

MOBILITY AND URBAN FORM

Heightened concerns over climate change, rising gasoline prices, traffic congestion and social exclusion have sparked renewed interest to explore the link between mobility and urban form.¹ Worldwide, city officials share relatively similar concerns about travel time, air quality, road accidents, social integration, better accessibility and improved use of different modal transport solutions.

Despite this, most cities, particularly in developing countries and emerging economies, continue to prioritize motorized transport and related urban infrastructure. A large number of cities both in the developing and developed countries are experiencing fast and uncontrolled growth in their peripheries. Consequently, there is a wide variety of urban forms, defined by land-use and transportation systems that are not conducive to the provision of 'efficient' forms of urban mobility. There can be little doubt that designing neighbourhoods, cities and regions in a way that can reduce private car dependency, promote healthier, more sustainable urban forms and a variety of travel solutions, can make the city more accessible to all. The pressure to develop sustainable transportation and mobility systems is particularly acute in urban areas.

In recent years, city planners, developers and policy-makers have increasingly looked towards designing more compact cities with a mixture of land uses in order to achieve a more sustainable urban form. The 'compact city' policy, although difficult to implement, can help shorten travel distances, thus lower emissions and fuel consumption, reduce travel costs and improve quality of life in many cities. However, there is need for better solutions on how to move from current unsustainable trends in urban form and transportation towards a more sustainable future.

There is increasing evidence that the form and functionality of the city is crucial for the promotion of sustainable mobility. Indeed, transforming cities wherein a mix of activities is closer together, in a more compact configuration, and interlaced by

high-quality pedestrian and bicycle infrastructure, is tantamount to the creation of a more *accessible* city. As stressed in Chapter 1, accessibility lies at the core of achieving an urban form that is environmentally sustainable, socially equitable and inclusive, with higher potential to generate economic interactions that lead to productivity and income gains. Sustainable mobility is an outcome of how cities and neighbourhoods are designed and take form, but it also shapes the urban form itself. This reflects the powerful, bi-directional relationship between mobility and urban form that underscores the importance of carefully coordinating and integrating the two. A re-invigorated notion of urban planning, solid institutions and governing structures is therefore required, which can lead a process for this transformative change.

A number of pressing mobility and environmental issues, which policy-makers at all levels of government are wrestling with today, hinge on changes in the design and form of cities for a more efficient and sustainable solution. With the transport sector accounting for nearly a quarter of greenhouse gas emissions in metropolitan areas worldwide, campaigns to stabilize the global climate include the creation of less car-dependent urban forms.² Stopping sprawl,³ promoting public-transport-oriented growth and creating compact, walkable neighbourhoods that reduce vehicle-kilometres travelled (VKT) per person are the cornerstones of such campaigns. The EU's Climate Change Programme calls for the promotion of 'low-emission land-use activities' as a way to moderate VKT growth, making an interesting connection between urban form and transport.⁴ It is important to track VKT per capita, as it is the strongest single correlate of environmental degradation and resource consumption in the urban transport sector. It has been projected that, in the absence of substantial reductions in VKT per capita worldwide, all increases in fuel-efficient and low-carbon fuels will only slow, not reverse, the rise in per capita CO₂ emissions.⁵

The form and functionality of the city is crucial for the promotion of sustainable mobility

Accessibility lies at the core of achieving an urban form that is environmentally sustainable, socially equitable and inclusive

‘Sprawl’ [burdens] municipal budgets, imposing high costs for extending infrastructure and public services to suburbs and exurbs

Environmental objectives are but one reason for moderating urban travel. There are important economic and social considerations to be made as well. Spread-out, car-oriented development patterns, commonly referred to as ‘sprawl’, burden municipal budgets, imposing high costs for extending infrastructure and public services to suburbs and exurbs. The ‘hard cost’ of providing local roads and utilities for low-density growth is upwards of US\$30,000 more per household in the US compared to more compact, mixed-use growth.⁶ If one-third of the future urban growth of the US were directed toward central cities and inner-suburbs, an estimated US\$10,000 per household (in year 2000 US\$) could be saved.⁷ A recent study estimated that converting peripheral housing projects to infill planned residential developments in the consolidated parts of Malaysian cities could reduce the financial costs for municipal services by 19 per cent.⁸

Physical separation from jobs, schools, and health clinics imposes economic burdens on the poor

Growing concerns over social equity have also prompted interest in the design of cities. Physical separation from jobs, schools and health clinics imposes economic burdens on the poor, many of whom reside on the urban periphery. Overcoming this physical separation often means devoting disproportionate shares of income to public transport fares and enduring long journeys. Besides shortening journeys and making social amenities more accessible, the connection between adequate transport solutions and the provision of public goods can promote more social interactions and when done properly, gives rise

to urban form that is conducive to community building and ‘place making’.

This chapter describes current global trends and conditions that have influenced urban form and as a result, mobility (or the lack thereof). Forces propelling the spread-out growth of cities and the impacts of these trends on urban mobility are discussed. The capacity of higher urban densities to encourage alternative means of travel, particularly public transport usage, is reviewed. Other elements of built environments, such as the diversity of land uses and urban designs, like integrated bikeway networks, and their implications for travel, are also examined. Creating compact, mixed-use and highly walkable neighbourhoods and cities can create more accessible urban landscapes, and in so doing moderate levels of motorized travel and the ill-effects associated with it. More accessible cities are also more socially equitable and inclusive. The other direction of the relationship – how urban transport infrastructure, such as motorways and metro-rail systems, shapes urban form – also receives attention. The chapter closes with discussions on the potential of various policy strategies, such as transit-oriented development (TOD) and regional jobs–housing balance, to strengthen mobility–urban form linkages and promote sustainable transport modes.

Box 5.1 Suburbanization in Eastern Europe

The transitional economies of Eastern Europe have witnessed rapid suburbanization. During the era of centralized planning, most cities in Eastern Europe were products of integrated transportation and land development, characterized by extensive urban rail networks with residential towers, shopping districts and industrial zones physically oriented to stations. The change to free-market economies and privatization of land development quickly unravelled this. In some Eastern European countries, the rate of suburbanization has surpassed that of cities in Western Europe. The latest studies of land-cover changes have ranked cities in Estonia, Latvia, Croatia, Slovakia, Poland, Hungary and Bulgaria, as among the most sprawling urban areas in Europe. By one account:

“‘communist’ urban forms were by many measures more environmentally friendly and, thus, more sustainable than capitalist urban forms. They were more compact and had smaller ecological footprints; they were high-density and had a clear urban edge rather than sprawling and mono-functional suburban-type peripheries; they had better integrated land uses and were less socially polarized; they had abundant parks and greenbelts; and, they had reliable

public transit systems. Ironically, all these aspects of the communist city are hallmarks of urban sustainability. Most of them were lost during the post communist transition.”^a

Privatization of land development, such as the construction of mega-malls and housing estates on the periphery, coincided with the abandonment and often discontinuation of former state-owned urban rail services, which along with the rapid growth in private car ownership resulted in motorways being built in their place. Some observers have criticized international aid agencies – such as the European Bank for Reconstruction and Development and the European Investment Bank – for fanning the flames of sprawl in Eastern Europe by favouring investments in suburban motorways over revamping and upgrading aging inner-city rail lines. Hyper-suburbanization has spawned dramatic shifts in travel, such as in Prague, Czech Republic, where former trips by foot or public transport to central-city shops are rapidly being replaced by long-distance car trips to freeway-served malls and large-scale retail outlets, dramatically increasing VKT.

Sources: Suchorzewski, 2011; Hirt and Stanilov, 2009; Hook, 2001; Newmark et al, 2004; ^a Hirt and Stanilov, 2009, p63.

Box 5.2 Dispersed growth in India

In recent years, Indian cities have witnessed an accelerated transformation of agricultural lands on their peripheries to new townships, residential subdivisions and commercial centres. This has led to marked increases in traffic congestion, air pollution, demand for roads and parking, accidents and energy consumption. Around Mumbai, seven new towns have emerged within 50 kilometres of the old city. Around Delhi as well, new urban centres have cropped up within 20 to 50 kilometres radius of the city centre.

Most public policies in India encourage sprawl. In an explicit attempt to decongest city centres, government regulations limit floor to land area ratios for buildings in the centre, and thus restrict building heights and development densities. By contrast, government regulations allow higher floor space indexes in suburban areas, effectively pushing new growth from the core to the periphery.

Sources: Bertaud, 2011; Glaeser, 2011.

DECENTRALIZATION, CAR DEPENDENCE AND TRAVEL

This section reviews the influences of decentralized urban growth on mobility and travel worldwide, the role played by transport in the decentralization process, as well as the impact of urban densities and urban land coverage on travel.

The dispersal metropolis

The dispersal of growth from the urban centre is a worldwide phenomenon. Dispersal, as a form of decentralization, at least when it is poorly planned, lies at the heart of unfolding patterns of urban development that are environmentally, socially and economically unsustainable. With dispersal come: lower densities, separation of land uses and urban activities, urban fragmentation, segregation by income and social class, consumption of precious resources such as farmland and open space and more car-dependent systems. While megatrends like rising affluence and modernization have fuelled the dispersal of cities worldwide, social-cultural factors have played a role as well. In Latin America, land held by government agencies, military authorities and religious foundations often triggers leapfrog (i.e. skipped-over) development.⁹ Social exclusion, class segregation and poverty itself can also stretch the boundaries of cities; *tugurios* and *favelas* (i.e. slums) mark the peripheries of most Latin American cities. In Chinese cities, peri-urban development is partly driven by financial motives, e.g. municipalities buy land at low agricultural prices and lease the land to developers at higher prices as a way to raise revenues. Like in China, the transition to free-market economies has accelerated suburban growth throughout Eastern Europe (Box 5.1). In India, zoning policies that suppress permissible densities as a means of decongesting central cities have been blamed for inducing sprawl in recent decades (Box 5.2). Easy-to-obtain credit for low-income housing has triggered an explosive growth in low-cost but isolated residential enclaves on the outskirts of many Mexican cities,

which over time has led to abandonments; between 2006 and 2009, some 26 per cent of such housing that was built was unoccupied.¹⁰ Nearly a third of individuals who abandoned their homes did so because of poor access to jobs, schools and family.

Urban dispersal has an unmistakable and profound influence on travel. Spread-out growth not only lengthens journeys by separating trip origins and destinations, but also increases the use of private motorized vehicles. In developed countries, suburban living, associated with the lowering of population and employment densities, has contributed to rising motorization rates and the environmental problems related to car dependency. When urban dispersal is driven almost exclusively by market forces and is largely unplanned, car dependency, energy consumption, environmental degradation and social problems in urban areas are further exacerbated (Box 5.3). Over-regulation of urban development (e.g. zoning codes that require significant supplies of off-street parking) can also induce car-dependent sprawl by suppressing market preferences. Increasingly, trends both in developed and various developing countries suggest that many young adults want to live in compact, walkable neighbourhoods.¹¹

Urban sprawl is increasingly prevalent in developing countries. From 1970 to 2000, the physical expansion of all urban areas in Mexico was nearly four times more than their urban population growth.¹² In Cairo (Egypt), Sana'a (Yemen), Panama

Dispersal of growth from the urban centre is a worldwide phenomenon

Box 5.3 Urban sprawl

The term 'urban sprawl' describes low-density, dispersed, single-use, car-dependent built environments and settlement patterns that, critics charge, waste energy, land and other resources and divide people by race, ethnicity and income/wealth. A cardinal feature of sprawl is the physical separation of co-dependent land uses – e.g. housing is isolated from jobs, schools, hospitals, retail activities, etc. – leading to increasingly lengthy (and thus resource-consuming) journeys. Sprawl is synonymous with poorly planned, piecemeal and haphazard patterns of urban growth, requiring larger shares of trips to be made by motorized modes over increasingly longer distances.

Sources: Ewing, 1997; Burchell, 2005; Burchell and Mukherji, 2003; Tsai, 2005.

Class and income disparities are deeply embedded in the spatial arrangements and mobility challenges of many developing-country cities

Urban densities can be expected to decline another 26 per cent by 2040

The advent of low-cost urban transport modes . . . has accelerated the outward physical expansion of cities

City (Panama) and Caracas (Venezuela), sprawl is blamed for consuming scarce agricultural lands and dramatically increasing municipal costs for infrastructure and service delivery.¹³ In urban Sub-Saharan Africa, Latin America and South Asia, sprawl has been associated with class segregation. Often, higher-income households occupy the most accessible and expensive districts near the urban core, forcing many low-skilled, low-income immigrants from rural areas and displaced low-income inner-city residents to outlying, marginal areas, where land is cheaper. Class and income disparities are deeply embedded in the spatial arrangements and mobility challenges of many developing-country cities.¹⁴

Global urban density patterns and trends

Figure 5.1 shows that Asian and African cities are, on average, around 35 per cent denser than cities in Latin America, 2.5 times denser than European cities, and nearly 10 times denser than cities in North America and Oceania (mostly from the US, Australia and New Zealand). Overall, 39 of the world's 100 densest urban areas were situated in Asia in 2010.¹⁵ Cities of developing countries have been sprawling more rapidly than those in developed countries. From 1990 to 2000, average urban densities fell from 3545 to 2835 people per square kilometre in developed countries compared to a drop from 9860 to 8050 people per square kilometre in developing ones.¹⁶

A two-century perspective reveals dramatic longitudinal declines in urban densities, especially in developing countries. Figure 5.2 traces the downward trend in built-up area densities for 25 cities from as early as the late 1700s to 2000. Densities declined fourfold from their peak, from an average of 43,000 persons per square kilometre to an average

of 10,000 persons per square kilometre around the year 2000, at an average annual rate of 1.5 per cent.¹⁷ At this rate, urban densities can be expected to decline another 26 per cent by 2040. According to one projection, a continuation of the trends in sprawl translates into a tripling of land area for each new resident by 2030, converting on average some 160 square metres of non-urban to urban land.¹⁸ If past trends hold, this invariably translates into more car-dependent, and thus inherently less sustainable, cities of the future.

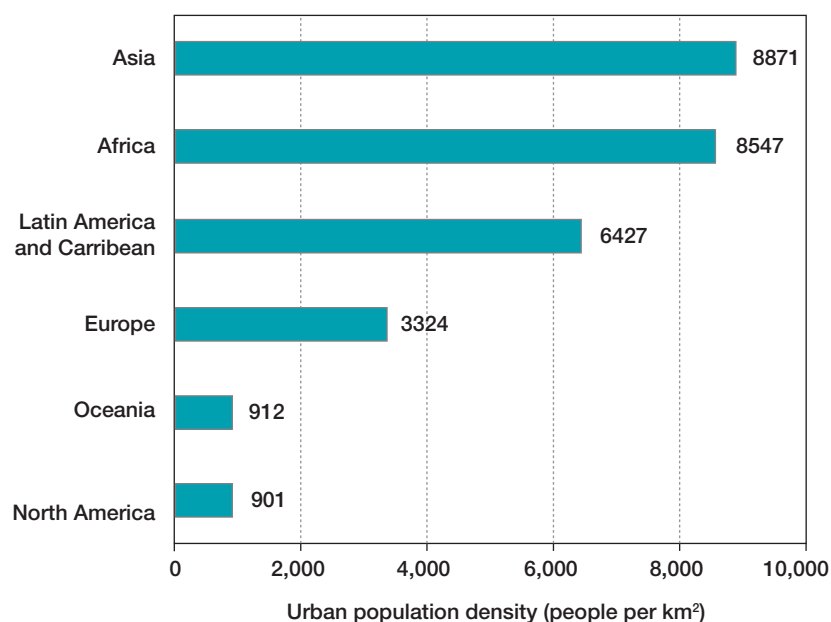
Urban transport as a factor increasing urban sprawl

As many cities worldwide continue to experience sprawl, built-up densities become lower. Transport has played an important role in the sprawl of cities.¹⁹ Indeed, the advent of low-cost urban transport modes – omnibuses, horse cars, trolleys, commuter trains and later buses and cars – has accelerated the outward physical expansion of cities, making density declines possible.²⁰ In the pre-automobile era, movements within cities tended to be restricted to walking, and urban forms compact, in order to reduce the need for physical travel. The location of homes, shops, restaurants and even factories kept urban distances short and walkable. However, extreme overcrowding, lack of privacy and the overpowering stench of manure from horse-drawn carriages forced many who had the means to escape. Streetcar cities, which emerged and expanded with the development of electrical power in most western cities, were heralded as a triumph over the walking and horse-car city. This is because they allowed the middle class to move to lower density suburbs and escape the suffocating urban densities of the early 1900s. Soon afterwards, rail-served suburbs blossomed. Streetcars defined the

Figure 5.1

Urban population densities of 1366 cities, mean densities by region (2000–2010)

Source: UN-Habitat database.



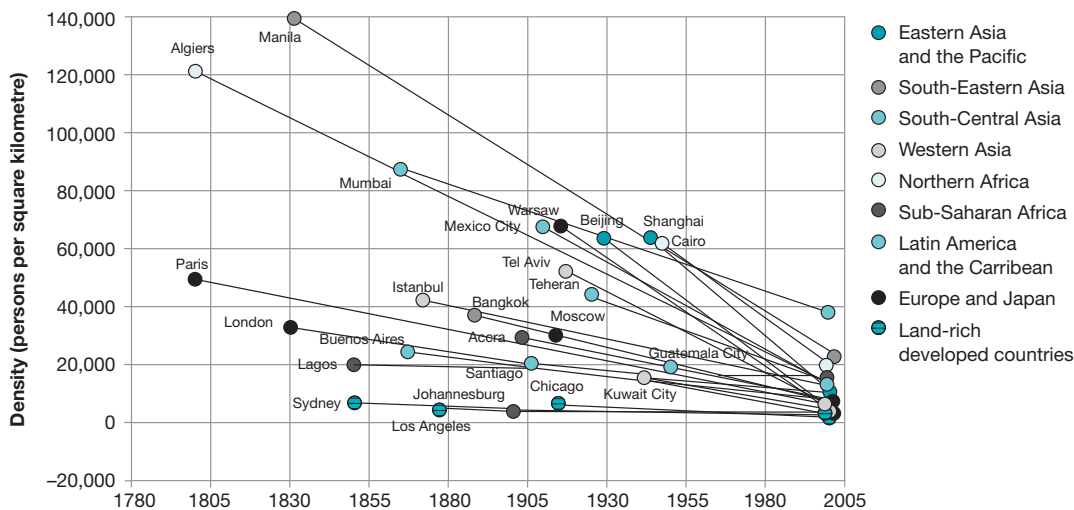


Figure 5.2

Long-term decline in built-up area densities in 25 selected cities (1800–2000)

Source: Angel, 2011.

radial spines of most regions, extending urban boundaries five-fold or more beyond those of the walking city.²¹ The internal combustion engine car technology developed rapidly during the twentieth century, and with it came the advent of the automobile city. The automobile city allowed development to fill in the wedges between radial corridors of the streetcar city and metropolitan boundaries to extend outward four to five times.²² The automobile city, and notably the provision of grade-separated, limited-access freeways, further accelerated the dispersal of economic activities, unleashing low-density, discontinuous patterns of urban growth associated with sprawl.²³ Alongside the freeways (among other factors), a more polycentric urban form was developed, marked by shopping malls, office parks, airports and other major activity centres, congregated near major access points.²⁴

Seventy years ago, a noted urban sociologist observed that urban form is largely a product of the dominant transportation system that was in place during a city's prevailing period of growth.²⁵ European cities such as London (UK), Madrid (Spain) and Prague (Czech Republic) that grew, in relative terms, most rapidly in the 1800s, retain many features of walking and streetcar cities in their urban core. US cities such as Atlanta, Los Angeles, and Houston, whose explosive periods of growth coincided with the construction of freeways, by contrast, are sprawling and car dependent. This increasingly characterizes the outskirts of Jakarta (Indonesia), Lagos (Nigeria), São Paulo (Brazil) and many other cities in developing countries that are presently experiencing rapid motorization and population growth. Further, the urgency of advancing sustainable mobility and urban-form practices in rapidly expanding towns and cities of developing countries, such as India and China, is underscored.

