Transforming the Urban Space
through Transit-Oriented Development
The 3V Approach

Serge Salat and Gerald Ollivier

WORLD BANK GROUP

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MDTF Sustainable Urbanization

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Contents

Acknowledgments

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Book at a Glance

	Key messages	Chapters
Overview	Adopt TOD for more sustainable city development.	Introduction
Metropolitan scale	Maximize citywide accessibility to jobs through a hierarchically integrated transit system. Embrace nonuniform densities, concentrating jobs where accessibility is highest. Ensure local accessibility to health, education, and amenities.	1, Appendix A
Network scale	Align network centrality characteristics and intensity of land use.	1, 2
Station scale	Create accessible, diverse, dense, mixed-use, vibrant communities based on station characteristics and good design.	1, 3, 4
3V[a] Framework	Cluster stations based on node, place, and market potential value. Identify imbalances between values to stimulate interagency dialogue and understand opportunities.	2, Appendix B
Developing solutions	Understand the drivers of and interplay between values. Apply infill, intensification, and transformation strategies based on the 3V typology.	2, 3
Station examples	Hammarby, Bo01, Marina Bay, Hudson Yards, King's Cross	4, 5, 6
Corridor examples	Crossrail, Line 3 (Zhengzhou)	7, 8
City examples	London, Zhengzhou	7, 8

[a] 3V stands for 3 Value.

Message to City Leaders

Imagine a city that is more competitive, with higher-quality neighborhoods, lower infrastructure costs, and lower CO_2 emissions per unit of activity. This city has lower combined transportation and housing costs for its residents than other cities at similar levels of economic activity. Its residents can access most jobs and services easily through a combination of low-cost public transport, walking, and cycling. Its core economic and population centers are resilient to natural hazards. It is able to finance improvements to public space, connectivity, and social housing by capturing value created through integrated land use and transport planning. Such a vision has never been more relevant for rapidly growing cities than it is today.

Transit-oriented development (TOD) can play a major role in achieving such a vision. It is a planning and design strategy to achieve compact, mixed-use, pedestrian and bicycle-friendly urban development closely integrated with transit stations. It embraces the idea that locating amenities, employment, shops, and housing around transit hubs promotes the use of public transit and nonmotorized travel. Well-planned TOD at the city level is inclusive, because it focuses on ensuring access to jobs for all social groups through public transit.

TOD is often considered an effective way to create value through good design combined with good planning at the neighborhood level. Good urban design supports increased density and ensures that people do not feel oppressed by congestion and density. It requires significant streetscape improvement to turn streets into places for people. It creates a spirit of place; makes a city more "legible"; and evokes a feeling of enclosure, human scale, coherence, image, and linkage.

For rapidly growing developing cities, TOD needs to go beyond the mere redevelopment of specific neighborhoods. It must create an urban space able to accommodate hundreds of thousands or even millions of new residents in a way that provides high accessibility to jobs at the city level combined with amenities, services, and good-quality environment at the neighborhood level to give a sense of community. In such a context, TOD becomes relevant at the metropolitan and city scale.

Observation of large sustainable cities reveals wide variation in densities, which needs to be reflected in TOD planning. Jobs concentrate where accessibility to other firms is greatest. Housing concentrates in areas with good job accessibility by public transport. Large cities follow a finely orchestrated hierarchy of centers and subcenters, with high peaks of concentration of jobs and housing in areas with high transit accessibility. Recognizing this natural concentration can help design more effective urban space and mass transit networks.

Opposite page:
Traditional high-quality urban fabric and modernist icons (the Shard building) create high value in London.
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Mass transit systems shape the city form and the distribution of its economic densities for decades. Stations that are more central, are more connected to others, and have more traffic play a special role in such process, which needs to be reflected in TOD planning. Feedback loops between transit network characteristics and density patterns tend to be self-reinforcing and appear to create a lock-in effect. Cities can thus be described as networks from which locations emerge. Accordingly, determining the shape of the mass transit network becomes central to creating a compact urban form combining core and polycentric centers well linked by transit.

Applying the concept of integrated economic, transport, and land use planning is often complex, because different agencies do not understand it in the same way. The use of clear objectives for accessibility at the city level can facilitate such integration. Singapore, for example, decided that by 2030, 80 percent of residents will live within 10-minute walk from a train station and 75 percent of peak-hour trips will be made by public transport. Such objectives can be achieved only through an integrated interagency approach, applying TOD principles for job and housing concentration around stations.

Based on an observation of methodologies applied in different countries, the Bank's Community of Practice on Transit Oriented Development has developed a methodology called the 3 Value (3V) Framework, which considers the node, place, and market potential value of each station. The 3V Framework outlines a typology to facilitate TOD implementation at the metropolitan and urban scale in various contexts as part of a methodology that aims to:

- identify the economic development potential of different transit corridors and different areas around mass transit stations in terms of type, scale, and timing, considering the level of connectivity and market demand through quantified indicators
- develop planning and implementation measures and prioritize limited public resources to create such value through coordinated interagency measures
- develop and communicate with residents, government agencies, and private developers a vision for the city that articulates development around its mass transit network.

By doing so, the 3V Framework can facilitate an alignment of TOD strategies at the metropolitan, city, network, and local levels.

The 3V Framework equips policy and decision makers with quantified indicators to better understand the interplay between the economic vision for the city, its land use and mass transit network, and urban qualities and market vibrancy around its mass transit stations. It enables agencies in charge of transport, land use, and economic planning to identify misalignments and to select measures to address those. On the basis of such a vision, planners can provide the necessary service infrastructure to support higher densities in priority areas and analyze the specific economic returns of different programs, considering all related social and environmental aspects, responding in particular to the challenges of an equitable urban growth.

This book provides examples of approaches taken by cities like London and New York to align their economic, land use, and transport planning to generate

jobs and high value. It illustrates the application of the 3V Framework in reviewing plans for the city of Zhengzhou, in China. We hope the book will help readers develop a coherent vision, policies, and strategy to leverage the value created through enhanced connectivity and accessibility and make cities even more appealing places to live, work, play, and do business.

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Abbreviations

BCR   Building to Cost Ratio
BedZED   Beddington Zero Energy Development
BRT   Bus Rapid Transit
CASA   Centre for Advanced Spatial Analysis
CBD   Central Business District
CTOD   Center for Transit Oriented Development
DBLVC   Development-Based Land Value Capture
DfT   Department for Transport (UK)
DIB   District Improvement Bonuses
DIF   District Improvement Fund
DLR   Docklands Light Railway
EHESS   Ecole des Hautes Etudes en Sciences Sociales
ESMAP   Energy Sector Management Assistance Program
FAR   Floor Area Ratio
FSI   Floor Space Index
FSR   Floor Space Ratio
GDP   Gross Domestic Products
GVA   Gross Value Added
H+T®   Housing + Transportation
HKSAR   Hong Kong Special Administrative Region
HS1   High Speed 1 (Channel Tunnel Rail Link)
HS2   High Speed 2 (Channel Tunnel Rail Link)
HSR   High Speed Rail
HYDC   Hudson Yards Development Corporation
HYIC   Hudson Yards Investment Corporation
ICT   Information and Communications Technology
IRT   Interborough Rapid Transit Company
ITDP   The Institute for Transportation and Development Policy
KCCLP   King's Cross Central Limited Partnership
LCR   London and Continental Railways
LEED   Leadership in Energy and Environmental Design
LIRR   Long Island Rail Road
LSE   London School of Economics
LTA   Land Transport Authority
LVC   Land Value Capture
MRT   Mass Rapid Transit ((Hong Kong SAR, China)

MTA	Metropolitan Transport Authority (NYC)
MTRC	Mass Transit Railway Corporation
NYCED	New York City Economic Development Corporation
NYCIDA	New York City Industrial Development Agency
OECD	Organization for Economic Co-operation and Development
OSD	Over Station Development
PILOT	Payments In Lieu Of Taxes
PPP	Public-Private Partnership
R+P	Rail Plus Property (program implemented by MTR Corporation, Limited, Hong Kong SAR, China)
RTS	Rapid Transit System
SAR	Special Administrative Region
TAD	Transit-Adjacent Development
TDR	Transferable Development Rights
TfL	Transport for London
TIF	Tax Increment Financing
TOD	Transit-Oriented Development
TransFORM	Transport Transformation and Innovation Knowledge Platform (China-World Bank)
ULI	Urban Land Institute
URA	Singapore Urban Redevelopment Authority
UTEP	Uniform Tax Exemption Policy
VOA	Valuation Office Agency
VoT	Value of Time
ZHVI	Zillow Home Value Index

Glossary

Agglomeration effects: Benefits from concentrating output and housing in particular areas.

Air rights sale: Sale of unused development rights on a given property to another developer allowing it to go beyond the limits specified in land use regulations (for example, FAR). Such sale, often by the government, allows funds to be raised to finance public infrastructure and services.

Betweenness centrality: Number of times a node in a network acts as a bridge along the shortest path between two other nodes. The concept, introduced by Linton Freeman in 1977, quantifies the control of one person over communication between other people in a social network. Nodes that have a high probability of occurring on a randomly chosen shortest path between two randomly chosen nodes have high betweenness. In transit networks, a station with high betweenness centrality has greater influence over the transfer of passengers through the network. These stations areas have high development potential.

Building coverage ratio: Size of constructed buildings' floor in relation to total size of land plot. Building area is the floor space of a building when looking down at it from above (aerial view). The formula for building coverage ratio (BCR) is as follows: BCR (percent) = (building area)/ (site area) × 100.

Catalytic development: Holistic development to revitalize the urban fabric through a series of projects that drive and guide urban development.

Central business district (CBD): Areas where cities' major businesses (financial institutions, stores, convention and sport facilities, hotels, and so forth) are concentrated. CBDs produce agglomeration economies.

Centrality: In graph theory and network analysis, indicators of centrality identify the most important nodes. Centrality can be used to identify the most influential people in a social network, key infrastructure nodes in the Internet or urban networks, and superspreaders of disease. Betweenness, closeness, and degree centrality are the three most important indicators for transit networks.

Closeness centrality: A measure of accessibility to a node within a network that measures the inverse of the sum of the distances of a node from all other nodes.

Compact city: Urban planning and urban design concept that promotes city with short travel distances. Compact cities are usually based on concentrated residential density, mixed land use, an efficient public transit system and an urban layout that encourages walking and cycling, low energy consumption, and reduced pollution. A compact city provides opportunities for social interaction as well as a feeling of safety. It is more sustainable than urban sprawl, because it is less dependent on the car and requires less (and cheaper per capita) infrastructure provision.

Degree centrality: Number of ties a node has with other nodes in a network. In transit networks, interchange stations between many lines or modes (*hubs*) have a high degree centrality.

Density gradient: Spatial variation in density over an area.

Employment density: Number of jobs in an area.

Enclosure: Degree to which buildings, walls, trees, and other vertical elements define streets and other public spaces.

Floor area ratio (FAR): Ratio of a building's total floor area to the size of the land on which it is built. The higher the FAR, the higher the density. Also referred to as floor space ratio (FSR) or floor space index (FSI).

Floor space index (FSI): See Floor area ratio (FAR).

Greenfield development: New development that takes place on lands that were not previously developed as urban land, including agricultural, rural, and unused land.

Human density: Total number of people and jobs in an urban area divided by the land area.

Infill: Rededication of land in an urban environment, usually open space, to new construction or construction on any undeveloped land.

Intensification area: Built-up area with good existing or potential public transit links that can support redevelopment at higher than existing densities.

Intensity of node activity: Strength of traffic flows in a node; can be described by frequency of departures by public transportation and/or ridership.

Intermodal hub: Place where passengers can switch between different lines or transport modes. Intermodal hubs include large subway stations with multiple lines, train stations, rapid transit stations, bus stations, tram stations, and airports. Some complex hubs combine several modes in a single integrated multimodal station or complex of stations.

Land readjustment scheme: Scheme in which landowners pool their land for reconfiguration and contribute a portion of it for sale to raise funds to partially defray the costs of developing public infrastructure.

Land value capture (LVC): Public financing method in which governments (a) trigger an increase in land values through regulatory decisions (for example, the change in land use or floor area ratio) and/or infrastructure investments; (b) institute a process to share the land value increment by capturing part or all of the change; and (c) use the proceeds to finance infrastructure investments (such as investments in transit and TOD or other improvements required to offset impacts related to the changes (for example, densification) and/or implement public policies to promote equity (for example, provision of affordable housing to alleviate shortages and offset potential gentrification). There are two main categories of LVC: development-based LVC and tax- or fee-based LVC. Development-based LVC can be facilitated through direct transaction of properties whose values have been increased by public regulatory decisions or infrastructure investment. Tax- or fee-based LVC is facilitated through indirect methods, such as extracting surplus from property owners through various tax or fee instruments (such as property taxes, betterment charges, and special assessments).

Legibility: Ease with which people can create a mental map so that the spatial structure of a place can be understood and navigated as a whole.

Local value recycling: Reinvestment of revenue generated by a development in that same development, to further increase asset value and positive socioeconomic impacts.

Market potential value: Unrealized market value of a station area, sometimes measured through a composite index considering major drivers of demand, including current and future human densities, current and future number of jobs accessible within 30 minutes by transit, and major drivers of supply (including the amount of developable land, potential changes in zoning, and market vibrancy).

Mixed-use development: Pattern of development characterized by diversified land uses, typically including housing, retail shops, and private businesses, either within the same building space (vertical mixing) or in close proximity (horizontal mixing).

Node value: Measure of importance of a public transit station based on passenger traffic volume, intermodality, and centrality within the network; measured through a composite index.

Opportunity Areas: London's major source of brownfield land. Most can accommodate at least 5,000 jobs, 2,500 new homes, or a combination of the two, along with other supporting facilities and infrastructure.

Pareto distribution: Inverse power law probability distribution used in the description of social, scientific, geophysical, actuarial, and many other types of phenomena.

Sometimes referred to as the Pareto principle or the 80–20 rule, which states that 20 percent of a given statistical population represents 80 percent of the total value.

Permeability: Extent to which urban forms permit the movement of people or vehicles in different directions.

Place value: Determinants of the attractiveness of a place, including amenities; schools; health care facilities; type of urban development; local accessibility to daily needs by walking and cycling; quality of the urban fabric around the station, in particular its pedestrian accessibility; small size of urban blocks and fine mesh of connected streets, which create vibrant neighborhoods; and mixed pattern of land use. It is measured through a composite index.

Population density: Number of people living in an urban area divided by the land area.

Power law: Functional relationship between two quantities in which one quantity varies as a power of another. The distributions of a wide variety of physical, biological, and manmade phenomena approximately follow a power law over a wide range of magnitudes. Quantities following power laws lack well-defined average values, making it incorrect to apply traditional statistics that are based on variance and standard deviation (such as regression analysis). Appendix A shows that most quantities in urban space (densities, network centralities, economic productivity, and so forth) that are the core indicators for applying the 3V Framework are not distributed around average values but follow power laws.

Public-private partnership (PPP): Formal partnership between a public sector entity and a private corporation often used to construct and operate infrastructure facilities or develop certain urban areas.

Public realm: Publicly owned streets, pathways, rights of way, parks, publicly accessible open spaces and any public and civic building and facilities.

Redevelopment/regeneration: Type of development that seeks to reinvest in already developed areas, typically targeting parcels that are underutilized, such as vacant or abandoned properties.

Transit-adjacent development (TAD): Development located near a transit node that fails to leverage on such proximity because it lacks key characteristics of transit-oriented development, such as pedestrian-friendly development or mixed use.

Transit-oriented development (TOD): Planning and design strategy to ensure compact, mixed-use, pedestrian- and bicycle- friendly, and suitably dense urban development organized around transit stations. TOD embraces the idea that locating amenities, jobs, shops, and housing around transit hubs promotes transit usage and nonmotorized travel. Well-planned TOD is inclusive and integrates resilience to natural hazards.

TOD typology: Tool for prioritizing where and when to make investments, determining the types of investments that are appropriate in different communities, and guiding the timing and scale of those investments. Provides a means of classifying and differentiating transit communities in a city by grouping them based on shared characteristics. A TOD typology aims at creating an aspirational vision of future land uses, prioritizing stations for investment, providing guidelines and actions for implementation, and measuring performance on a range of metrics.

Transit core: 400-meter radius area immediately surrounding a premium transit station.

Transit neighborhood: 800-meter radius area surrounding a premium transit station.

Transit supportive area: 1.6 kilometer-area immediately surrounding a premium transit station.

Transfer of development rights: Ability to buy and sell air rights (within the limit of their floor area ratio allotment or the unused development rights that remain when a building does not use up its FAR allotment). Typically applies only to certain parcels that often can be transferred only to specific "receiving" parcels.

Urban block: A city block, urban block, or simply block is a central element of urban planning and urban design. A city block is the smallest area that is surrounded by streets. City blocks are the space for buildings within the street pattern of a city. They form the basic unit of a city's urban fabric.

Urban fabric: Physical aspect of urbanism, including building types, thoroughfares, open space, frontages, and streetscapes.

Urban morphology: Study of the form of human settlements and the process of their formation and transformation that seeks to understand the spatial structure and character of a metropolitan area, city, town or village by examining the patterns of its parts and the process of its development.

Urban realm: Spatial components of a metropolis.

Value capture finance: Appropriation of value generated by public sector intervention and private sector investment in relation to an underused asset (land and/or structure) for local reinvestment to produce public good and potential private benefit.

Zoning: Control by authority of use of land and the buildings on it. Areas of land are divided into zones within which various uses are permitted. Zoning aims to promote orderly development and to separate incompatible land uses, such as industrial uses and homes, to ensure a pleasant environment.

Introduction

Transit-oriented development (TOD) is a planning and design strategy for achieving compact, mixed-use, pedestrian- and bicycle-friendly urban development closely integrated with transit stations. It embraces the ideas that locating amenities, jobs, shops, and housing around transit hubs promotes transit use and non-motorized travel and that careful place-making softens the perception of density and facilitates the emergence of vibrant communities. It can be applied to metropolises like Hong Kong SAR, China, as well as smaller cities like Copenhagen, a municipality of about 592,000 people.

Benefits of Transit-Oriented Development

Making Cities More Competitive, Raising Real Estate Values, and Contributing to Growth

Transit-oriented cities are more competitive than other cities, as a result of agglomeration effects. Doubling job density increases economic productivity by 5–10 percent (Salat and others 2017). In New York, the world's most competitive global city, 60 percent of office space is agglomerated on only 9 square kilometers (1 percent of the city's land area) (Salat 2017). This concentration offers opportunities to reinvent urban spaces with high-quality public and green areas. Copenhagen and Stockholm (box I.1), both of which have embraced TOD principles, rank among the world's top cities in terms of per capita GDP, the Green City Index, and the UN-Habitat City Prosperity Index (UN-Habitat 2015).

TOD increases and concentrates real estate value in the best-connected areas. Since 1996 the growth of home values in TOD neighborhoods in the United States has outpaced the growth of home values nationally by a margin of nearly 2 to 1; in 2014 the average home in a TOD neighborhood was worth 3.5 times more than the average home (Infrastructure USA 2015).

Cities like Hong Kong SAR, China; London; New York; and Tokyo capture part of these increases in value and use it to finance additional enhancements of infrastructure and the public realm, creating a positive feedback loop between development and urban growth. For example, the rail plus property model in Hong Kong, SAR China brought in about HK$140 billion in revenues between 1980 and 2005 and unlocked land for 600,000 public housing units (McKinsey Global Institute). Part of this value capture can be used for social housing in well-connected areas to counterbalance the negative impacts of gentrification and preserve access for all.

Opposite page:
Copenhagen has been planned according to TOD since 1947. It is the first city to target becoming carbon neutral by 2025, and ranks second worldwide in UN Habitat City Prosperity Index. Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

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BOX I.1   **Transit-Oriented Development in Stockholm**

The growth of Stockholm's built-up area has generally followed the city's main public transport corridors. Over the decades, the containment of urban development along these corridors has ensured a threshold level of density that has facilitated a public transit–oriented transport system. Even over the last 10 years, Stockholm's containment index—which measures the growth of population within the city core compared with growth within the outer belt—has remained positive.

Within the Organisation for Economic Co-operation and Development (OECD), Stockholm's urban containment is second only to London; its long-term growth, levels of wealth, and rates of productivity are among the highest in the OECD. Stockholm's metropolitan economy, measured as gross value added per capita, grew 41 percent from 1993 to 2010. Over the same period, greenhouse gas emissions per capita decreased 35 percent, to 3.5 tCO_2e (Floater and others 2013).

Saving People Time and Money

Transport and housing are traditionally the largest expenditures for households, often accounting for more than half of their income. Inclusive TOD plans for low-income and affordable housing near mass transit stations enhance access to job opportunities for all. In the United States, people living near TOD stations spend 37 percent of their income on transport plus housing against 51 percent for other people (Reconnecting America 2009).

Reducing Greenhouse Gas Emissions and Increasing Resilience to Natural Hazards

TOD can reduce infrastructure costs and CO_2 emissions per unit of activity (ESMAP 2014). Hong Kong SAR, China, for example, increased gross value added per capita by 50 percent between 1993 and 2011 while reducing its CO_2 emissions for transportation per capita and road gasoline consumption per capita by about 10 percent (Rode and others 2013). Copenhagen and Stockholm also achieved this decoupling.

TOD can also make cities more resilient to natural hazards than other kinds of development if implemented strategically. Because TOD leads to a concentration of activities and housing at the city level, it allows cities to locate such areas of high density in lower-risk zones, address risks in those areas more systematically, ensure that peak concentration occurs primarily in areas with high levels of network redundancy, and turn those areas into well-connected refuge zones in case of emergency.

Principles of Transit-Oriented Development

The World Bank's TOD Community of Practice is a group of transport, urban, social, and land specialists working in or with the World Bank on TOD projects. It has

summarized eight key principles for implementing TOD, based on international experience in TOD:

1. Align human densities, economic densities, mass transit capacity, and transit network characteristics for greater accessibility.
2. Create compact regions with short commutes.
3. Ensure the resilience of areas connected by mass transit.
4. Plan and zone for mixed-use and mixed-income neighborhoods at a corridor level.
5. Create vibrant, people-centric public spaces around mass transit stations.
6. Develop neighborhoods that promote walking and cycling.
7. Develop good-quality, accessible, and integrated public transit.
8. Manage demand for private vehicles.

Transit-Oriented Development at the City and Station Level

Many rapidly growing developing countries are investing massively in transit systems. China, for example, adds on average 450 subway stations every year. By 2020 Beijing will have 1,050 and Shanghai 970 kilometers of subways, making their networks among the longest in the world. In India, cities are constructing more than 600 kilometers of metros and planning another 250 kilometers.

The best-planned cities set specific objectives quantifying how such systems will connect households to jobs and services and provide the backbone for peak-hour transport. Singapore's masterplan targets for 2030 include ensuring that 8 in 10 households live within a 10-minute walk of a transit station, 85 percent of public transport journeys are completed within 60 minutes, and 75 percent of all journeys in peak hours are undertaken on public transport (LTA 2013). Such accessibility targets provide clear guidance to transport, land, housing, and economic agencies and require them to work together, because the targets can be achieved only through combined and aligned interventions.

