Perspectives on Urban Last-Mile Logistics

MIT CTL Executive Education

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Matthias Winkenbach, Ph.D.
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MIT Center for Transportation & Logistics

- M.Sc. in Business with specializations in Finance and Economics, WHU – Otto Beisheim School of Management, Germany
- Studies at NYU Stern School of Business, New York City, and the École des Hautes Études Commerciales (HEC) Montréal, Canada
- Ph.D. in Logistics and Supply Chain Management from WHU
- Visiting Ph.D. Candidate and Visiting Scholar at MIT CTL before joining as a Research Associate in 2015

- Winner, Science Award for Supply Chain Management in 2014 by the German Logistics Association (BVL)
- Finalist, 2015 Daniel H. Wagner Prize for Excellence in Operations Research Practice
- Recent publications in Transportation Science, Interfaces, the Wall Street Journal, and the MIT Sloan Management Review

- Professional experience with Volkswagen in South Africa, Deutsche Telekom in Germany, McKinsey & Company in the United States and in Germany, as well as various other projects in the mining, shipbuilding, consulting and logistics industries

A close collaboration with industry & public partners ensures our real-world impact

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Active First-Tier Project Partners

...and others

Extended Network

Public Sector

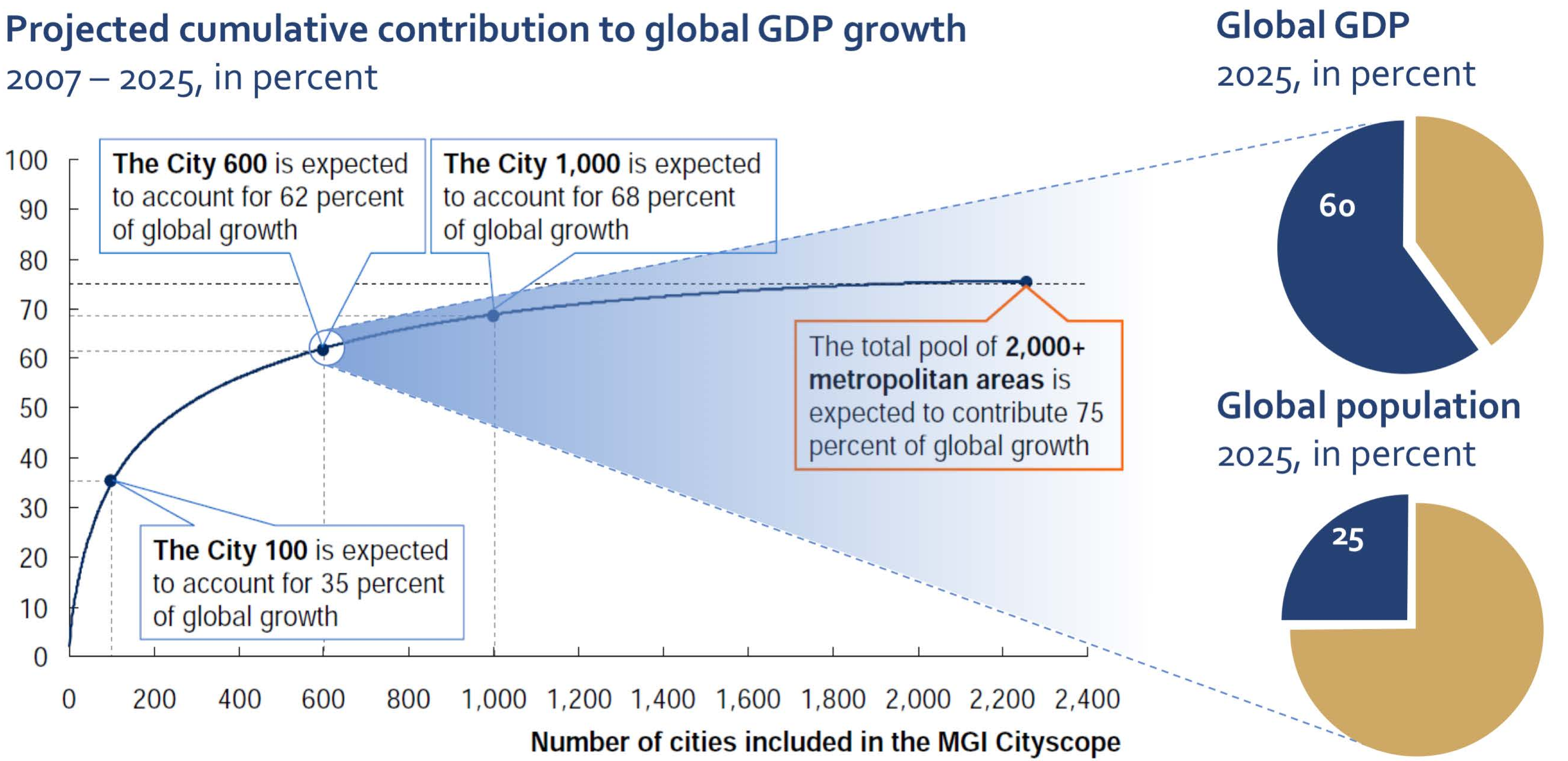
Private Sector (For-Profit)

Non-Profit Organizations

As urbanization continues…

THE RISE OF MEGACITIES

Urban last-mile distribution affects the hotspots of future economic growth



Source: McKinsey Global Institute (Dobbs et al. 2011)

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At the same time, it is the most costly, and difficult to optimize part of a supply chain

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120

delivery stops on an average UPS route

6,689,502,913,449,135,000,000,000,000,000,000,000,000,
000,000,000,000,000,000,000,000,000,000,000,000,000,000,
000,000,000,000,000,000,000,000,000,000,000,000,000,000,
000,000,000,000,000,000,000,000,000,000,000,000,000,000,
000,000,000,000,000,000,000,000,000,000,000

possible combinations to sequence these stops

55,000

delivery routes in the US per day

1 mile

of reduction in average route distance results in

$50,000,000

of annual cost savings in the US

Sources: Wall Street Journal (2015), BusinessInsider

The MIT Megacity Logistics Lab focuses on three major research building blocks

Distribution Network Design

- Multi-tier distribution
- Multi-modal distribution
- Multi-/omni-channel distribution

Urban Freight Policy & Practices

- Freight policy and regulation
- Infrastructure investments
- Best practices for urban freight

Data Analytics & Technology

- Low-cost sensor technologies
- Big Data analytics
- Augmented Reality
- Robotics and automation

Beyond size...

CITIES LOOK DIFFERENTLY

Rivers & waterways

Barrier to mobility?

Part of the transportation infrastructure?

Source: MIT Megacity Logistics Lab, Edgar E. Blanco

Bangkok – Thailand

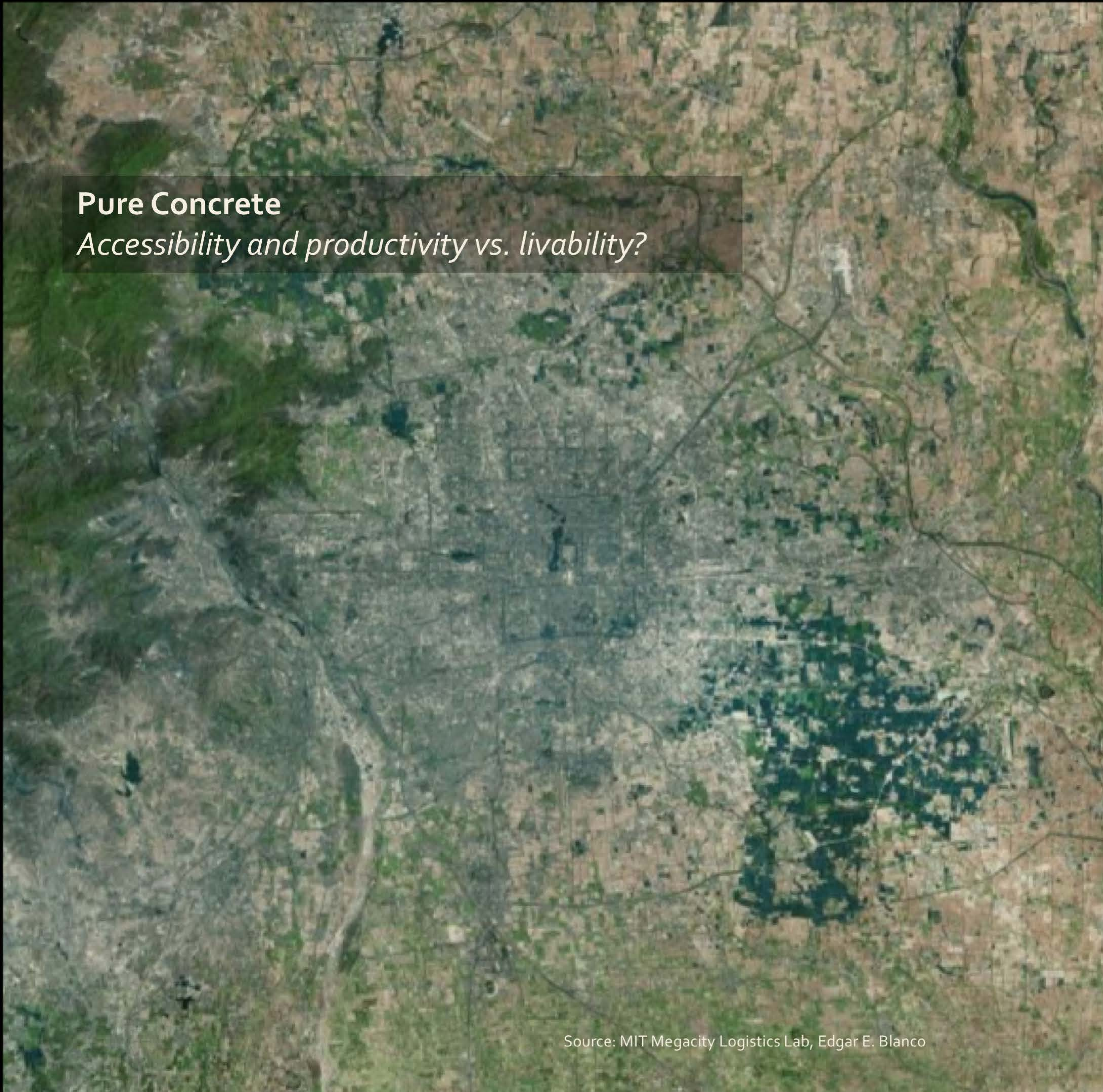
Population : 14.91 million

Land Area : 2444 sq.kms.

Pop. Density : 6100 per sq.km.

Pure Concrete

Accessibility and productivity vs. livability?



Source: MIT Megacity Logistics Lab, Edgar E. Blanco

Beijing – China

Population	: 19.28 million
Land Area	: 3779 sq.kms.
Pop. Density	: 5100 per sq.km.

Geography & Density

Barriers and bottlenecks

Source: MIT Megacity Logistics Lab, Edgar E. Blanco

Manila – Philippines

Population : 22.71 million
Land Area : 1577 sq.kms.
Pop. Density : 14400 per sq.km

Size & Sprawl

Growth vs. planning

Source: MIT Megacity Logistics Lab, Edgar E. Blanco

Sao Paulo – Brasil

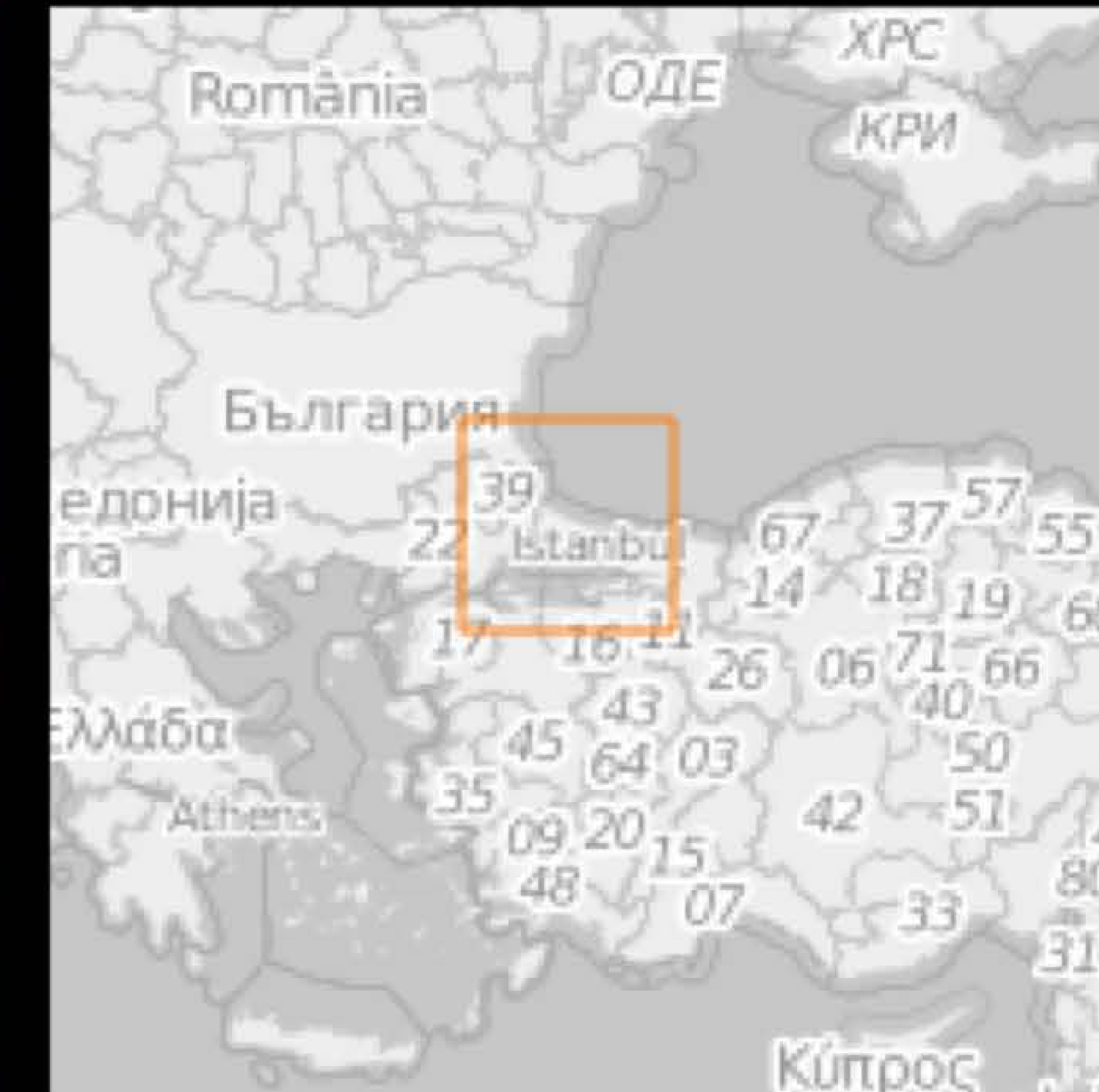
Population : 20.27 million
Land Area : 2855 sq.kms.
Pop. Density : 7100 per sq.km.

