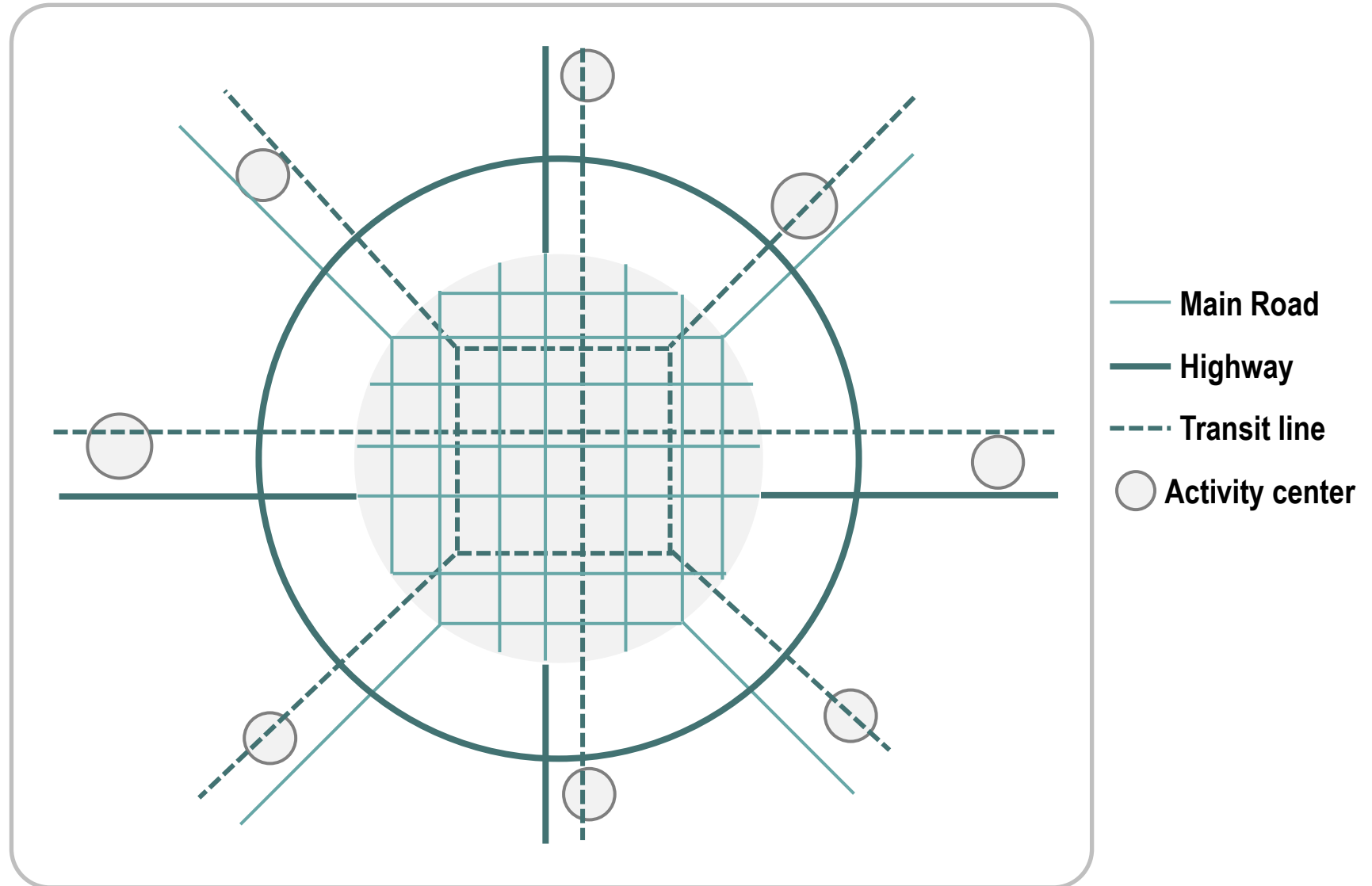
Type I - Completely Motorized Network



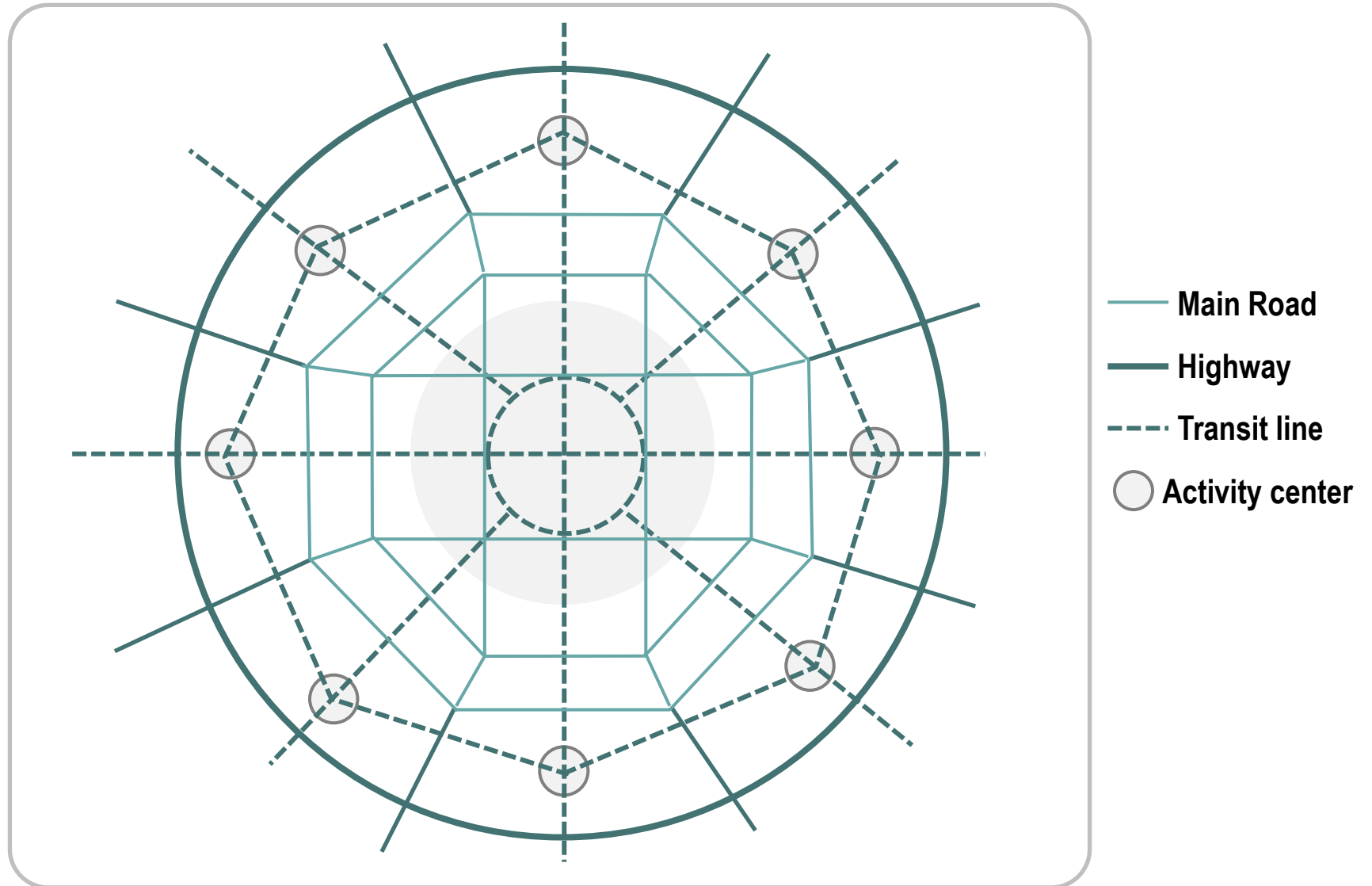
Type II - Weak Center



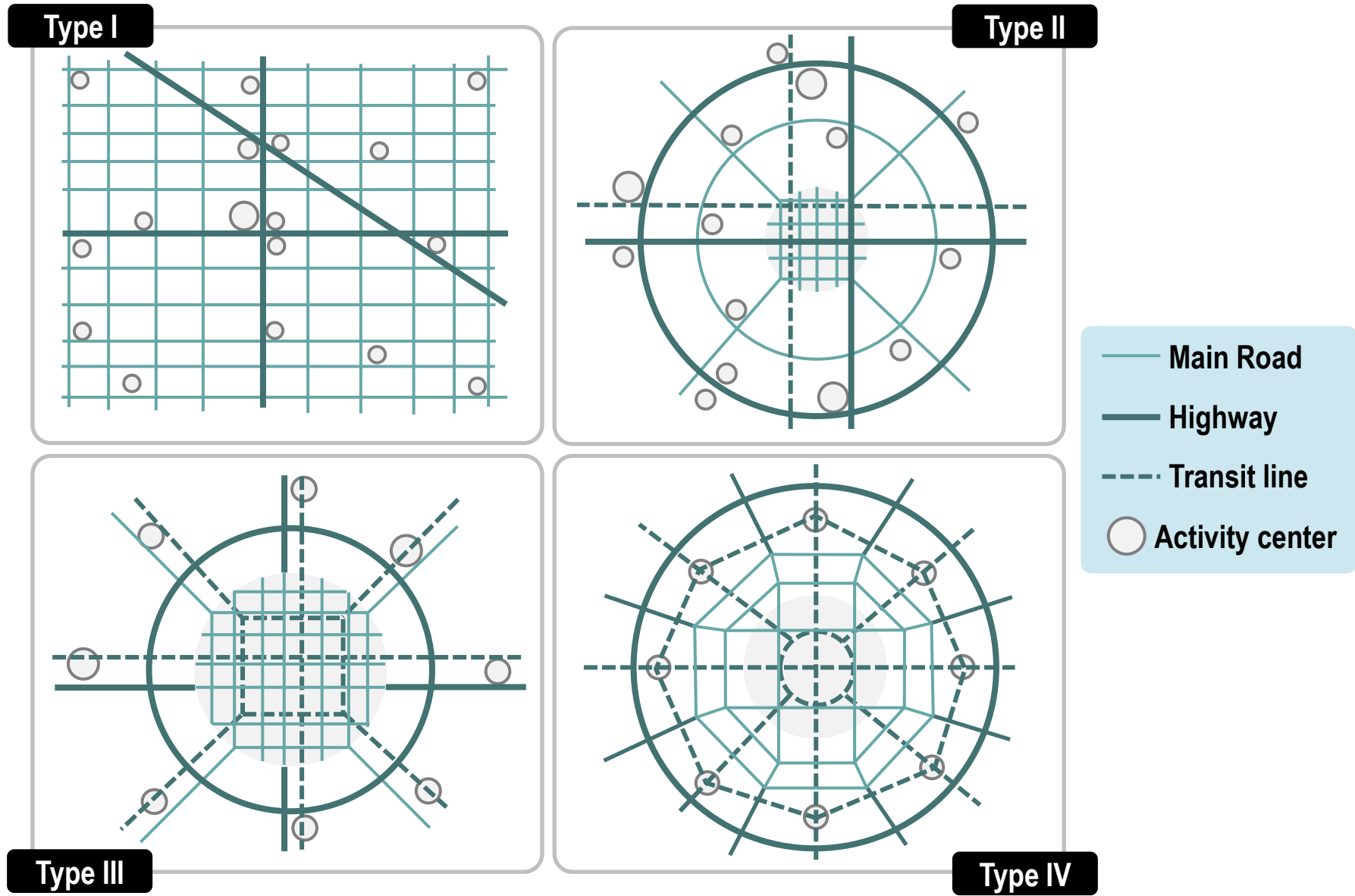
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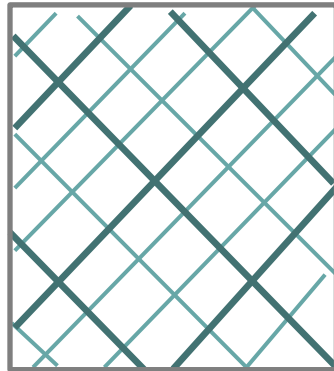
Type IV - Traffic Limitation



Transportation and the Urban Spatial Structure



Street Network Types



**Conventional Grid
Pattern (c 1900)**



**Curvilinear Loop Pattern &
Beginning of Cul-de-Sacs (1930-1950)**

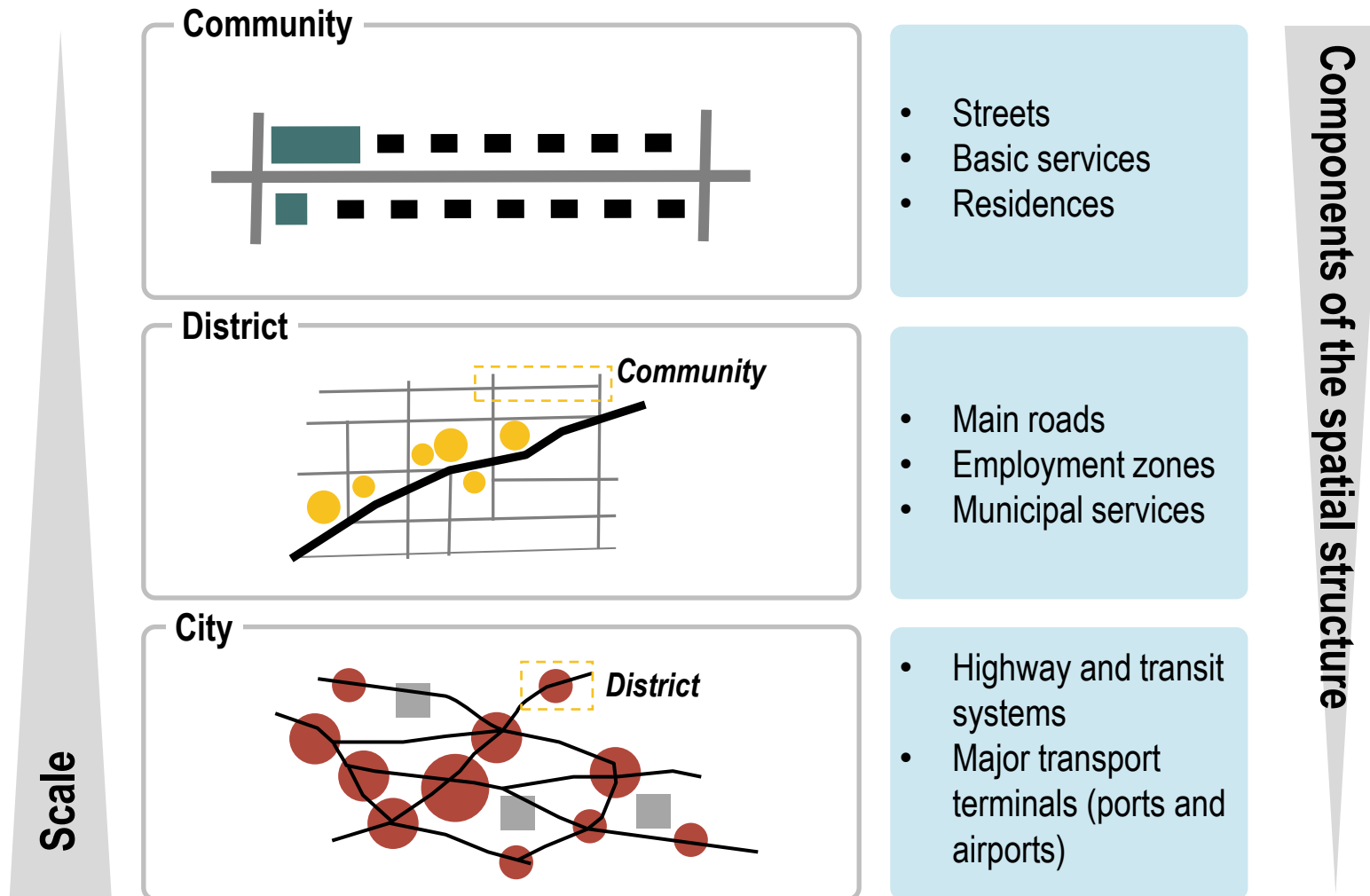


**Conventional
Cul-de-Sac Pattern
(since 1950)**

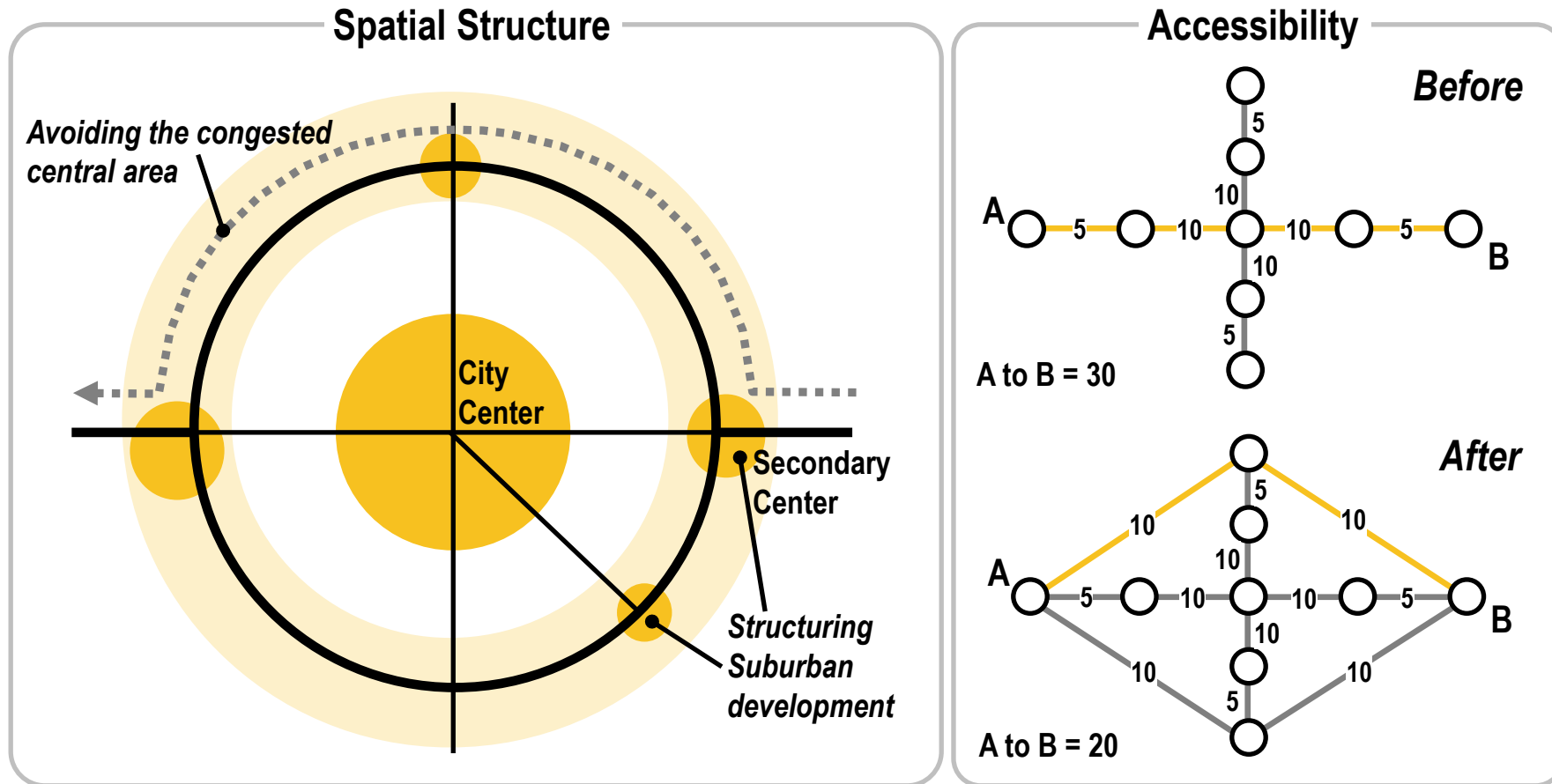
— *Arterial road*

— *Local street*

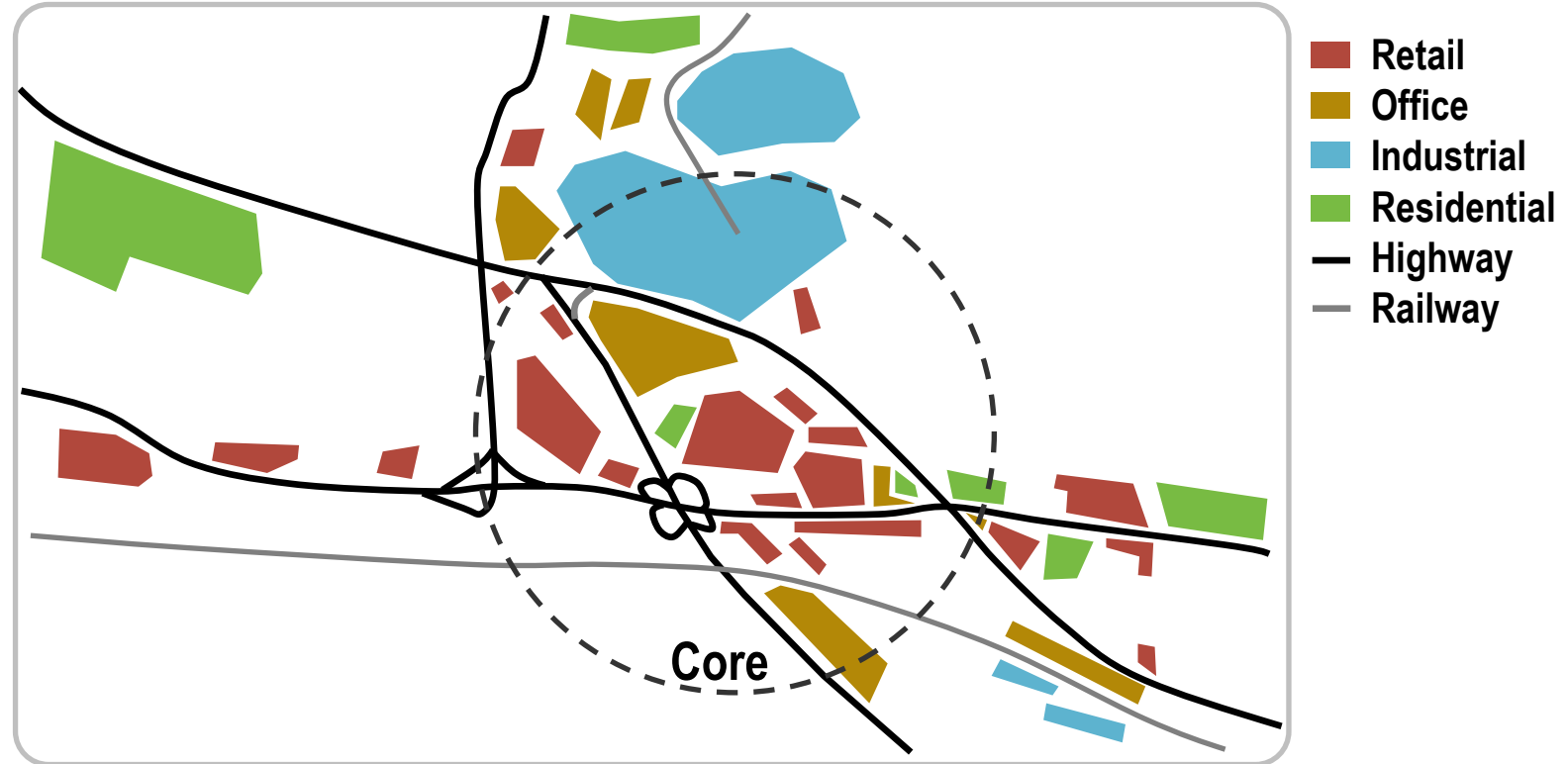
Scale and Urban Spatial Structure

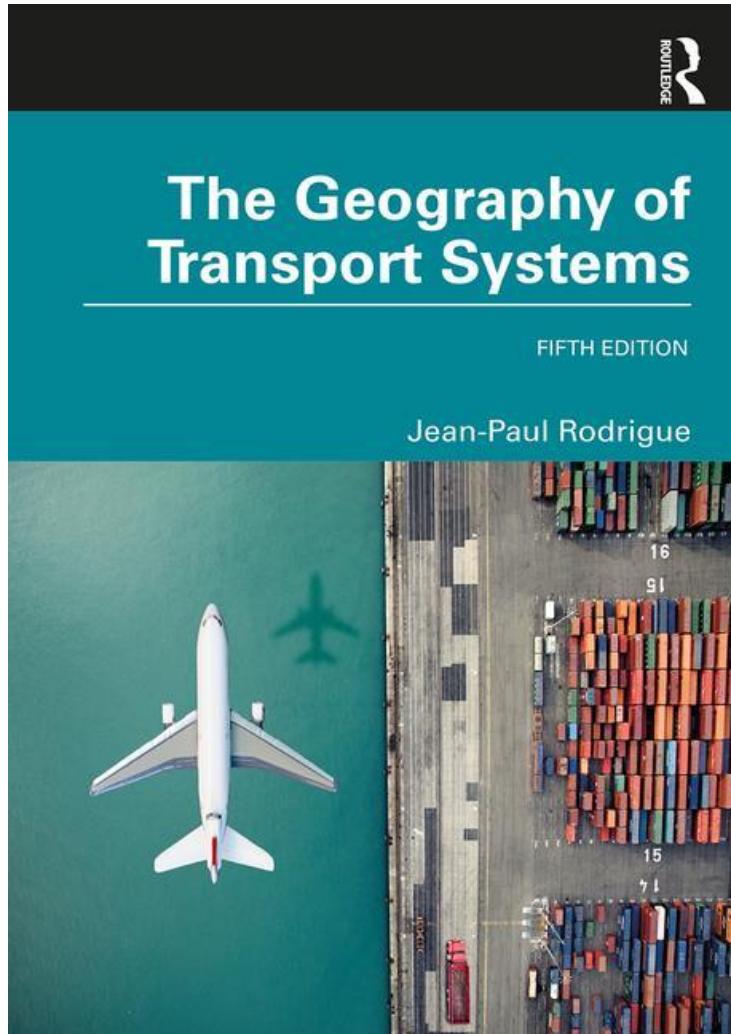


The Rationale of a Ring Road



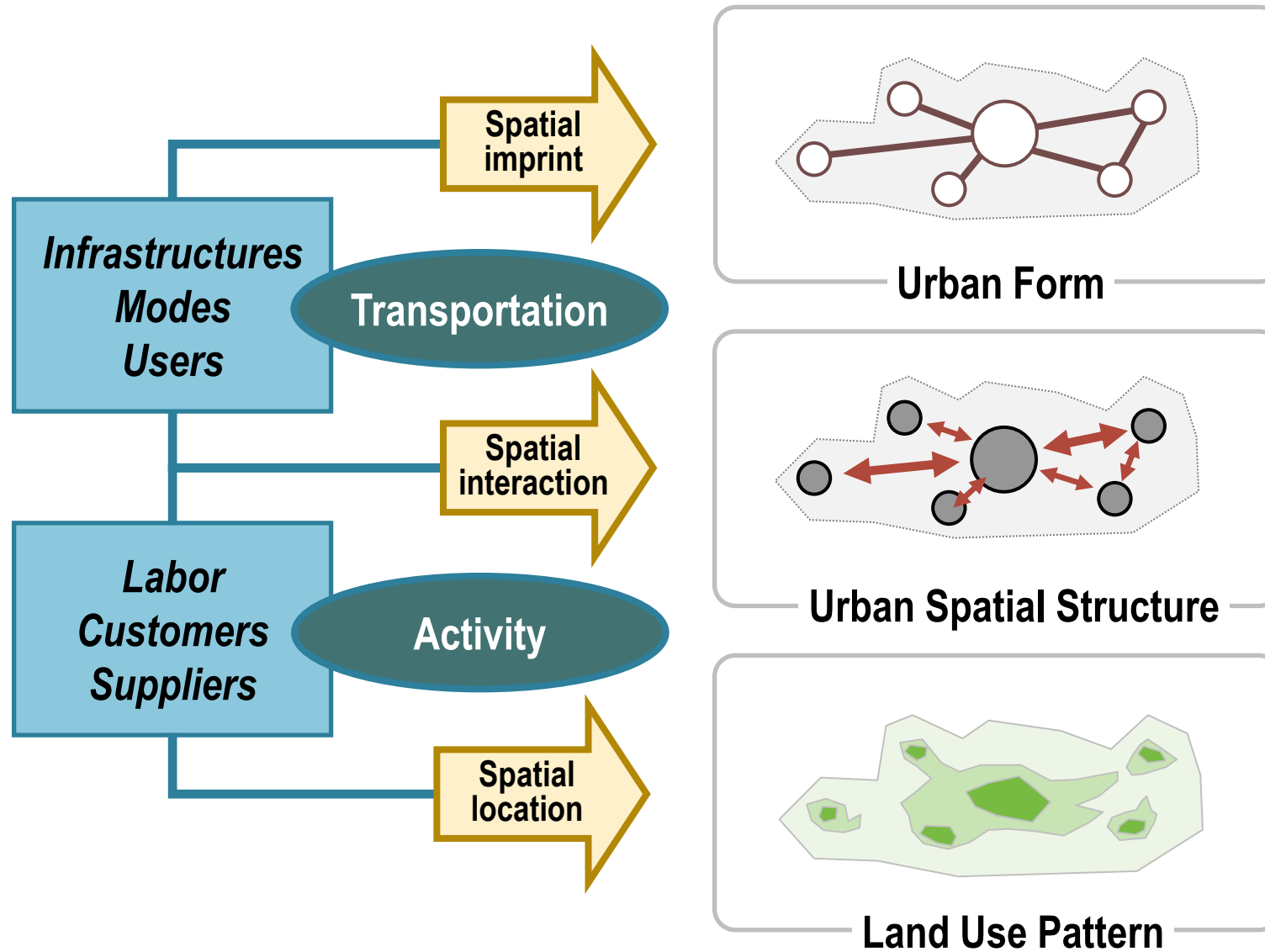
Suburban Development along a Highway Interchange



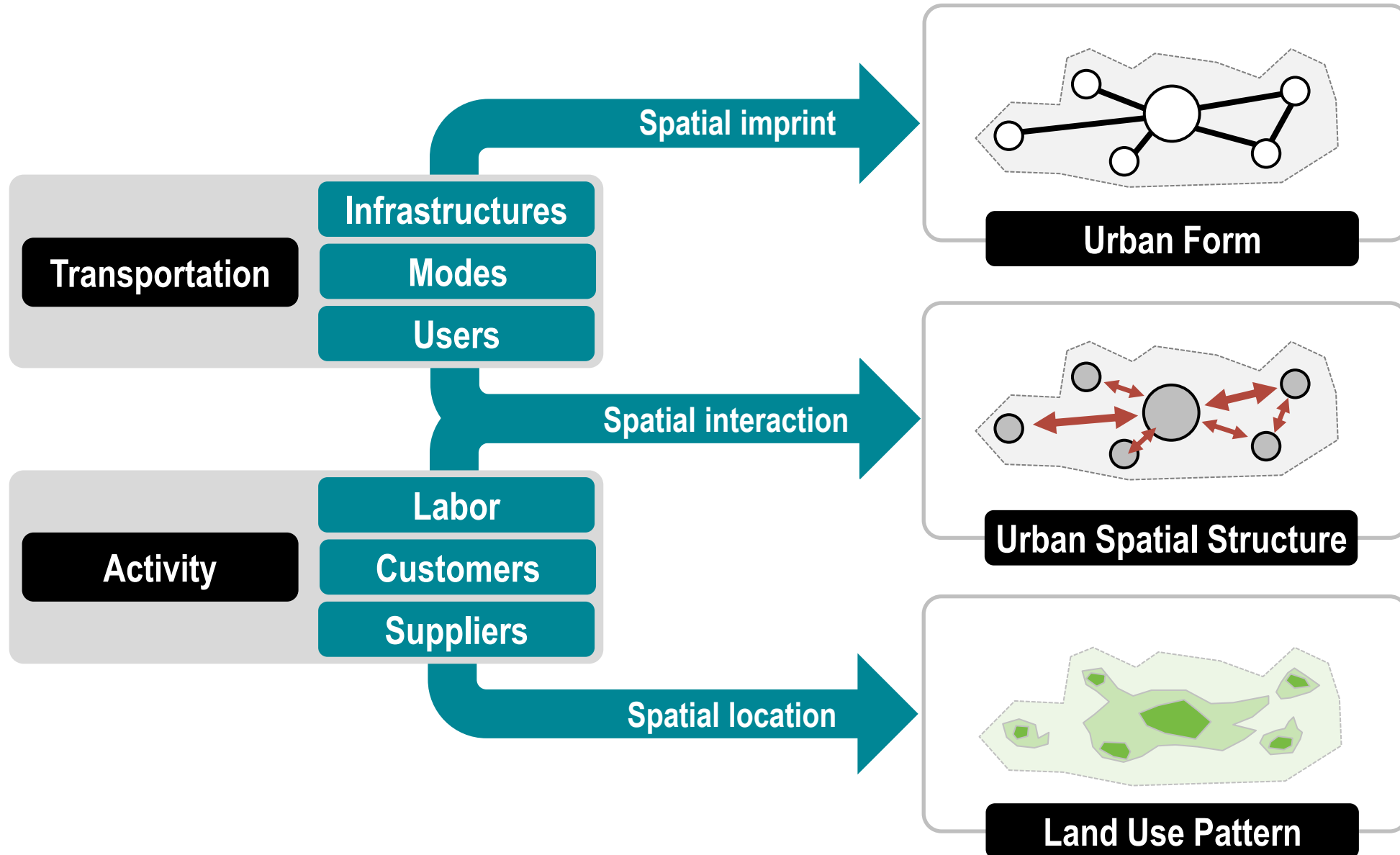


Transportation and Land Use

Transportation, Activity Systems and Land Use



Transportation, Activity Systems and Land Use



Formal and Functional Land Use

Formal Land Use

- Built up
- Paved
- Other

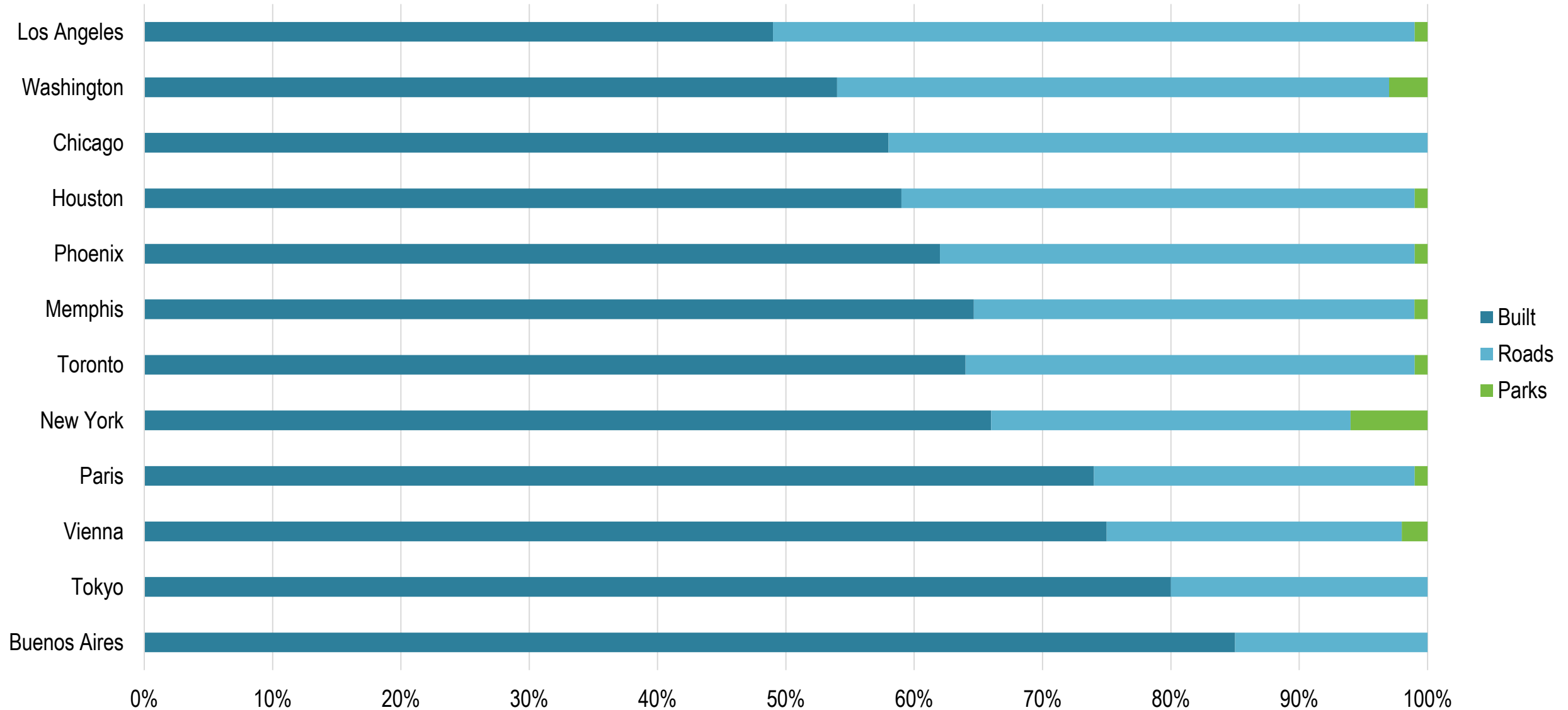


Functional Land Use

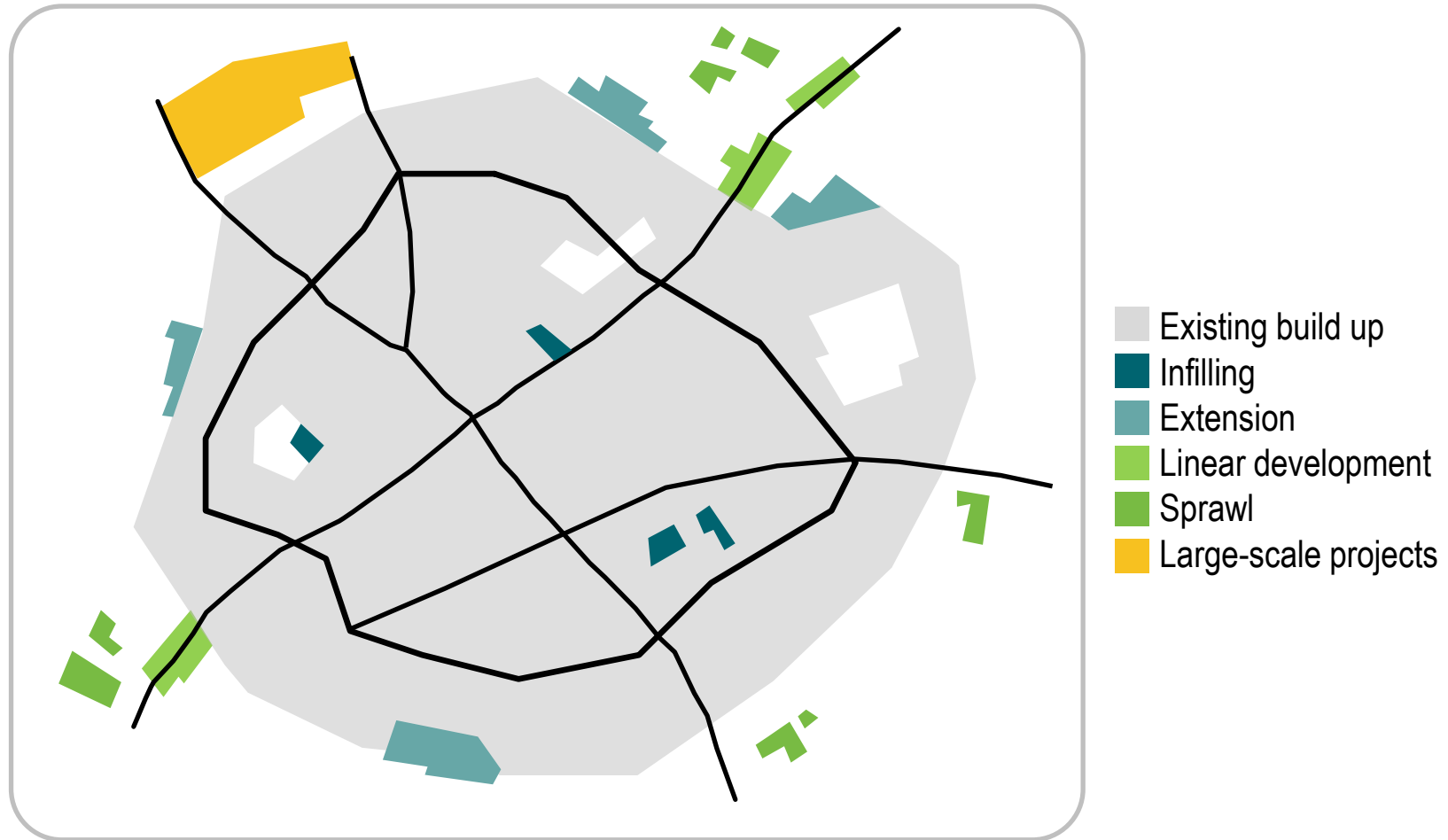
- Institutional
- Commercial
- Light industrial
- Residential
- Roadway
- Parking