Urban density and travel

Urban densities strongly influence travel. The impact of densities on travel – and therefore, energy consumption and natural environments – gained particular attention in the 1990s, in the wake of a global energy crisis and economic recession. A 1989 cross-sectional comparison of 32 cities showed transport-related energy consumption declines precipitously with urban densities (Figure 5.3).²⁶ US cities averaged the lowest densities and nearly twice the petrol consumption per capita as Australian cities, around four times as much as more compact European cities, and ten times that of three compact Asian cities – Hong Kong, Singapore and Tokyo. These results were attributed to far higher usage and kilometres travelled by private cars in sprawling cities than in compact, public-transport-oriented ones. Follow-up studies of 37 cities in 1999 found similar results: low-density cities averaged considerably higher VKT per capita than high-density ones.²⁷ Even within countries, this relationship remains strong. Panel studies of density and travel in the US and the UK have associated the doubling of urban densities with 15 per cent and 25 per cent declines in VKT per capita.²⁸ However, what accompanies density – e.g. lower car ownership rates, less road space per capita, fewer and more expensive parking and better quality public transport services – can also be important factors associated with density.²⁹ In most instances, density is a necessary, though not a sufficient, condition for moderating private car use and fuel consumption.

City-level studies such as shown in Figure 5.3 have also been criticized for being too aggregate, thus masking variations within cities, and differences among subpopulations. However, even within the same metropolitan area, substantial differences in VKT per capita have been recorded. A study of three US metropolitan areas – Chicago, Los Angeles

The automobile city . . . accelerated the dispersal of economic activities, unleashing low-density, discontinuous patterns of urban growth

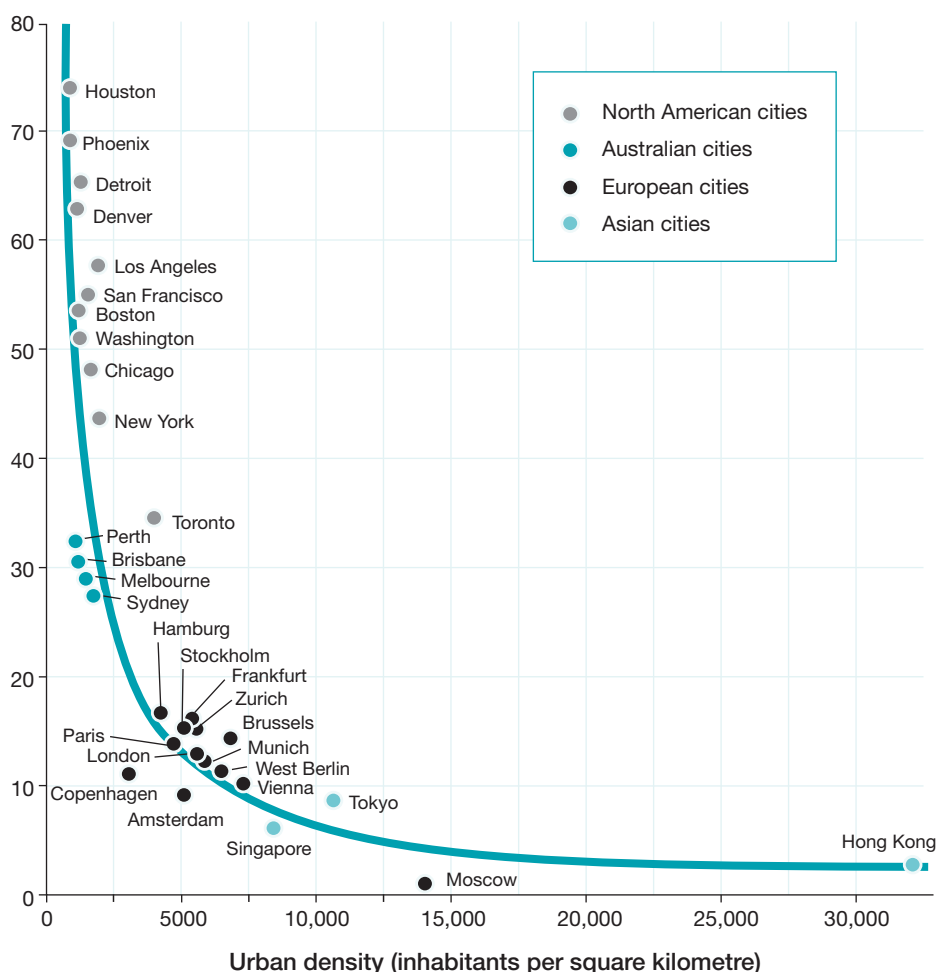
Urban form is largely a product of the dominant transportation system that was in place during a city's prevailing period of growth

Figure 5.3

Influences of urban densities on transport-related energy consumption, 32 cities (1989)

Source: Newman and Kenworthy, 1989; cited in Lefèvre, 2009.

Transport-related energy consumption Gigajoules per capita per year



Going from very low-density sprawl . . . to modest densities of town homes and duplexes, produces the biggest declines in transport-sector energy consumption and VKT

and San Francisco – found, after controlling household size, income effects and using odometer readings, that car ownership and use declined in a systematic and predictable pattern as a function of increasing residential density.³⁰ Similarly, evidence suggests a negative association between urban densities and vehicular travel in other big cities that are rapidly motorizing including Santiago (Chile), Beijing (China), Lisbon (Portugal) and Moscow (Russia).³¹ Once average density levels are reached, the rate of drop-off tapers, offering a useful policy guide to the association between mobility and urban form. For example, Hong Kong style high-rise densities are not needed for major declines in energy consumption and motorized movements to be achieved. Rather, going from very low-density sprawl (e.g. the suburbs of car-oriented Houston) to modest densities of town homes and duplexes, produces the biggest declines in transport-sector energy consumption and VKT.

The risk of potential self-selection bias is also worth noting. Might less car travel be due to density or the fact that those who walk or bike more in compact, mixed-use neighbourhoods choose such

places because of lifestyle and personal preferences? One way to control for such possible effects is to study changes in travel among individuals who moved from one neighbourhood type to another. A study from Seattle, US, found that those moving to neighbourhoods with higher accessibility (e.g. dense, mixed-use settings closer to other destinations) logged far fewer kilometres in vehicles.³² Furthermore, a recent review of 38 studies that statistically controlled for self-selection effects revealed that virtually all studies found that built environments, including density metrics, still had statistically significant influences on travel.³³

Other attributes of urban form influencing travel

Density is but one element of urban form that influences travel. The spatial distribution of population and employment densities are also important.³⁴ Where people live, work, shop and socialize, sets the stage for travel by defining the location of trip origins and destination, and thus the length of trips and the energy they consume.

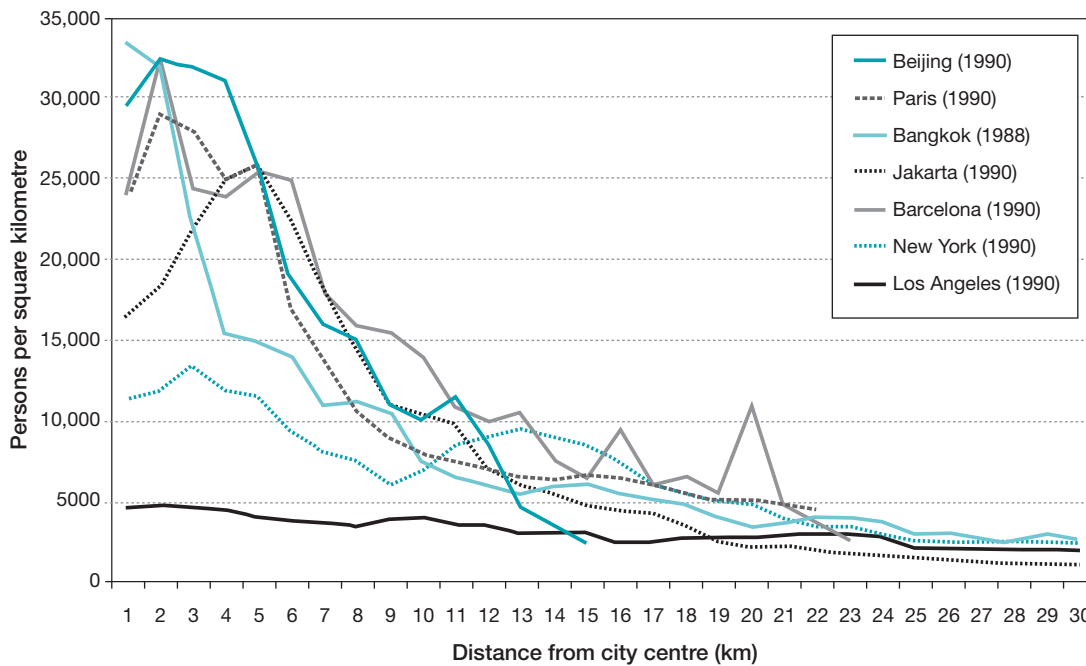


Figure 5.4
Population density gradients of seven cities
Source: Based on Bertaud and Malpezzi, 2003.

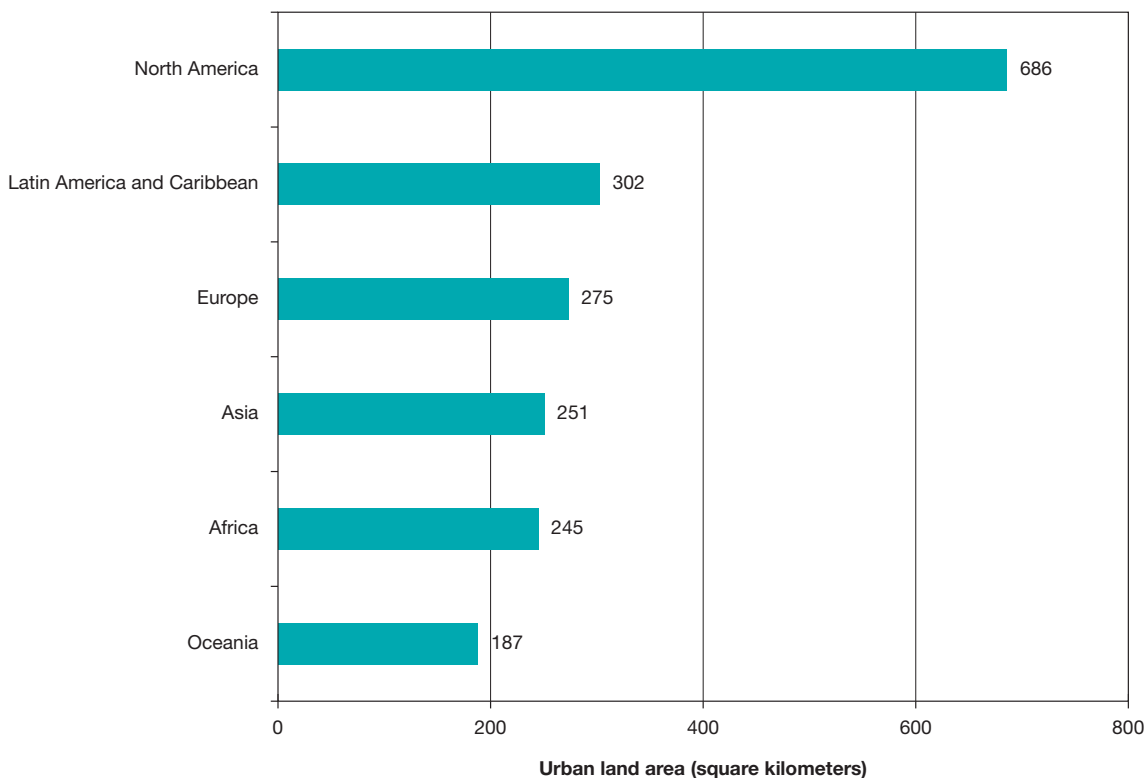


Figure 5.5
Average land coverage by region, among 1366 cities (2000–2010)
Source: UN-Habitat database.

Density gradients – i.e. the rate at which densities taper with distance from the core – are another way to represent urban form. Figure 5.4 shows that densities fell sharply from the centres of Asian and European cities. This is characteristic of a mono-centric or strong-centred metropolis. In contrast, the density gradients of US cities are more flat, revealing a more sprawling, car-oriented urban form (even for greater New York City). Higher densities in the core than the outskirts reflect higher market demand, and higher real estate prices for more central and accessible locations. The regulation of permissible

densities through zoning restrictions along with factors such as rising affluence and the construction of high-capacity freeways, have flattened the density gradients of US cities and increasing numbers of European cities. It has also resulted in the lengthening of journeys and induced private car travel in the process.³⁵

Urban land cover (i.e. the total built-up area of a city) and compactness (i.e. the degree to which a city's footprint approximates a circle rather than a tentacle-like shape) are additional ways to characterize urban form.³⁶ Figure 5.5 shows that, on

Zoning restrictions along with factors such as rising affluence and the construction of high-capacity freeways, have flattened the density gradients of US cities

North American cities take up more than twice as much land as Latin American cities

A monocentric urban form . . . mostly produces radial trips

Polycentric regions can mount successful public transport services by using sub-centres to interlink high-quality and synchronized rail services

average, North American cities take up more than twice as much land as Latin American cities, which consume slightly more land than European, Asian and African cities.

Tracing city footprints of Bandung (Indonesia) and Accra (Ghana) reveals the types of land consumed by new development in two fast-growing developing-country cities. Between 1991 and 2011, Bandung's urban footprint roughly doubled, from 108 to 217 square kilometres.³⁷ Of the newly built-up area, 60 per cent consisted of urban expansion into farmland and open space, 17 per cent was leapfrog or non-contiguous development, and the rest was urban infill (i.e. redevelopment of existing built-up areas). Leapfrog development can be costly to serve since basic infrastructure, such as sewerage and piped-water, must be extended to far-flung, outlying settings. Overall, Bandung's urban densities declined 1.4 per cent annually over this ten-year period. From 1985 to 2000, Accra's land area grew 153 per cent, which is twice as fast as its population growth. Accra's urban growth consisted largely of the extension of city boundaries into former agricultural areas.

Urban form and travel

Just as density influences the distances and modes of travel, other attributes of urban form – including the spatial distribution of population and employment and land coverage – shape the spatial patterns of trips. A monocentric urban form, wherein the vast majority of jobs and commercial activities are concentrated in the city centre and most households reside on the periphery, mostly produces radial trips (Figure 5.6). Whereas the convergence of vehicles near the centre often gives rise to extreme road congestion, it also allows for heavily patronized radial public transport networks to thrive. A multi-centred, or polycentric, form results in more dispersed, lateral and cross-town travel patterns, which generally favour flexible forms of mobility, such as private cars.³⁸ Polycentric regions can mount successful public transport services by

using sub-centres to interlink high-quality and synchronized rail services, such as those in Singapore and Paris. Suburban centres and nodes effectively become the interchange points for connecting large-scale public transport networks. The degree to which station nodes average higher densities depends on the larger shares of trips by non-motorized modes such as walking and cycling.

Like densities, urban land coverage influences travel. From 1980 to 2005, average kilometres driven per person in the US increased by 50 per cent, a change partly explained by the nearly 20 per cent increase in land consumed per person over the same period.³⁹ In India, trip lengths are more influenced by land area (Figure 5.7) than by urban densities (Figure 5.8). Among India's 21 largest cities, the relationship between population density and average trip length is slightly positive. The slope of the plot of urbanized land area and trip length, however, is noticeably steeper. This reflects the sprawl-inducing effect of floor space index (FSI) restrictions in the urban cores of most Indian cities, used to decongest the centre. Redirecting growth to the periphery might lessen central-city traffic congestion at the expense of longer distance trips, which are more dependent on motorized transport (including two- and three-wheelers).

