Transport Decarbonisation and Regional Territorial Development / Descarbonización de transportes y desarrollo regional territorial

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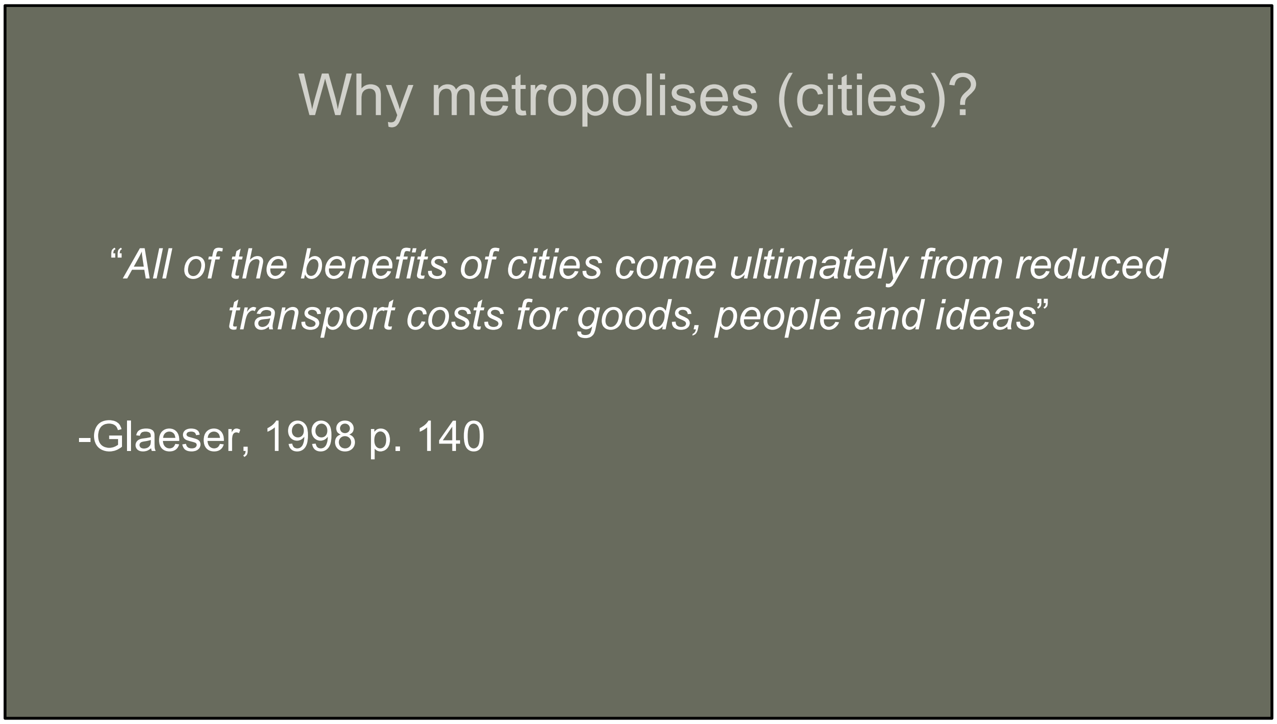
Content

- Territory-Mobility = Metropolitan Accessibility
- Accessibility = Built Environment + Mobility + Connectivity
- Mobility, the Built Environment and Greenhouse Gases (GHGs)
- Mobility and the Built Environment
- The Built Environment and Mobility
- Using the Relationships for Decarbonization
- Where are we going?



Most of us are familiar with the fact that we now live in the so-called "urban age" – more than half of the planet's humanity resides in "urban areas."

urban areas today exist because of their role in reducing mobility costs, or has the well-known Harvard Economist, Edward Glaeser has said:

Urban areas are, by definition, relatively dense concentrations of people, firms, and other organizations who have come together because of some value of physical connectedness. This connectedness can be achieved via proximity (density) and/or speed (mobility).

The mobility-territory system serves one primary purpose: allowing access to daily wants and needs (to school, friends, work, products and services, recreational opportunities, etc.): In other words, it provides accessibility.
Van Wee et al, define accessibility as the “extent to which the land-use and transportation systems enable (groups of) individuals to reach activities or destinations”.

I argue that maintaining this capability “to provide non-declining accessibility in time” is the fundamental operational
definition of sustainable metropolitan mobility. So, by extension, decarbonization must aim to maintain accessibility with low-/no-carbon.

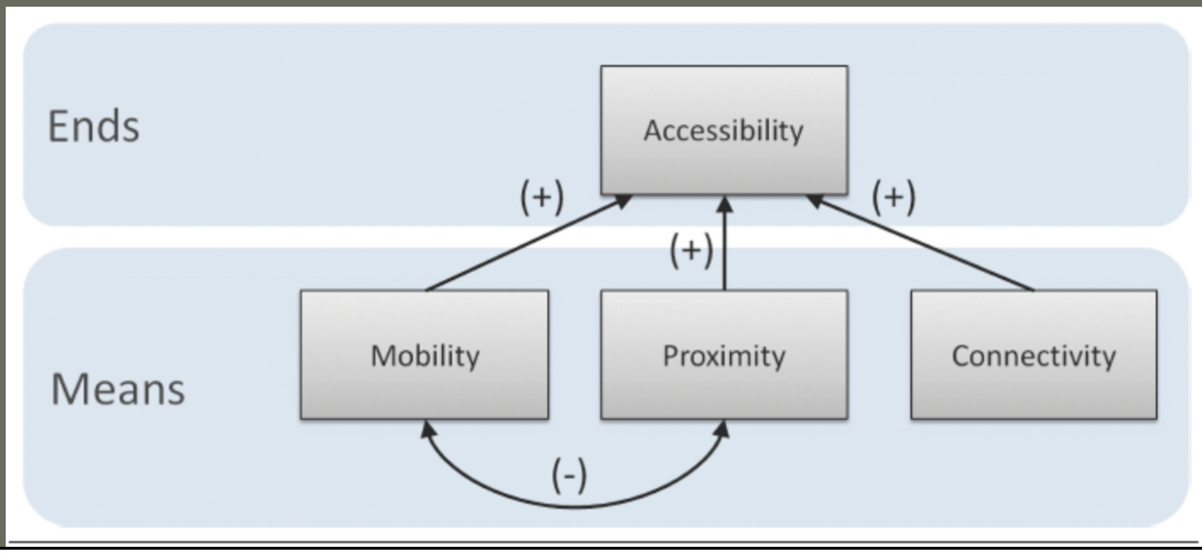
We cannot equitably expand accessibility infinitely. We must balance the expansion of accessibility and the scarcity of the resources implied.

System Components	Effect on Accessibility (all else equal)
Mobility	Improved with more links, faster or cheaper service
Spatial distribution of “opportunities”	Improved if proximity of opportunities is increased
Individual (personal/firm) characteristics	Improved with physical, mental, economic ability to take advantage of opportunities
Quality of opportunities	Improved with more, or better, opportunities within same distance/time
Telecommunications	Improved with more links, faster, cheaper, higher quality service

Within a metropolis, people, firms, and other institutions interact with their land use and mobility sub-systems
creating accessibility,

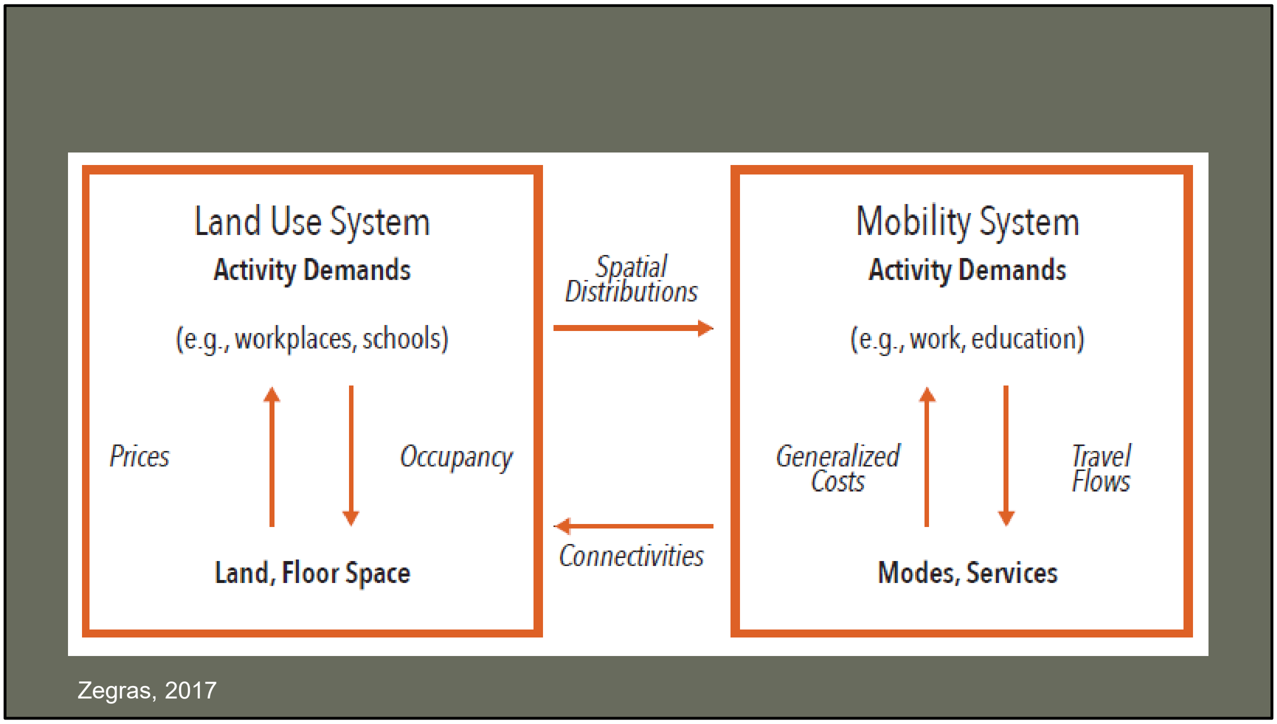
Accessibility: contributing factors in sum….