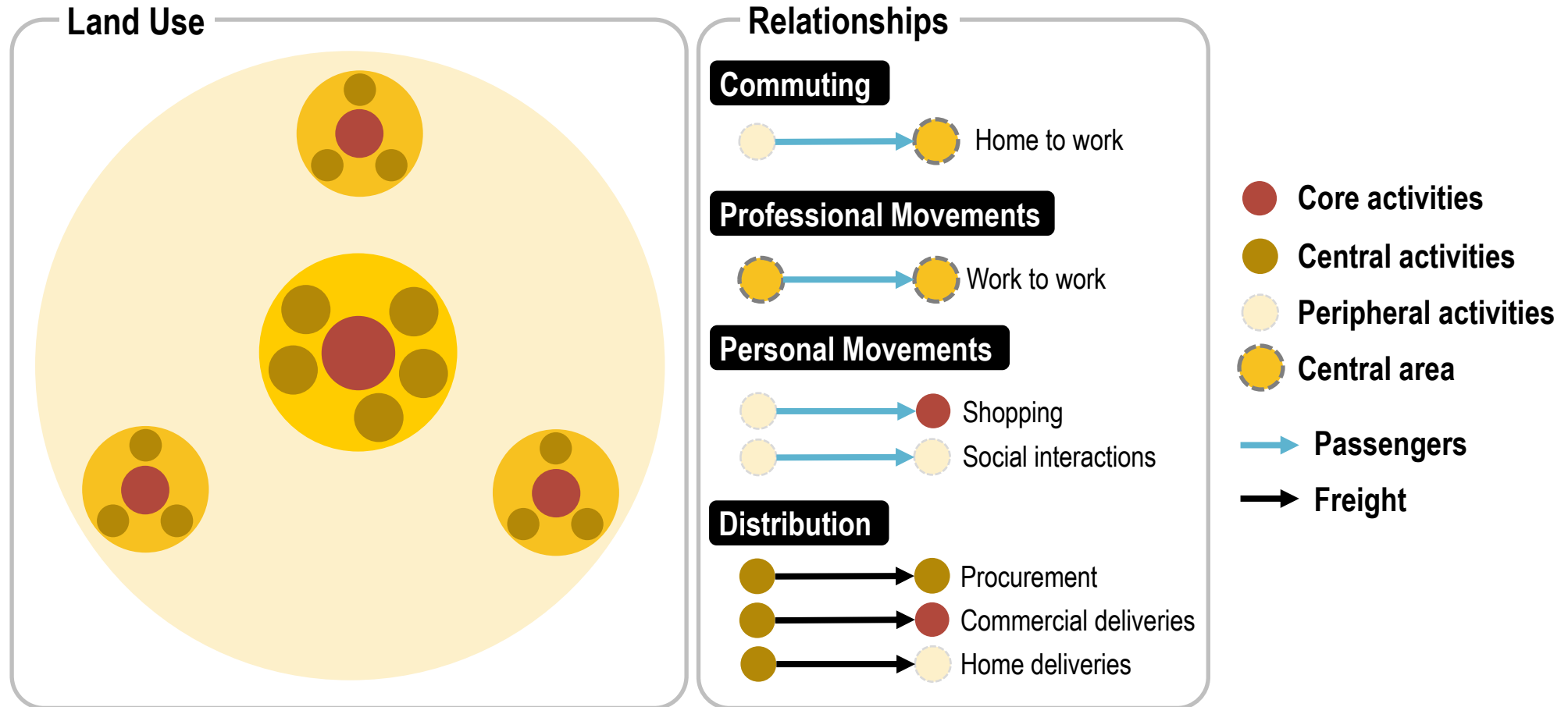
Land Use Footprint in Selected Central Areas



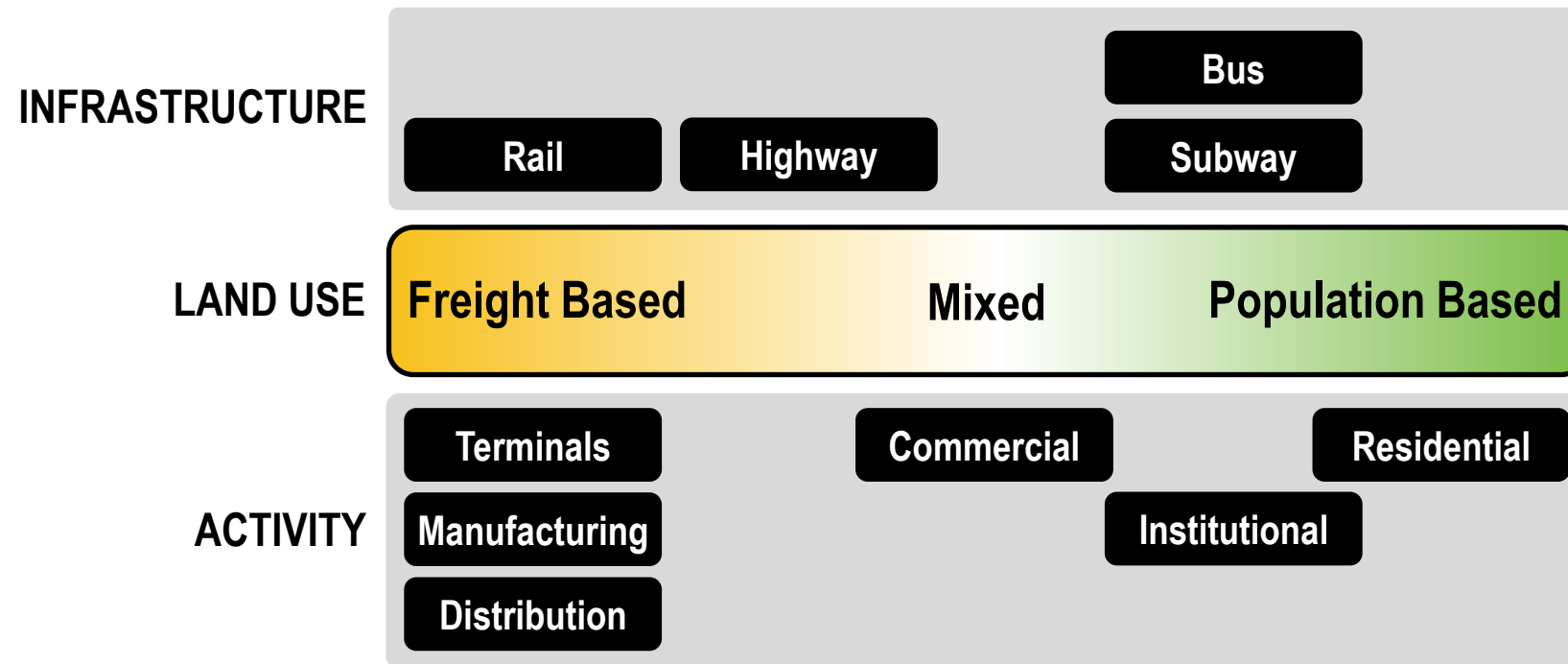
Types of Urban Expansion



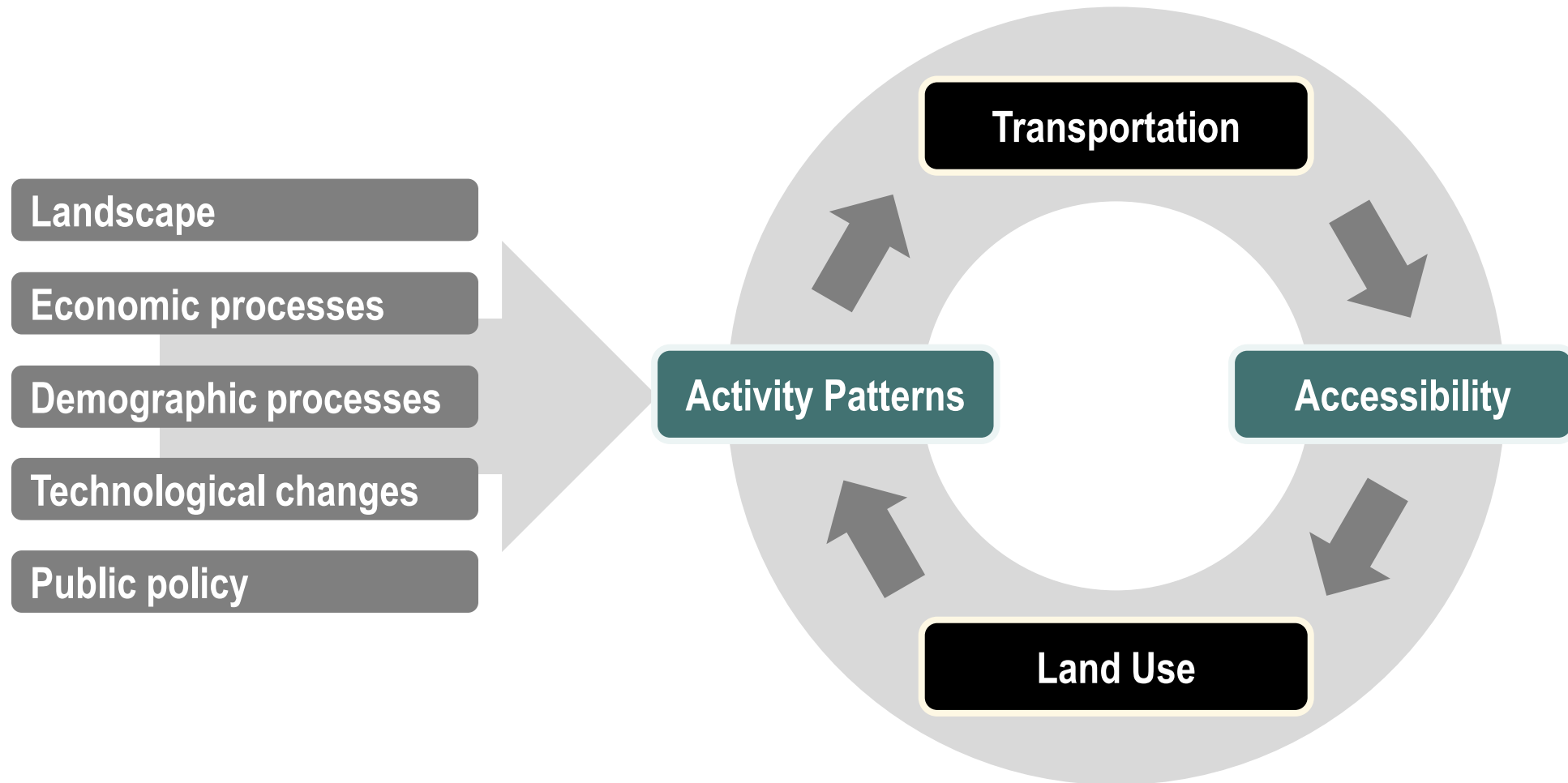
Relationships between Land Uses



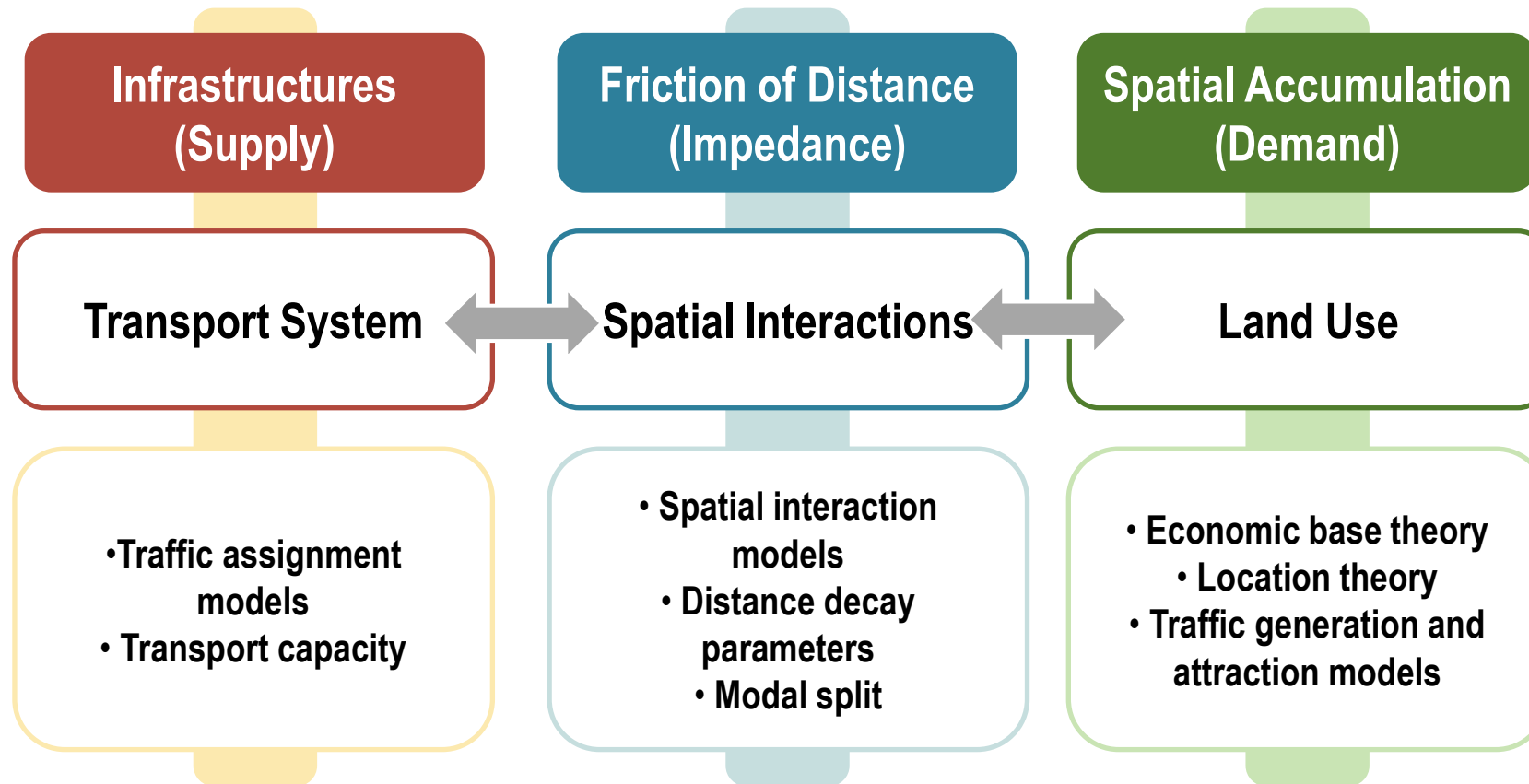
Transport Infrastructure and Activity Location



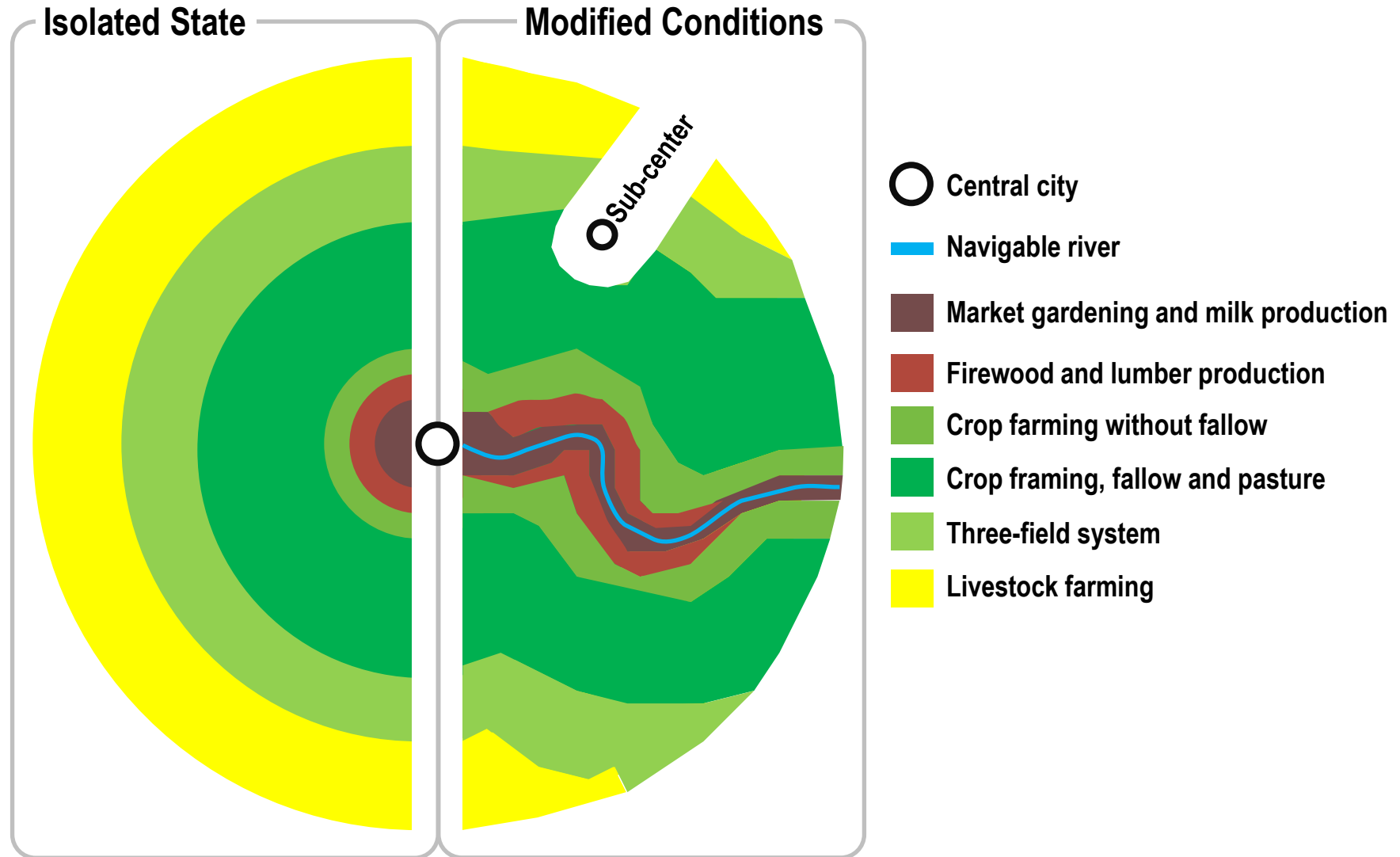
Transportation / Land Use Interactions



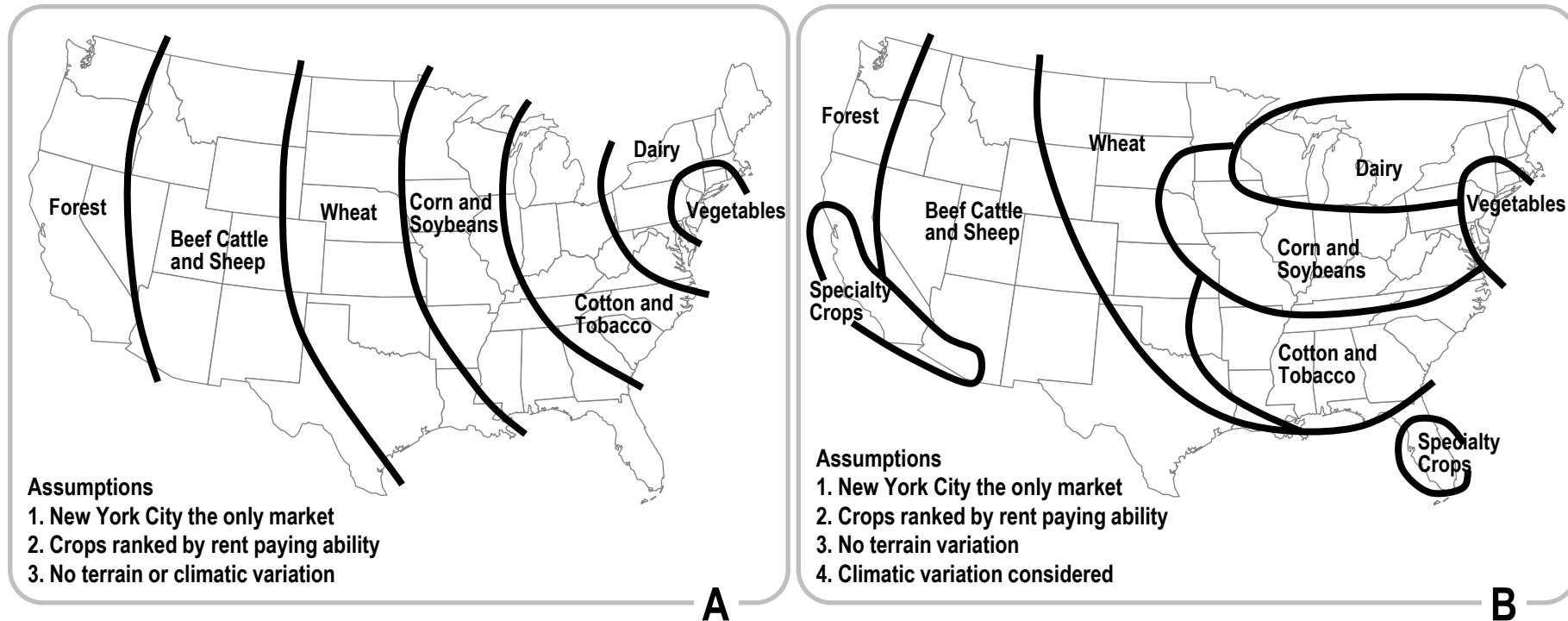
The Transport / Land Use System



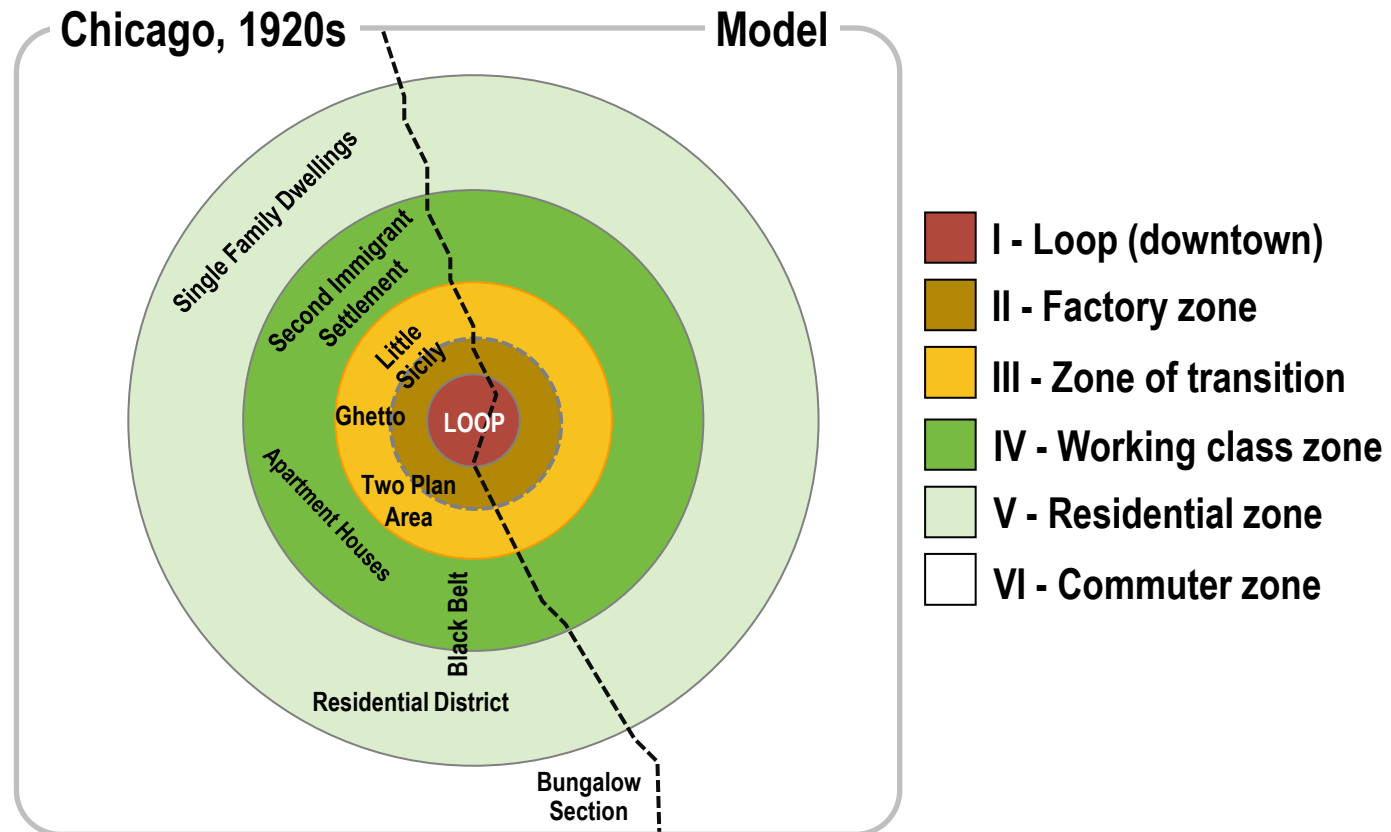
Von Thunen's Regional Land Use Model



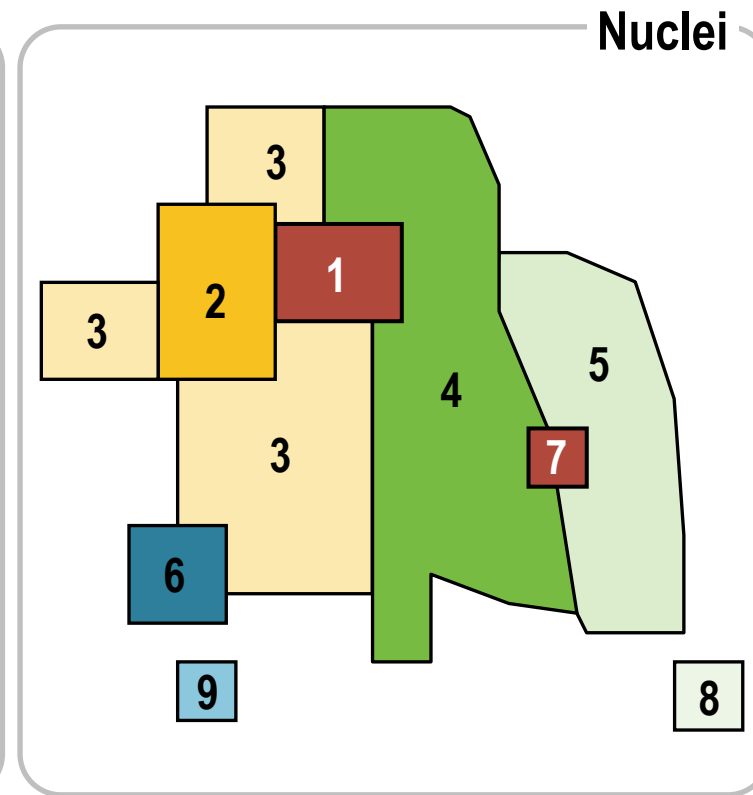
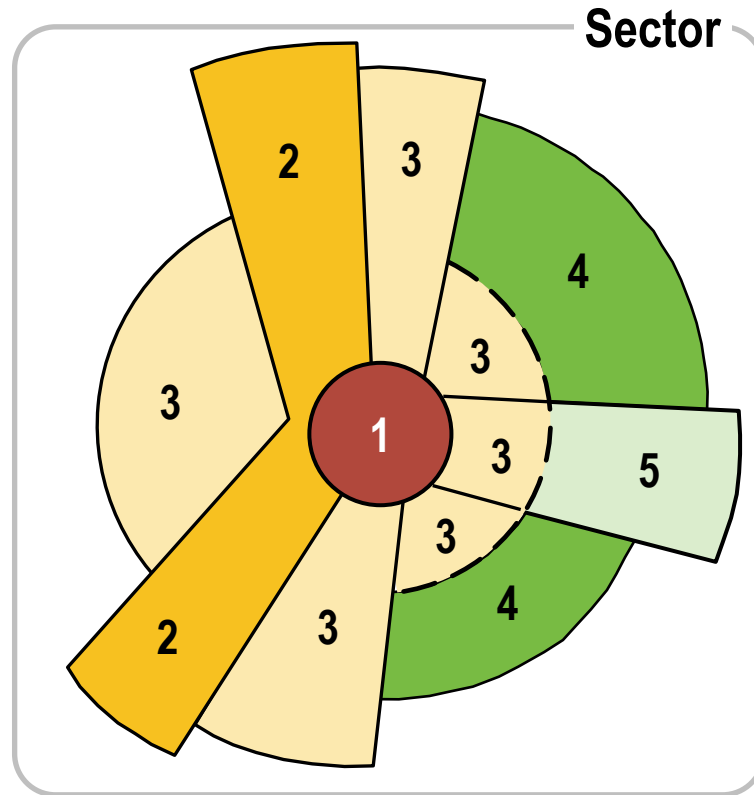
Inference of Von Thunen's Model to the Continental United States



Burgess' Urban Land Use Model



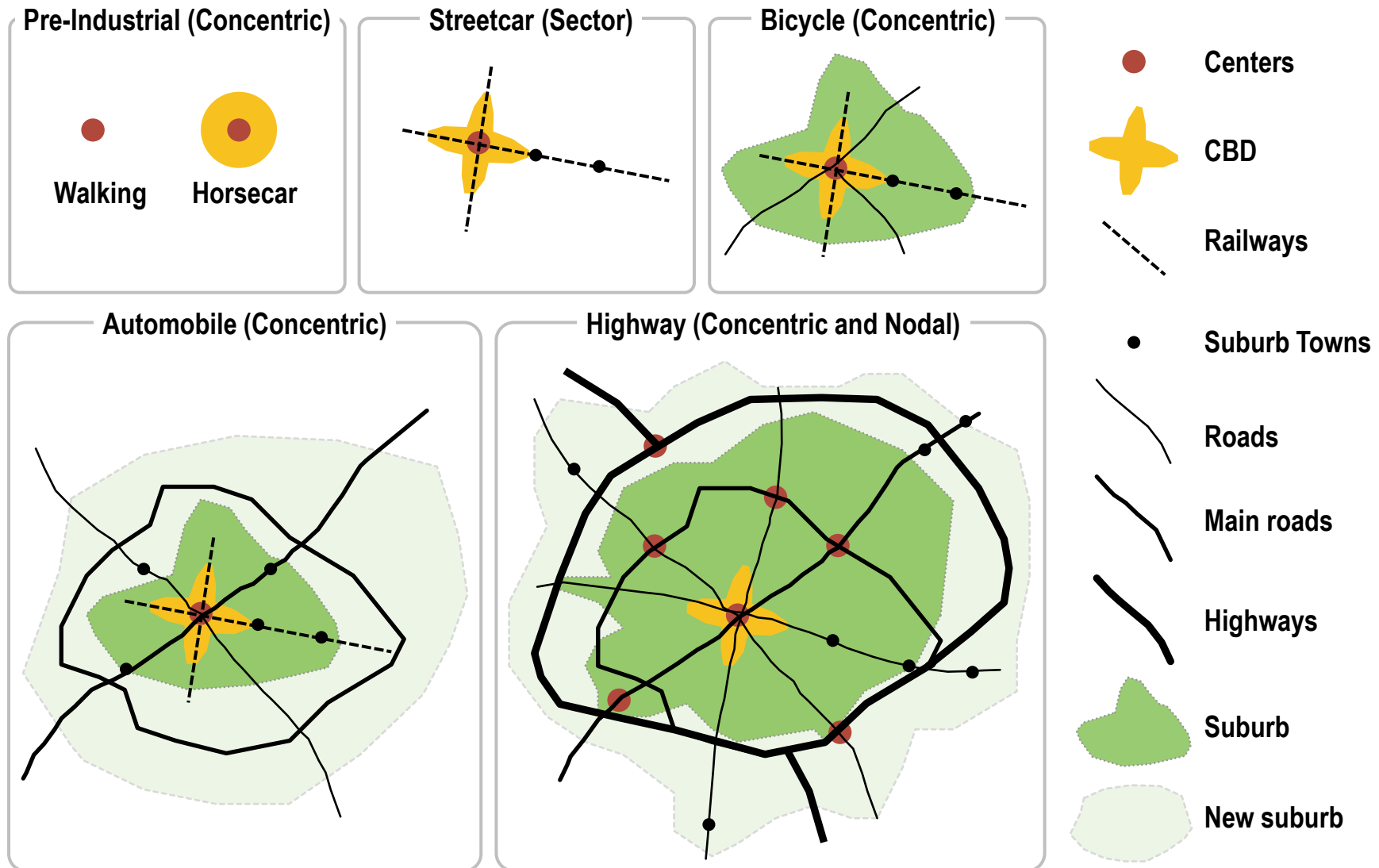
Sector and Nuclei Urban Land Use Models



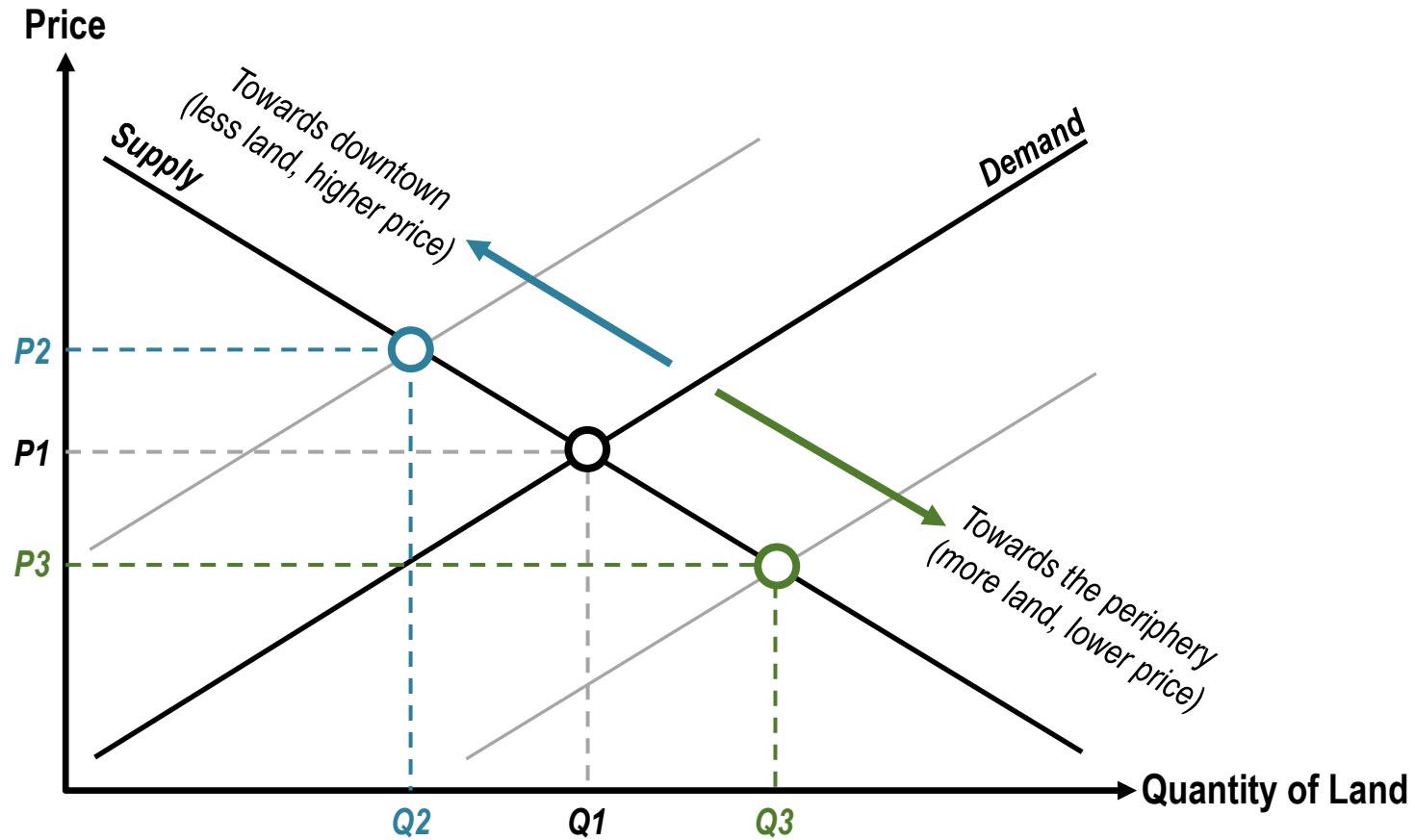
- 1 CBD
- 2 Wholesale and light manufacturing
- 3 Lower-class residential
- 4 Middle-class residential
- 5 Upper-class residential

- 6 Heavy manufacturing
- 7 Sub business district
- 8 Residential suburb
- 9 Industrial suburb