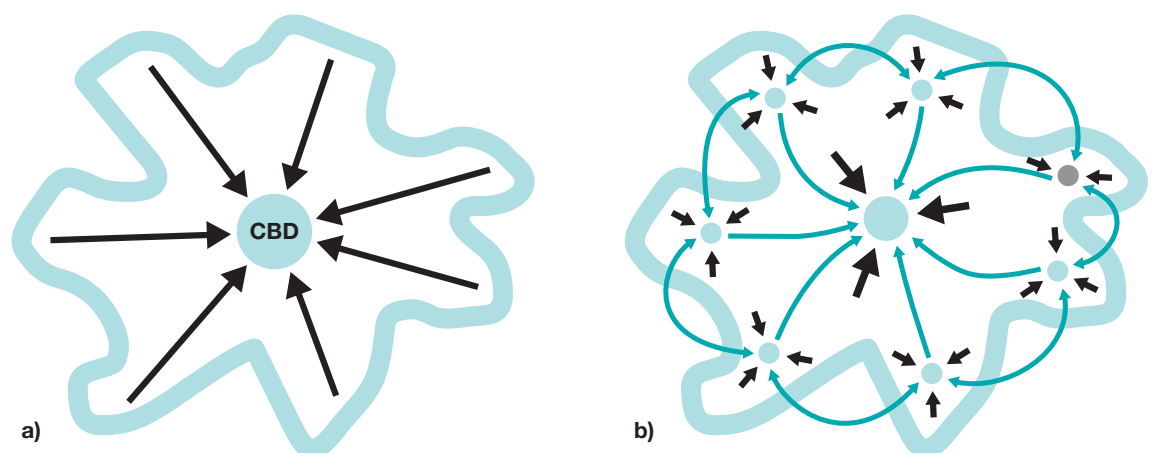
The larger the city, the greater its complexity and the potential to influence future traffic conditions, particularly if not well managed. Larger cities have significantly higher average urban densities than smaller cities and thus higher traffic densities (e.g. vehicles travelling roads per square kilometre). Between 1990 and 2000, a doubling of population among 120 cities worldwide was associated with a 16 per cent increase in density.⁴⁰ As city size and spatial coverage increase, so do the average lengths of trips, the severity of traffic congestion and environmental pollution. Traffic congestion is part of the territory of megacities, regardless of the quality of metro services.⁴¹ The rate of congestion growth is also increasing rapidly in medium-sized cities that

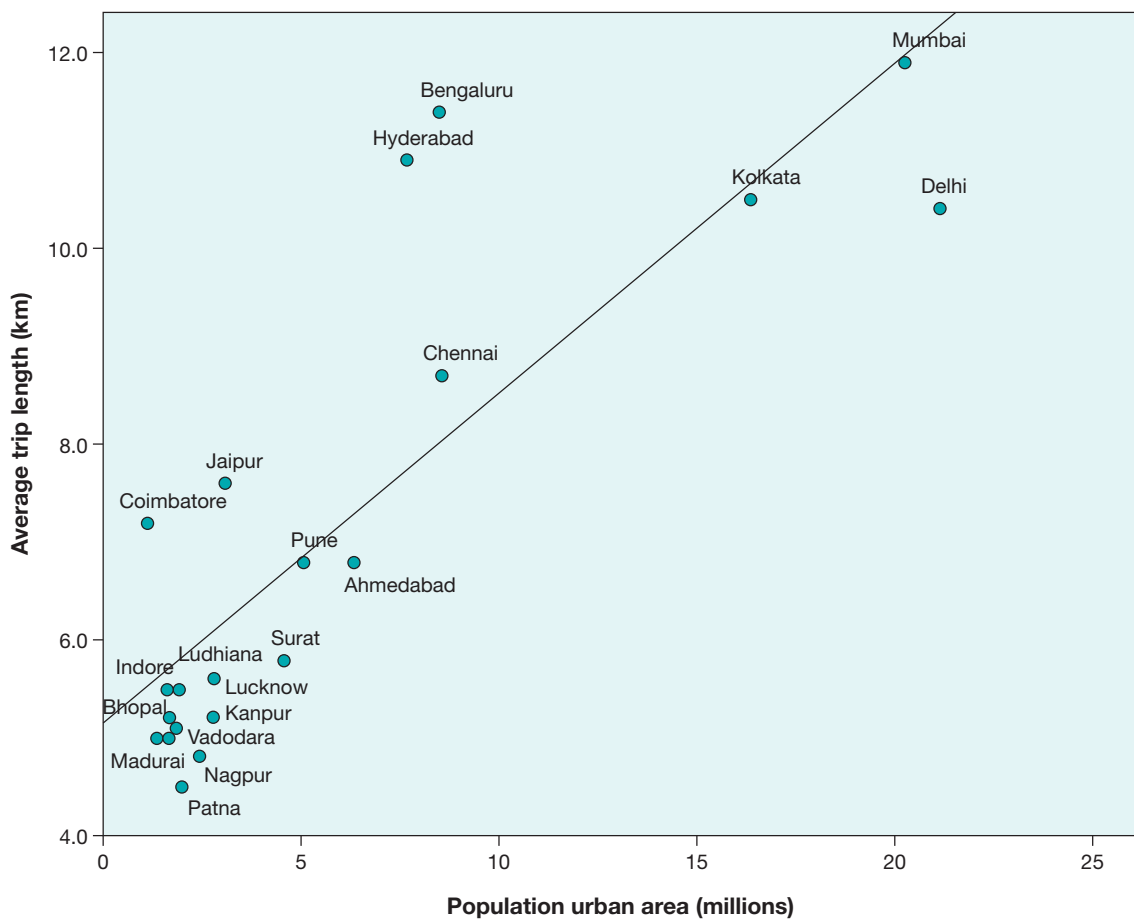
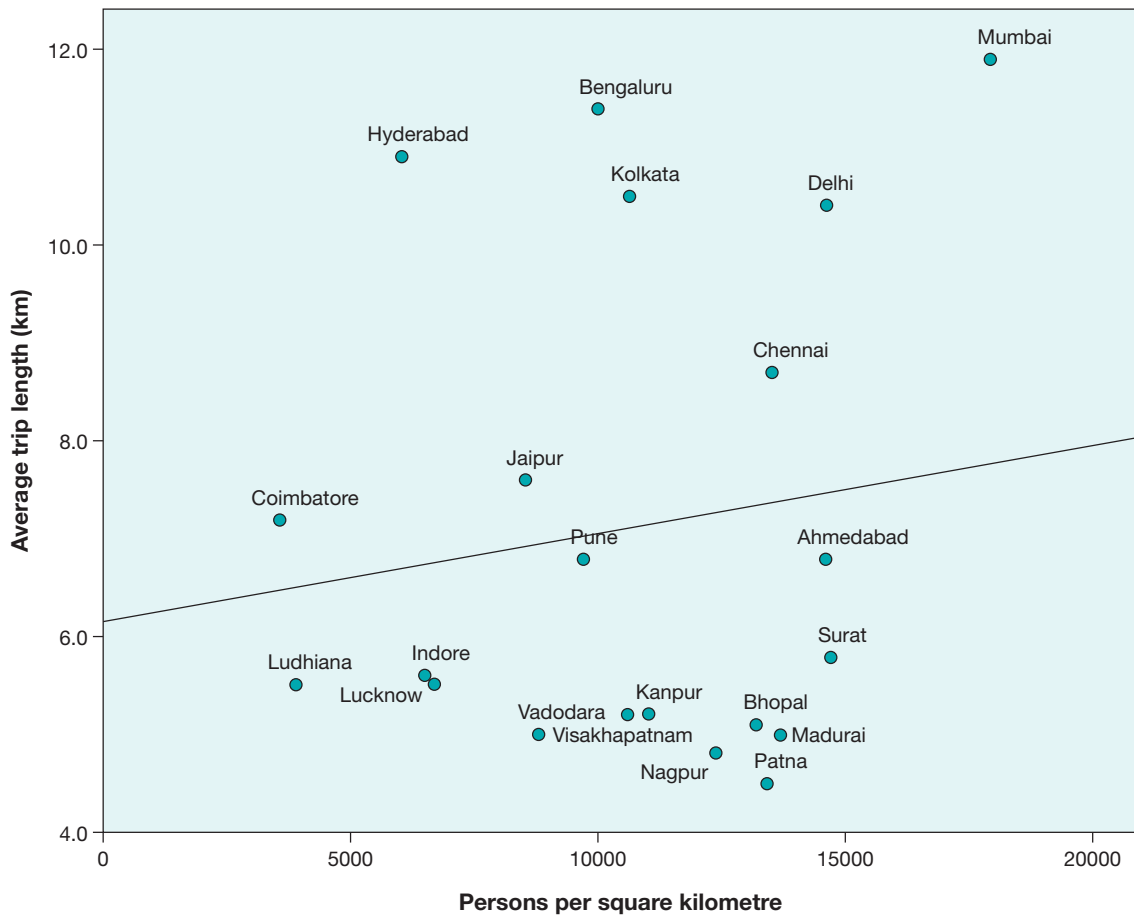
Figure 5.6

Urban form and the spatial pattern of travel flows

Note: Monocentric cities (a), with a dominant central business district, generate radial trips. Polycentric cities (b), with multiple urban centres, produce a mix of radial and lateral trips. Black arrows represent strong links; blue arrows denote weaker links.

Source: Based on Bertaud, 2001, cited in Lefèvre, 2009.





Box 5.4 Mobility and over-concentrated development in Beijing, China

Beijing's 2005 master plan called for the creation of 11 new towns in peripheral regions of the city. The primary aim of shifting growth to the outskirts has been to mitigate over-crowding in the city's central built-up area. The city has built a total of seven ring roads in an attempt to connect the new towns and divert traffic from the city's core. While new town development embraced the idea of China's capital city becoming a polycentric one, Beijing's urban form is characterized as high-density monocentric, rather than multi-centred. The city has witnessed a seemingly continuous outward expansion from the central built-up area, with densities tapering only slightly from the core. That is, the region has become a high- to moderate-density development, from the traditional core to the outskirts, with few dominant centres.

The high and continuous concentration of urban activities over a large geographic territory has led to extreme traffic congestion and air pollution. The fact that the city has failed to create relatively self-functioning suburban clusters has undermined its ability to develop cost-effective high-capacity public transport services, leading to high levels of car usage and VKT per capita. Beijing's failure to implement a multi-centred urban form stems from the tendency for ring roads to spread development evenly in all directions, from the traditional core. Expanded rail investments and a policy commitment to TOD – i.e. concentrating more growth around metro stations – could give rise to a more clustered pattern of suburban development in the future, with increased mobility and environmental benefits.

Sources: Yang et al, 2012; Zhao, 2011.

Agglomeration diseconomies ... is expressed in the form of lost labour productivity from extreme traffic congestion, increasing air pollution, and an overall decline in the quality of urban living

suffer from deficient street layouts, poor connectivity and inadequate public transport. These conditions are further exacerbated when traffic demand approaches or exceeds the available capacity of the transport system during peak hours. The expansion of cities and high densities inevitably creates challenges in the urban environment, particularly in developing countries. For example, the large concentration of employment and economic activities, coupled with inadequate public transport in megacities such as Manila (the Philippines), Lagos (Nigeria), Jakarta (Indonesia) and Mexico City, have resulted in exceedingly high traffic densities, and comparatively long trips by motorized transport.⁴²

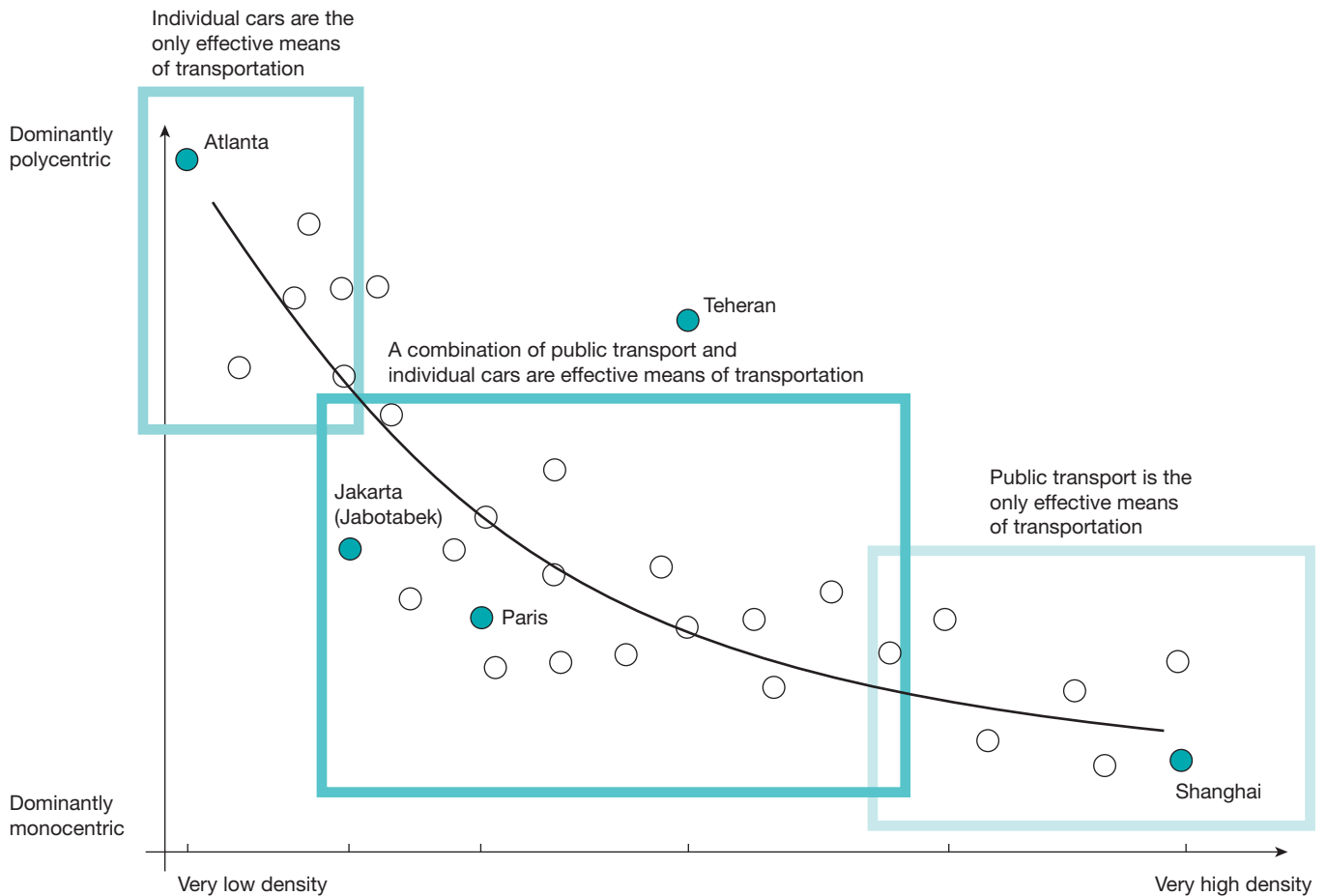
While urban agglomeration allows for job specialization, efficient market transactions and knowledge spillovers, if concentrated growth is not well planned – such as the integration of urban growth with metro investments – the resulting economic benefits tend to erode. Agglomeration diseconomies – i.e. the inefficiency and loss resulting from poorly planned concentrations – is expressed in the form of lost labour productivity from extreme traffic congestion, increasing air pollution and an overall decline in the quality of urban living. The over-concentration of activities in the city's urban core has been blamed for Beijing's increasing traffic congestion and environmental problems (Box 5.4). Evidence from recent studies conducted in UK cities revealed that decongesting the core by dispersing growth to sub-centres can raise economic productivity without increasing transportation energy use, greenhouse gas emissions and air pollution levels.⁴³

URBAN DENSITIES AND PUBLIC TRANSPORT THRESHOLDS

No aspect of urban form and travel has been more closely studied than the influences of urban densities on public transport ridership. It is widely accepted that high densities are essential for sustaining cost-effective public transport services. Mass transit, it is said, needs 'mass', or density. As observed almost a half-century ago, 'nothing is so conducive to the relative economy of rail transit as high volumes and population density. High population density increases the costs of all urban transportation systems, but substantially less for rail than for other modes'.⁴⁴ Rail, with its high up-front capital costs and economies of scale, needs to attain a threshold density of trips, in order to cost less than accommodating the same trips by car or bus. Since rail-based public transport needs high passenger volumes to be cost-effective, it also needs high concentrations of people and jobs around stations.

Figure 5.9 indicates a relationship between public transport ridership and urban form. Very low-density cities with a predominantly polycentric form are unabashedly autocentric. In spread-out cities such as Atlanta (US), public transport has a difficult time competing with the private car. Public transport that is cost-effective can only be achieved through high urban densities and a large share of jobs and retail activities concentrated in the urban core (such as in Shanghai, China), or in polycentric cities with multi-directional travel patterns (such as Stockholm, Sweden). Many large cities, such as Jakarta (Indonesia) and Paris (France), lie somewhere between the aforementioned extremes: both private mobility and public transport can compete for trips when densities

High densities are essential for sustaining cost-effective public transport services



are moderately high and activities span the mono-centric–polycentric spectrum.

Figure 5.10 shows that there is a positive correlation between urban population density and public transport ridership per capita. Hong Kong, with extremely high densities, is a statistical outlier – averaging comparatively low transit trips per capita relative to its high densities. This may be attributed to the fact that many trip destinations are close to each other, thereby resulting in an extraordinarily high share of trips made by foot. Removing the Hong Kong case from the database produces an even stronger statistical fit.

The reliance of public transport on urban densities has prompted efforts to define the minimum density thresholds required to support successful public transport services. On one hand, cities need to average 3000 inhabitants per square kilometre to support reasonably cost-effective public transport services.⁴⁵ On the other hand, for wealthier, more car-oriented countries such as the US, UK, Canada, Australia and New Zealand, a minimum threshold of 3500 people and jobs per square kilometre is necessary if public transport is to generate sufficient ridership to cover costs.⁴⁶ Evidence suggests that new suburbs in these countries rarely achieve more than half of this minimum threshold.⁴⁷ A similar study in Athens (Greece) found that public transport trips per

capita sharply increased to 20,000 persons per square kilometre and then tapered, suggesting this figure as a planning norm for successful public transport services.⁴⁸ While density thresholds have long been set to guide public transport investments and TOD planning in the US, these benchmarks are based on limited data points and experiences (Box 5.5).

A recent US study examined the job and population densities that are associated with cost-effective public transport investments, based on the country's experiences with recent light-rail and BRT investments.⁴⁹ Figure 5.11, which is based on this study, shows that a BRT system that costs US\$30 million per kilometre would need around 4000 jobs and residents per square kilometre within 800 metres of its station to be in the top 75 per cent of cost-effective investments. A light-rail investment at the same per-kilometre cost requires 11,000 jobs and residents per square kilometre; and a heavy-rail investment requires nearly 14,000 per square kilometre to fall in the top quartile.

However, as there are many city features that influence public transport ridership, some observers have cautioned against a fixation on density.⁵⁰ The walkability and land-use mixes of neighbourhoods that surround stations are also important to viable public transport services. If people cannot safely and conveniently walk the half kilometre to or from a

Figure 5.9

Relationship between urban form and cost-effective public transport

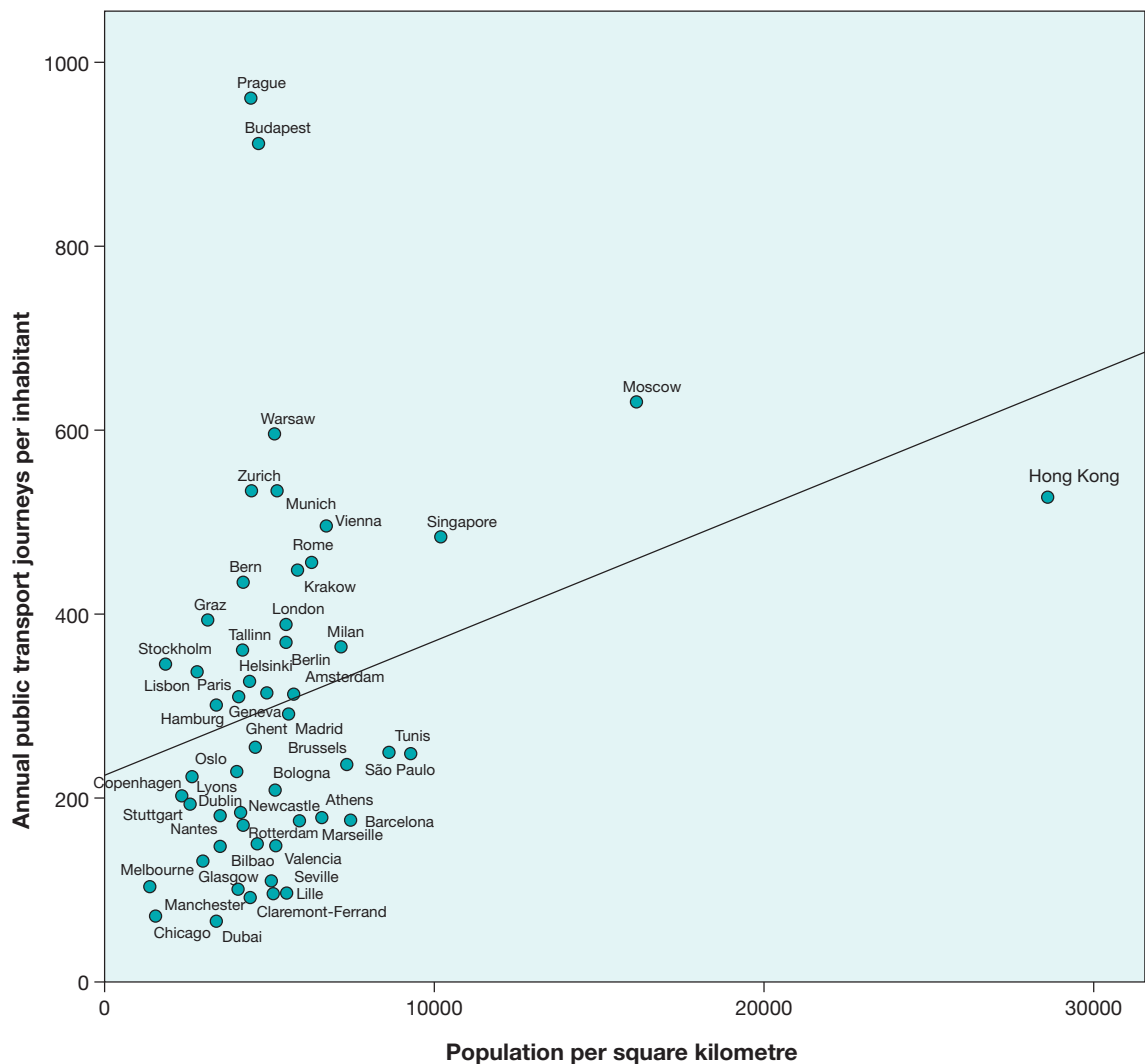
Source: Bertaud and Malpezzi, 2003, cited in Lefèvre, 2009.