Concentrating development in the one-kilometer radius around transit stations offers a unique opportunity to shape cities and make them more livable, efficient, and inclusive. Cities can take supportive measures to prioritize development around stations. They can take as a core performance benchmark the percentage of jobs and residents within one kilometer of mass transit stations and the percentage of new development taking place in those well-connected areas as opposed to other parts of the city. They can support such concentration by placing priority on new public infrastructure in those well-connected areas while restricting development in other areas. At the level of corridors, cities can encourage greater economic opportunities by supporting a mix of uses and income groups. Around stations, cities can facilitate the creation of health, education, shopping, and recreation facilities to enable communities to thrive locally. Such approach has long-term impact on reducing energy consumption, CO_2 emissions, and transport cost as a share of GDP.

However, not all stations are equal in terms of development potential. The number differs from city to city, but generally about 15 percent of station areas are

expected to achieve very high densities (World Bank and Development Research Center of the State Council, P.R. China 2014). Other areas may not have the commercial value required for such development.

Typologies for Identifying Where, When, and How to Create Economic Value

There is no one size fits all to TOD throughout a city. Early projects often focus on greenfield sites, where development is easier, or at central locations and highly accessible transit hubs, where high-density development is supported by high land value. But other types of opportunities exist outside these major areas. They require tailored approaches.

Understanding where, when, and how potential value can be created requires tools that help differentiate the opportunities offered by different stations in a mass transit network. Improving transit at a location creates conditions favorable to its development. In turn, development of a location creates conditions favorable to the further development of the transport system.

A TOD typology differentiates transit station areas based on their suitability for accommodating growth. It links regional and local public policy recommendations to support the type of development that is best suited for a specific site and community. A TOD typology aims at creating an aspirational vision of future land uses, prioritizing stations for investment, providing guidelines and actions for implementation, and measuring performance on a range of metrics.

Traditional Transit-Oriented Development Typologies

Academics have long developed TOD typologies based on their observations of past TOD development in cities. Bertolini (1999) introduced a node/place model (see chapter 3) seeking to explore the underlying relationships between node and place values, with a focus on station areas. Such model was further supported by the transport land use feedback cycle developed by Giuliano (2004), Meyer and Miller (2001), and Wegener and Fuerst (1999). Cervero and Murakami (2008) developed a typology drawing on the experience of Hong Kong SAR, China; Singapore; and Tokyo.

More recently, cities have developed such typologies to support their strategic planning. Baltimore developed a typology to identify and assign station area investment needs to a broad range of TOD actors and stakeholders (CTOD and others 2009). Its plan was folded into a broader TOD strategic plan that has enabled Baltimore to fund transit-supportive projects more systematically rather than through a usual piecemeal approach.

Denver created a typology to provide a vision (Transit-Oriented Denver) for the appropriate density and land use mix in each of the city's existing and planned light rail station areas. Its plan served as a guide for subsequent detailed station area planning studies.

Portland developed a typology for identifying overall needs related to implementing TOD regionwide and determining where TOD development is most ap-

propriate (CTOD and Nelson/Nygaard n.d). The typology and recommendations of the cost-effectiveness model helped evaluate not only where investments should be made but what types of investment made most sense. Portland's typology strives to leverage opportunities by strategically targeting TOD investments and helping public agencies and programs with an interest in TOD understand the types of investments that are appropriate given variable local physical and market contexts. It aims to ensure an investment response to changing market cycles and variable local market conditions.

Going Beyond Traditional Typologies: The 3V Framework

The 3 Value Framework, or 3V Framework, generalizes these international approaches based either on the node/place model or a market/place model (such as the Baltimore and Portland typologies) by identifying the three values that can characterize a transit station:

- *Node value* describes the importance of a station in the public transit network based on its passenger traffic volume, intermodality, and centrality within the network. Node value is measured through a composite index.
- *Place value* describes the urban quality of a place and its attractiveness in terms of amenities, schools, and health care; the type of urban development; local accessibility to daily needs by walking and cycling; the quality of the urban fabric around the station, in particular its pedestrian accessibility, the small sizing of urban blocks, and the fine mesh of connected streets that create vibrant neighborhoods; and the mixed pattern of land use. Place value is measured through a composite index.
- *Market potential value* refers to the unrealized market value of station areas. It is derived through market analysis (the study of demand and supply). It is measured through a composite index that includes major drivers of demand including current and future human densities (residential plus employment); the current and future number of jobs accessible by transit within 30 minutes; and major drivers of supply, including developable land, potential changes in zoning (such as increasing floor area ratios (FARs)), and market vibrancy. The approach looks forward rather than backward.

The 3V Framework is a methodology for identifying economic opportunities in areas around mass transit stations and optimizing them through the interplay between the node, place, and market potential values. It provides a typology to cluster stations based on the three values. It equips policy and decision makers with quantified indicators to better understand the interplay between the economic vision for the city, its land use, its mass transit network, and its stations' urban qualities and market vibrancy. It outlines planning and implementation measures for the different clusters of stations that can help prioritize limited public resources and create value through coordinated interagency measures.

Such analysis enables a city to develop and communicate a vision that articulates development around its mass transit network and facilitates the alignment of TOD strategies at the metropolitan, city, network, and local levels. The 3V Frame-

work can be used to engage with citizens, private developers, investors, financiers, companies, and other stakeholders to develop, refine and advance such a vision and update it regularly. On the basis of such a vision, cities can develop plans to provide the necessary infrastructure to support higher densities in priority areas and analyze the economic returns of different programs, considering all related social and environmental aspects, responding in particular to the challenges of equitable urban growth.

Applicability of the 3V Framework

The 3V Framework is applicable to large cities with extensive networks and smaller cities with only a few mass transit lines or a bus rapid transit system. The model works for growing cities and declining ones. It seeks to determine the relative areas of potential within a city rather than across cities.

The examples presented in this book are mostly urban regeneration of previously stagnant areas (King's Cross, Hudson Yards, the redevelopment of docklands in Sweden). In all of these settings, planners spurred urban growth at the local scale, using a strategy that could be applied at a larger scale to foster growth in declining cities through urban catalysts.

The 3V Framework presents two main interests for policy makers. First, it allows them to build a typology of stations that classifies all stations in a mass transit network into clusters, to which different development strategies can then be applied.

Second, the framework allows policy makers to identify the imbalances between connectivity, accessibility, place quality, and market potential values at a given station by plotting those across the three values (figure I.1). Addressing these imbalances creates high potential for economic value creation—by, for example, creating place value around an important connective node or bringing additional connectivity to a booming area. Quantification allows the various government agencies deal-

FIGURE I.1 **The 3V Framework**
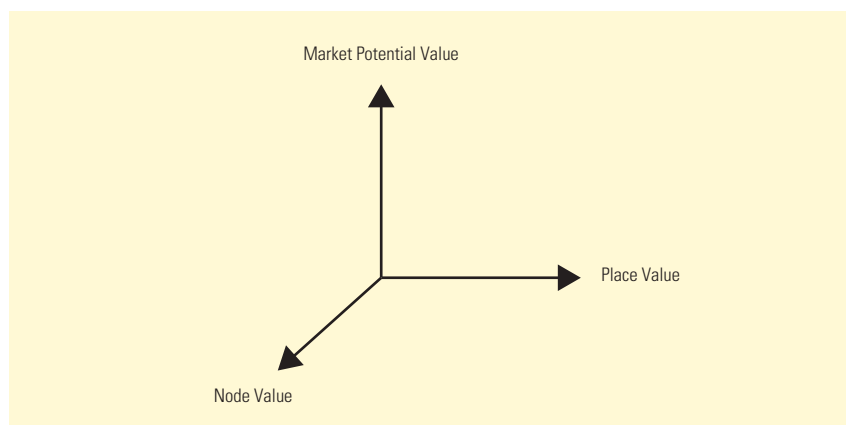
FIGURE I.2 **Synchronization of Node, Place, and Market Potential Values**
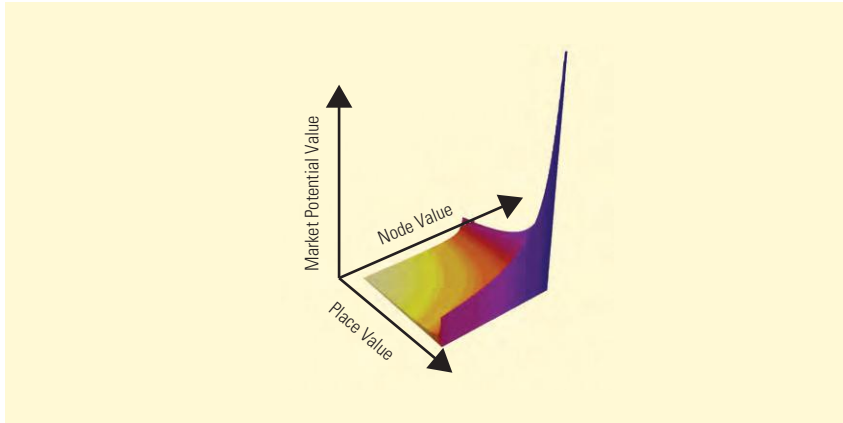
ing with urban, transport, and economic planning to start a conversation and to synchronize high peaks of node value (major connecting hubs) with high-quality place-making to create spikes of market potential value (figure I.2).

Several levers can be used to increase individual node, place, and market potential value (table I.1), keeping in mind that the greatest impact is achieved when addressing imbalances between those values.

Structure of this Book

The book comprises a glossary, a foreword, an introduction, eight chapters, a conclusion and two appendices. The first four chapters explain the 3V Framework and how it applies to TOD strategies in different contexts and at different geo-

TABLE I.1 **Levers to Increase Node, Place, and Market Potential Values**

Type of value	Policy lever
Node	• Increase the number of hubs and the number of lines/modes they connect to. • Interlink neighboring stations into clusters. • Increase accessibility for all within the network.
Place	• Increase compactness (proximity to existing urban activity and short travel time to main destinations). • Increase the diversity of uses. • Increase the concentration of commercial, cultural, and educational amenities. • Design neighborhoods that promote walking and cycling. • Create a vibrant public realm.
Market potential	• Increase residential density. • Increase job density. • Increase human density. • Increase the diversity of land parcels to create a vibrant land market. • Increase floor area ratios.

graphical scales. Chapter 1 describes TOD strategies at the metropolitan, network, and local levels to address the challenges of urban growth and inclusiveness. Chapter 2 details the drivers, policies, and strategies to increase values with the 3V Framework. It identifies the main policy levers and describes how planners can cluster stations according to their values and develop contextualized policies for different types of stations. Chapter 3 describes the interplay of values and the contribution a better alignment between those values can play. It analyzes the positive feedback loop of value creation and capture that can be initiated through public and private investments in underutilized assets. Chapter 4 describes in more detail one key lever of value creation: good urban design of the public realm.

Chapters 5–8 are detailed case studies. Chapter 5 describes the strategies applied by to redevelop the massive Hudson Yards project, in New York. Chapter 6 describes King's Cross, an urban regeneration project in an area of London with exceptional connectivity that was once a railyard land. Chapter 7 examines the new subway line in London (Crossrail), showing the differentiated strategies used to increase place and market potential value depending on the location and centrality of stations in relation to the London subway network and its economic cores. Chapter 8 shows how the 3V Framework can be applied to integrating the space economy of an entire city (Zhengzhou, China). It highlights the potential misalignments between the increases in accessibility and centrality created by investments in the subway network and the projected decentralization of people and jobs at the periphery of the city in areas less accessible by subway.

Two appendices complement these chapters. Appendix A describes how mathematical regularities (power laws) structure the distribution of urban values across urban space, network centralities, and the intensity of passenger flows in stations and commuting lines. Appendix B provides definitions and calculation formulas for the key metrics of each value.

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Transit-Oriented Development Strategies at the Metropolitan, Network, and Local Levels

By 2050 the world urban population is expected to nearly double, making urbanization one of the most transformative trends of the 21st century. Such transformation will place a high demand on new infrastructure and good planning to address the challenges many cities face in terms of pollution, congestion, and social inequity.

Rapidly growing cities can learn from cities that applied transit-oriented development (TOD) principles in shaping their urban space and transport network at the metropolitan, city, network and neighborhood levels. They can create urban spaces able to accommodate hundreds of thousands or even millions of new citizens of different income levels in a way that offers high accessibility to jobs citywide. They can design their mass transit network to match the diverse densities in jobs and housing across the urban space. They can build thousands of new compact communities with amenities, services, and good-quality environment centered on rail, subway, urban rail, and bus rapid transit stations. Cities that have followed such TOD principles have managed to spur economic growth, contribute to inclusive development, and decouple their economic growth from their transport greenhouse gas emissions per capita.

The Global Infrastructure Challenge and the Risks of Uncoordinated Urban Growth

Cities will accommodate up to 2 billion more people in the next 30 years. An estimated 177 new cities with more than 1 million inhabitants will emerge (United

Nations 2014). As witnessed over the past two decades throughout the world, in particular in Asia (World Bank 2015), this urbanization is likely to be accompanied by a rapid expansion of urban land, with a potential trebling of urban land in developing country cities between 2005 and 2030 (Shlomo, Sheppard, and Civco 2005).

The McKinsey Global Institute (2013) estimates the cost of global infrastructure between 2013 and 2030 at $57 trillion (3.5 percent of global GDP)—$3.2 trillion a year simply to keep up with projected global GDP growth. An estimated 40 percent of these needs consist of transportation infrastructure (roads, rail, ports, and airports). The center of gravity of this global infrastructure spending has already shifted to developing economies and cities, following the path of economic growth.

Funding the world's infrastructure needs is likely to become more difficult for a variety of reasons. The growing level of indebtedness since the 2008 financial crisis will place constraints on public sector budgets. More volatile resource prices have made long-term budget planning more complex for many developing countries. At the same time, countries face additional costs to make their infrastructure resilient to climate change.

Well-planned cities are engines of growth. Urbanization therefore presents an opportunity to lift hundreds of millions of people out of poverty. But rapid and fragmented urban growth can adversely affect economic output, by reducing potential and actual economic agglomeration, increasing inequalities in housing and access to jobs, and raising infrastructure costs. Worse still, it can lock cities into inefficient paths of dependence on high resource consumption and low productivity combined with severe externalities like congestion and pollution.

Impacts of Transit-Oriented Development

TOD is a policy framework for urban spatial development with long-term structural impacts. Transport infrastructure is the single most important determinant of urban expansion; land-use patterns, in turn, directly shape mobility behavior (LSE 2013). Land-use and transport policies are central tools for city governments; they should be better integrated, in order to enable agglomeration economies through better job matching, knowledge sharing, and networking opportunities (Cervero 2001; Fallah, Partridge, and Olfert 2011); reduce carbon emissions and resource use through efficient public transit; and improve social inclusion with more accessible urban form.

The actions of a multiplicity of stakeholders and consistent policy frameworks across many geographical scales are needed to leave a long-term positive impact on city form and maximize economic efficiency. One city that has been successful in doing so is Copenhagen, which has shaped its urban form and achieved high levels of green growth through TOD (box 1.1).

Living near public transit saves both time and money. TOD planning can enhance social inclusiveness at the city level by increasing accessibility to jobs, particularly for the urban poor, as New York has done (box 1.2).[1] TOD planning allows policy makers to consider both transportation and housing costs by developing inclusionary housing policies (box 1.3). In Portland, for example, combined hous-

BOX 1.1 Promoting Green Growth in Copenhagen through Transit-Oriented Development

Copenhagen's "Finger Plan" links the municipality with the surrounding region, promotes urban growth along rail corridors radiating from the city center, and protects "green wedges" from development. First proposed in 1947, it received renewed regulatory support at the national level through the 2007 Danish Planning Act. The Act endorsed the station proximity principle, which requires most new offices of more than 1,500 square meters to be located within 600 meters of a railway station. Regulation of retail development promotes the location of stores in town centers by restricting their size and specifying the location of town centers where retail development is permitted. City-level land-use planning stimulates mixed-use, high-density development around stations and limits parking provisions.

In the 1990s, rail expansion was built in advance of demand to steer growth along desired transit corridors. In this way, Copenhagen was able to help developers identify which areas to prioritize in development.

TOD has led to the development of dense, walkable urban centers connected by rail-based public transit. Box map 1.1.1 shows the concentration of activities in the city center and along rail corridors. The radial links separated by green wedges give shape to the city's metropolitan structure.

Copenhagen has seamlessly linked transit, cycling, and walking facilities. One-third of

BOX MAP 1.1.1 Population and Employment Density along Major Transit Routes in Copenhagen
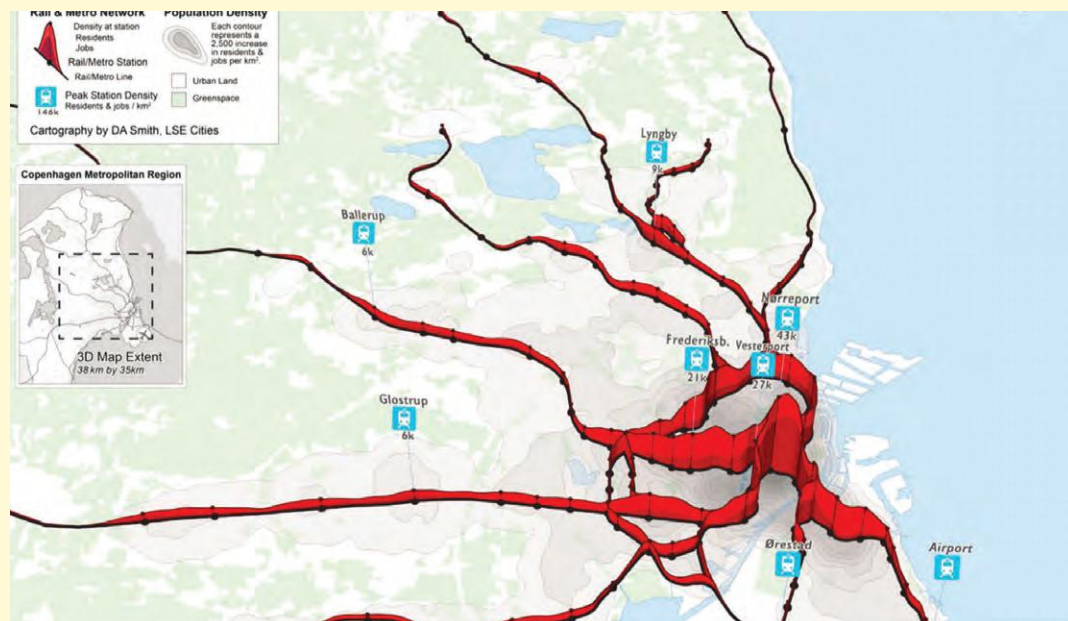
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BOX 1.1 **Promoting Green Growth in Copenhagen through Transit-Oriented Development** *(continued)*

suburban rail-users use bicycles to access stations. Investments support urban regeneration, city-center densification, and public realm improvements.

About 36 percent of all trips to work or educational institutions in Copenhagen were by bicycle in 2008–10 (compared with 2 percent in London and 7 percent in Stockholm). This high modal share is a key element in the declared goal of making Copenhagen CO_2-neutral by 2025. Copenhagen's overall goal for cycling includes goals for the number of cyclists as well as the quality of cycling (sense of security, safety, travel time, and comfort). The city now has almost 370 kilometers

of dedicated cycle lanes. It has integrated cycling with the public transit network and implemented various information, training, and safety initiatives. Copenhagen aims to be the world's best bicycle city and has set a target that 75 percent of all trips be by foot, bicycle, or public transit by 2025.

Measured by gross value added per capita, Copenhagen's metropolitan regional economy grew 30 percent between 1993 and 2010. Over the same period, transport-related carbon emissions decreased by 9 percent, to 0.76 tCO_2 per capita (box figure 1.1.1). Sprawling Houston spends about 14 percent of its GDP on transport; Copenhagen spends just 4 percent (Floater and others 2014).

BOX FIGURE 1.1.1 **Green Growth in Copenhagen, 1993–2009**
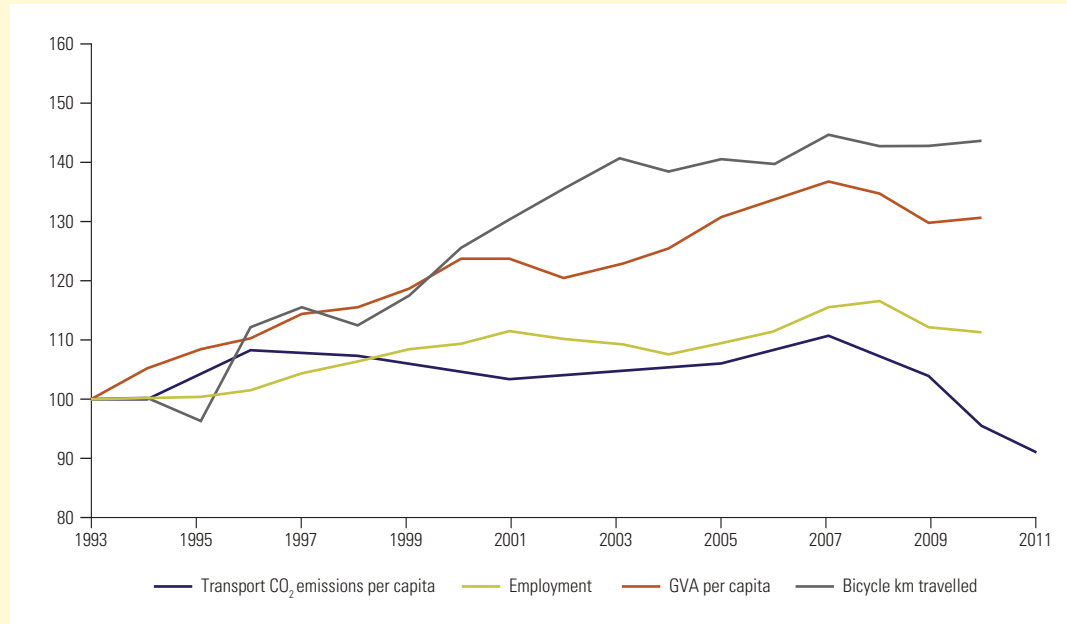
Source: LSE Cities 2013 © LSE Cities. Used with the permission of LSE Cities. Further permission required for reuse. All variables are indexed 1993 = 100.

Source: LSE Cities 2013.

BOX 1.2 Increasing Access to Jobs in New York City

New Yorkers rely on public transportation more than residents of any other U.S. city. Indeed, 56 percent of New York trips to work are made on public transit; the average for the next 10 largest U.S. cities is just 11 percent.

New York's public transit fuels economic growth. The average New Yorker can reach more than 1.4 million jobs, or nearly 40 percent of payroll jobs, using public transit in 45 minutes (Rudin Center 2015). Although average access to jobs by public transit is high, differences across neighborhoods are significant. High

housing prices push low-income people to neighborhoods far from job centers. In more than half of the city's neighborhoods with below-average household income (home to some 2.3 million residents), the number of jobs accessible by transit is below average.