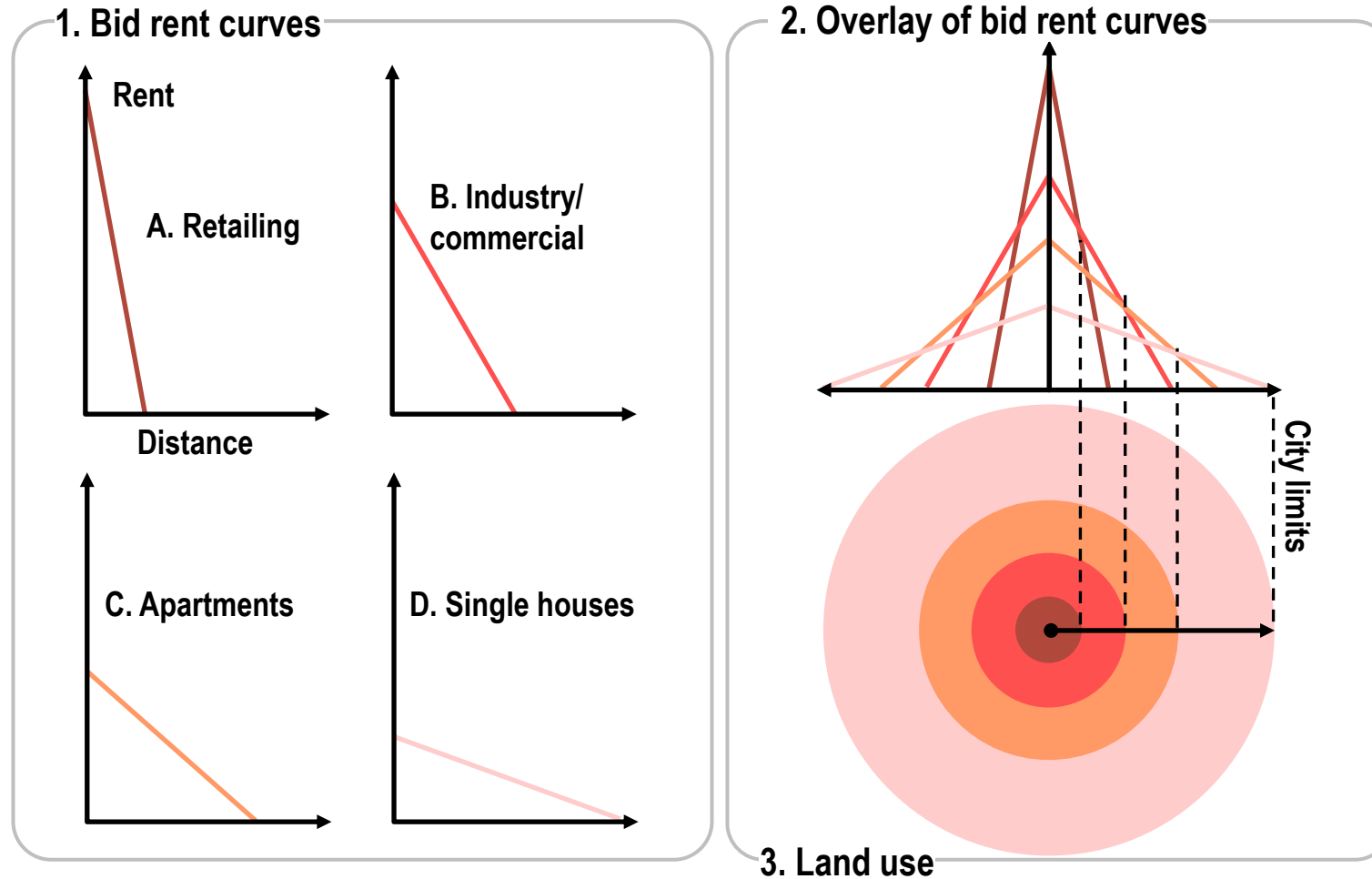
The Hybrid Land Use Model: Transportation and the Formation of Urban Landscapes



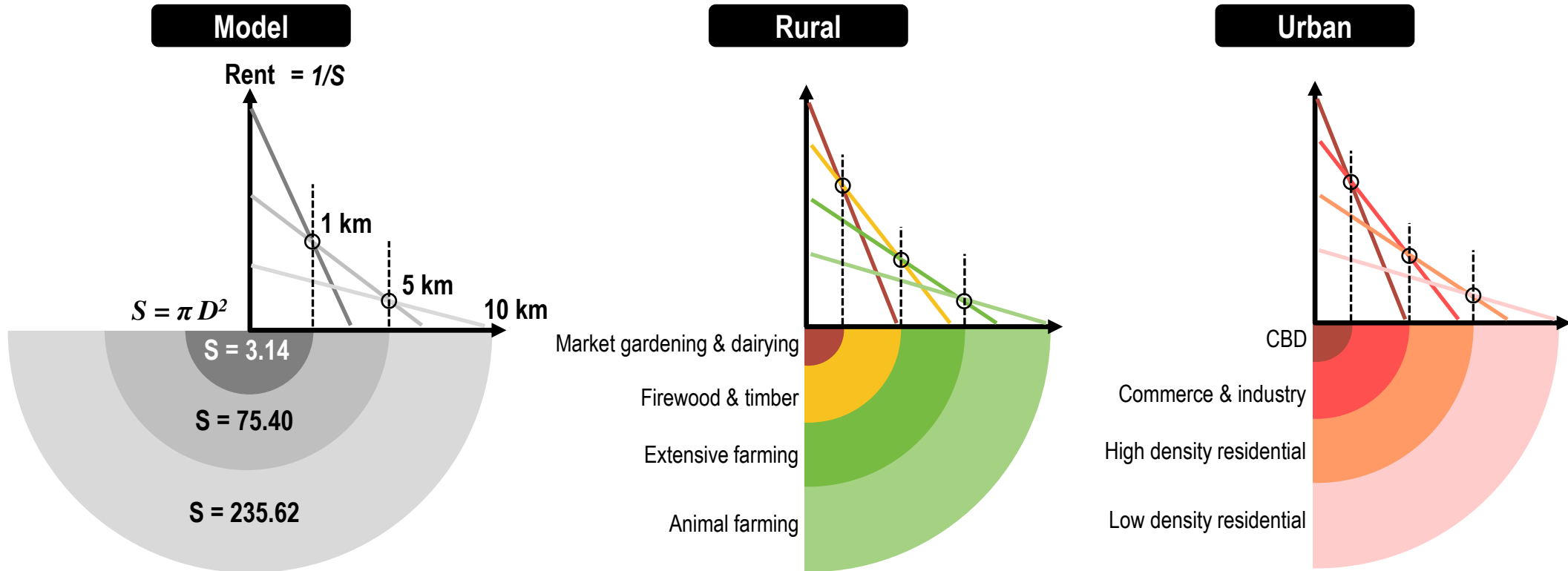
Basic Land Economics



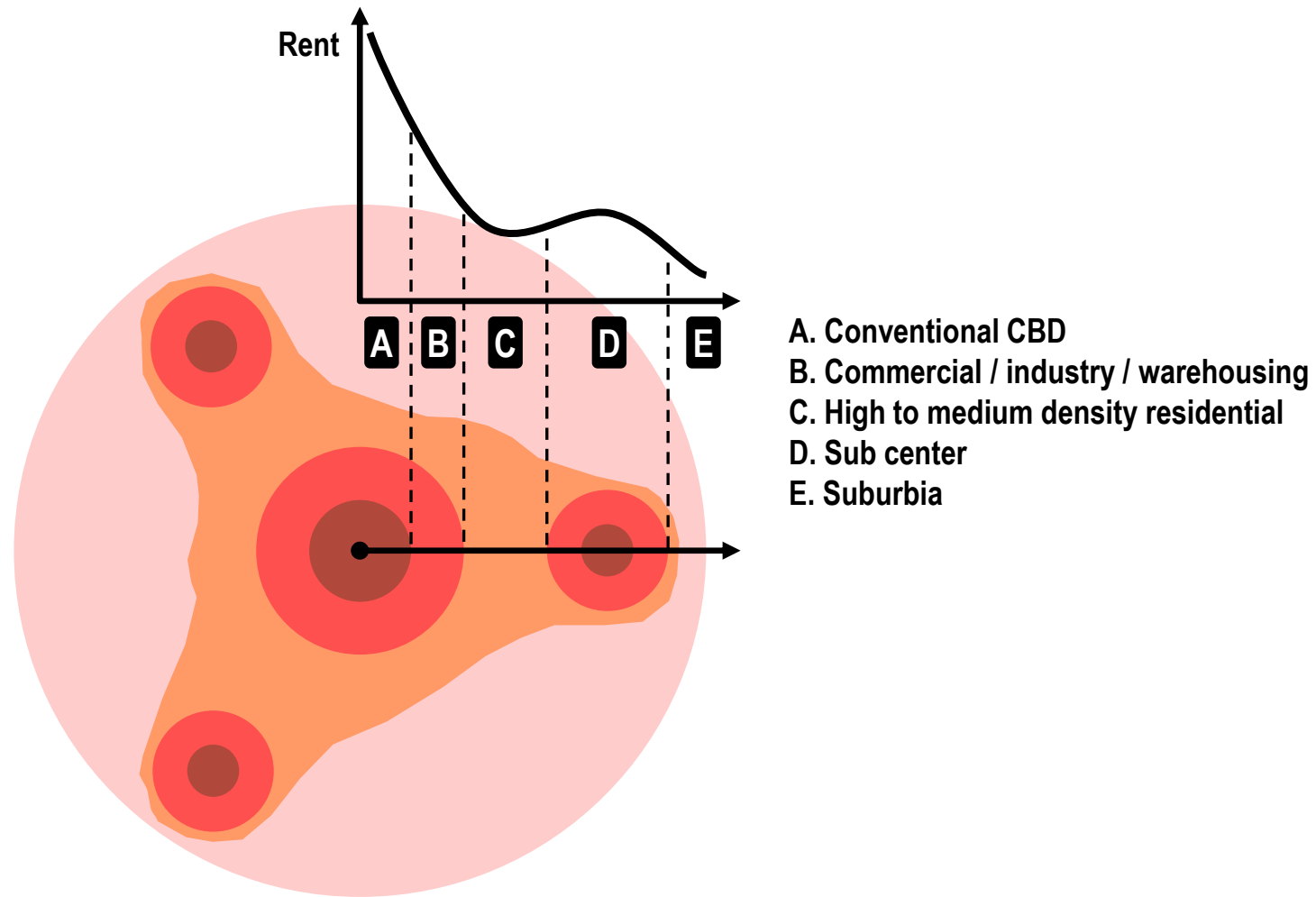
Land Rent and Land Use



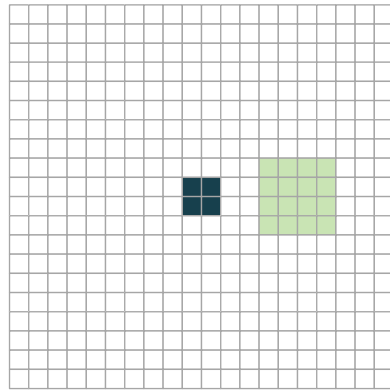
Land Rent Theory and Rent Curve



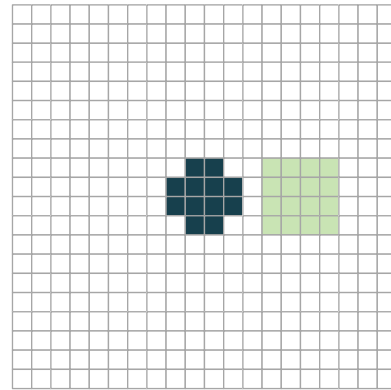
Contemporary Modifications of the Land Rent Theory



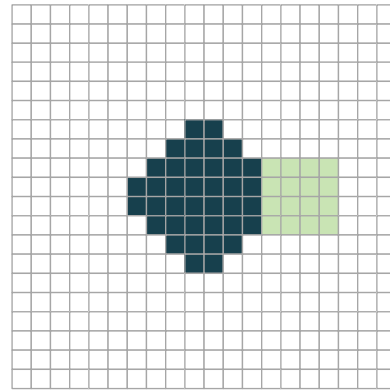
Cellular Automata Land Use Dynamics



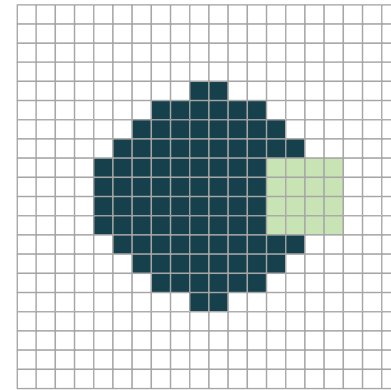
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t=1

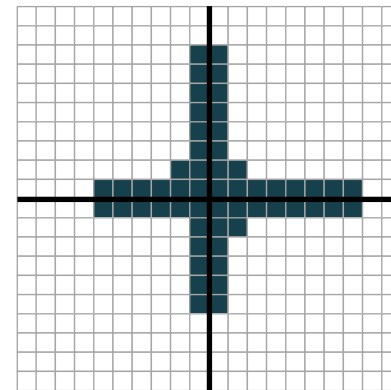
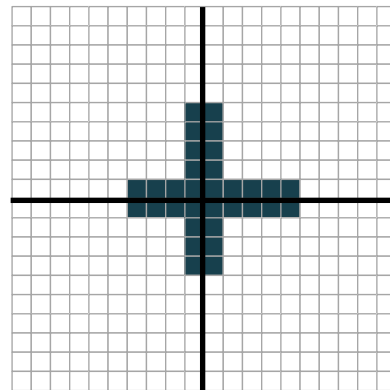
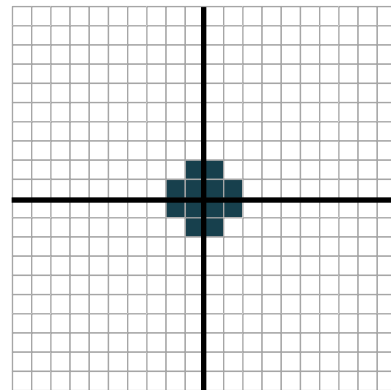
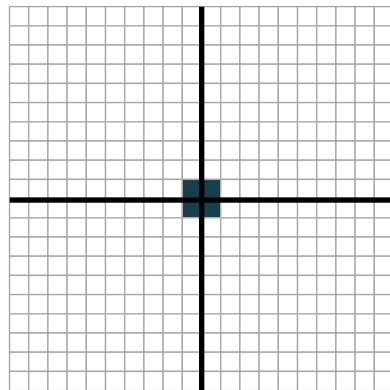


t=2

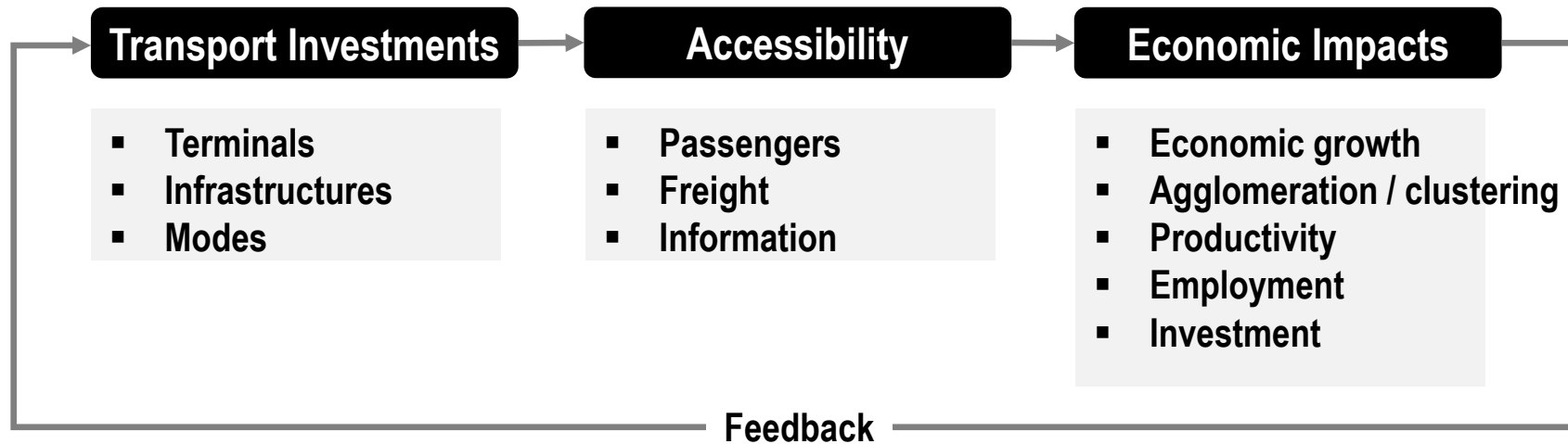


t=3

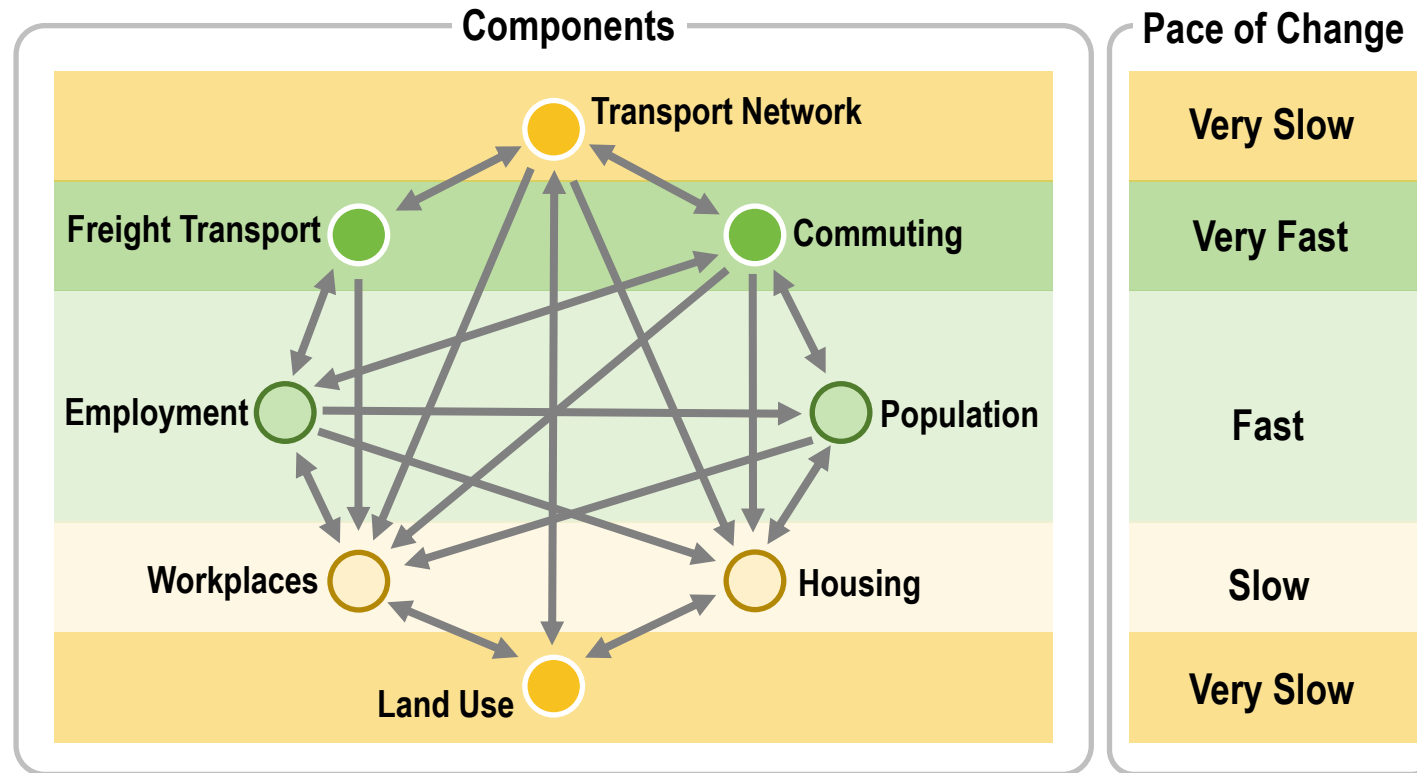
- Urban land use
- Non-urban land use
- Protected land use
- Highway

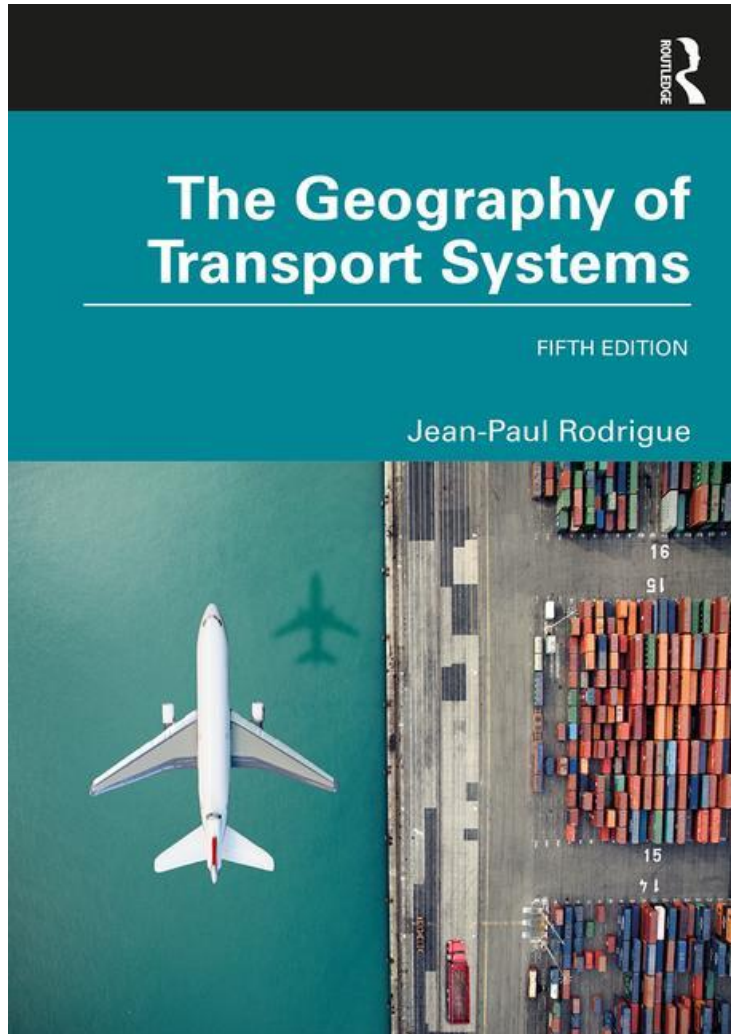


Basic Urban Dynamics



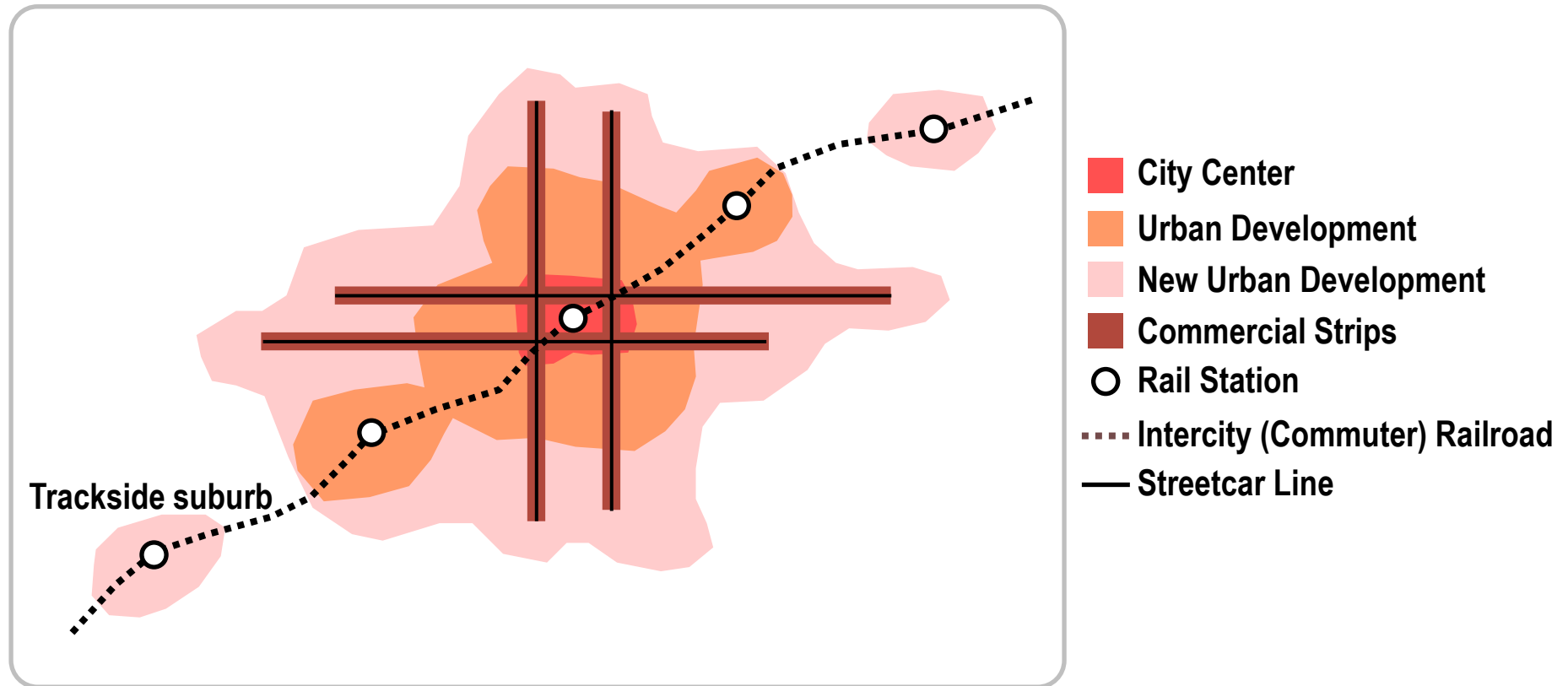
Dynamics of Urban Change





Urban Mobility

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

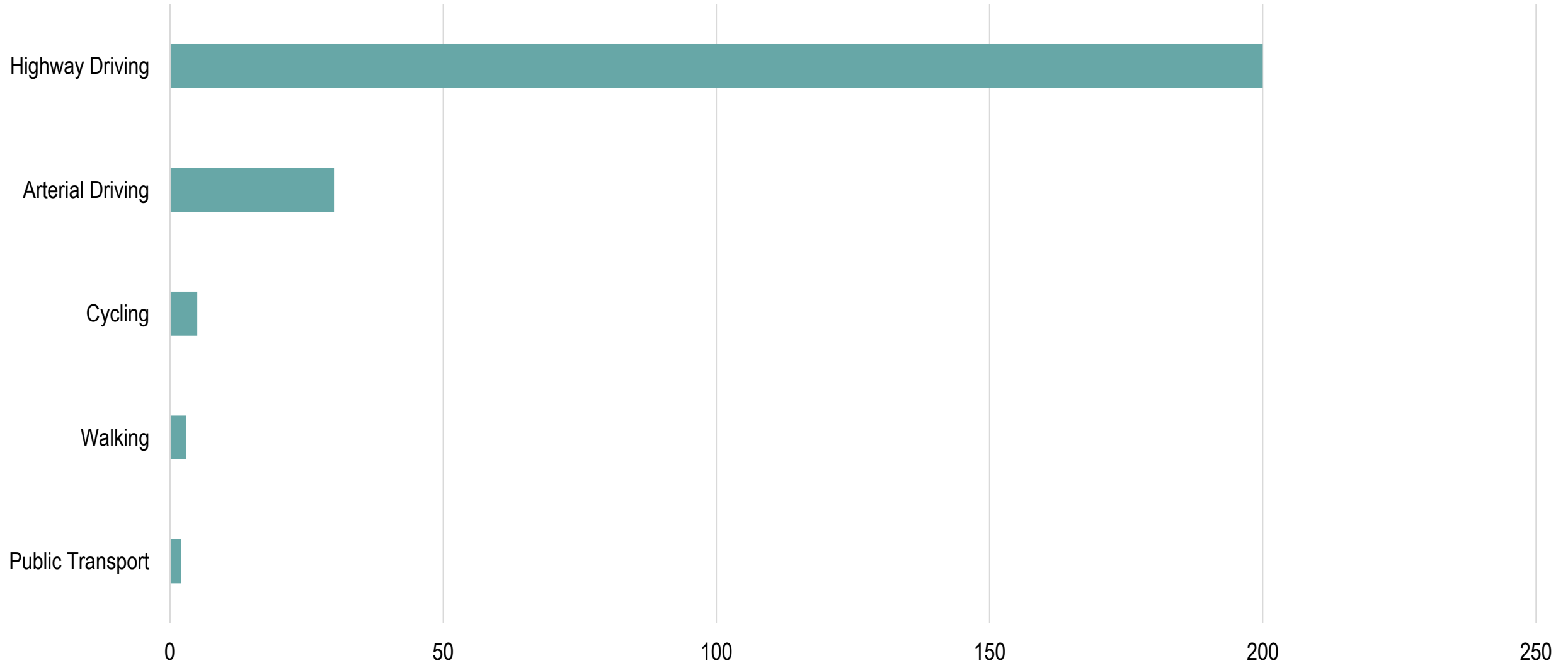


Suitability of Travel Modes

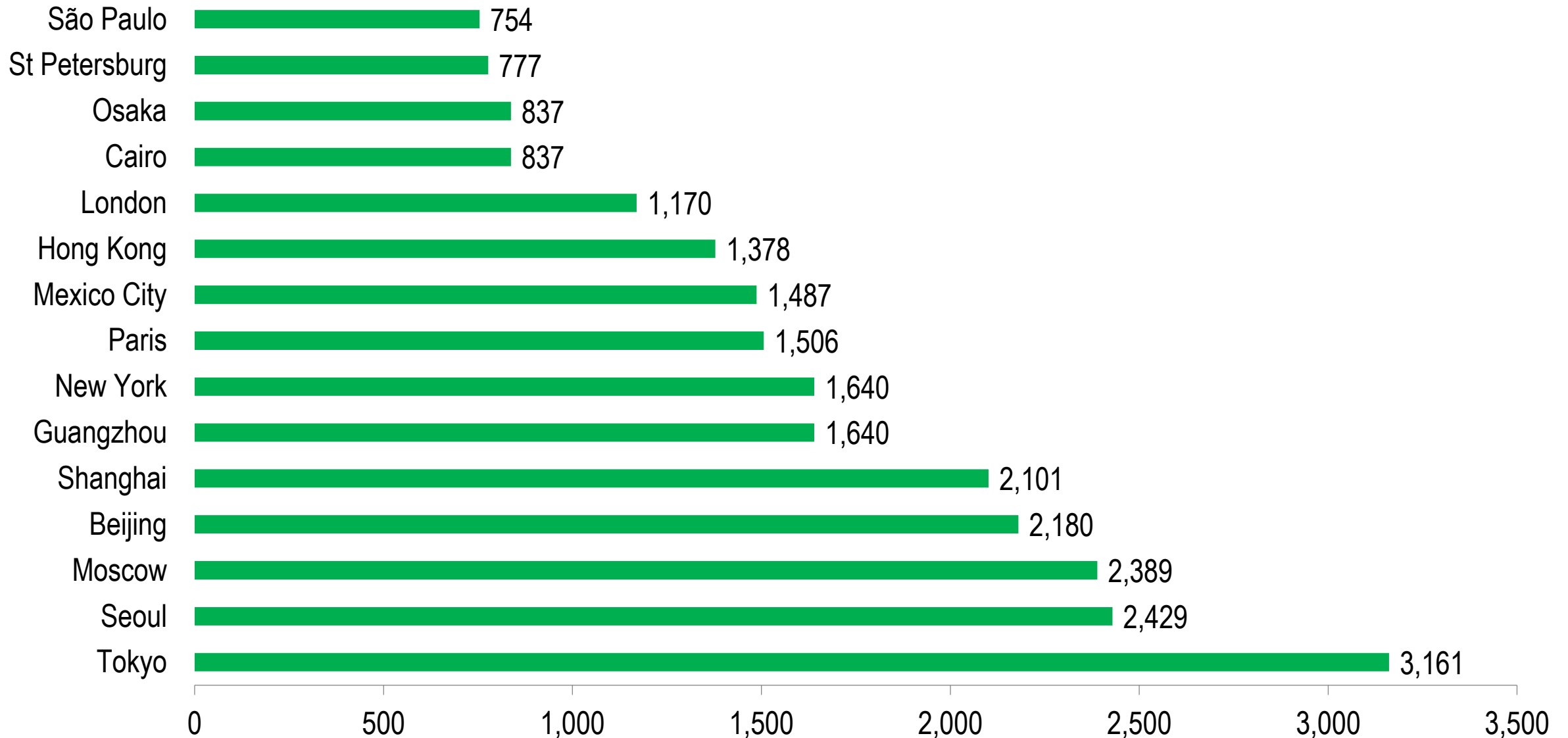
Mode	Limitations	Most Appropriate Uses
Walking	Requires physical ability. Limited distance and carrying capacity. Difficult or unsafe in some areas.	Short trips by physically able people.
Bicycle	Requires bicycle and physical ability. Limited distance and carrying capacity.	Short to medium length trips 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 busy corridors.
Paratransit	High cost and limited service.	Travel for disabled people.
Auto driver	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 who do not own an automobile.
Motorcycle	Requires riding ability and motorcycle. Average fixed costs.	Travel by people who can ride and afford a motorcycle.
Telecommuting	Requires IT equipment and skills.	Alternative to some types of trips.

Space Required per Passenger on Road Transport Modes

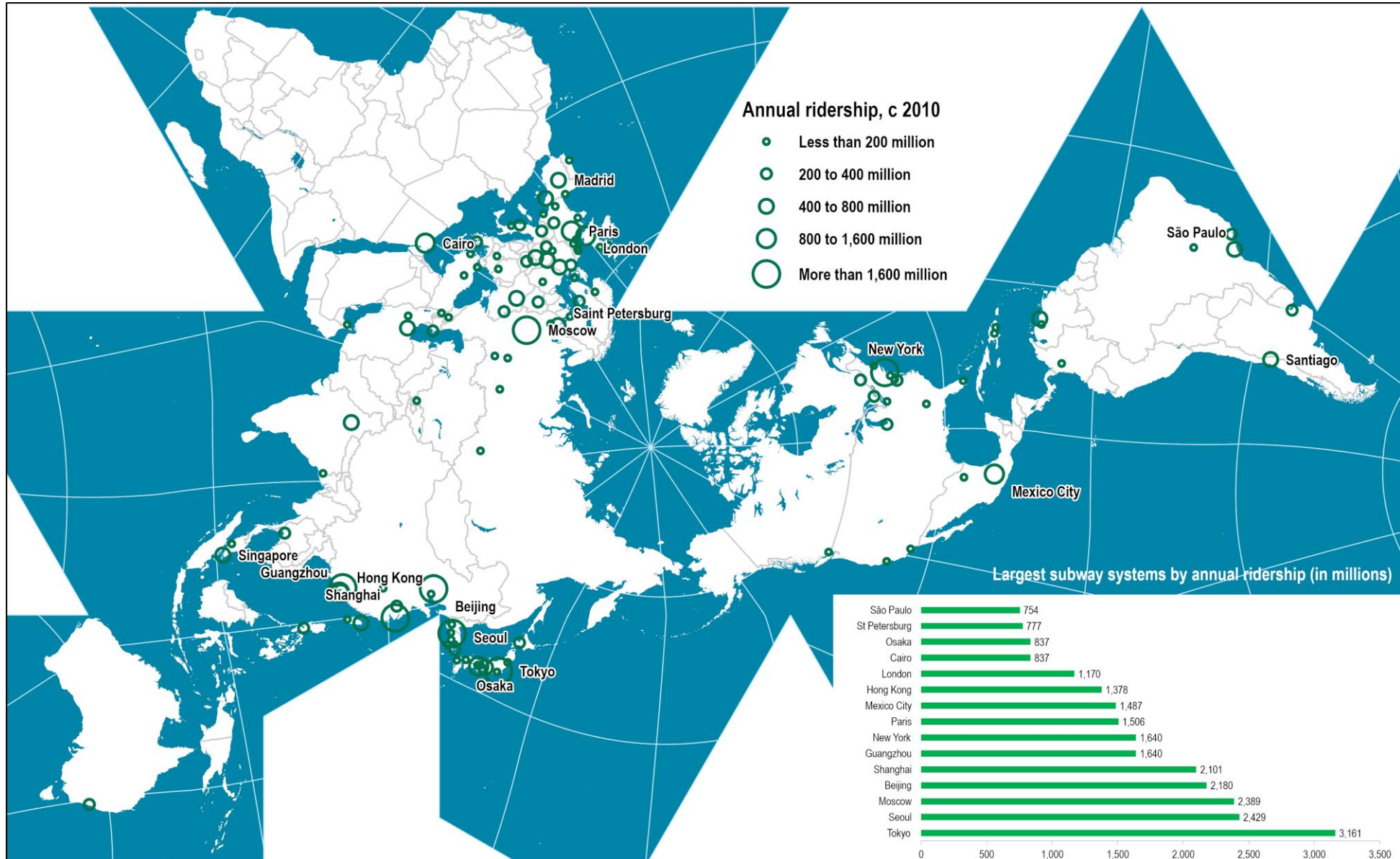
Square Meter per Passenger

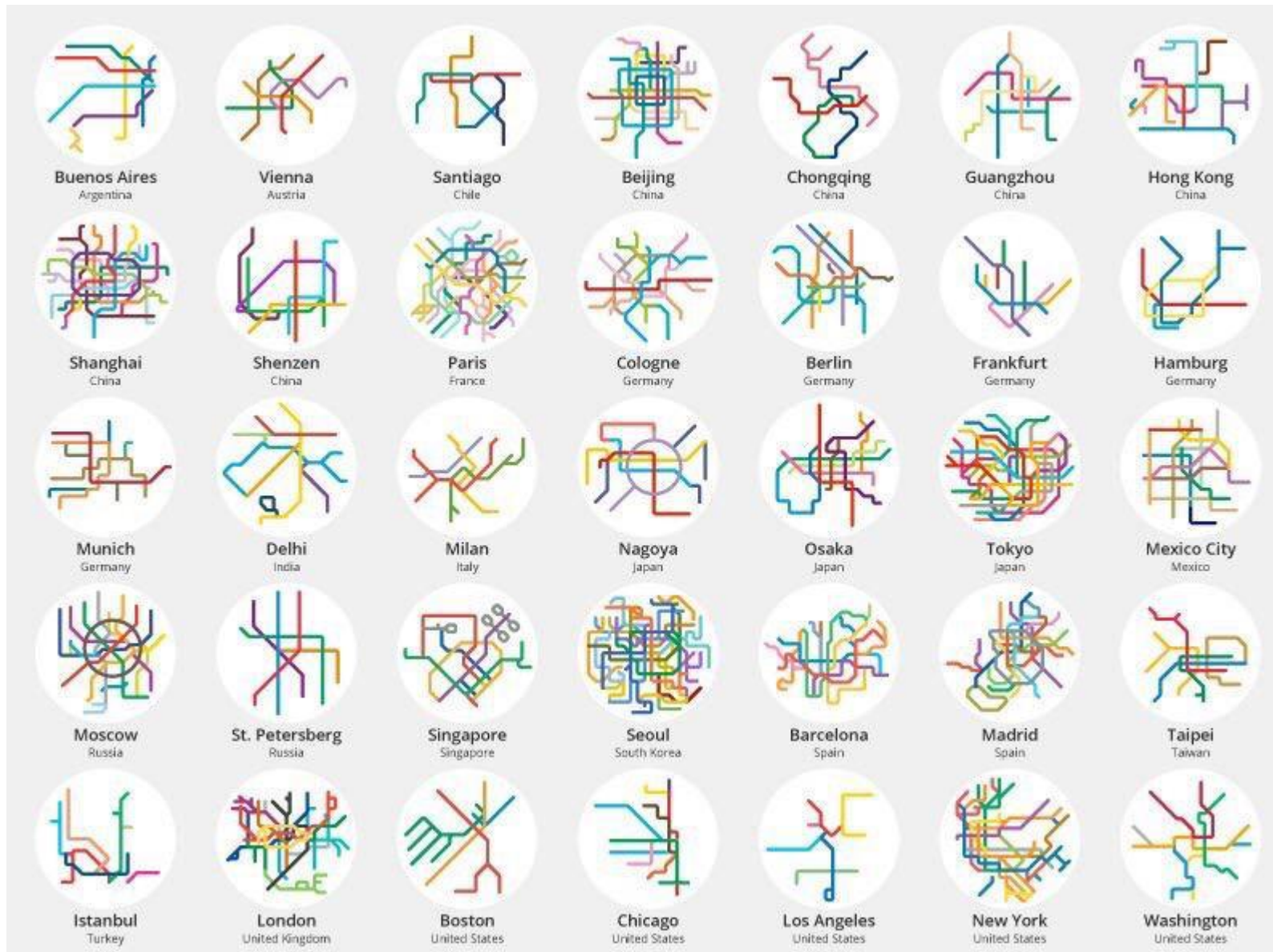


Largest Subway Systems in the World by Annual Ridership, c2010 (in millions)