Levine et al. 2012



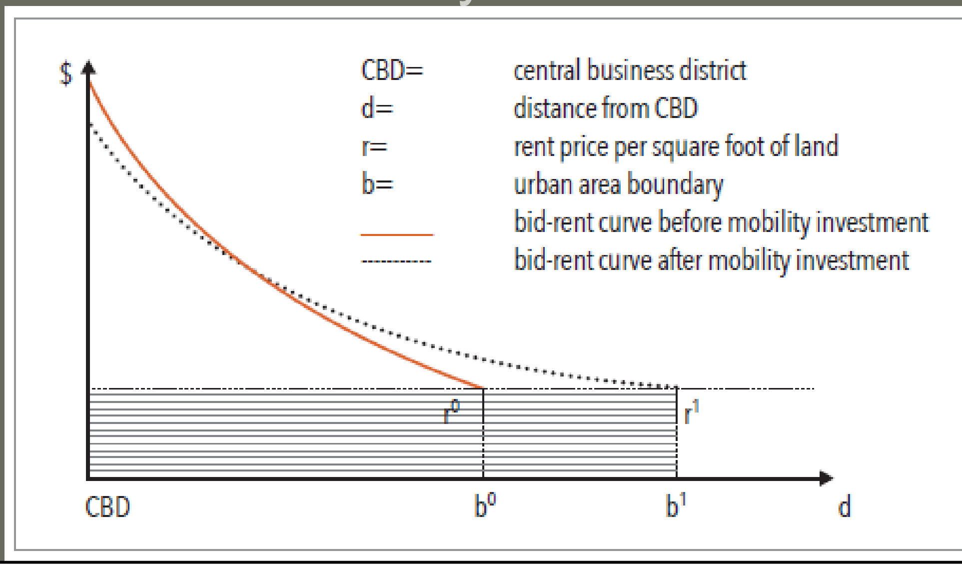
We can see clearly that the mobility and proximity systems contribute to accessibility, but in contradicting ways: more mobility, reduces proximity. More mobility tends to come with more carbon – so it is a more carbon-intensive-way of providing accessibility.

A **decarbonized** mobility system provides: higher accessibility at lower carbon, zero carbon. For the same level of accessibility, walking is more sustainable than driving (or taking the bus, or biking). For motorized modes (or any mode that can be shared), occupancy plays an important role since, ceteris paribus, higher occupancy means more people receiving accessibility benefit at less total mobility throughput.



Just as land use and mobility interact to generate accessibility, each of these sub-systems influences the other (Figure 1). The land use system, most basically, determines the locations of potential trip origins and destinations and influences the relative attractiveness of different travel modes. The mobility system, in turn, influences the relative desirability of different places and properties, positively improving connectivity, but sometimes with negative consequences, for example air and noise pollution. A major transportation investment, such as a new highway, will change the accessibility profile across a metropolitan area and the relative land and economic development attractiveness. A major new housing development will change the mobility demand patterns of a metropolis and impact highway and public transport services. Some basic coordination between these two sub-systems, at a minimum, seems like a self-evident requirement.

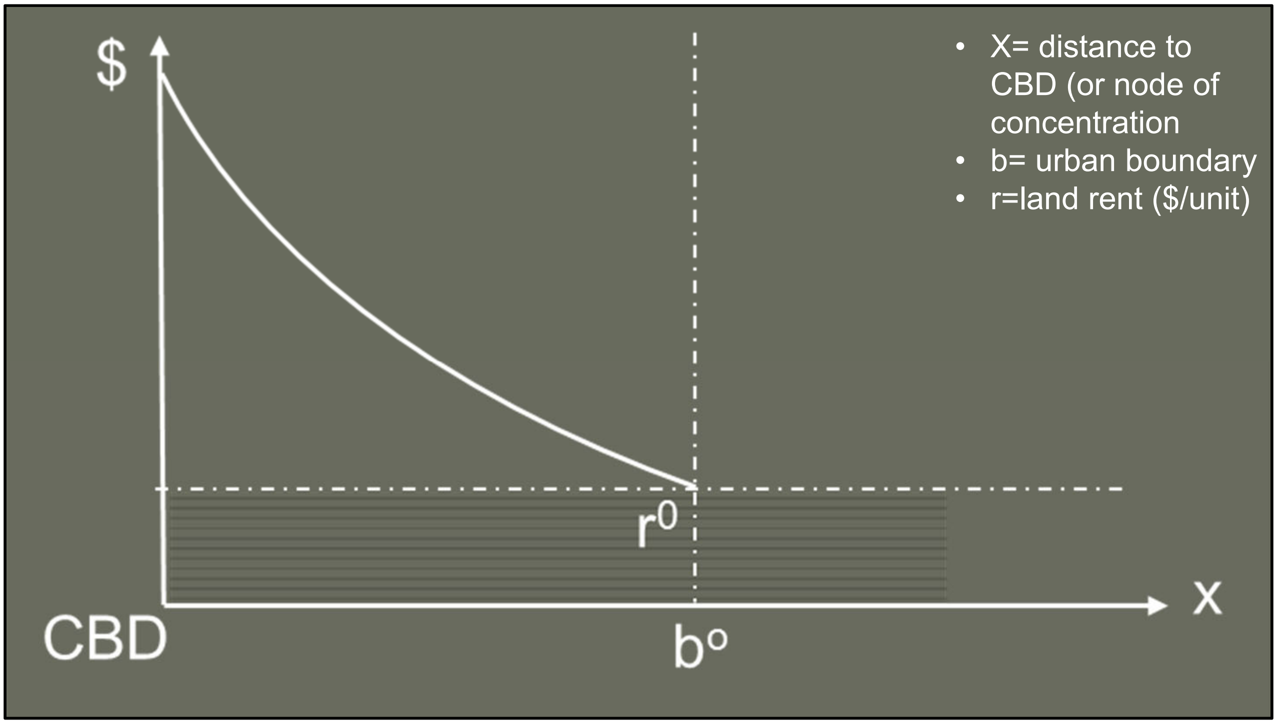
The Classic Monocentric Bid–Rent Curve with a Mobility Investment



Zegras, 2017

William Alonso (a Harvard-educated architect, city planner, and economist) extended the von Thunen model to urban land uses, predicting land uses and prices relative to distance from the central business district (CBD). When a purchaser acquires land, she acquires two goods (land and location) in one transaction. This leads to a possible trade-off: quantity of land versus transport costs (and other attributes related to location). For example, using the case of a household, the “bid-rent” function is the amount a household could pay (in rent) at different locations (with different transportation costs) while deriving a constant level of satisfaction (or utility). In other words, when deciding where to live, the household assesses the land price that would allow them to buy enough land (and other goods) which provide as much utility (satisfaction) at a given price, and amount of land, at the city center. A similar logic holds for firms, with profit replacing utility.

This figure shows stylized “bid-rent” curves for different types of firms and for households; in reality, of course, the shape of these curves vary by types of households, types of firms, etc. Some value privacy or space more than proximity, for example. By this theory, the generalized transport costs – basically time and money – dictate the shape of the curve, or the willingness to pay for proximity, and the “end” of the built-up zone, or the urban area boundary.



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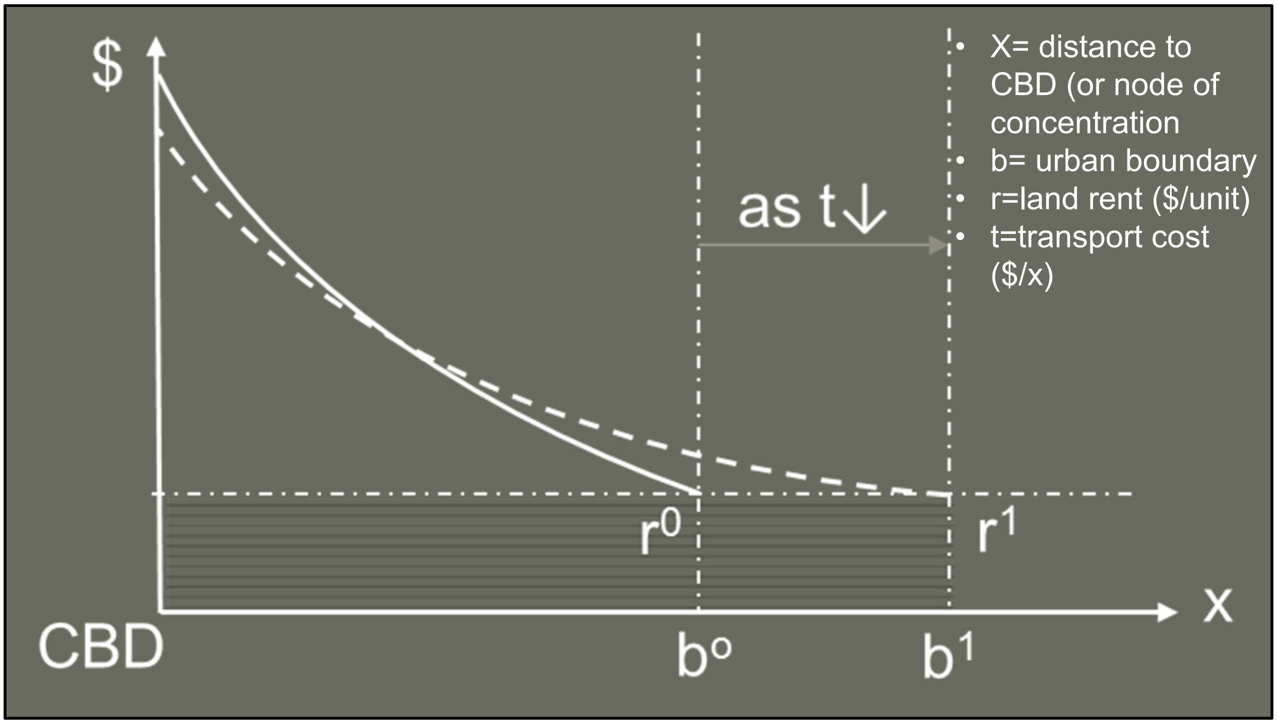
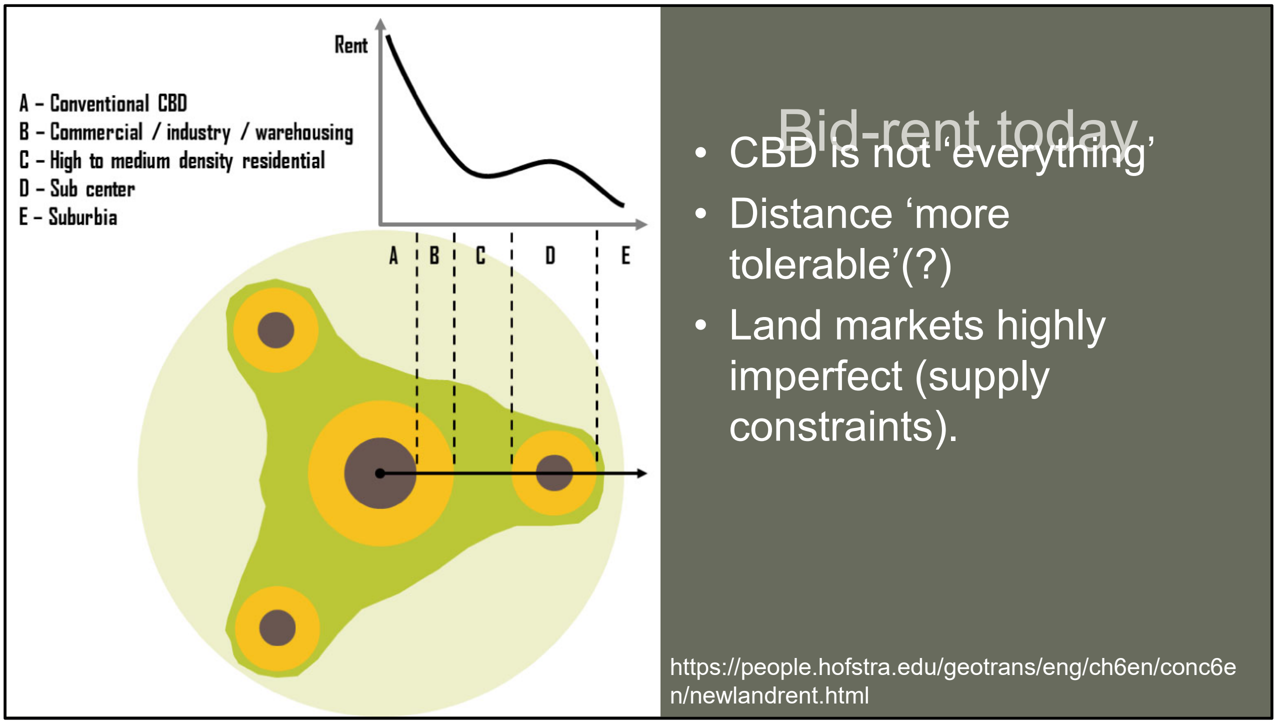