For achieving greater equality, the city targets a 25 percent increase in transit access to jobs for all New Yorkers by 2030 and is focusing on neighborhoods in which job access is particularly low by ensuring that 90 percent of New Yorkers can access at least 200,000 jobs within 45 minutes. New public transit and growing jobs in the outer boroughs will help close this gap.

New York's plan features initiatives to improve jobs access for New Yorkers in four main ways:

- Supporting the growth of jobs closer to housing.
- Preparing New Yorkers to access more jobs through workforce development opportunities.
- Creating and preserving housing close to jobs and transit.
- Improving transit connectivity by expanding the city's Select Bus Service network with free transfer between bus and subway services, creating a citywide ferry network, and supporting other system-wide investments.

Source: City of New York 2014a and b.

BOX 1.3 Using the H+T® Index to Measure a Neighborhood's Affordability

The Center for Neighborhood Technology's Housing and Transportation (H+T®) Affordability Index provides a more comprehensive way of thinking about the true affordability of a place by taking into account the cost of transportation as well as housing. It incorporates transportation costs—usually a household's second-largest expense—to show that location-efficient places can be more livable and affordable.

Traditionally, a home is considered affordable when rent or mortgage costs consume no more than 30 percent of household income. Based on this metric, 55 percent of US neighborhoods are affordable for the average household. When transportation costs are added to the equation, however, the number of affordable neighborhoods—defined as combined costs of less than 45 percent of typical household income—declines to 26 percent (Center for Neighborhood Technology 2011).

ing and transportation costs are lower around station areas (40 percent of income) than in the Portland region as a whole (50 percent) (Center for Transit-Oriented Development 2011).

Transit-Oriented Development Strategies at the Metropolitan/City Level

International experience suggests that the intensity of land use should not be evenly distributed across the city but should instead peak where accessibility to jobs is greatest. Firms locate where they can increase their productivity through agglomeration and localization effects (Salat 2017). Manufacturing firms locate where they can connect to large logistics infrastructure and land is cheap. In contrast, providers of high value added activities (finance, research and development, professional services) locate where they can access large number of similar firms. In Manhattan, for example, 60 percent of all office space is concentrated in only 9 square kilometers (1 percent of land area), despite high land and real estate prices (Salat 2017).

High concentrations of economic activity foster local economic development through economies of urbanization and localization (Rosenthal and Strange 2004), which attract skilled workers and more productive entrepreneurs and firms (Behrens, Duranton, and Robert-Nicoud 2014). Higher densities of people and firms allow for ideas to flow, giving birth to innovation. Density also allows firms to benefit from economies of scale and links to input and product markets. Research shows that doubling job density increases economic productivity by 10 percent (Salat 2016).

Agglomeration economies made London outperform the rest of the United Kingdom in terms of economic productivity in 2015—something it did not do in the 1990s. On only 0.2 percent of Greater London's land area, the Square Mile of the City of London produces 14 percent of the city's GDP—equivalent to 3 percent of the United Kingdom's total economic output. Job density in the Square Mile increased 30 percent in the last 10 years, to 150,000 per square kilometer. As a result, productivity per job in the Square Mile is twice that of Greater London and three times that of the United Kingdom (Salat 2017). The quality of public transit connections has a strong effect on business location choices in Central London (Sivaev 2013).

Job concentration in the city core and a dense urban form aligned with the transit network are key factors of competitiveness (Jenks, Burton, and Williams 1996). Hong Kong SAR, China, illustrates how the coordination of transit infrastructure provision, land use planning, and economic policy has shaped urban forms for economic efficiency, social inclusiveness, and environmental impacts (box 1.4).

Positive agglomeration effects concentrating jobs at high densities are driven by transit accessibility both to a large number of other jobs and other firms and to a large pool of workers. International research suggests a 30-minute threshold for these effects: People and jobs tend to concentrate at high density in areas where a high number of jobs, firms, and people can be accessed (Salat and Bourdic 2015b).[2] Restrictive zoning policies should not constitute a barrier to these con-

BOX 1.4 Spurring Economic Growth through Rail-Based High-Density Development in Hong Kong SAR, China

Hong Kong's spatial planning is based on rail-based development and a commitment to doing more with less. Hong Kong prioritizes regeneration of existing urbanized territory rather than expanding into greenfield areas. Regulation and guidelines specify where development can occur and at what density levels; they also limit parking. Urban expansion can occur only in strictly defined areas: 46 percent of Hong Kong's territory has been legally protected since the 1970s as "country park"; another 30 percent of land remains undeveloped and subject to various degrees of protection under a hierarchy of no-go areas. Land is zoned according to maximum floor area ratios (the ratio of a building's gross floor area to the size of the piece of land upon which it is built), with extremely dense

building permitted directly above and adjacent to rail stations (LSE 2013) (box map 1.4.1).

This pattern of development has led to the decoupling of economic growth and gasoline consumption per capita (box figure 1.4.1). Gross value added per capita rose 50 percent between 1993 and 2011 while CO_2 emissions per capita and gasoline consumption per capita declined by about 10 percent.

The rail and metro network now encompasses 210 kilometers of track and 84 stations. The government-controlled Mass Transit Railway Corporation (MTRC) operates a unique rail plus property business model that captures the increase in property value resulting from new railway infrastructure, using revenue from property develop-

BOX MAP 1.4.1 Population Density along Major Transit Routes in Hong Kong SAR, China
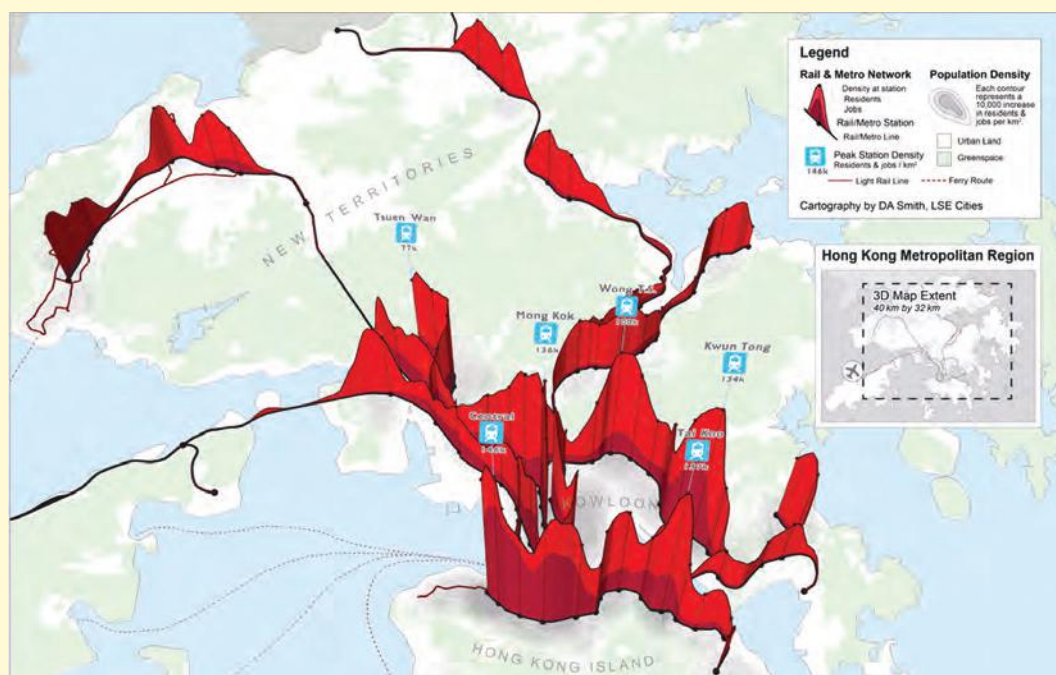
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(continued on next page)

Spurring Economic Growth through Rail-Based High-Density Development in Hong Kong SAR, China *(continued)*

ment to fund the railway's construction and operation. MTRC earns profits, generating cost savings for taxpayers from an unsubsidized public transit system. Passenger fares are low by international standards. The MTRC estimates direct financial benefits to the government resulting from the rail plus property program at $27 billion since the establishment of the company in the 1970s. Land value capture associated with subway development has unlocked land for 600,000 public housing units.

Integration of land use and transit planning has put 75 percent of people and 84 percent of jobs in Hong Kong SAR, China, less than 1 kilometer from a mass transit station. The city has one of the highest rates of public transit use (90 percent of motorized journeys) and lowest rates of car ownership (56 cars per 1,000 people, compared with an average of 404 in OECD countries).

Annual carbon emissions from passenger transport are 378 kilograms per person, compared with about 1,000 in European cities and more than 5,000 in Houston, Texas. Hong Kong SAR, China spends about 5 percent of GDP on motorized travel, compared with 12–14 percent in cities such as Melbourne and Houston (LSE 2013).

About 45 percent of the population lives in areas with densities of more than 50,000 people per square kilometer. This figure is close to the peak densities in New York (58,500 people per

BOX FIGURE 1.4.1 Annual Gross Value Added, Employment, Gas Consumption, and Carbon Dioxide Emissions in Hong Kong SAR, China, 1993–2009

Legend: CO$_2$ emissions per capita — Employment — GVA per capita — Road gasoline consumtion per capita

BOX 1.4 **Spurring Economic Growth through Rail-Based High-Density Development in Hong Kong SAR, China** *(continued)*

square kilometer). Only 6 percent of the population lives in areas with less than 5,000 people per square kilometer, compared with 36 percent in London. The negative effects of density have been mitigated by good design and layout and the inclusion of open spaces and community facilities. A substantial proportion of Hong Kong's urban population does not view high density as a problem. Indeed, many people prefer the presence of a large number of people (Yeh 2011).

High density creates more efficient land use, makes it easier to provide public services and facilities, reduces energy and infrastructure costs, and maximizes the effectiveness of public transit while minimizing the distance between sites of day-to-day activities. It also supports agglomeration economies, including access to a large pool of skilled labor within easy commuting distance. The high density of firms in the inner city improves networking opportunities and knowledge spillovers. Such interactions in the advanced services sector have helped Hong Kong SAR, China, secure its position as the third global financial hub, after London and New York.

Source: Based on LSE 2013.

centrations or to densification of the most accessible urban areas around the most important and most central transit stations. Box 1.5 shows how transit accessibility to a large number of jobs determines firms' locational choices in Paris.

This book underlines the agglomeration benefits of concentrating jobs in the city core, but the city core in large cities is often based on compact polycentric development.

In London, New York, and Tokyo, the core is made of several growing subcenters linked by transit. The case studies on London describe subcenters like King's Cross (considered a fringe location by London planners) and Canary Wharf (about a 20-minute transit ride from the City of London). In New York they include Midtown, Lower Manhattan, Downtown Brooklyn, and Long Island City. In Tokyo, the Yamanote line links a ring of rapidly growing subcenters along a 33-kilometer circle line around Tokyo.

Transit-Oriented Development at the Network Level

The layout of transit networks, often in the form of a core-and-branch system, plays a key role in shaping forces of agglomeration and the distribution of densities across the urban space. Network analysis shows the benefits of developing subcenters around stations at the intersection of inner subway networks and suburban rail stations, because they concentrate passenger flows and have high growth potential. Such approach also supports the polycentric development of cities.

In the cities profiled in this book, two-thirds of jobs are typically located outside the core area, providing opportunities for creating mixed-use development around

BOX 1.5 Access to and Location of Jobs in Paris Based on Transit

More than 1.5 million jobs can be reached in Paris in less than 30 minutes in areas well connected by transit. This number falls to less than 100,000 jobs in poorly connected areas (box map 1.5.1). The best-connected areas correspond roughly to the Paris of 1859, showing the spatial permanence of city structures once established.

Firms locate preferentially where prospective employees can reach them easily (box map 1.5.2)

BOX MAP 1.5.1 Number of Jobs in Paris Accessible by Public Transit in Less than 30 Minutes, 2015
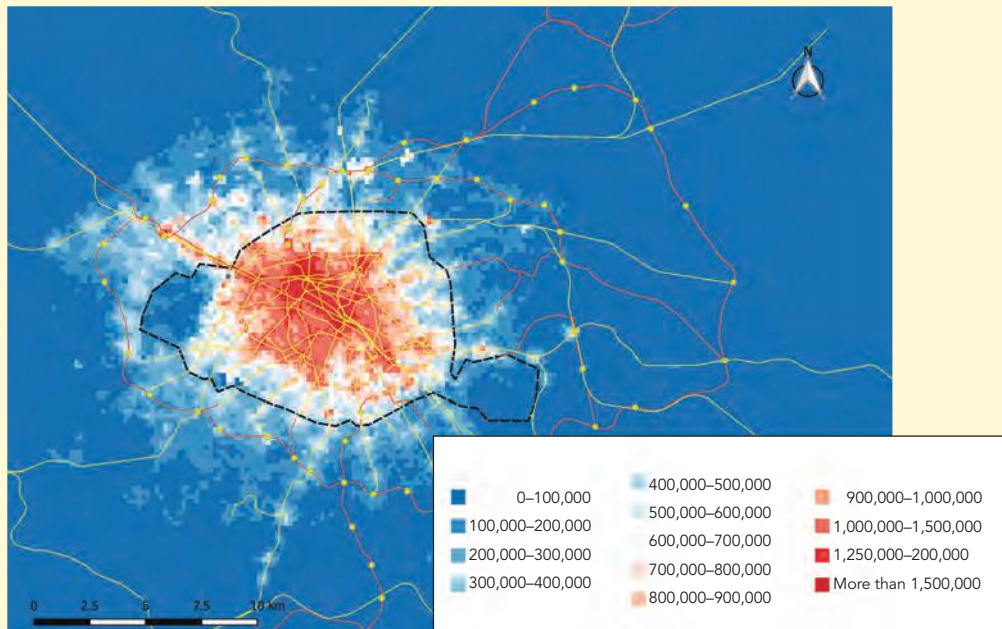
0–100,000	400,000–500,000
100,000–200,000	500,000–600,000
200,000–300,000	600,000–700,000
300,000–400,000	700,000–800,000
	800,000–900,000
900,000–1,000,000	
1,000,000–1,500,000	
1,250,000–200,000	
More than 1,500,000	

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stations that are not fast-growing core stations. Jobs and social activity are concentrated near transit stations along the branches radiating from the core of the subway network and benefit from multimodal integration. The intensity of human development and the job/housing ratio are higher closer to the network core, which corresponds well with the 3V Framework model. The effectiveness of such network is reinforced through concentrated development around stations, ensured through proper zoning.

BOX 1.5 **Access to and Location of Jobs in Paris Based on Transit** *(continued)*

BOX MAP 1.5.2 Density of Firms in Paris per Square Kilometer, 2015
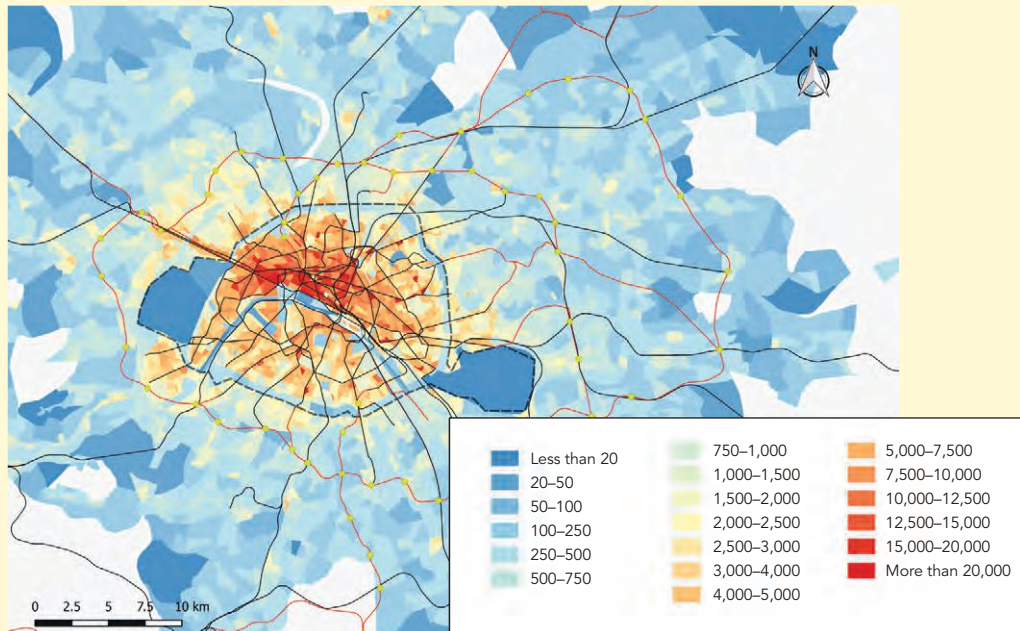
Less than 20	750–1,000	5,000–7,500
20–50	1,000–1,500	7,500–10,000
50–100	1,500–2,000	10,000–12,500
100–250	2,000–2,500	12,500–15,000
250–500	2,500–3,000	15,000–20,000
500–750	3,000–4,000	More than 20,000
	4,000–5,000	

0   2.5   5   7.5   10 km

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Core-and-Branch Systems

Many subway systems in global cities are characterized by a core-and-branches structure (Roth and others 2012). The core is densely connected with stations at constant densities, interconnected by crisscrossing lines. It provides high levels of accessibility for people and companies. The density of stations decreases sharply moving away from the city core on branches.[3]

The core-and-branches layout has a strong impact on local development potential. It determines the long-term trajectory of densities and accessibilities, as highlighted in box 1.6.

The London, Paris, and Tokyo subways started their development around the same time. All three cities created a circle line (in 1884 in London, 1900–1910 in Paris, and 1885 in Tokyo) surrounding the core city (about 30 square kilometers in London, 45 square kilometers in Paris, and 60 square kilometers in Tokyo).

BOX 1.6 **Transit, Job, and Population Densities in Paris**

The Paris subway opened in 1900. Its circle line, built between 1900 and 1910, still defines the limits of the 45-square kilometer core, where 1.5–2 million jobs are accessible by transit within 30 minutes. This area corresponds to the limits of Paris before the annexations of 1859. Early decisions about the subway network layout have shaped the city form and the distribution of its economic densities.

The distribution of stations within successive concentric circles shows a dense central core with an almost constant density of stations within the five-kilometer radius of the center of Paris (box map 1.6.1). Density then declines rapidly beyond the core, following a power law ($R^{-1.63}$ (where R is the distance from the center.

Job (box map 1.6.2) and population (box map 1.6.3) densities are also denser within the three-kilometer radius of the 1910 subway circle line. These densities decrease less sharply than the density of subway stations when crossing the core, resulting in a decrease in accessibility to transit and an increase in car dependency beyond the subway core.

In the maps below, the black line delineates the city of Paris including the woods of Boulogne and Vincennes (total municipal area of 105 square kilometers). The red lines are the future lines of the major subway extension in the low-density suburbs (Grand Paris Express 4 lines totaling 200 kilometers).

BOX MAP 1.6.1 **Number of Subway Stations in Paris per Square Kilometer, 2015**
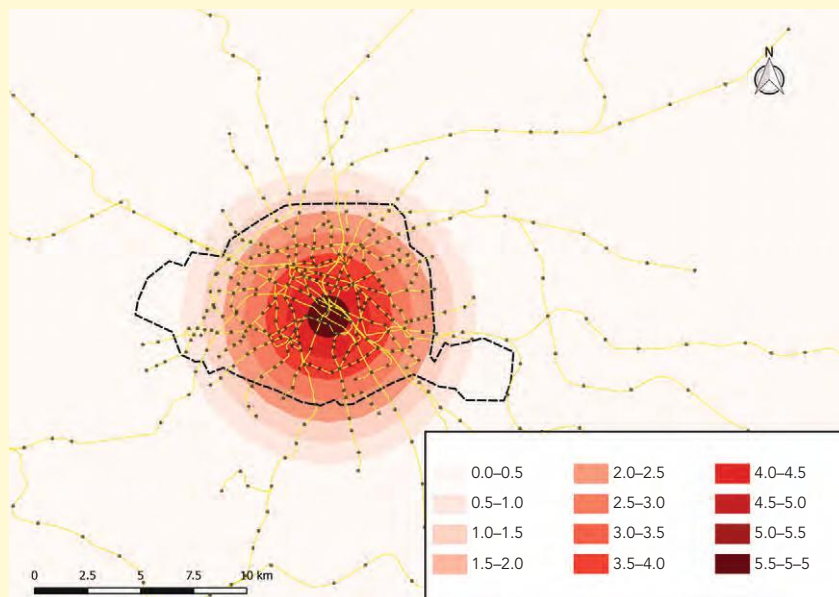
0.0–0.5	2.0–2.5	4.0–4.5
0.5–1.0	2.5–3.0	4.5–5.0
1.0–1.5	3.0–3.5	5.0–5.5
1.5–2.0	3.5–4.0	5.5–5–5

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Note: The black line delineates the city of Paris, including the woods of Boulogne and Vincennes (total municipal area of 105.40 square kilometers).

BOX MAP 1.6.2 Job Density in Paris per Square Kilometer, 2015
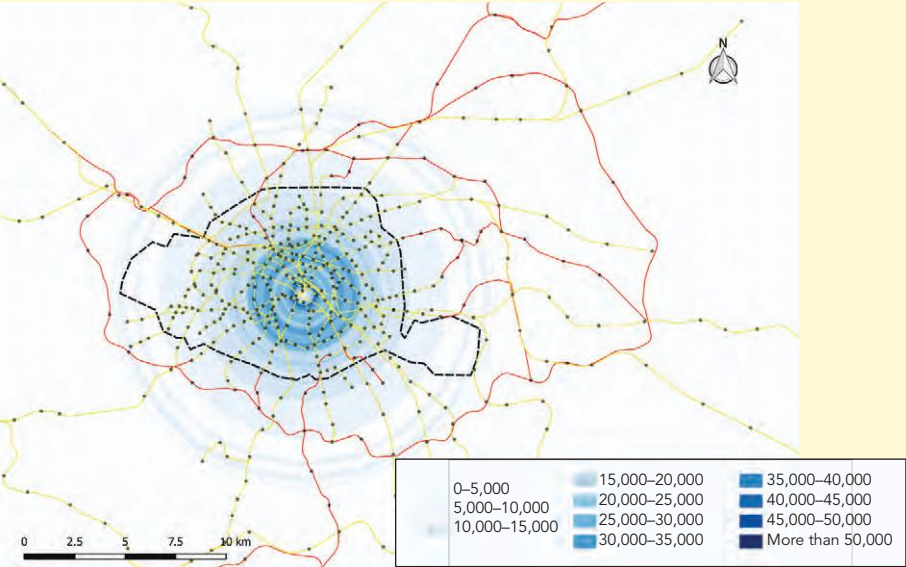
0–5,000	15,000–20,000	35,000–40,000
5,000–10,000	20,000–25,000	40,000–45,000
10,000–15,000	25,000–30,000	45,000–50,000
	30,000–35,000	More than 50,000

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BOX MAP 1.6.3 Residential Density in Paris per Square Kilometer, 2015
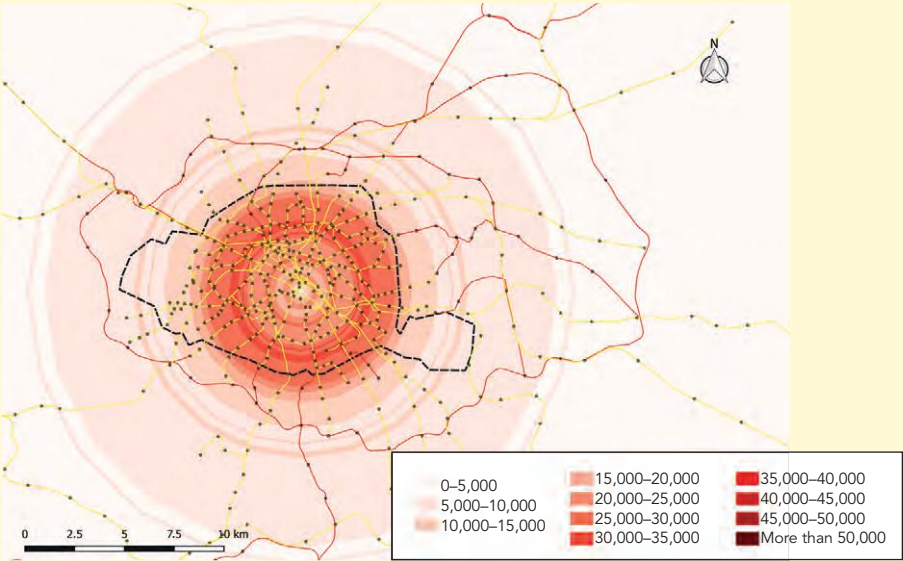
0–5,000	15,000–20,000	35,000–40,000
5,000–10,000	20,000–25,000	40,000–45,000
10,000–15,000	25,000–30,000	45,000–50,000
	30,000–35,000	More than 50,000

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From this circle line, branches of suburban rail radiate into the suburbs. The density and interconnectedness of stations is high in the network core and low in the branches, creating job and economic hyperdensities in the core. Network layouts shape densities—or put another way, cities are networks from which locations emerge.