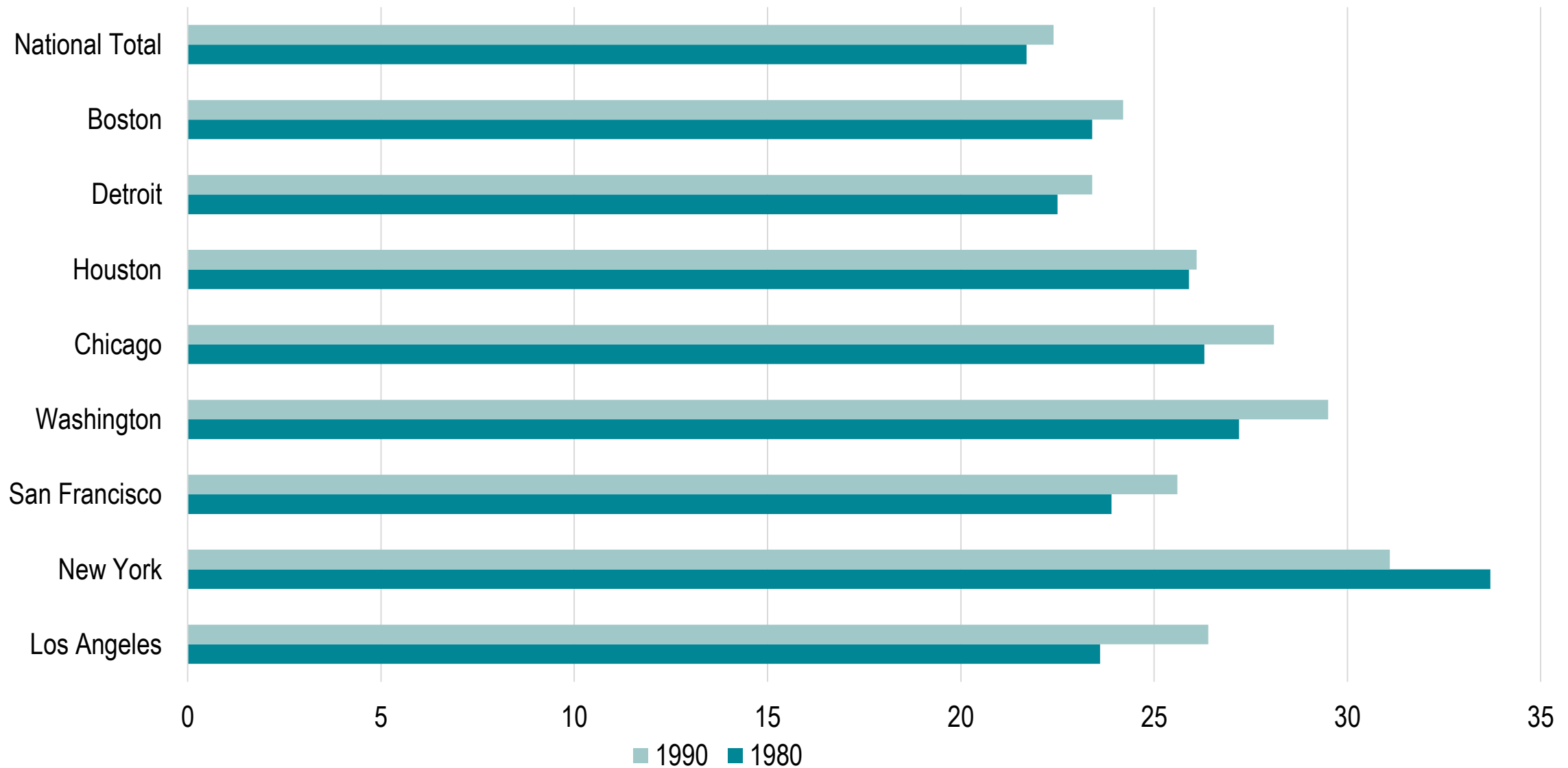


World's Main Subway Systems, c2010

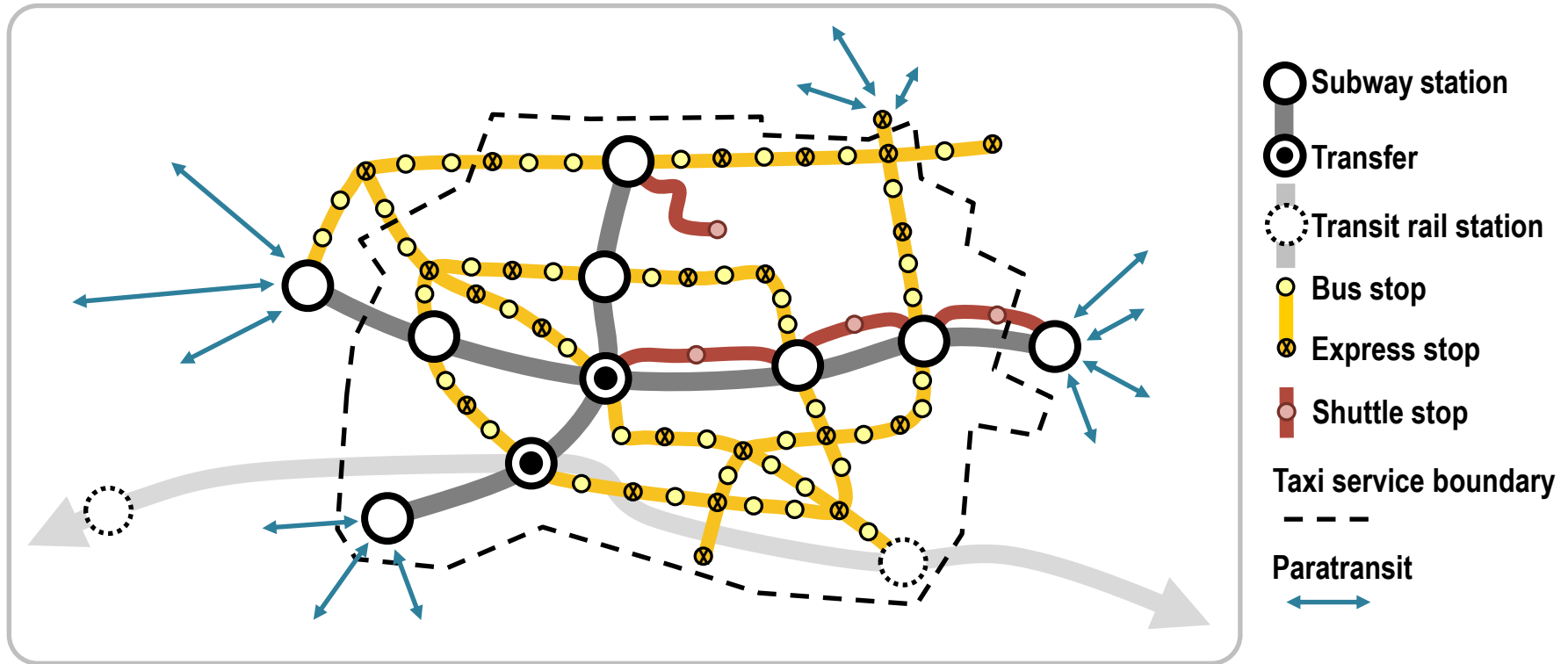




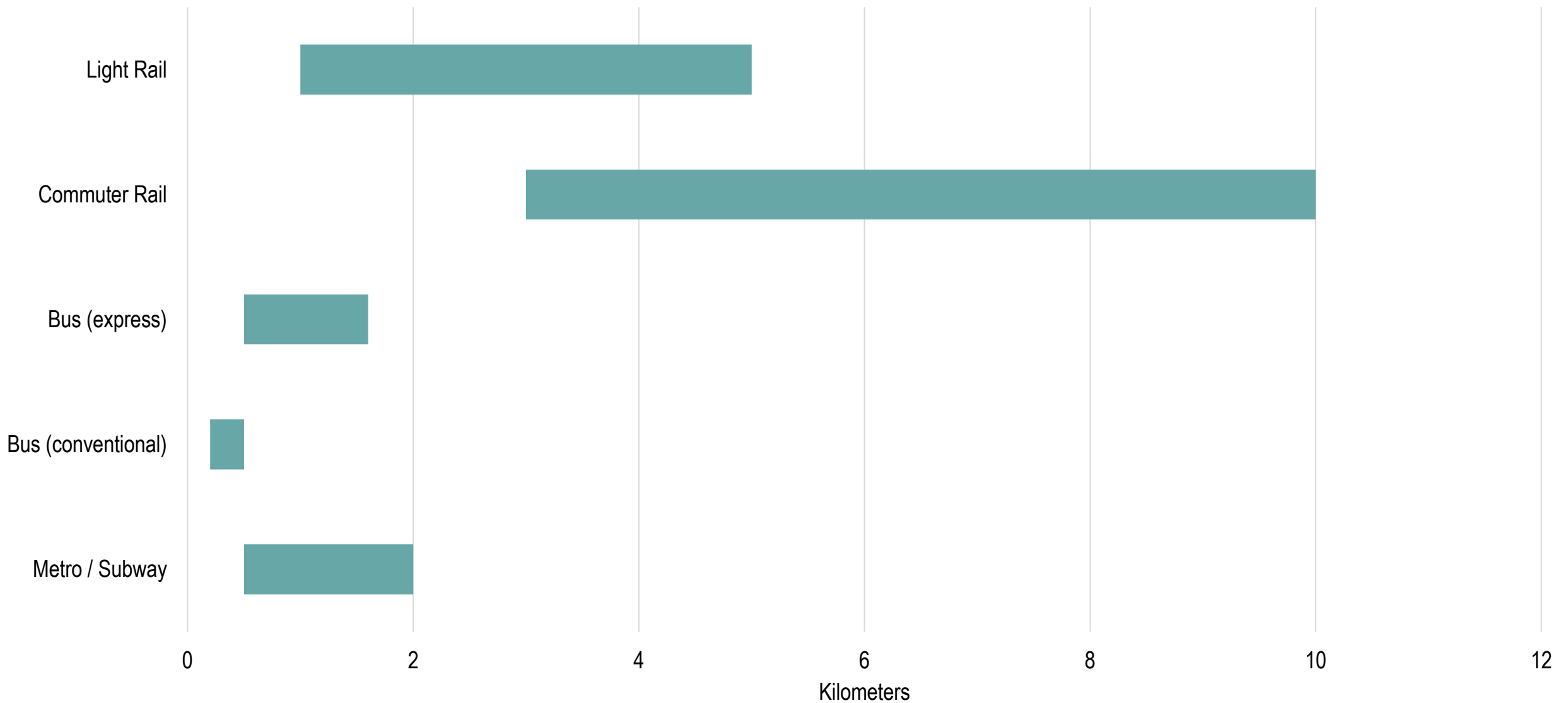
Mean Travel Time to Work for Selected American Cities (in minutes), 1980-1990



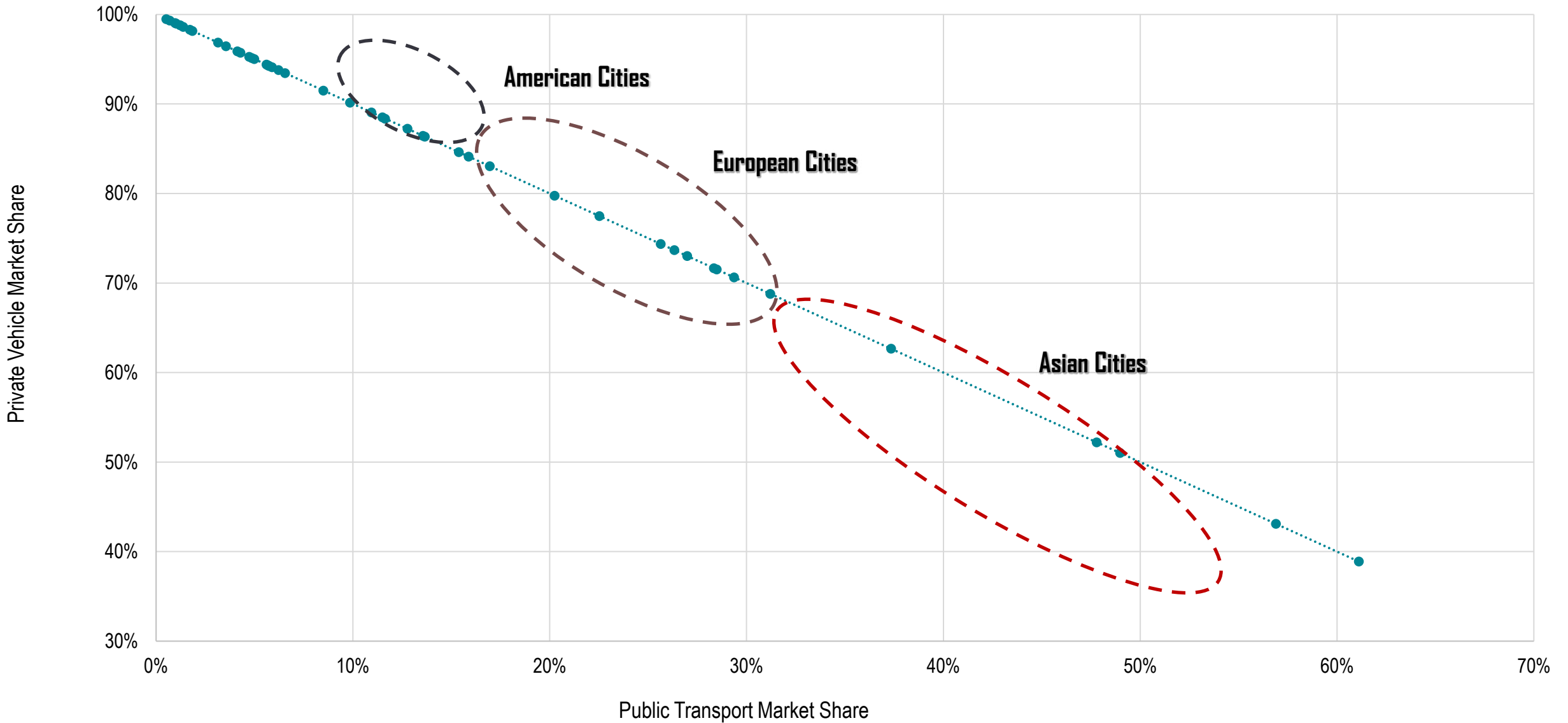
Components of an Urban Transit System



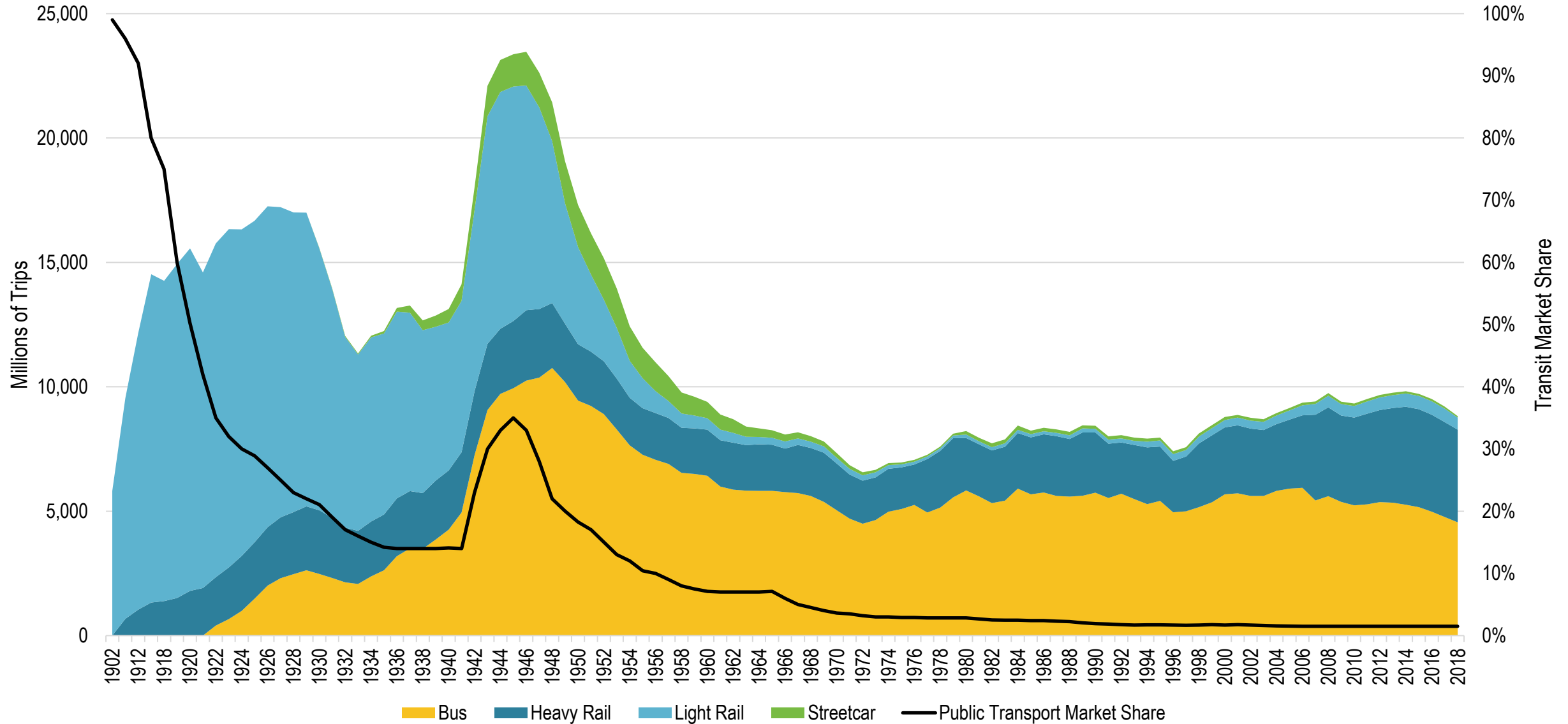
Distance between Access Points to Public Transit



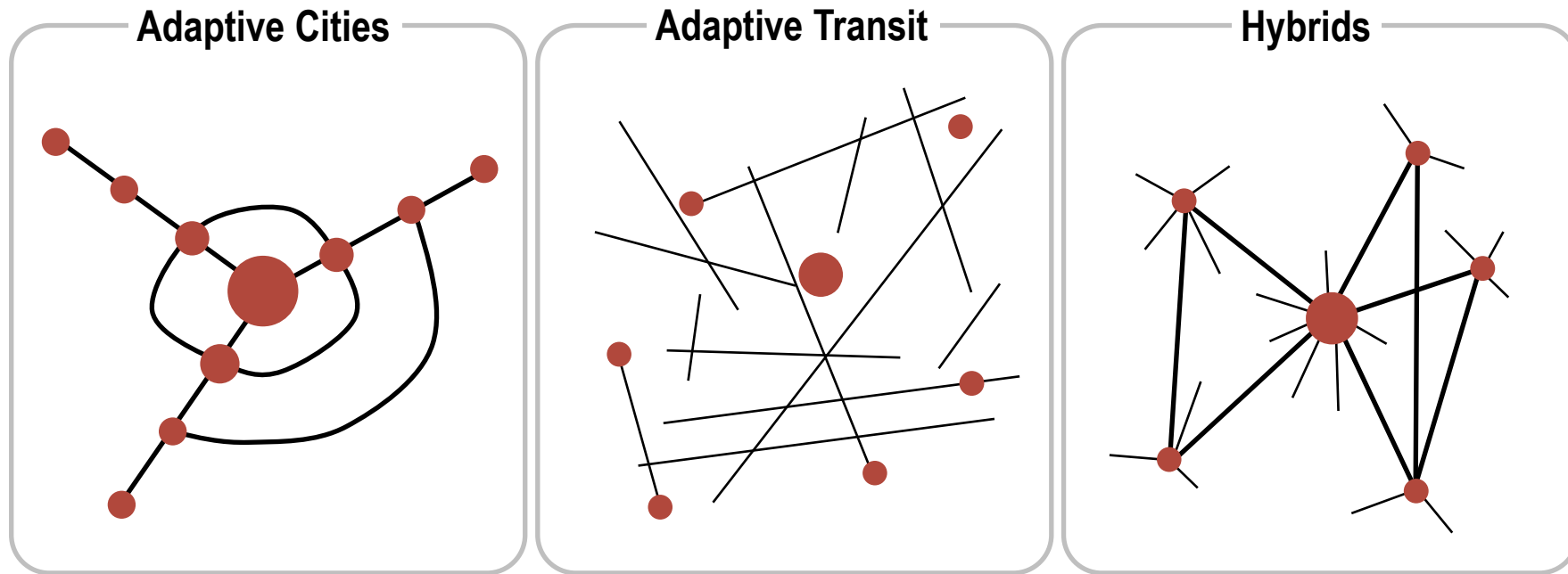
Private Vehicle and Public Transport Market Share, 1990/91



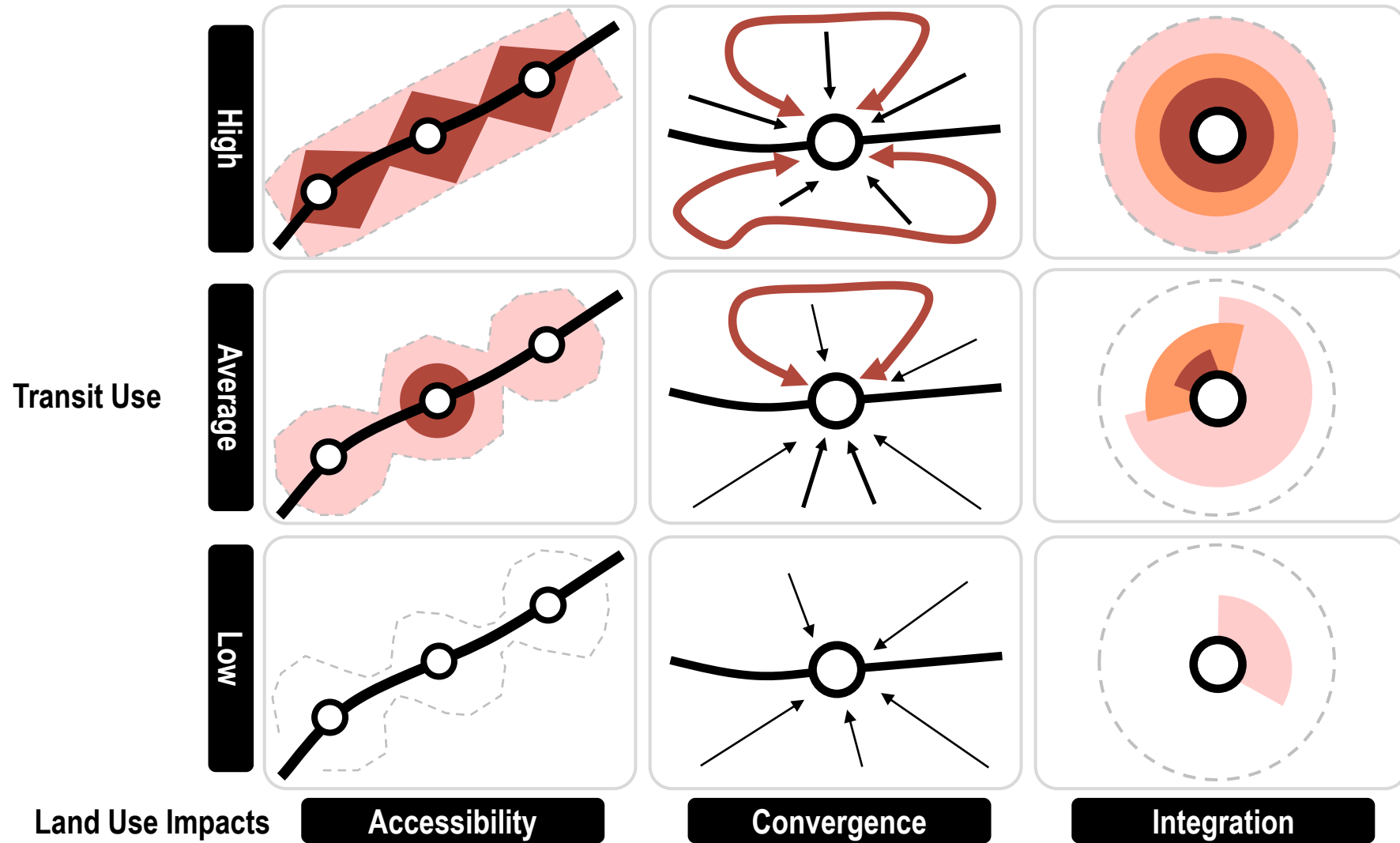
Trips by Public Transport in the United States, 1903-2018



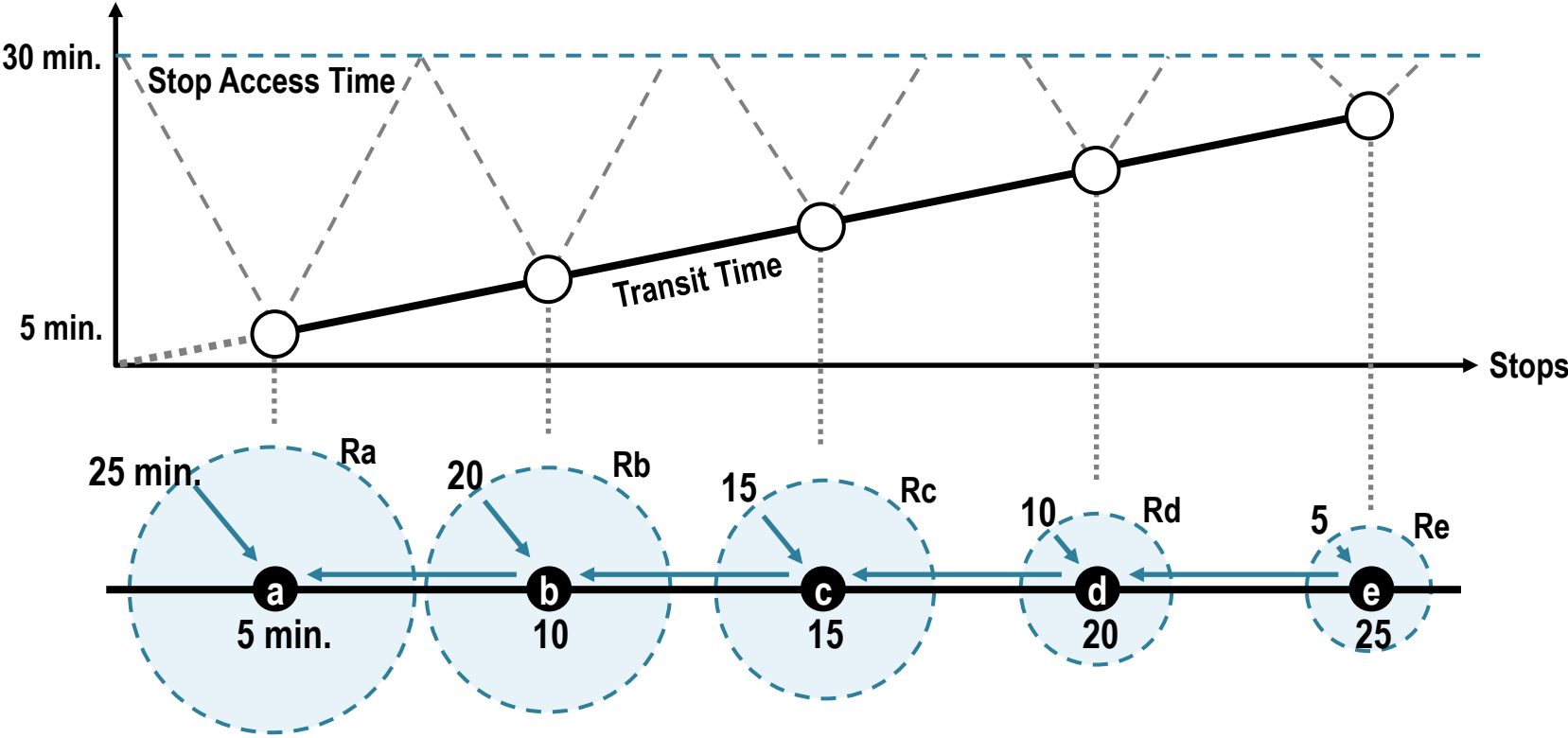
Transit and Urban Form



Transit and Urban Land Use Impacts



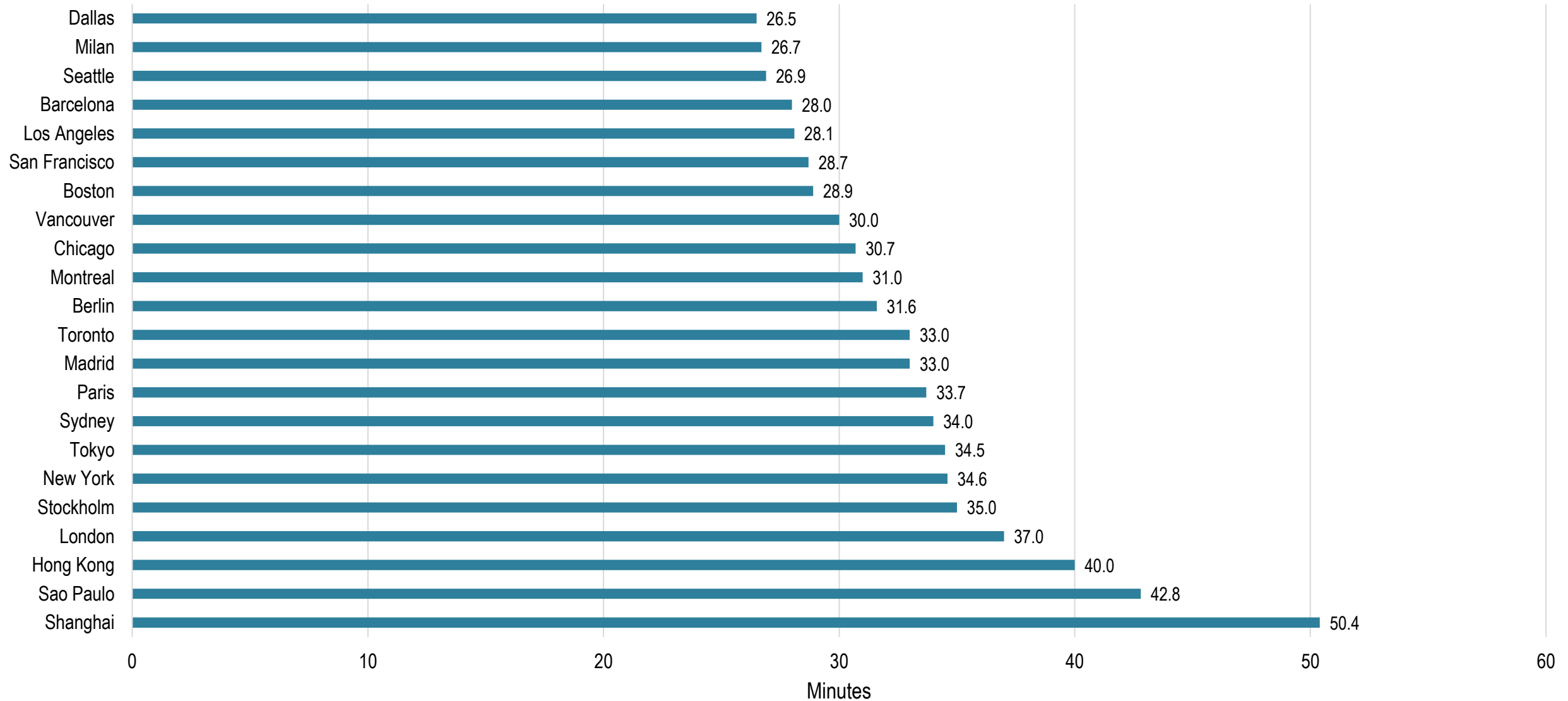
Accessibility along a Transit Line



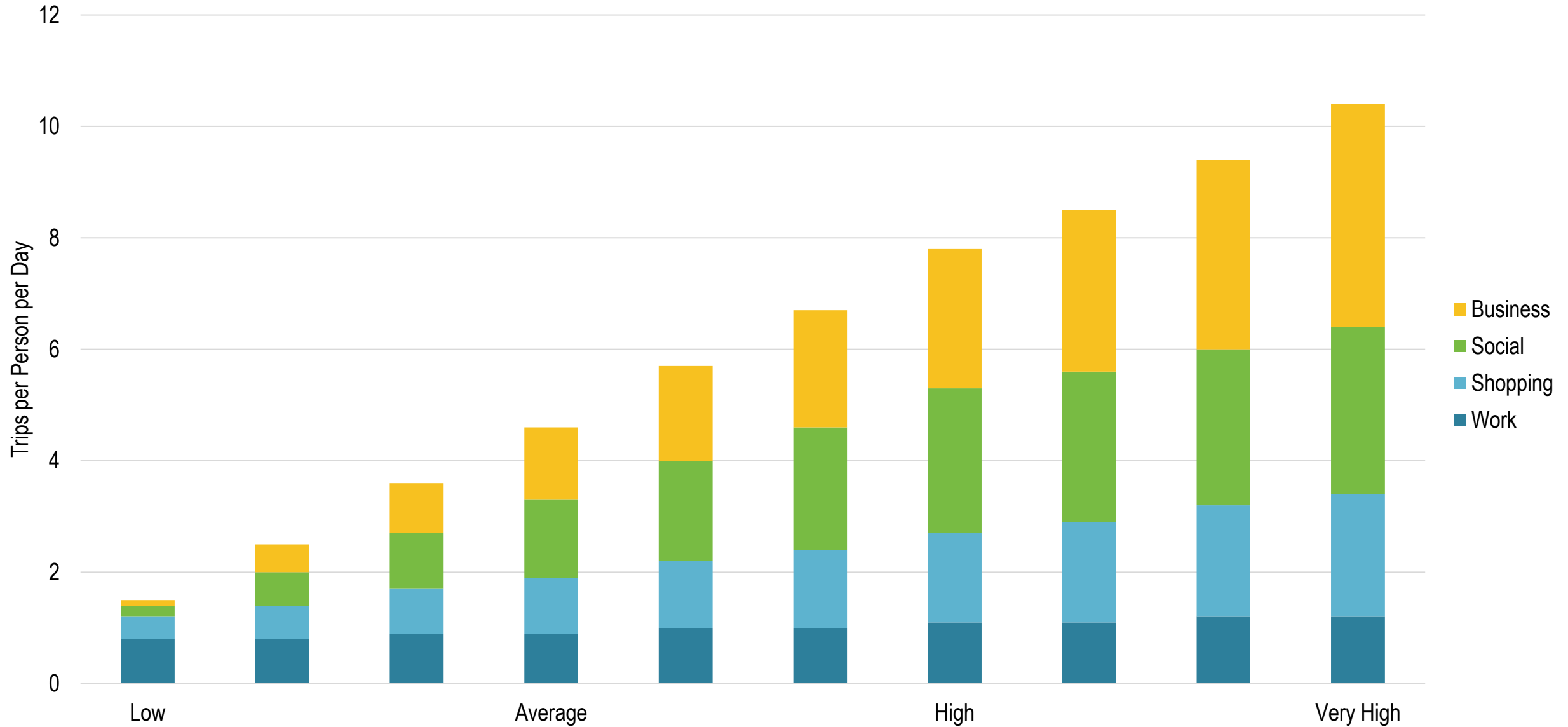
Types of Urban Movements

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

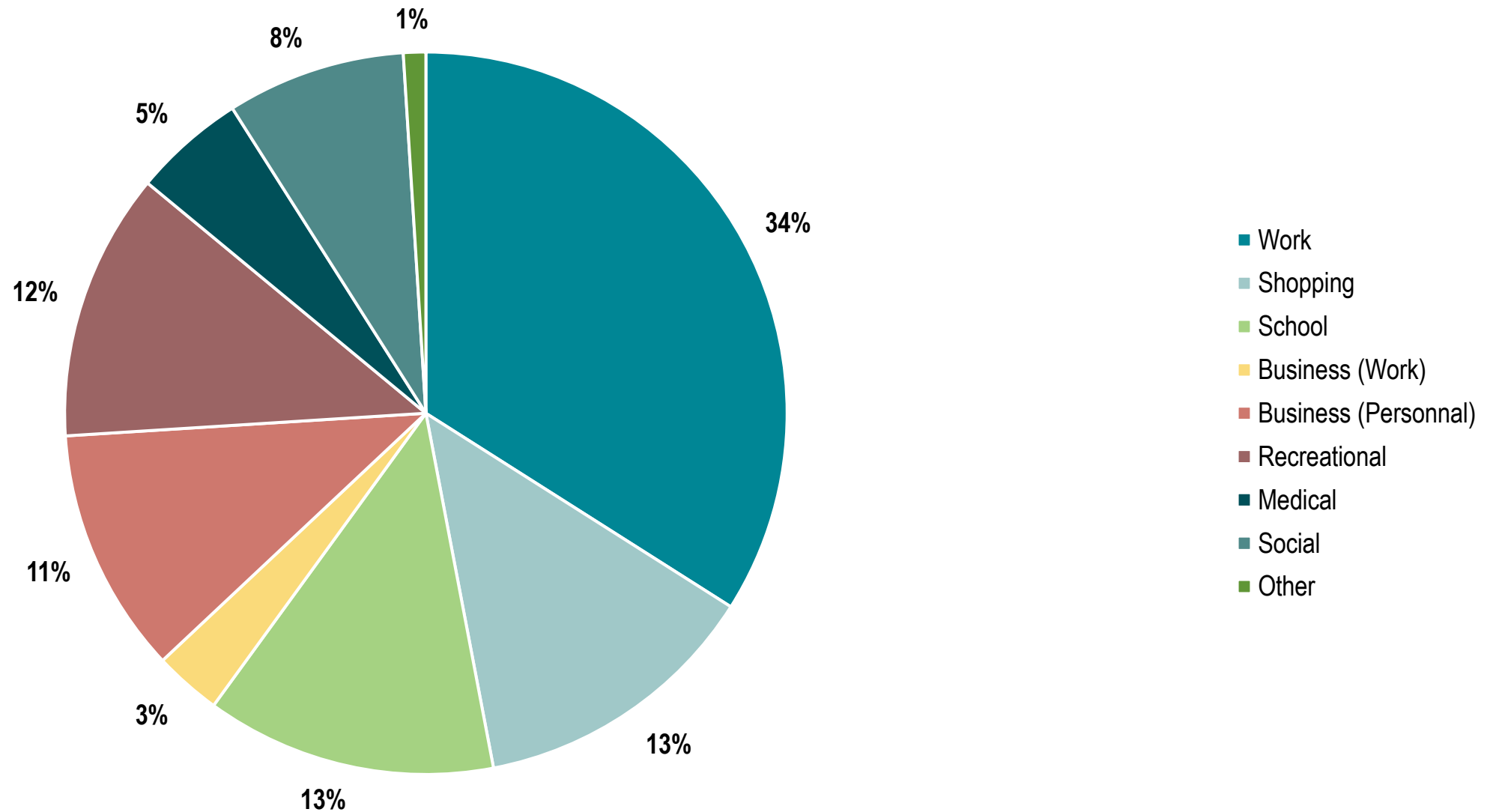
Average Commuting Time (One Way), Selected Metropolitan Areas