Mexico City – Mexico

Population : 20.3 million
Land Area : 2071 sq.kms.
Pop. Density : 9800 per sq.km.

Ocean
Division vs. trade

Source: MIT Megacity Logistics Lab, Edgar E. Blanco



Istanbul – Turkey

Population : 13.19 million
Land Area : 1345 sq.kms.
Pop. Density : 9800 per sq.km.

Geography, Density & Fragmentation

No limits to complexity

Source: MIT Megacity Logistics Lab, Edgar E. Blanco

Mumbai – India

Population	:	17.67 million
Land Area	:	547 sq.kms.
Pop. Density	:	32300 per sq.km

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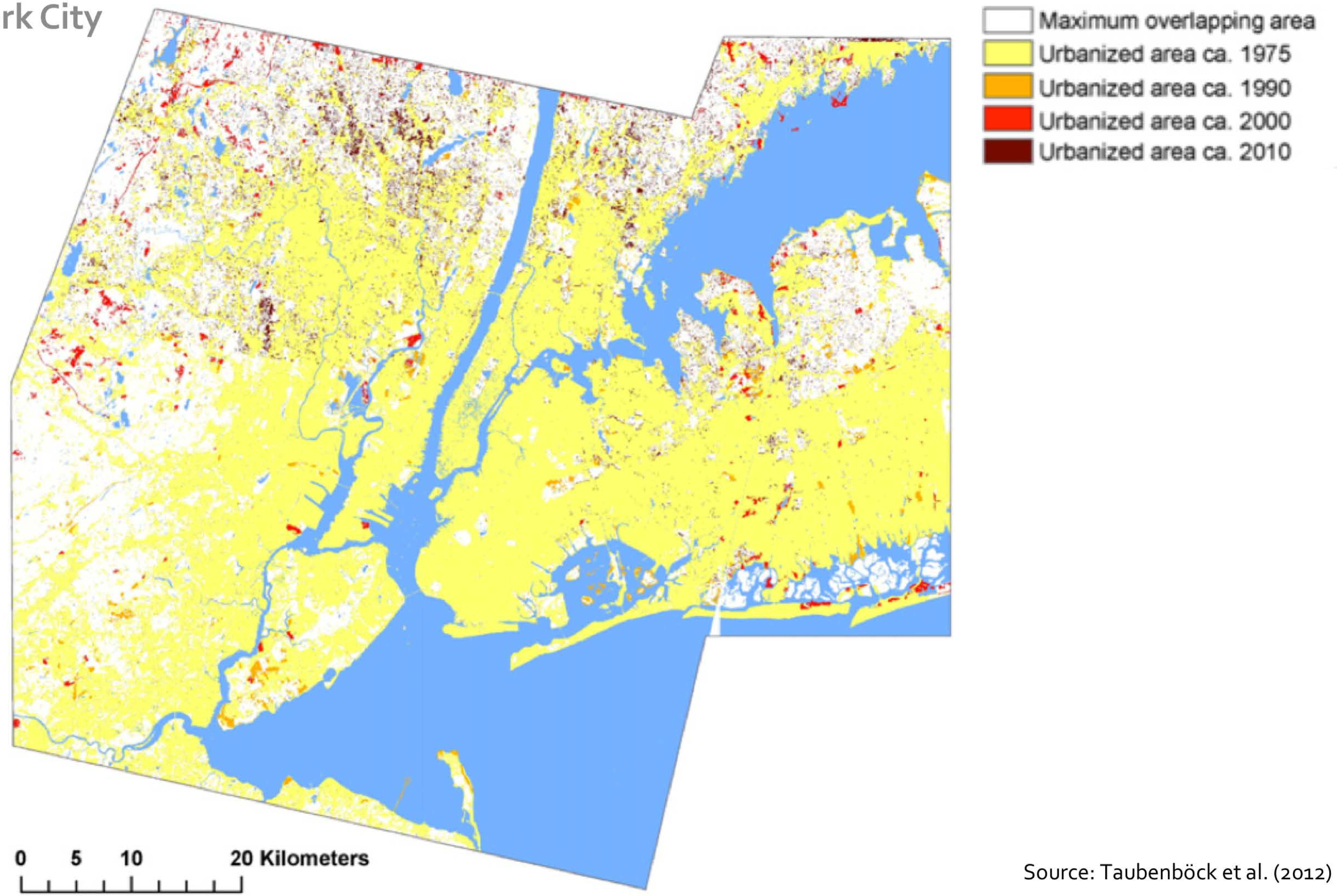
Looking closer…

CITIES HAVE GROWN DIFFERENTLY

Cities have different histories and growth patterns

New York City



Source: Taubenböck et al. (2012)

Cities have different histories and growth patterns

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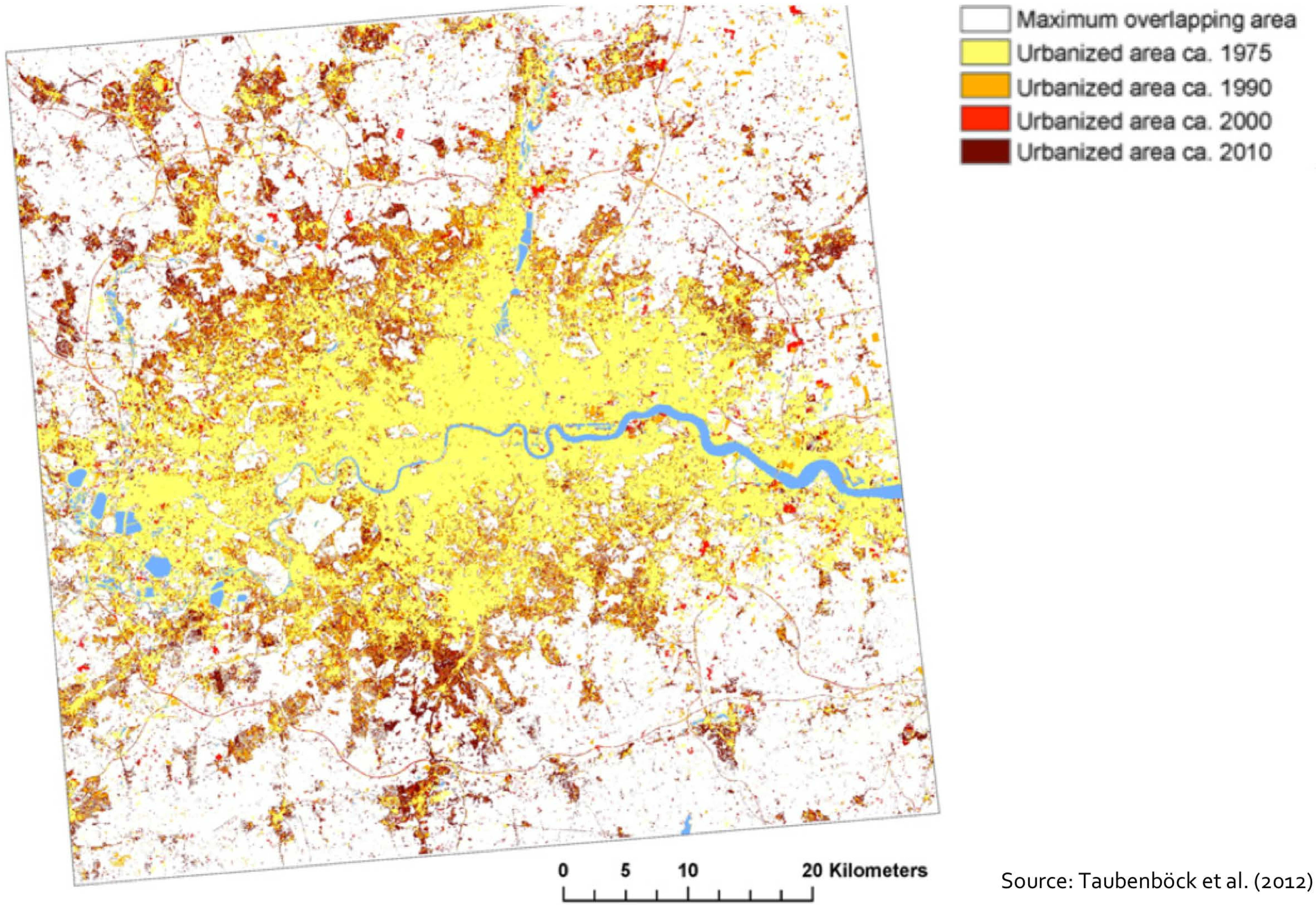
London



Source: Taubenböck et al. (2012)

Cities have different histories and growth patterns

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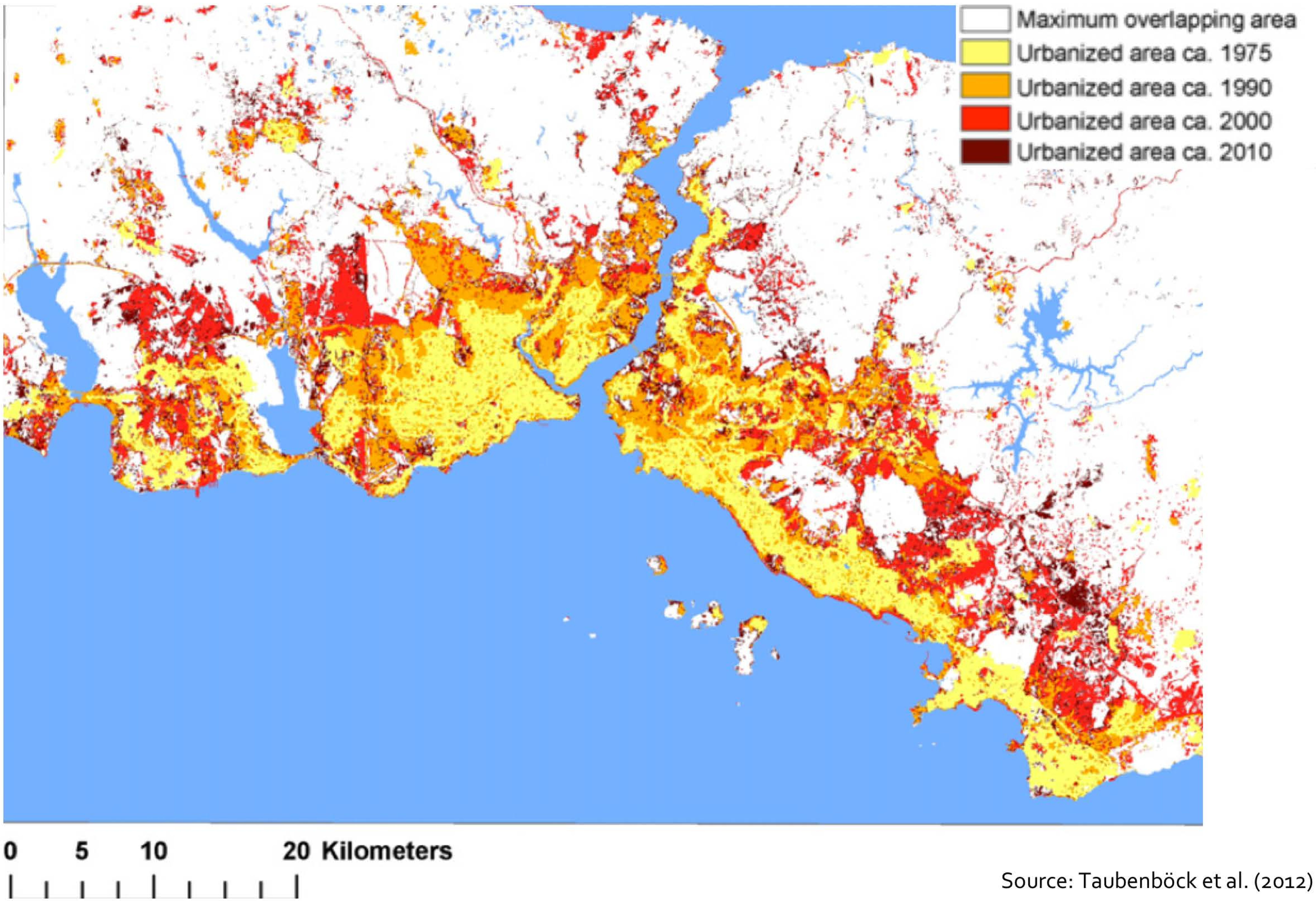
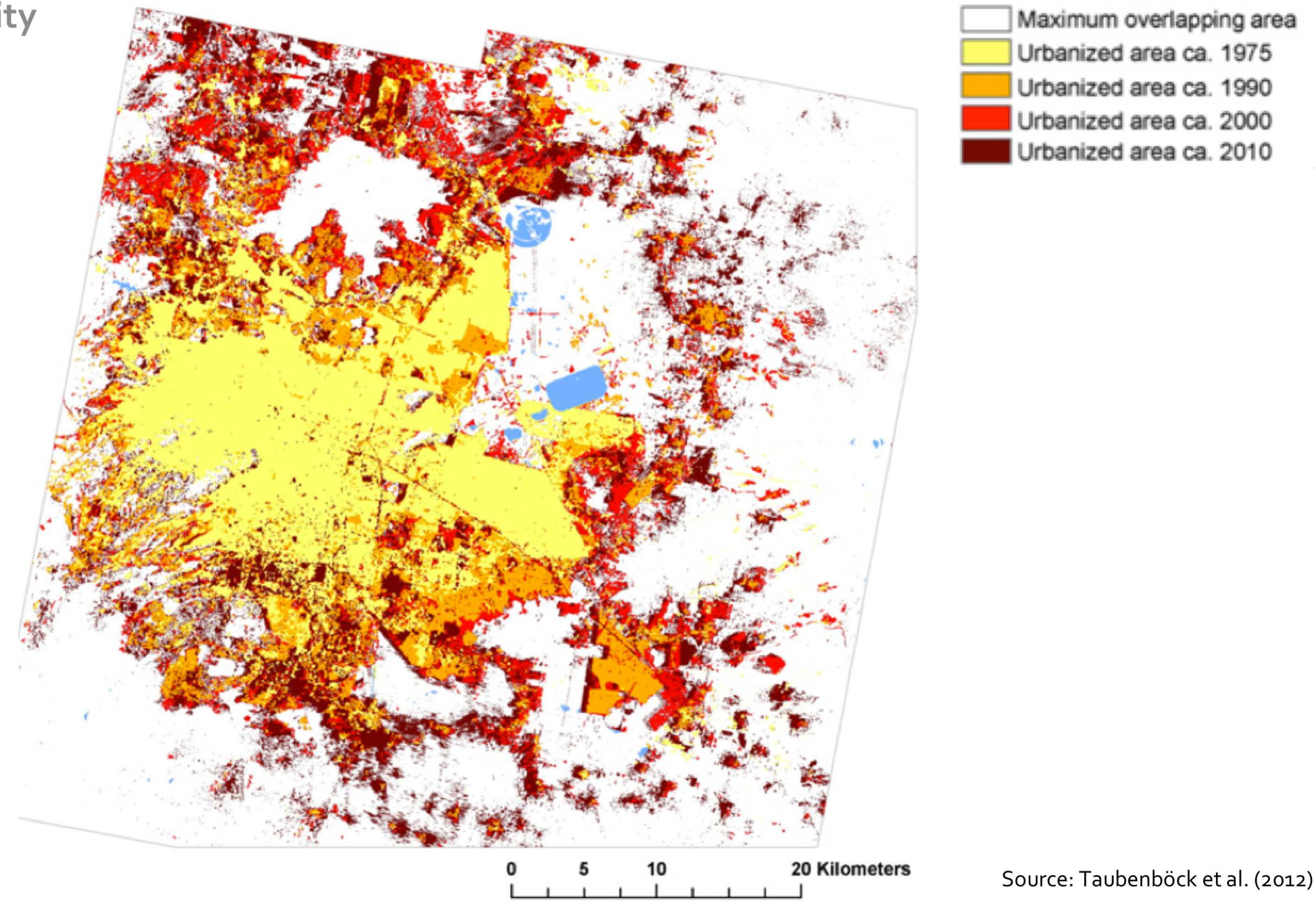
Istanbul