Cities need to average 3,000 inhabitants per square kilometre to support reasonably cost-effective public transport services

Figure 5.10**Urban population density and public transport travel**

Note: Data drawn from a sample of 50 cities in 2001, primarily in developed countries.

Source: UITP, 2006.

**Box 5.5 Density thresholds for cost-effective public transport in the US**

The development of minimum density thresholds for successful public transport investments in the US has been the focus of numerous studies undertaken and policy initiatives introduced to the world's most car-dependent country. Between the 1960s and 1970s, it was estimated, that the high costs of heavy-rail investment required a minimum net residential density of at least 3000 households per square kilometre. A minimal light-rail investment, by comparison, would require at least 2400 households per square kilometre. A more recent study of 59 capital investments in public transport in the US since 1970, found light rail to be more cost-effective than heavy rail, resulting in approximately 7000 people and jobs per gross square kilometre. Across these 59 US projects, a 10 per cent increase in total population and

jobs per square kilometre corresponded with a 3.2 per cent decrease in annualized capital costs per rider.

While capital investment costs also rise with density, US experiences show the increased ridership more than offsets these costs per passenger kilometre. As a result, the justification for fixed-guideway public transport investments has led to the adoption of density thresholds in US cities. The city of San Diego, for instance, has adopted TOD guidelines that call for a minimum of 6300 dwelling units per square kilometre for light rail services serving urban transit-oriented districts. In its TOD guidelines, metro Portland has set slightly higher thresholds – 7500 dwelling units per square kilometre for development within one city block of light rail stations.

Sources: Pushkarev and Zupan, 1977; Guerra and Cervero, 2011.

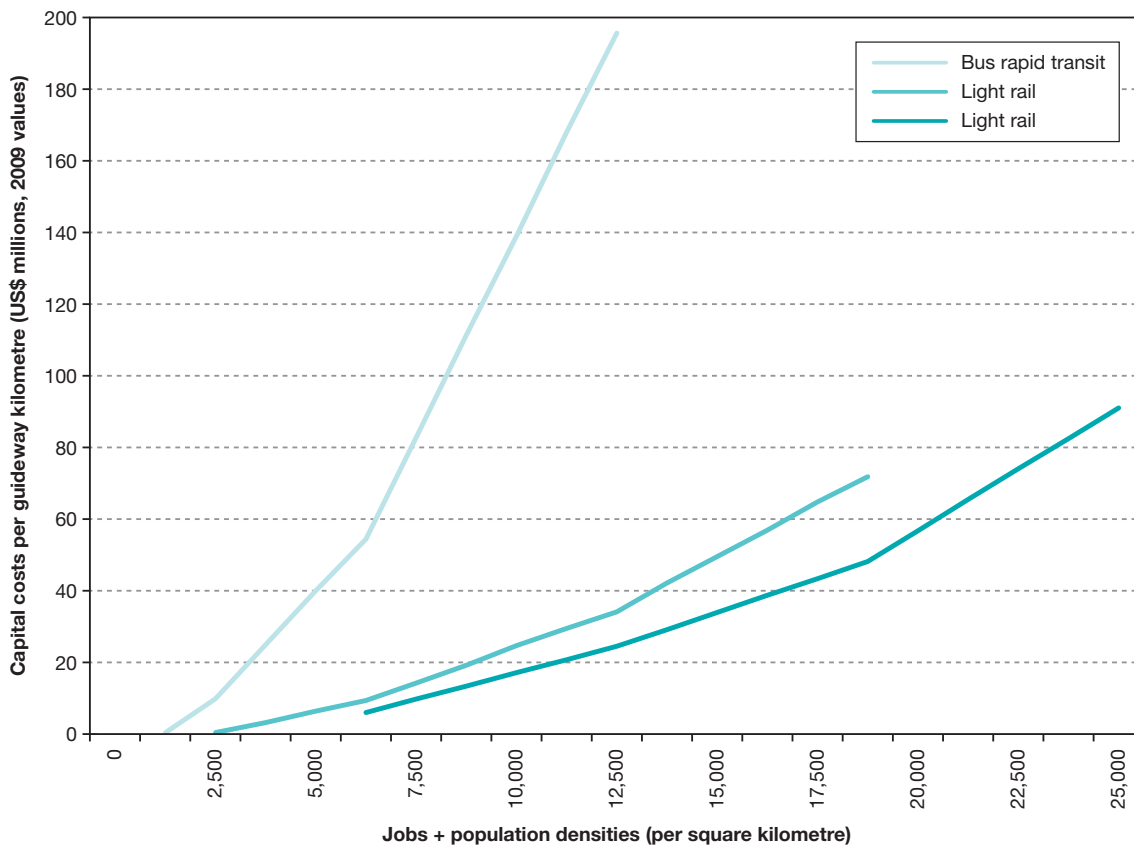


Figure 5.11

Minimum urban densities needed for top-performance investments, fixed-guideway capital costs in the US

Sources: Based on Guerra and Cervero, 2011.

Box 5.6 Dysfunctional densities of Los Angeles, US

The city of Los Angeles averages the highest overall population density in the US matched by a thicket of criss-crossing freeways and major arteries, which form a dense road network. The city also averages the highest level of vehicular travel per capita, and the worst traffic congestion in the US. This dysfunctional combination of high population and road densities has been called the 'worst of all worlds' – because traffic congestion increases exponentially with car density and city size; so do the externalities associated with car travel. The suburbs of Los Angeles are dotted with three to four

story walk-up garden-style apartments, horizontally stretched within superblocks, creating long walking distances. Whereas densities are high by US standards, they are not public transport-oriented by European standards. In Los Angeles, densities are generally too high for a car-dependent city and are not organized along linear corridors in public transport-friendly manner. Such population densities are too high for cars and too poorly organized for successful public transport – they are, in effect, dysfunctional densities.

Sources: Eiden, 2005; Schrank and Lomax, 2007; Cervero, 1998.

station, chances are they will not use public transport. Conversely, if they can easily run errands and coordinate trips on the way to or from a station, they are more likely to take public transport. Further, the presence of a convenience retail store along the walk-access corridor to a public transport stop increases the odds of public transport riding.⁵¹ The manner in which densities are designed also matter. Lineal and well-articulated densities aligned along busways, such as the case of Curitiba (Brazil), are far more conducive to public transport travel than the uniformly spread-out, poorly planned densities in Los Angeles, US (Box 5.6). Where there is a mismatch between the *geometry* of transportation systems

(e.g. point-to-point rail systems) and the *geography* of travel (e.g. many origins to many destinations), public transport will struggle to grab reasonable market shares of trips regardless how good services might be.⁵²

PLANNING THE ACCESSIBLE CITY

Coordinating and integrating urban transport and land development is imperative to creating sustainable urban futures. Successfully linking the two is a

Lineal and well-articulated densities aligned along busways, such as the case of Curitiba (Brazil), are . . . conducive to public transport travel

Box 5.7 'Compact cities' or 'smart growth'

'Compact cities' or 'smart growth' are terms that have gained currency in the field of urban planning for describing urban development that is compact, resource-efficient and less dependent on the use of private cars. The term of 'smart growth' is most commonly used in North America, while in Europe and Australia the term 'compact city' is often used to connote similar concepts. As an antidote to sprawl, these terms aim to reduce the municipal fiscal burden of accommodating new growth, while at the same time promoting walking and cycling, historical preservation, mixed-income housing that helps reduce social and class segregation and diversity of housing and mobility choices that appeal to a range of lifestyle preferences. Ten accepted principles that define such developments have:

- 1 mixed-land uses;
- 2 compact building design;
- 3 a range of housing opportunities and choices;
- 4 walkable neighbourhoods;
- 5 distinctive, attractive communities with a strong sense of place;
- 6 preservation of open space, farmland, natural beauty and critical environmental areas;
- 7 development directed towards existing communities;
- 8 a variety of transportation choices;
- 9 development decisions that are predictable, fair and cost effective;
- 10 community and stakeholder collaboration in development decisions.

Sources: Bullard, 2007; Duany et al, 2000; <http://www.smartgrowth.org/network.php>, last accessed 6 May 2013.

Design and layout of a city strongly influence travel demand

signature feature of 'compact cities' or 'smart growth' (Box 5.7).⁵³ Successful integration means making the connections between transport and urban development work in both directions. As noted, the design and layout of a city strongly influence travel demand. At the same time, transportation infrastructure is an essential feature that shapes the city. The coordination and integration of transport planning and development, as well as spatial planning and development are key.

The coordinated planning of urban mobility and land development starts with a collective vision of the future city, shared by city government and major stakeholders of civil society. Thereafter, a strategic plan that orchestrates urban development is developed to realize the shared vision, and must include, among other things, building the institutional, regulatory and fiscal capacities to implement the plan. A strategy plan aims to translate urban development goals into long-range implementation in terms of where and in what form development and redevelopment occurs, and the tools (e.g. laws and regulations, fiscal instruments, organizational reforms) necessary to achieve desired outcomes.⁵⁴ Visioning the future city as a precursor to transportation decision-making reflects the derived nature of travel. People travel to reach places, and it is these places that serve the purposes of trips and the aspirations of people who make them. Well-planned cities, such as Singapore, Stockholm (Sweden) and Curitiba (Brazil), crafted cogent visions of the future to shape transportation investments and achieve the best outcomes, whether measured in economic prosperity, energy resourcefulness, cleanliness of the natural environment or quality of life.⁵⁵

The city of Copenhagen (Denmark) and its celebrated 'Finger Plan' is a text-book example of a long-term planning vision, which shaped rail invest-

ments and urban growth. A five-finger hand became the metaphor for defining where growth would and would not occur. Each finger was oriented to a traditional Danish market town within the orbit of metropolitan Copenhagen. The construction of rail-based public transport was purposed to steer growth along the desired growth axes, in advance of travel demand. Also, greenbelt wedges set aside as agricultural preserves, open space and natural habitats were designated and major infrastructure was directed away from the districts.

Ottawa, Canada, with a population under 900,000, offers a good example of concordance between urban vision and transportation investments. The 1974 plan called for a multi-centred urban structure, with five directional corridors of future growth emanating from the city centre. Ottawa's leaders began with a concept plan that defined desired growth axes, thereafter invested in a high-quality, high-capacity busway to drive growth along these corridors. A combination of land-use regulations and incentives (e.g. targeted infrastructure investments) channelled commercial and employment growth to the busway corridors. The plan mandated, for example, that all shopping centres over 354,000 square metres gross leasable space had to be sited near the busway or future extensions. Transportation demand management measures such as mandatory parking charges were also introduced. In 2007, Ottawa adopted guidelines that called for building designs and set-backs that create attractive human-scale development; public art to enliven station areas; and short street blocks to make it easier and more enjoyable for pedestrians to access busway stations.⁵⁶ Since 1990, the public transport's mode share in Ottawa has remained steady at 15 per cent of daily trips, while declining in nearly all other Canadian cities.⁵⁷

Well-planned cities, such as Singapore, Stockholm, and Curitiba, crafted cogent visions of the future to shape transportation investments and achieve the best outcomes

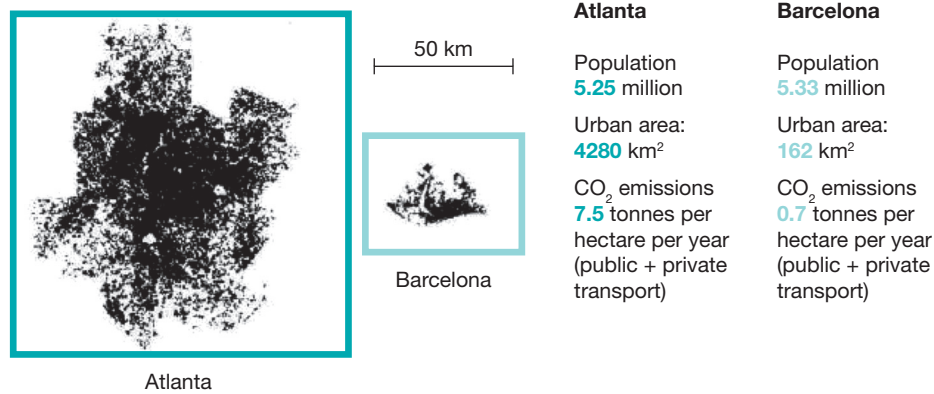


Figure 5.12
Comparison of urban forms and transport-sector CO₂ emissions in Atlanta (US) and Barcelona (Spain)

Source: Lefèvre, 2009, citing Newman and Kenworthy, 1999.

The two examples above of where the urban-form ‘horse’ leads the transportation ‘cart’, with transport investments that have been used as tools to create hoped-for outcomes. Similarly, local authorities can utilise a range of tools to influence urban growth such as land-use regulations; infrastructure investments; tax policies (e.g. enterprise districts); and land purchases (e.g. greenbelts). However, experience shows that transportation investments are one of the most important.⁵⁸ This is particularly the case in fast-growing cities with vibrant economies, worsening traffic congestion and a high pent-up demand for mobility. Arguably, ‘transport-land use links are the most important ones in infrastructure plans and thus should take precedence’.⁵⁹

Rather than being site or corridor specific about where growth should take place, and in what form, some cities opt to advance principles and ideals, expressed in fairly general terms, about desired growth. This is often in the form of **strategic spatial plans** that contain long-range directives and conceptual ideas, as opposed to detailed spatial designs.⁶⁰ An example is Barcelona’s recent strategic plan, which calls for maintaining a compact urban form, preserving the city’s legacy of high-quality urban design and keeping the city walkable.⁶¹ The plan provides a framework for this vision to be refined and set into motion, through a series of local multi-sectoral projects, such as housing development and brownfield redevelopment, as well as proactive investments in sustainable transportation infrastructure.⁶² With a population similar to Atlanta’s, Barcelona’s longstanding commitment to planning and designing a compact, mixed-use walkable city has produced a spatial coverage and carbon footprint that is only a fraction of Atlanta’s (Figure 5.12). The short distances created by a compact city have meant that 20 per cent of trips made by Barcelonans are by foot.⁶³

In developing countries, long-term strategic plans governing the growth of cities tend to be less clearly defined. In its ‘Accessible Ahmedabad’ plan, the city of Ahmedabad (India) embraced the principle of creating a city designed for accessibility rather than mobility, without specific details on the siting of new growth.⁶⁴ The plan calls for guid-

ing development and investing in transportation so as to: (1) reduce the need for travel; (2) reduce the length of travel; and (3) promote the use of public transport and non-motorized vehicles to reduce car dependence. The city’s BRT system forms the backbone of Ahmedabad’s evolving transportation network. A better articulation to urban development was needed to make ‘accessibility’ a key element of mobility and city growth.

Planning the accessible city also involves increasing the percentage of urban land allocated to streets, to enhance connectivity. Studies show that the overall connectivity of the city can be measured by proxy, by comparing the ratio of urban land allocated to streets with the total land area of the city.⁶⁵ Current trends indicate that the bulk of urban population growth is occurring in developing countries, most of which have a limited street and other infrastructure required for increased accessibility. While it is important for these cities to invest in streets, it should be noted, however, that having a high percentage of urban land allocated to streets is only the first step in making a city more accessible. There is, in addition, a need to take into account the efficiency of the street system and its adaptability to essential urban mobility modes such as high-capacity public transport systems (such as metros or BRTs), walking and cycling. An efficiently laid out street system integrates three main variables, namely; the proportion of land area allocated to streets, the number of street intersections and the distance between these intersections. Furthermore, the hierarchy – arterial, primary and secondary, as well as bikepaths and footpaths – of the street system constitutes another essential element of the connectivity matrix for the city, which is a fundamental aspect of accessible urban mobility systems.⁶⁶ Each city thus needs to invest in adequate and well-laid out street networks, according to its economic, institutional, social and environmental capacities.

Integrated mobility planning and urban growth need to occur at multiple spatial scales – e.g. the region as a whole, districts and corridors, as well as neighbourhoods. Such multi-level planning is a centrepiece of Portland, Oregon’s widely celebrated

Transport investments . . . have been used as tools to create hoped-for outcomes

The short distances created by a compact city have meant that 20 per cent of trips made by Barcelonans are by foot

Having a high percentage of urban land allocated to streets is only the first step in making a city more accessible

Integrated mobility planning and urban growth need to occur at multiple spatial scales

The regional scale best captures the ecological contexts in which cities exist

The district or corridor scale captures the spatial context in which many day-to-day economic transactions take place

5 Ds strongly influence travel demand – notably, the number of trips made, the modes chosen, and the distances travelled

approach to smart-growth development. There, a long-term regional vision of multiple, hierarchical growth centres, interlaced with high-quality public transport and secondary bikeway/pedway systems, has been adopted. The formation of an urban growth boundary has been pivotal to Portland's efforts to curb urban sprawl, reduce car-dependence and create a healthier, more liveable city. This boundary works at the regional scale, ensuring that future growth is inward and upward, not outward. The regional scale best captures the ecological contexts in which cities exist, and spatially corresponds to fragile resources such as airsheds and water tributary areas. The district or corridor scale captures the spatial context in which many day-to-day economic transactions take place, such as going to work and shopping for everyday items. For a public transport corridor, say, a necklace of pearls urban form (Figure 5.15) might take shape wherein nodes of mixed-use, public transport-served centres encourage residents to use public transport for their daily activities. In the case of the neighbourhood scale, activities such as convenience shopping, socializing with neighbours and walking to school usually take place where urban design approaches such as gridded street patterns and TOD are targeted. Spatial harmonization between these three levels – regions, districts/corridors and neighbourhoods – can be crucial for the successful integration of transportation and urban development, as experienced in Portland (US) and Curitiba (Brazil).