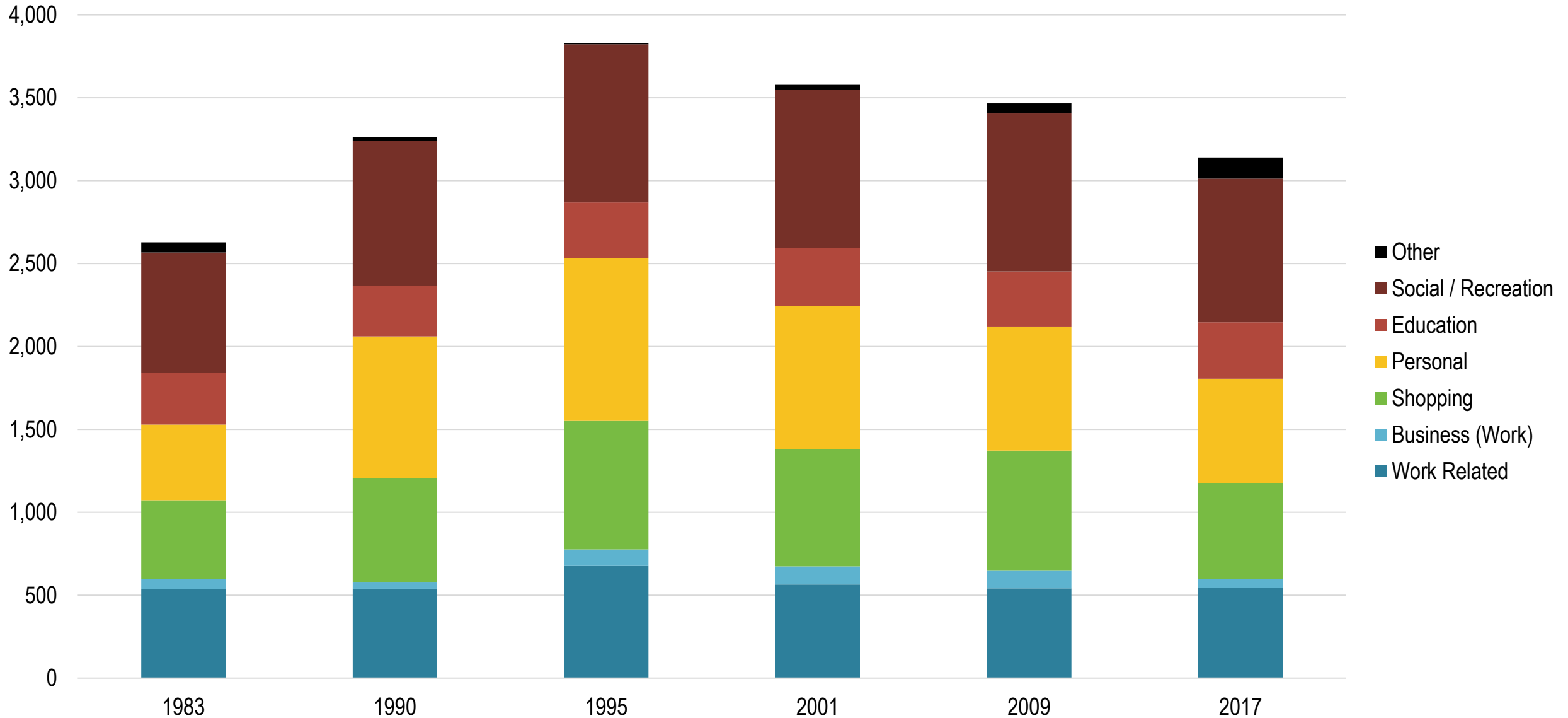
Income and Urban Transport Demand



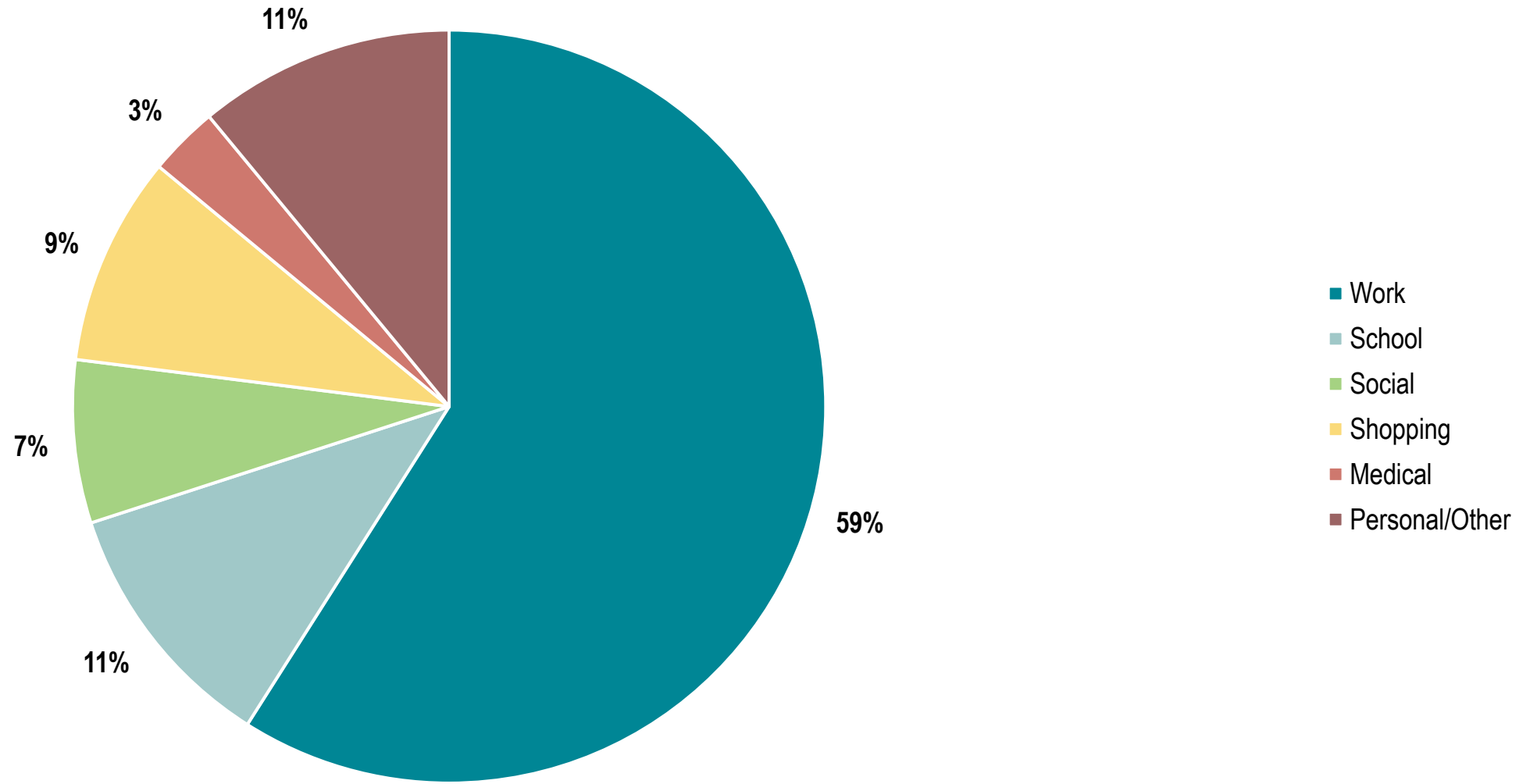
Main Purposes of Passenger Trips in the United States, 2001



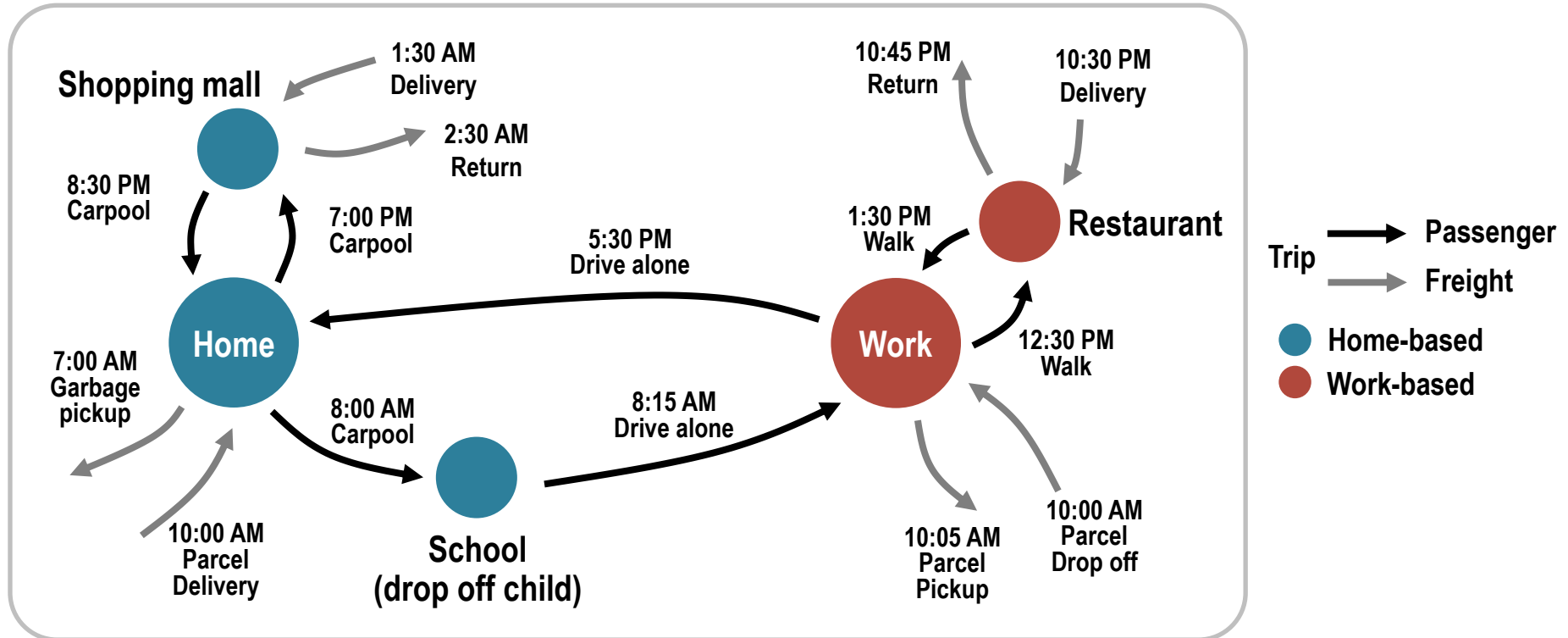
Average Annual Person Trips per Household by Trip Purpose, United States, 1983-2017



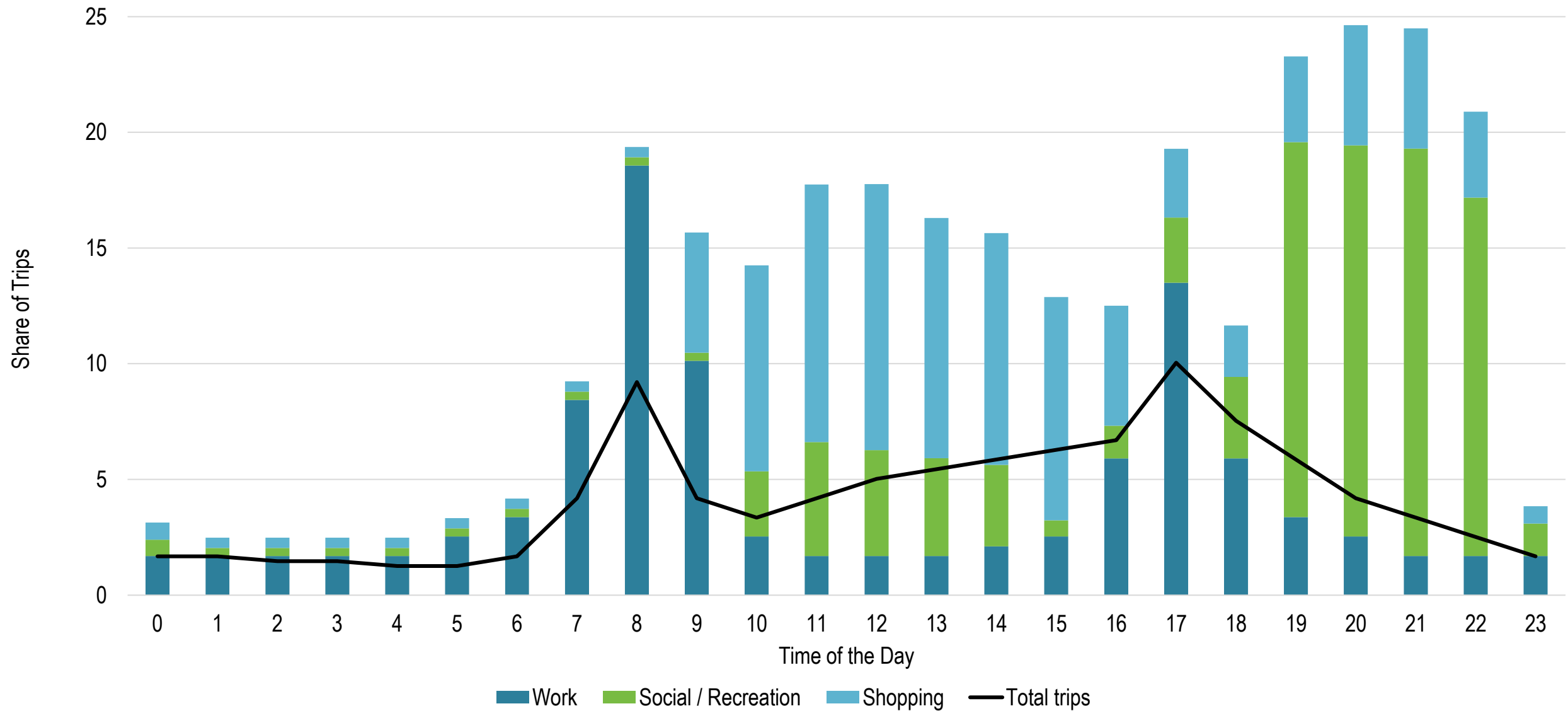
Main Purposes of Transit Trips in the United States, 2007



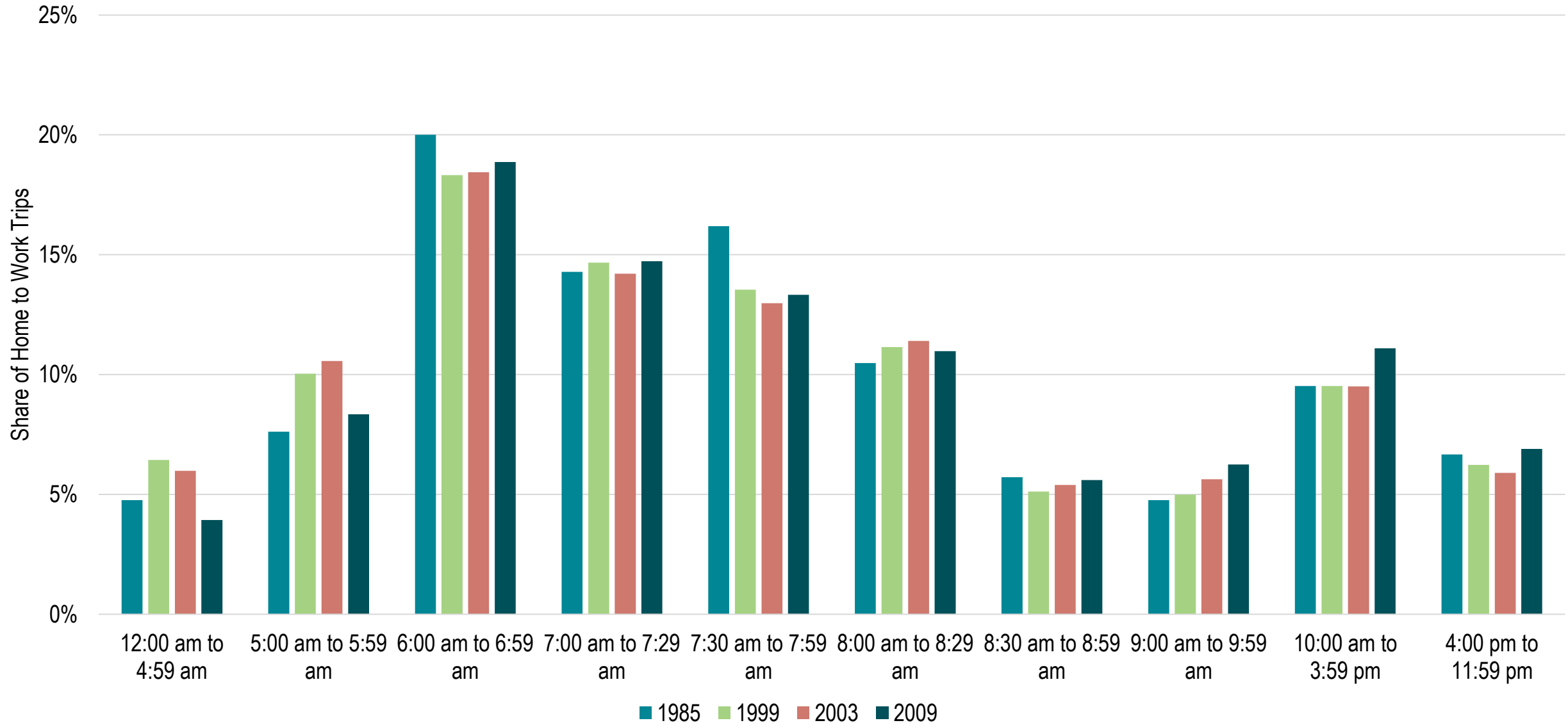
Typical Activity Space of an Urban Working Adult



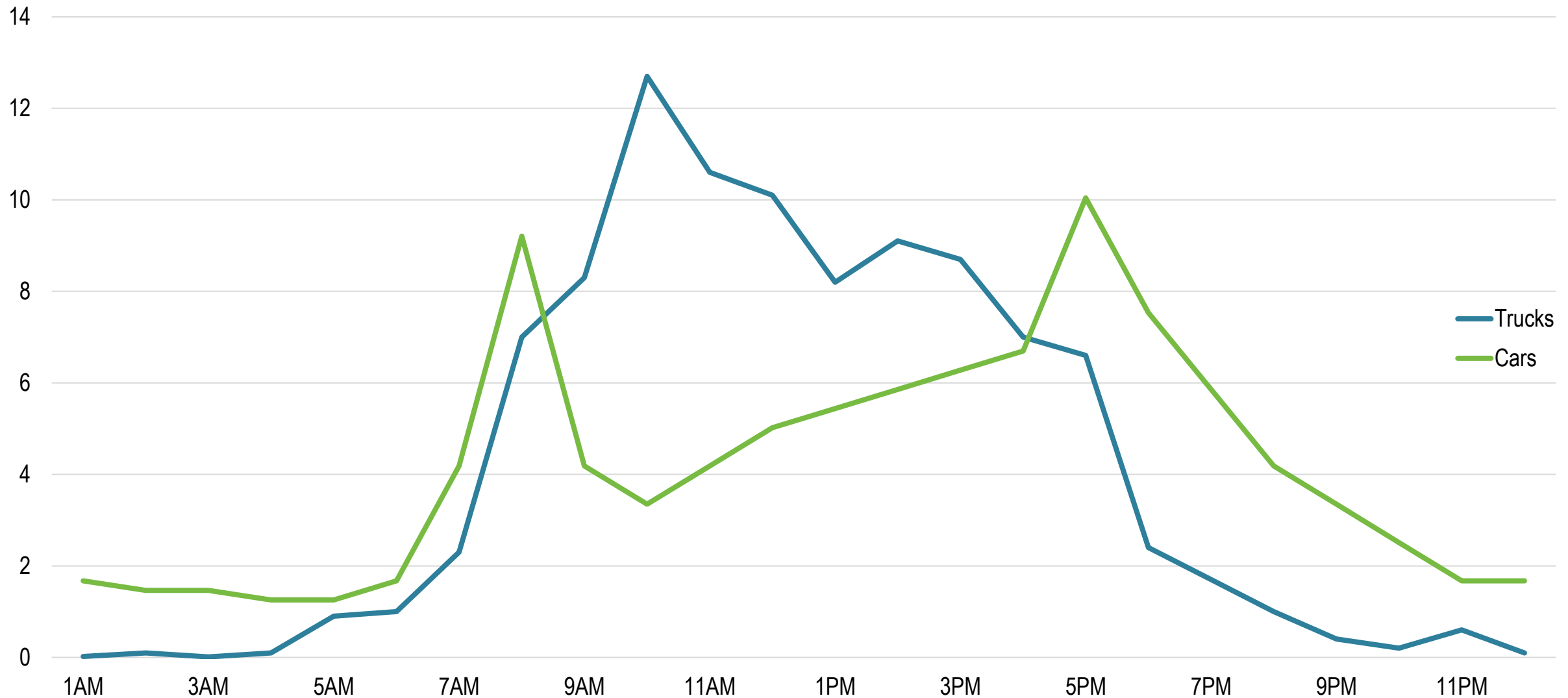
Urban Travel by Purpose and by Time of the Day in a North American Metropolis



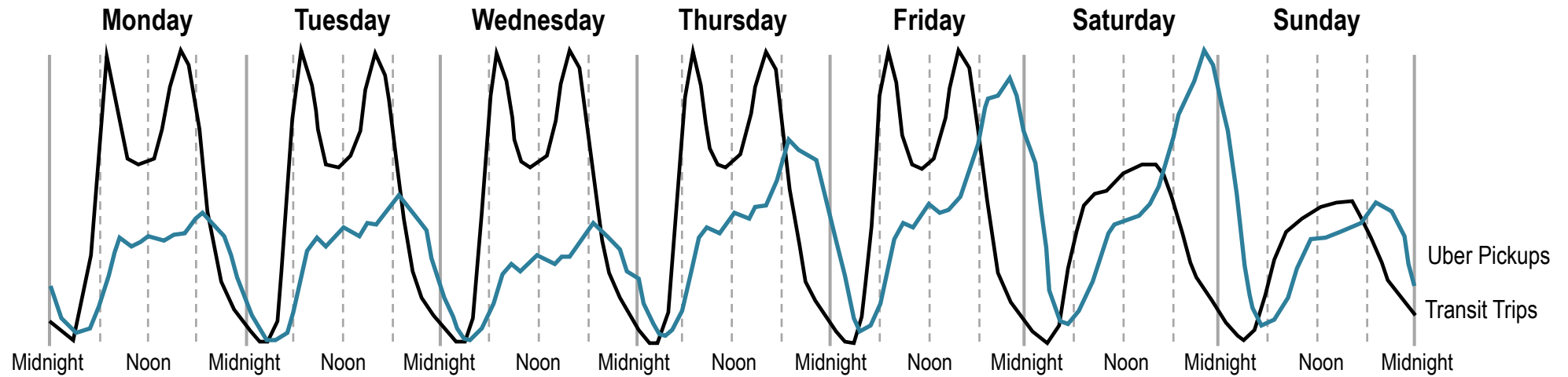
Time of Departure for Home to Work Trips, United States



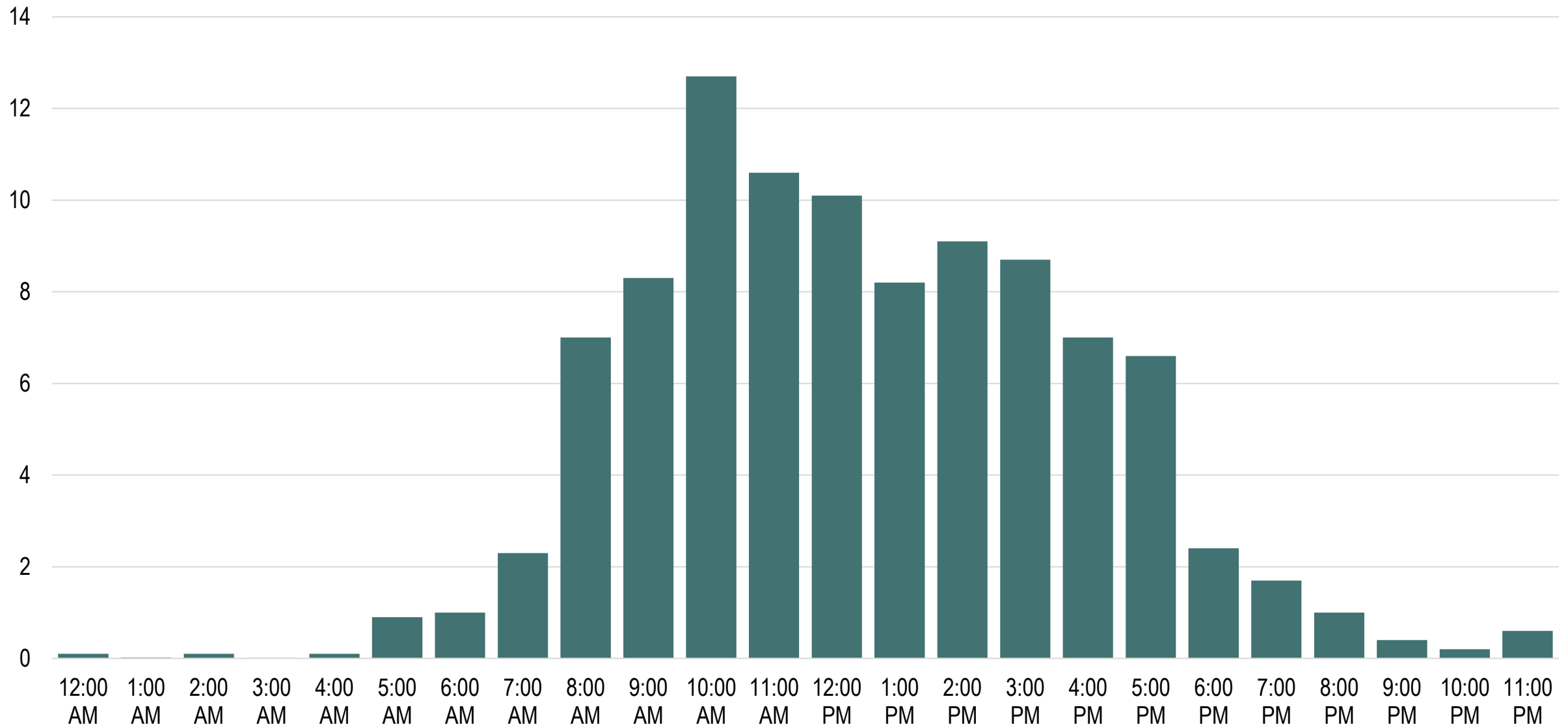
Typical Car and Truck Trips Distribution by Time of the Day



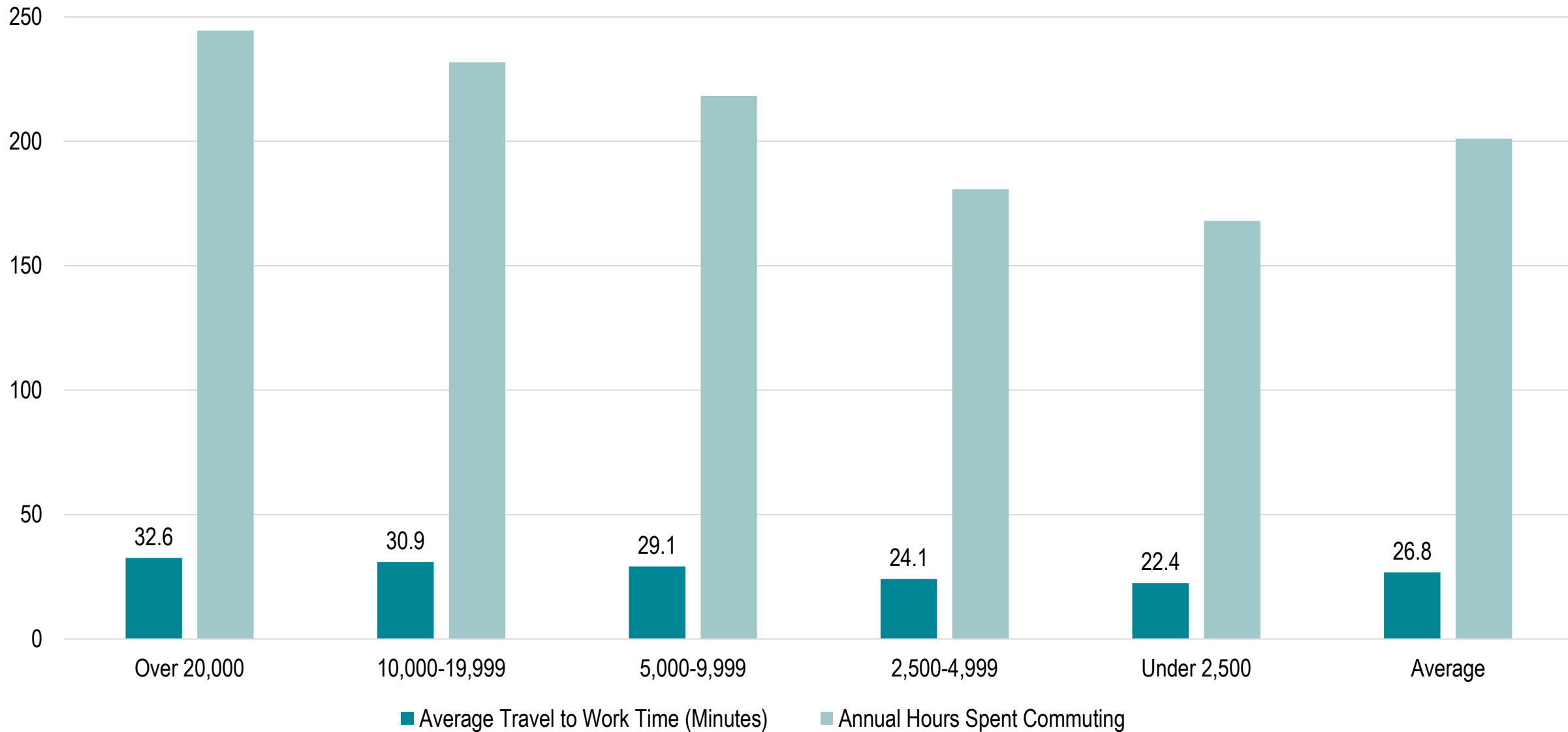
Weekly Distribution of Transit Scheduled Trips and Uber Pickups, Los Angeles



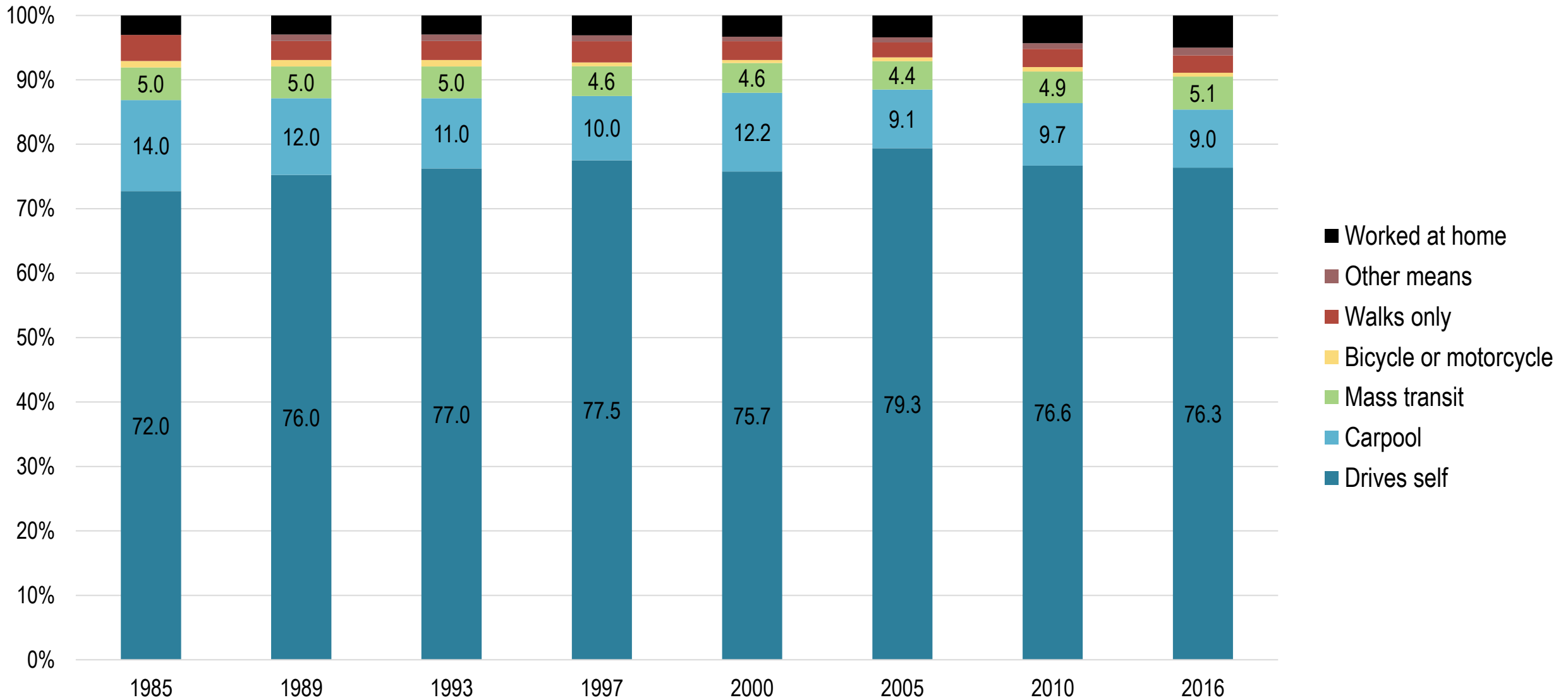
Typical Truck Trips Distribution by Time of the Day



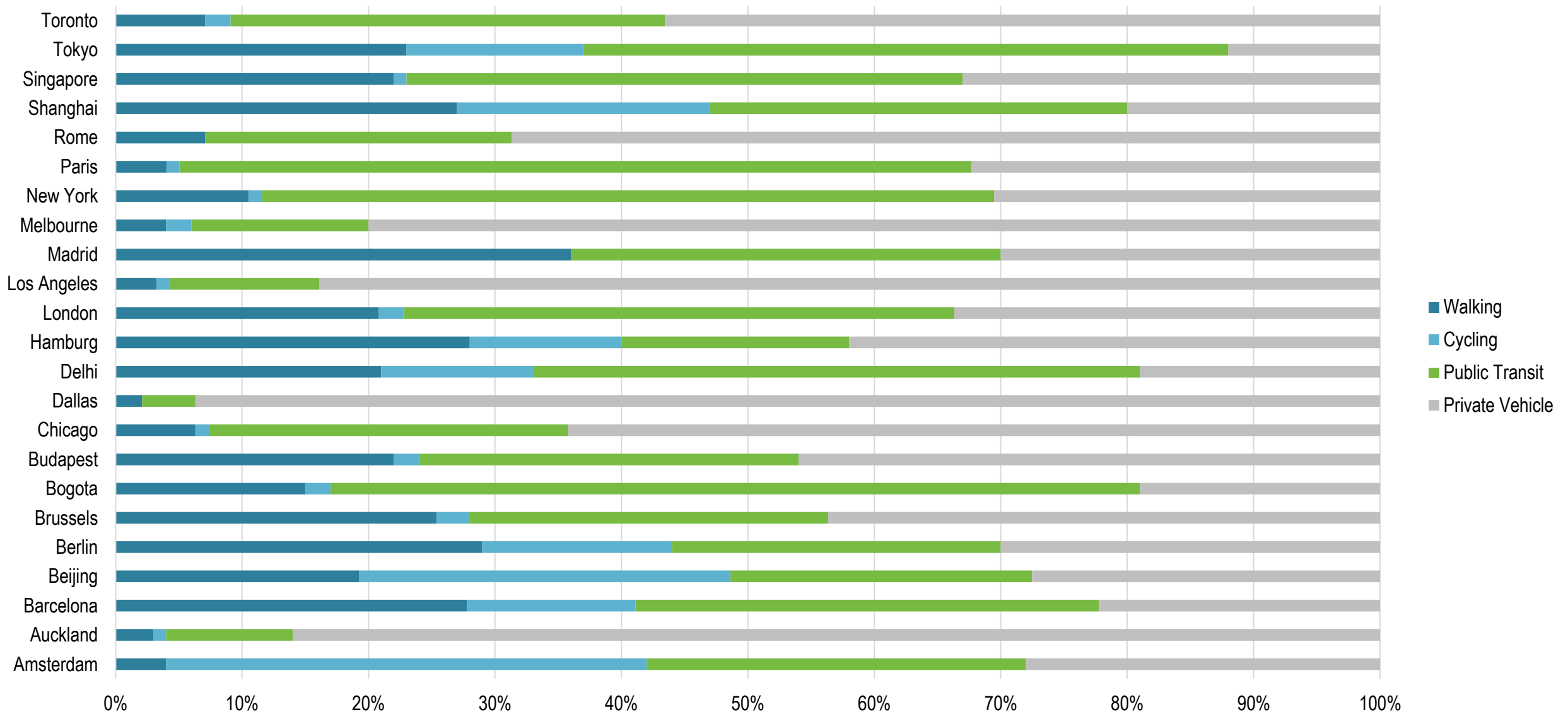
International Journey to Work Travel Times by Population Density, 1990