Source: Taubenböck et al. (2012)

Cities have different histories and growth patterns

Mexico City



Source: Taubenböck et al. (2012)

Cities have different histories and growth patterns

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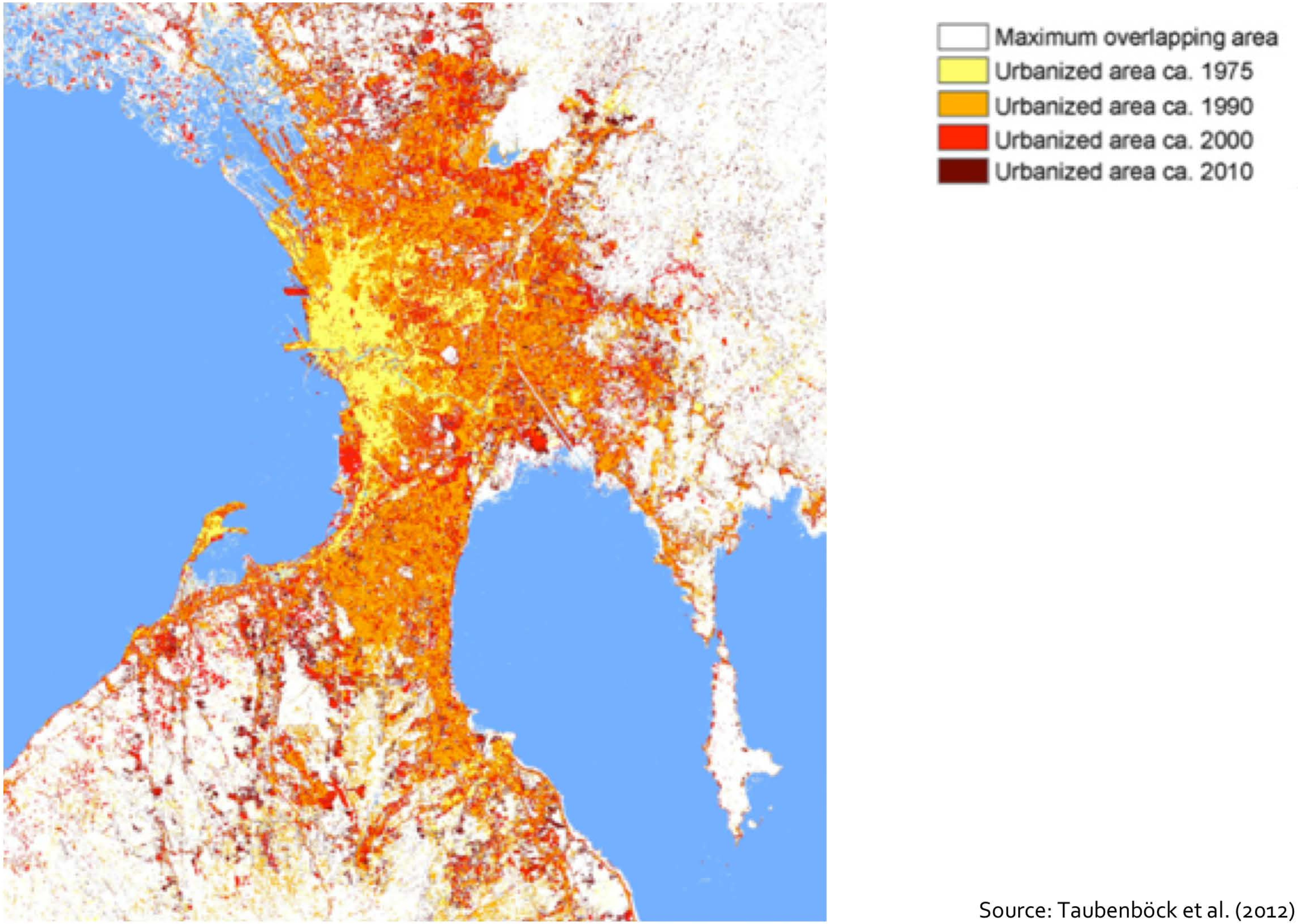
Manila



Source: Taubenböck et al. (2012)

Mexico City

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Urban landscape

How does it affect how people consume?
How does it affect urban mobility?
How do you reach your customers?
And where?

Source: Pablo Lopez Luz, Reddit

D

São Paulo

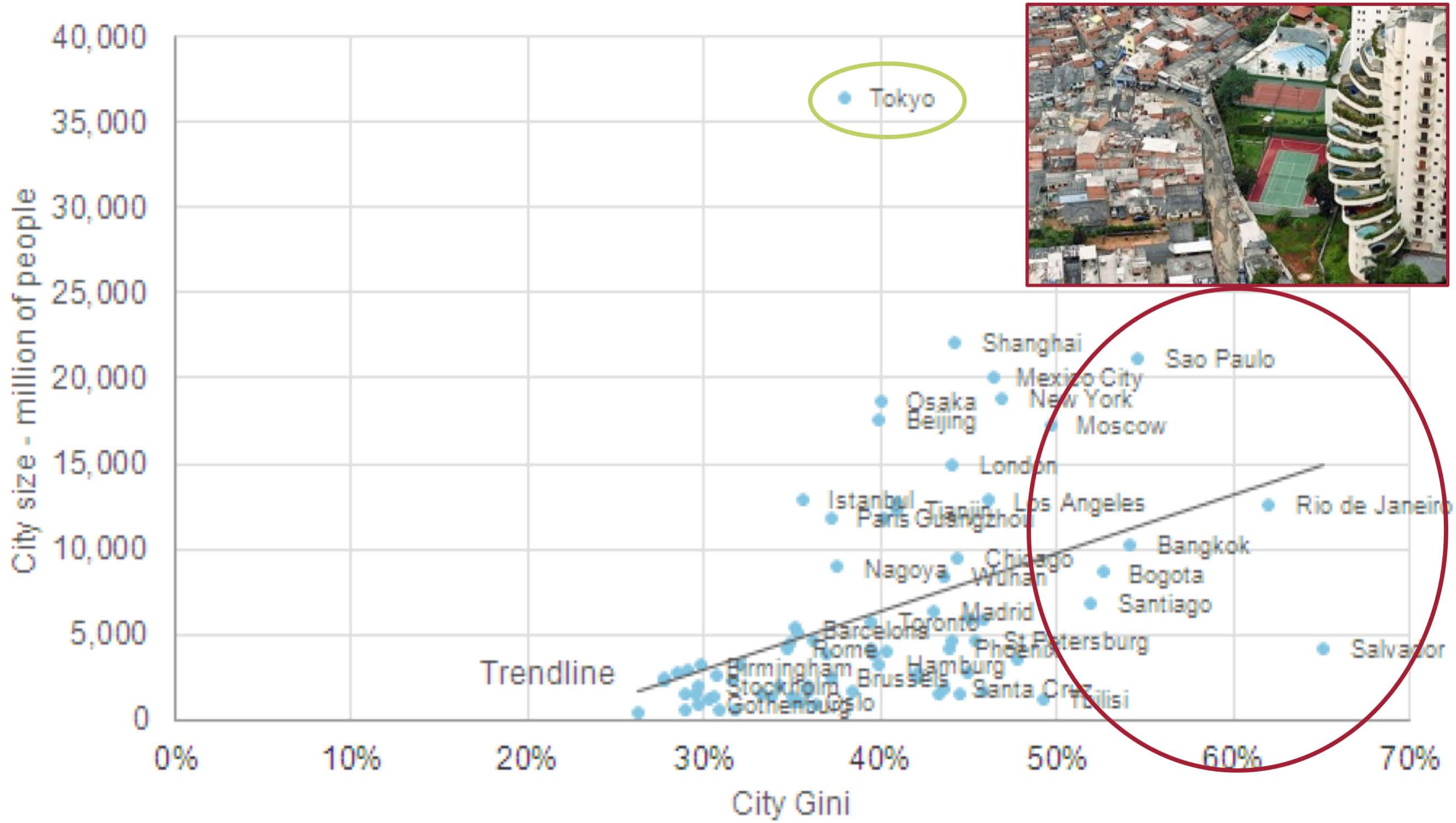
Source: Barbieri, USP (2012)

Tokyo

Urban landscape
How does it affect how people consume?
How does it affect urban mobility?
How do you reach your customers?
And where?