The core-and-branches structure of most subway networks leads to concentration of jobs within the core. In London, for example, one-third of all jobs (1.5 million) are concentrated in the 15-square kilometer hypercore, the most accessible and central part of the subway network.

Polycentric Systems

Most subway systems are polycentric, with a ring of strong economic subcenters along the loop line (the Yamanote line in Tokyo is one example). Seoul's subway network, inaugurated in 1974, 90 years after London Circle line, is less concentrated and more grid-like, encouraging the emergence of subcenters such as Gangnam-gu.

TOD planning encourages the intensification of human density (people and jobs) with a good job/housing mix around the most connected transit stations outside the core while preventing development in the less accessible areas between the branches. As a complement to the core, polycentric centers linked via transit avoid creating one-way flows at peak work hours. China Development Bank Capital, Energy Innovation, and Energy Foundation (2015) recommends that the job-resident ratio (the number of people employed divided by the number of residents) should be 0.5–0.7 in every commuting district and the area should not exceed 15 square kilometers.

Multimodality

When choosing new line layouts, planners need to pay attention to enhancing the connective strength of the entire network, the hierarchy of its centralities, and its alignment with economic concentrations. Effective transit systems are hierarchically integrated in terms of service, fares, and information; they combine mass transit options for the densest corridors, regular bus services for lower-density corridors, and last-mile connectivity solutions at the neighborhood level. In large emerging cities spilling across multiple local governments (such as the Lima metro area or mega-urban regions such as the Yangtze Delta River), doing so requires the creation of regional agencies to ensure coordination of infrastructure investment across multiple jurisdictions.

Multimodality across scales—that is the seamless combination of different transport modes for a given trip—creates strong hubs that connect urban, regional, national, and even continental scales. London's Crossrail provide new transport links with the Tube, Thameslink, the National Rail, the *Docklands Light Railway* (DLR), and the London Overground. More than 200 million passengers are projected to use Crossrail in its first year of operation in 2019. Crossrail station interchanges with Tube stations and high-speed rail lines (the existing HS1 and the planned HS2) will create very high node values, spurring urban development to

align place value with the very high node values of the most central stations. Main hubs where jobs are already concentrated will have more connections and more lines after Crossrail becomes operational. These hubs, which sit atop the London transit system hierarchy, are clustered. Crossrail will provide a direct connection between all of London's main business centers, linking Heathrow with Paddington, the West End, the City, and Canary Wharf. Reductions in travel times, improvements in passenger experience, and increases in the frequency of rail service will have significant impacts on London's economic performance. New residential and commercial investment is expected to have a transformational effect on key locations along the route.

Zoning Around Stations

To reap the benefits of investment in transit networks, cities encourage development at major interchanges, at the most accessible stations in the network, and at stations that are major articulations in the network; moderate development in areas that are less accessible; and discourage development in areas that are more than 1 kilometer from a subway station. This approach is central to the achievement of city-level accessibility targets.

Zoning policies can be fine-tuned to coordinate the provision of transit infrastructure and the development of land. An effective planning instrument for achieving optimal land use intensity at city level and around transit stations is the floor area ratio (FAR), also known as the floor space index (FSI), the site ratio, and the plot ratio.

Good practice includes setting FARs at different levels depending on uses and accessibility. In Manhattan, for example, the FAR is 24.0 for highly accessible areas around Grand Central Terminal, 21.6 along Park Avenue, and 14.4–18.0 in other areas to the east and west (New York City 2013). Singapore (box 1.7) and Seoul (box 1.8) also use FARs finely tailored based on proximity to stations.

Good practice also includes a margin of flexibility for both transferring development rights between different uses as the market changes and allowing private developers to adjust the intensity of development based on market needs. In London's Kings Cross, margins of flexibility were provided to the main developer between uses (residential, office, retail) of up to 20 percent. Such an approach increases the marketability of real estate operations in developments that take years to complete. This flexibility can also be used to capture part of the value created by real estate development to finance transit infrastructure provision, public space, and affordable housing.

Zoning in the Hudson Yards project in Manhattan sets FARs at 10–33 for predominantly commercial use, 6.5–12 for mixed use, and 6–15 for predominantly residential use. The range between base and maximum FARs is intended to provide flexibility and capture value. Developers who want to exceed the base FAR can do so by making bonus payments to the District Improvement Fund (DIF). The DIF can be used to finance subway lines extensions, public space, and inclusionary housing, creating a positive feedback loop of development (see chapter 3) from the initial rezoning at higher density and a social mix within a high-end mixed-use business district.

BOX 1.7 Setting Floor Area Ratios Based on Metro Accessibility in Singapore

Singapore is a city with a 171-kilometer long mass transit system, an extensive network of feeder buses, and congestion pricing for cars in the central business direct (CBD). Singapore's urban form has been shaped by zoning policies that increase densities according to transit accessibility. The floor area ratio is very high in the CBD (8–25), 6.0 next to the CBD, and 1.5–4.0 in most residential areas (box map 1.7.1).

BOX MAP 1.7.1 Floor Area Ratios in Downtown Singapore

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Transit-Oriented Development at the Local Level

Local communities are the building blocks of TOD. In a TOD community, the interface between a station and the community it serves is critical. Both TOD and transport-adjacent development (TAD) focus on an 800-meter or 10-minute walk radius from a new station, but they deliver different experiences and built environ-

BOX 1.8 Using Zoning to Encourage High-Density Development Around Major Transit Nodes in Seoul

Seoul's zoning regulations set floor area ratios as high as 10 for commercial uses around the most connected and central transit stations, 2–4 for mixed residential and business areas, and 1–2 for residential uses. Uses are defined with fine granularity, depending on proximity to and the importance of transit stations (box map 1.8.1). The result is a varied city in which small residential neighborhoods abut thriving business districts and higher FARs (shown in red in the maps) are allowed near metro stations (indicated by blue circles) (box maps 1.8.2 and 1.8.3).

BOX MAP 1.8.1 Floor Area Ratios in Seoul
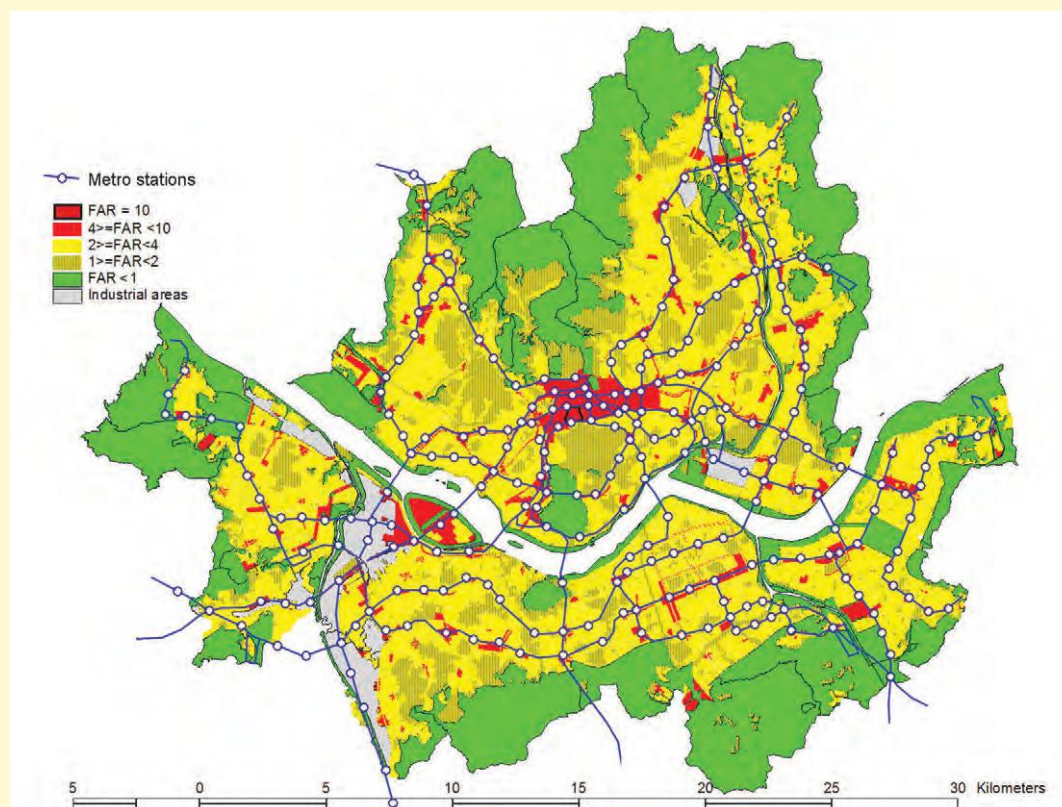
ments. Like TOD, TAD is near transit. Unlike TOD, however, it fails to capitalize on this proximity. It lacks functional connectivity to transit in terms of land-use composition, station access, and site design.

Once a development is built, transitioning from TAD to TOD typically takes a major push from local government in partnership with private sector partners—and retrofitting is almost always more expensive and complex than starting with a

BOX 1.8 **Using Zoning to Encourage High-Density Development Around Major Transit Nodes in Seoul** *(continued)*

BOX MAP 1.8.2 **Seoul Zoning (Area Scale)**
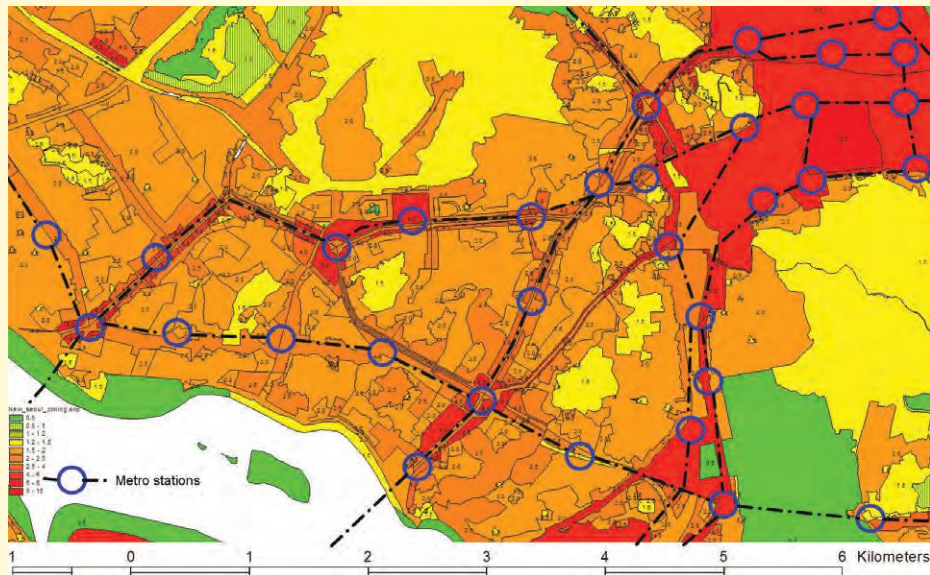
BOX MAP 1.8.3 **Seoul Zoning (Neighborhood Scale)**
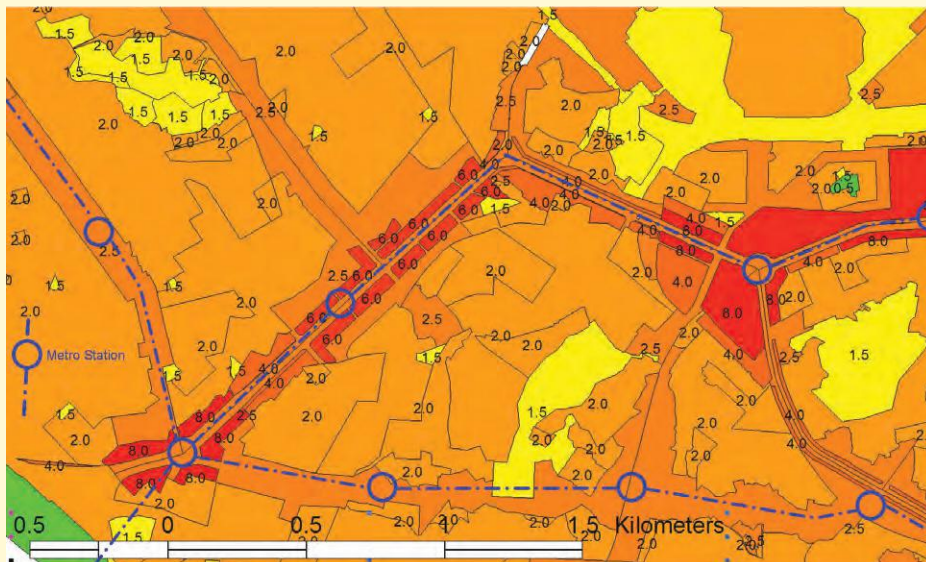
Source: © Alain Bertaud. Used with the permission of Alain Bertaud. Further permission required for reuse.

proper TOD plan. Thus, it is important to focus at the early planning stage on the transformational effect of transit lines for delivering more vibrant, inclusive, and sustainable communities.

Part of the infrastructure investment can be financed through value capture (see chapter 3). New rail access in an area justifies higher-density planning policies, because increased accessibility will lead to higher potential market value. Many local authorities encourage more intense and diversified development near transit stations, increasing the potential for developer-funded community amenities (see chapters 5 and 6 for the description of financing instruments to capture value from developers for funding local amenities in Hudson Yards and King's Cross).

Principles for local community development include the following:

- Embrace and maximize the quality of station design and enhance station accessibility, in order to improve the public realm for increasing place value.
- Prioritize public investment on key interventions.
- Facilitate the availability of health, education, shopping, and recreation facilities.
- Guide and leverage private sector activity.

Station-based urban regeneration or development offers great opportunities—as long as local authorities and developers adopt a proactive approach. Successful strategies that work for one station area can be replicated across the network for the same type of stations.

Types of Stations

Location within the network involves a complex interplay of place, network, and market potential (these concepts are defined in the introduction and developed in chapter 2). This complex interplay implies that different types of TOD should be selected depending on the location of the station within the network.

The benefits of increased transit accessibility are seldom shared uniformly across a network. Location within the network leads to a variety of local factors and planning contexts. The market potential impact of London's Crossrail (profiled in chapter 7) varies significantly across stations, and is used for illustration below.

Every community around a station has a different market profile, a distinct set of opportunities and challenges, and a unique set of resources at its disposal. The right policy levers and delivery mechanisms for realizing regeneration and development around each station therefore vary widely.

The 3V Framework is a policy tool for clustering stations based on their different values. It allows planners to identify key experiences for station types and to use them to help determine how infrastructure projects can deliver more. TOD common principles should be adapted to different contexts with planning strategies (infill, intensification, and transformation) described in chapter 2.

Major hubs
The most promising type of stations are major hubs in central locations. They have a high node value because they connect several lines and urban scales. They often

have a diversified urban fabric, sometimes with unique architecture and cultural heritage that create high place value.

London's Tottenham Court Road Station is a hub that connects the Central and Northern lines and many bus routes. Its status as a transit hub is set to grow with proposals for the Crossrail 2 route, which would see two Crossrails interchange between Tottenham Court Road and Dean Street.

Despite its high connectivity, the Tottenham Court Road locality has underperformed for decades. Crossrail unlocks the latent growth potential in the area (market potential value) by alleviating transport capacity constraints. The opportunity in this type of station is to use the new line as a catalyst for urban transformation. Doing so involves designing a more supportive street network and a better environment for pedestrians. The investments of Crossrail in the public realm also have a catalytic effect on improving low-quality building facades, which depressed the retail sector in the area and limited development values. Improvements to the built area will help create a place where a much broader range of uses can be accommodated.

Stations at urban fringe locations
Urban stations at fringe locations are close to the urban core but not at the most central locations. Increased connectivity acts as a catalyst to intensify activity at these stations. An example is the approach to regeneration in the area around Whitechapel station, in London (see chapter 7). Efforts in this project seek to encourage investment by restoring historic buildings and spaces to highlight cultural richness, improve ease of movement both along and across the route, and provide better walking and cycling opportunities to stimulate a healthier urban environment. The Whitechapel Vision: Regeneration Prospectus (Tower Hamlets), released in May 2015, envisions urban intensification supporting the development of 3,500 new homes and 5,000 new jobs in the community; transforming Whitechapel Road into a destination shopping area; creating seven new public squares and open spaces; and creating a world-class life science campus.

Suburban stations
An often-neglected type of stations are suburban stations at the end of lines. They have a low node value and in the case of Crossrail are often located within post 1950s urban infrastructures that dominate and fragment the area (which therefore has a low place value). Communities are mostly residential.

Developers and investors looking at these communities face two challenges. The first is the lack of developable sites. In the absence of a masterplan, opportunities are not obvious; they are there, they are just fragmented.

The second challenge comes from their lower market value, which that reduces the appeal for developers. Lack of developer confidence in the market means that early schemes might have to be developed in partnership with the public sector or a housing association.

An example of such a station is Abbey Road, which sits at the terminus of the southeast surface section of the Crossrail route. An infill regeneration strategy is envisioned based on diversifying uses in the community. A partnership was formed to implement a comprehensive redevelopment on a largely derelict 4-hectare

brownfield site to the north of the station. The development, known as Cross Quarter, will "develop a heart" for the area, which will include a new Sainsbury's supermarket, addressing the lack of major convenience retail in Abbey Wood. Cross Quarter will also include 220 new homes, community facilities (including a day care and children's center, a hotel, and units aimed at start-up businesses.

Creating Communities

Creating vibrant, inclusive, and sustainable communities involves much more than increasing density or designing a project. It also requires social and economic actions. The Complete Communities program launched by the Urban Land Institute defines the following goals:

- Living: To create and preserve communities that provide affordable housing, integrated transportation systems, and quality education.
- Working: To enhance regional economic prosperity through jobs, training, and access to education in a way that is designed to retain and attract new businesses.
- Moving: To promote increasing and improving movement around the region using public transit, electric cars, and walking and bicycling to achieve better physical well-being.
- Thriving: To support communities that provide access to healthy foods, arts, recreation, and entertainment that make people happy and feel meaningful through active civic engagement.

Tying urban rail projects into broader policies for community development can be mutually beneficial, significantly increasing the quality, effectiveness, and efficiency of other important areas of economic and social policy, including employment, health, education, and economic development (Jones and Lucas 2012).

All strategies for station areas redevelopment include a strong component of urban quality improvement. Good urban design adds place value, supports increased density, and helps ensure that it does not feel oppressive. It requires significant streetscape improvement, so that streets are places for people. Urban design that creates a spirit of place creates a feeling of enclosure, human scale, coherence, and linkage. (Chapter 4 discusses the core qualities of good urban design.)

Notes

1 On the links between TOD and the affordability of housing, see Center for Transit-Oriented Development (2009), Cervero and Murakami (2009), City of Dallas (2010), Center for Housing Policy (2011), McKinsey Global Institute (2014), and City of New York (2014b).
2 An extensive body of literature examines the link between transit accessibility and agglomeration spillovers. See in particular Baird (2004); Graham (2005); Department for Transport (2006); and Targa, Clifton, and Mahmassani (2006).
3 The sharp decrease in density of stations with distance to city center follows an inverse power law of the form $R^{-1.6}$, where R is the radius from the city center and -1.6 is the exponent (see Salat and Bourdic 2015).

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2

Drivers, Policies, and Strategies to Increase Values Using the 3V Framework

The 3V Framework is based on three values that characterize transit stations: node value, place value, and market potential value. This chapter presents key drivers of node, place, and market potential value; describes how planners can cluster station areas based on their values; and defines strategies of urban transformation to increase value. Increasing a value (node, place, or market potential) in a station area has an impact on other values. The main goal of the 3V Framework is to reveal imbalances in the structure of values across the urban space and around stations. These imbalances offer opportunities to improve the alignment of values, drive urban growth, and initiate positive feedback loops of value capture.

The 3V Framework introduces two main changes to the node/place model proposed by Bertolini in 1999. First, it bases node value on recent research about the structure of networks and the roles played by three kinds of centralities: degree, closeness, and betweenness. Network science has progressed considerably since 2000, with important discoveries about structural similarities shared by the Internet, social networks, DNA, and neural networks. This body of knowledge has been applied to subways to explain why station areas such as Shinjuku in Tokyo are booming. This work has important implications for public policies, as it reveals that network layouts matter for creating value.

Second, the 3V Framework clearly separates place value (the quality and diversity of the urban fabric) and market potential value. This separation is useful because different agencies, policies, and instruments are used to affect market and place dimensions; decision makers can clearly develop specific strategies to improve one or the other. Place and market potential value enhancements also take

Opposite page:
High multimodal connectivity and people-oriented design create high value in London's Kings Cross.
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place at different stages of development—which can lead to positive feedback loops between the two—making the split particularly meaningful. The case studies on Hudson Yards (chapter 5) and Kings Cross (chapter 6) illustrate this well. In China, for example, it is essential to separate these dimensions so that decision makers realize that without addressing the use of superblocks in urban planning much value will be lost.

The 3V Framework explores different aspects of planned stations, including their role in the transit network (node value); the scale of change expected (comparing existing uses to future uses and assessing place value); and how market timing, development opportunity, and the scale of investment can come together to identify opportunity sites and key activities to support or strengthen market activity.