The next three sections of this chapter refer to each of these three scales, namely: neighbourhoods, corridors and regions. In addition, the directions of the transportation–urban form relationship are discussed at these scales. In particular, these sections

look at how urban development and land-use patterns influence travel, and how transportation investments and policies influence the growth and shape of the city. Examples are cited that highlight the successes and challenges of integrating transportation and urban development at each scale.

BUILT ENVIRONMENTS AND TRAVEL AT THE NEIGHBOURHOOD SCALE

The mobility influences of finer-grain features of the city – such as the size of city blocks, the layout of street networks, parking arrangements and the intermixing of land uses – are best measured at the neighbourhood scale. Contemporary forms of smart growth, such as TOD and new urbanism, both discussed in the next section, aim to place many daily activities within a five to ten minute walk of each other. This corresponds to the spatial coverage of a typical neighbourhood.

Many studies have been conducted on the potential to reduce motorized travel through changes in the built environment.⁶⁷ Analysts often express features of built environments along five core dimensions or the '5 Ds': density, diversity, design, destination accessibility and distance to transit (Box 5.8). These 5 Ds strongly influence travel demand – notably, the number of trips made, the modes chosen and the distances travelled – and are evident in many contexts and settings.⁶⁸ Both singularly and collectively, the 5 Ds affect VKT per capita.

Box 5.8 5 Ds of built environments that influence travel

- **Density** gauges how many people, workers or built structures occupy a specified land area, such as gross hectares or residentially zoned land.
- **Diversity** reflects the mix of land uses and the degree to which they are spatially balanced (e.g. jobs–housing balance), as well as the variety of housing types and mobility options (e.g. bikeways and motorways).
- **Design** captures elements such as street layout and network characteristics that influence the likelihood of walking or biking – e.g. pedestrian and bike-friendliness. Street networks vary from dense urban grids of highly interconnected, straight streets, to sparse suburban networks of curving streets forming loops and lollipops.
- **Destination accessibility** measures ease of access to trip destinations, such as the number of jobs or other attractions that can be reached within 30 minutes travel time.
- **Distance to transit** is usually measured as the shortest street routes from the residences or workplaces in an area to the nearest rail station or bus stop.

These are not separate dimensions and indeed are often co-dependent. Having high-rise housing and office towers will yield few mobility benefits if the two activities are far from each other. A diversity of uses and improved accessibility to destinations from home or work are needed if denser development is to translate into more pedestrian and transit trips. City downtown areas are considered the densest part of most cities. They also tend to be the most diverse in terms of land use and the most walkable – e.g. small city blocks, complete sidewalk networks and fine-grain grid street patterns.

Sources: Cervero and Kockelman, 1997; Ewing and Cervero, 2010.

Most evidence on this comes from developed countries. A recent meta-analysis of more than 100 studies in North America, Table 5.1 shows the average influence of each D factor on VKT, expressed as elasticities (denoting the per cent change in VKT for a 1 per cent change in each D factor). The study's conclusion is that 'destination accessibility' is by far the most important land use factor that strongly influences travel – on average, a doubling of access to destinations (e.g. the number of jobs that can be reached within 30 minutes by public transport) is associated with a 20 per cent decline in VKT. Almost any development in a central, accessible location will generate less motorized travel than the best-designed, compact, mixed-use development in a remote location.

Other attributes that influence travel include: urban design (e.g. street connectivity and safe, complete sidewalk provisions) and well-sited pedestrian routes. Box 5.9 describes the importance of land-use diversity such as level of mixing, which tends to exert strong influences on travel modes and distances to the workplace, rather than the residential end of trips. The rather weak statistical relationship between density and travel in the US reflects the fact that density is intertwined with other D variables – e.g. dense settings commonly have mixed uses, small city blocks, and central locations, all of which shorten trips and encourage walking. While individual elasticities might appear low in Table 5.1, their influences are additive.

European studies on the 5 Ds and travel, largely corroborate US experiences. As in the case of the US, location within a region matters. Isolated neighbourhoods with poor accessibility result in a high level of car use. A study in Copenhagen, Denmark, revealed that VKT increased by 30 per cent with a doubling of distance to the city's downtown area.⁶⁹ The importance of road designs and land-use mixes is revealed by a study of two European cities with similar land areas and household incomes – the

	Elasticity	Per cent change in VKT from a doubling of value of the 'D' variable
Density (intensity of use)	-0.05	-5%
Diversity (mix of use)	-0.07	-7%
Design (walkability)	-0.08	-8%
Destination (accessibility)	-0.20	-20%
Distance (to transit)	-0.05	-5%

Note: Data are drawn principally from empirical studies in the US.
Sources: Ewing and Cervero, 2001; Ewing and Cervero, 2010.

master-planned British new town, Milton Keynes, and the more traditional Dutch community, Almere.⁷⁰ Almere was designed for walking and cycling, while Milton Keynes is a car-oriented city laid out on a super-grid of four-lane thoroughfares, separating homes, offices and shops into different quadrants. The study found that two-thirds of the out-of-home trips made by urban residents in Milton Keynes were by car, compared to 42 per cent in Almere. In addition, the average trip distances in Almere were 25 per cent shorter. A more recent comparison of Milton Keynes with another Dutch master-planned new town, Houten, that was more consciously designed for bicycle travel revealed greater differentials. In 2010, 55 per cent of all trips made by Houten residents were by bike, as compared to 20 per cent of the trips made by urban residents in Milton Keynes.⁷¹

While very little is known about the 5 Ds and travel in developing countries, evidence is beginning to trickle in. In Santiago (Chile) evidence revealed that between 1991 and 2001, the effect of urban densities on car ownership doubled, with increasing population densities reducing the likelihood of households owning a car.⁷² Being close to a subway station also reduced car ownership rates. However, land-use diversity had a minimal influence on travel.

Table 5.1

5 D influences on VKT, expressed as average elasticities

'Destination accessibility' is by far the most important land use factor that strongly influences travel

Isolated neighbourhoods with poor accessibility result in high level of car use

Box 5.9 Land-use diversity

Mixing up land uses can shorten trips and encourage non-motorized travel. A recent study of six mixed-use activity centres across the US found that 30 per cent of generated trips were internal to the project – i.e. short journeys, mainly by foot. Trips meant for private cars to external destinations away from the development were instead on-site and often by foot. Such trips put no strain on the surrounding road networks and generate relatively few vehicle kilometres of travel. Unless such benefits are accounted for in traffic impact studies, the traffic-inducing impacts of mixed-use developments become overstated.

Other benefits of mixed land uses include opportunities for shared parking and an even distribution of trips (and thus a

flatter peak period) throughout the day and week. Situating employment and entertainment activities close to each other, for example, means the parking used by white-collar employees during working hours can also be used in the evenings and weekends by theatre-goers and restaurant patrons. In such settings, co-locating land uses whose parking demands vary by the time and the day of week can shrink the footprints of impervious parking surfaces by as much as 35 per cent. Parking regulations and liability laws might need to be adjusted to allow shared parking among various activities in mixed-use settings.

Sources: Cervero, 1988; Ewing et al, 2011; Zengras, 2010.

The quality of the walking environment has important age and gender dimensions

Globally, various neighbourhood designs and retrofits are being introduced to reduce the need for travel by private cars and invite more sustainable forms of mobility

[In the pre-automobile era], traditional neighbourhoods were compact and highly walkable

'New urbanism' ... sought to return neighbourhoods to their pre-automobile designs and ambiances

In Colombia, a study of Bogotá residents found that while density and land-use diversity had very little influence on the amount of time spent walking and cycling, neighbourhood design attributes such as street connectivity and sidewalk provisions had significant impacts.⁷³ Moving from a neighbourhood in Bogotá with low levels of road connectivity (measured by the ratio of links to intersections) to higher levels, resulted in an increased likelihood (by 220 per cent) that residents walked 30 minutes or more per day.⁷⁴ Many of Bogotá's older neighbourhoods that evolved organically during the pre-car era had strict zoning laws, thereby resulting in urban neighbourhoods that exhibit similar densities, mixes of land use and access to public transit. The quality of the walking environment varied, however, and did not strongly influence non-motorized travel. Similarly, in Taipei and Hong Kong (China) street designs tend to strongly influence walking, as compared to high densities and mixed land uses (which are commonplace in both cities).⁷⁵

The quality of the walking environment has important age and gender dimensions. In Teheran, a recent study found highly walkable neighbourhoods to be most conducive to the elderly, resulting in their walking more often.⁷⁶ Environments designed with more street lighting and a mixture of land uses that generate foot traffic are likely to decrease the risk of violence to women.⁷⁷ Further, people of all ages and genders tend to socialize more and are physically active in compact, mixed-use neighbourhoods.⁷⁸ Well-designed streetscapes with destinations close by tend to draw city residents to sidewalks and public spaces, creating what urban designers call 'natural surveillance' and more 'eyes on the street'.⁷⁹ Bogotá's proactive investment in walkways, plazas and sidewalks close by, and the city's connection to the Transmilenio BRT system has further enhanced public safety and encouraged households to upgrade their homes and neighbourhoods.⁸⁰

Expanded, improved and better connected pathways are important features of slum upgrading programmes. In La Vega Barrio, one of Caracas, Venezuela's largest and oldest informal settlements, 30 pathways that criss-cross steep hillsides have been built or rehabilitated to enhance access to jobs, schools and medical clinics, as part of a major neighbourhood upgrading initiative.⁸¹ Design features such as smaller city blocks can also encourage foot travel in developing cities. Smaller blocks mean that trips made by foot are likely to be less circuitous. In Ahmedabad, India, only 13 per cent of trips made by those living in neighbourhoods with an average block size of 4 hectares, were by foot, compared to the recorded 36 per cent in a similar neighbourhood, with average block sizes of 1.2 hectares.⁸²

Experiences from China reveal how changes in built environments fundamentally change travel in rapidly growing settings. Paralleling China's shift

to a market economy have been dramatic transformations of urban environments – from a traditional high-density, pedestrian- and cyclist-oriented urban form to an increasingly spread-out, auto-oriented one.⁸³ The liberalization of land markets in the 1990s resulted in the displacement of many Chinese working-class households to the periphery – often to isolated superblock development enveloped by wide streets.⁸⁴ The change from organically evolved, mixed-use enclaves – where many people lived, worked and shopped in the same area – to car-oriented large-block suburbs, dramatically enlarged households' travel footprints. A study on the travel impacts of 900 households that moved from Shanghai's urban core to isolated, superblock and gated housing units on the periphery revealed dramatic shifts from non-motorized to motorized travel and journeys of far longer duration. This resulted in a 50 per cent increase in VKT from the households surveyed.⁸⁵ Another study found that residents living in higher-density areas in Shanghai, with smaller blocks and denser street networks averaged around one-half of the car ownership levels, compared to the urban residents living in more car-oriented, superblock districts.⁸⁶ Moreover, residents of pedestrian/cycle-friendly neighbourhoods travelled shorter distances than those of other neighbourhoods, even in cases whereby the travel mode was the same.

Globally, various neighbourhood designs and retrofits are being introduced to reduce the need for travel by private cars and invite more sustainable forms of mobility. Among these are: traditional neighbourhoods, also known as new urbanism; TOD; and car-restricted districts.

Traditional neighbourhoods and the new urbanism

Before the advent of the private car, traditional neighbourhoods were compact and highly walkable. Daily activities (e.g. shops, restaurants and schools) that were no more than five minutes away were characteristic of the pre-automobile era.⁸⁷ In the early 1980s, an urban design movement, called 'new urbanism', was developed in the US. This movement sought to return neighbourhoods to their pre-automobile designs and ambiances – places that promoted walking, allowed daily face-to-face interaction of people from all walks of life and provided a range of housing types, workplaces, commercial-retail offerings and public places.⁸⁸ Diversity and place-making became catchwords of the movement.⁸⁹ In contrast to the sameness and sterility of suburban sprawl, new urbanism emphasized the fine details of what makes communities enjoyable, distinctive and functional – such as gridiron street patterns well suited to walking, prominent civic spaces that draw people together (and thus help build social capital),

tree-lined skinny streets with curbside parking and back-lot alleys that slow car traffic, and a mix of housing types and prices.⁹⁰

More than 600 new urbanism neighbourhoods have been built, planned or are under construction in the US.⁹¹ Most notable is Seaside, Florida, that was launched in the early 1980s. In Europe, a number of former brownfield sites have been redeveloped since the 1980s, based on traditional versus modernist design principles. One example is Poundbury, England, on the outskirts of Dorchester.⁹² Other notable European new urbanism communities already built or taking form include Heulebrug (Belgium), Pitiuosa (Greece), Agelada de Cima (Portugal), Hardelot Plage (France) and Kemer in Istanbul (Turkey). In developing countries, recent examples of neighbourhood designs and redevelopment projects that follow new urbanism principles to varying degrees are Orchid Bay (Belize), Rosetown outside of Kingston (Jamaica), Timphu (Bhutan) and Melrose Arch in Johannesburg (South Africa).⁹³ However, these projects mainly cater for the middle- or high-income households that can afford the neighbourhood amenities (e.g. civic squares, streetscape enhancements, etc.) that accompany new urbanist communities. Accordingly, they have contributed little to relieving deeply entrenched social problems such as slums and concentrated poverty.

Among the objectives for designing communities, like those proposed by new urbanism, is that there will be a reduction in car dependence by making the communities pleasant places to walk and cycle. Experience largely bears this out.⁹⁴ In the Research Triangle area of North Carolina a study found that VKT reductions were due to the substitution of out-of-neighbourhood car trips for within-neighbourhood walk trips.⁹⁵ At similar income levels, those living in compact, mixed-use 'traditional' neigh-

bourhoods made as many daily trips as those in low-density, single-family suburban neighbourhoods. However the switch from driving to walking and the shortening of trip distances resulted in around 20 per cent fewer VKT per household each weekday.

Transit-oriented development (TOD)

TOD is traditional or new urbanism development that is physically oriented to a public transport station.⁹⁶ By concentrating a mix of pedestrian-oriented development around public transport nodes, residents and workers are more likely to catch a train or a bus for out-of-neighbourhood trips, and walk or bike for shorter within-neighbourhood trips.⁹⁷ TODs aim to function as community hubs, and places where people not only 'pass through' but also choose 'to be' – e.g. for public celebrations and demonstrations, outdoor concerts, farmers' markets and other activities that help build community (Box 5.10).⁹⁸ If there is a logical place to concentrate urban growth and redevelopment, it is around public transport stops – an idea that planners, politicians and lay-citizens alike understand. Of course, high-quality, well-connected public transport service must exist to draw passengers to the station area in the first place, thus TOD relies on and implicitly assumes public transport is safe, reliable and time-competitive with the private car.⁹⁹

Increasingly, TOD is globally recognized as a viable model for shaping urban growth. TOD is most fully developed in Europe, and particularly in Scandinavia. Step one in making TOD a reality is the formulation of a vision and conceptual image of the future metropolis, such as Copenhagen's celebrated 'finger plan' and Stockholm's 'necklaces of pearls' (Figure 5.16). In both these cities, corridors for channelling overspill growth from the urban centres

TOD is traditional or new urbanism development that is physically oriented to a public transport station

TODs aim to function as community hubs

TOD is globally recognized as a viable model for shaping urban growth

Box 5.10 Transit-oriented development

The term TOD refers to compact, mixed-use, pedestrian-friendly development that is 'oriented', and not just adjacent to, urban rail and busway stations. Besides being the 'jumping off' point for catching a train or bus, TOD also serves other community purposes. In the Scandinavian model, TOD is characterized by a large civic square that functions as a community's hub – a gathering place for public events, such as open-air concerts, farmers' markets, public demonstrations and civic celebrations. Thus, TOD can serve both functional and symbolical purposes, as the centrepiece of communities. Experience shows that the Scandinavian approach to TOD designs can have significant benefits to communities such as: increasing public transport ridership; providing mobility choices; increasing public safety; reducing air pollution and energy consumption rates; building social capital; and increasing commerce and economic activities.

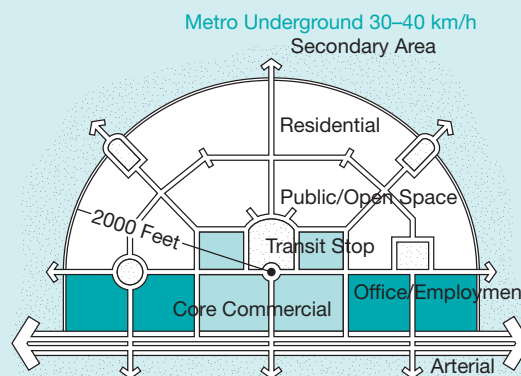


Figure 5.13
Neighbourhood-scale TOD site design, with mixed-use development within a walkshed (650 metres) of a public transport stop, with densities tapering with distance from the station

Source: Curtis et al, 2009, citing Calthorpe, 1993.

TODs can reduce car use per capita by half, thus saving households around 20 per cent of their income

With traffic calming, the street becomes an extension of a neighbourhood's liveable space – a place to walk, chat, and play

were defined early in the planning process, and rail infrastructure was built, often in advance of demand, to steer growth along desired growth axes.

Traditionally, few cities in developing countries were public-transport oriented, featuring fine-grain mixes of land uses, plentiful pathways for pedestrians and cyclists, and ample transit services on major roads. In Latin America, TOD is being planned or has taken form to varying degrees around BRT stations in Curitiba (Brazil), Santiago (Chile) and Guatemala City. Other noteworthy experiences with bus-based TOD can be found in Asian cities such as Kaoshiung, Qingdao and Jiaxing (China) and Kuala Lumpur (Malaysia).

Many cities in China are looking to TOD in order to manage growth and capitalize upon massive rail and BRT investments. Recently, Beijing and Guangzhou adopted TOD as a guiding design principle in their long-range master plans.¹⁰⁰ However, failure to articulate densities (e.g. tapering building heights with distances from stations), the siting of stations in isolated superblocks and poor pedestrian access have undermined TOD efforts in many Chinese cities.¹⁰¹ Over the past two decades, Beijing's investment in a massive 372-kilometre subway metro network has seen housing projects gravitate to rail corridors outside of the urban core, with a few jobs and consumer services following suit.¹⁰² Many rail-served neighbourhoods have become veritable dormitory communities, skewing commuting patterns. A study of three residential neighbourhoods in Beijing's rail-served northern suburbs found as many as nine times the number of rail passengers heading inbound in the morning peak as those rail passengers heading outbound.¹⁰³ In addition, poor integration of station designs with the surrounding development has produced chaotic pedestrian circulation patterns and long passenger queues at suburban stations.¹⁰⁴

Evidence on how TOD has influenced travel and environmental quality comes mainly from the US. There, studies show that TODs can reduce car use per capita by half, thus saving households around 20 per cent of their income since they have, on average, one less car or often none.¹⁰⁵ Typically, TOD residents in the US commute by transit four to five times more than the average commuter in a region.¹⁰⁶ Similar ridership bonuses have been recorded for TOD projects in Toronto, Vancouver, Singapore and Tokyo.¹⁰⁷ In China, a recent study found smaller differentials of around 25 per cent in rail commuting between those living near versus away from suburban rail stations.¹⁰⁸

While TOD planning tends to focus on residences, experience from the US shows that concentrating jobs around rail stops in well-designed, pedestrian-friendly settings can exert even stronger influences on the choice of travel mode.¹⁰⁹ The location of TOD in a region and the quality of con-

necting public transport services can strongly influence the choice of travel mode. A TOD as an island in a sea of auto-oriented development will have little influence on travel.