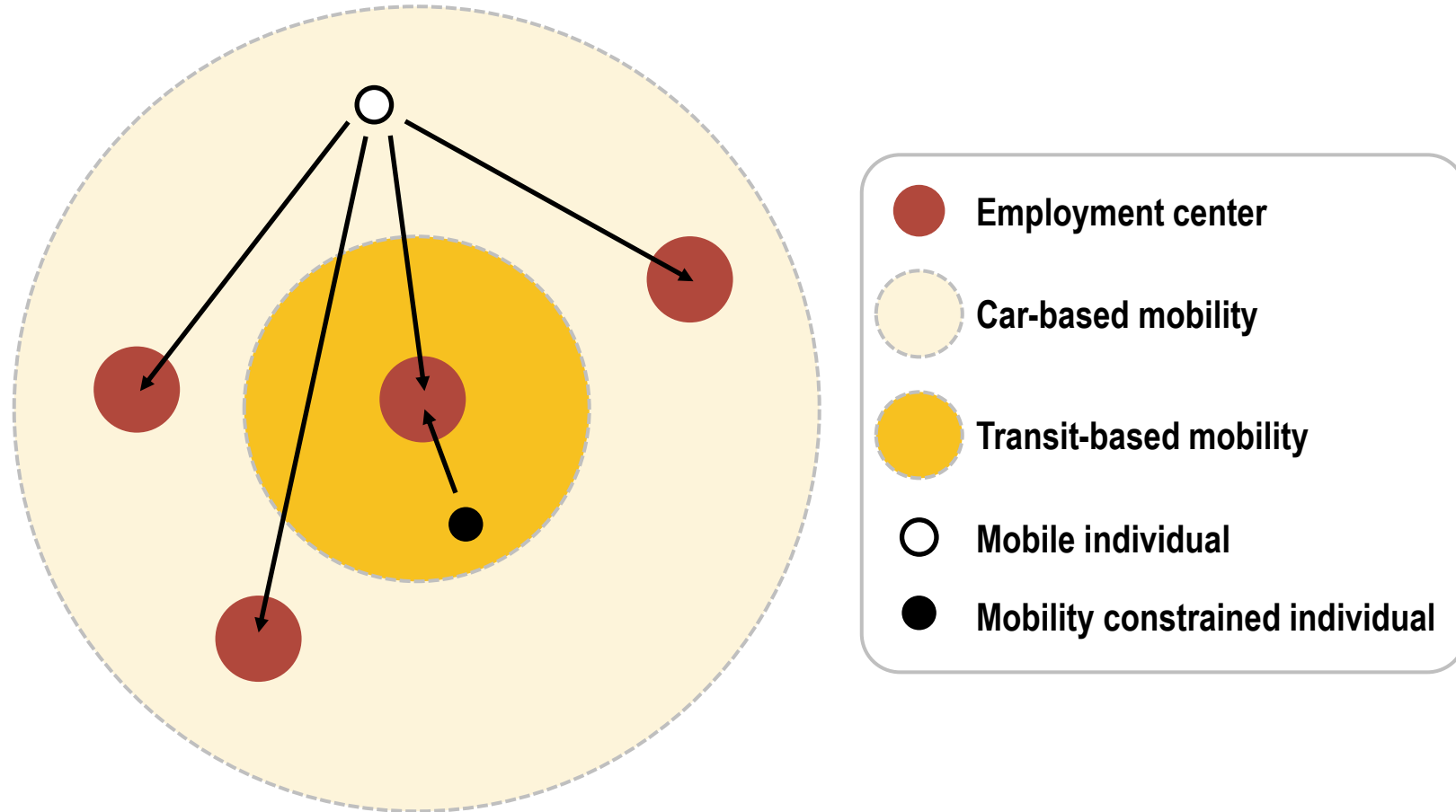
Home-to-Work Trips Modes, United States, 1985-2016



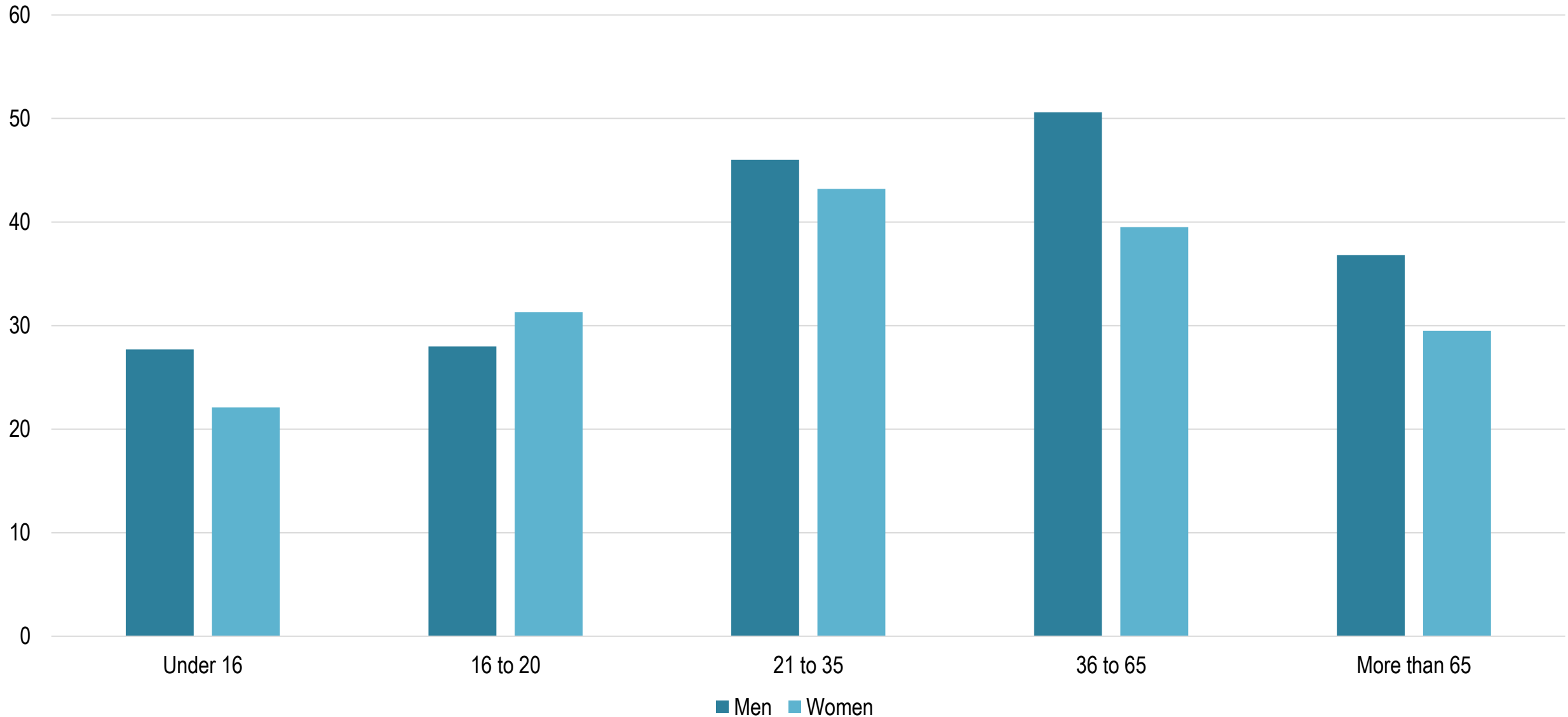
Modal Split, Journey to Work Trips, Selected Cities



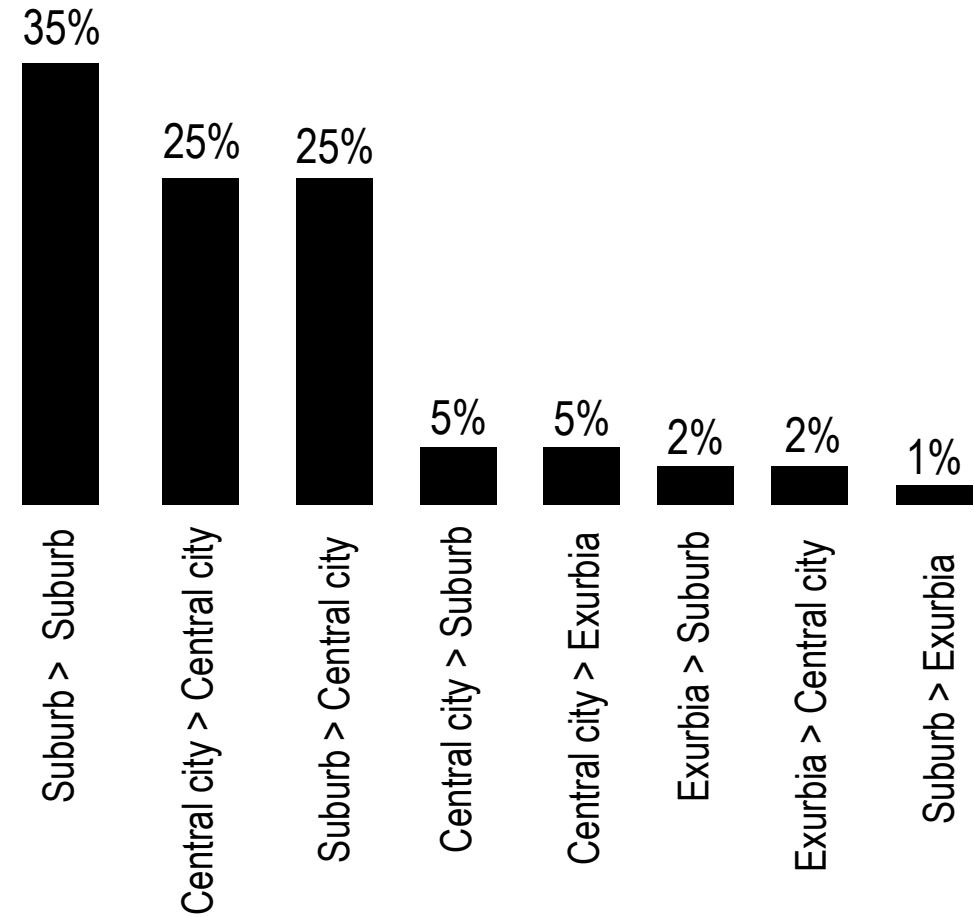
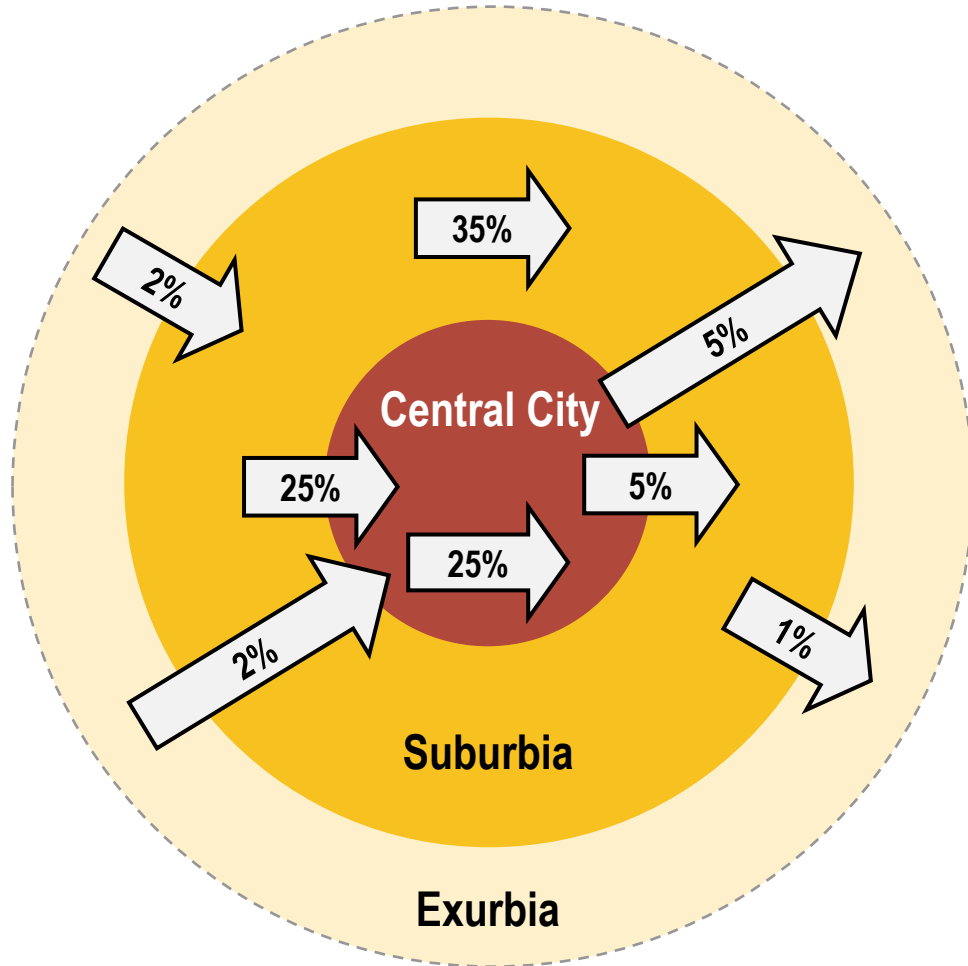
Mobility Gaps in Urban Areas



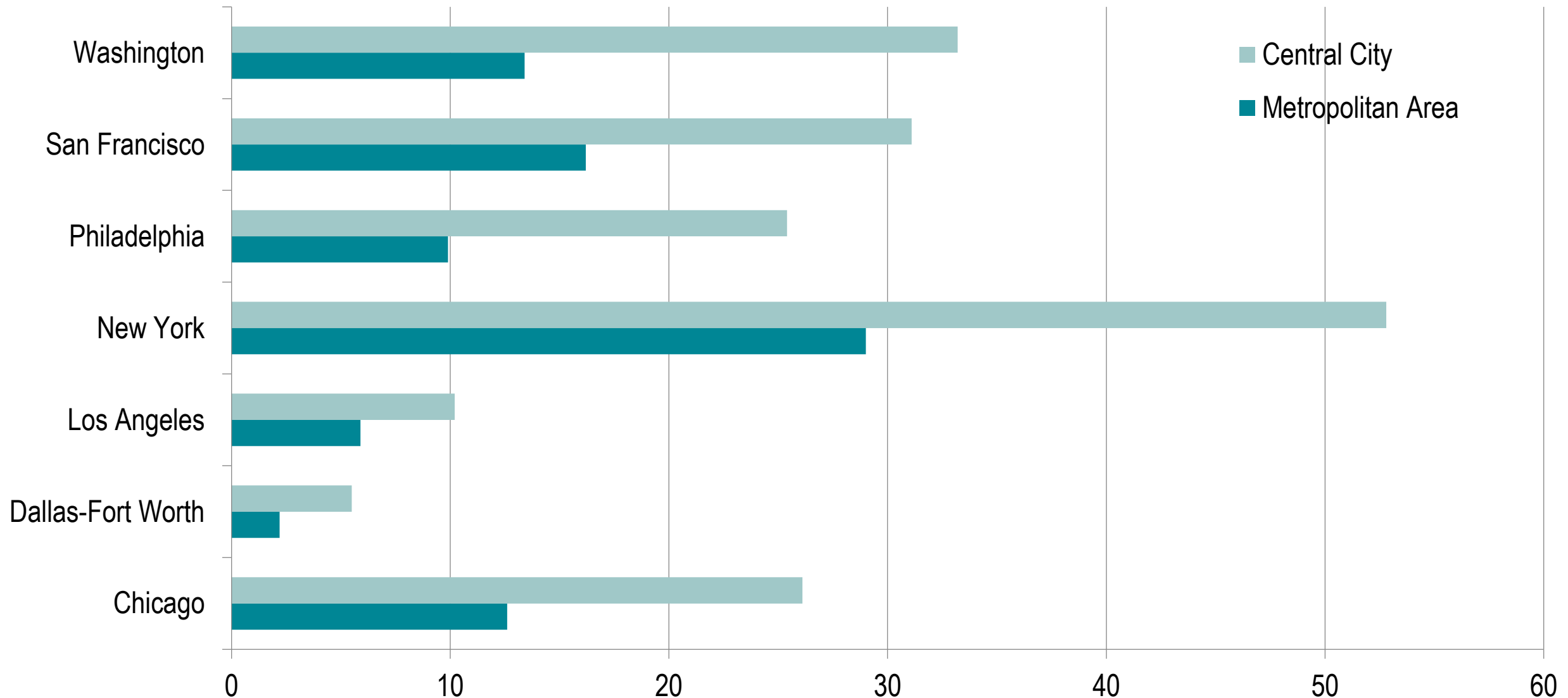
Daily Person Miles of Travel per Person by Age and Gender, 2017



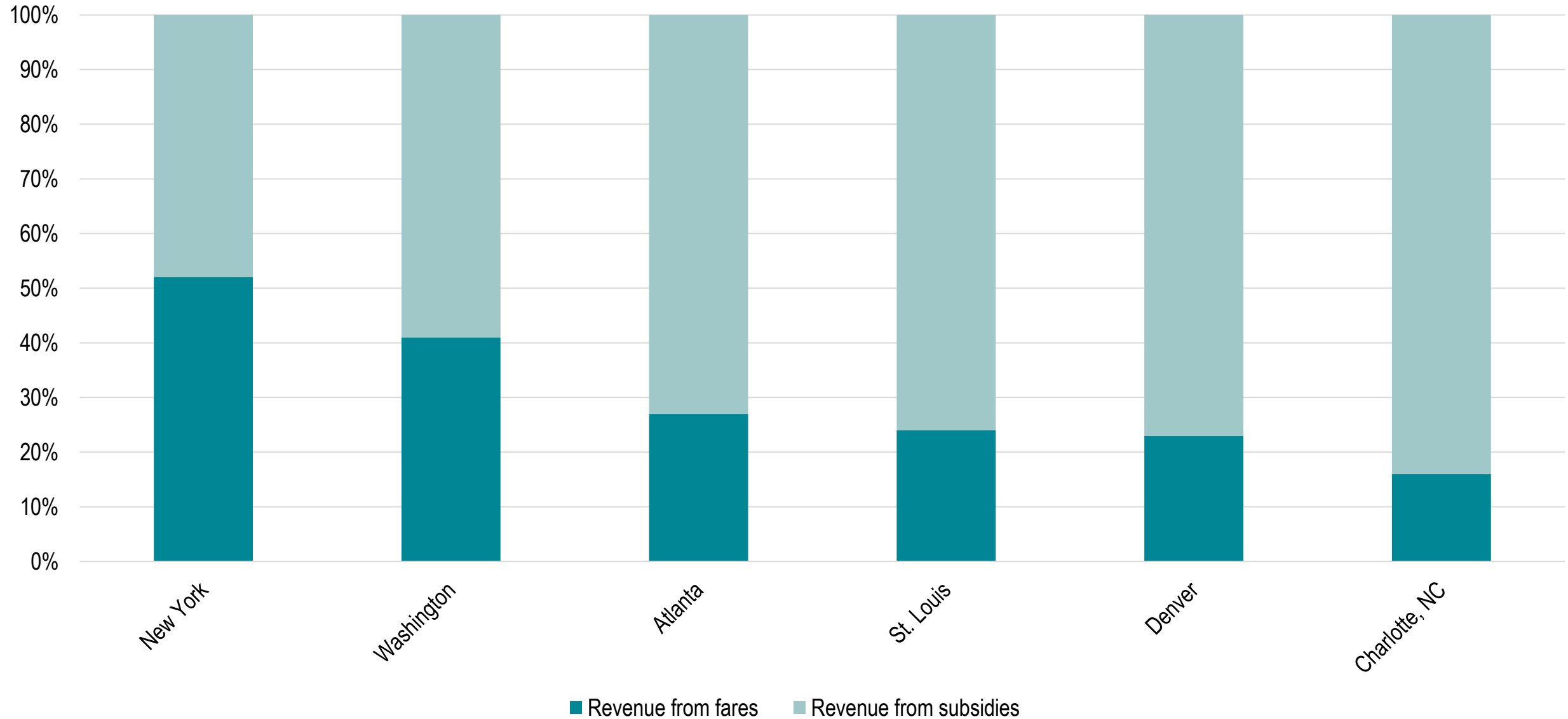
Work-Related Mobility in the United States



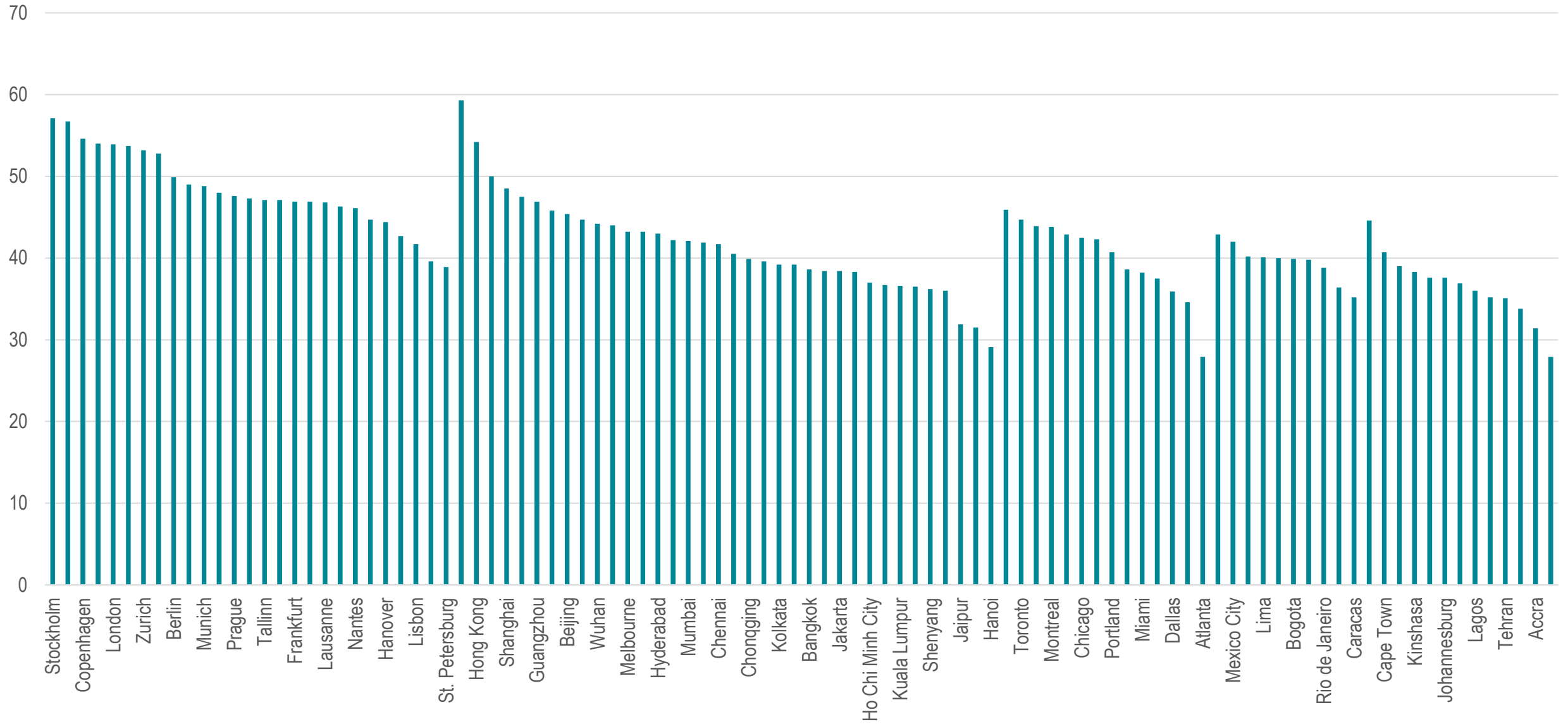
Percentage of Workers Using Public Transportation, Selected Urban Areas, 2000

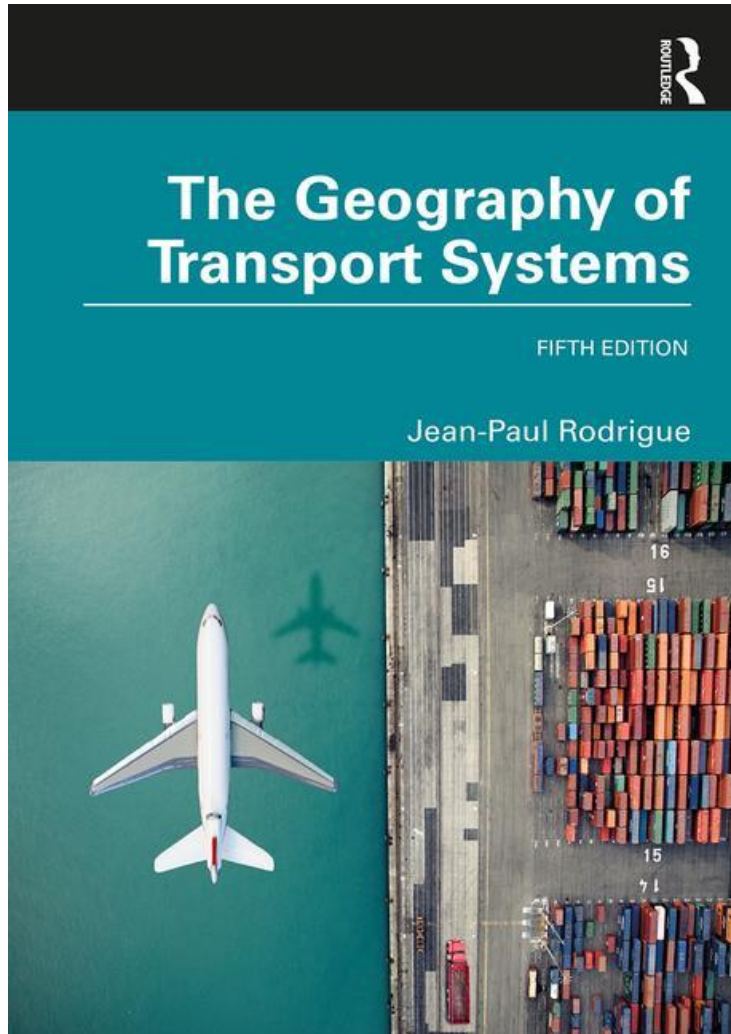


Source of Revenue for Some American Transit Systems, 2008



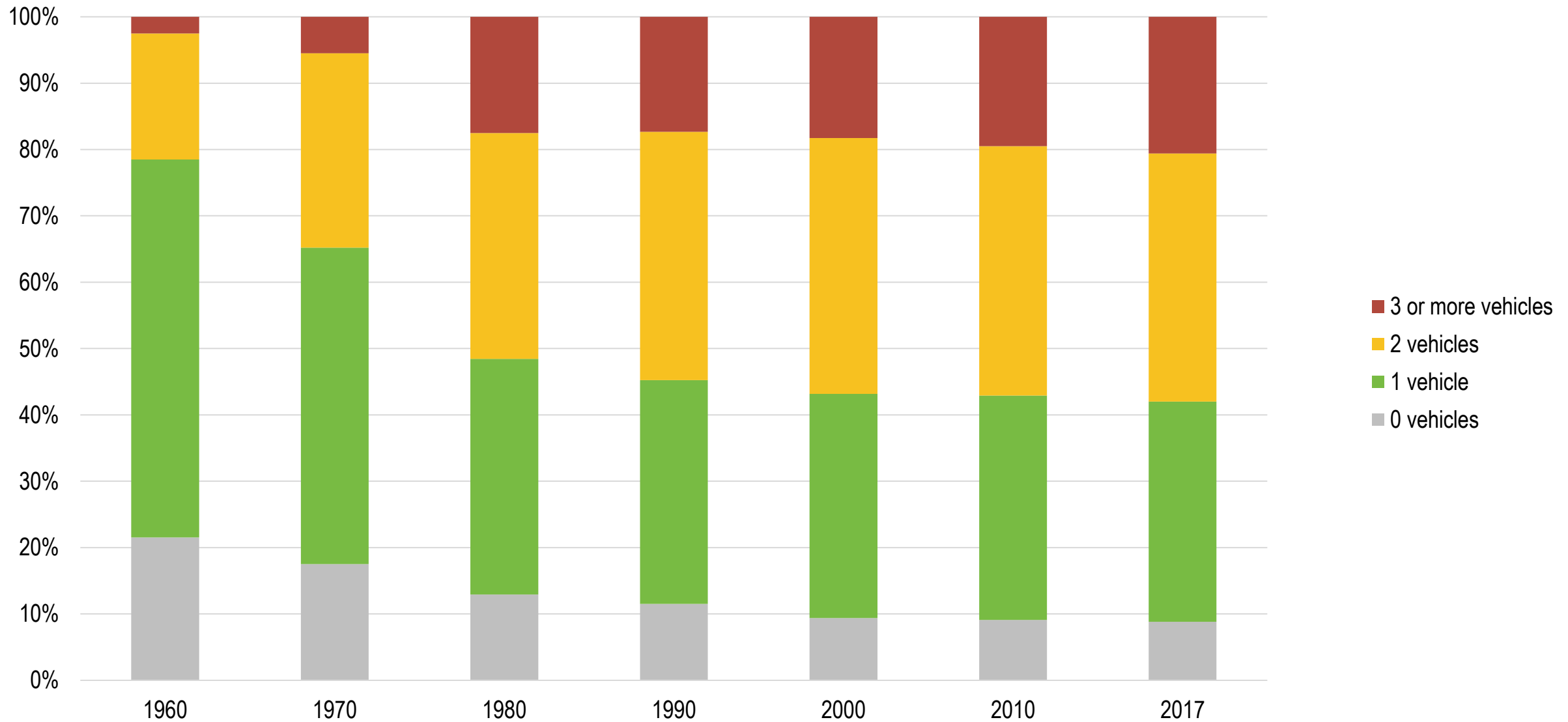
Urban Mobility Index, 2017



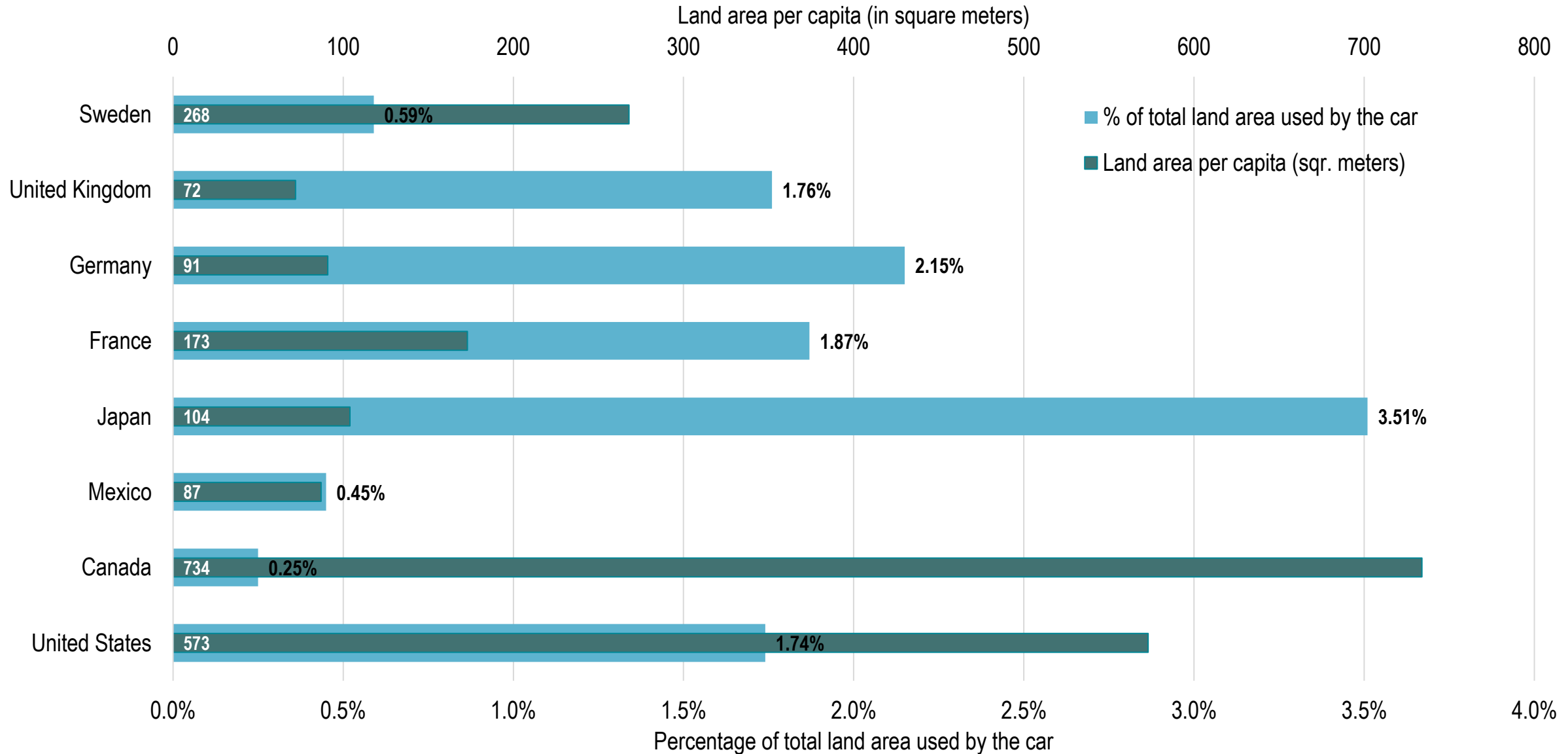


Urban Transport Challenges

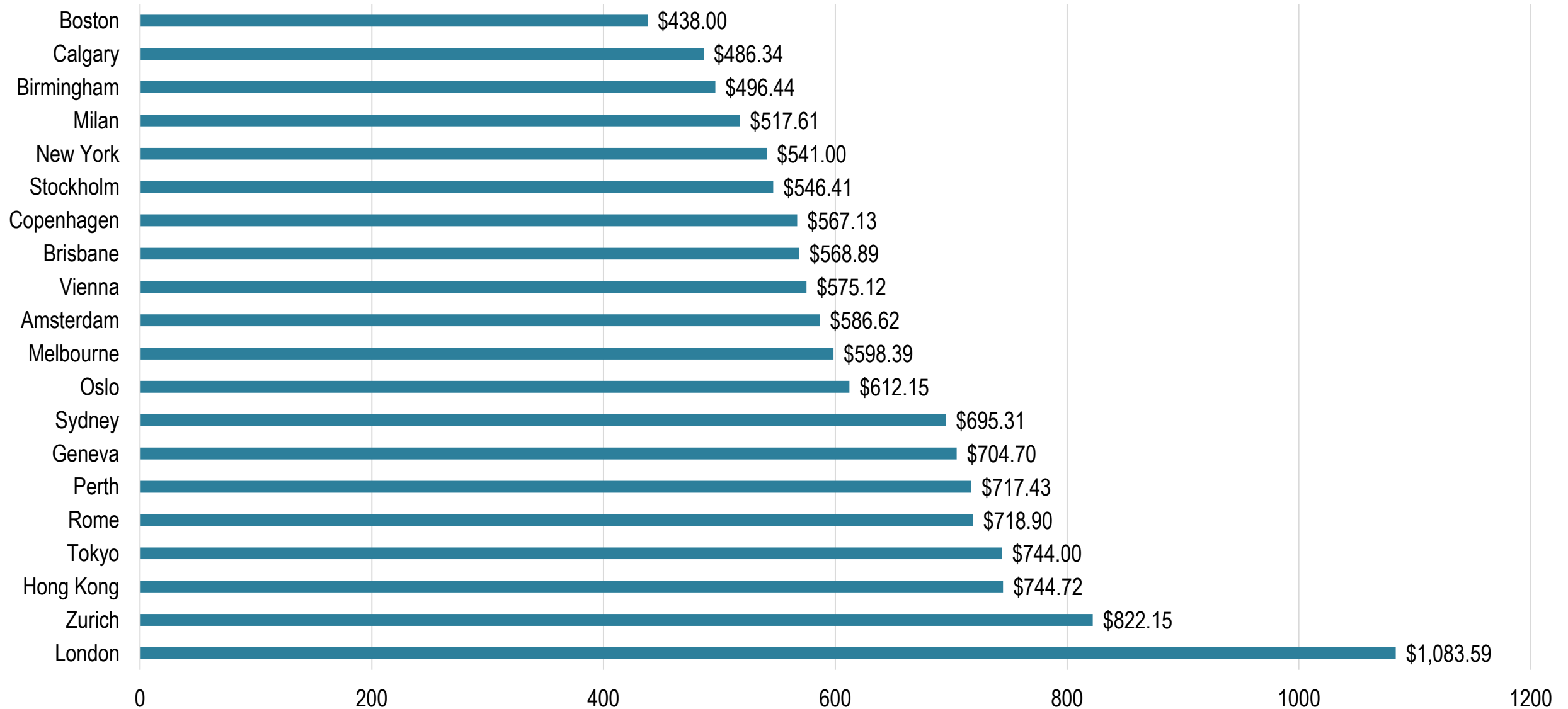
Percentage of Households by Number of Vehicles, 1960-2017



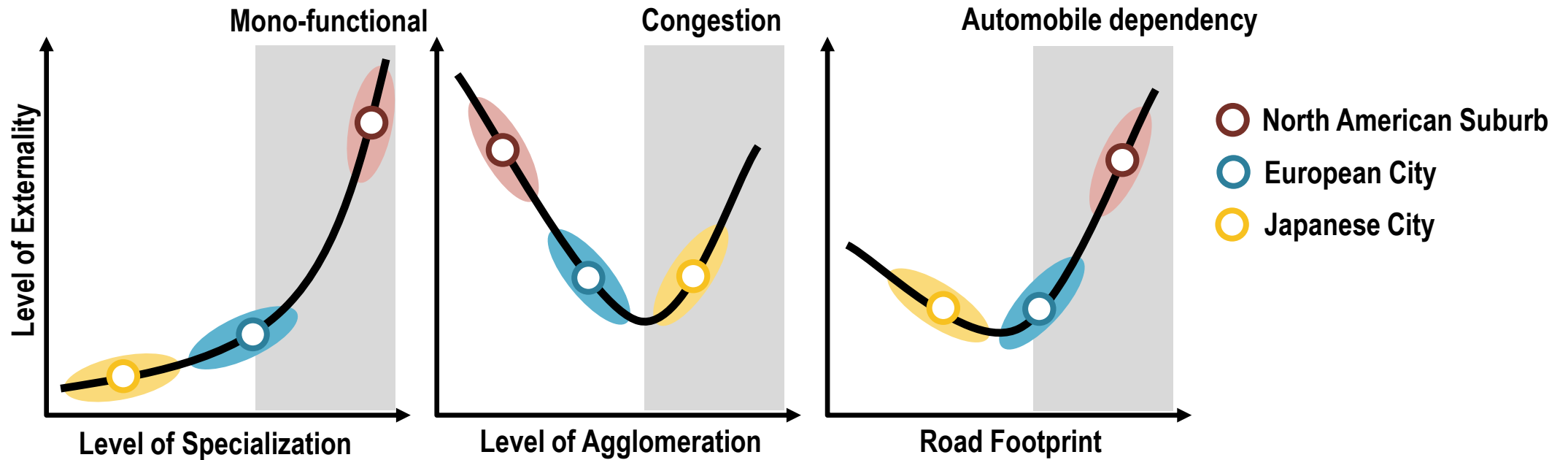
Land Area Consumed by the Car in Selected Countries, 1999