Source: Tokyo Travel Assist (2016)

Emerging market megacities exhibit harsh socio-demographic contrasts



Source: Euromonitor (2013); Photo: Paulo Saldiva from C. Cunha Barbieri, USP (2013)

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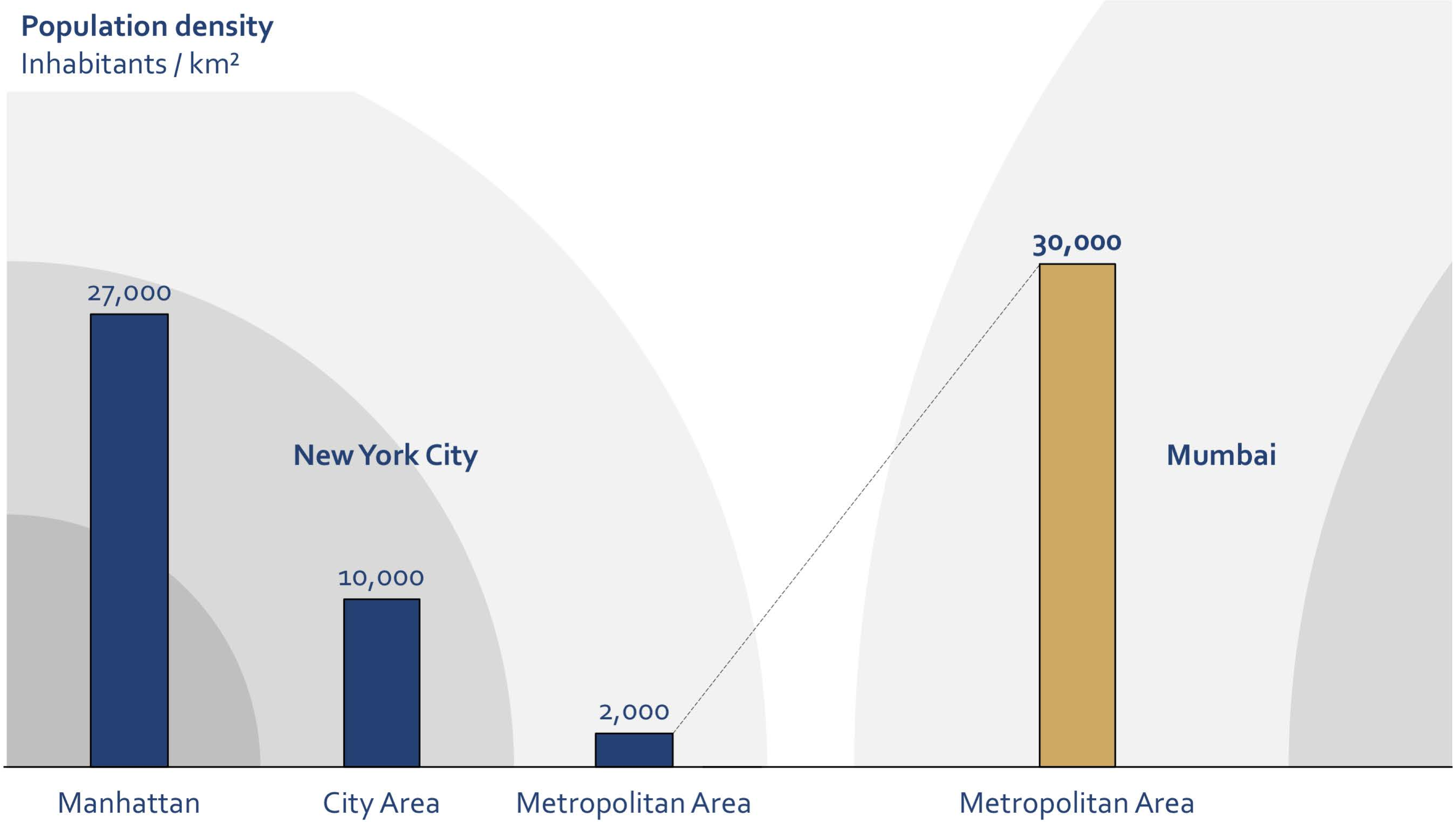
Fat and slim…

DENSITY AND THE SHAPE OF CITIES

Extreme levels of population density

Source: Google Street View of Bogotá (2015)

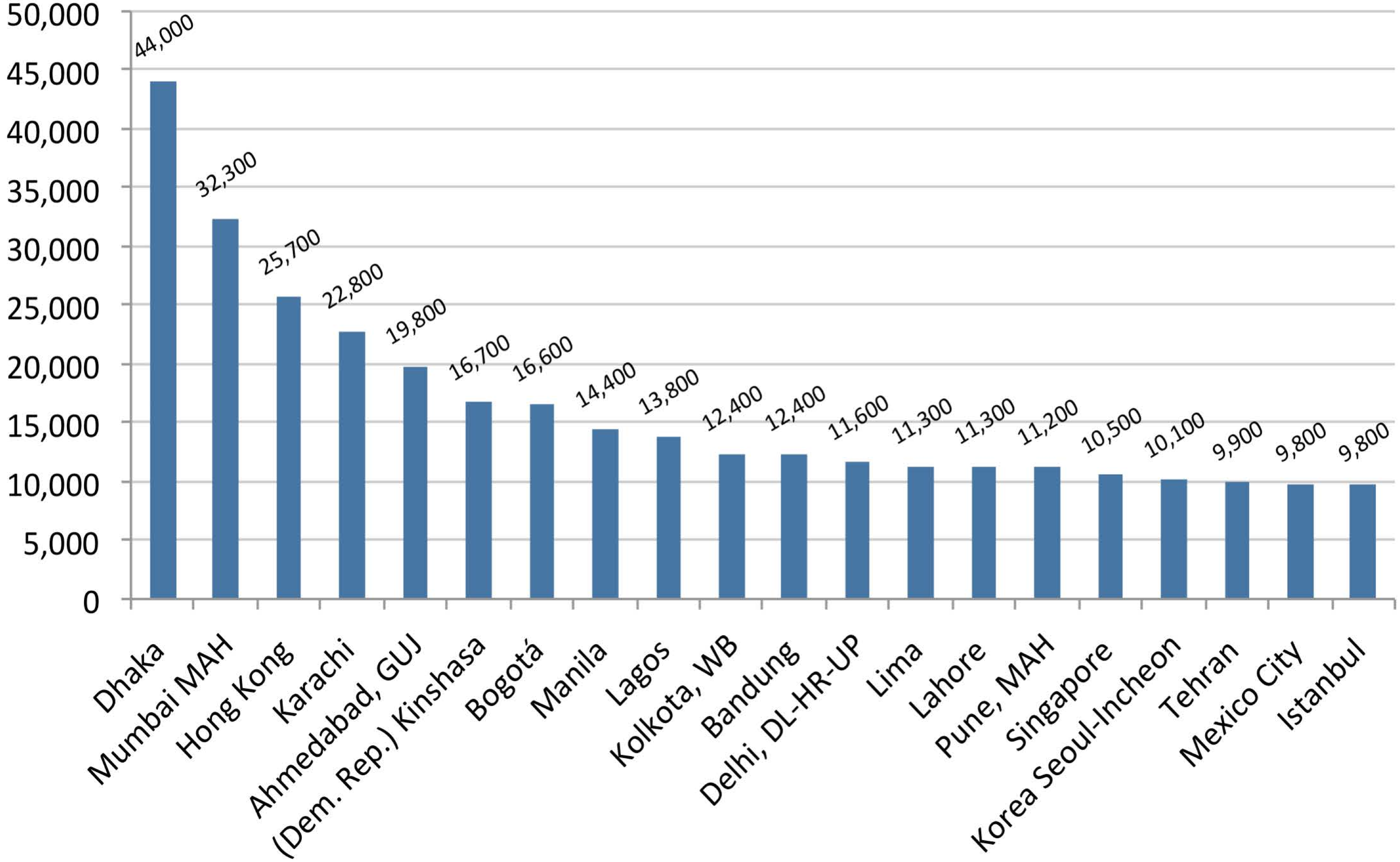
Extreme levels of population density



Source: Blanco and Fransoo (2013)

Extreme levels of population density

Population density, metropolitan area
Inhabitants / km²

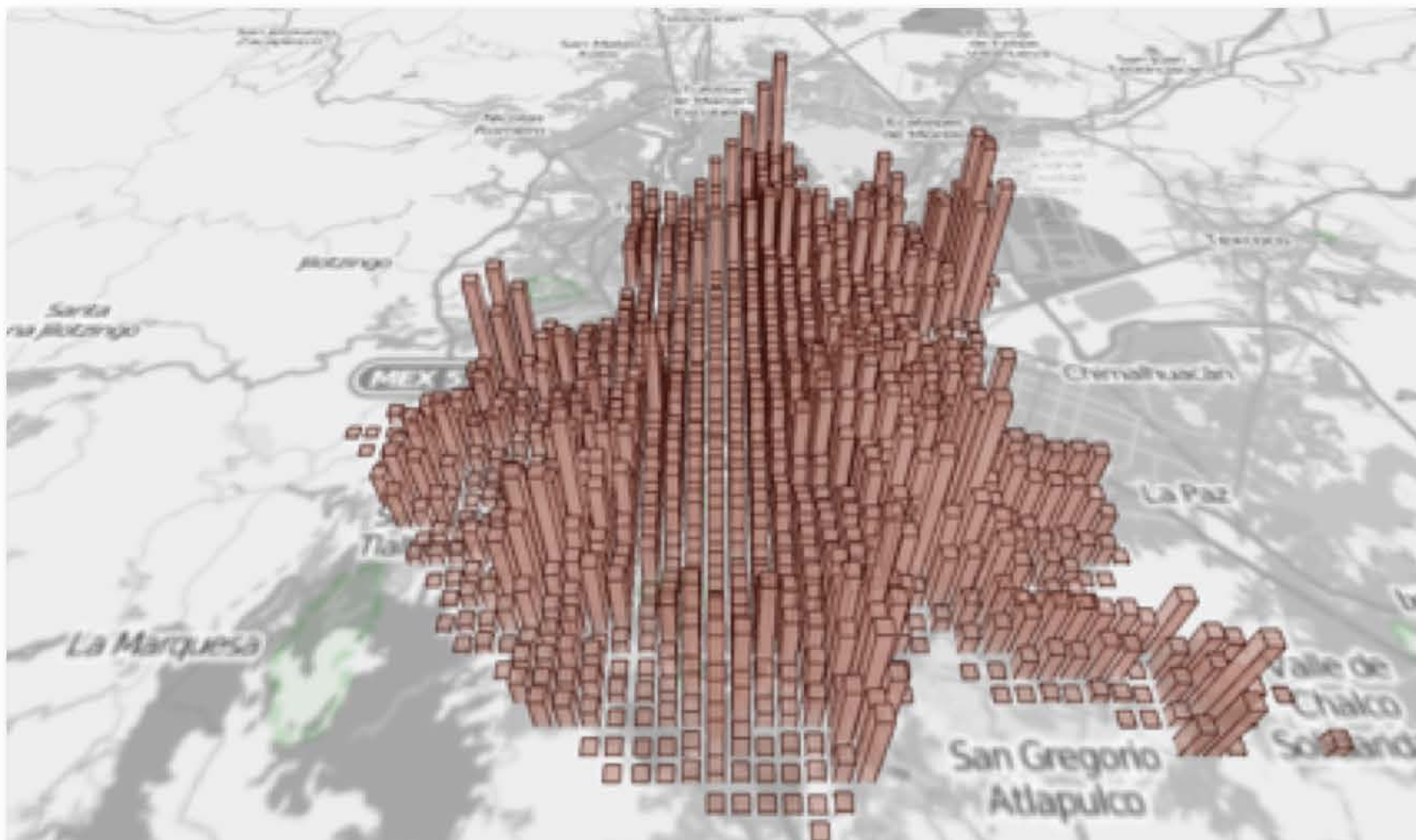


Where is New York?

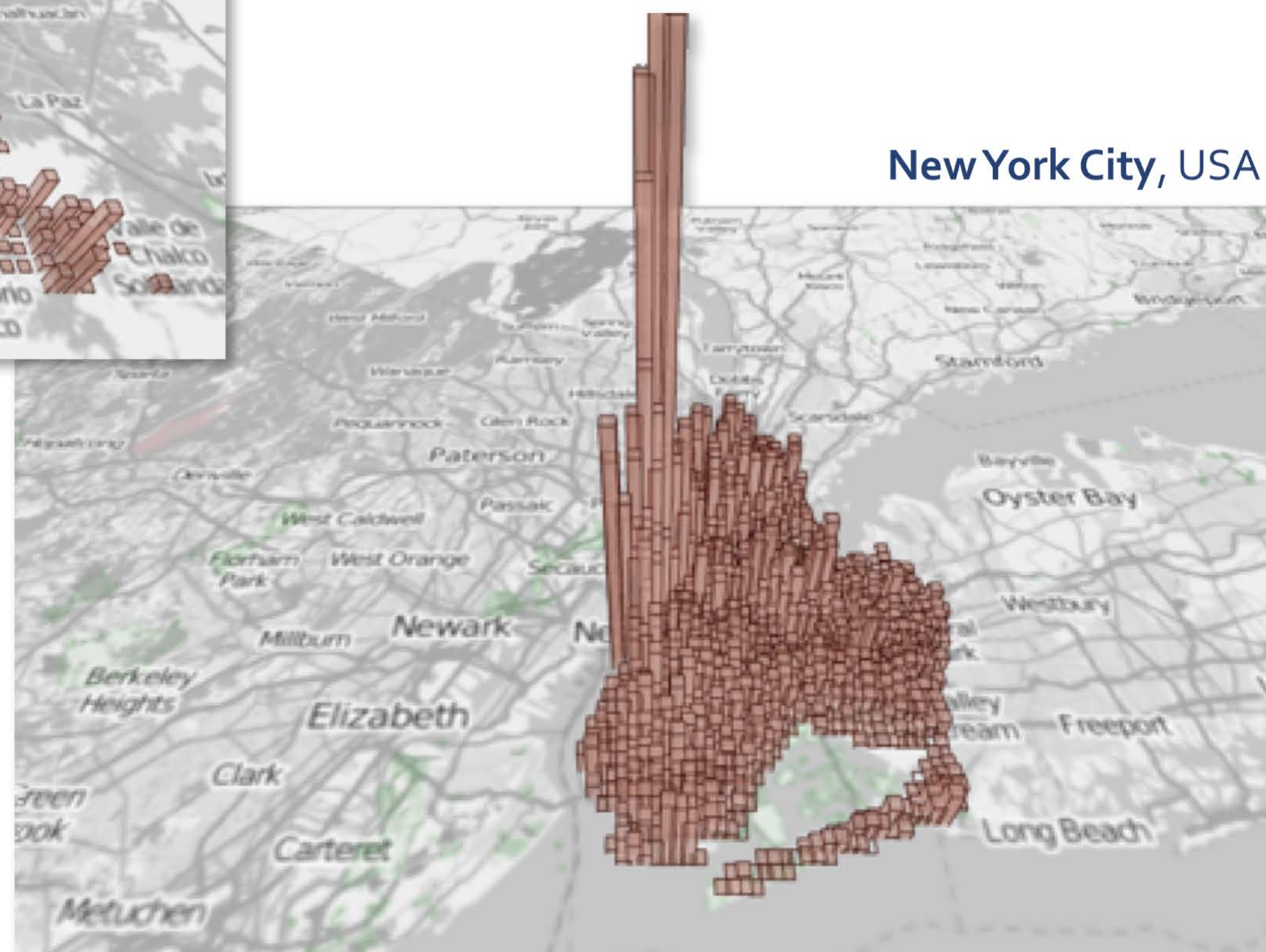
Source: MIT Megacity Logistics Lab, Demographia