Traffic-calmed and car-restricted neighbourhoods

Many European cities have brought liveability and pedestrian safety to the forefront of transportation planning. Initiatives have sought to tame and reduce dependence on the private car.¹¹⁰ Traffic calming is one such example, pioneered by Dutch planners who have added speed humps, realigned roads, necked down intersections and planted trees and flowerpots in the middle of streets to slow down traffic. With traffic calming, the street becomes an extension of a neighbourhood's liveable space – a place to walk, chat and play. Car passage becomes secondary. After traffic calming its streets in the early 1990s, the city of Heidelberg, Germany, witnessed a 31 per cent reduction in accidents and 44 per cent fewer casualties.¹¹¹

An even bolder policy in the same direction has been the outright banning of cars from the core of traditional neighbourhoods and districts, complemented by an upgrading and beautification of pedestrian spaces. This practice has become commonplace in many older European cities, whose narrow and winding inner-city streets were not designed for motorized traffic. Today, car-free historical districts thrive in Athens (Greece), Seville (Spain), Lübeck and Bremen (Germany), Bologna and Siena (Italy) and Bruges (Belgium), as well as substantial portions of university towns such as Groningen and Delft (the Netherlands), Oxford and Cambridge (UK) and Freiburg and Münster (Germany). Extended pedestrian-only shopping streets and promenades have also gained popularity, such as Copenhagen's Strøget (Denmark), Lisbon's Baixa (Portugal) and Gamla Stan in old town Stockholm (Sweden). Similarly, multi-block car-free streets and enhanced pedestrian zones are also found in developing-country cities, including Curitiba, Brazil (20 city blocks), Buenos Aires, Argentina (12 blocks of Florida Street and several car-free waterfront redevelopment projects), Guadalajara, Mexico (15 downtown streets) and Beirut, Lebanon (much of the historical core). Entire residential communities, either newly built or redeveloped, that are car-restricted can be found such as Vauban (Box 7.12) and Rieselfeld outside of Freiburg (Germany), Amsterdam's GWL Terrein brownfield redevelopment (the Netherlands), Vienna's Mustersiedlung Floridsdorf housing project (Austria), Munich's Kolumbusplatz neighbourhood (Germany), the Stellwerk 60 project in Cologne (Germany) and Masdar City outside of Abu Dhabi (United Arab Emirates).¹¹²

	Retail sales transactions and turnovers			Total %
	Increase %	Decline %	No change %	
Pedestrianized area				
Retailing	83	3	14	100
Hotels	28	8	64	100
Restaurants	63	1	36	
Outside pedestrianized area				
Retailing	20	17	63	100
Hotels	20	2	78	100
Restaurants	25	5	70	100

Source: Hass-Klau, 1993.

Table 5.2

Changes in retail sales transactions in pedestrianized areas of West German cities (1965–1975)

Some European communities have opted for traffic calming measures using cellular neighbourhood designs that require motorists to follow round-about routes, while providing direct connections to cyclists and pedestrians when going from one cell to another. One example is Houten, a master-planned, largely bedroom community of 41,000 inhabitants south of Utrecht (the Netherlands), which was designed and built to prioritize travel by bicycle and walking. Despite some initial uneasiness by business merchants, residents and politicians, global experiences with creating car-free districts, auto-restricted neighbourhoods and pedestrian-only streets have generally been positive. However, consideration needs to be made to ensure that high-quality and frequent public transport services are in place to absorb displaced car traffic. A study of pedestrianization in German cities recorded increases in pedestrian flows, public transport ridership, land values and retail sales transactions (Table 5.2), as well as property conversions to more intensive land uses, matched by fewer traffic accidents and fatalities.¹¹³ A study of over 100 cases of road-capacity reductions (e.g. car-free zones, pedestrian-street conversions as well as street and bridge closures) in developed countries found an average overall reduction in motorized traffic of 25 per cent, even after controlling for possible increased travel on parallel routes. This ‘evaporated’ traffic represented a combination of people forsaking low-value, discretionary trips and opting for alternative modes, including public transport, walking and cycling.¹¹⁴

CORRIDOR CONTEXTS

A transportation ‘corridor’ consists of ‘one or more primary transportation facilities that constitute a single pathway for the flow of people and goods within and between activity centers, as well as the abutting land uses and supporting street network’.¹¹⁵ Corridors represent the spatial context in which significant challenges are often faced in coordinating transportation and land development across multiple jurisdictions. They are also where ‘access

management’ – trading off the mobility versus site-access functions of roads – can pose significant policy challenges, particularly in fast-growing cities and regions.¹¹⁶ If well planned and designed, corridors also present a spatial context for designing a network of TODs.

Mobility and development trade-offs

Transportation corridors function to move people and goods but often face intense development pressures that over time can erode their mobility function.¹¹⁷ Experiences show that building motorways without carefully managing urban growth is a sure-fire recipe for future traffic tie-ups.¹¹⁸ This is particularly the case of developing country cities. New roadways open up access to new territories, spawning building construction and land development and thus more traffic.¹¹⁹ In Sub-Saharan Africa, road improvements have stimulated the local production of cash crops, spurring urbanization in secondary towns where farmers sell their products and buy services and imported goods.¹²⁰ Access to port cities is especially crucial since most African trade is trans-oceanic. A study of 287 cities in 15 African countries found that cities relatively closer (465 kilometres) to a major port via paved roads grew 6 per cent faster, between 2002 and 2008, than otherwise similar cities.¹²¹ Another study of proposed road upgrades between northeast Congo and the Central African Republic estimated that, in addition to stimulating urban growth, goods traded via this route would increase from a current value of US\$16 million to US\$142 million, nearly 800 per cent increase.¹²² The study concluded that trade expansion promoted by the upgrading would exceed costs by about US\$220 billion over a period of 15 years.

With time, induced economic growth and new urbanization generates new trips, congesting roadways. Unless such growth is properly managed, economic and urbanization benefits will diminish.¹²³ Effectively, the roadway’s role and function transforms from one of providing *mobility* to providing *site access* (Figure 5.14). The two are in fundamental

Consideration needs to be made to ensure that high-quality and frequent public transport services are in place to absorb displaced car traffic

Transportation corridors function to move people and goods but often face intense development pressures that over time can erode their mobility function

Figure 5.14

Mobility and accessibility trade-off along freeway corridor

Note: Top: multiple interchanges enhance site access, inducing new growth that over time slows mainline traffic flows. Bottom: limited interchanges constrain land development and thus help preserve speeds.

Source: Ferrell et al, 2012.

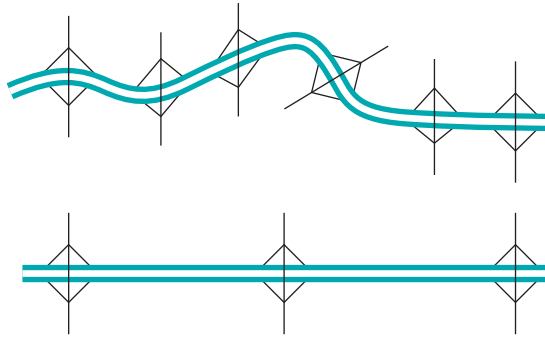
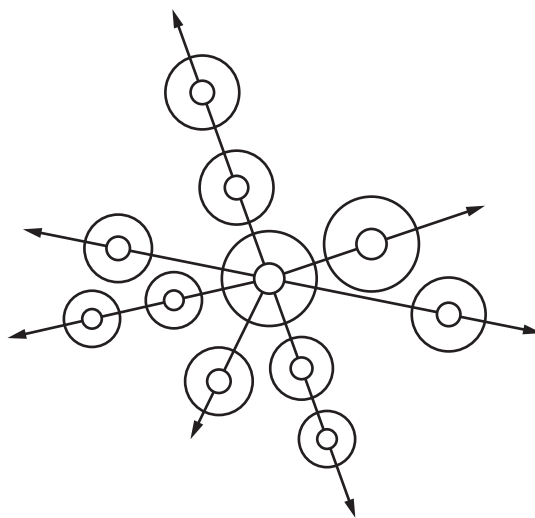


Figure 5.15

Public transport corridors as 'necklaces of pearls'

Note: 'Necklace of pearls' = strings of TOD aligned along public transport corridors.

Source: Cervero and Murakami, 2008a, p23.



Freeways and rail systems can complement rather than compete with each other through multi-modal corridor planning and design

'Necklace of pearls' built form not only induces public transport riding but can also produce balanced, bi-directional flows . . . through land-use intermixing

conflict. High corridor access, marked by frequent driveways, curb cuts and slow-moving cars accessing/exiting sites interferes with through-traffic movements. Further, travel speeds decline and accident levels increase. The problem is often accentuated when different institutions control infrastructure and land development along the corridor. If a national government or state builds a new road to improve cross-city traffic flows, the intention of local governments is to take advantage of the added capacity by allowing new development – a means to grow the local economy and generate property tax income.¹²⁴ Such scenarios whereby localities exploit newly provided roadway infrastructure, in order to leverage new growth and increase tax revenues at the expense of intercity mobility, are particularly problematic in parts of Sub-Saharan Africa and South-Eastern Asia.¹²⁵

One approach to mitigating unintended consequences is improved corridor access management.¹²⁶ This can be done through growth management, road designs, price signals or other policy instruments (e.g. license-plate restrictions on travel). An example of a road-design response is the construction of frontage roads that separate through-moving traffic from local, slower-moving traffic. This is a common practice in North America and Europe. Front roads

and auxiliary lanes are common in wealthier countries where sufficient rights of way have been preserved to accommodate them. However, these can be difficult to build in Sub-Saharan Africa and Asia because of land constraints. Limited-access toll-ways can also be built to allow those willing to pay for travel-time savings to avoid local congestion.¹²⁷

In lieu of supply-side corridor-management responses (e.g. construction of frontage roads and curb-cut restrictions), corridor-level growth management plans that link land use to new or expanded improvements can also be developed. Both land development and transport infrastructure need years for implementation. Therefore, coordinated and strategic long-range planning is essential. Once a transport investment is committed and land-use policies are adopted, the two can co-evolve over time.

Freeways and rail systems can complement rather than compete with each other through multi-modal corridor planning and design.¹²⁸ In the suburbs of Munich (Germany), suburban trains and motorways are physically integrated to allow motorists to efficiently switch to trains. Large digital screens inform motorists of downstream traffic speeds and expected travel times for reaching the city centre via train.¹²⁹

Public transport-oriented corridors

Some cities have directed land uses that are scattered throughout suburbia – e.g. housing, offices, shops, restaurants, strip malls – to corridors served by public transport.¹³⁰ Scandinavian cities such as Stockholm (Sweden), Helsinki (Finland) and Copenhagen (Denmark) have created networks of linked TODs – that is, public transport-oriented corridors. This 'necklace of pearls' built form (Figure 5.15) not only induces public transport riding but can also produce balanced, bi-directional flows (and thus more efficient use of infrastructure) through land-use intermixing. While some stations have a balance of land uses, others are more specialized, functioning as either employment centres or residential communities. However, within the 10–15 kilometre linear corridors served by rail, one finds a balance of jobs, housing, retail and population services. Consequently, there are multi-directional flows of traffic during peak hours. Public transport is efficiently used in both directions, rather than the asymmetrical flows found in imbalanced settings.

Greater Stockholm has evolved along public transport-oriented corridors. During the last half-century, strategic regional planning has given rise to regional settlement and commutation patterns that have substantially lowered car-dependency in Stockholm's middle-income suburbs.¹³¹ The city's investment in radial rail lines has produced a necklace-of-pearls urban form and a balanced use of land for work and housing. A number of mixed-use

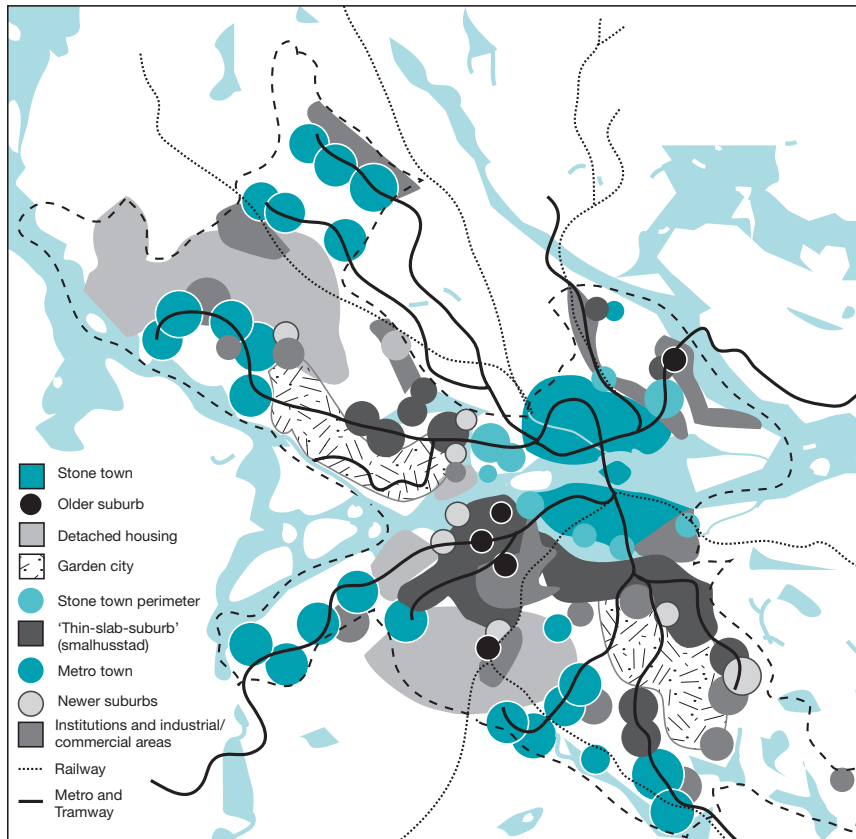


Figure 5.16

Stockholm's necklace-of-pearls built form

Source: Stockholm Municipality, 2000.

neighbourhoods dot the region's extensive radial rail network, interspersed by lower-density development and open space (Figure 5.16). Stockholm planners consciously created jobs–housing–retail balance along rail-served axial corridors, leading to a high share of trips self-contained within sub-regional corridors, and a directional balance of travel flows during peak hours. Less cross-hauling from one quadrant of the region to another has reduced traffic burdens on the region's transportation networks and rationalized travel flows to produce short-to-moderate distance trips that are well served by railway and fast-bus services. This has resulted in high modal splits for public transport (higher than in larger rail-served cities such as Berlin, Germany; and London, UK) and comparatively low CO₂ emissions per capita in the transport sector (lower than Tokyo, Japan; New York, US; and Rome, Italy).¹³² Most residents in Stockholm use public transport to commute to work, and selectively use private cars for grocery shopping or when travelling on long weekend excursions.

Curitiba, Brazil, one of the world's most sustainable, well-planned cities, is another text-book example of successful public transport-oriented corridors, albeit using a lower-cost public transport technology than in Stockholm, namely: BRT. By emphasizing planning for people rather than cars, Curitiba has evolved along well-defined radial axes lineal corridors that are intensively served by dedicated busways. Along some corridors, streams of

double-articulated buses haul 16,000 passengers per hour, comparable to what much pricier metro-rail systems carry. The city's current system of 390 routes served by 2000 vehicles carries 2.1 million passengers per day, double the count of 15 years ago. To ensure a public transport-oriented built form, Curitiba's government mandates that all medium- and large-scale urban development be sited along a BRT corridor.

A design element used to enhance accessibility and ensure balanced corridor growth in Curitiba is the 'trinary' – three parallel – roadways with compatible land uses and building heights that taper with distance from the BRT corridor (Figure 5.17). Zoning ordinances and urban design standards promote ridership productivity and environmental quality. The first two floors of buildings along the busway – which do not count against permissible plot ratios (building height/land area) – are devoted to retail uses. Above the second floor, buildings must set back at least 5 metres from property line to allow sun to cast on the busway. The inclusion of upper-level housing entitles property owners to density bonuses, leading to vertical mixing of uses within buildings. Further, the higher densities produced by the trinary design have resulted in increased ridership. Concentrated commercial development has also channelled trips from residences beyond BRT terminuses to the trinary corridors. In 2009, for example, 78.4 per cent of trips boarding at the ter-

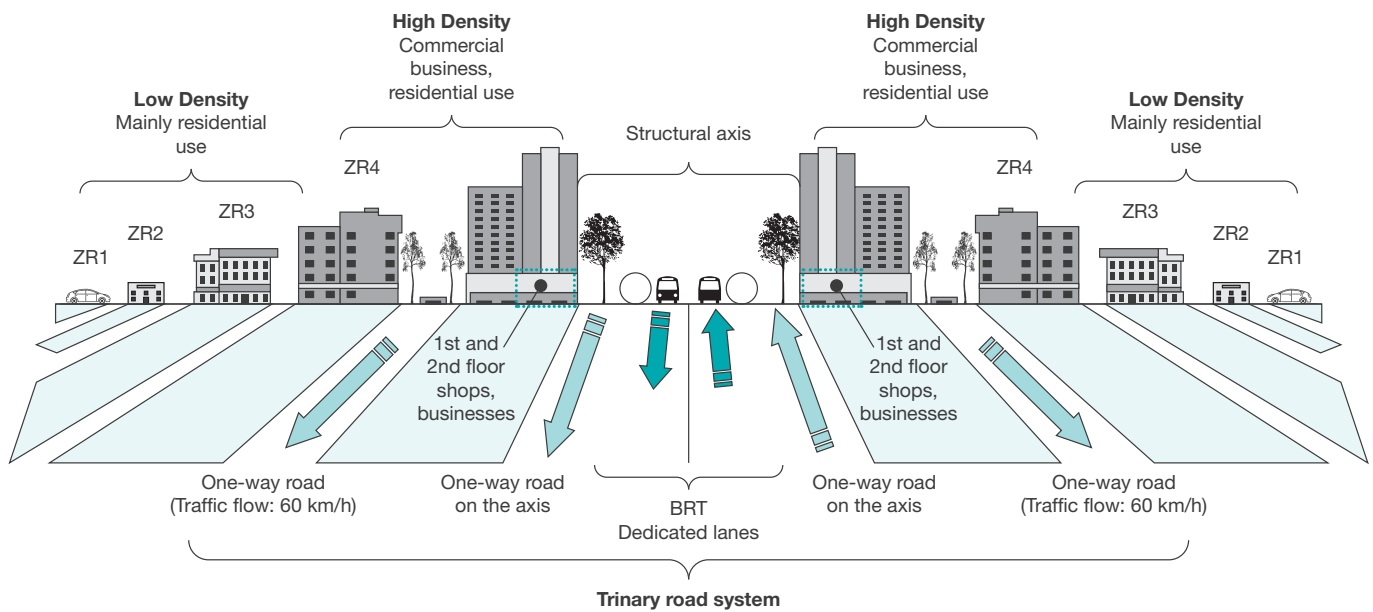


Figure 5.17

Curitiba's trinary road system, Brazil

Source: Suzuki et al, 2010.