What Drives Node, Place, and Market Potential Values?

For residents, value is driven by the characteristics of a place (the fit with personal preferences in terms of urban form, schools, access to daily amenities such as parks, heath facilities, and recreation centers, walkability and bikeability) and the connections between the place and job opportunities or other amenities used less than daily in the rest of the city. For companies, value is derived from maximizing profitability, which in the service industries will typically lead to converging to space with a high agglomeration of jobs. The application of transit-oriented development (TOD) principles can support such value creation, by strengthening the quality of life at the local level while providing for enhanced job opportunities through good connections to jobs at the network and city levels using mass transit.

Drivers of Node Value: The Impact of Centralities in the Network

Node value is driven by the importance of a node in a transportation network. All nodes in a network are not equal. Differences in the number of lines and modes of transport a node offers, as well as differences in centrality within the network, create a hierarchy of nodes. Nodes that are strong and complex hubs, more central, more accessible, or combine all these qualities have a higher value, because they tend to serve more passengers. Shinjuku, in Tokyo—the world's busiest station, with 3.5 million passengers a day—ranks high in terms of centrality.

From intermodal hubs to simple nodes
Hubs are among the most important nodes. A transport hub (also known as a *transport interchange*) is a place where passengers can switch between lines or between transport modes. Public transit hubs include large subway stations with multiple lines, train stations, rapid transit stations, bus stations, tram stations, and airports.

Some complex hubs combine several modes in a single integrated multimodal station, or complex of stations. Examples include Hongqiao Airport in Shanghai;

Tokyo Station, which link the high-speed rail station to six subway stations; and Union Station in Washington, which combines long-distance trains, commuter trains and buses, with metro and city buses. The number of lines and modes connecting at a hub defines its importance.

The hierarchy of nodes is as follows:

- Highly connective hubs offer transfers between many lines and transport modes. They are clustered at the core of the network.
- Core transfer stations connect two or three lines. Most are located in city centers.
- Single line stations radiate from the core of the network.

The core-and-branches structure

Some nodes in a network are more accessible than others (accessibility refers to the distance of a station to all other stations). In a well-organized city, jobs tend to cluster around the more accessible nodes within networks. These highly accessible nodes are usually clustered in the dense and interconnected core of the transit network.

Efficient subway layouts in global cities (including the systems in, Shanghai, Tokyo, Seoul, London, Paris, and New York) converge toward a similar layout, characterized by a core-and-branches structure (figure 2.1), despite their geographical and economic differences (Roth and others 2012). Densely interconnected by crisscrossing lines, the core provides maximum accessibility to jobs and people. It usually extends only about 5 kilometers, because it would be costly to maintain a high density of stations beyond this radius. Outside this area stations tend to be located on branches, and the density of stations decreases sharply when moving away from the city core (see appendix A).[1]

FIGURE 2.1 Core-and-Branches Structure of Subway Network
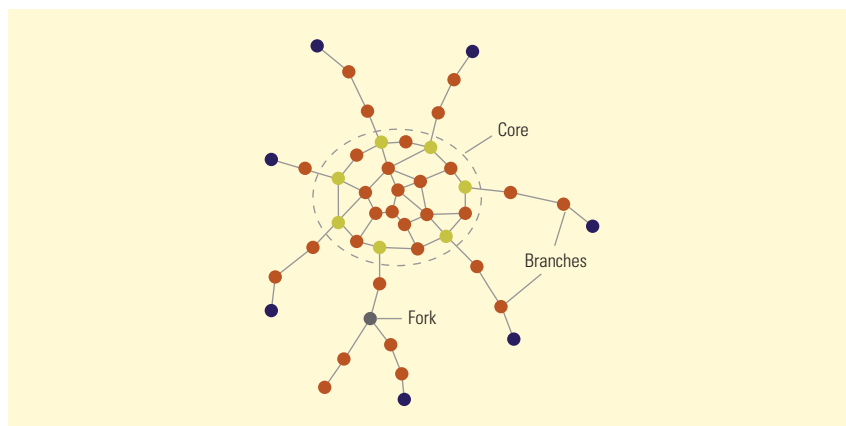
Source: Roth and others 2012. Copyright: © 2011 Roth and others[a].
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The core-and-branches layout and the differences in centralities in subway networks have a strong impact on local development potential. Major subway extensions with radiating branches, such as the one built in Seoul in the 1990s, made the central stations within the core more accessible from all other stations, creating strong market potential at the center. As a result, land prices rose, and development opportunities increased. Major subcenters may develop when subway extensions lead to large increases in accessibility, as they did in Gangnam-ku in Seoul, where, over a period of 20 years, a booming real estate market raised the property value in an area of 40 square kilometers above that of Busan, the second-largest Korean city and one of the first global container ports.[2]

Centrality in transit networks
Centrality is a structural characteristic of stations (nodes) in the network that quantifies how a station fits within the transit network overall. Stations with high centrality scores are more likely to be key conduits of people and to help concentrate jobs and economic activities. Low-centrality stations can be termed peripheral. Lower centrality is associated with lower growth potential and fewer job opportunities. Three of the most commonly used measures are *degree*, *closeness*, and *betweenness* centrality.[3]

Degree centrality
Degree centrality is the number of links per node. It is an important property of many networks, in particular the Internet (figure 2.2).

A map of London's subway shows the dominance of King's Cross as the most connected London node (map 2.1).[4] The highest degree centralities—and thus

FIGURE 2.2 Degree Centrality of Financial Trading Networks
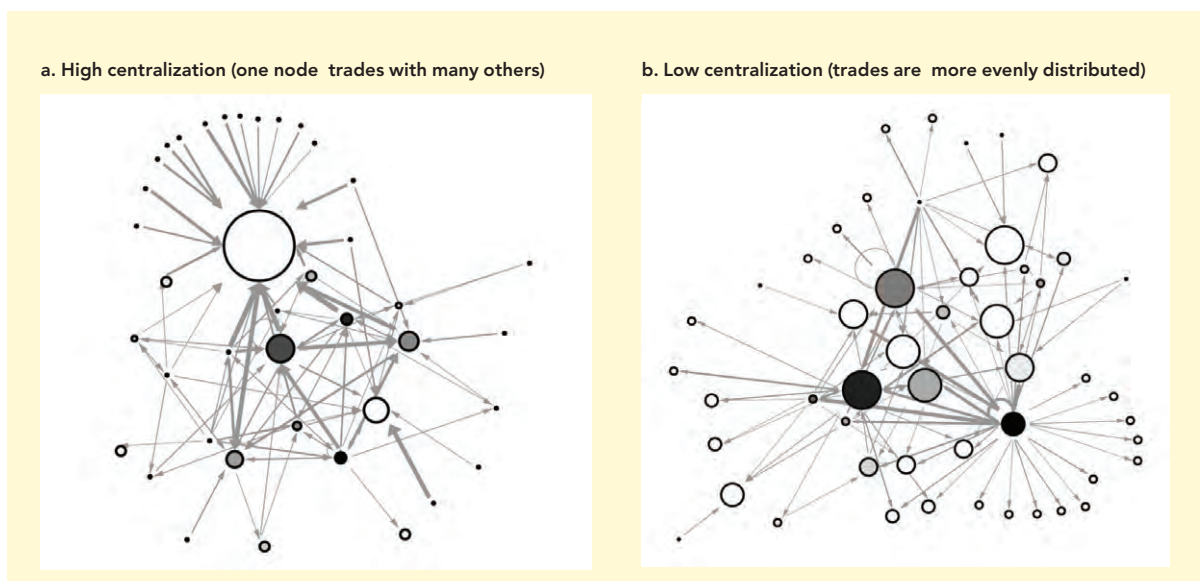
a. High centralization (one node trades with many others)

b. Low centralization (trades are more evenly distributed)

Source: © Lada Adamic. Used with the permission of Lada Adamic. Further permission required for reuse.

MAP 2.1 **Degree Centrality of Subway Stations in London**
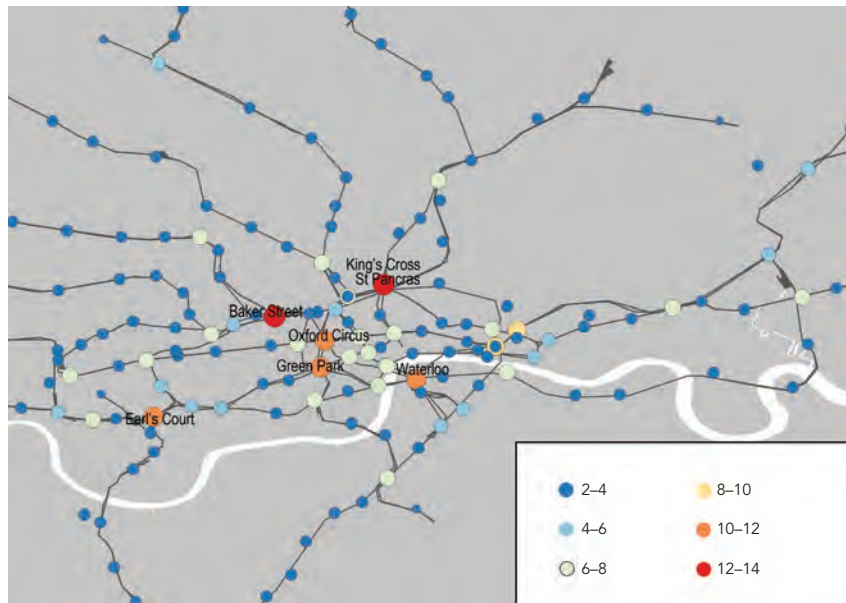
Source: © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse.

the highest growth potentials—are located around the Circle Line and along the Central Line, defining Central London. There is a higher density of high-degree stations in the western part of Central London, where one third of London's jobs are concentrated.

Closeness centrality
Closeness centrality expresses the average distance, measured in number of links, from a station to every other station in the network. Stations who connect to most others through many intermediaries get closeness scores that are increasingly nearer to zero. One property of closeness centrality is that it tends to assign high scores to stations that are near the center of local clusters.

Closeness centrality is an important property of many networks, including social networks (figure 2.3) and the London subway (map 2.2). Closeness centrality in London's subway network confirms that Central London is the most accessible part of the network.

Betweenness centrality
The betweenness centrality of a station is equal to the number of shortest paths from all stations to all others that pass through this station. A station with high betweenness centrality has a large influence on the transfer of passengers through the network, under the assumption that passenger transfer follows the shortest paths. This calculation identifies the stations that are necessary conduits for passengers that must traverse disparate parts of the network, such as suburban trains

FIGURE 2.3 Degree and Closeness Centrality of the Facebook Network
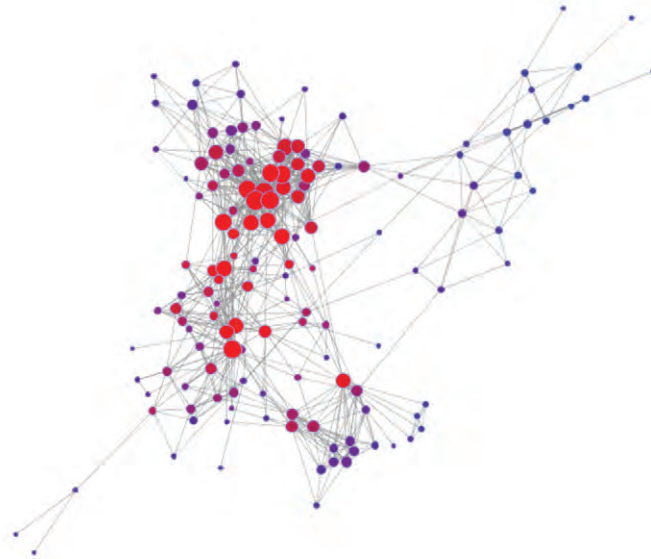
Source: © Lada Adamic. Used with the permission of Lada Adamic. Further permission required for reuse.
Note: Degree centrality (the number of links) is denoted by size. Closeness centrality (the sum of the length of the shortest paths between the node and all other nodes) is denoted by color.

MAP 2.2 Closeness Centrality of Subway Stations in London
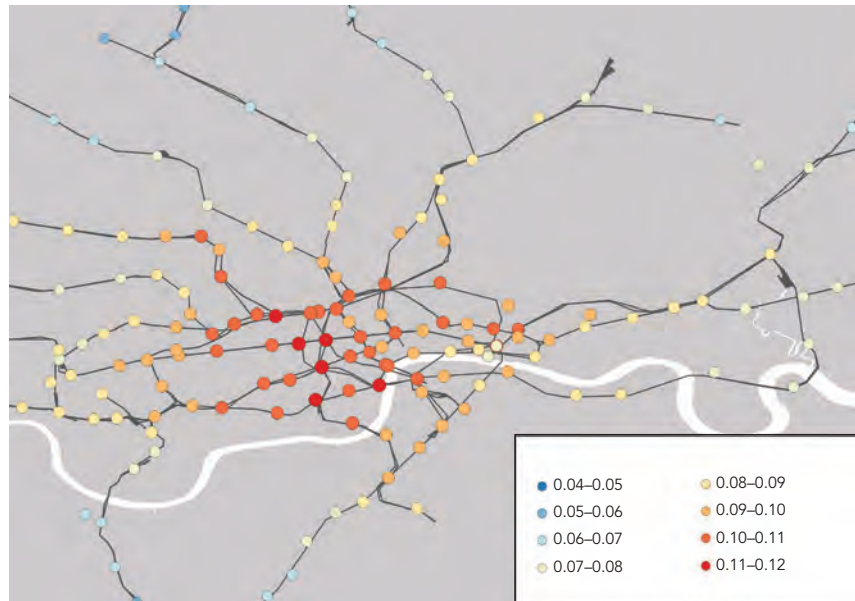
- 0.04–0.05
- 0.05–0.06
- 0.06–0.07
- 0.07–0.08
- 0.08–0.09
- 0.09–0.10
- 0.10–0.11
- 0.11–0.12

Source: © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse.

FIGURE 2.4 **Degree and Betweenness Centrality of the Facebook Network**

Source: © Lada Adamic. Used with the permission of Lada Adamic. Further permission required for reuse.
Note: Degree centrality (the number of connections) is denoted by size. Betweenness centrality (the ability to broker between groups) is denoted by color.

and subway lines or core-and-branches in a subway network. An example is the interchange stations along the Yamanote Line in Tokyo, which have high levels of betweenness centrality. Stations with high levels of betweenness centrality often do not have the shortest average path to every other station, but they have the largest number of shortest paths that have to go through them.

Betweenness centrality is an important property of many networks. The concept finds wide application, including in computer and social networks, biology, transport, and scientific cooperation. In the Facebook network (figure 2.4), individuals who act as bridges between clusters in the network have high betweenness centrality.

Map 2.3 highlights the betweenness centrality of the Circle Line, built in 1884. Most of London's original train stations are located on the Circle Line, which connects the radiating branches of suburban trains with the Central London transit network.

Like the Circle Line, the Yamanote Line in Tokyo (built in 1885) is shaping growth, through a high level of centrality for its stations (box 2.1).

Calculating node value
The following key metrics are used to estimate node value. An index of node value is built by weighting these metrics (see appendix B).

MAP 2.3 **Betweenness Centrality of Subway Stations in London**
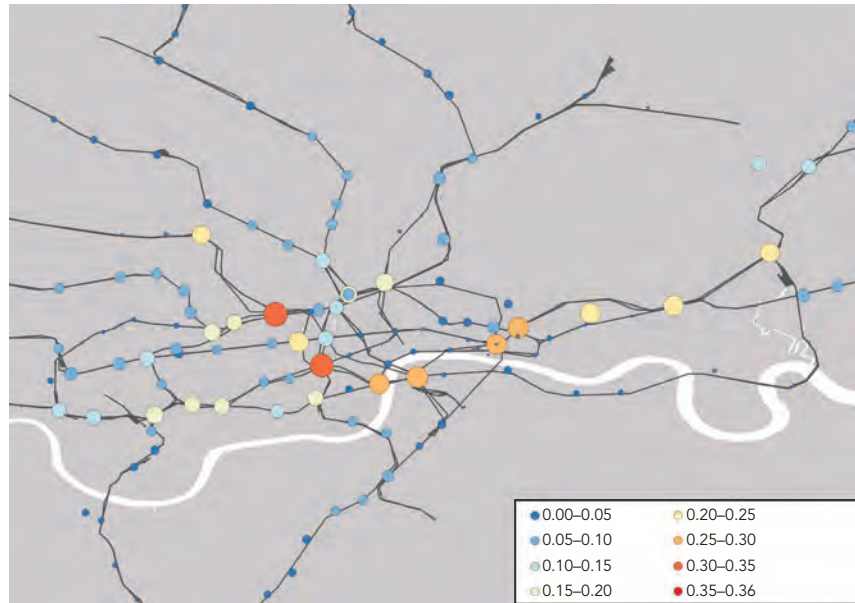
● 0.00–0.05	○ 0.20–0.25
● 0.05–0.10	● 0.25–0.30
○ 0.10–0.15	● 0.30–0.35
○ 0.15–0.20	● 0.35–0.36

Source: © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse.

BOX 2.1   Shaping Growth through Centrality in Tokyo

The first part of what would eventually become the Tokyo circular line, the Yamanote Line, started operating in 1885, the same year the London subway was inaugurated. The loop was completed in 1925. It has structured the city's development, connectivity, and densification since the beginning of 20th century. As both the Yamanote loop and the streetcar network within the loop were government owned, the government did not want competition from private railway operators, applying the same logic as in London. Tokyo's metropolitan government prevented outside trains from entering Tokyo. Private railway operators had to establish their terminals along this circular line (they became high peaks of betweenness centrality), forcing millions of commuters to switch trains there.

The network today consists of several radial lines running from the suburbs to the center of Tokyo (box map 2.1.1). With the exception of the Chuo Line, all these lines terminate on the Yamanote Line, a circular line that connects most of Tokyo's urban centers. This structure created natural growth points at the intersections of the main radials and the loop (Sorenson 2001; Chorus and Bertolini 2011), which became the seeds of urban subcenters.

The integrated development of railways and their surroundings was stimulated by the fact that private railway developers owned not only the railway infrastructure but also large parts of the areas surrounding it. Today, Tokyo's subcenters with the highest peaks of value creation and the

BOX MAP 2.1.1 Tokyo's Yamanote Line
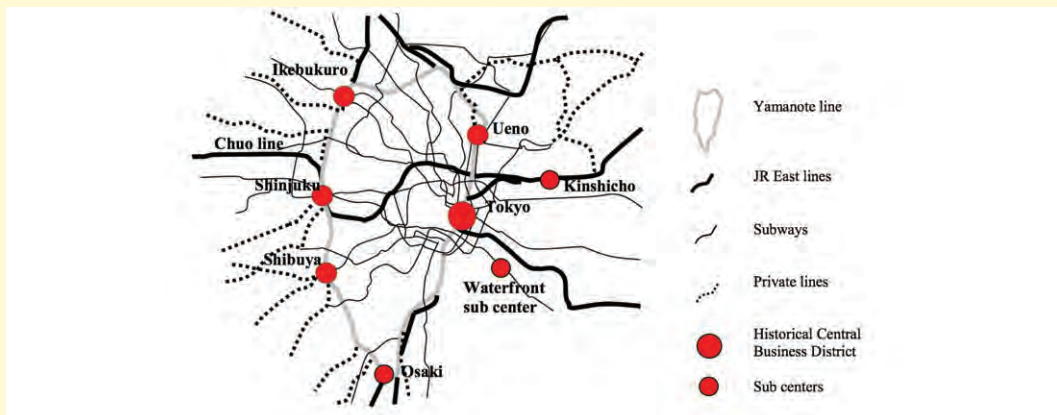
Source: Chorus and Bertolini 2011. © Paul Chorus and Luca Bertolini. Used with the permission of Paul Chorus and Luca Bertolini. Further permission required for reuse.

highest densities of jobs and GDP concentrated along the Yamanote Line. Box map 2.1.2 illustrates the intensity of activity by showing the density of tweets across the metropolitan area (with a gradient in intensity from blue to red with red representing the highest levels of density).This urban form was created by a century of policies integrating transport and land use.

Today the Yamanote Line is the most connected line in Tokyo. It spans approximately 12 kilometers North-South and 6 kilometers East-West, unofficially defining Central Tokyo, which is about the size of Manhattan. Only 2 of 29 stations do not offer connections with other subway or train lines. The other stations are mostly major hubs connecting to the high-speed train. Every day an average 3.55 million passengers circulate on the line, some 1.3 billion passengers a year. Box figure 2.1.1 shows the hierarchy of connectivity along the Yamanote Line in 2015 (transfers to Shinkansen stations were included to take into account the connectivity of the stations to the rest of Japan).

BOX MAP 2.1.2 Distribution of Tweet Activity in Tokyo
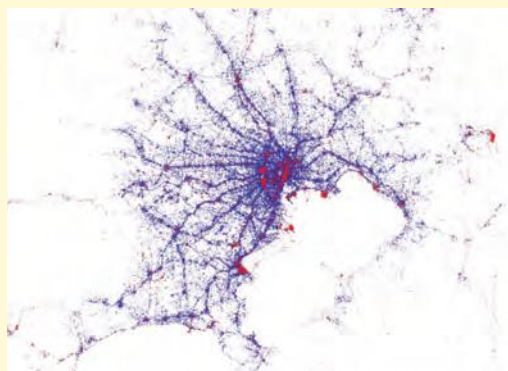
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Public investment has leveraged huge amounts of private investment, while land value capture has allowed the financing of transit investments. The success of the Japanese programs of land value

BOX 2.1 Shaping Growth through Centrality in Tokyo *(continued)*

capture is based on adding lines that increase the interconnectivity of the network. Most of the 48 urban rail and subway companies in Tokyo are private and derive a large part (up to a third) of their revenue from their activities as developers and property managers. They are highly sensitive to the real estate potential of new lines developments. When they build additional lines, they look systematically at increasing the number of interchange stations in order to reap the market benefits of the increase in node values by developing the land around the new hubs.