A mobility improvement vis-à-vis the CBD will lower the land value at the CBD, flatten the slope of the bid-rent curve, and extend the built-up area boundary (Figure 2).

This is also associated with more travel, and, thus, more GHGs.



Alonso (1964) conceptually extended his model beyond the monocentric assumption and to different types of transportation networks. Furthermore, a range of "modern" factors have influenced the underlying bid-rent characteristics. Transportation technologies play an important role, for example: the central business district (or CBD) is not necessarily the most accessible location anymore – due to highway expansions and mass automobility. More generally, improvements in transportation and telecommunications have made distances at least more tolerable. Today's modern metropolises are a mosaic of interlinked centers, woven together by the wonders of modern mobility and communication networks.

CBD **not necessarily the most accessible location**.

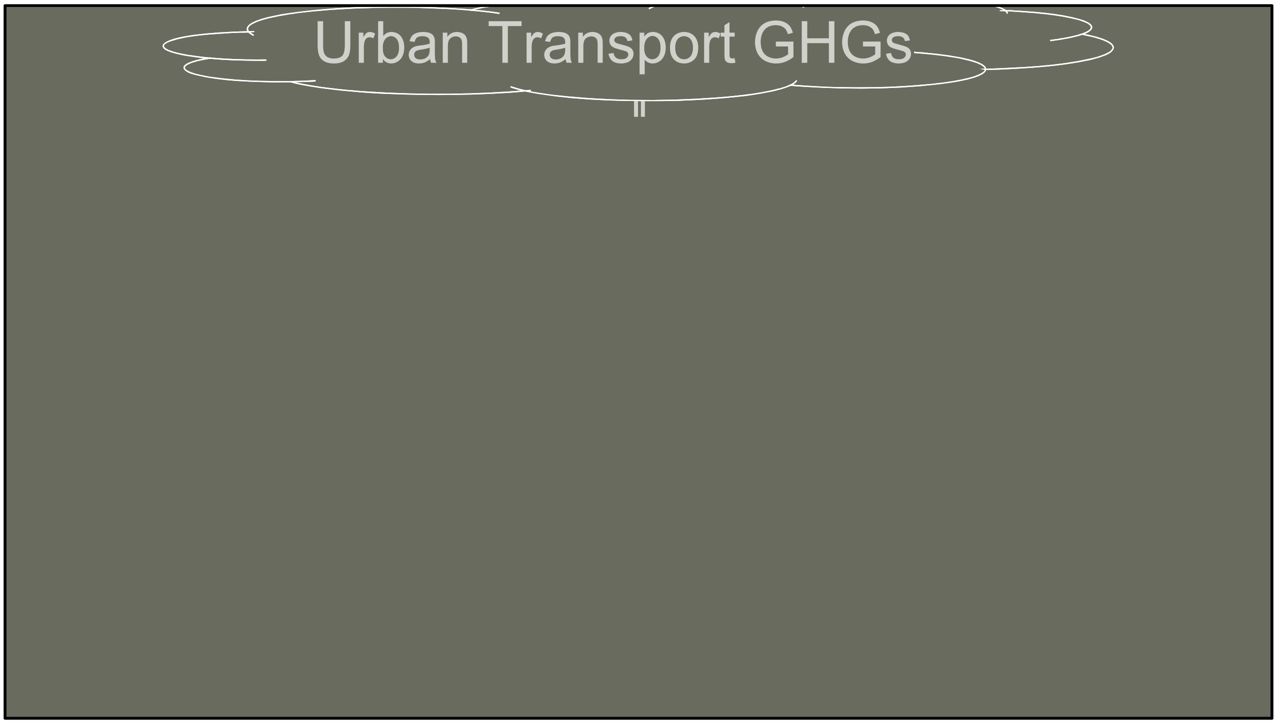
- highway expansions

Improvements in transportation and telecommunications

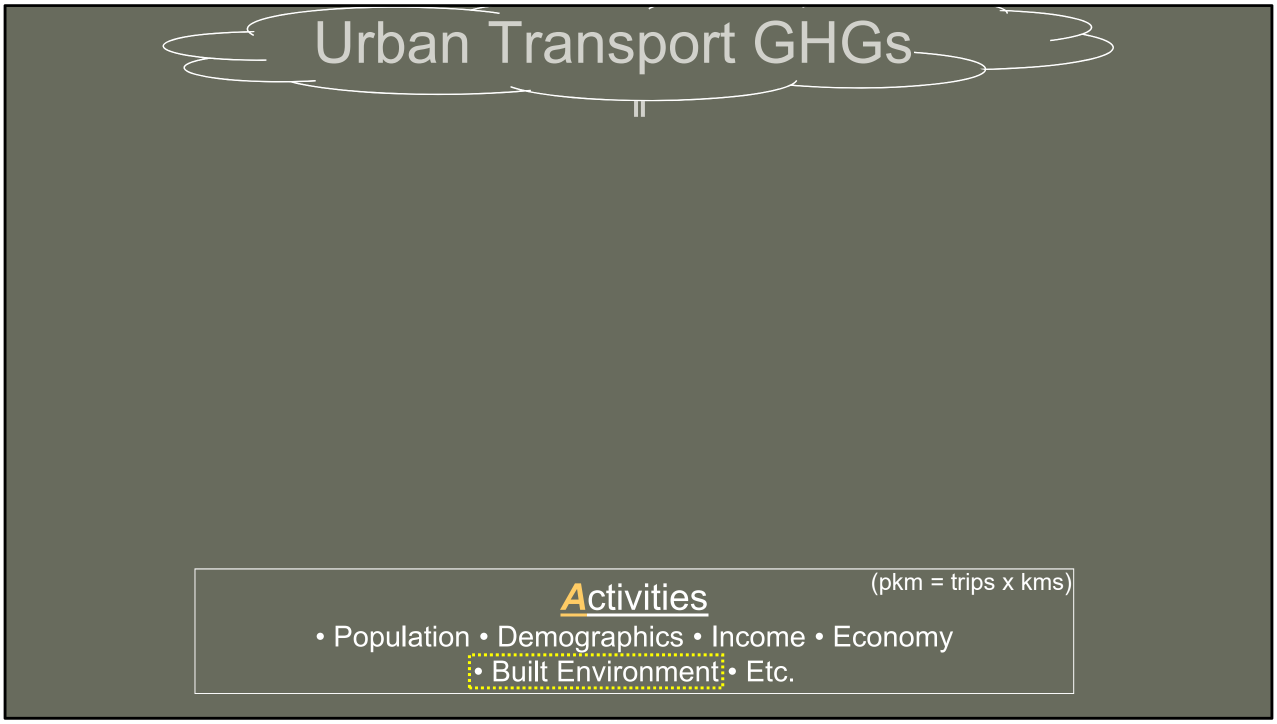
- Distances more tolerable

Land out of market

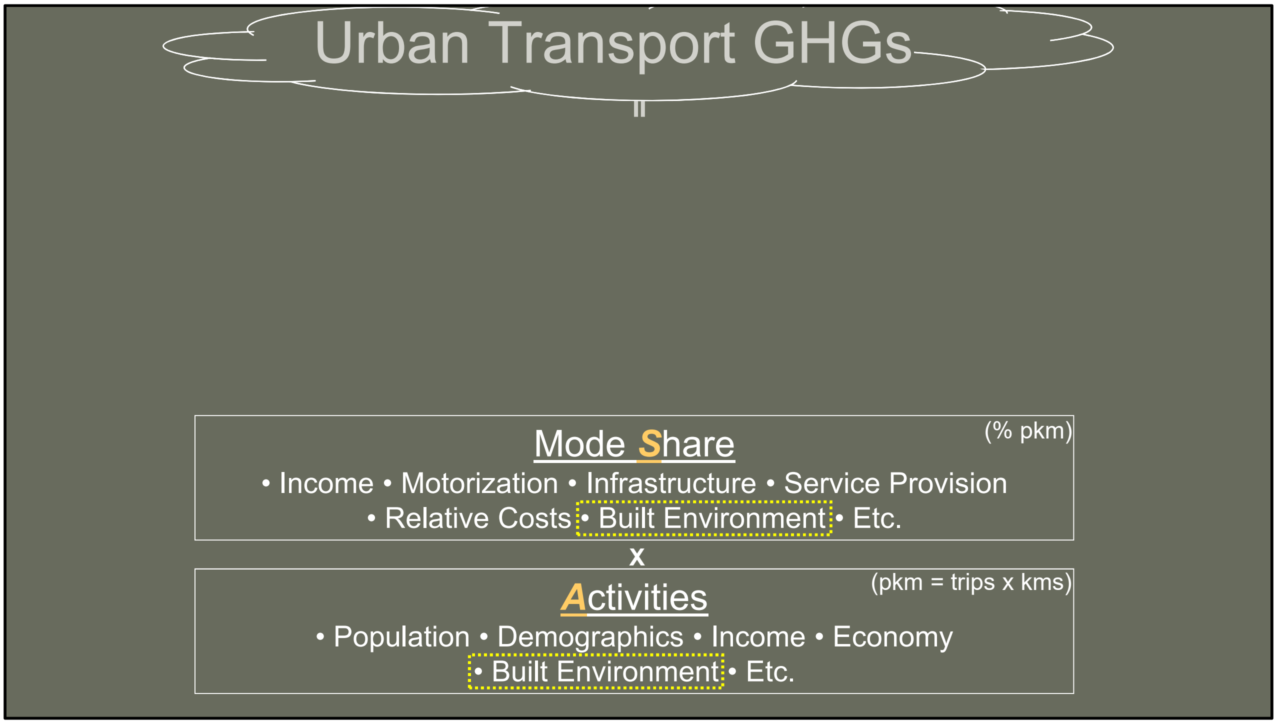
- governments, institutions, parks, infrastructures
- 'artificial' land scarcity, higher prices, further sprawl.



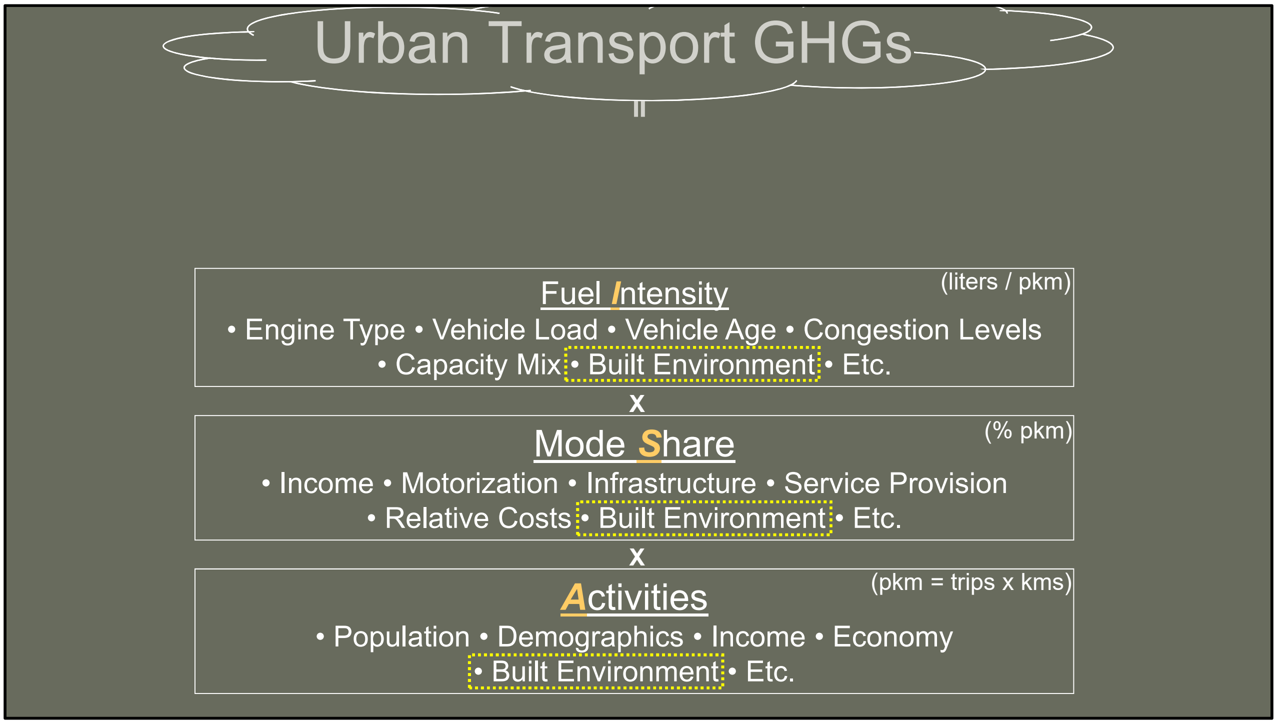
In looking more closely at the "territorial dimension" to mobility decarbonization, let's use the late Lee Schipper's "ASIF" framework. ASIF distinguishes transportation GHGs as a product of total activity (A), mode share (S), fuel intensity (I), and fuel type (F) (thus, ASIF). Multiple factors influence each of the ASIF components with many affecting more than one component. I will briefly illustrate the framework using the case of personal mobility, although the ASIF framework applies analogously to goods mobility and, can be adapted to other mobility impacts, such as local pollutant emissions and safety. I will use the "built environment" as a term to capture various dimensions of territorial development: urban expansion, land uses, design and layout of settlements.