Curitiba has Brazil's highest public transport mode splits (45 per cent), the lowest congestion-related economic losses and lowest rate of urban air pollution

minus of Curitiba's north to south trinary corridor were destined to a bus stop on the same corridor.¹³³ Figure 5.18 shows daily ridership at stops along Curitiba's north to south BRT line superimposed on the corridor's skyline. Typically, experience shows that when densities increase, so does public transport ridership. In addition, the mixing of land uses along the trinary corridors has produced bi-directional flows, ensuring efficient use of bus capacity.

The mobility and environmental benefits from Curitiba's three-plus decades of integrated development along public transport corridors are well celebrated. Curitiba has Brazil's highest public transport mode splits (45 per cent), the lowest congestion-related economic losses and lowest rate of urban air pollution (despite being an industrial city).¹³⁴ On a per capita basis, Curitiba is one of Brazil's wealthiest cities, yet it averages considerably more public-transport trips per capita than much-bigger

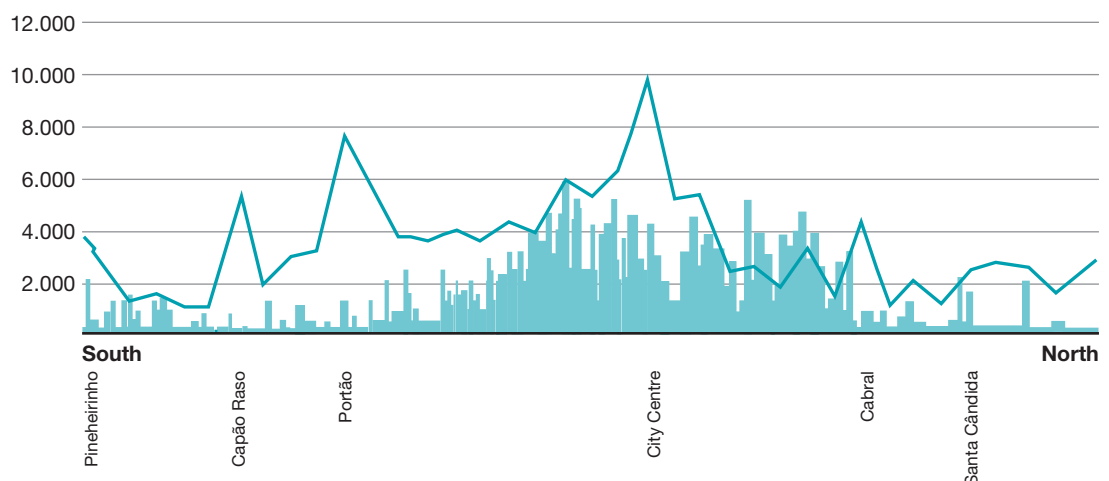
Rio de Janeiro and São Paulo.¹³⁵ In 2005, Curitiba's VKT per capita (7900) was only half as much as in Brazil's national capital Brasília, a city with a similar population size and income level but a sprawling, autocentric built form.¹³⁶ Based on 2002 data, Curitiba's estimated annual congestion cost per capita of US\$0.67 is only a fraction of São Paulo's (US\$7.34).¹³⁷ The strong, workable nexus that exists between Curitiba's bus-based public transport system and its mixed-use linear settlement pattern deserves most of the credit.

Sustained political commitment has been an important part of Curitiba's success. The harmonization of transport and land use took place over 40 years of political continuity, with forward-looking, like-minded mayors who built on the work of their predecessors.¹³⁸ A cogent long-term vision and the presence of a semi-autonomous municipal planning organization¹³⁹ to implement the vision have been

Figure 5.18

Correspondence between daily public transport boardings (vertical axis) and skyline profile along Curitiba's north to south trinary axis

Source: Duarte and Ultramari, 2012.



crucial in allowing the city to chart a sustainable urban pathway.

In recent years, Curitiba has begun to experience the limits of rubber-tire technologies. With buses operating on 30-second intervals on main routes during the peak hour, bunching problems have disrupted and slowed services. Veritable elephant-trains of buses have increased operating costs and precluded the kinds of economies of scale enjoyed by single-driver operated trains. Extreme overcrowding has prompted many middle-class choice travellers to switch to driving.¹⁴⁰ A long-discussed light-rail line, to replace overcrowded buses, has yet to gain momentum due to cost concerns.¹⁴¹

Curitiba has also been criticized for giving short shrift to intermodal connections to BRT corridors. Only six of the city's 22 BRT stations, for example, are connected by dedicated bicycle paths, which is a smaller share than Bogotá's Transmilenio BRT.¹⁴²

REGIONAL CONTEXT

Cities have grown and spilled beyond their walls and jurisdictional boundaries for centuries. However, the development of city clusters and large urban agglomerations is more recent. The modern approach to new town development began with Ebenezer Howard's concept of the 'Garden City' in 1898, leading to the evolution of Letchworth and Welwyn Garden City.¹⁴³ This development was followed by the UK new towns movement in the late 1940s, which has since been emulated in many countries, particularly in the building of new national capitals such as Canberra (Australia), Dodoma (Tanzania) and New Delhi (India), which are designed as cluster or regional cities. Many countries, especially China, have adopted new towns as the preferred planning approaches previously adopted in European and US cities.¹⁴⁴ For example, Shanghai has developed extensive plans for its metropolitan region. Other Asian cities, such as Delhi (India), Kuala Lumpur (Malaysia) and Jakarta (Indonesia), are perusing new town approaches to the planning and development of their region based on clusters. Navi Mumbai, adjacent to the Indian city of Mumbai, is being planned as the largest new town in the world.¹⁴⁵ Latin American cities such as Buenos Aires (Argentina), Rio de Janeiro (Brazil), Santiago (Chile) and Mexico City have also adopted new town approaches to regional development based on clusters. The concept of city cluster development was applied to the planning of Abuja (Nigeria) and Brasília (Brazil), Shanghai (China), Mumbai (India) and Hanoi (Viet Nam), promoting cross-river expansion into new urban growth areas. Growth triangles, such as in Singapore, Johor Baru (Malaysia) and Bintan (Indonesia), and Shenzhen, Hong Kong and Macau (China), are examples of network planning approaches based on a regional agglomeration concept.

Connectivity and large urban configurations

Cities of different sizes have increasingly started to merge and form new spatial configurations that typically take three principal forms, namely: mega-regions, urban corridors and city regions. These forms act as nodes where global and regional flows of people, capital, goods and information combine and commingle, resulting in faster growth, both demographic and economic, than the growth of the countries where they are located.¹⁴⁶ Connectivity and regional transport are crucial for the development of these large agglomerations.

In some cases, large cities such as Cairo (Egypt), Mexico City or Bangalore (India) are creating large urban configurations in which they dominate the surrounding regional space, amalgamating other cities and towns within their economic orbit. In other cases, two or more large cities, such as Mumbai and Delhi in India; São Paulo and Rio de Janeiro in Brazil; or Ibadan, Lagos (Nigeria) and Accra (Ghana) form transport corridors for the purposes of industrial development, business services and trade. Still, in other cases, the government creates planned 'supra-agglomerations' as part of a regional and national development strategy. This is the case in China, where the Guangdong Provincial Government recently announced the development of the Pearl River Delta mega-region, which would include nine large cities, with an aggregate surface area of 40,000 square kilometres, and an impressive transport infrastructure (Box 5.11). Similarly, the large economically prosperous cities of Shanghai and Guangzhou have invested in infrastructure to connect peripheral towns and enhance the large urban configuration.¹⁴⁷

Such large urban configurations, grouped in networks of cities, amplify the benefits of economies of agglomeration, increasing efficiencies and enhancing connectivity. They also generate economies of scale that are beneficial in terms of labour markets, as well as transport and communication infrastructure, which in turn increases local consumer demand.

City cluster variances and transport responses

There are significant differences in the patterns of city clusters between regions and sub-regions. These are explained by factors related to geography, climate, population size, natural resources, culture, land management, political history, infrastructure, markets and levels of development. In addition, they are also defined by economic activities and the roles played by transport and connectivity.

In Europe, urban and regional planning has had much more influence than in any other region of the world. Large urban configurations have been located along major transport routes that use multi-modal

A cogent long-term vision and the presence of a semi-autonomous municipal planning organization to implement the vision have been crucial in allowing [Curitiba] . . . to chart a sustainable urban pathway

Connectivity and regional transport are crucial for the development of . . . large agglomerations

Large urban configurations, grouped in networks of cities, amplify the benefits of economies of agglomeration, increasing efficiencies and enhancing connectivity

In Europe, urban and regional planning has had much more influence than in any other region of the world

Box 5.11 Pearl River Delta mega-region

Megacities have become so large that some countries have moved to planning supra-cities. These are network cities with populations of over 40 million. In 2010, the Guangdong Provincial Government in China announced it was planning to create the world's biggest 'mega-city' by merging nine cities into a mega-region metropolis. The new megacity would incorporate a large part of China's manufacturing heartland, and stretch in an arc from Zhuhai to Shenzhen and include the cities of Foshan, Dongguan, Zhongshan,

Zhuhai, Jiangmen, Huizhou and Zhaoqing. The nine large cities that would make up the new mega-region account for nearly a tenth of China's economy.

Transport infrastructure will improve connectivity and spatially integrate the network of cities that make up this large urban/regional configuration.

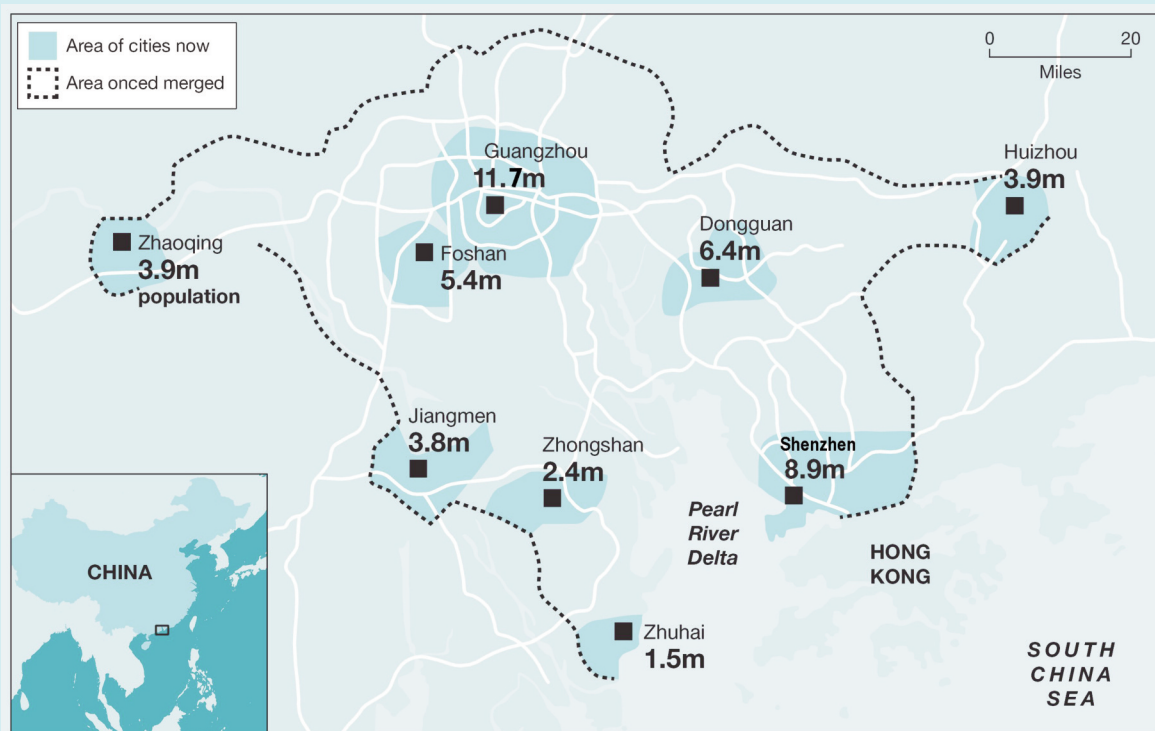


Figure 5.19

Pearl River Delta mega-region

Source: Moore and Foster, 2011.

City clustering in North American cities . . . is the result of massive investment in freeway systems and planned urban/regional development

networks that integrate land, sea and air transport systems. The Trans-European Transport Network (TEN-T) has constituted a key element in boosting competitiveness and employment through a better connectivity that allows goods and people to circulate quickly and easily for higher economic, social and territorial cohesion.¹⁴⁸ TEN-T is working to improve citizens' quality of life and strengthening the economy by promoting sustainable urban mobility and increased use of clean energy-efficient vehicles.¹⁴⁹ The regional infrastructure looks at specific inter-modal platforms at city level for better mobility and connectivity at different scales.

Large urban configurations in Europe have emerged as specialized industrial and business centres along key transport routes. However, these urban configurations have populations that are less dense than their counterparts in developing regions. Many European capital cities have become so called supra-clusters¹⁵⁰ of cities, with massive integrated national transport systems and the national capital as a hub. Eastern and Southern European city clusters

are becoming much more dispersed, taking the form of regional city dominated clusters. Cities such as Warsaw (Poland) and Moscow (Russia) have expanded in a concentric pattern from the historic city centre. Moscow has many features similar to Beijing (China) and Dallas (US), with an expanding ring road system and decentralized employment and residential development.

City clustering in North American cities, particularly in the US, is the result of massive investment in freeway systems and planned urban/regional development, with dispersed urban settlement patterns and specialized functions. Most cities in these large urban configurations have populations of over 1 million, and the typical morphology is polycentric in terms of both urban form and economic structure. Most North American cities have well-established central business districts. However, an increasing proportion of economic and employment activities is occurring outside these areas. The Washington DC region, for example, has expanded as a large polycentric city into adjacent Maryland and Virginia.

It is made up of cluster or sub-regional global employment centres located near the intersection of the beltway and freeway systems. This is repeated in cities such as Dallas, Boston, San Francisco, Los Angeles and Chicago, to name just a few.

A network of strategic highways made up of 260,000 kilometres, known as the National Highway System, connects major airports, ports, rail or truck terminals, railway stations, pipeline terminals and other strategic transport facilities in the US. Although the system includes 4 per cent of the nation's roads, it carries more than 40 per cent of the highway traffic, 75 per cent of heavy truck traffic and 90 per cent of tourist traffic. All urban areas with a population of over 50,000 and about 90 per cent of America's population live within 8 kilometres of the network, which is the longest in the world.¹⁵¹ Inter-city or high-speed rail systems in the US are undersized, with only one high-speed rail line in operation. The Acela Express runs between Washington and Boston via New York City (633 kilometres). As a result of the dispersed population and great distance between major cities, high-speed rail in the US is of less value than air or car travel. In comparison, China with its high population densities has a high-speed railway network that spans over more than 8300 kilometres already in service, and about 17,000 kilometres under construction.¹⁵²

Large urban agglomerations in Asia are more dispersed and less well planned. Densities of large urban agglomerations in newly industrialized countries are typically much higher – over 15,000 persons per square kilometre – but in city regions, they can be twice as high, particularly in inner-city areas. Large urban configurations are becoming more specialized, including industrial cluster development (high technology and traditional manufacturing) and services (health, technology and transport). There is significant variance in the city cluster development in Asian sub-regions. The lack of basic services, overcrowding and high levels of congestion and pollution in South, Central and South-Eastern Asia have led to a dispersed pattern of urban city cluster development, with industrial/commercial development moving out from the congested inner-city areas. Cities in these sub-regions are becoming much bigger, more decentralized and specialized. Some cities, such as Manila (the Philippines), Delhi (India) and Kuala Lumpur (Malaysia), have well developed sub-metropolitan centres of employment, including commercial centres and large export enterprise zones. However, the links and integration of transportation systems and services between the city centres are poor. Uncontrolled leapfrogging of urban development and satellite city development has occurred unabatedly in most cities in these sub-regions. As a result, urban densities across these city clusters are rapidly declining, with some cities

recording annual decreases in density rates of more than 3 per cent.¹⁵³

Based on the regional planning principle to use large cities to drive the development of small cities, China has pursued its strategy of spatial concentration of urban population and industries. Clusters of cities are grouped along the horizontal axes of Longhai Railway (Lianyungang–Lanzhou) and the coastal area of China, along Beijing–Guangzhou and Beijing–Harbin Railways and Baotou–Kunming transportation corridors, respectively. Africa has very few large urban configurations. Those in existence tend to be linear along transport corridors or coastal trading routes (e.g. the Abidjan (Côte d'Ivoire)–Accra (Ghana)–Lagos (Nigeria) corridor) and major arterial roads between adjacent provincial cities (Johannesburg–Pretoria, South Africa, and Lagos–Ibadan, Nigeria). The Abidjan–Lagos coastal corridor (998 kilometres) links some of the largest and economically most dynamic capitals in Africa, such as Abidjan, Accra, Lomé, Cotonou and Lagos. The corridor serves a population of over 35 million people with up to 10,000 people and several thousand vehicles crossing borders daily, accounting for the highest traffic in West and Central Africa.¹⁵⁴ These corridors are not properly planned. As a result, transport services are poor and so are infrastructure and transport logistics. Employment in these areas is driven primarily by trading, natural resources and low-level services. The typical pattern combines high population density in inner cities and low densities in outer areas. Eastern, Middle and Southern African large urban agglomerations tend to form into low-density urban cluster development, dispersed over large peri-urban areas. This results in poor connectivity and nascent transport infrastructure.

Despite having the highest proportion of urban population in the world, Latin American and the Caribbean region has very few large urban configurations. Initially, the historic pattern of urbanization was monocentric. However, with the development of secondary cities and better connectivity, a city cluster pattern has emerged resulting in a polycentric urban growth. Recently, a small number of mega-regions have emerged, such as the one that stretches from São Paulo to Rio de Janeiro (Brazil) that is home to 43 million people. This mega-region is mainly served by road and commercial flights, though there is a project to develop a high-speed train in the near future. City regions such as Rio de Janeiro, Santiago (Chile) and Caracas (Venezuela) are constrained by physical geography, leading to spillover corridor development along valleys and inter-provincial highways. Various other large cities are growing in a diffuse, low-density pattern with peripheral industrial development and housing.