Average vs. local density: Mexico City vs. New York City

Mexico City, Mexico

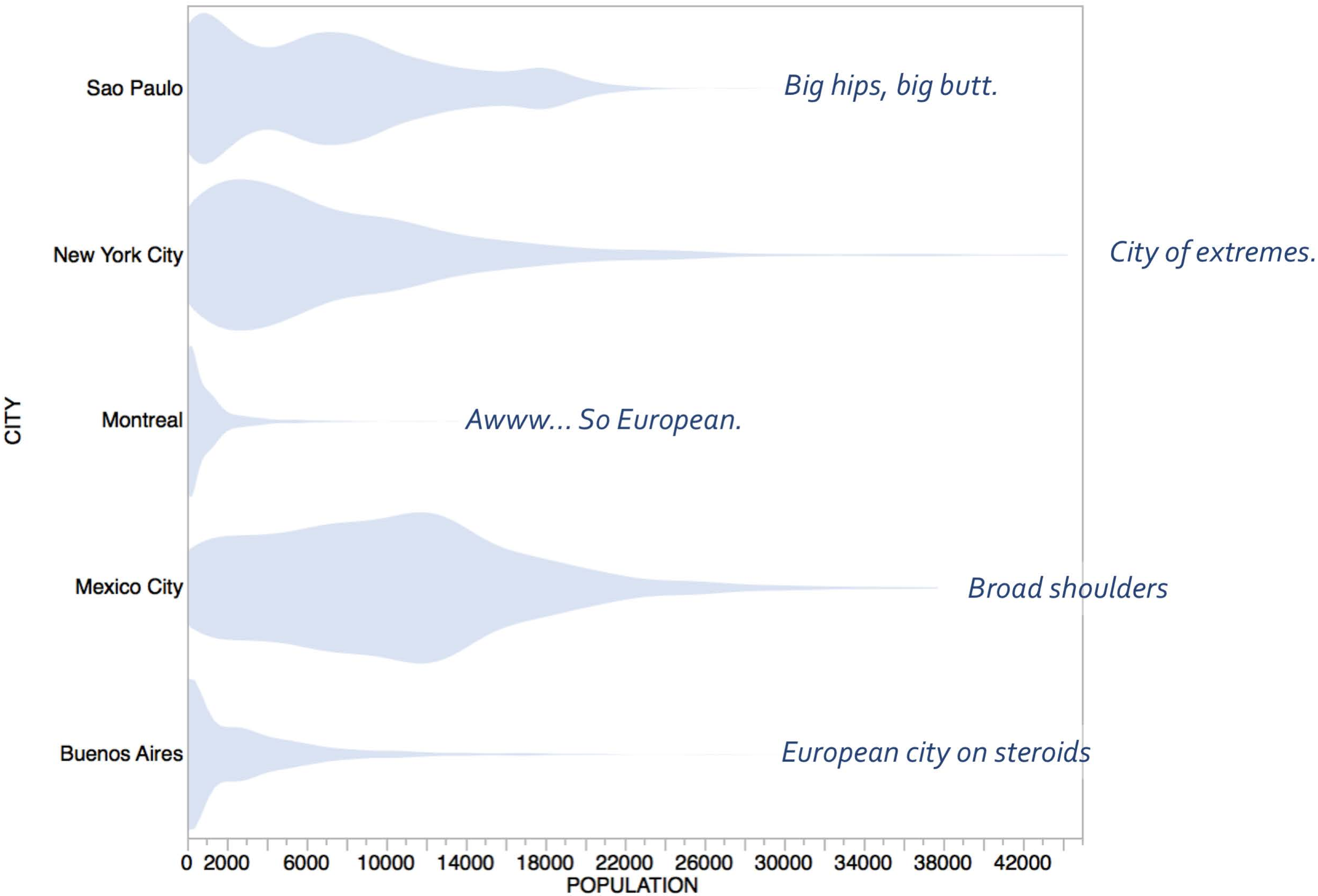


New York City, USA



Source: MIT Megacity Logistics Lab

Average vs. local density: The „body type“ of cities



Source: MIT Megacity Logistics Lab

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Massachusetts Institute of Technology

Where do all these people shop?

RETAIL DYNAMICS IN EMERGING MARKET MEGACITIES

Where do all these people shop? Here!

D

Making the most of space

Receiving, storing, advertising, and selling goods in the absence of space

Source: Y. Boulaksil, POMS 2014

A little bit of everything

How to plan and optimize your assortment?

How to choose which brands to carry?

Source: Y. Boulaksil, POMS 2014

D

Size matters

In which pack size are your products delivered, stored, sold?

Which pack sizes to provide?

Source: Y. Boulaksil, POMS 2014

Everything in one place
When competing for space in emerging market nanostores, logistics is the key to success!

Source: LOGyCA

In the emerging markets, last-mile delivery suffers from density and fragmentation

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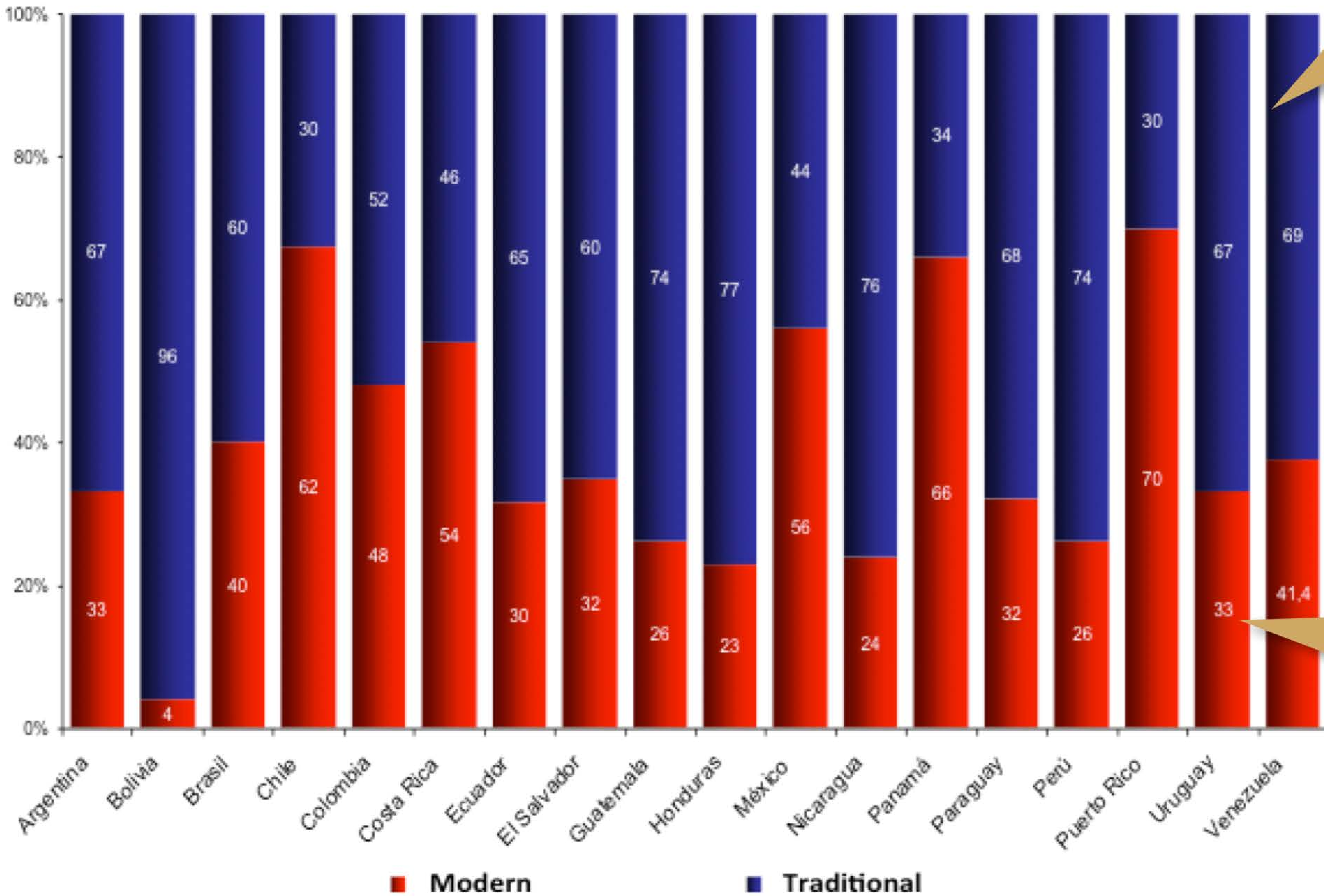
Density of traditional “nanostores” in Mexico City

Sources: INEGI 2012, MIT Megacity Logistics Lab, S.A. Caballero (ITESM, 2015)

Why is traditional retail so dominant? Why do nanostores survive?

Market share of traditional vs. modern retail channel
Percent of sales



Barriers of access to modern channel

- No access to required **transport** infrastructure
- Insufficient **cash / formal credit**

Advantages of traditional channel

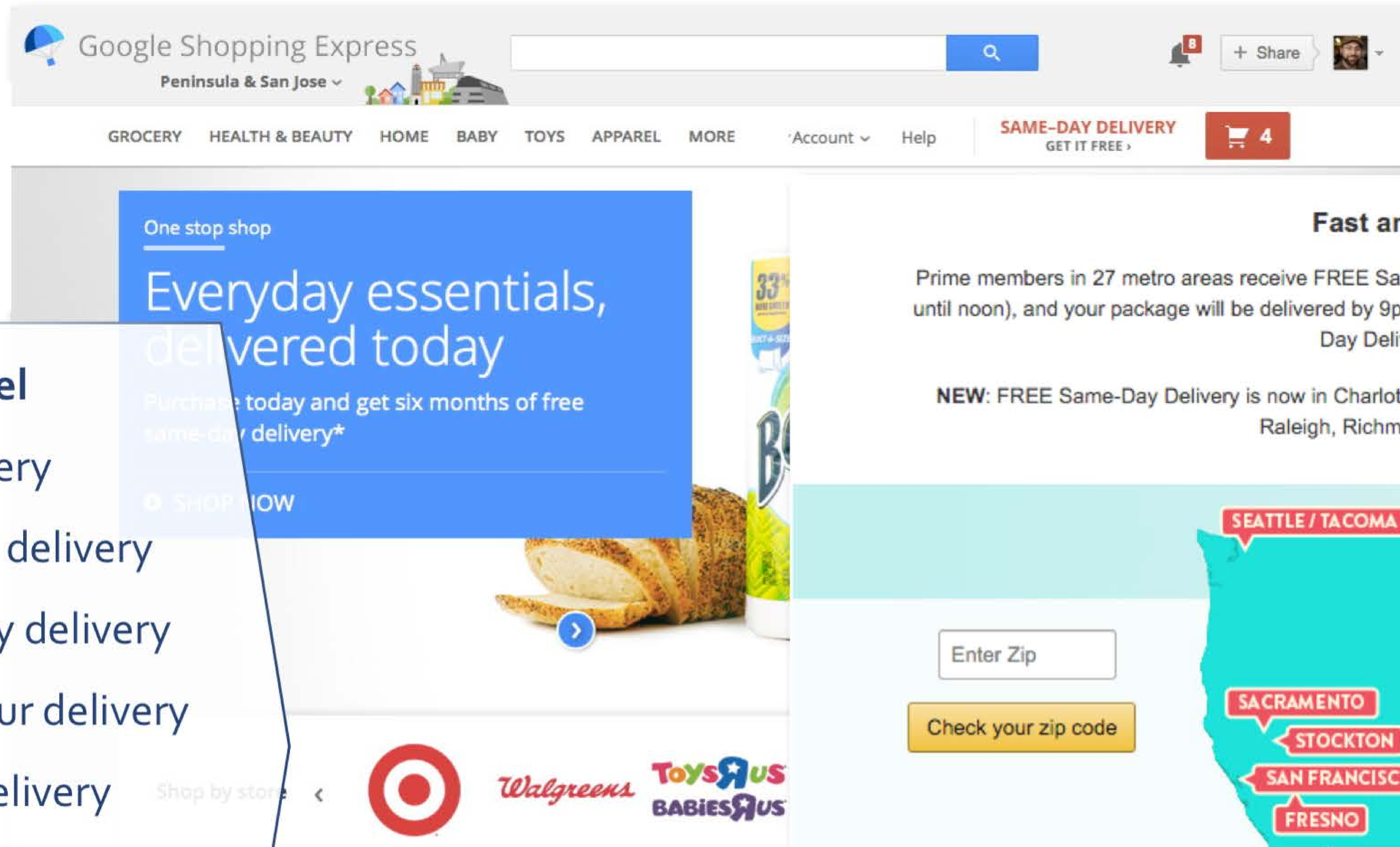
- No transport required
- Informal, **relationship-based** credit
- Small **package sizes** / single item purchases
- Low **barriers of entry**
- Interest of CPG manufacturers to have them survive (higher **margin**, growth)
- In-store **consumption**
- Proximity / **Convenience**