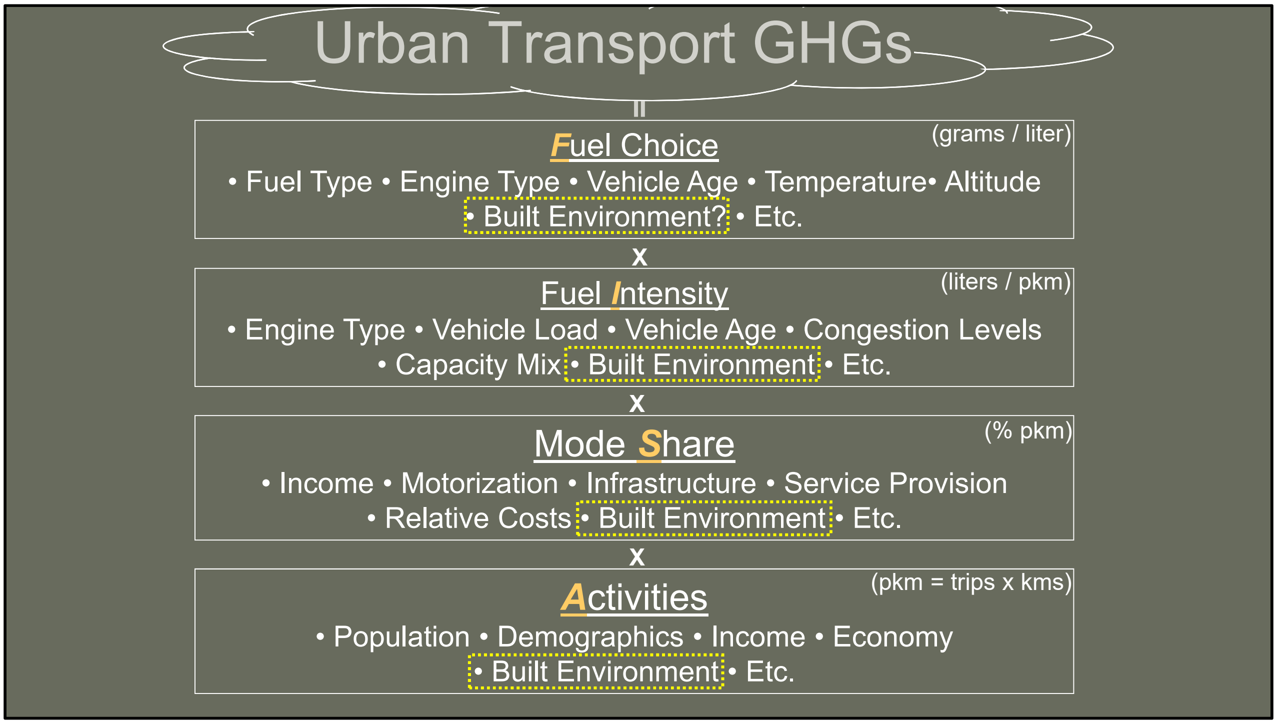
We start with Activities (A) which comprise the underlying force driving mobility emissions. Activities represent our fundamental demand for accessibility. In our desire for accessibility, to carry out activities, we often make trips, across distances. A range of factors influence our activity demands and their translation into mobility demand. These include: age and gender; income; the economy and its composition; and urban form and size, which affect the spatial distribution of activities and total travel distances.



Mode share (S) influences mobility energy use and emissions because different travel modes have different emission rates, with human-powered transportation, for example, producing no direct emissions. Again, multiple factors play a role: income influences people's value of time and thus demand for speed, comfort and privacy. Income also influences vehicle ownership, determining the availability of different modes. Infrastructure provision can affect the willingness to choose walking or bicycling options, dictate the availability of certain fixed-transit options, and influence modal attractiveness through effects on speed and reliability. The quality of services provided also plays a role, as do the relative out-of-pocket costs. Again, urban form and design characteristics and local street patterns may well play a role.



In terms of fuel intensity (I) – that is, the consumption of fuel per work (passengers moved) – a range of technological factors play a role, including engine type, technology, and vehicle age. Movement conditions also affect fuel intensity (e.g., stop-and-start travel conditions worsen fuel consumption per distance traveled), as does vehicle occupancy. Urban form and design may influence the latter.