BOX FIGURE 2.1.1 Stations along Tokyo's Yamanote Line, Ranked by Degree Centrality
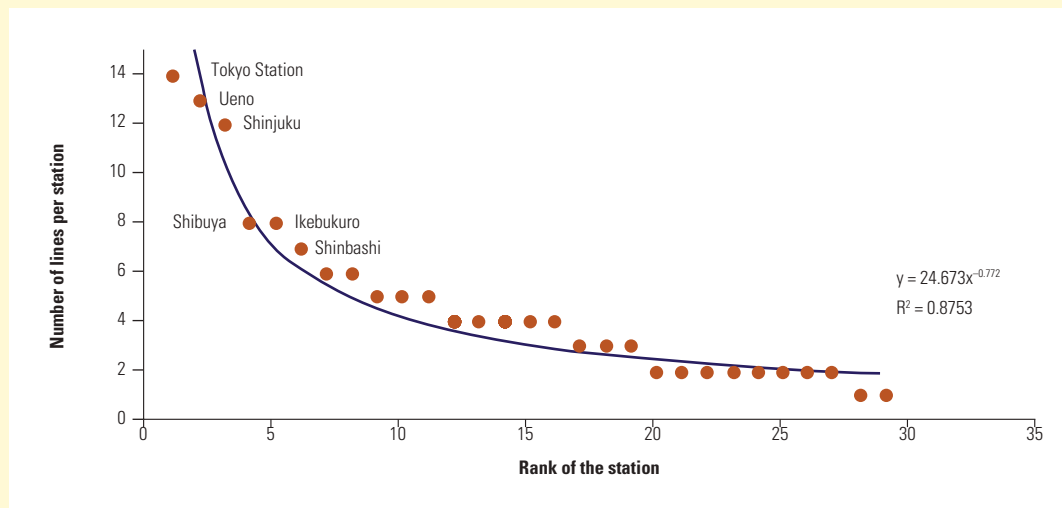
$y = 24.673x^{-0.772}$
$R^2 = 0.8753$

Source: © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse.
Note: Figure shows inverse power law characteristic of a complex system. The exponent of the power law is higher than in London, because of the higher complexity and integration of Tokyo's subway.

- *Degree centrality* describes the number of links in a node. For example, King's Cross in London connects 6 subway lines and has 12 links. The Shanghai subway network will have 95 transfer stations, including 16 with 3 lines or more.
- *Closeness centrality* ranks the nodes based on their distance to all other nodes in the network.
- *Betweenness centrality* ranks the nodes based on the number of shortest paths between all other nodes that pass through a given node.
- *Intensity of node activity* captures the strength of traffic flows in a node. It can be described by the frequency of departures of public transportation and/or by the *daily ridership* of a node, a comprehensive measure of node activity. The

ridership of Shinjuku Station, in Tokyo, is 3.5 million passengers a day, the highest in the world.

- *Intermodal diversity* refers to the number and variety of transportation modes a station connects. The more options and variety of choices a station offers, including connection to subways, buses, and high-speed rail, the higher its connectivity. Providing a variety of modes and integrating bicycles and bus facilities, as in Malmö, Sweden, is key for increasing transit connectivity and enhancing accessibility to jobs, as shown in the Zhengzhou case study (chapter 8).

Drivers of Place Value: Local Connectivity, Fine-Grain Urban Fabric, and Mixed Use

Because place value varies widely, the types of planning, urban design, public policies, and investment strategies will be different based on local station area context. Place value for residents is derived from vibrant, sustainable communities that provide easy access to jobs, shopping, and services on foot or bicycle. Such communities provide a range of benefits, including reduced transportation costs, improved access to various amenities (including high-quality education), and improved public health.

A key driver of place value is the quality of the urban fabric, which is based on human scale, permeability, diversity, and the capacity to evolve. High quality is achieved by small blocks, subdivided into land lots of various sizes, and a high density of street intersections.

The block is a central element of urban planning and urban design. It is the smallest area that is surrounded by streets. City blocks are the space for buildings within the street pattern of a city; they form the basic unit of a city's urban fabric. City blocks can be subdivided into smaller land lots, usually privately owned. City blocks are usually built up to varying degrees and thus form the physical containers of public space. The Portland Transit-Oriented Strategic Plan demonstrates a correlation between block size and land value, with smaller blocks having higher land values (CTOD 2011).

Place value is unevenly distributed across an urban area. Places across cities have a wide range of intensities and a mix of land uses. In a typical city, many stations areas are mainly residential, with low intensity, while a few are more job oriented and mixed use, with high intensity.

Walkability also varies. It depends on the street patterns and the design of streets as places for people. Street patterns determine not only whether residents and workers can access rail and bus transit but also whether they can access the shopping, jobs, and services located in their immediate neighborhood. Street patterns with blocks about 100 meters per side and high connectivity enhance local accessibility (see box 2.2). In contrast, superblocks and gating decrease accessibility.

An index of place value can be built using a weighted sum of the following metrics (see appendix B):

- *Density of street intersections* measures the density of street intersections within an 800-meter radius of each station. Connected street patterns with a

BOX 2.2 Small Block Size and Livability in Manhattan

Urban blocks in Manhattan are 60 x 190–280 meters, about the same size as in the historical center of Paris (box photo 2.2.1). In the North-South direction, the average distance between intersections is similar to that of European Medieval cities; in the East-West direction, the average distance is slightly greater than in most European 19th century cities. The size of Manhattan's blocks make the city highly walkable. The block composition is highly diversified, including public spaces such as Rockefeller Center (box photo 2.2.2).

As a result of its small blocks, dense street pattern and dense subway network, 100 percent of the workforce in Manhattan is within easy reach of a transit station by walking.

BOX PHOTO 2.2.1 Grid of Manhattan Showing Small Block Size

Source: Salat with Labbé and Nowacki 2011. © Serge Salat. Used with the permission of Serge Salat. Further permission required for reuse.

BOX PHOTO 2.2.2 Rockefeller Center, a Public Space in Manhattan

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

high density of intersections promote accessibility and walkability. International best practice shows that an intersection density of about 100 intersections per square kilometer enhances accessibility.

- *Pedestrian accessibility* measures the proportion of the area within 800 meters of a station that is within a 10-minute walk. Block sizes of about 100 meters per side with vibrant edges (facades with businesses on the perimeter) promote more compact development and walkability.
- *Diversity of land uses* measures the different types of land use with an 800-meter radius of a station. Areas with commercial urban amenities such as restau-

rants, grocery stores, and specialty retail shops allow residents to perform daily activities.

- *Density of social infrastructure (amenities)* measures the number of cultural, educational, and health services as well as the social infrastructure, within 800 meters of a station. When concentrated in a compact area or easily accessible, such amenities increase place value.
- *Pedestrian/bicycle connectivity* measures access to sidewalks and bikeways, which encourage people to walk or cycle to transit stations and neighborhood destinations. It can be added to the other measures where appropriate.

Drivers of Market Potential Value: The Interaction of Supply and Demand

The market potential value of a station area is assessed by understanding the unrealized market value around it. Market demand at the city level also needs to be understood, to put such analysis in context. The availability of relevant data varies widely from city to city; the approach needs to be tailored accordingly, focusing on local drivers of demand and supply.

Drivers of demand

Market potential depends on overall demand for real estate development at the city level and on the economic activity and attractiveness of the specific place for developers and businesses. For businesses and commercial activities, local job densities and high accessibility to other job concentrations across the urban area and expected growth are crucial, because they determine the agglomeration economies of locating around a specific station. For residential development, market potential depends greatly on the number of jobs accessible in 30–45 minutes from a location.

Drivers of supply

Market potential depends on available land opportunities, the ease with which land can be redeveloped, and the volume of construction permitted. When a location is highly attractive, the market develops high-density programs with mixed-use programs, as long as FARs are adjusted upward, as is in King's Cross in London (26 hectares) and Hudson Yards in Manhattan (22 hectares).

Emerging areas that have some market potential but few mixed-use buildings may be good candidates for TOD investment. TOD policy can help push a ripening market and escalate development intensity and quality. In areas with less market potential, strong incentives are needed to encourage market development and the desired mix of land uses and building types.

Market activity

Market activity is an important component of market potential value. It derives from the intensity of market transactions during a sufficiently long period for residential and mixed-use (residential/commercial) land uses. Box 2.3 illustrates the role of an increase in connectivity and high-quality public space in building strong market demand in Canary Wharf, in London.

BOX 2.3 Exploiting High Market Potential Value at London's Canary Wharf

Canary Wharf is the highest peak of job and office space density in London, with about 105,000 jobs on 28.8 hectares. Development of Canary Wharf owes much to the extension of the Jubilee Line, which began in 1993. The increase in the value of Canary Wharf rose by an estimated £3.9 billion between 1992 and 2002, of which up to £1.9 billion can be attributed to the extension, according to the real estate firm JLL. High-quality landscaping and architecture supported the transformation (box photos 2.3.1 and 2.3.2).

BOX PHOTO 2.3.1 Water Landscaping at London's Canary Wharf

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

BOX PHOTO 2.3.2 Canary Wharf Subway Station

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

Calculating market potential value

Market potential value metrics provide a rough measure of the feasibility of TOD development based on local conditions (see appendix B). It depends on overall demand for additional real estate at the city level. Market potential can be measured with a weighted combination of demand-side and supply-side measures.

Demand-side measures include the following:

- *Human density* measures the number of people and jobs per square kilometer within a catchment area of 800 meters around a transit station. The number of residents and workers in an area and the balance between jobs and working-age population is correlated with the attractiveness of an area for residents and businesses and with the development of a strong real estate market.
- *Activity mix* measures the mix of residents and jobs in an area. It can be measured through the job to resident ratio.
- *Forecasted rate of growth in human density* indicates the expected evolution around a station. It is typically forecast as part of urban mobility plans or mass transit development plans.
- *Number of accessible jobs* measures the number of jobs accessible through transit and walking within a given time (usually 30–45 minutes). It measures an area's attractiveness for residents and companies, which want strong linkages with other dense nodes of jobs within the urban region.

Supply-side measures include the following:

- *Real estate opportunities* measures the potential for developable floor space located within 400 meters of a station for the highest premium and 400–800 meters for a lower premium. Real estate opportunities are based on additional square meters of floor space that can be built on land adjacent to the station—the difference between the maximum floor space that can be built within the regulatory FAR and the existing built floor space. High FARs support a high density of people and jobs and a high volume of construction.
- *Volume of transactions* provides useful indications of the state of the market. A decades' worth of data should be examined (where available), to provide a longer-range look at performance. Overall demand for additional real estate at the city level should be considered.

Impact of Station Locations on Values

International experience suggests that node value (high connectivity and accessibility within the network) plays a major role in dense core areas, where it fosters economic and jobs concentration and commercial real estate development. Canary Wharf and King's Cross in London are examples of projects where increased connectivity caused spikes in market value.

Connectivity plays a less important role than place value in low- to medium-density areas. One of the key features of residential property value is the residential self-selection process (a process in which individuals select places that fit their preferences, in particular for amenities and schools). Self-selection explains large varia-

tions between value changes (and direction) at different stations on a given line (Higgins 2015), even though all benefit from increased accessibility. Stations where place value is more important than node value are typically in the long tail of single-line stations, for which node value is generally weak (the strongest node values are major hubs, which are usually within the core part of subway systems).[1]

Types of Station Areas

The three values are unevenly distributed across station areas.[2] Some stations are important interchanges between different subway lines and different transport modes. These stations offer high potential for new developments. Other stations offer less potential, because they are in suburban areas, with less vibrant real estate markets and fewer connections to the rest of the network. These stations offer different opportunities, such as cheap available land to redevelop, as the analysis of risks and opportunities in fringe and central locations along the Crossrail route in London demonstrates (chapter 7). Different types of stations require different types of development strategies, investments, and policy instruments. A methodology is needed to cluster stations based on their node, place, and market potential values.

Clustering Station Areas Based on Node Value

Node value is higher at subway network cores than at the periphery. At network cores, stations are interconnected in dense clusters around major hubs. At the periphery of the network, stations are spaced much farther apart.

The mathematical regularities in the core-and-branches layout of many subway networks, the distribution of transit centralities, and the intensity of flows across many subway systems allows a clustering of node value into single-line stations, core transfer stations, and highly connective hubs

1. Single-line stations belong mostly to the branches of the urban rail system extending outward into the suburbs.
2. Core transfer stations are transfer stations with two or more lines concentrated at the city core.
3. Highly connective hubs rank high in intermodality, centrality, and intensity of passengers flows. They have the highest node values.

Clustering Station Areas Based on Place Value

Station areas can be grouped into three types based on their place value: suburban, urban, and intense urban.

1. Suburban areas are generally nontransit areas or areas close to transit that do not possess the urban character that would best support TOD. This category generally describes low to moderately populated areas that lack a combination of street connectivity, pedestrian and bicycle facilities, and urban amenities to more fully support the level of transit service. Suburban areas are generally

mono-functional (either residential or industrial or business parks, with no mixed use) on large areas of land.

2. Urban areas are moderately or substantially populated areas with a good or improving pedestrian/bicycle network and some mix of neighborhood retail and service amenities as well as a moderate mix of supporting jobs.

3. Intense urban areas combine a high diversity and intensity of uses with high economic concentrations, making these areas the most likely to support a transit lifestyle.

Clustering Station Areas Based on Market Potential Value

Station areas can be clustered into three types based on their market potential value: limited, emerging, and strong.

1. Limited areas have weaker market conditions and lack the demand necessary to support new compact and/or mixed-use development. TOD investments in these areas are less likely to catalyze additional private development and should be used only on a limited basis. An emphasis on visioning and planning, to begin to develop interest, is more appropriate.

2. Emerging areas have limited to moderate real estate market conditions; intensive building types are generally not supported in the near term. Although they may lack immediate market support for TOD, emerging areas may be ideally suited for catalytic TOD investments to enhance local market strength, because land and development costs are not high and small investments may catalyze further market investment.

3. Strong areas have market conditions that are already ripe or ripening, TOD investments should focus on improving urban living amenities and developing prototype developments.

    This approach is not predictive of the financial feasibility of a new development in a category. Rather, it provides a sense of how a station area is likely to perform.

Policies for Different Types of Stations: Infill, Intensification, and Transformation

The 3V Framework is a virtuous circle. Higher place, node, and market potential values induce higher economic value, which in return raises place and node value, as more and more opportunities emerge and investments become more profitable. The 3V Framework integrates the different aspects and scales of urban development.

    TOD investments are intended to stimulate a market response, but many other critical investments and incentives are needed. TOD investments should take a comprehensive view of programs and policies that can help realize the full range of TOD benefits. These comprehensive strategies include investments in human capital, neighborhood services, and business development, which may improve

FIGURE 2.5 Matrix of Recommended Strategies for Value Clusters
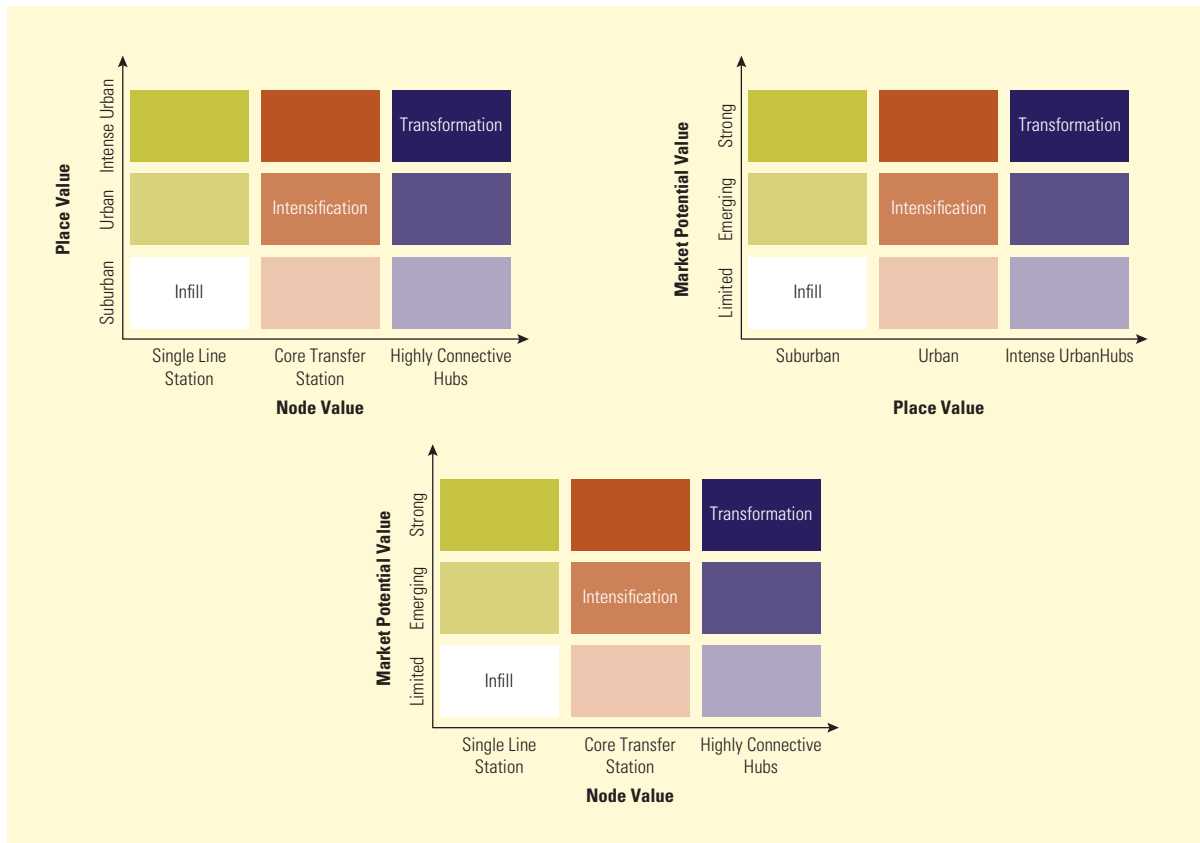
an area's long-term prospects for TOD. Scaling up TOD at the metropolitan region level requires changes in a range of geographic and economic contexts, not just in core urbanized areas. Many suburban stations have limited near-term market development potential but substantial land opportunities. Station area planning and implementation efforts are needed in these areas. Many suburban stations in Chinese cities, for example, have low densities and significant developable land, which can accommodate urban growth.

Overlaying node, place, and market potential values creates nine area types, each of which calls for different public policies and timing of investments (figure 2.5). This classification is the first step in an investment strategy at the city scale. Many of the types face similar challenges and would benefit from similar investments strategies.

Depending on their TOD and market potential, three types of implementation strategies can be defined:

- *Infill* is mainly for nodes in suburban neighborhoods with single transit lines and low market value. It involves the reuse of urban land for new, higher-density construction. The strategy is to promote long-term planning and increase activ-

ity levels and transit service through increased densities; plan and fund multi-modal transportation system; and plan for maintaining equity in vulnerable or challenged communities. Such locations can provide good opportunities for affordable housing.

- *Intensification* is for emerging station areas in urban neighborhoods with inter-changes and emerging markets. Intensification areas are typically built-up areas with good existing or potential public transit links that can support redevelopment at higher than existing densities. The strategy is to invest in catalytic TOD projects to prime and push the market, promote development-oriented planning, and evaluate and address missing multimodal connections and accessibility.[3] Such locations can be prime opportunities to provide affordable housing.
- *Transformation* is the strategy to apply in major hubs. Creating a high level of place value—through job concentration and good urban design, including major investments in public spaces—can create high peaks of land and real estate value. The strategy is to invest in aggressive TOD projects to push the market, through significantly higher densities and lower parking ratios; innovative building types and advancements in urban design; employment opportunities; some affordable or workforce housing; and increased transit service, capacity, and amenities to support intensity of uses.

The nine types of development in each matrix are grouped into three clusters. The types on the diagonal are balanced types, needing infill, intensification, or transformation depending on their value. The most promising types are the ones outside the diagonal, which can be considered as unbalanced. They offer great potential for transformation, such as the massive redevelopments at King's Cross and Hudson Yards. These matrices are not to be considered as static descriptions but as dynamic tools for identifying the levels of possible transformations of different TOD areas.

The actionable strategies depend on the relative strengths of values at each location. A location with a high node value (a highly connective major hub) such as King's Cross, for example, can acquire a high market potential value through massive investments in high-quality public space when the market timing is right. Such a strategy is transformative. At the other end of the range, in suburban stations on a single line with a limited market potential value, infill development would be favored.

Key Strategies for Increasing Values

Planners can adopt the following approaches for increasing values.

Increasing Node Value

Network structures vary. Some have more hubs than others and interconnect more neighboring stations with criss-crossing lines. These network organizations shape land uses and land values differently. Networks that present strong concentrations of lines in focal points, which interconnect many lines and transportation modes, shape economic concentrations in spikes, with high peaks of value concentration. In con-

trast, networks that are flat, with no major hubs and no dense concentration of lines in a core, do not offer strong opportunities for capturing high land values around stations. As efficient urban spatial organizations require concentrating production factors to create agglomeration economies, the more hierarchy a network presents, the better it is for shaping land uses in a productive way for economic growth.

In London, Tokyo, and Seoul, transit network structures determine how concentrated population, jobs, and economic densities will be. The spatial development strategy of cities like these is to first create a hierarchy of hubs in the transit network and then to encourage public and private investment to create high place value around these nodes. Subway systems in China, developed much more recently, are less hierarchical so far than subways that evolved under market forces and over long periods of time, like the London or Tokyo subways.

Key strategies for increasing node value include interlinking neighboring stations into clusters and increasing accessibility of core stations within the network. Interlinking—that is, increasing the density of links between neighboring stations—creates many triangles between neighboring stations and tightly connects the network, offering passengers varied possibilities for interchange. Increased accessibility of stations within the network makes a given station more valuable. Successful subway extensions, such as the addition of four lines in Seoul, cluster a large number of highly accessible stations in the network core, concentrating density and economic activity. Such a network level approach needs to be supported by increased service levels and service integration.

Increasing Place Value

TOD creates place value through greater compactness, mixed-use development, and an urban environment that supports vibrant and active communities.[4] The optimal mix of economic, educational, transport, and recreational opportunities ultimately gives rise to a people-centered city, where the needs of all people are placed at the core of all planning processes. TOD creates new street-life patterns where people can move about easily and confidently, linger, and get together with other people.

The City Prosperity Initiative (UN-Habitat and International City Leaders 2015) provides a comprehensive assessment of cities' prosperity based on indicators along six dimensions: productivity, infrastructure, quality of life, equity and social inclusion, environmental sustainability, governance, and legislation. According to this index, 85 percent of cities with a very solid prosperity index are in Europe, led by Oslo, Copenhagen, Stockholm, Helsinki, Paris, and Vienna (Amsterdam, Tokyo, London, and Zurich are also in the top 20). These cities offer high-quality public spaces and dense street patterns. Box 2.4 summarizes key benchmarks for enhancing place value derived from international best practice and UN-Habitat recommendations.

Key strategies for raising place value are increasing compactness and increasing the diversity of land uses. As identified early by Jane Jacobs (1961), the compact city (or city of short distances) is an urban planning and urban design concept that promotes relatively high residential density with mixed land uses.

At the scale of the city, being compact means being integrated spatially by public transit systems. Compactness can be applied to a neighborhood scale, re-

BOX 2.4 UN-Habitat Benchmarks for Enhancing Place Value

The UN-Habitat established the following recommendations for planning for sustainable neighborhoods, based on best practice in the most prosperous cities. These recommendations need to be adapted to the topographic, historic, cultural, and other types of characteristics of the terrain, which should be preserved and enhanced to reinforce place singularity.

- Local accessibility based on small blocks and on dense and connected street patterns with at least 80–100 street intersections/square kilometers. (This is a minimum compared with the average density of intersections in the cores of the most livable and prosperous cities (as identified by UN-Habitat City Prosperity Index). Street intersection density is 108 in Copenhagen; 163 in Zurich 185 in Paris (Louvre); 187 in London (Mayfair); 255 in Amsterdam (see Jacobs 1995 and Salat 2011).
- Adequate space for streets. Based on international benchmarks of efficient, inclusive, and sustainable cities, UN-Habitat recommends that the street network occupies at least 30 percent of the land and with at least 18 kilometers of street length per square kilometer.
- High-quality public space.