Large urban agglomerations in Asia are more dispersed and less well-planned

Africa has very few large urban configurations. Those in existence tend to be linear along transport corridors or coastal trading routes . . . and major arterial roads between adjacent provincial cities

IMPACTS OF TRANSPORTATION INVESTMENTS ON URBAN FORM

Transportation investments shape urban form

Transportation is a necessary but hardly a sufficient precondition for land-use changes

Urban rail systems, like metros and light-rail, are potential city-shapers

Often, rail-based public transport investments end up being a stronger force toward decentralization than concentration

Just as urban form and land-use patterns shape transportation, transportation investments shape urban form. The opening of a new road or public transport line influences the locations, intensities and types of development as well as the value of land. It is the changes in accessibility, not the physical infrastructure itself, that drive urban-form and land-use changes, following transportation infrastructure investments. Matching the infrastructure *hardware* with supportive policy *software* is essential, if hoped-for land-use outcomes are to follow. Supportive policies might include permissive zoning that allows densification near metro-rail stations, or complementary expansion of sewerage/water-supply trunk line capacities that accommodate new growth.

The section below reviews the impacts of public transport investments on urban form. This is followed by discussions of motorways and their urban development impacts. Collectively, experiences show that transportation is a *necessary* but hardly a *sufficient* precondition for land-use changes.

Impacts of public transport investments

History shows that urban rail systems, like metros and light rail, are potential city-shapers.¹⁵⁵ They often define the growth spines and axes of cities, leading to higher density concentrations of industries, offices and businesses along rail-served corridors. Rail-based public transport investments – matched by frequent, high-quality services – strengthen the economic primacy of central-city locations. They also spur sub-centring and decentralization, and

are contingent on levels of proactiveness in leveraging new development and minimizing the growth-restricting impacts of onerous regulations (Figure 5.20).¹⁵⁶ In cities such as Toronto (Canada), Portland (US) and Munich (Germany), regional governing systems help orchestrate TOD through a combination of regulation and incentive-based policies (e.g. assistance with land assembly and underwriting development costs in redevelopment districts). The new rail systems in these cities have attracted significant shares of new developments to station areas.¹⁵⁷

Public transport investments in rail-based services exert their strongest spatial influence in large, congested cities.¹⁵⁸ While most empirical knowledge is drawn from developed countries, theory suggests that the city-shaping impacts of new rail investments in developing countries might be stronger. This is due to rapid rates of population growth and motorization, high levels of congestion (and thus a pent-up demand for siting new development in accessibility-enhanced locations) and rising disposable incomes. In developing-country cities, however, weak institutions for regional-scale planning and an orientation toward near-term project investments versus long-term strategic planning are working against successful public transport and land-use integration.¹⁵⁹

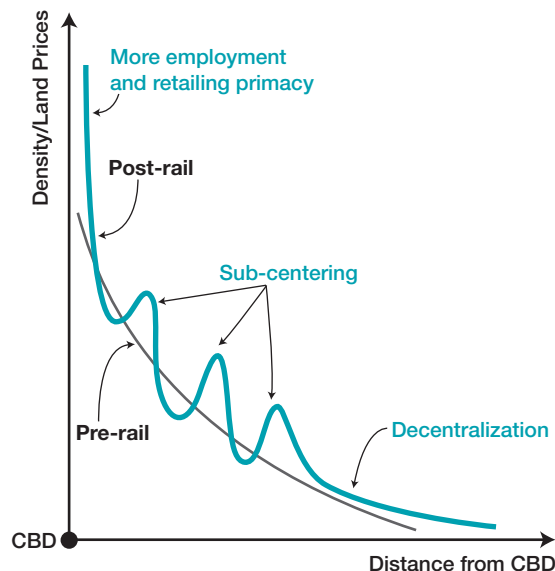
Often, rail-based public transport investments end up being a stronger force toward decentralization than concentration, by adding new layers of accessibility to outlying settings (Figure 5.20). While growth might be funnelled in a particular direction as a result of a new public transport line, more often than not, this direction will be outward.¹⁶⁰ Metro-rail investments in Santiago, Mexico City and other Latin American cities have also contributed to the segregation of households by income and class, displacing the urban poor to the metropolitan periphery, while modernizing and opening the inner city to wealthier segments of the population.¹⁶¹ Critics argue that such mal-distributive impacts are rooted in transportation investments that favour the mobility interests of wealthier individuals. This situation is further exacerbated by lack of compensatory programmes, such as affordable housing requirements, to moderate such displacements.¹⁶² A more balanced portfolio of transportation improvements that ensures benefits accrue to all socioeconomic groups can help mitigate such unintended consequences. The desire to better serve the mobility needs of the poor partly explains Bogotá's proactive investments in world-class BRT and bikeway networks over the past decade.¹⁶³

Global experiences show that a number of preconditions are necessary for urban public transport investments to spawn sustainable urban-form outcomes. Some of these are outlined in Box 5.12, and are based on insights from a number of empirical studies on the impacts of high-capacity public transport systems on urban form in both developed and developing countries.

Figure 5.20

Urban public transport investments and urban-form outcomes

Source: Cervero, 1998.



Box 5.12 Prerequisites to urban-form changes

Proactive planning is necessary if decentralized growth is to take the form of sub-centres. Whether decentralized growth takes a multi-centred form rests largely with the degree of public commitment to strategic station-area planning, carried out on a regional scale. Experiences in cities such as Toronto (Canada), Stockholm (Sweden), Munich (Germany), Hong Kong (China) and Singapore show that an aggressive stand to leverage the benefits of rail services can lead to more concentrated forms of decentralized growth. Given public-resource commitments, railways and busways do not only strengthen the core but also produce multiple sub-centres.

Railways and busways can spur central-city redevelopment under the right conditions. When government agencies are willing to absorb some of the risks inherent in redeveloping economically stagnant neighbourhoods, public transport can help attract private capital and breathe new life into struggling areas, as revealed in large cities such as Tokyo (Japan), Hong Kong (China), London (UK), San Francisco Bay Area and metropolitan Washington (US).

Other pro-development measures must accompany public transport investments. In addition to financial incentives, experiences show that supportive policies and public actions must be in place to leverage land development. Foremost among these are:

- permissive and incentive zoning (e.g. density bonuses);
- the availability of nearby vacant or easy-to-assemble and developable parcels;
- support for land-use changes among local residents (i.e. organized opposition and NIMBY forces);
- a hospitable physical setting (in terms of aesthetics, ease of pedestrian circulation and a healthy neighbourhood image);
- complementary public improvements (e.g. upgrading of sidewalks, expansion of water and sanitation trunk-line capacities and burying utilities);
- an absence of physical constraints (e.g. pre-emption of land development by park-and-ride lots or the siting of a station in a busy freeway median).

Public transport service incentives and private car 'equalizers' (disincentives)^a help induce station-area land-use changes. The provision of frequent and reliable rail and feeder bus connections is needed if private capital is to be enticed to station areas. Only then will railways become time-competitive with the private car. Such pro-public transport measures often need to be accompanied by 'equalizer' policies^a that remove many of the built-in incentives to drive, such as the availability of plentiful, low-cost parking. Congestion pricing in Singapore, Stockholm (Sweden) and London (UK) partly explains why railway services in these cities are heavily patronized and not unrelated, and why new land development is occurring around these cities' rail stations. The combination of TOD and transportation demand management can be especially powerful, yielding synergistic benefits, as suggested by experiences in Singapore, Copenhagen (Denmark), Stockholm and Ottawa (Canada).

Network effects matter. For fixed-guideway public transport systems (e.g. railways and BRT systems with exclusive rights of way) to induce large-scale land-use changes, it is essential that they mimic the geographic coverage and regional accessibility of their chief competitors, limited-access freeways and highways. Good intermodal connections between high-capacity public transport systems and secondary systems, like bus and paratransit feeders, serve to extend the spatial reach of backbone systems. The strong city-shaping influences of metros in Paris (France), London (UK) and Tokyo (Japan) are, to a large extent, a result of such network effects, wherein railways serve shares of origin-destination combinations that are comparable to freeway and motorway networks. The addition of a new railway or BRT line creates spillovers and synergies, benefiting not only the newly served corridors but existing ones as well. For existing metro lines, newly opened lines increase the number of regional origin-destination combinations that can be served.

Note: ^a The term 'equalizer' is preferred to 'disincentive' as such policies are not punitive, and aim to 'level the playing field' so as to remove any unfair advantages to private car travel.

Sources: Knight and Trygg, 1977; Pucher and Lefèvre, 1996; Cervero, 1998; Cervero et al, 2005; Mees, 2009; Suzuki et al, 2013.

Public transport and land price appreciation

Accessibility benefits conferred by rail systems get capitalized into land prices. Higher values of rail-served parcels in turn exert market pressures to intensify land development. Land-value premiums of commercial parcels within walking distance of metro-rail stations are sometimes as high as 100 per cent in the downtowns of some large cities.¹⁶⁴ A survey of 150 rail projects in the US, UK and Europe found that public transport services generated positive effects on residential as well as commercial proper-

ties, though the magnitude of impacts varied considerably.¹⁶⁵ When rail investments are carefully coordinated with land development through public-private partnerships, as in Portland, Oregon, the results can be dramatic and catalytic. Portland's east and west light rail lines attracted over US\$2.4 billion in investment within walking distance of their stations.¹⁶⁶ The city's new streetcar line through the mixed residential-commercial Pearl District triggered US\$2.3 billion in private investments. According to estimates, every dollar in public investment in public transport leveraged US\$31 in private investments in Portland.¹⁶⁷

Accessibility benefits conferred by rail systems get capitalized into land prices

Public transport value captures not only add revenues to the public coffers, but also . . . [reduces] land speculation

Land-value appreciation presents an opportunity to recapture the value created by public investments in public transport, as practiced in Hong Kong, China (Box 8.7) and Tokyo, Japan (through private railway consortia). Public transport value captures not only add revenues to the public coffers, but also by sharing the value-added from public investments, land speculation is reduced. In Hong Kong, the 'Rail+Property' approach also creates market demand that ensures high-ridership services.¹⁶⁸ Hong Kong's version of public-private partnership is not about off-loading the cost of building railways to the private sector. Rather, it is about 'co-development' – each sector bringing a natural advantage to the table (e.g. land acquisition powers in the case of the public sector; access to equity capital in the case of the private sector). The resulting 'win-win' situation leads to financially viable investments and an intimate connection between rail systems and nearby real-estate development that attracts tenants, new investors and public transport riders. Public-transport joint developments (e.g. the leasing of air rights above metro-rail stations to private developers) are another way to financially capitalize on the accessibility benefits conferred by public rail investments.¹⁶⁹

Bus-based public transport and urban-form adjustments

Conventional wisdom holds that traditional bus services have imperceptible influences on urban form and land-use patterns because, in contrast to many rail systems, they fail to deliver appreciable accessibility benefits. This is especially the case in developed countries where high levels of private car ownership mean conventional buses are considerably slower than cars for the vast majority of trips. The ability to alter bus service levels, change bus routing, as well as the stigma attached to the low-income status of bus patrons, most likely suppress the land-development impacts of conventional bus services. An exception, however, is BRT wherein buses are provided with an exclusive, dedicated lane, which significantly improves the quality of service. BRT investments in Ottawa (Canada), Pittsburgh (US), Brisbane (Australia) and Curitiba (Brazil) generated land-use benefits that were as large as those that would have been created by railway investments.¹⁷⁰ Thus, it is not public transport 'hardware' – i.e. steel-wheel trains or rubber-tire buses – that unleash land-use changes, but rather the quality of service and more specifically, the comparative travel-time savings of taking public transport vis-à-vis the private car.

As with rail, where BRT investments have triggered land intensification, property markets have responded. Significant land price increases have also been recorded near BRT stops in Bogotá (Colombia), Seoul (Republic of Korea), Brisbane (Australia) and Los Angeles (US).¹⁷¹ One study

revealed that multi-family housing units within five-minutes walking distance of Bogotá's TransMilenio BRT, were rented for appreciably more per square metre than those units located farther away.¹⁷² Pedestrian-friendly environments near TransMilenio stops, further increased land-value benefits.¹⁷³ Bogotá's TransMilenio has also enjoyed network effects: the addition of new TransMilenio lines increased housing rents for currently served residences more than opening new lines to previously unserved ones.¹⁷⁴ Such land-value appreciations create opportunities for value capture, just as with urban rail systems. Bogotá practices value capture to finance urban infrastructure under a programme called Plusvalía, however implementation problems – including high revenue collection costs and charges of assessment biases and institutional corruption – have undermined the programme.¹⁷⁵ More successful has been Ahmedabad's programme of exacting surcharges from landholders, for the right to increase their building densities by up to 30 per cent, along the 89-kilometre Janmarg BRT system in India. Some of the funds received are channelled towards building affordable housing, particularly for low-income households displaced by BRT expansion. In addition, the construction of parallel cycle tracks to the Janmarg BRT is helping to create multi-modal corridors and an ethos of 'complete streets' in the minds of system designers and local citizens.¹⁷⁶

Impacts of motorways

Motorways generally exert stronger influences on urban form than public transport lines.¹⁷⁷ Since access is nearly ubiquitous with a car-based system, activities tend to be dispersed and segregated. US metropolises such as Los Angeles and Phoenix are testaments to the sprawling effects of motorways. Like a rail system, whatever clustering and agglomeration occurs tends to be around freeway interchanges – e.g. shopping malls and large stand-alone retail outlets. Also, impacts are often context specific, shaped by the permissiveness of land-use regulations and local real estate market demands. Other impacts include the institutional capacity to supplement roadways with other supportive infrastructure to accommodate new growth, and the ability to moderate potential neighbourhood opposition to nearby infrastructure investments.

Worldwide, the impacts of new roads may vary considerably. In poorer countries, road investments generate new economic growth, opening access to new markets and expanding trade-sheds. Developed countries, by contrast, experience impacts that are largely redistributive, hence shifting growth that might otherwise occur in some settings to newly served highway settings.¹⁷⁸ This is mainly due to the fact that accessibility levels are usually already so high in developed settings that the economic impacts of any new highway tend to be marginal.

Motorways generally exert stronger influences on urban form than public transport lines

In poorer countries, road investments generate new economic growth, opening access to new markets and expanding trade-sheds

CONCLUDING REMARKS AND LESSONS FOR POLICY

A paradigm shift is occurring in the relationship between transportation systems, mobility and cities. Public-policy turnarounds, like the removal of elevated freeways, the building of high-rise downtown towers interlaced by great pedestrian infrastructure and transit-oriented corridors, all recognize that travel is a ‘derived demand’ – secondary to the primary objective of connecting people and places. As long as transportation is rightfully cast as a means to an end, and not an end in and of itself, policies can be put into place that enhance mobility while avoiding (or at least reducing) negative externalities and promoting community stability and cohesion.

Urban form is principally a product of the dominant transportation system in place during the period of a region’s prevailing growth. Cities that grew rapidly when high-capacity public transport systems were being built, such as Toronto (Canada) and Curitiba (Brazil) have high-density and lineal built forms. Those that sprouted at the time when freeways were being built – such as in Phoenix and Houston (US) – have low-density, autocentric layouts. As cities develop and prosper in developing countries, unprecedented opportunities will arise for linking land development and transport infrastructure. While levels of motorization are stabilizing in developed countries, they are increasing rapidly elsewhere. Given the fact that a vast majority of future urban growth is projected for cities with a current population of less than 500,000 inhabitants, a bus-based form of smaller scale TOD interlaced by high-quality infrastructure for pedestrians and cyclists may be appropriate in many urban settings. Cities introducing railway and BRT solutions are bound to trigger meaningful land-use changes, including rapid growth and rising real incomes. This, of course, assumes there is supportive planning and zoning, public-sector leveraging and risk sharing, a commitment to travel-demand management to remove many built-in incentives to car use, and the capacity to manage the land-use shifts that are put into motion by transportation infrastructure investments.

There are signs that cities in different parts of the world are moving towards the development of more compact forms. Numerous cities have unveiled development plans that emphasize urban designs that shorten trips, create complete streets, encourage mixed-use developments and make cities more liveable.¹⁷⁹ Globally, there is a growing appreciation in various developing-country cities that integrated transport and land-use planning is critical toward future economic success, more equitable development and environmentally sustainable solutions.

Global experiences reveal that a cogent regional vision helps considerably in ensuring transportation investments produce desired urban-form outcomes. Visions need visionaries, such as Curitiba’s Jaime Lerner, Bogotá’s Enrique Peñalosa and Seoul’s Myong-Bak Lee. However, visions are malleable, and are therefore subject to change as realities unfold. Often, cities are path dependent in their spatial evolutions, thus breaking away from established practices can be difficult and slow. Traditionally, highways were built to serve urban sprawl, which in turn requires the construction of more highways. This vicious cycle of road construction and urban growth feeding off each other is often difficult to break. Accordingly, sustained leadership in working toward a common urban-form visionary becomes all the more crucial.

While the importance of linking land use and city form to transportation and mobility is increasingly recognized, moving from rhetoric to reality is not always easy. The list of true success stories is quite short. Whereas the experiences of Curitiba (Brazil), Portland (US), Singapore, Copenhagen (Denmark) and Stockholm (Sweden) are well-chronicled, there is a need for best-case practices that are directly applicable and relevant to the unique problems of cities in developing countries. Another notable gap is the limited knowledge about the influences of ‘goods movements’ on urban development patterns and vice versa. The siting of large warehouse distribution complexes on urban peripheries no doubt contributes to sprawl. As noted in Chapter 4, the spatial needs for goods handling and freight terminals, warehousing, commercial markets and the array of formal and informal delivery carriers are rarely given due priority in urban planning. Opportunities exist for improving urban logistics, such as the creation of freight consolidation centres on the periphery that allow a single truck to deliver goods to multiple destinations. Compact, mixed-use development, moreover, can promote efficient urban logistics by allowing few-stop deliveries.

The integration of transportation, city form and function and mobility strategies are not, in and of themselves, a panacea to the multitude of problems facing today’s major cities. Transportation and land-use integration, with the development of more sustainable densities in strategic locations, is but one of a number of strategies that must be pursued if substantial headway is to be made in shrinking the transport sector’s ecological footprint. In addition to the environmental dividends of improved transportation and land-use integration, there are other reasons – such as social inclusion, economic growth and municipal cost savings – for creating more accessible, more liveable and less car-dependent cities of the future. Such issues are discussed in the next three chapters of this report.

As cities develop and prosper in developing countries, unprecedented opportunities will arise for linking land development and transport infrastructure

A bus-based form of smaller scale TOD interlaced by high-quality infrastructure for pedestrians and cyclists may be appropriate in many urban settings

A cogent regional vision helps considerably in ensuring transportation investments produce desired urban-form outcomes

The importance of linking land-use and city form to transportation and mobility is increasingly recognized

NOTES

- I In this report, the term 'urban form' is used broadly to express the physical layout, design, space and morphology of cities, including buildings, roads and streets. It represents the spatial configuration of a city and, as discussed throughout the chapter, is both shaped by and gives form to transportation infrastructure and services. The term 'built environment' is often used to reflect the many physical dimensions of a city and its neighbourhoods that influence travel. In this report, terms such as urban form, land use and built environment are used interchangeably.
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