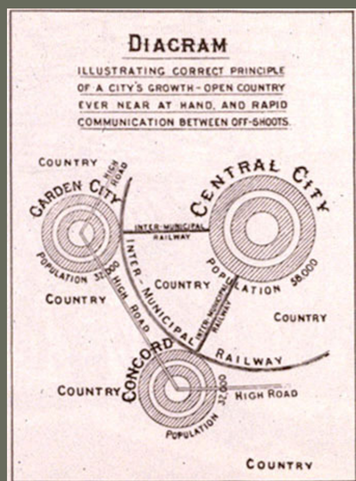


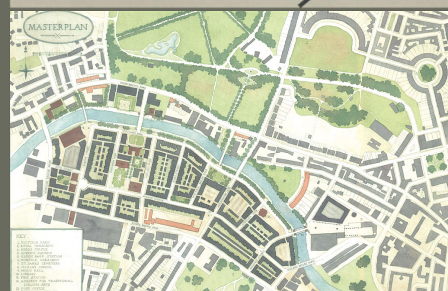
Finally, fuel choice (F) plays a role because GHG concentrations in exhaust differ by fuel type. Natural gas has different GHG emissions than diesel, than gasoline, and so on. In the case of electric-powered mobility, GHG emissions depend on how the electricity is generated, transmitted and distributed.

The fuel choice (F) discussion hints at an important issue: the need to consider lifecycle GHG emissions. Unlike local pollutant emissions, GHGs' ultimate impact (on climate change) is cumulative and relatively time- and place-independent. As such, we need to be concerned about emissions throughout the life-cycle, including: the entire fuel cycle (extraction to vehicle tank), the on-road cycle (vehicle tank to wheels), and the vehicle material cycle. Lifecycle emissions are an issue for all types of vehicles and infrastructures; again, impacts are roughly correlated with size, and speed.

Mobility = *f* (Built Environment)?

Something new?





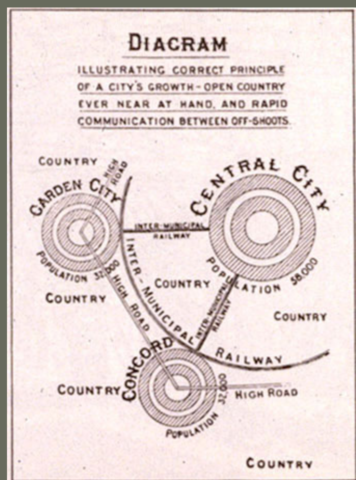
We have two basic ways to enhance accessibility: improve the mobility system, such as with more and/or faster connections; and/or make our desired trip origins and destinations closer together. We can, in short, increase mobility or increase proximity. The latter, **proximity**, is more consistent with decarbonized territories.

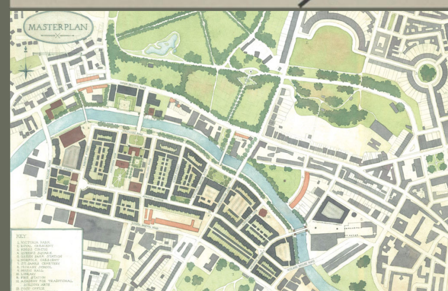
The built environment can be planned and designed in such a way as to influence mobility towards desired outcomes.

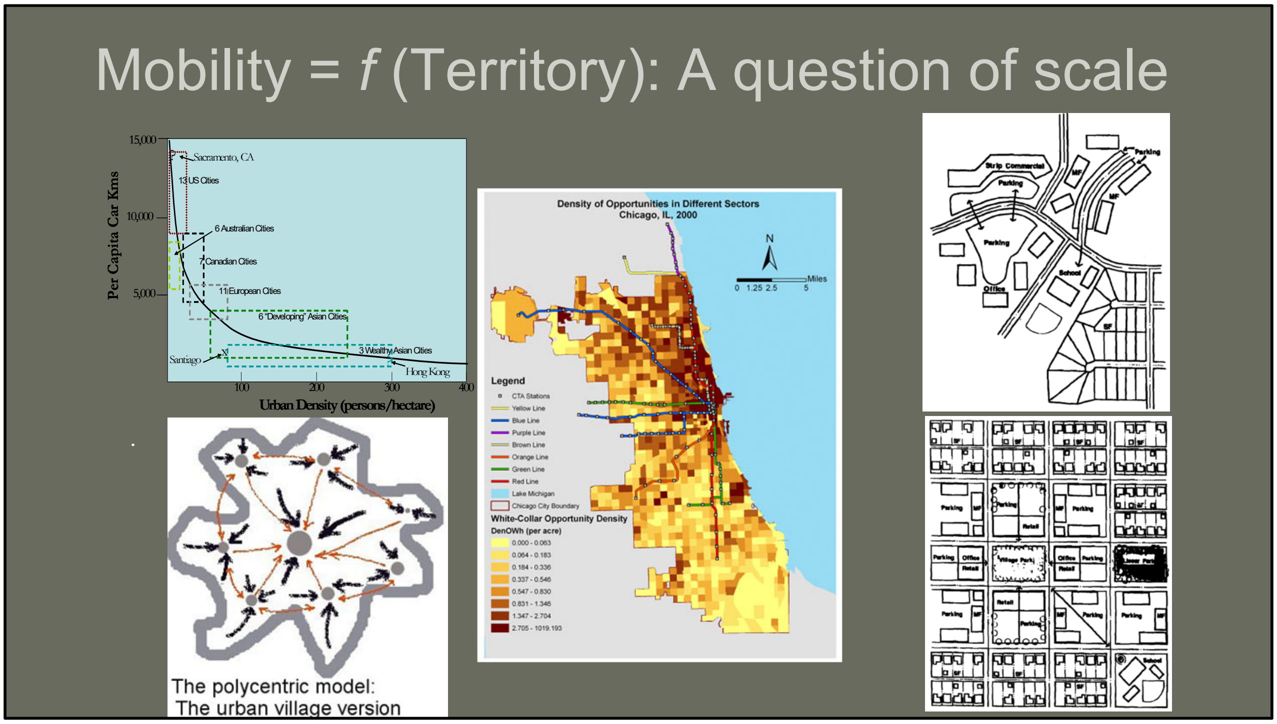
Indeed, efforts aimed at using urban design and planning to influence travel behavior can be seen in the Howard's original "Garden City" movement of the early 20th Century in the UK, the mid- 20th Century "new community" movement in the U.S., and Dutch spatial planning policies begun in the 1960s.

Mobility = *f* (Built Environment)?

Something new?





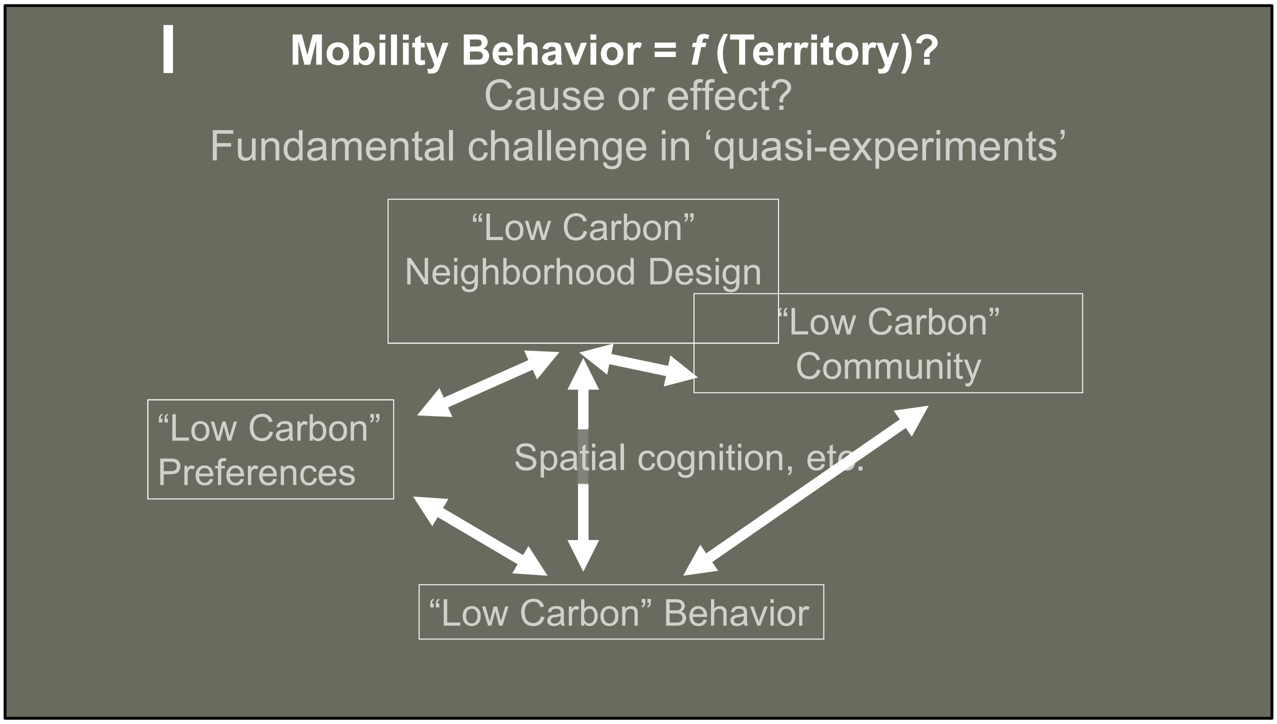


In metropolitan areas, the BE's potential influences on travel behavior play out at three different spatial scales: the metropolitan (structural) scale, since total city spatial size is apparently associated with total motorized distances traveled (e.g., Cameron et al., 2003); the intra-metropolitan scale (or relative location, "meso"-scale), since, for example, household distance to the city center apparently correlates with motor vehicle trip rates (e.g., Crane and Crepeau, 1998); and the local/neighborhood ("micro"- or "design"-) scale, since characteristics like dwelling unit density, block size and land use mix may influence vehicle and person distances traveled (e.g., Krizek, 2003).