- Good-quality pedestrian connections (sidewalks, street crossings).
- Traffic calming, traffic and parking management.
- Density levels adapted to magnitude of transit investment. UN-Habitat recommends densities of at least 15,000 per square kilometers for sustainable neighborhoods.
- Mixed land use. Such land use will attract occupants, create an attractive environment (services, amenities, public infrastructure, design qualities), and produce substantial ridership. Specific mix will vary depending on location in region, local context, relation to other stations in corridor. At least 40 percent of floor space should be allocated for economic use in a sustainable neighborhood.
- Limited land-use specialization. To limit single function blocks or neighborhoods, single function blocks should cover less than 10 percent of any neighborhood.
- Social mix. The availability of houses in different price ranges and tenures in a TOD neighborhood should accommodate different incomes; 20–50 percent of the residential floor area should be for low cost housing; and each tenure type should be not more than 50 percent of the total.

sulting in spatial integration by good walking and cycling connectivity and orientation toward transit stations. A large resident population provides opportunities for social interaction as well as a feeling of safety. A compact city is also a more sustainable urban settlement type than urban sprawl, because it is less dependent on cars and requires less infrastructure provision per capita. The two performance objectives for compactness focus on the proximity of a development to existing urban activity and short travel time to major trip generators in the central and regional destinations (ITDP 2014).

Providing diverse and complementary uses within the same or adjacent blocks reduces trip lengths and support the clustering of economic activity (photo 2.1). Mixed-use development helps create high-quality neighborhoods with vibrant and sustainable communities amenable to a concentration of commercial, cultural, and educational amenities.

PHOTO 2.1 Small, Mixed-Use Blocks in Berlin's Potsdamer Platz

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In high-value places, personal motor vehicles become largely unnecessary in day-to-day life, making it possible to reduce the roadway area. Scarce and valuable urban space resources can be reclaimed from unnecessary roads and parking space and reallocated to more socially and economically productive uses (ITDP 2014). Despite wealthy populations, Paris intra-muros and Manhattan have extremely low rates of car ownership, because people find cars unnecessary, expensive, and inconvenient. Half of Paris intra-muros households and less than half of households in New York own a car. Within the five boroughs, ownership is lowest in Manhattan (23 percent of households), followed by Brooklyn (44 percent) and the Bronx (46 percent). In contrast, a large majority of households in Queens (64 percent) and Staten Island (84 percent) own at least one car. These overall ownership rates are far lower than in the rest of the United States, where 92 percent of all households own at least one car and 20 percent own three or more vehicles.

To support compactness and mixed use, neighborhoods need to be designed in a way that promotes walking and cycling, reclaiming the streetscape from cars. Walking and cycling are the most natural, affordable, healthy, and clean modes of travel for short distances—and a necessary component of the vast majority of transit trips.

The size of urban blocks and the street network influence walkability and bikeability. Small block sizes reduce vehicle miles traveled and raise property values (CTOD 2011). Dense networks of streets and paths and small blocks enhance walkability. Certain thresholds differentiate pedestrian cities, TOD cities, and car-dependent cities. Japanese cities with an average distance between intersections of 50 meters (even in modern Tokyo) are highly pedestrian friendly (Salat 2011). European cities built in the 19th century as well as the historical core of U.S. and some Asian cities have average distances between intersections of 100–150 meters, the TOD planning sizing.

Figure 2.6 and photo 2.2 show a simple street network model. In an area of 1 square kilometer, 10 vertical and 10 horizontal streets are designed to form a street grid. The distance from centerline to centerline between two adjacent streets is 111

FIGURE 2.6 Street Network Model Design
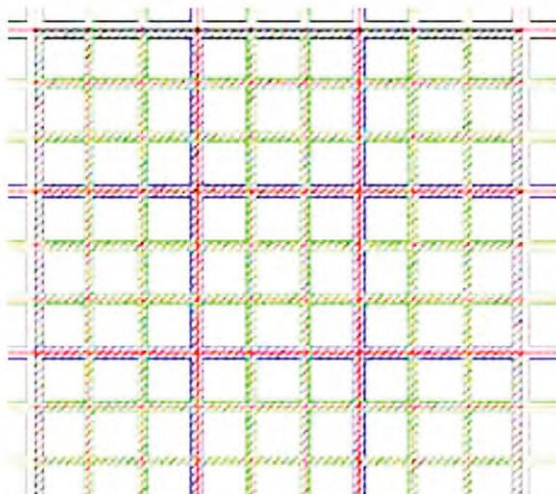
Source: Adapted from UN-Habitat 2014.
Note: Purple lines indicate arterials. Green lines indicate feeder streets

PHOTO 2.2 Barcelona Urban Street Grid on an 800-Meter Side Square

Source: © Urban Morphology and Complex Systems Institute. Used with the permission of Urban Morphology and Complex Systems Institute. Further permission required for reuse.

meters. Taking into account that each street on the perimeter of the diagram is counted as half (because it belongs to two squares of 1 square kilometer each), the total street length is 18 kilometers and the number of intersections per square kilometers is 81. In this street network model, recommended by UN-Habitat, both street hierarchy and block size are considered. This simple model illustrates a good balance between street and other land uses. Other patterns, like the rectangular pattern in New York, are also effective. Cities have much to gain in terms of quality of the urban space in developing a street density level similar to the one recommended in the model.

The creation of a vibrant and active pedestrian public realm plays a major role in stimulating walking. Walking can be highly attractive when sidewalks are animated and lined with useful ground-floor activities and services, such as storefronts and restaurants. Pedestrians and cyclists increase the exposure and vitality of local retail shops.

Cities are rediscovering the value of developing cycling networks; early adopters have realized that cycle-friendliness enhances place value. It is strongly promoted in Amsterdam, Paris, and Malmö (photo 2.3). Key factors encouraging cycling are safe street conditions, in particular at intersections, and secure cycle parking and storage. A safe cycling network connecting all buildings and destinations through the shortest routes available is a basic TOD requirement (ITDP 2014). Cycling can be an attractive travel option only to the extent that bicycles can be securely locked.

PHOTO 2.3 **Bicycle Parking in Malmö, Sweden**

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

Increasing Market Potential Value

Increasing residential density

Market potential is increased on the demand side by encouraging higher residential and employment densities and higher employment rates. It is increased on the supply side by greater diversity of land parcel sizes, which create a vibrant land market, and higher FARs near transit stations.

Residential densities are not uniformly distributed (figure 2.7). High residential density around stations results in well-populated streets, ensuring that urban places are lively, active, vibrant, and (often) safe places where people want to live. Density delivers the customer base that supports a wide range of services and amenities and makes local commerce thrive. As many of the most famous and desirable neighborhoods in the world attest, high-density living can be highly attractive if supported by the right level of infrastructure (photo 2.4). Cities can stimulate increased density around stations by adjusting their land-use plans.

High residential density does not imply vertical urban forms. With 21,000 inhabitants per square kilometer (25,000 excluding the Bois de Boulogne and Bois de Vincennes), seven-story-high intra-muros Paris, where strict regulations ban high-rises, achieves the same average residential density as Manhattan. Indeed, several districts have densities of 40,000 inhabitants per square kilometer—much higher than in vertical urban forms. Vertical growth is most often low density, because of inefficient land use (much urban land is left empty or occupied by oversized road infrastructures). Cities benefit from growing in a more compact form, with traditional low- and medium-rise buildings in small-perimeter blocks.

Increasing job density

Job density feeds economic productivity as a result of economies of agglomeration.[5] A doubling of employment density in U.S. cities corresponds to a 6 percent increase in hourly labor productivity (Haughwout 2009). A study of 261 Chinese

FIGURE 2.7 **Residential Density Peaks in London, New York, and Hong Kong China, SAR**

LONDON
PEAK 27,100 pp/km²

NEW YORK
PEAK 59,150 pp/km²

HONG KONG
PEAK 111,100 pp/km²

Source: LSE Cities © LSE Cities/Urban Age. Used with the permission of LSE Cities/Urban Age. Further permission required for reuse. Image by Duncan A. Smith, based on data from U.K. Census 2011, U.S. Census 2010, and Hong Kong Census 2006.

PHOTO 2.4 High Residential Density in Paris

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cities shows that economic productivity in China increases by 8.8 percent with a doubling of employment density (Fan 2007). Economies of agglomeration are the benefits firms obtain by locating near one another. This concept relates to the idea of economies of scale and network effects. As more firms in related fields of business cluster, their costs of production may decline significantly. Even when competing firms in the same sector cluster, there may be advantages, because the cluster attracts more suppliers and customers than a single firm could achieve. Cities form and grow to exploit economies of agglomeration.

Job density increases market potential values as economic density determines firms' locational choices. Across the United States, job density explains half of the variation in economic productivity per capita. Job and business densities are key to reaping the benefits of agglomeration economies, increasing economic productivity, and fostering innovation. Concentrating economic activity in particular locations enables firms to reap economies of scale and scope and bring talented people together to share ideas and innovate. Job densities reflect such phenomena by exhibiting high peaks of concentration (figure 2.8).

Increasing human density

Human density is the total number of residents and jobs in a district. It gives an indication of the intensity of development. The number of residents and workers in an area and the balance between jobs and the working-age population has a direct correlation with the attractiveness of an area for residents and businesses and thus the development of a strong real estate market. Cities can create the conditions to allow such increases in human density to take place by setting a vision, building consensus, planning actions, and investing in infrastructure that supports such increases.

FIGURE 2.8 Job Density Peaks in London, New York, and Hong Kong China, SAR
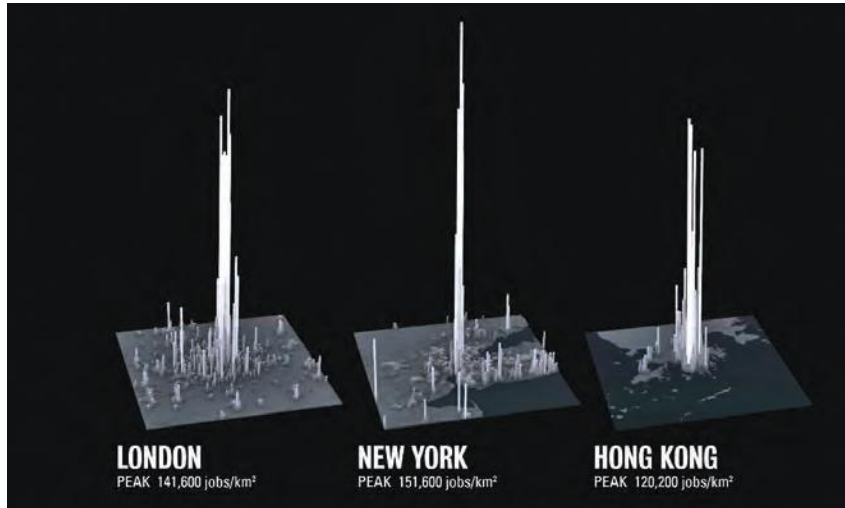
Source: LSE Cities © LSE Cities/Urban Age. Used with the permission of LSE Cities/Urban Age. Further permission required for reuse. Image by Duncan A. Smith, based on data U.K. Business Register 2009–11, US Census 2011, and Hong Kong Census 2011.

Increasing the diversity of land parcel sizes to create a vibrant land market
Diversifying the size of land parcels can help create an adaptive city that can meet future demand. Manhattan provides a good example of such an approach. Originally, its land parcels were sold in units of 200 square meters (about 300,000 units of land for sale on an area the size of Manhattan [about 60 square kilometers]). Such small parcels fostered an active land market with great potential of future mixed use. Over time plots of land in Manhattan have been consolidated, but 40 percent of all land still remains the initial size set two centuries ago. Very few parcels occupy whole urban blocks (figure 2.9).

FIGURE 2.9 Plot Consolidation in Manhattan

a. Original plot size, 1811
(205 square meters)

b. Intermediary plot size, 2013
(255 square meters)

c. Extreme plot size, 2013
(6,100 square meters)

Source: Urban Morphology and Complex Systems Institute.

Plots in urban China are much larger: current urban development is based on 400 meter x 400 meter superblocks. On an area the size of Manhattan, there would be only 250 units of land for sale in a Chinese new town. Cities can increase the vibrancy of their land market by creating a wider range of block sizes and encouraging diversity of development.

Increasing floor area ratios near transit stations

In TOD projects, local authorities often reset FARs at higher values, to allow for densification and to generate revenue streams that can be captured to finance infrastructures (transit and public spaces). Commercial FARs can be raised near stations; residential FARs can also be reset, albeit at lower values than commercial FARs.

Such approach has an impact on both land value and compactness. A 2015 analysis of the options for Shanghai found that existing areas around metro stations would be sufficient to accommodate the required built area for the estimated growth in population by 2050 if FARs are raised to levels in Hong Kong SAR, China; New York; Seoul, Singapore; and Tokyo; (World Bank and Chreod Ltd. 2015).

Notes

1   In statistics a long tail in a distribution is the portion of the distribution having a large number of occurrences far from the "head" or central part of the distribution. In inverse power laws, the long tail is the high frequency of occurrences of small values (in metro systems the large number of stations with only one line passing through them). The term *long tail* has gained popularity in recent times for describing the retailing strategy of selling small numbers of a large number of unique items, usually in addition to selling a small number of popular items in large quantities.
2   This section draws on some of the terminology and definitions used in CTOD (2011).
3   Urban catalysts (used, for example, in New York) are new redevelopment strategies comprising a series of projects that drive and guide urban development. In the past, redevelopment efforts such as urban renewal and large-scale redevelopment projects often jeopardized the vitality of downtowns. The difference between an urban catalyst and these redevelopment strategies is that catalytic redevelopment is a holistic, not a clean-slate, approach to revitalizing the urban fabric.
4   This section draws on UN-Habitat's work on sustainable planning and city prosperity and on the TOD standard of the Institute for Transportation and Development Policy (ITDP 2014).
5   New economic geography provides an integrated and micro-founded approach to spatial economics. It emphasizes the role of clustering forces in generating an uneven distribution of economic activity and income across space. The approach has been applied to the economics of cities, the emergence of regional disparities, and the origins of international inequalities (Bogart 1998; Brueckner 2005; Coe, Kelly, and Yeung 2007; Strange 2008; Venables 2008; Moretti 2013).

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3

The Dynamic Interplay of Values and Its Contribution to Value Capture

Urban transit systems and urban regeneration are essential for promoting urban economic growth and improving the quality of life by providing access to places and activities for work, education, services, and leisure. To establish affordable, high-quality transport systems, cities must ensure that their transport systems are financially sustainable. Revenue from users, indirect beneficiaries, and public sources must be sufficient to pay for new investments in infrastructure and fund maintenance and operation of existing facilities and services.

Many cities in developing countries face underfunding for urban transport. In these cities, the upfront investments needed for new transport infrastructure are large compared with their fiscal capacity, and revenue from their still small-scale and often poor-quality systems and other sources is insufficient to cover maintenance and operation expenses, let alone new investments.

By choosing the most appropriate sets of financing instruments and focusing on wise investments, cities can design comprehensive financing for all types of urban transport projects, using innovative, multilevel revenue sources that promote efficient pricing schemes; increase overall revenue; strengthen sustainable transport; and cover capital investments, operation, and maintenance for all parts of a public transit system. (For a framework for achieving comprehensive and sustainable urban transport financing, see Ardila-Gomez and Ortegon-Sanchez 2016.)

Suzuki and others (2015) describe how cities can use land value capture to finance and encourage more inclusive urban growth. By investing some of the captured value in parks, sidewalks, street lights, and cycle lanes, city governments can work with transit agencies, developers, and communities to develop efficient, attractive, and safe public places, increasing property values. By offering bonus floor area ratios (FARs) and other regulatory incentives, they can require developers to

65

provide affordable housing and daycare centers in their new facilities (chapters 5–7 describe how New York and London have used these mechanisms.)

This chapter introduces value capture in the context of the 3V Framework by describing how the dynamic interplay of values (particularly node and place value) creates economic value and facilitates value capture that can be used to finance investments in urban growth and transit. Transit-oriented development (TOD) is the key to turning node-place dynamics into market success stories such as King's Cross in London and Hudson Yards in New York, described in chapters 5 and 6. Addressing imbalances between values can unleash development potential.

The Dynamic Power of Imbalances between Values

The 3V Framework allows policy makers to assess development potential in a proactive and dynamic way. Not only are the values of stations unevenly distributed; the different types of values for each station may differ greatly. The most promising areas of development are the ones where increased connectivity through public investment comes in places where there is room for further development.

Bertolini's (1999) node-place model considers place and node values.[1] It includes an analysis of the dynamic interplay of place and node values to create market potential and economic value. According to Bertolini, by increasing accessibility, improving the transport provision (node value) of a location will create conditions favorable to the further development of the location. In turn, the development of a location (an increase in its place value) will create conditions favorable to the further development of the transport system, initiating a positive feedback loop of development. This model highlights the dynamic potential of imbalances of values within the same station area (box 3.1).

Unbalanced nodes and unbalanced places create strong development opportunities, because they are underutilized assets. When leveraging these development opportunities, specific policies should be put in place to ensure equity, such as professional training for local populations or inclusionary housing.

King's Cross was an unbalanced node, with one of Europe's highest levels of accessibility, connectivity, and centrality for high-speed rail, national and regional rail, urban rail, and subway networks (photo 3.1). The area had a strong imbalance, with underutilization of its 27 hectares of land. Creating place value with a high-quality public realm (40 percent of the land); 20 new connective streets; 10 plazas and gardens; and a mixed-use program that includes Google's second global headquarters, digital start-ups, inclusionary housing, a school for the arts, cafes, and retail stores increased place value, which in turn increased market potential.

Hudson Yards (image 3.1) is a major high-density, mixed-use land redevelopment planned and designed to capture job growth in the knowledge and creative economy. It was an underutilized land asset close to the highest concentration of creative and financial industries in Midtown Manhattan. Massive investment in transit infrastructure (the Line 7 extension) and high-quality public space increased place and node value, fostering high market potential.

BOX 3.1 Interplay of Values in Bertolini's Node-Place Model

The node place model distinguishes five types of situations based on a station's node and place value (box figure 3.1.1).

1. Balance: Both node and place are strong. Transportation infrastructure and local land use support each other, maximizing market value.

2. Stress: The intensity and diversity of infrastructure and land use come close to the maximum. Although station areas may be considered under stress and at maximum development, international experience shows that development in areas with peaks of connectivity and land use intensity tend to continue growing, as experienced in Shinjuku in Tokyo where real estate is still booming and new lines are added.

3. Dependence: There is no competition for free space, and demand for infrastructure is low. Both node and place values are relatively weak; factors other than node-place dynamics (for example, subsidies) must intervene for the area to sustain itself.

4. Unbalanced node: The supply of infrastructure is stronger than land use. There is potential of development in enhancing place value to leverage on the relative oversupply of connecting infrastructure. An example is King's Cross (chapter 6).

5. Unbalanced place: The intensity of land use exceeds the supply of infrastructure. Local devel-

BOX FIGURE 3.1.1 Bertolini's Node Place Model
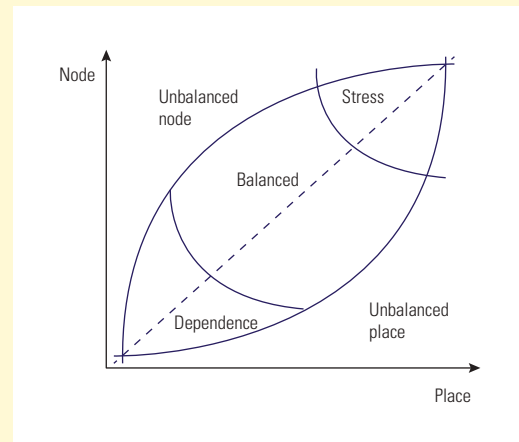
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opment potential should be encouraged by providing supportive infrastructure that increases connectivity. An example is Hudson Yards (chapter 5), where anticipated intense real estate development, encouraged by raising FARs, called for the extension of subway Line 7. Higher connectivity encourages existing economic activity and increases market value potential.

Source: Adapted from Bertolini 1999. © Luca Bertolini. Used with the permission of Luca Bertolini. Further permission required for reuse.

The choice of case studies in this book underscores the potential of run-down, underutilized areas as drivers for creating market potential value when increasing connectivity (increasing node value) and putting in place sufficient investment in urban fabric regeneration through a high-quality public realm. King's Cross is a former rail industrial site that was regenerated. Hudson Yards is being built above a rail yards. Malmö and Hammarby (in Sweden) regenerated suburban docklands. They demonstrate that high market potential can also be created in suburban areas if good linkage is established with the core city and the area is well planned and designed. Malmö and Hammarby underline the importance of the quality of urban design in creating value (chapter 4). Examples of urban redevelopment along Crossrail also demonstrate the potential of fringe locations (chapter 7).

The Feedback Loop of Value Creation and Capture in Transit-Oriented Development

New transit infrastructure or planning decisions (such as rezoning at higher values or investing in the public realm) increase land value around transit stations. Capture of this value can create a positive feedback loop for financing infrastructure,

PHOTO 3.1 High Connectivity at King's Cross

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

IMAGE 3.1 Hudson Yards, Viewed from the Empire State Building

Source: © Related Oxford. Used with the permission of Related Oxford. Further permission required for reuse.

enhancing the public realm, and supporting inclusionary housing.[2] The unlocking of an increase in the potential value of underused assets (land and/or structures) as a result of a public sector intervention (rezoning or provision of transit infrastructure) stimulates demand from the private sector. Subsequent investment and development from the private sector ensure that potential asset value increase is realized (Huxley 2009). Figure 3.1 illustrates this feedback loop.

Value capture finance can be defined as "the appropriation of value generated by public sector intervention and private sector investment in relation to an underused asset (land and/or structure) for local reinvestment to produce public good and potential private benefit" (Huxley 2009). It can take the form of monetary or in-kind contributions from the private to public actors. Local value recycling is the reinvestment of monetary or in-kind contributions from the private sector within the same development site or scheme. This reinvestment can pay for the initial public intervention but tends to fund further interventions.

Value capture finance increases the incentive for both public intervention and private investment by creating a win-win situation. It divides the cost of urban development between the public and private sectors, without the public sector necessarily undertaking a large share of the initial investment. Figure 3.1 captures the positive feedback loop of value capture.