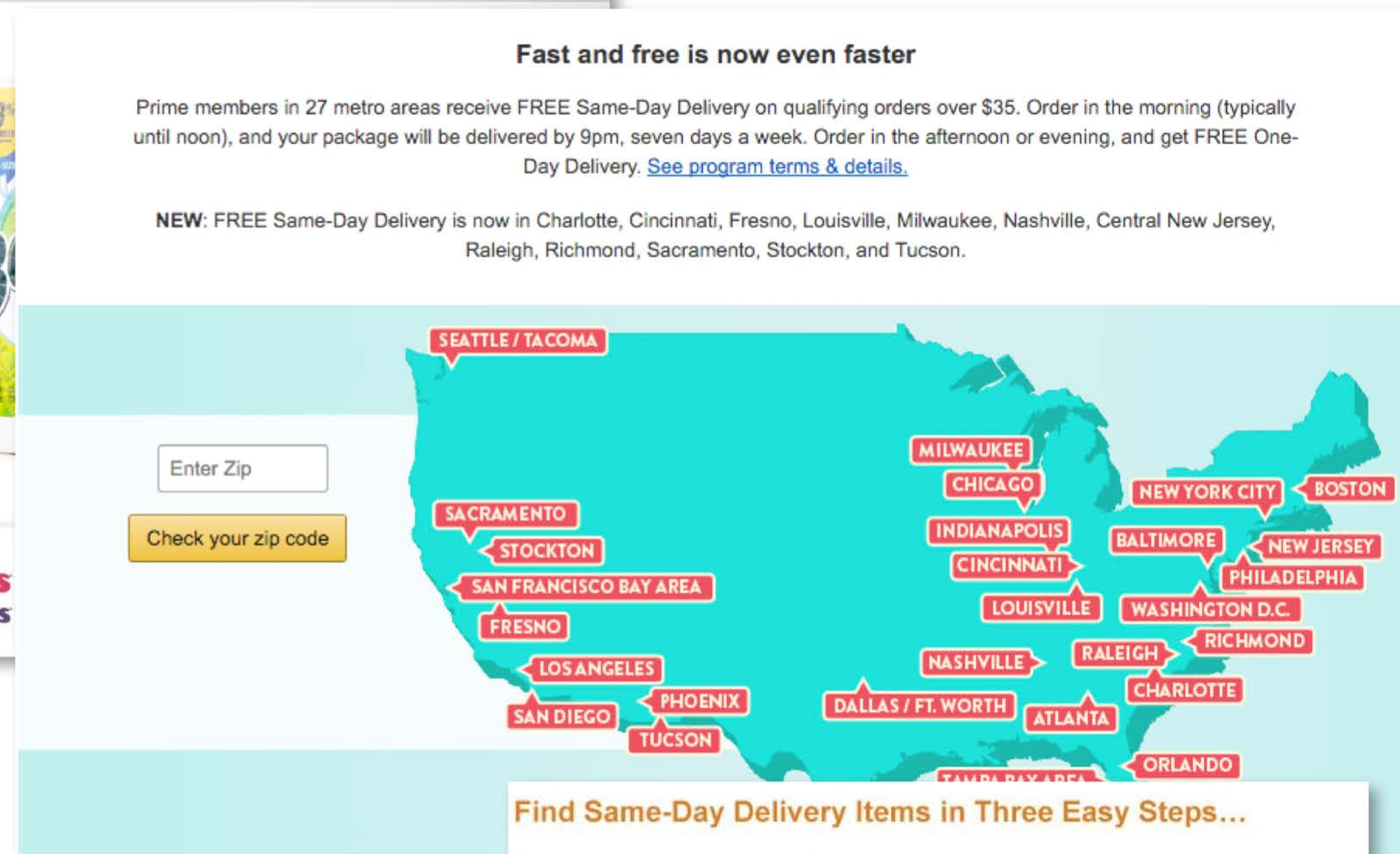
Source: Blanco (2012); Blanco and Fransoo (2013)

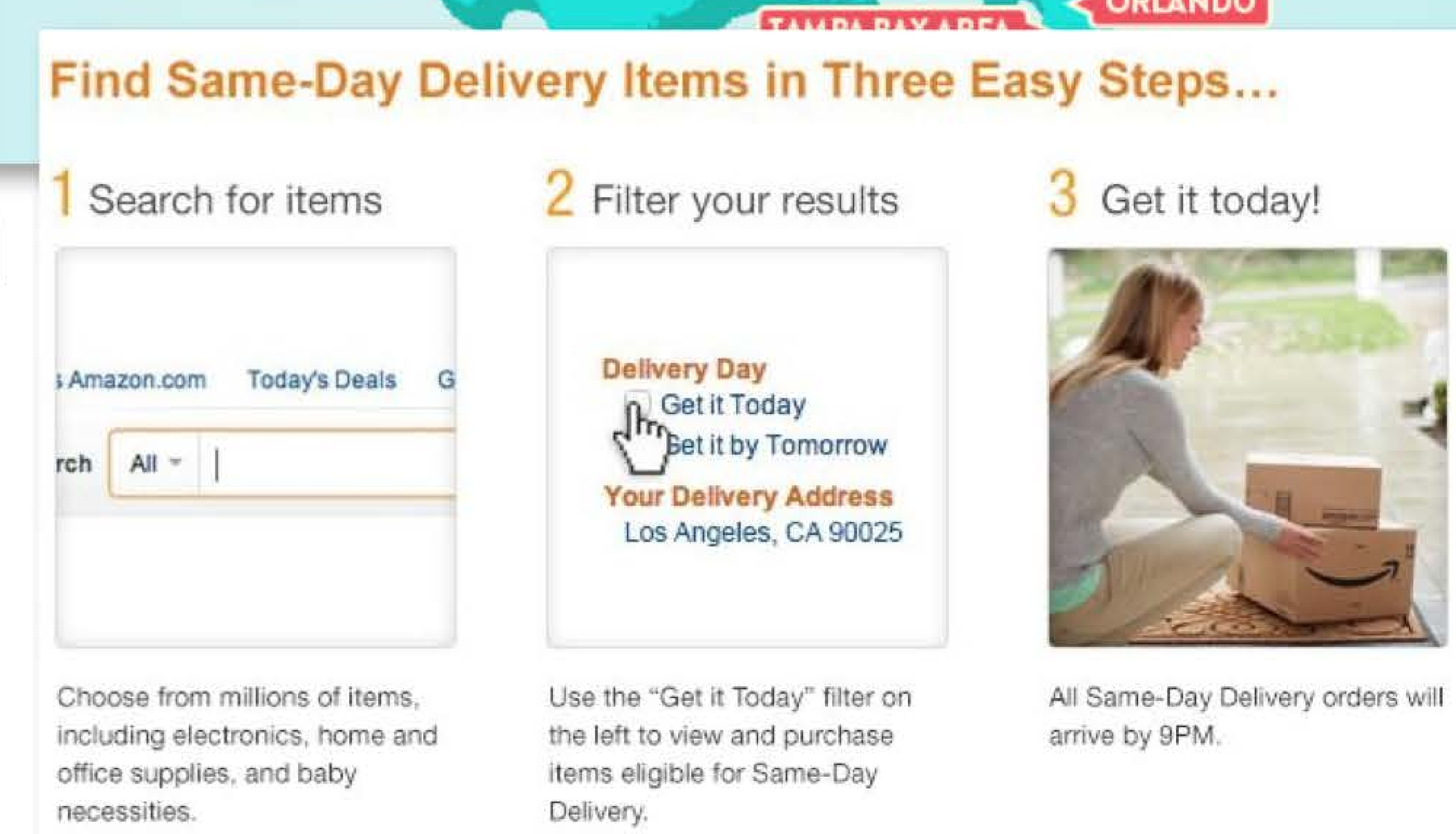
How and where will all these people shop?

FUTURE RETAIL DYNAMICS IN MEGACITIES

Customers expectations are rising – while their willingness to pay is not







Service Level

- T+2 delivery
- Next-day delivery
- Same-day delivery
- Same-hour delivery
- Instant delivery
- Delivery time windows
- Anticipatory shipping

Smart devices transform shopping towards a seamless omni-channel experience

Density is a key enabler for successful and efficient omni-channel retailing

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The new buying process…

Anytime, Anywhere

- Product discovery
- Product search
- Purchase
- Product delivery / pickup
- Shipment re-routing
- Product return
- Used product recycling
- …

…needs to be **supported by flexible, reliable, efficient last-mile logistics**.

…and can only be sustainable in a **high-density, urban environment.**

10.9 mph
average daytime speed in NYC

≙

~ 1.27 miles, or **6 km²**
are equivalent to a 7 minute radius

×

25,000 people / km²
Manhattan population density

=

150,000 people
within 7 minutes

What will it be?

THE FUTURE OF LAST-MILE DELIVERY

Big data, new technologies, and disruptive business models spark last-mile innovation

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Sources: Merchán (2014), MIT Media Lab (2015), BMW, TNT, Mercedes Benz, Amazon, Glue Home, and others

D

Drones – more than just a buzz?

Source: Amazon (2014). Amazon Prime Air

Autonomous electric vehicles are probably 5 – 10 years down the road

Source: MIT Media Lab

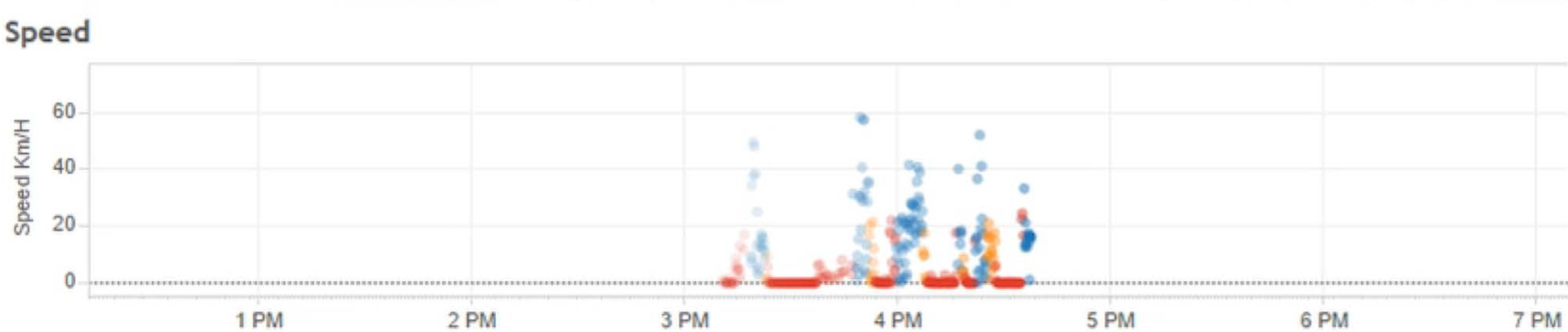
IoT devices can have immediate operational implications on urban last-mile delivery

Data Analytics

USING DATA TO UNDERSTAND AND IMPROVE CITIES

Tracing the movement of vehicles creates real-time visibility of your operations

Within the vehicle traces, we can identify various activities along the route

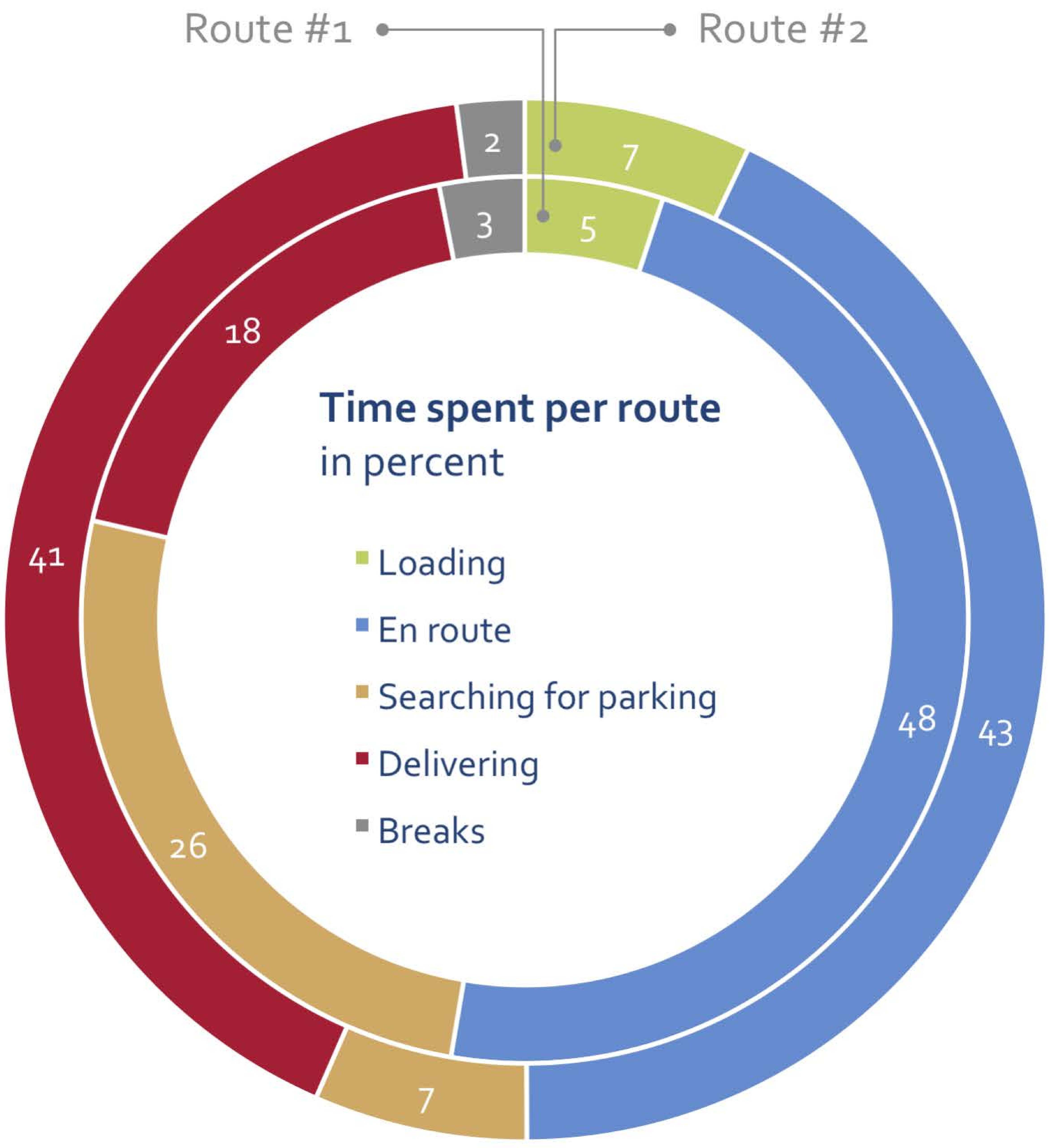


- Tracking route
- Approach / parking
- Stopped to deliver

Geospatial analysis allows for time-, driver-, route- or vehicle-specific KPI comparisons

Why does average time per delivery differ?
- Item size / weight
- Equipment
- Crew-specific behavior
  - re-parking vs. walking
  - local knowledge
- Customer requirements
- ...