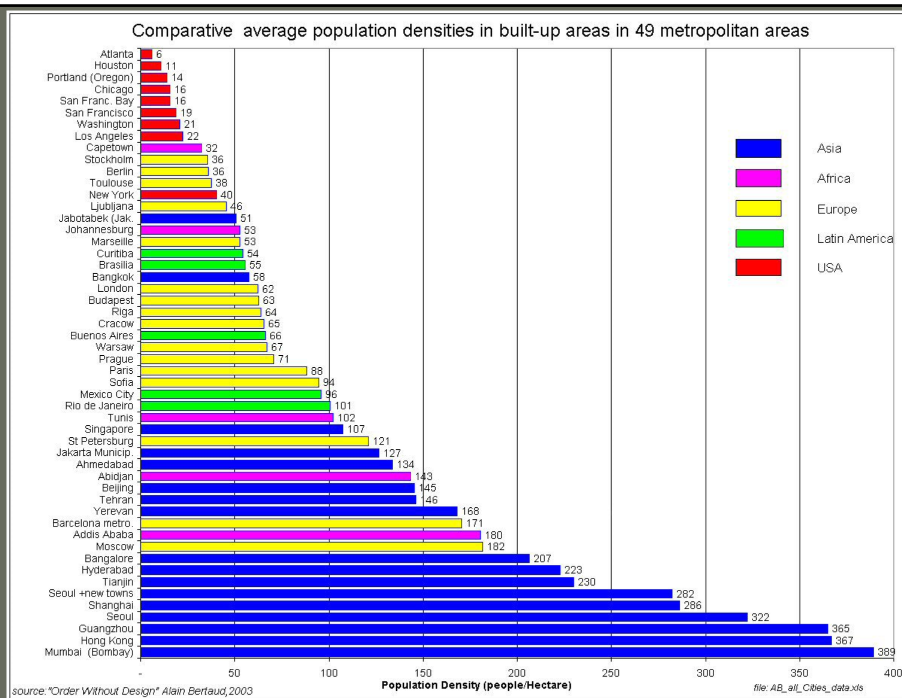
Theoretically, the BE at these three scales exerts the same general influence. The BE at least partly determines the total number and relative quality of potential activities (i.e., employment, shopping, entertainment, etc.); the relative distribution of those activities and, thus, travel distances; and the relative travel costs implicit in traversing those distances by various modes.

These scales do not operate in isolation. Influence each other, both b/c BE at micro scale might be conditioned by meso and macro scale and vice versa; and b/c behavioral implications at one scale influence another:
H1: Vehicle trip frequency and VKT (for work, shopping, and social/recreational purposes) within the local action space are mainly affected by urban micro-scale characteristics and

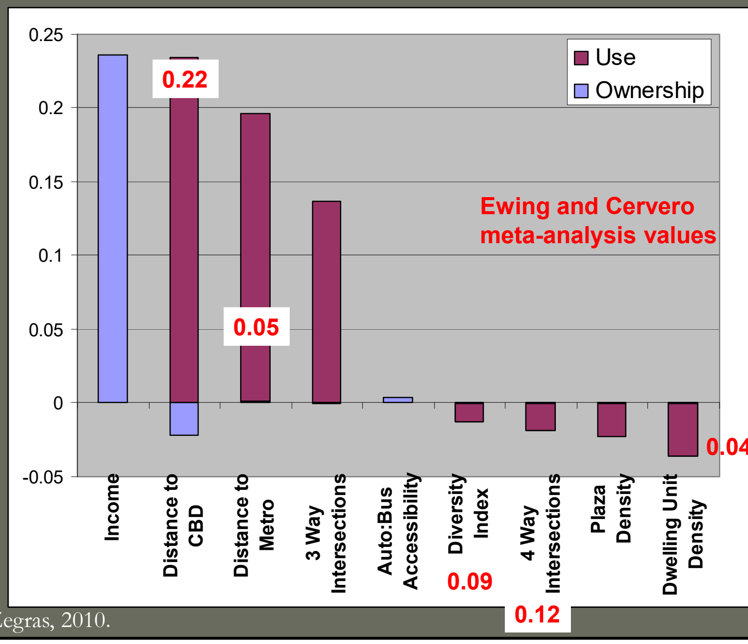
less affected by urban macro-scale characteristics.
H2: Vehicle trip frequency and VKT (for work, shopping, and social/recreational purposes) outside of the local action space are mainly affected by urban macro-scale characteristics and less affected by urban micro-scale characteristics.



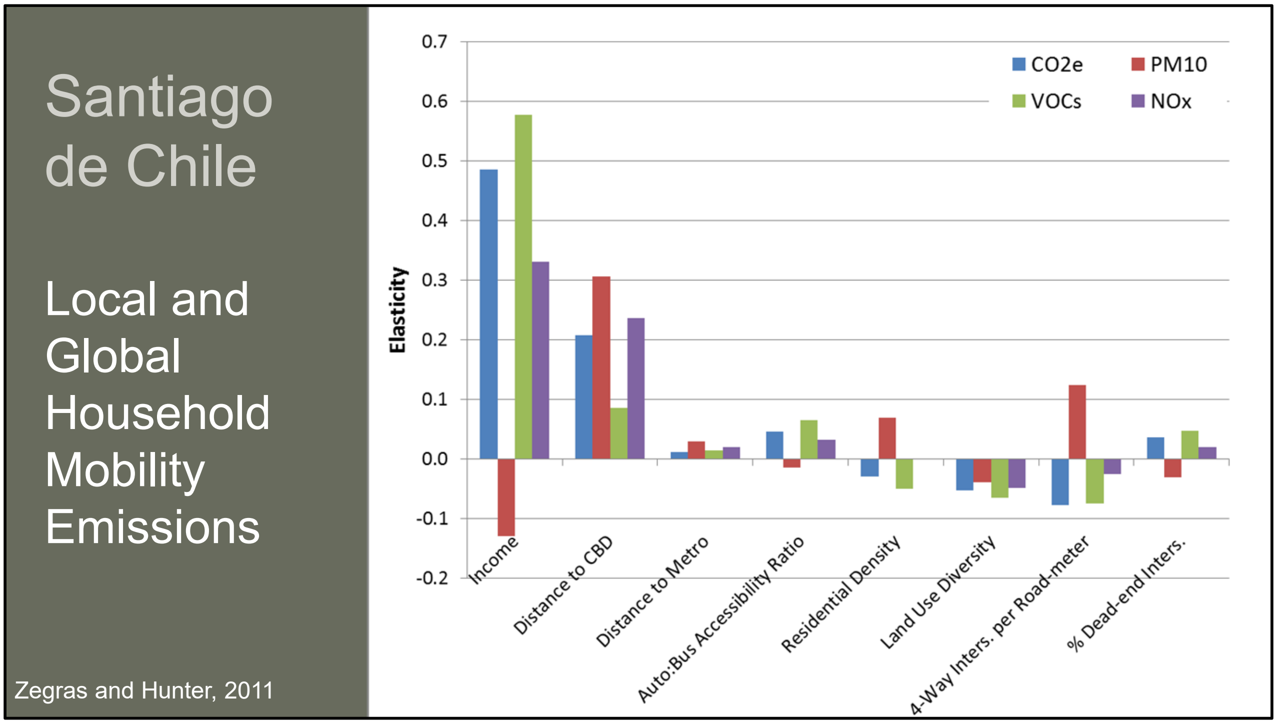
the impacts of the built environment on travel behavior are ambiguous and complex. We don’t know, for example, what people might do with travel time savings and the outcomes depend on complex time routines, lifestyles, family cycles, the type of potential activities and related constraints in time and space. Since we cannot know, a priori, what the built environment might do to mobility behavior, what does empirical evidence suggest?


Comparative average population densities in built-up areas in 49 metropolitan areas
Atlanta 6
Houston 11
Portland (Oregon) 14
Chicago 16
San Franc. Bay 16
San Francisco 19
Washington 21
Los Angeles 22
Capetown 32
Stockholm 36
Berlin 36
Toulouse 38
New York 40
Ljubljana 46
Jabotabek (Jak. 51
Johannesburg 53
Marseille 53
Curitiba 54
Brasilia 55
Bangkok 58
London 62
Budapest 63
Riga 64
Cracow 65
Buenos Aires 66
Warsaw 67
Prague 71
Paris 88
Sofia 94
Mexico City 96
Rio de Janeiro 101
Tunis 102
Singapore 107
St Petersburg 121
Jakarta Municip. 127
Ahmedabad 134
Abidjan 143
Beijing 145
Tehran 146
Yerevan 168
Barcelona metro. 171
Addis Ababa 180
Moscow 182
Bangalore 207
Hyderabad 223
Tianjin 230
Seoul +new towns 282
Shanghai 286
Seoul 322
Guangzhou 365
Hong Kong 367
Mumbai (Bombay) 389
Asia
Africa
Europe
Latin America
USA
- 50 100 150 200 250 300 350 400
Population Density (people/Hectare)
source: "Order Without Design" Alain Bertaud, 2003
file: AB_all_Cities_data.xls

Santiago de Chile: Elasticities of Auto VKT



Zegras, 2010.