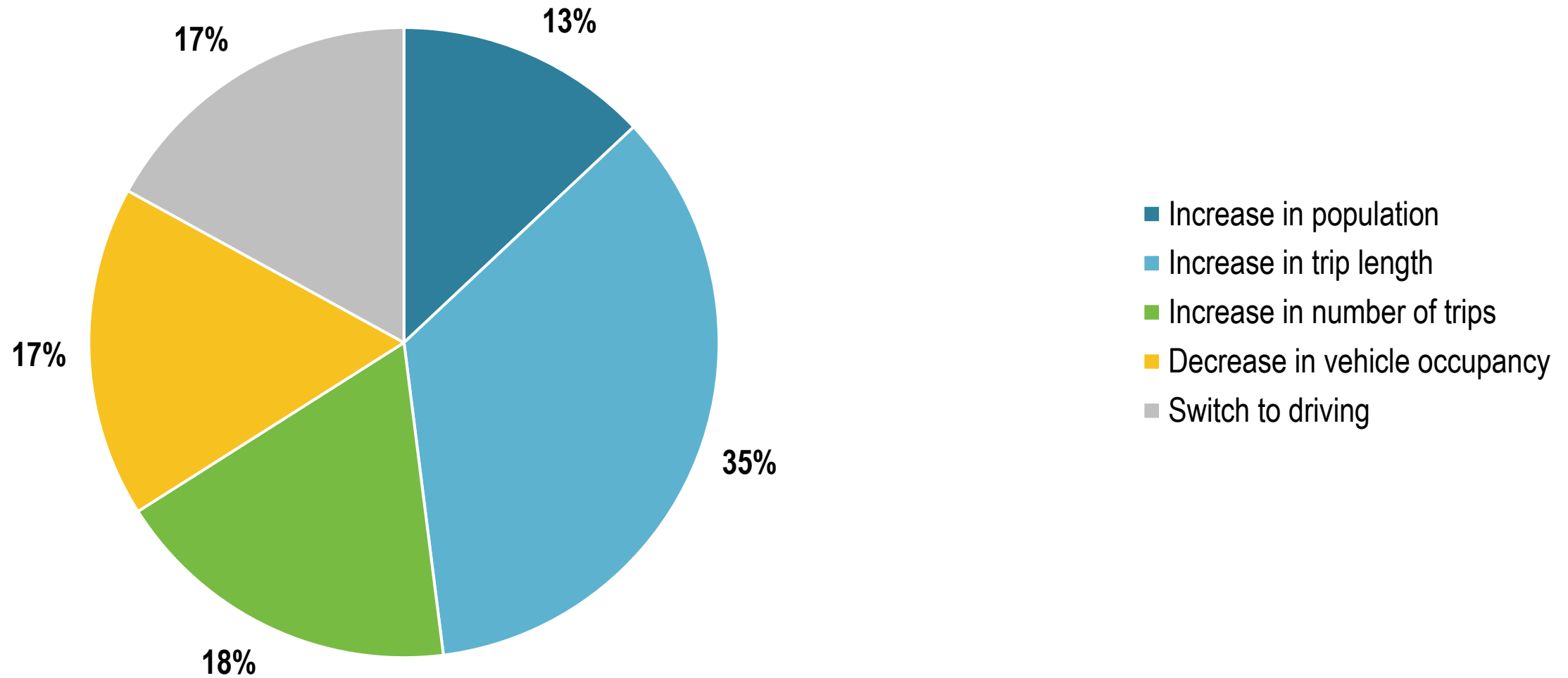
Central Business District Monthly Parking Rate, 2011



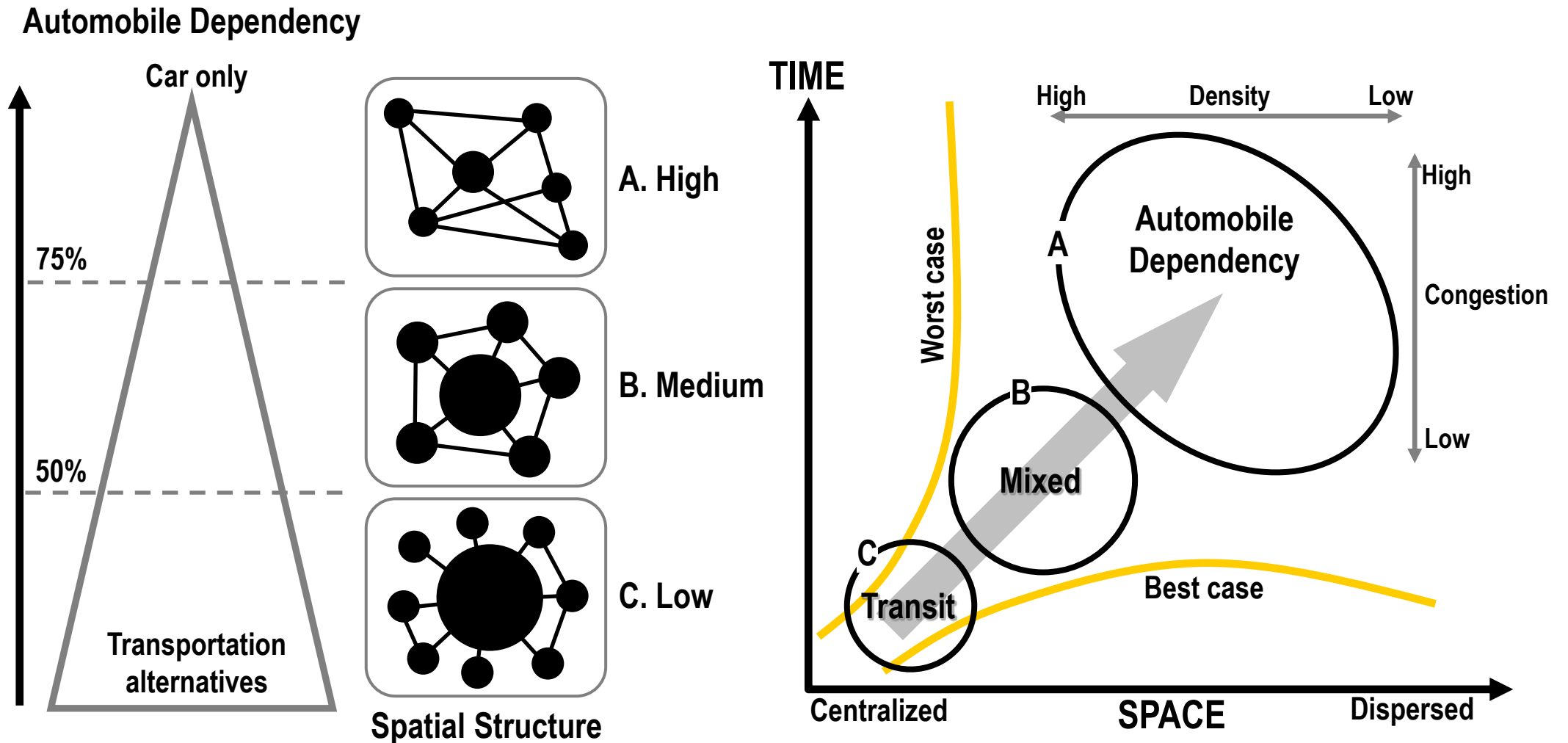
Geographical Paradoxes behind Urban Transport Problems



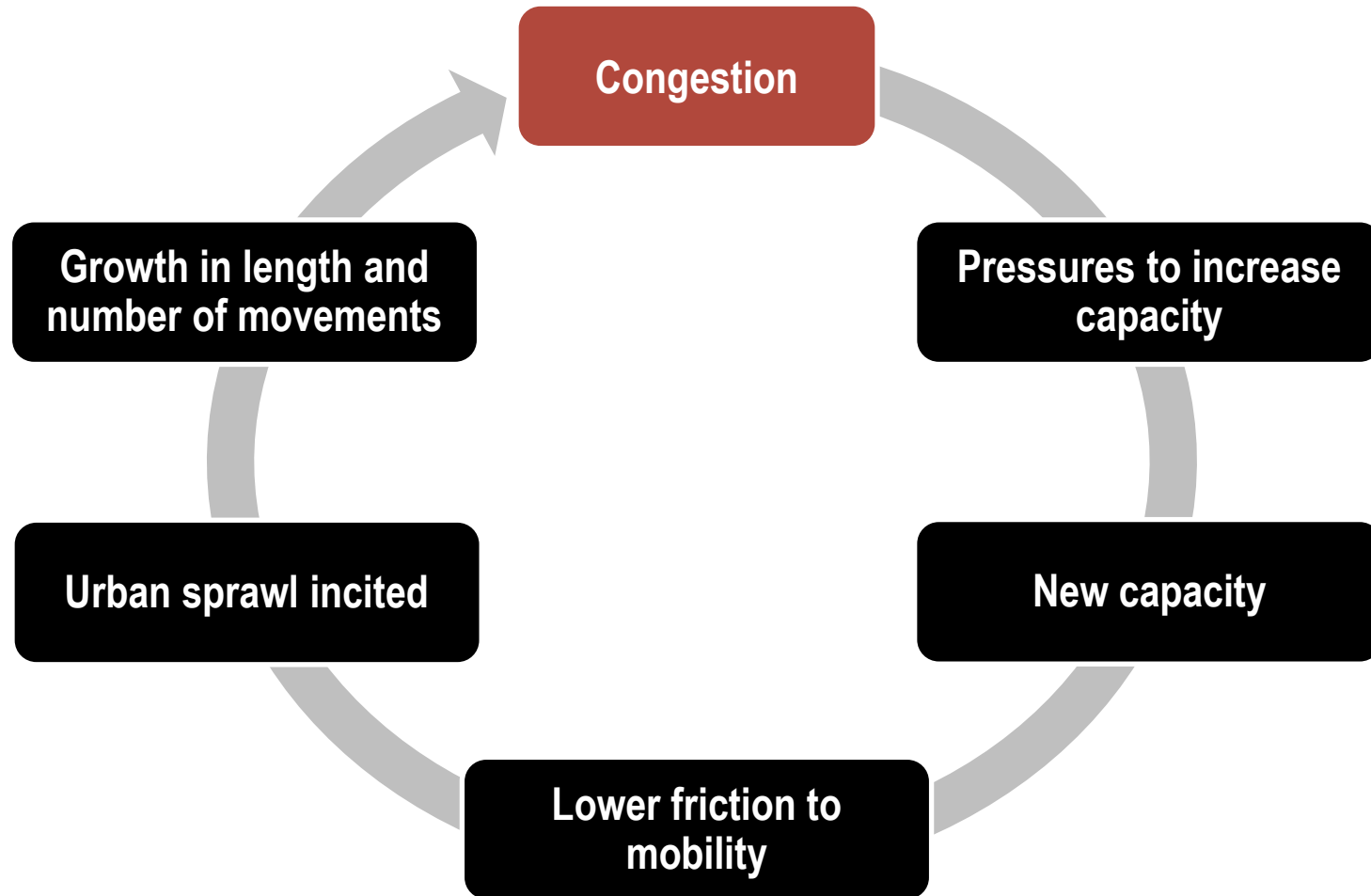
Factors Contributing to the Growth of Driving in the United States



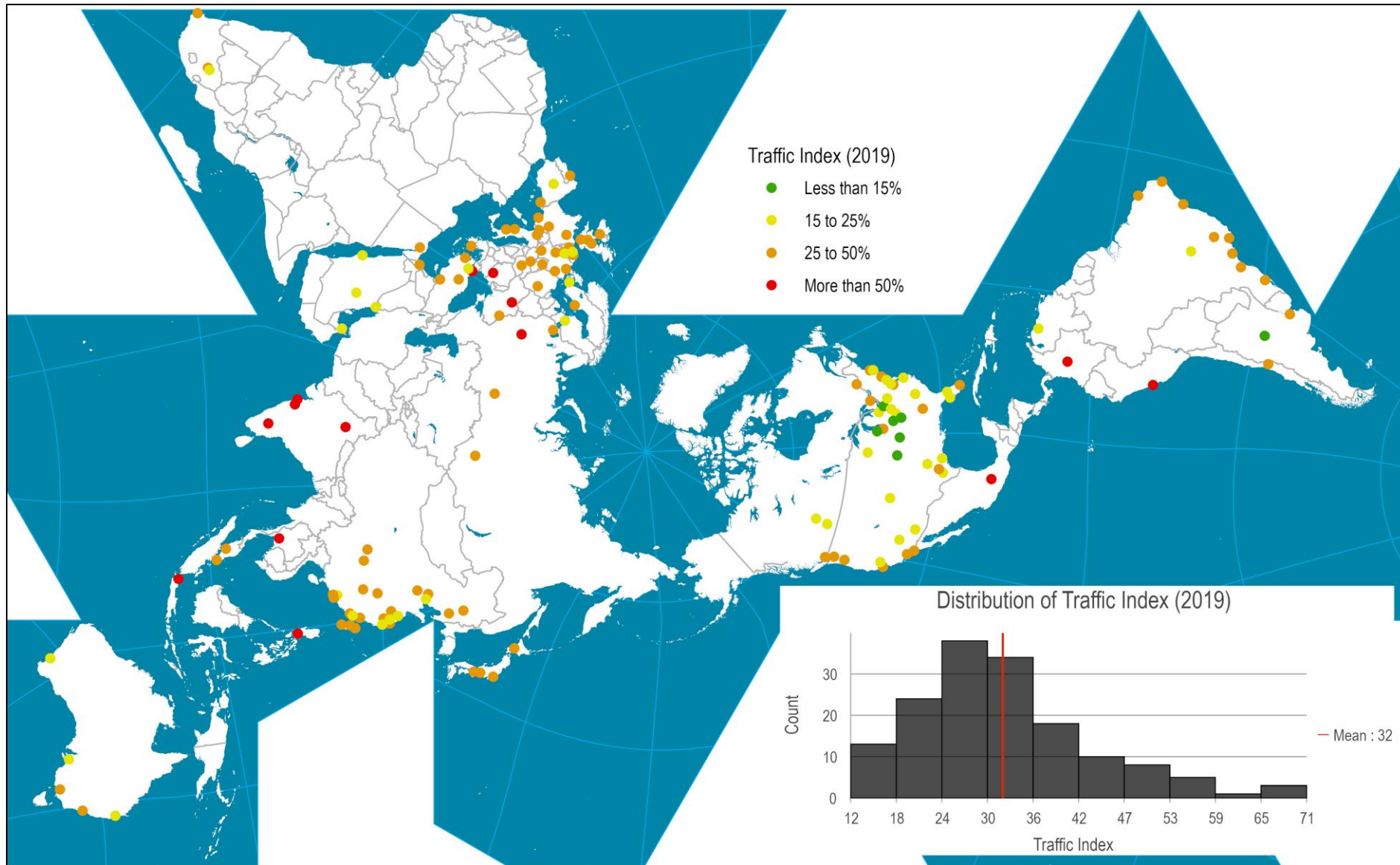
Automobile Dependency, Space / Time Relationships and Modal Choice



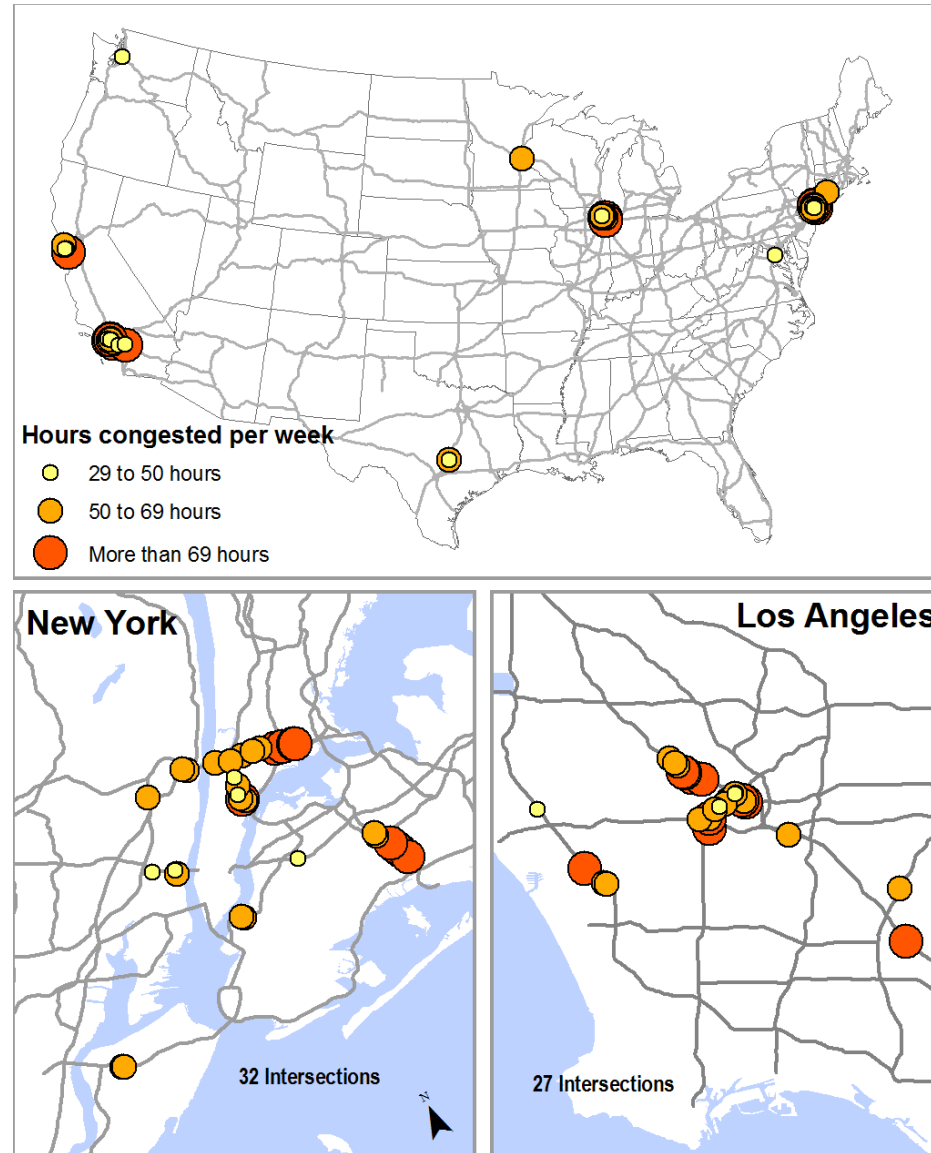
The Vicious Circle of Congestion



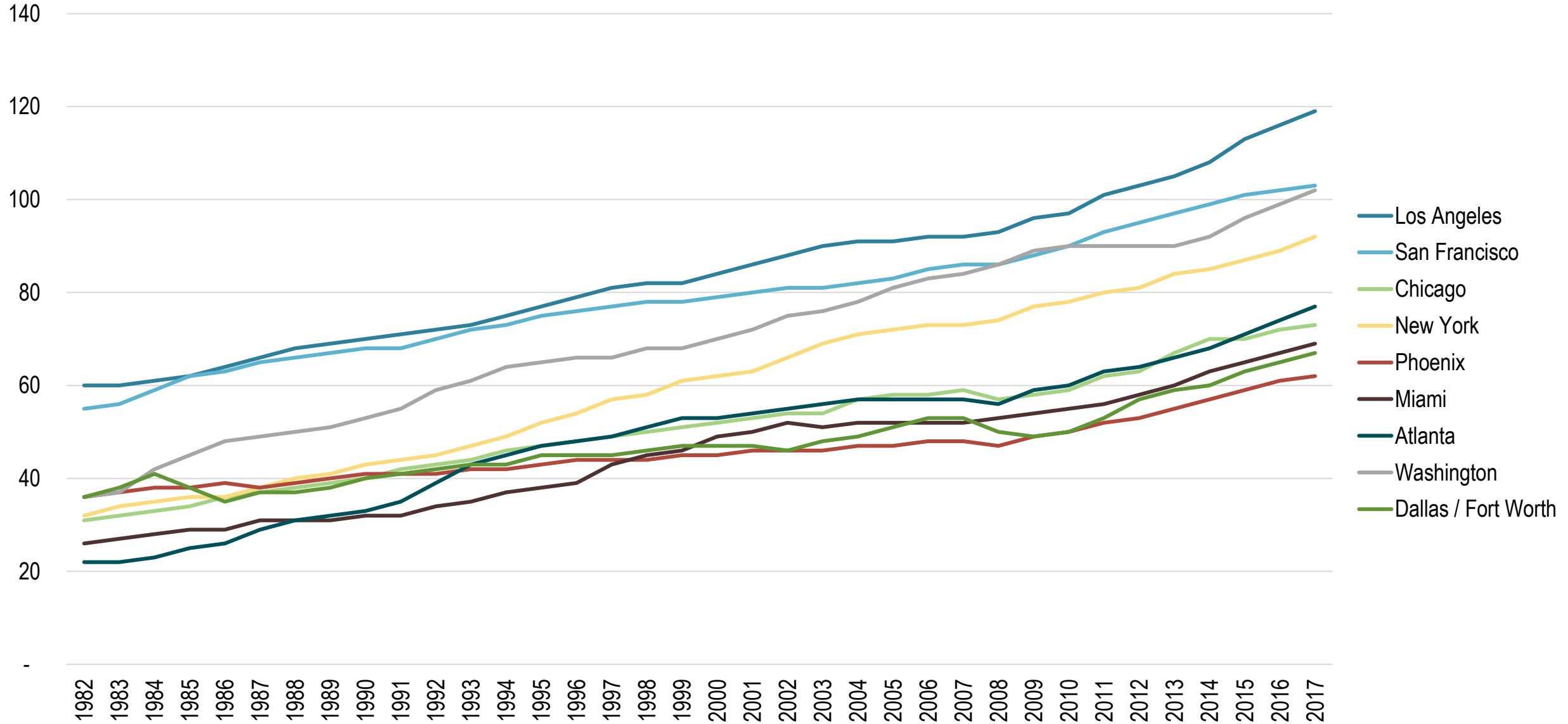
Traffic Index, Selected Metropolitan Areas



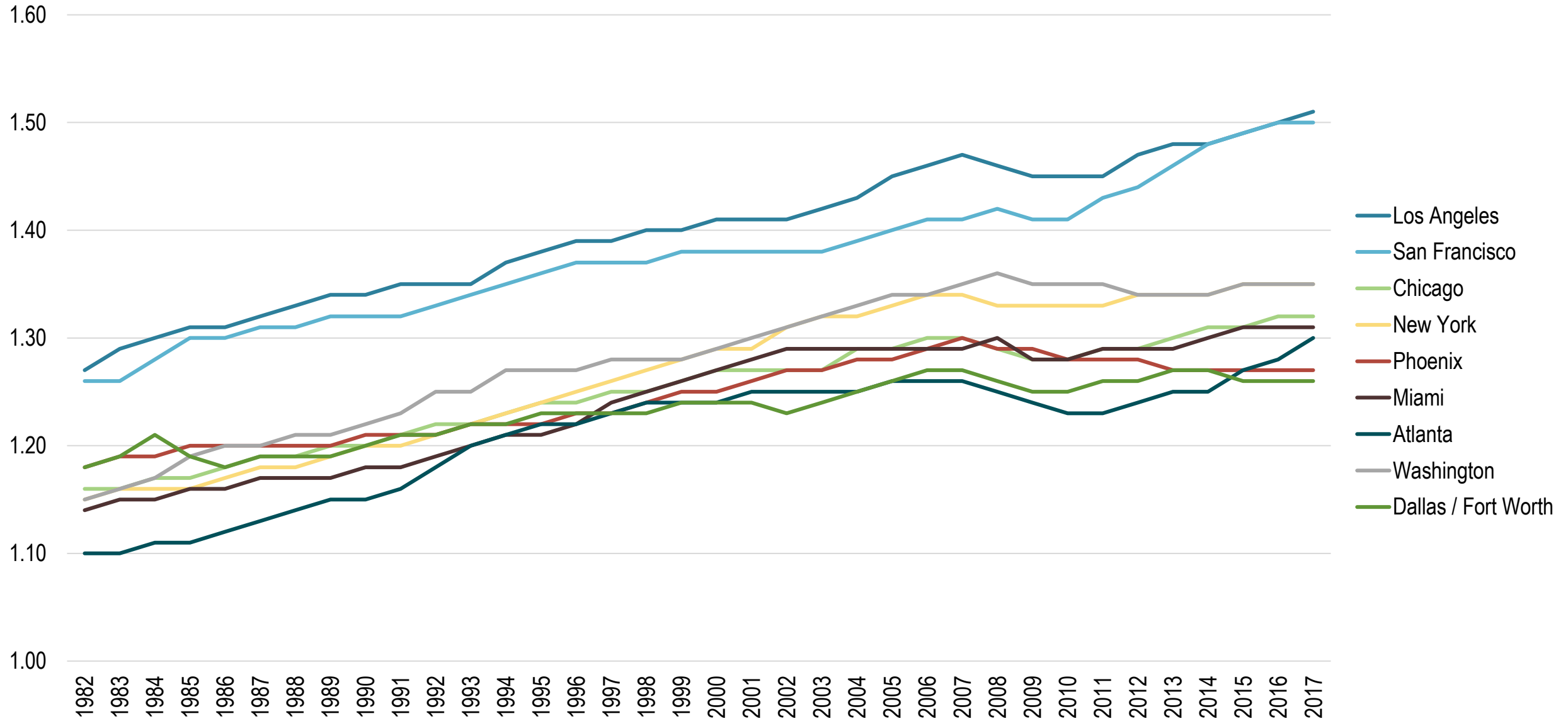
100 Most Congested Highway Intersections in the United States, 2006



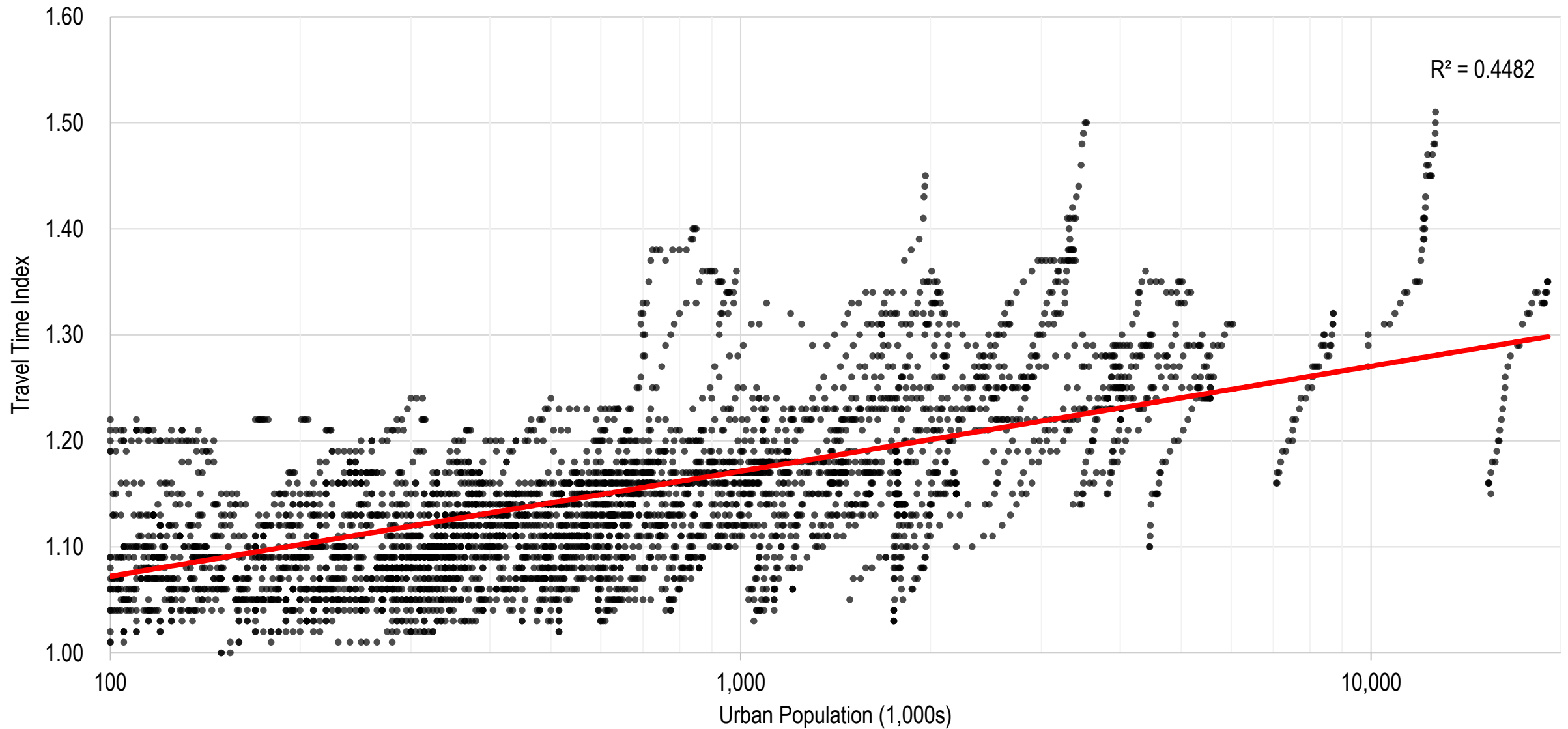
Average Number of Hours of Delay per Auto Commuter per Year, Selected American Cities, 1982-2017



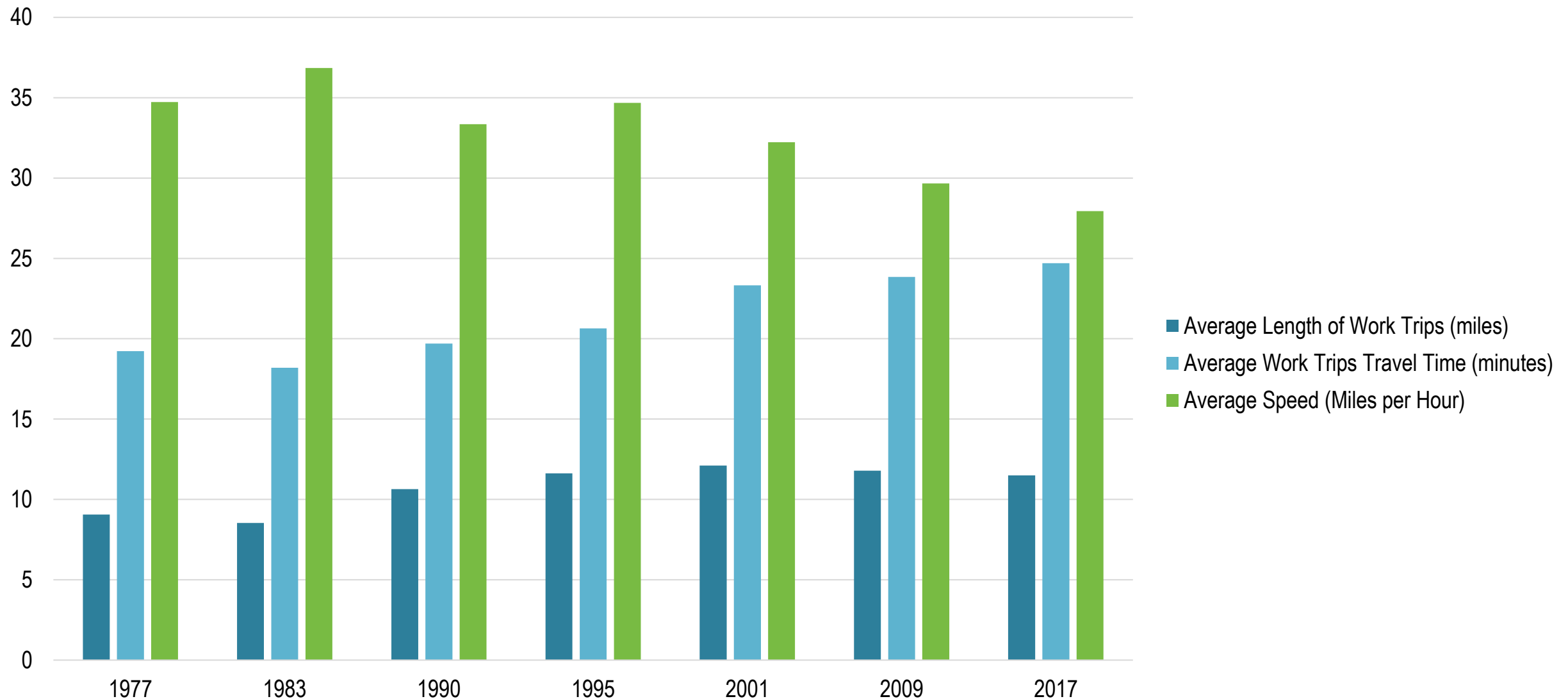
Travel Time Index per Year, Selected American Cities, 1982-2017



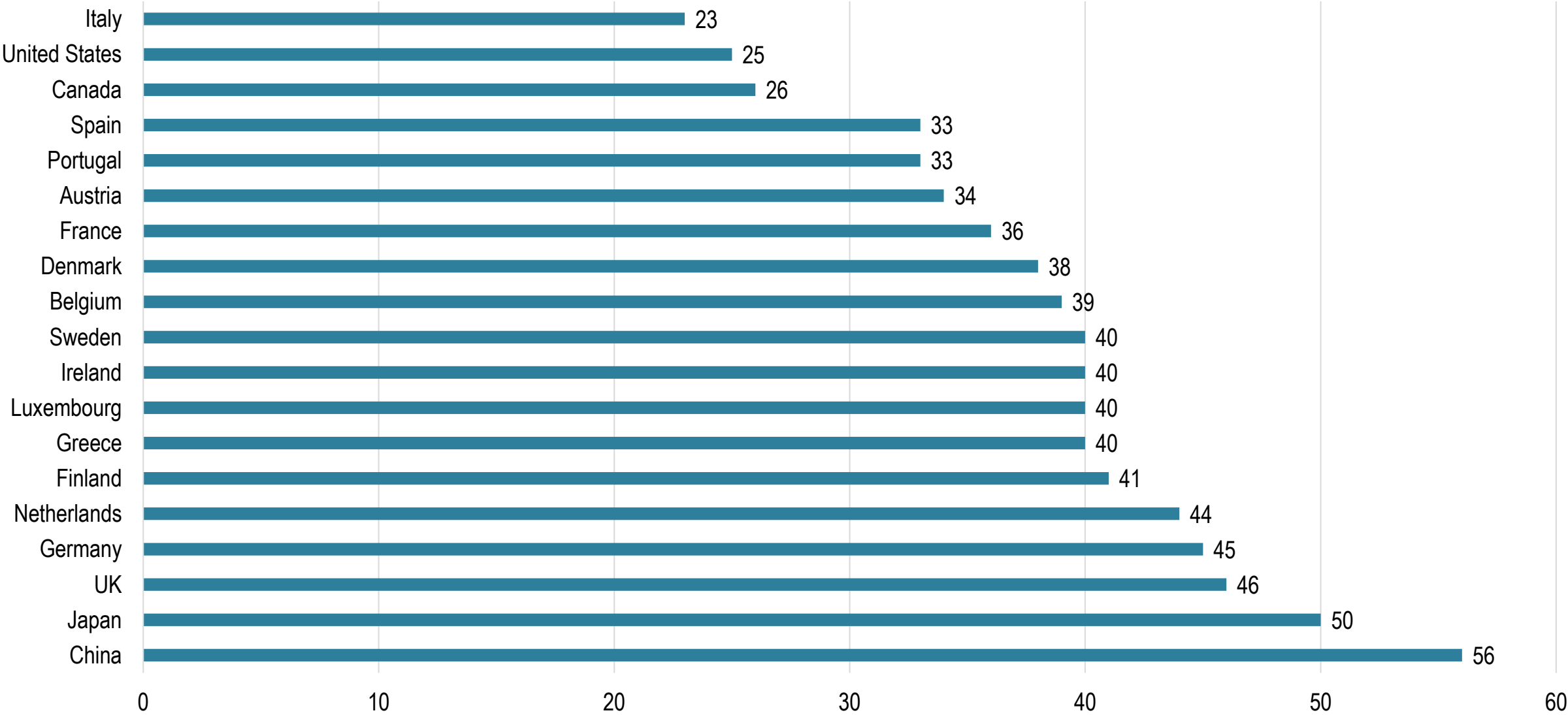
City Size and Travel Time Index, United States, 1982-2017



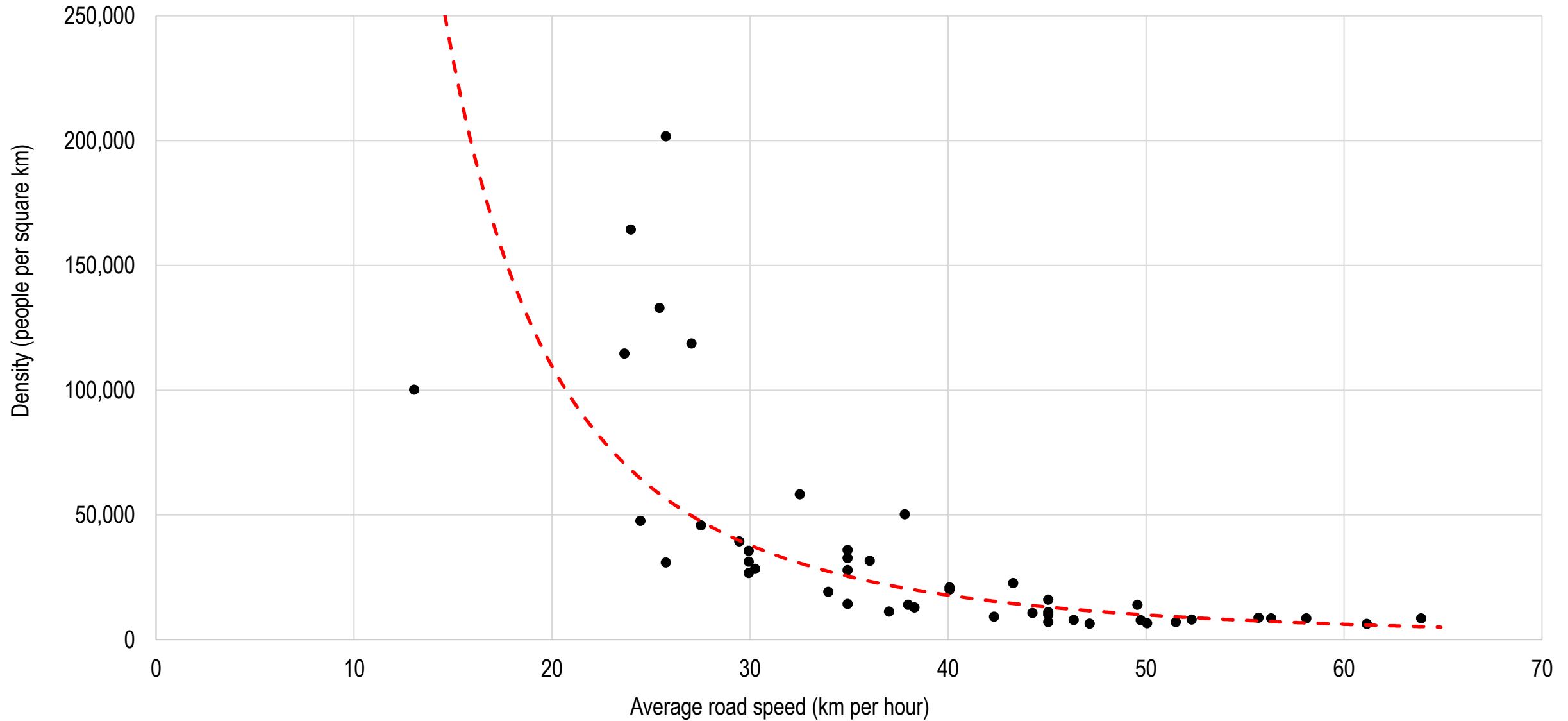
Home-to-Work Commute Profile, United States, 1977-2017