Why does average search time for parking differ?
- Parking availability
- Vehicle type
- Crew-specific behavior
  - re-parking vs. walking
  - local knowledge
- ...



Why does loading efficiency differ?
- Item size / weight
- Loading facility
- Personnel
- Management
- ...

Why could average transit time differ?
- Customer density
- Congestion
- Road network
- ...

High-resolution speed and emission profiles can inform planning and eco-improvement

Source: MIT Megacity Logistics Lab

Stop density drives a large fraction of the variability across city zones

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Highest density area

Area near Av. Paulista

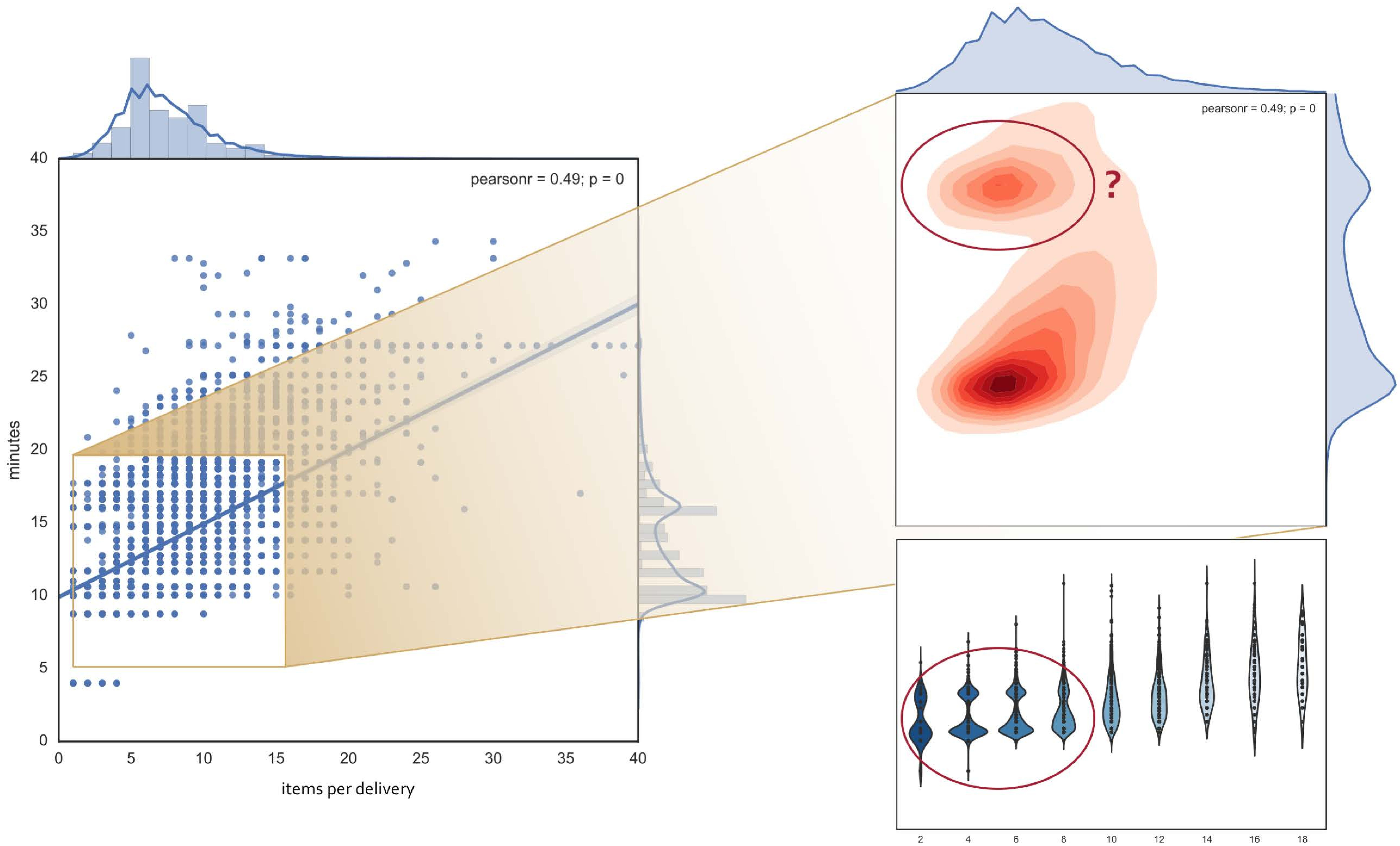
Pixel-specific definitions of demand

- Customer density
- Drop size distribution
- Delivery frequency distribution

Geo-tagged transactions inform capacity planning, vehicle routing, order dispatching

Source: MIT Megacity Logistics Lab

Transactional data by itself can already reveal insights on delivery performance



Source: MIT Megacity Logistics Lab

Adding geospatial information to transactional data can provide explanations

Source: MIT Megacity Logistics Lab

Geospatial data analysis can reveal activity hot spots within a city

It can reveal inefficiencies in last-mile delivery operations across companies

Source: MIT Megacity Logistics Lab

Geospatial data can inform simulations on the effect of infrastructure investments

We support the planning of urban freight infrastructure investments

Based on Google Maps data, we computed the ‘true’ circuity factors for various cities

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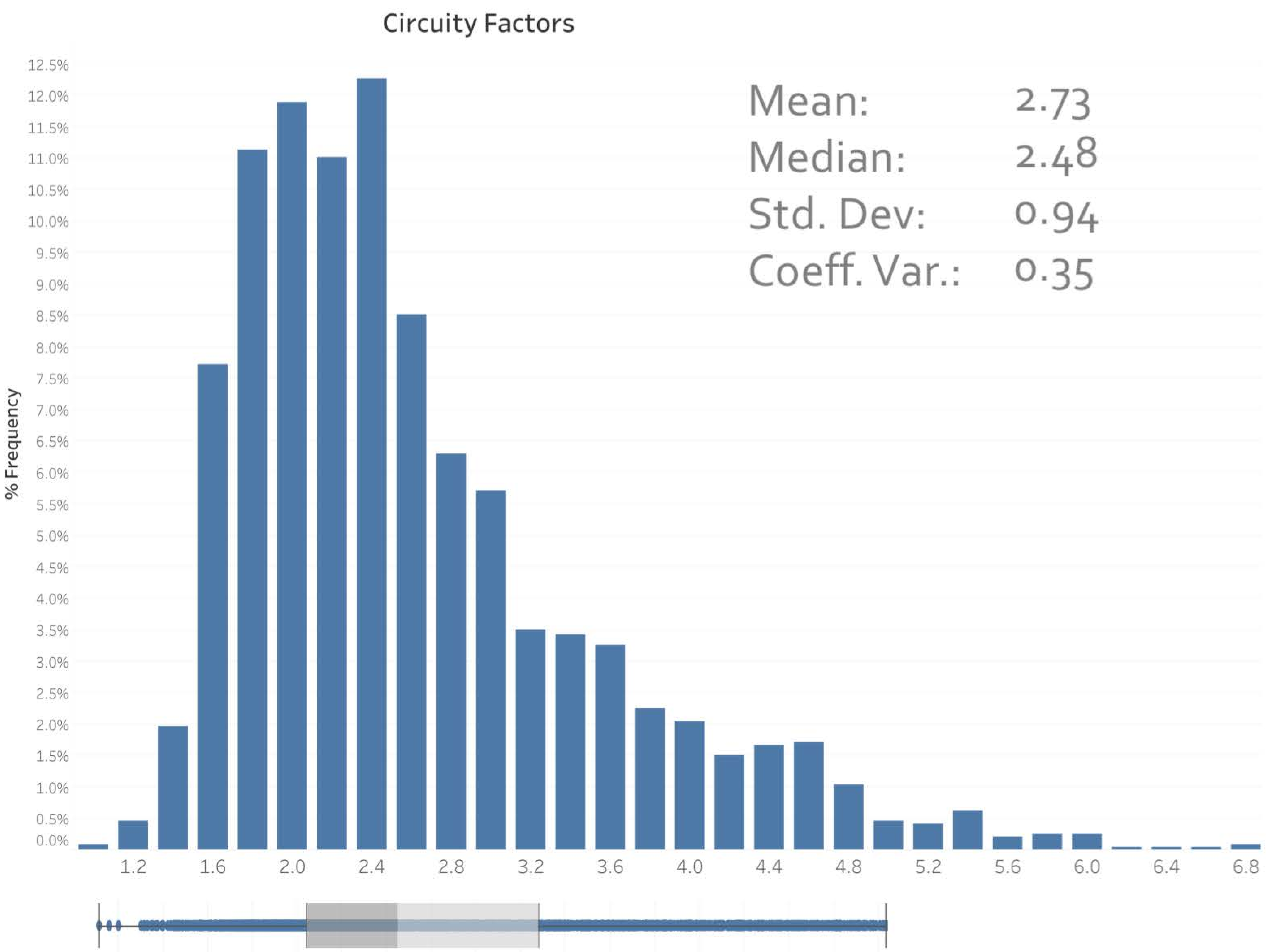
Massachusetts Institute of Technology

Across the board, we observe significantly higher values than what theory suggests

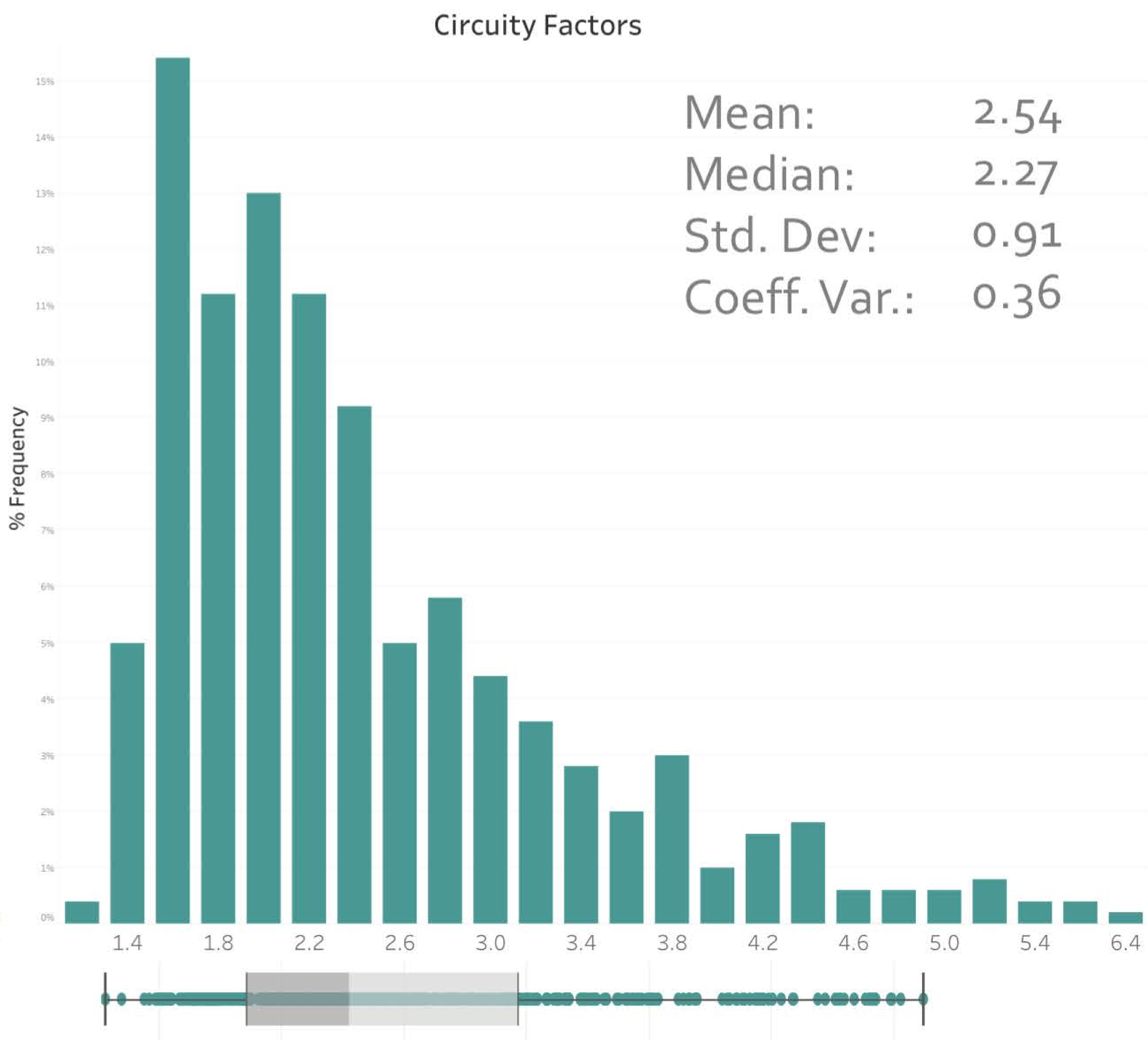
Case study: São Paulo

Total number of pixels: 2,400
Total simulated trips *: 380 K



Case study : Bangalore

Total number of pixels: 500
Total simulated trips *: 60 K



Data Source: Google Maps Services

We also estimated a factor that captures variability in land cost across the city