This Graphic shows the elasticity of household emissions with respect to various dimensions of relevance. It shows that income drives emissions (CO_2 and other emissions linked to car ownership and use); but a combination of factors related to territorial development also play a role:
The combination

USA: GHG Emission Sources

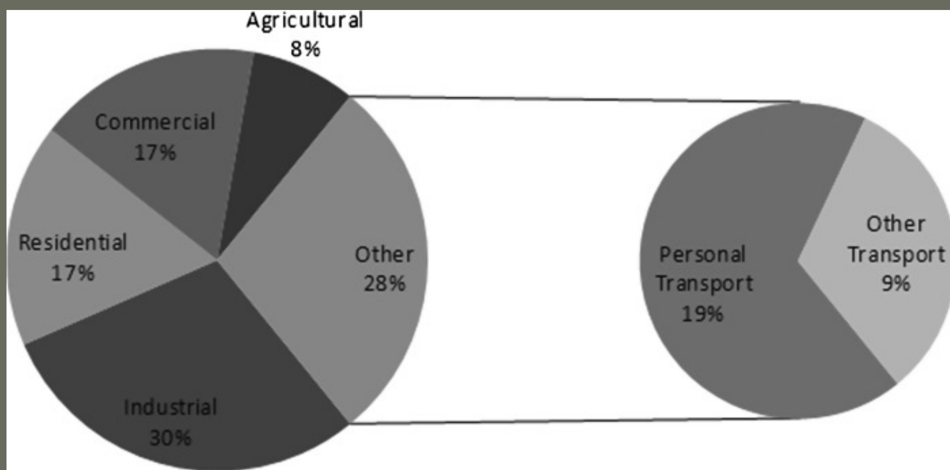
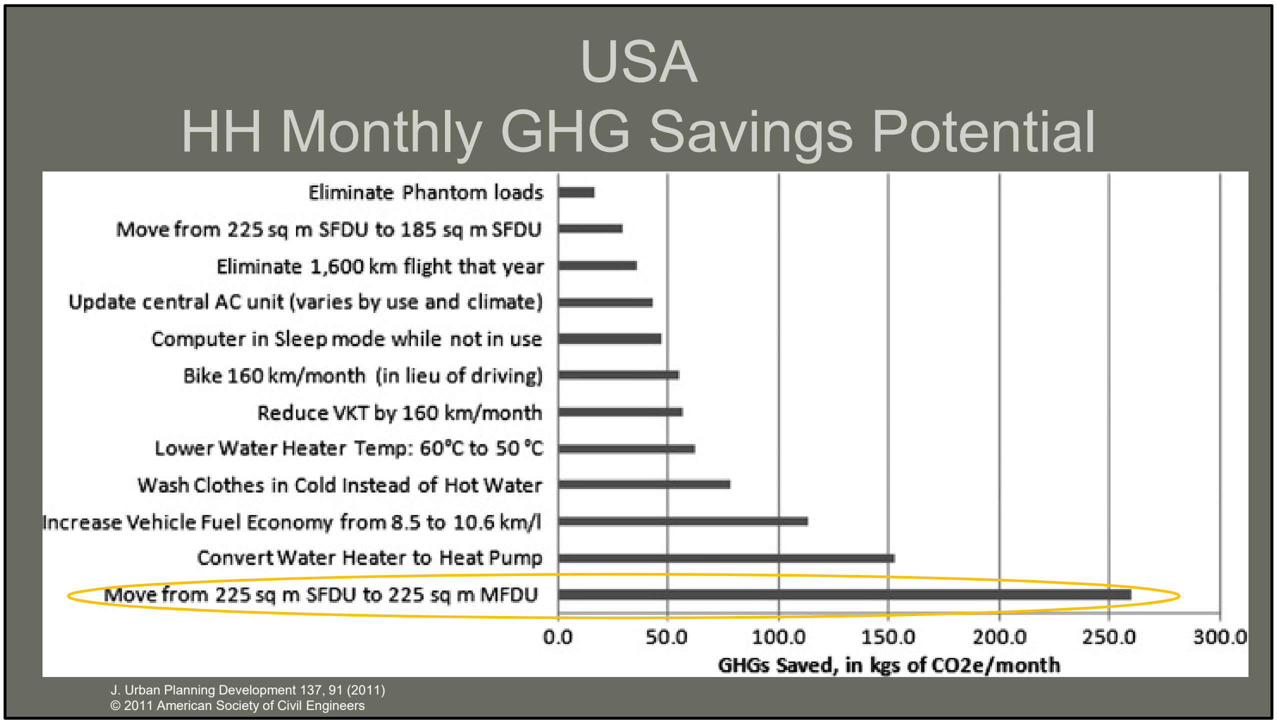


FIG. 1. U.S. sources of GHG emissions

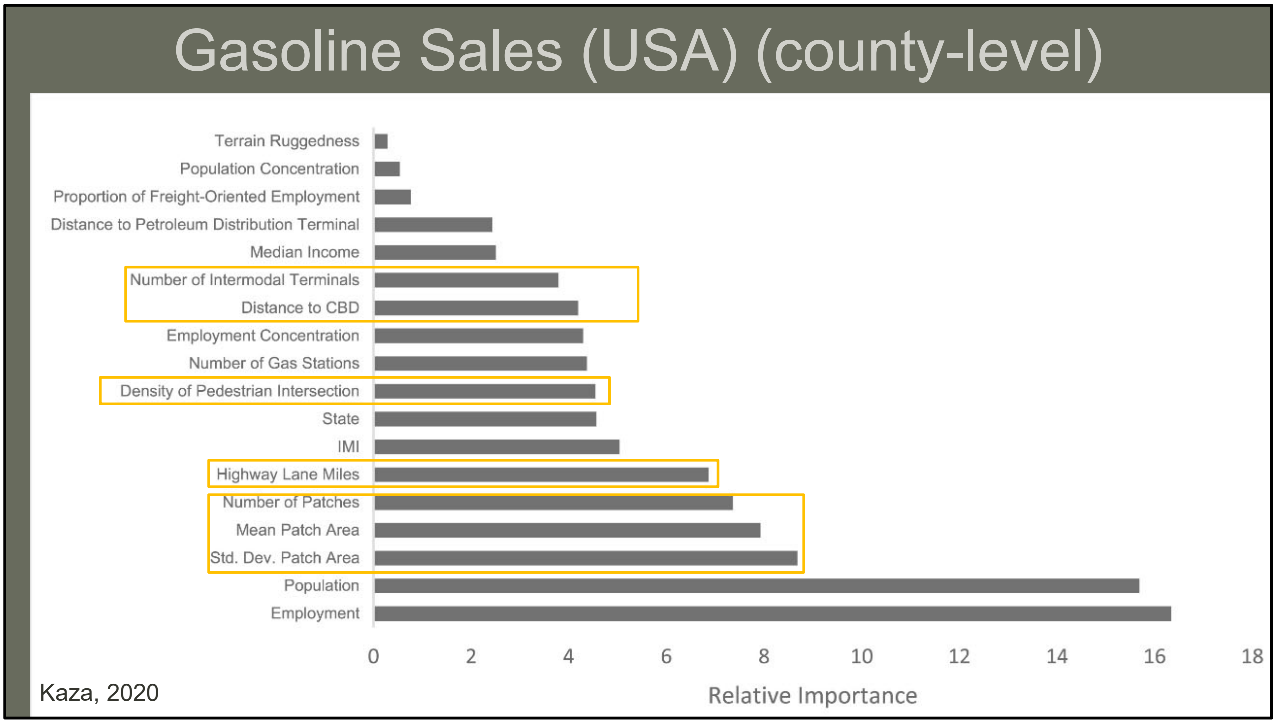
J. Urban Planning Development 137, 91 (2011)



An analysis about 10 years ago showed that the largest impact on household greenhouse gases would be to move from a single family dwelling unit to a multi-family dwelling unit.

Apartments are more energy efficient.

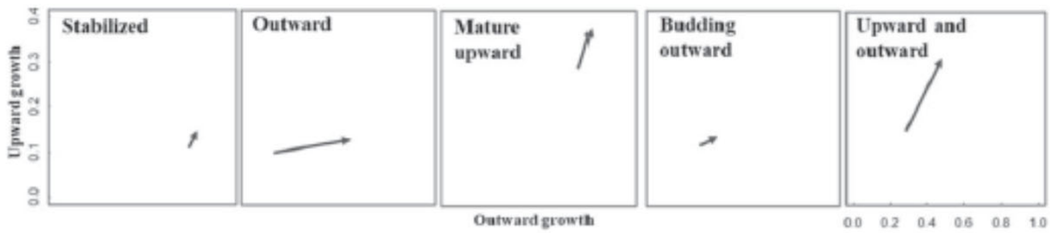
And, tend to be more consistent with compact development.



A recent analysis of gasoline sales in the USA. Most of the indicators of sprawling urban form are associated with higher consumption. But the effects are not large, relatively speaking.

Still changing the patterns of development can be beneficial. In particular, regulations such as urban growth boundaries and programs to promote infill development might reduce energy consumption patterns modestly.

The availability of highway infrastructure is also associated with increase in consumption and is an important indicator. This provides some evidence for induced travel. While the infrastructure availability is correlated with population and employment, its independent effect suggests that we should pay close attention to the decisions about road infrastructure. Lane miles are correlated to fragmentary patterns, especially in micropolitan and non-core counties, exacerbating the effect of urban form. Coupled with the fact, that large proportions of commuters use private automobiles, promoting alternative and less energy intensive and more healthy transportation modes such as biking and walking by providing more infrastructure for them would be useful. This conclusion is substantiated by the importance of pedestrian oriented intersections in the models.



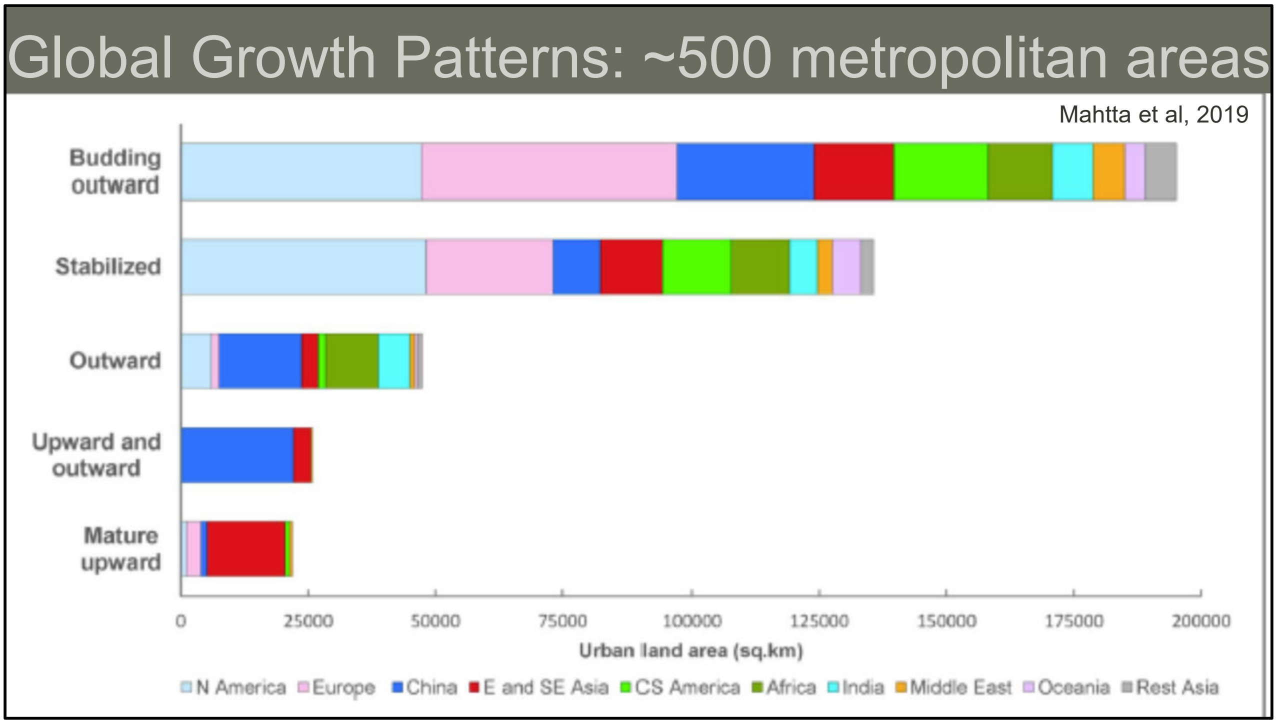
Urban growth typology	*Stabilized*	*Outward*	*Mature upward*	*Budding outward*	*Upward and outward*
Initial Horizontal extent (GHS 2000)	Very large	Very small	Very large	Small	Medium
Initial Vertical extent (PR 2001)	Medium	Very small	Very large	Small	Medium
Change in horizontal extent	Very low	Very high	Very low	Moderate	Moderate
Change in Vertical extent	Low	Low	Moderate	Very low	Very high