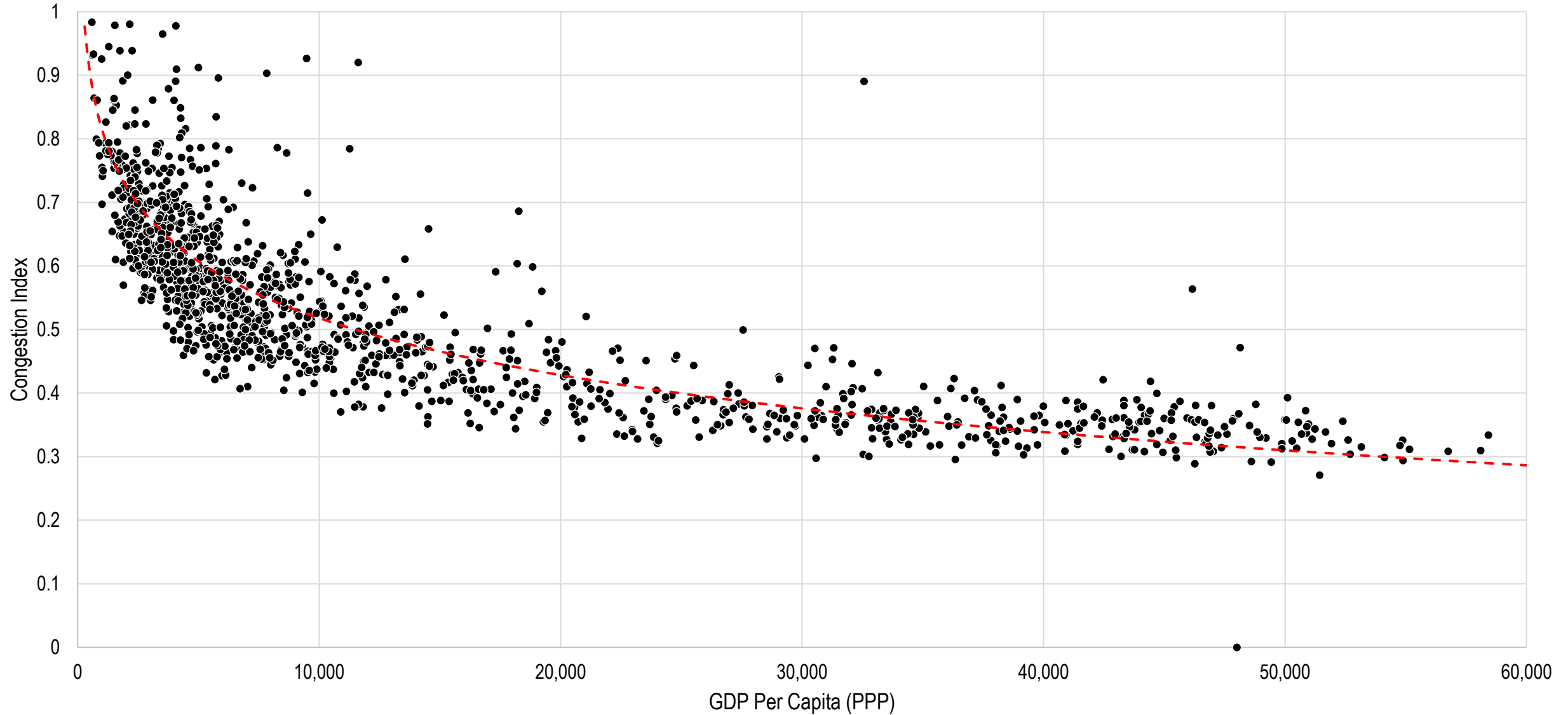
Average Daily Commuting Time, selected Countries, 2015 (in minutes)



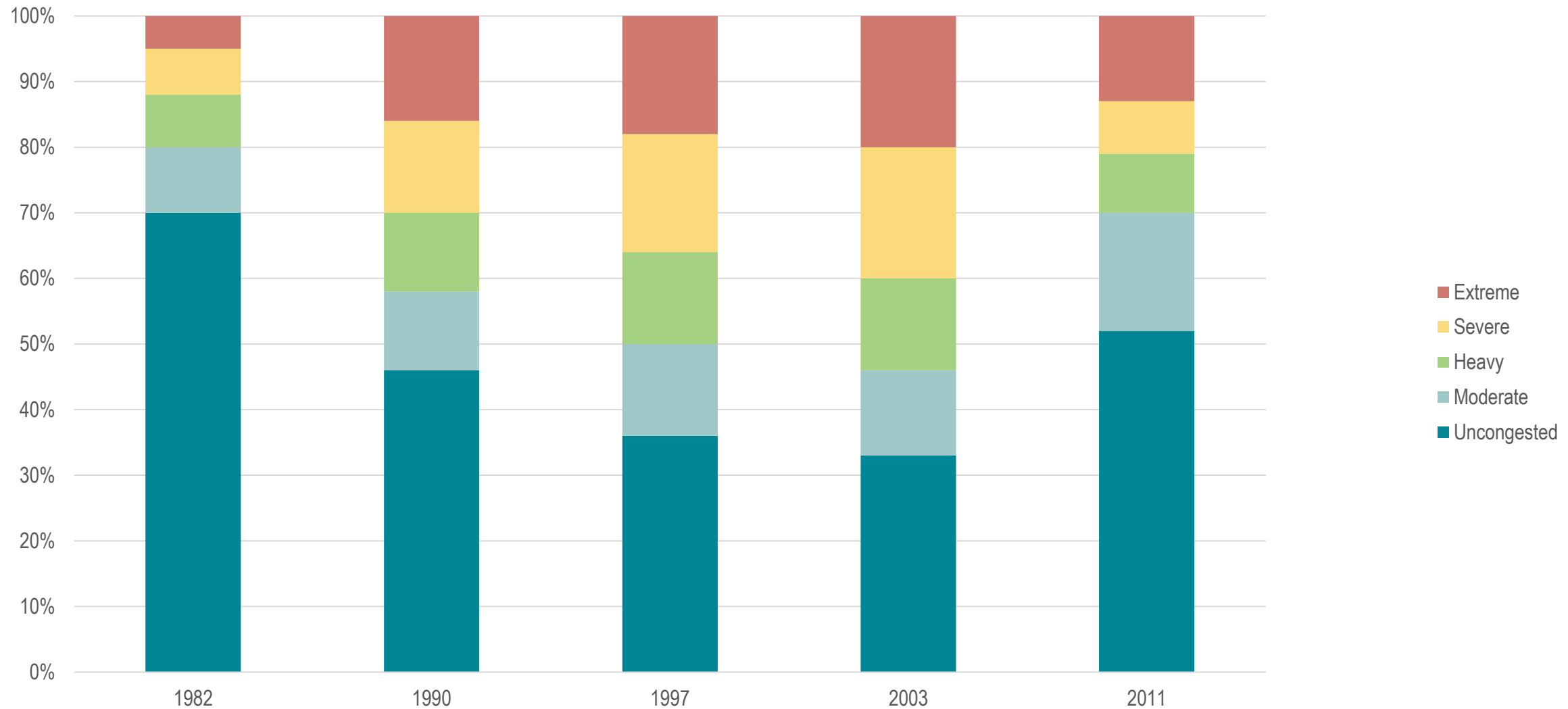
Urban Density and Driving Speed, Selected Global Cities



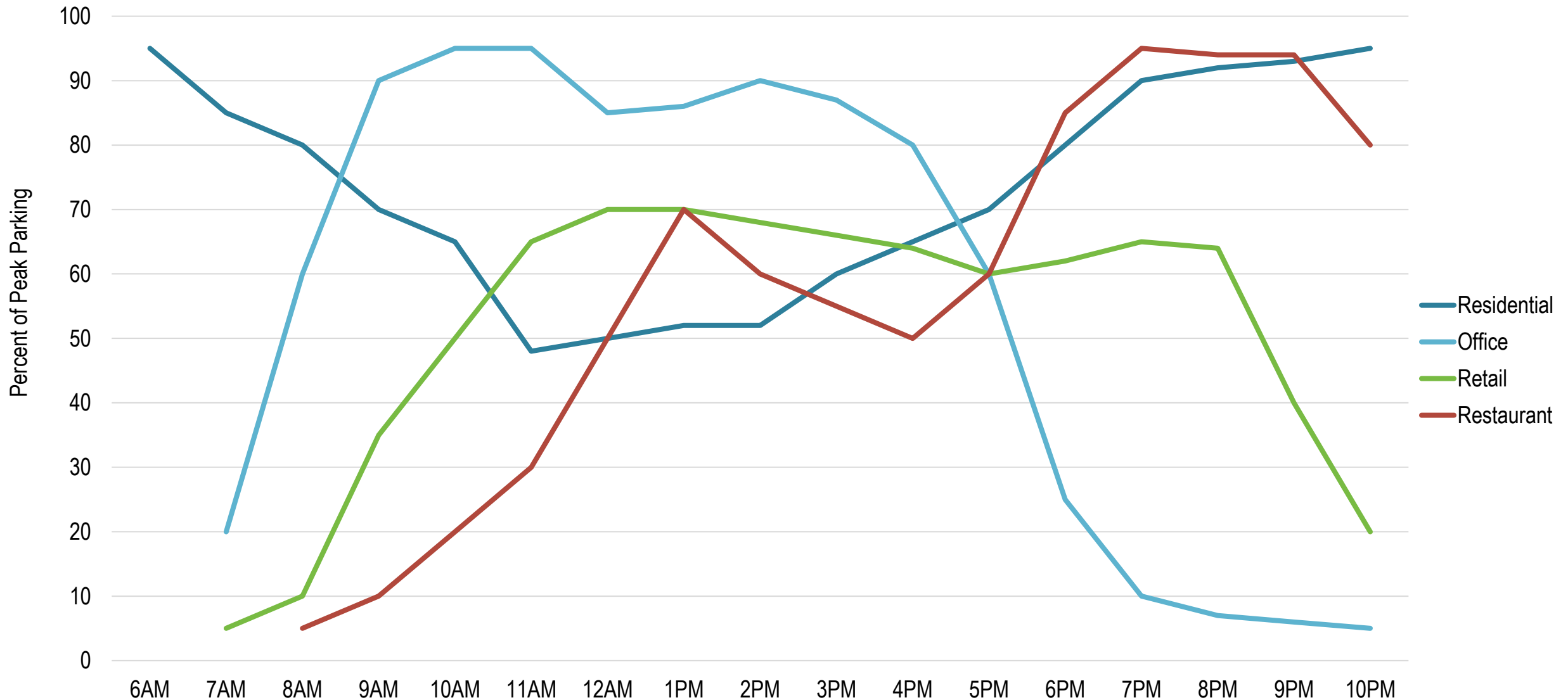
GDP Per Capita and Congestion Index, Selected Cities



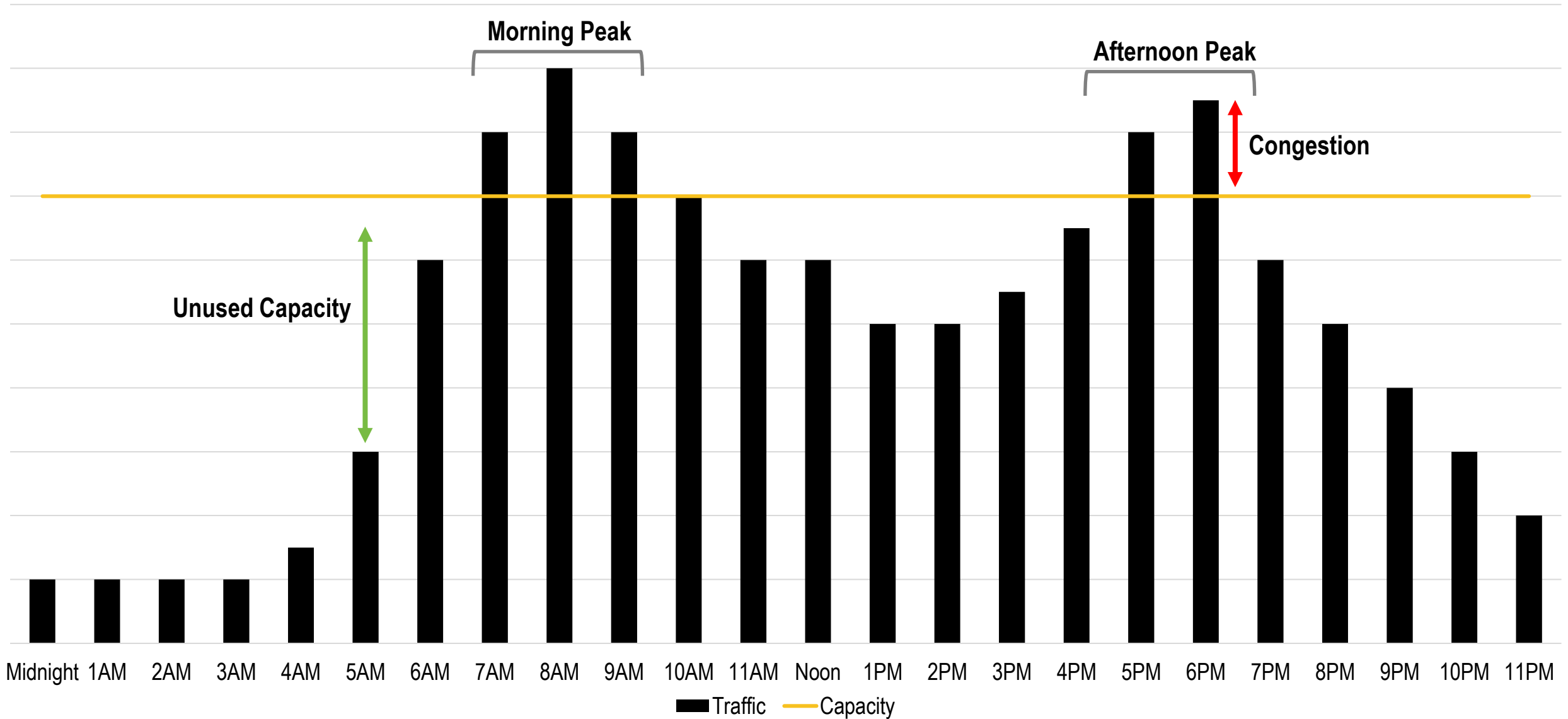
Traffic Conditions in Major American Cities, 1982-2003 (2011 data inconsistent)



Parking Accumulation by Land Use by Time of the Day

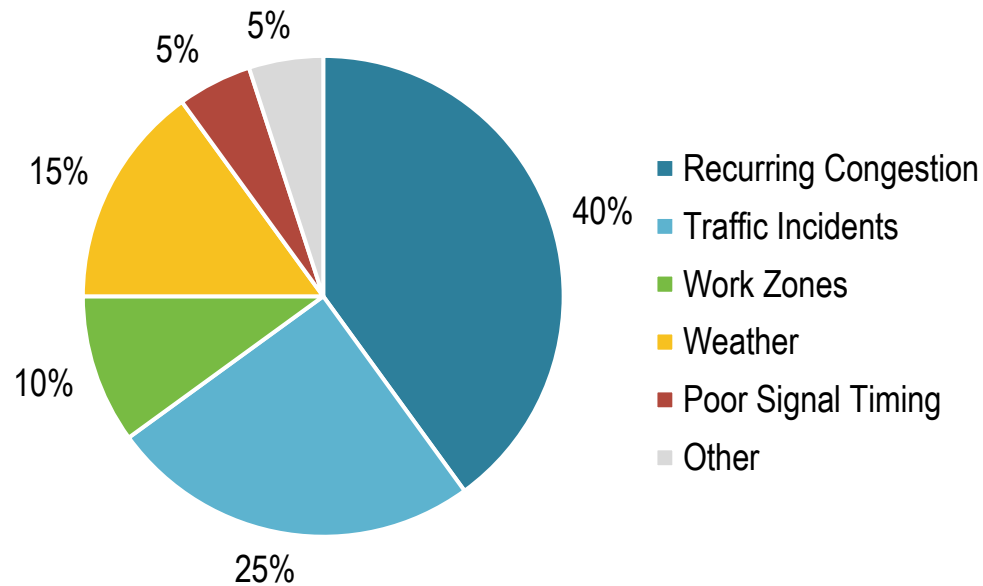


Recurring Congestion

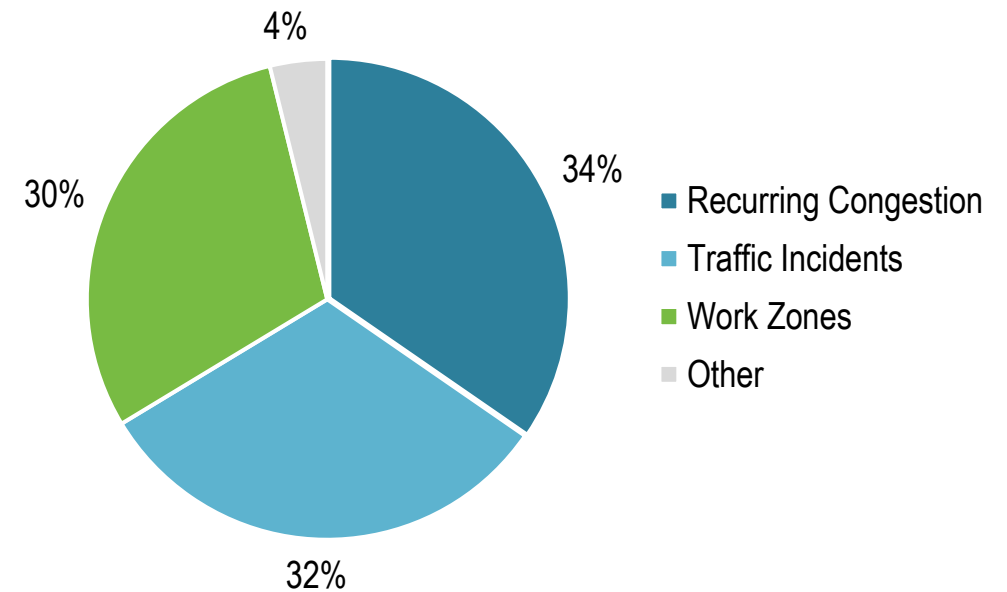


Major Sources of Recurring and Non-Recurring Congestion

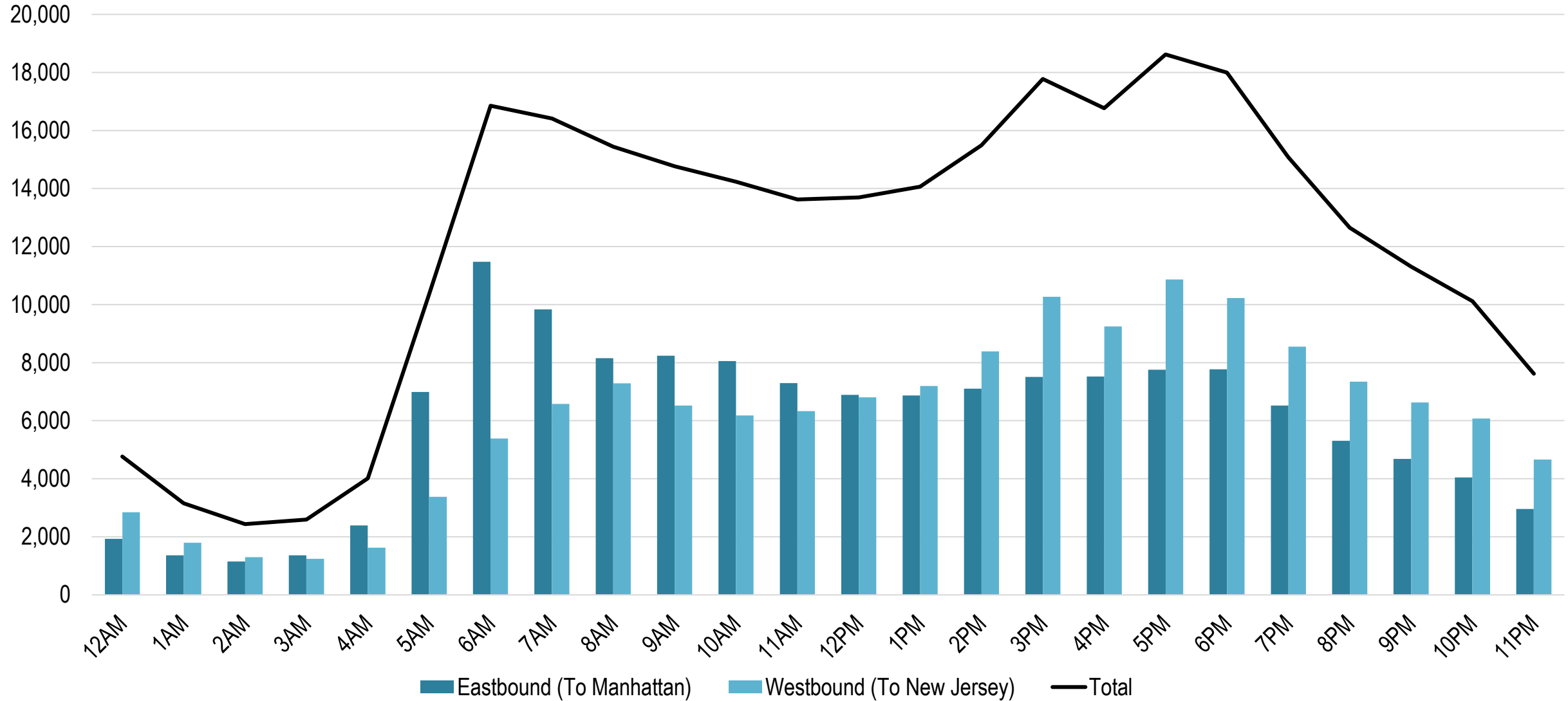
Congestion in the United States (hours by Cause)



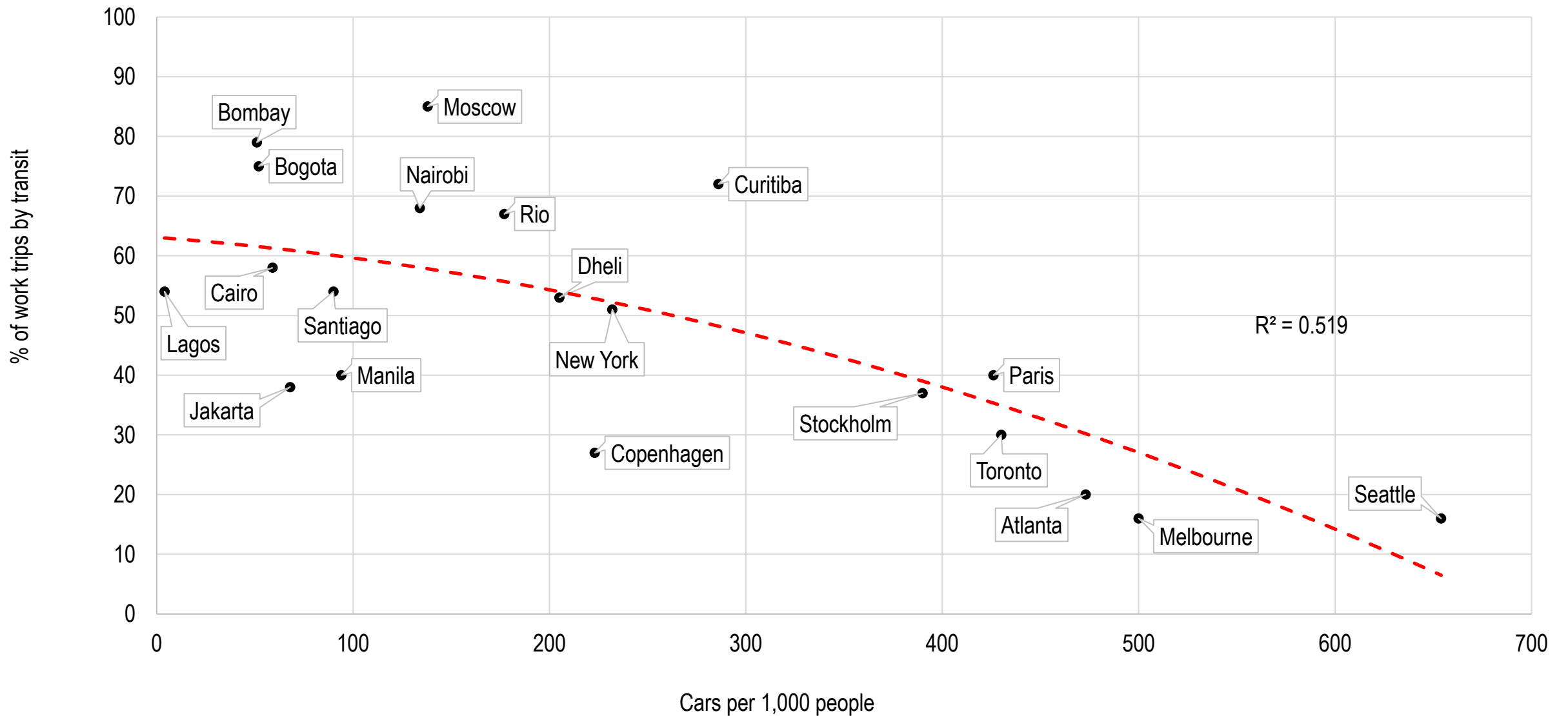
Congestion in Germany (hours by Cause)



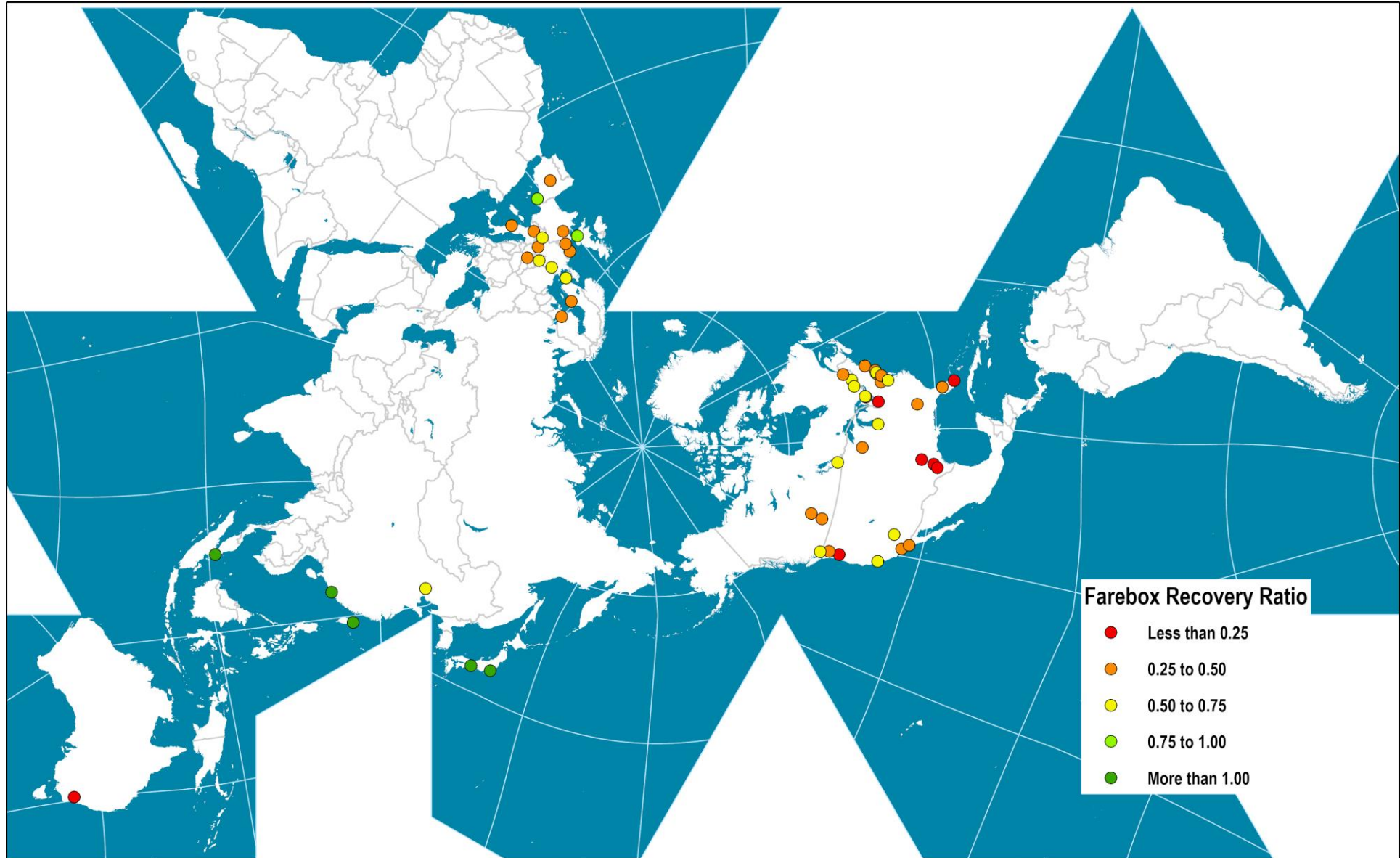
Average Hourly Traffic on George Washington Bridge, 2016



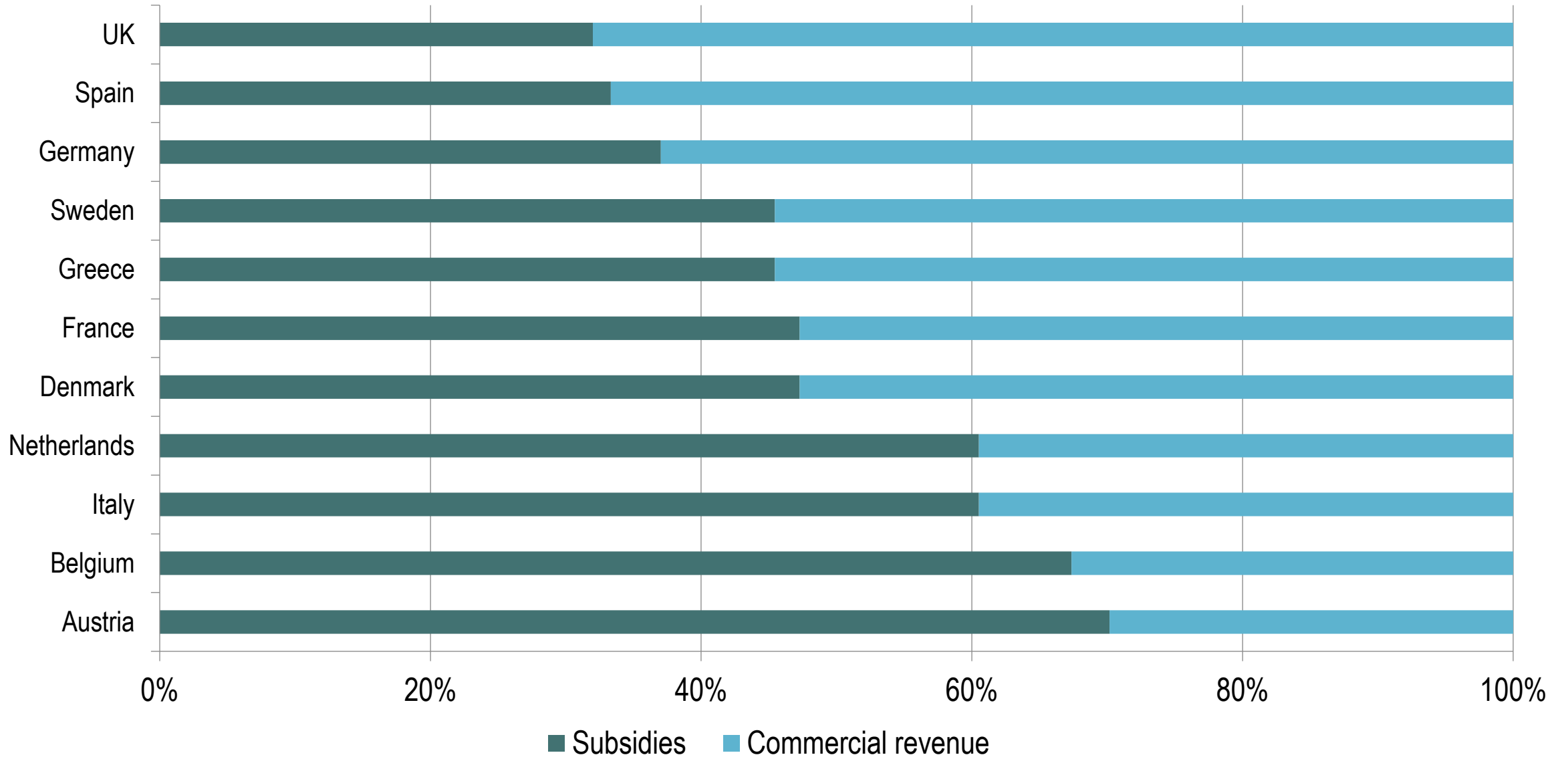
Transit Use and Car Ownership in Selected Cities, 1993



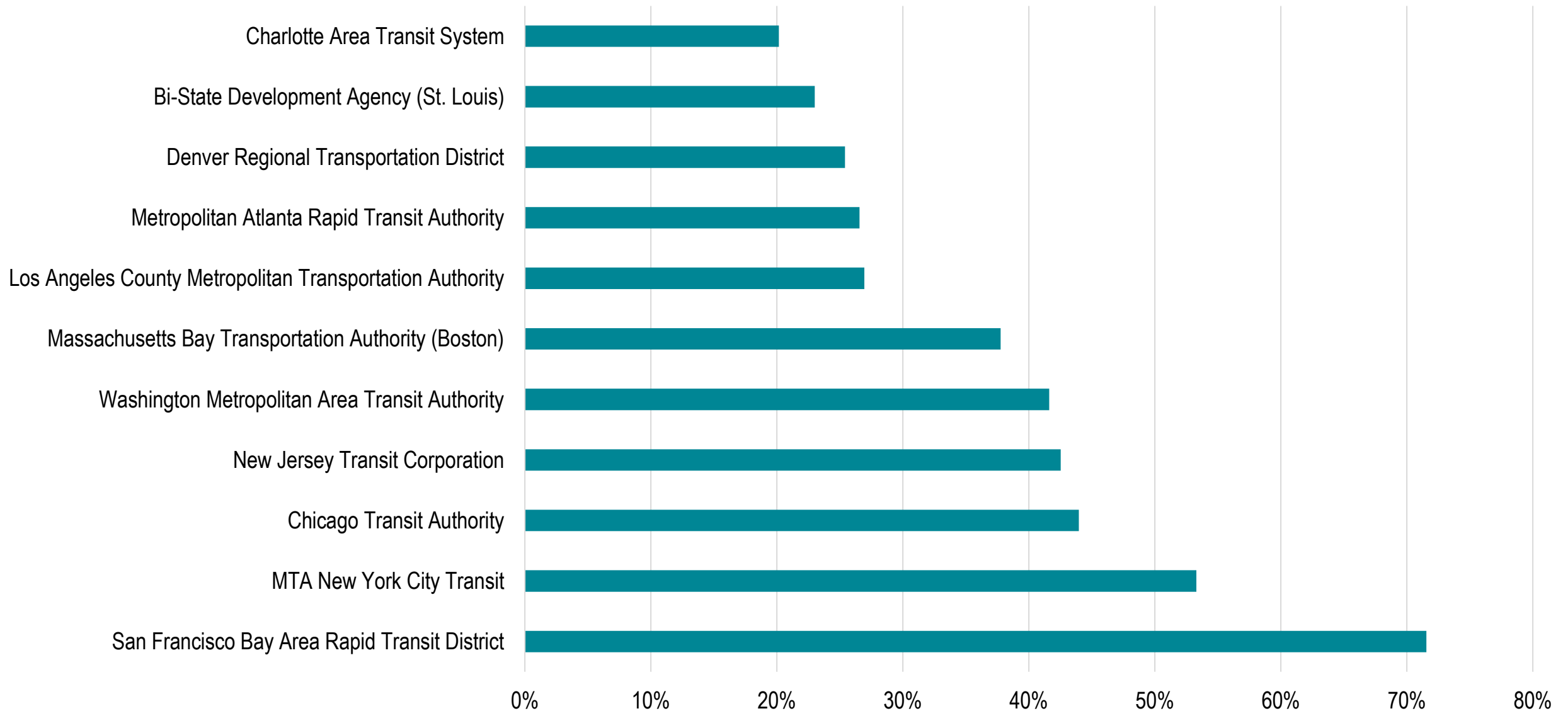
Farebox Recovery Ratio, Selected Transit Systems



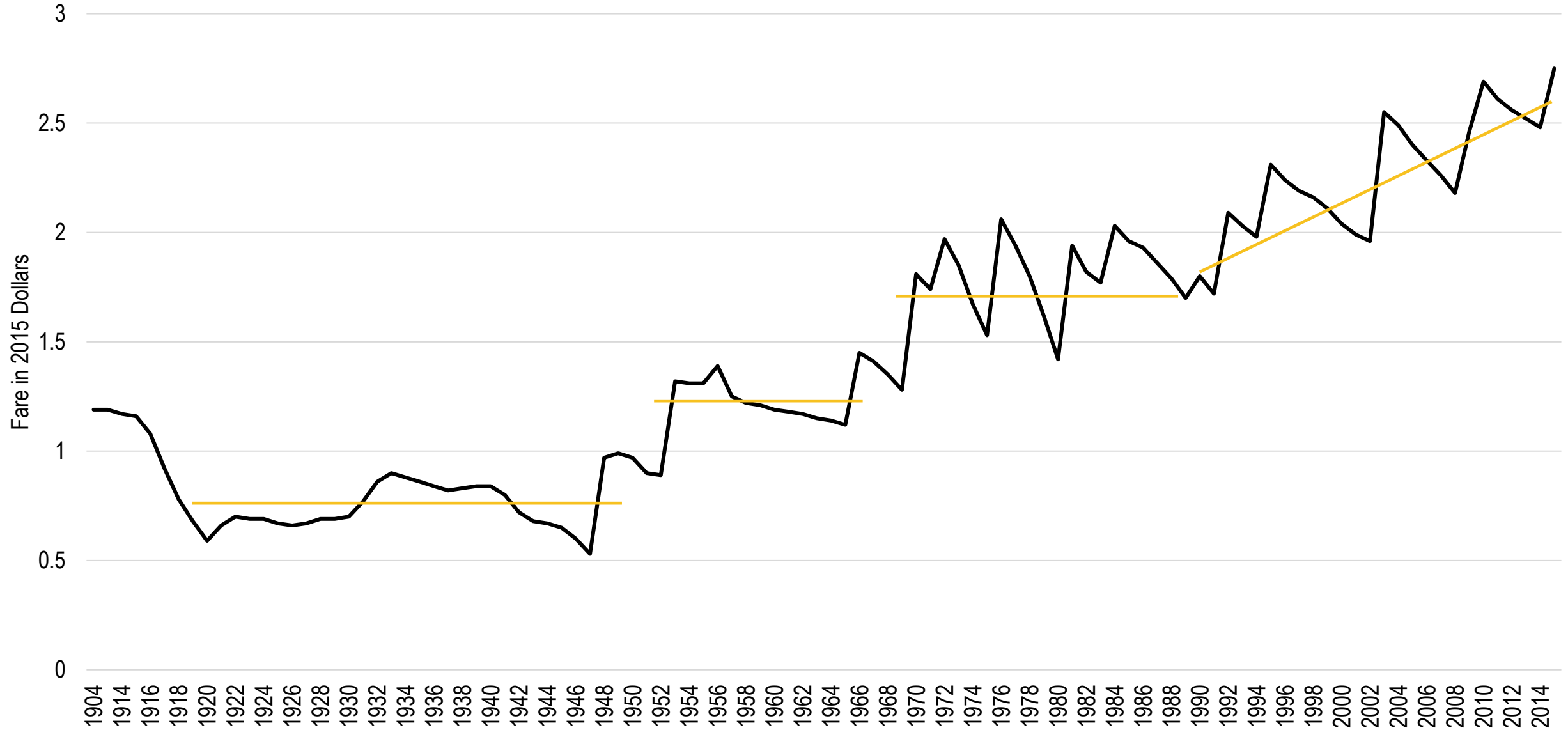
Source of Revenue for Bus Operations, Europe, 2002



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