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The robbery risk profile drives load capacity and vehicle safety technologies

MIT Center for Transportation & Logistics

 – chart no. 65

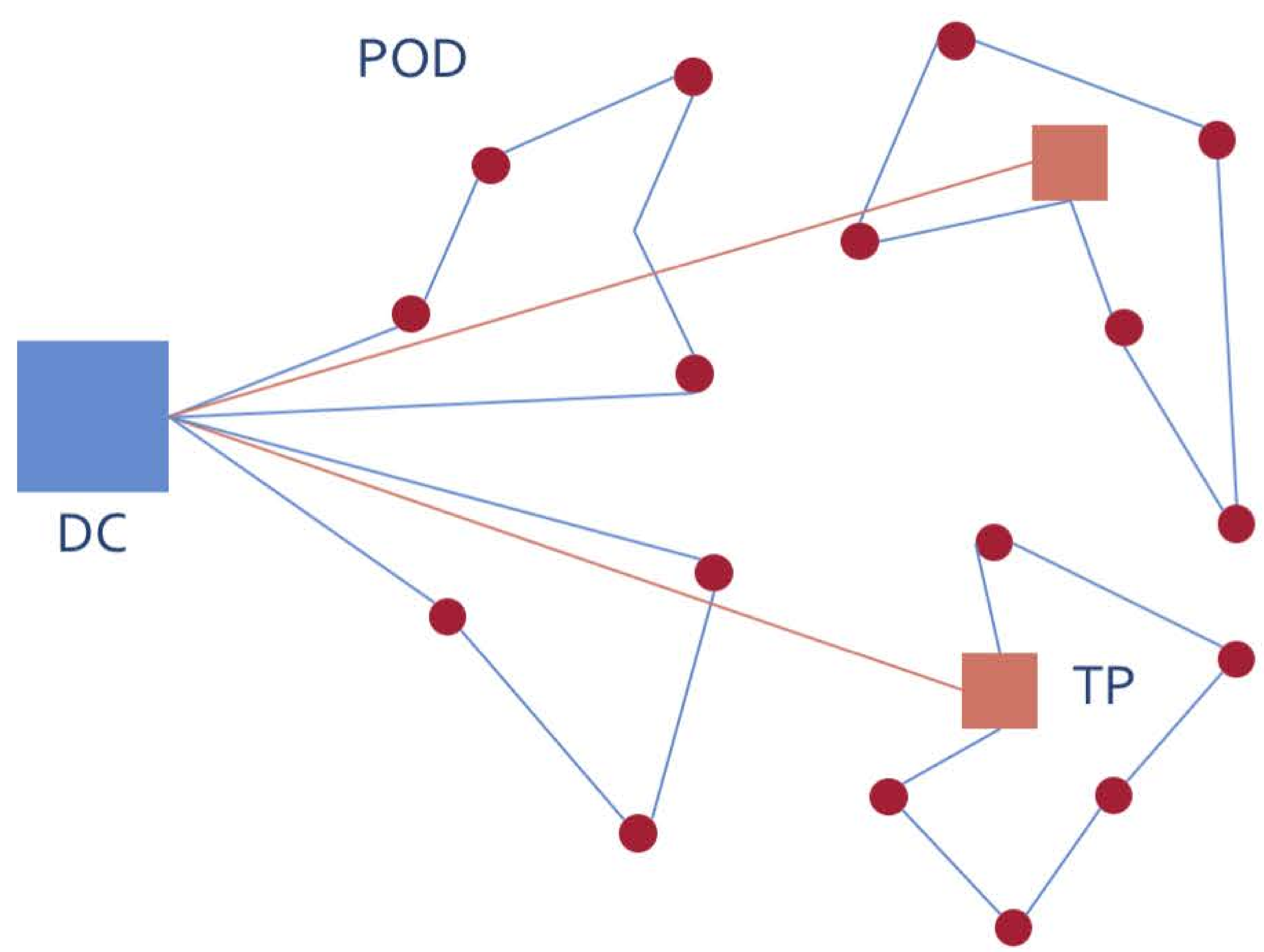
Massachusetts Institute of Technology

Modeling reality

DISTRIBUTION NETWORK DESIGN

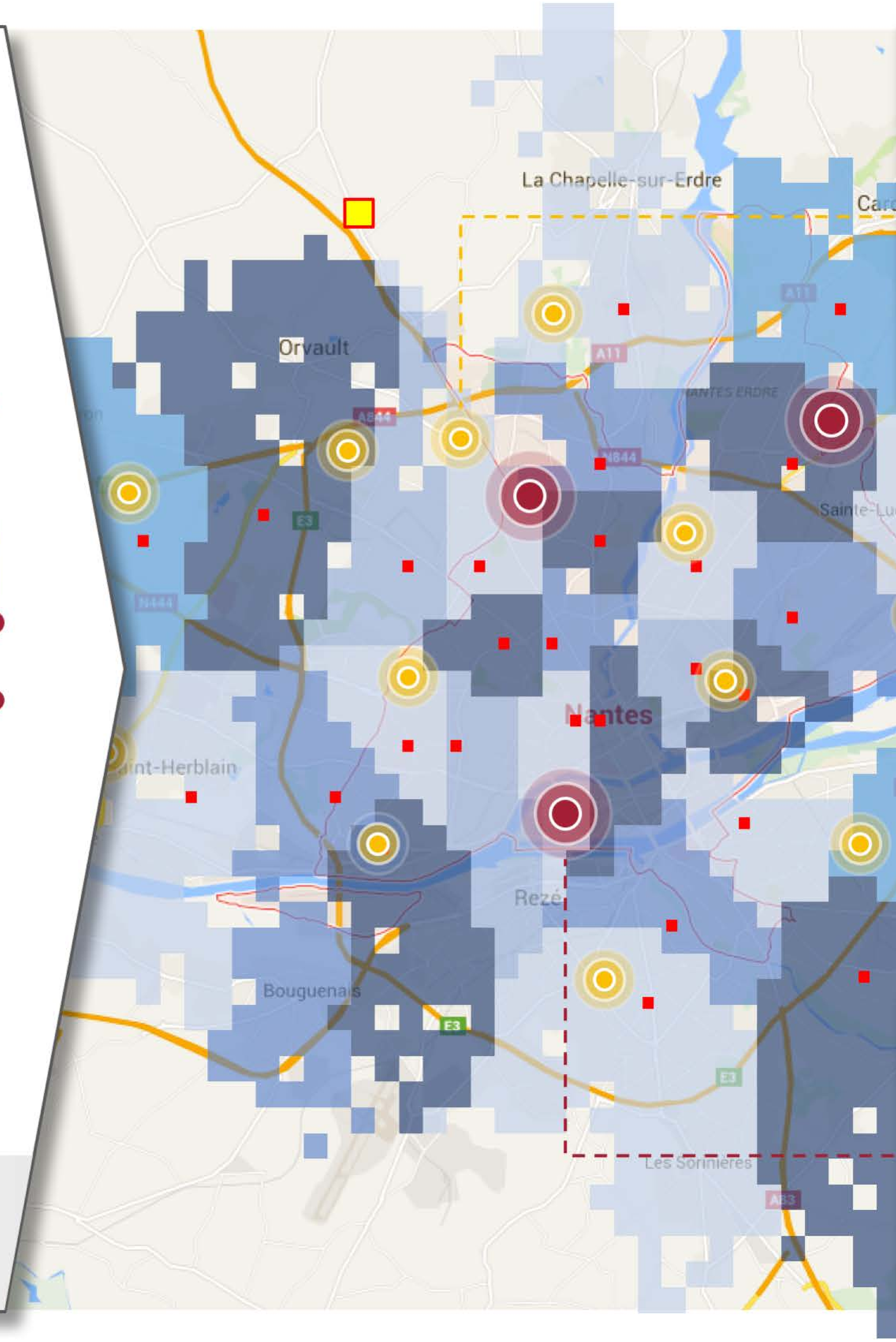
Efficient urban delivery requires flexible, multi-tier, multi-modal last-mile networks

Multi-tier last-mile distribution network design & analysis



python GUROBI OPTIMIZATION

Optimization & simulation models for planning & design



Source: MIT Megacity Logistics Lab, DHL, TNT

Innovative, tactile UI/UX enables interactive last-mile network design and data analytics

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Video demo

Source: MIT Megacity Logistics Lab, MIT Media Lab

Interactive visualization makes data and models accessible to decision makers

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Source: MIT Megacity Logistics Lab, MIT Media Lab

MIT CTL is building a dedicated lab around visualization and Augmented Reality UI/UX

demo

We aim to change the way companies use data, and way we train supply chain talents

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Augmented Reality technology can enable new ways of data-driven decision making

Microsoft demo

The true potential of AR lies in BIG Data analytics and scientific decision support

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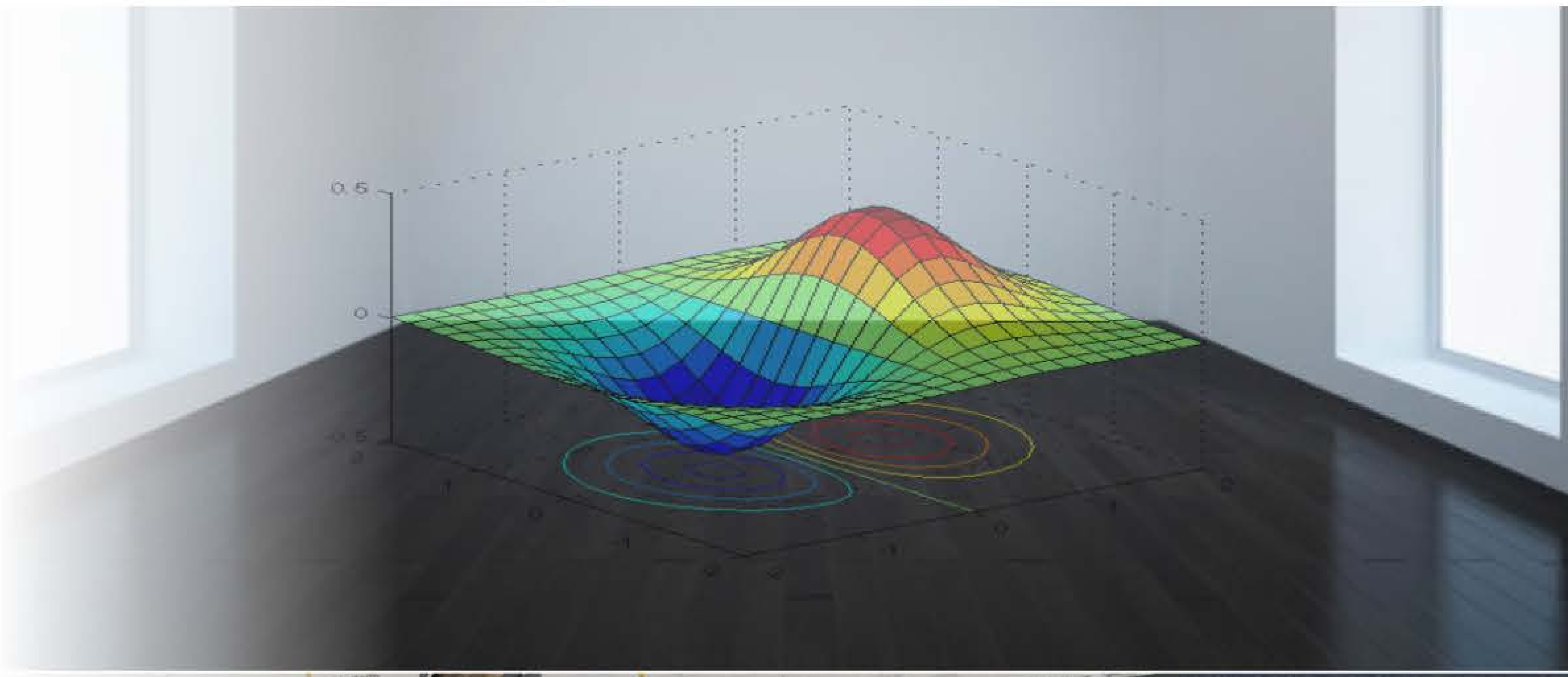
AR User Interfaces and Experience (UI/UX)

- **Tactile interaction** with data and models
- **Additional dimensions** to display and analyze data (depth, shape, color, location, movement, sound)
- **Intuitive control** via gaze, gesture, and voice
- **Natural interaction** with collaborators and the lab environment due to intelligent spatial mapping
- **Robust, scalable, and transferrable** technology
- **Compatibility** with enterprise level software

Microsoft HoloLens



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Wrapping it up

KEY TAKE-AWAYS

Key Take-Aways

1. **Urban last-mile operations** immediately affect the hotspots of future economic growth and population.
2. **Every city is different** and requires tailor-made approaches to last-mile delivery.
3. **Extreme levels of density and heterogeneity** are two key challenges of last-mile operations in the emerging markets.
4. **Nanostores** dominate the retail sector in many emerging economies, making last-mile operations particularly fragmented and challenging.
5. **Delivery anywhere, anytime** and other innovations in the retail landscape requires demand density to be feasible.
6. **Market pressures and technology innovations** force companies to re-think and re-design their last-mile operations.
7. **Data analytics and visualization** is the key to understanding city dynamics and operational performance and to improve last-mile design, planning, execution.

Thank you.

Questions?

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