Mahtta et al, 2019

Factors influencing growth patterns (highly generalized/stylized)

- Singapore and Hong Kong - constraints
- Japan and Korea- aging
- China upward and outward- strong govt control and land for money.
- India - outward. Money but also restrictions on FAR
- Africa - money and institutionality

Mahtta et al, 2019



Building up or spreading out? Typologies of urban growth across 478 cities of 1 million+
They identify 5 growth typologies:
"Budding Outward" dominates urbanization.
North America: budding outward or stabilized
Europe and CS America: budding outward (transport technology playing a role?)
East Asia: lots of heterogeneity

- Mature upward: Japan and Taiwan (most of the world's 'mature upward')

China has a big mix.

Implications

- Budding outward dominates: opportunity to shape future!
  - Can we move to ‘budding upward’?
- Many factors influencing patterns of growth: markets, policies, etc.
- Within-city variation is high
- Urban form is “carbon lock-in” – how to change?

Mahtta et al, 2019

Implications: Institutions matter

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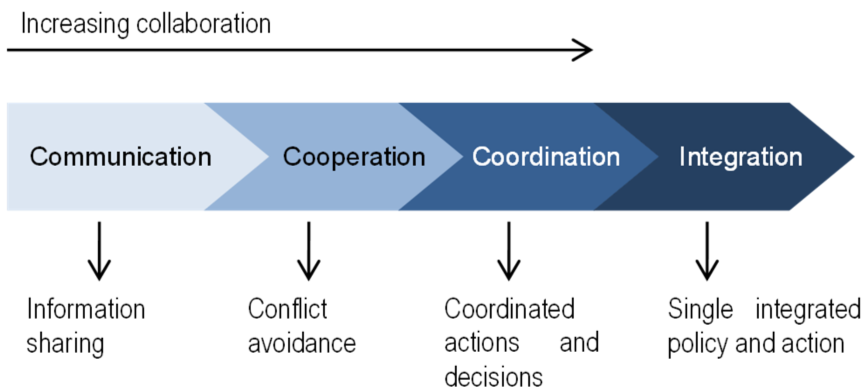
Collaboration Continuum



Rayle and Zegras, 2012.


KEEP RIGHT
DANGER
SIDEWALK
ENDS

“Public” Goods?

	Excludable	Non-excludable
Rivalrous	Private Good - Car	Common Good - Typical street, sidewalk
Non-rivalrous	Club/Toll Good - Private automobile travel? - Congestion-priced highway	Public Goods - Clean air… - National defense - Transport example?

Institutional Challenges: Disciplines?

Institutional Challenges: Disciplines?

- Models?
- Decision Criteria?
- Time Frame of Analysis?
- Culture of Analysis?
- Institutional Setting?
- Methods of Intervention?

Does a "solution" to metropolitan governance exist?

- Incrementalism is only likely path
- Depends on nature of 'problem' and perceptions of 'problem'
- Choice matters (variation in preferences)

- Collaboration feeds collaboration (positive feedback loop).
- Nature of collective action maters
  - TRANSACTION COSTS (negotiating, monitoring, enforcing agreements, etc.).

Incrementalism is only likely path
Depends on nature of 'problem' and perceptions of 'problem'
Choice matters (variation in preferences)

Collaboration feeds collaboration (positive feedback loop).
Nature of collection action maters: TRANSACTION COSTS (negotiating, monitoring, enforcing agreements, etc.).

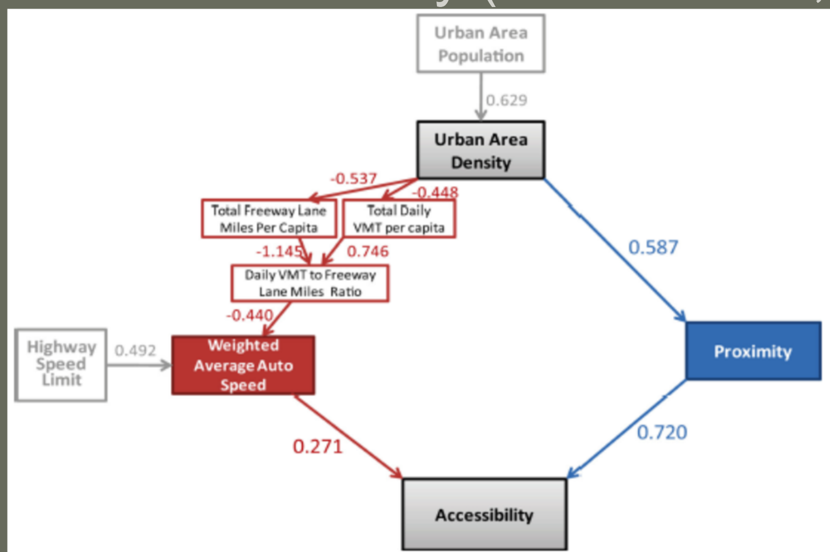
Institutional Challenges, in sum

History matters….

- Philosophical
- Political
- Disciplinary
- Government and Governance
- Types of “goods”

Common good vs. individual freedoms
Disciplines
Political structures: new institutions produce winners and losers; motivations differ.
Governance Structures and rules (history matters).

Speed versus density (Levine et al., 2012)

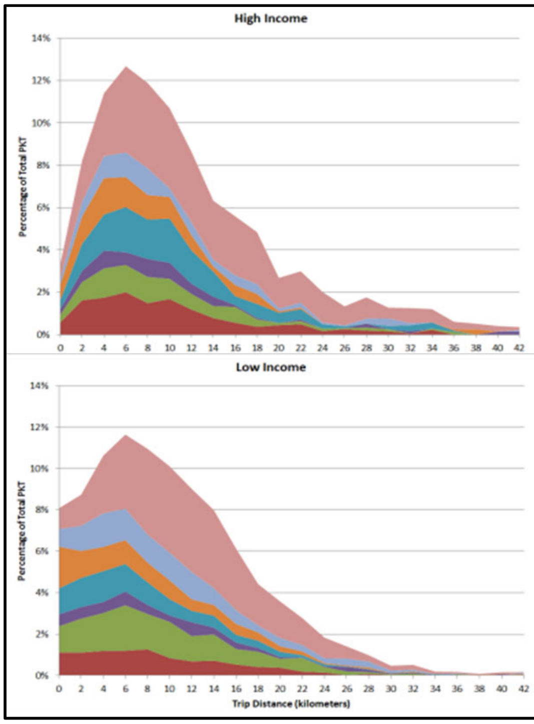


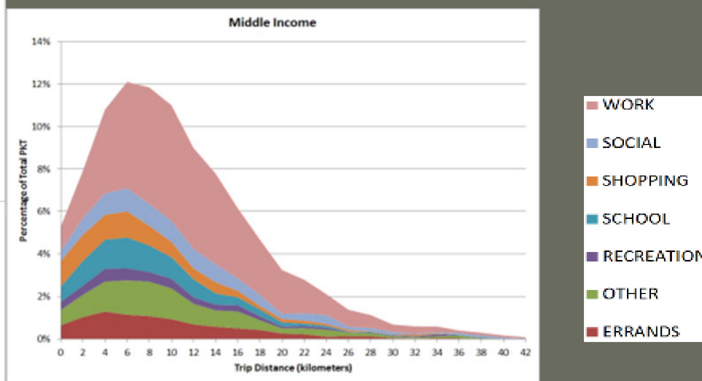
Higher density can mean lower speed; distances constant, accessibility goes down.
Higher density can shorten distances. Speed constant, accessibility goes up.

Levine et al look at work accessibility, gravity-based, by car. Auto is dominant mode; work is more universal, less diverse preferences. They use a single Beta value (impedance), rather than city-specific betas. Empirical Beta represents both shorter travel being possible as well as constraints on travel; so it gives 'credit' to longer trip-making regions. They derive a 'universal beta' by getting betas from 16 regions: beta= a times exp (b x pop) = (a = 0.109, b =–3.52 x 10^-8). Get beta for each region and then take the median beta for calculating accessibility for 38 regions.

Multiplying along paths and adding parallel paths, gives -0.123 for density to speed; 0.584 for density to proximity.
Total path on speed side is -0.033; on proximity side 0.423. more than times the effect on the proximity path.

Santiago





Share of Total Household Passenger kilometers traveled (PKT) by distance traveled and purpose

Zegras and Hunter, 2011

Santiago

HH Motor Vehicle Ownership (# vehicles) =
f (HH Characteristics, Urban Form, Urban Design)

Selection bias and endogeneity

Motor Vehicle Use (VKM/day) =
f (# vehicles, HH characteristics, urban form, urban design)