FIGURE 3.1 Feedback Loop of Value Capture Finance
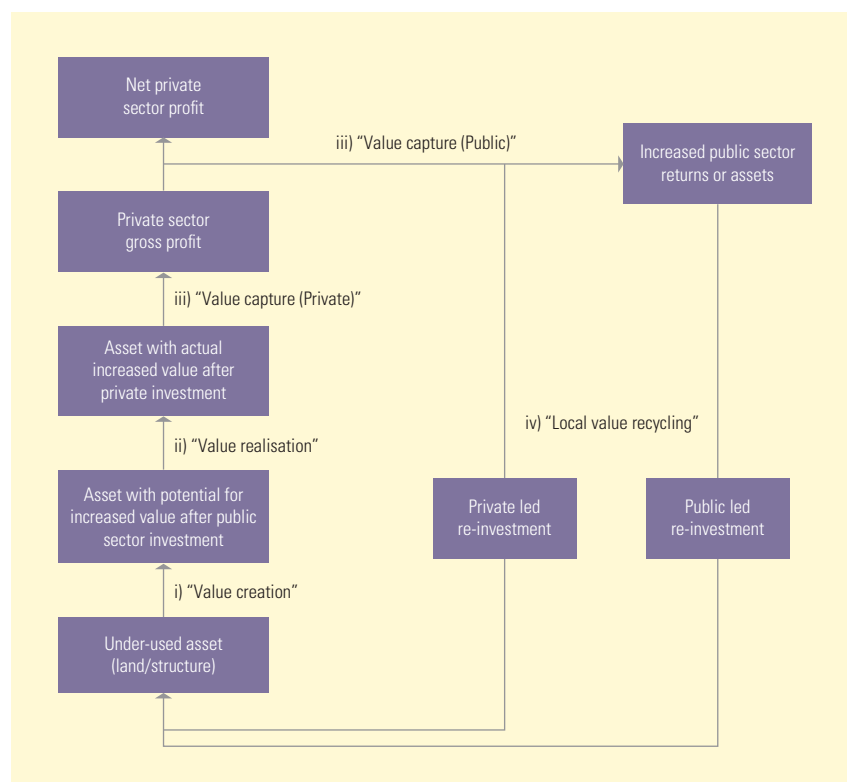
Source: Huxley 2009. © ULI. Used with the permission of ULI. Further permission required for reuse.

The 3V Framework identifies imbalances in local development and thus under-utilized assets (either because an increase in connectivity linked to public investment in infrastructure calls for a redevelopment or because high place value calls for investment in connectivity to create a positive feedback loop for market growth). It allows public investment be fine-tuned to market response potential in order to initiate these positive value capture feedback loops.

The case studies presented in later chapters illustrate the positive feedback loops created in New York and London by the coordinated actions of public and private sector. The different strategies initiating these positive feedback loops are discussed below, following both the 3V Framework and the framework proposed by Huxley.

Value Creation

Value creation strategies involve increasing node, place, and market potential value, with each one supporting the others. They are illustrated with a short summary of the strategies used in King's Cross and Hudson Yards, where potential asset values were created by public sector intervention that increased node and place value. Public investment in parks, mass transit, and infrastructure will help make these places the most livable areas of their cities.

In both projects, transport infrastructure supports higher node value. Major investments in local transport infrastructure (of £2.5 billion to date) turned King's Cross/St Pancras into the most significant interchange for local, national, and international travel in London. At Hudson Yards, investment in infrastructure includes extension of the No. 7 subway west and south from its old terminus at Times Square. A new station is being built at W. 34th Street and 11th Avenue. The $2.4 billion Line 7 extension was funded with New York City funds from municipal tax increment financing (TIF) bond sales, which are expected to be repaid with property tax revenues from future developments in areas served by the extension (Fitzsimmons 2015).

Higher place value was supported through environmental and social improvements and investments to enhance the urban quality and image of both sites. Development of King's Cross combined physical regeneration (developing sites, refurbishing buildings) with community regeneration (providing skills, training, community facilities). At Hudson Yards, the public sector renovated the Javits Center ($465 million). At both sites, much attention was given to high-quality public space and iconic architecture. Three major New York parks (the third section of the High Line, Hudson River Park, and Hudson Park & Boulevard) converge at Hudson Yards. They are supported by $630 million of public investment in public space and parks.

Higher market potential value was supported by allowing population increases and land use changes, using planning and regulatory tools. Both King's Cross and Hudson Yards are creating very dense mixed-use communities, with human densities (or projected densities) of about 1,750 per hectare. Such transformation is fostered by rezoning at a higher FAR, with transparent mechanisms to purchase rights for additional FAR above the base FAR, and with margins of flexibility for adapting to market changes. This allows the public sector to capture part of this increase in value to finance needed investments (box 3.2).

Enhanced destination branding and marketing enable new areas to emerge. King's Cross and Hudson Yards are being transformed from derelict industrial rail-

BOX 3.2 Capturing Value in Midtown Manhattan through Flexible Floor Area Ratios

The Department of City Planning is proposing a rezoning of Greater East Midtown, a 78-block area surrounding Grand Central Terminal, where densities are already among the highest in New York City (box map 3.2.1). The purpose of the rezoning is to ensure the area's future as a world-class business district and major job generator.

This proposal is a targeted plan involving multiple agencies. New commercial buildings on qualifying sites can exceed the base FAR in exchange for improvements to the area's public realm or transfer of unused floor area from the area's landmarks. FAR bonuses can be earned for pre-identified improvement in the subway infrastructure. Learning from an earlier attempt at rezoning the area, the transit or public improvement required from the developer to obtain additional FAR will be clearly identified in a catalog included in the rezoning, increasing transparency. A number of landmark buildings would be eligible to sell transferrable development rights to developers and obtain part of the proceeds (the city would retain a portion of the proceeds).

BOX MAP 3.2.1 High Floor Area Ratios in East Midtown in New York City

Source: © Alain Bertaud. Used with the permission of Alain Bertaud. Further permission required for reuse.

yard areas into beacons for creative professionals, hubs for fashion, design, communications, and the arts. Both areas are in the process of becoming home to Google and other fast-growing technology and digital media firms.

Value Realization

Private sector investment, comprehensive master planning, and area promotion increase potential asset values. For example, growth on New York's New West Side can be attributed to the success of the High Line, which spurred $2 billion of private investment, 12,000 new jobs, and 29 development projects since opening in June 2009. At both Hudson Yards and King's Cross, developers came up with innovative master plans that included high-quality public space and local connectivity. Both projects involved dialogue between the public and private actors. Public participation was extensive in the King's Cross development.

Value Capture

Higher asset values are captured for private profit and the public good. Private value capture is primarily via the rent or sale of new or enhanced housing, retail, or office units. The public sector uses a range of mechanisms to capture enhanced asset values realized by private actors. They include tax increment financing (TIF) and payment in lieu of taxes (PILOT) financing, both of which allow a municipality to sell bonds that are repaid with future tax revenues. Table 3.1 summarizes the main mechanisms of value capture.

TABLE 3.1 Key Features of Selected Land Value Capture Instruments

Instrument	Description
Tax or fee based	
Property and land tax	Tax levied on estimated value of land or land and buildings combined. Revenues usually go into budgets for general purposes.
Betterment levies and special assessments	Surtaxes imposed by governments on estimated benefits created by public investments, so as to require property owners who benefit directly from public investments to pay for their costs.
Tax increment financing (TIF)	Surtax on properties within an area that will be redeveloped by public investment to be financed by municipal bonds, against the expected increase in property tax, which is pledged. *Instrument mainly used in US.*
Exactions/impact fees	Fees (or in-kind contribution) collected from private developers to pay for the cost of providing additional public infrastructure and services, and to accommodate additional population generated by their new development projects.
Development based	
Land sale or land lease	Mechanism in which governments sell developers land for payment or land use right, in return for either an upfront leasehold charge or payments of annual land rent through the term of the lease.
Air right sale	Mechanism in which governments sell development rights extended beyond the limits specified in land use regulations (e.g., FAR) or created by regulatory changes to raise funds to finance public infrastructure and services.
Land readjustment	Mechanism in which landowners pool their land and contribute a portion of it sale to raise funds to partially defray public infrastructure development costs.
Urban redevelopment financing	Mechanism in which landowners, together with a developer, establish one cooperative entity to consolidate piecemeal land parcels into a single site that they then develop (e.g., high-rise building and/or mixed-use building) with new access roads and public open spaces. Local government modifies zoning codes and increases maximum floor area ratios in the targeted redevelopment district (typically around rail transit stations). Used mainly in Japan.

Source: Suzuki and others 2015.

Local Value Recycling

The captured value can be recycled, or reinvested, in the same development through public or private sector–led reinvestment. In the case of public sector–led reinvestment, increased public revenues captured from the private sector through higher local taxation, fees, and levies pay for additional government interventions within the same development area, reinforcing asset values and having positive social-economic impacts. The public sector offers private actors an opportunity to deliver community-oriented infrastructure directly, further increasing asset values and positive social-economic impacts.

As a result of these positive feedback loops, the area surrounding Hudson Yards is growing at a rate five times that of Manhattan as a whole. A report released in May 2016 (Related Companies and Oxford Property Group 2016) outlined the economic impact of the Hudson Yards development on New York City's economy. It claims that once fully operational, the project will contribute nearly $19 billion a year to New York City's GDP (accounting for 2.5 percent of the city's output), generating nearly $500 million in annual tax revenues.

The Real Estate Benefits of Transit-Oriented Development

TOD enhances place value and in turn increases market potential value and real estate benefits. Cross-country evidence suggests that property prices are much higher when densities and walkability scores around station areas are high. Renne (2014) studied prices around 4,000 train stations in the United States. He finds that the average home in a TOD area (with high densities and high walkability) was worth about 3.5 times more than the average home in the United States and that home prices in these areas rose by twice as much as national home prices between 1996 and 2013 (box 3.3). Characteristics of the urban fabric such as density, use, and walkability thus determine the livability of a place, define its place value, and have a strong impact on real estate prices.

Notes

1   The cities of Baltimore, Denver, and Portland explicitly consider market potential values in their public policies.
2   This chapter draws on the value framework and policy recommendations developed in Huxley (2009).

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BOX 3.3 How Does Transit-Oriented Development Affect Home Prices?

Renne (2014) calculates the differences in property prices between homes in TOD and transit-adjacent development (TAD) areas of the United States. (TOD areas are defined as walkable, mixed-use, dense communities within 800 meters of a train station. TAD areas are defined as areas around stations characterized by low-density, automobile-oriented land use.) Research indicates that gross housing densities should be at least 4,000 households within an 800-meter radius of a station in order to support transit ridership. Walkscore.com rates communities with a 70 or higher score (out of a possible 100) as "very walkable"; it rates areas with scores above 90 as "walkers' paradise."

Renne's TOD Index provides a new benchmark to track both home and rental prices in station areas across the United States. It includes stations in TOD, TAD, and hybrid areas. Each category is benchmarked against the national Zillow Home Value Index (ZHVI) or the national Zillow Rent Index (ZRI).

The study analyzes 4,000 passenger train stations, 1,441 of which meet TOD criteria of density and walkscore. Another 1,180 are hybrids, meeting the criteria of density or walkscore but not both. Some 1,775 stations are categorized as TAD areas, which meet neither criterion.

Assuming a price index of 100 in 1996, the index for home located in a TOD district was 400 in 2013, and the index for the home located in a TAD district was 225 (box figure 3.3.1). Assuming a rental index of 100 in 2012, the increase in the rental price of the home located in a TOD district was 18 percent; the rent in the TAD district rose by just 11 percent (box figure 3.3.2).

BOX FIGURE 3.3.1 Index of Purchase Price of Homes in Various Types of Areas, 1996–2013
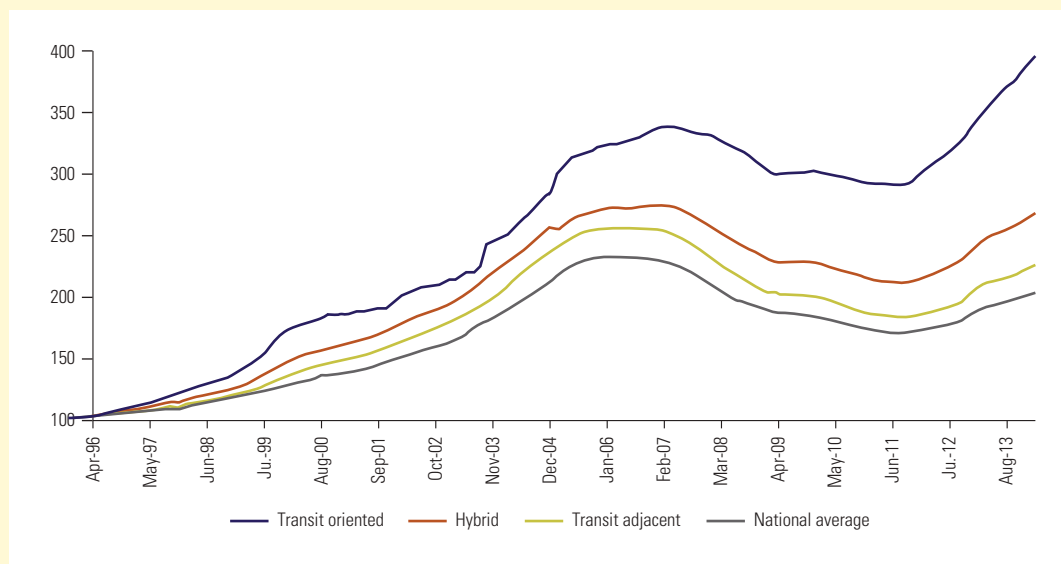
Source: Renne 2014.

BOX 3.3 **How Does Transit-Oriented Development Affect Home Prices?**
(continued)

BOX FIGURE 3.3.2 **Index of Rents in Various Types of Areas, January 2012–July 2014**
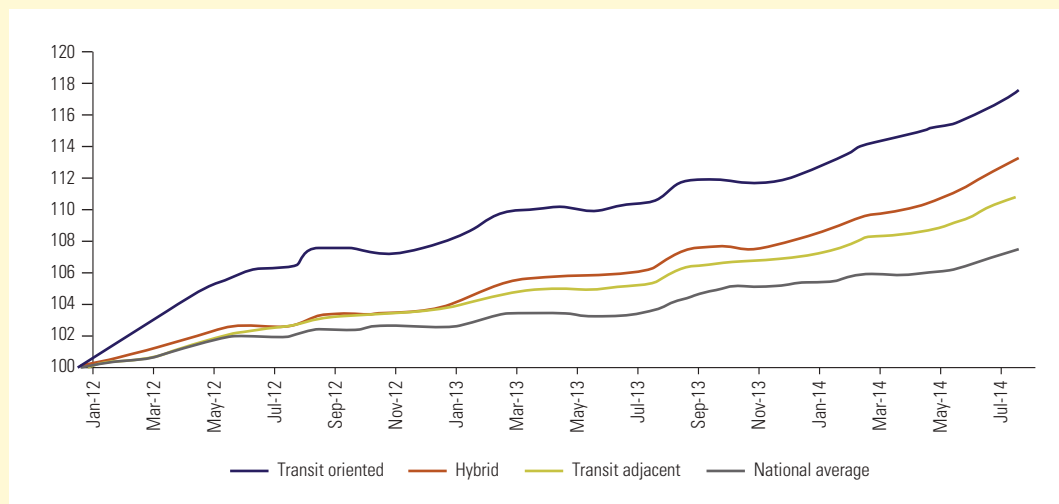
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Using Good Urban Design of the Public Realm to Create High Place Value

Good urban design creates place value that fosters urban economic growth. It supports increased density and ensures that people do not find congestion and density oppressive. It complements the planning approach presented in chapter 2. It includes significant streetscape improvements that make streets places for people; creates a spirit of place; makes the city more legible; and provokes a feeling of enclosure, human scale, coherence, image (see photo 4.1), and linkage.

This chapter focuses on urban qualities that create place value. The first two sections describe these qualities. The third section illustrates them with three case studies of good urban design that contributed to significant increases in market value.

Positive and Negative Space

Numerous perceptual qualities affect reactions to a place. They include the walking experience, the sense of safety, the sense of comfort, and the level of interest. To achieve walkability, urban designers should achieve "spirit of place," enclosure, human scale, layering of space, complexity, coherence, legibility, and linkage, the eight qualities examined below.

Urban design shapes perceptions of places and sequences of spaces. *Negative* spaces are empty spaces left between buildings without shape, sense of direction, or purpose. They do not sustain human interest even if benches and amenities are provided. Good urban design provides *positive space*—space with an identifiable

PHOTO 4.1 **The Great Court of the British Museum**

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

shape and direction. "An outdoor space is positive when it has a distinct and definite shape, as definite as the shape of a room, and when its shape is as important as the shapes of the buildings that surround it" (Alexander, Ishikawa, and Silverstein 1997). Positive space traditionally comprised not only streets, squares, and gardens but also the interiors of large buildings, such as courtyards of palaces and interiors of churches. There was no separation between street and buildings but rather a continuum of public space, the stage of urban life.

MAP 4.1 Examples of Positive and Negative Urban Space

a. Positive space in Rome (circa 1748)
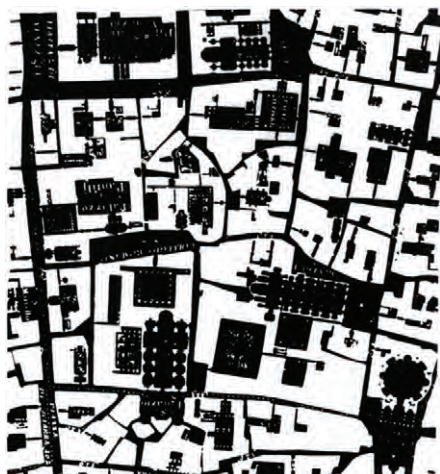
b. Negative space in Brasilia
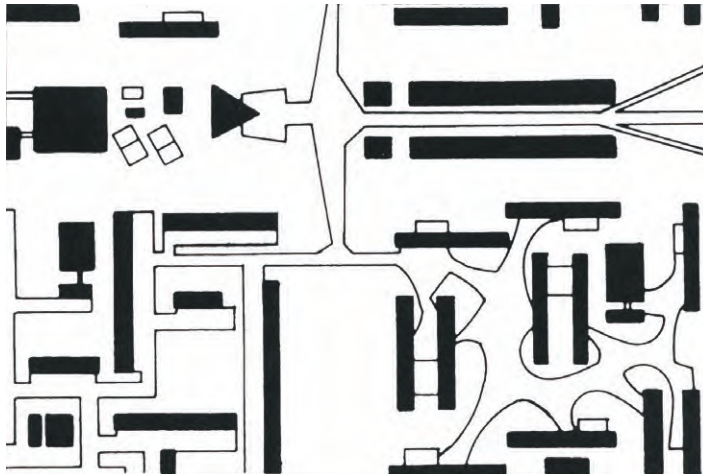
Source: Salat, with Labbé and Nowacki 2011.

Map 4.1 contrasts the positive public space in 18th century Rome with the disconnected public space of Brasilia. The map of Rome, drawn by Giambattista Nolli in 1748 (panel a), shows how the continuity and positivity of public space creates the high place value of traditional European cities. It reveals no division between interior and exterior spaces or between solid masses and empty spaces. The black areas show the continuous public space of streets, squares, large churches, and palace courtyards; the white areas show the compact mass of private buildings. In the map of Brasilia (panel b), the continuous public space is replaced by formless empty space between buildings—a space divested of its positivity that becomes pure negativity, creating no place value.

Streets and squares are the basic elements around which cities should be organized; for most people, they constitute the very essence of the phenomenon "city." In recent years, planners have made good use of streets (based on the linear pattern of human movement) and squares (based on the eye's ability to survey an area) to improve urban design. In contemporary developments such as Canary Wharf, King's Cross, and the Beddington Zero Energy Development (in London); Hudson Yards (in New York); and Hammarby Sjöstad and Malmö (in Sweden), the positive qualities of the public space have contributed to place value.

Eight Urban Qualities that Create High Place Value

Cross-country evidence and the analysis of numerous positive public spaces, historical and contemporary, suggest that positive space can be achieved when urban designers endow space with eight key urban design qualities.[1]

PHOTO 4.2 Creating Place Identity with a Landmark in Malmö, Sweden

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.
Note: The Turning Torso Tower, a neofuturist residential building, is the tallest building in Scandinavia.

Genius Loci (Spirit of Place)

Genius loci (spirit of place) is the quality of a place that makes it distinct and recognizable, a place one remembers. Image plays to the innate human ability to see and remember patterns. A memorable place is created when distinct elements are easily identifiable and grouped into an overall pattern (Lynch 1960).

Landmarks are a component of spirit of place. What is essential is their singularity and location in relationship to the context and the city. Landmarks act as visual termination points, orientation points, and points of contrast in the urban setting (photo 4.2). They give identity and structure to the urban space around them.

Spirit of place is related to sense of place. A visual theme contributes to a cohesive sense of place and inspires people to enter and rest there (Cullen 1961). Iconic architecture and human-scale passages characterize the Beddington Zero Energy Development, in London (photo 4.3) and the Queen Elizabeth II Great Court, the largest covered square in Europe, at the center of the British Museum (photo 4.4).

Enclosure

Enclosure refers to the degree to which buildings, walls, trees, and other vertical elements define streets and other public spaces. These vertical elements interrupt viewers' lines of sight. A sense of enclosure results when lines of sight are so decisively blocked as to make outdoor space seem room-like. Spaces where the height of vertical elements is proportionately related to the width of the space between them have a room-like quality.

"Enclosure, or the outdoor room, is, perhaps, the most powerful, the most obvious, of all the devices to instill a sense of position, of identity with the surroundings.… It embodies the idea of here-ness" (Cullen 1961). In an urban setting, enclosure is formed by lining the street or plaza with unbroken building fronts of roughly equal height. The buildings become the "walls" of the outdoor room; the street becomes the "floor"; and, if the buildings are roughly of equal height, the sky becomes an invisible ceiling. The total width of the street (from building to building) should not exceed the building heights, to maintain a feeling of enclosure. Box 4.1 illustrates the impact of such enclosure on the quality of public space.

Enclosure is eroded by breaks in the continuity of the street wall. Breaks filled by nonactive uses (vacant lots, parking lots, driveways) and large building setbacks create dead space. "Building setbacks from the street have actually helped greatly to destroy the street as social space" (Alexander, Ishikawa, and Silverstein 1977).

Human Scale

Human scale refers to the size, texture, and articulation of physical elements that match the size and proportions of people and correspond to the speed at which people walk. For pedestrians the information field offered by public space should be scaled to offer rich and coherent information at a pace of five kilometers per hour.

Building details, the pavement texture, street trees, and street furniture all contribute to human scale. Moderate-size buildings, narrow streets, and small spaces create an intimate environment; large buildings, wide streets, and large open spaces create the opposite effect.

Distance plays an important role in personal interaction. At 300–500 meters, people can identify other people as humans instead of objects. At 25–100 meters, they can identify individual characteristics and body language. At less than 25 meters, richness of detail and communication intensify dramatically meter by meter (Alexander, Ishikawa, and Silverstein 1977). These distances set the limits of human scale and the perceived quality of the human space. Decisions at the large scale (city and regional planning); the medium scale (site planning); and the small scale (the immediate environment) are inseparably linked. This interrelationship is

PHOTO 4.3 Human Scale around the Turning Torso Tower in Malmö, Sweden

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

**PHOTO 4.4 Iconic Architecture of London's Beddington Zero Energy
Development (BedZED)**

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for reuse.

important because the small scale is where people meet and evaluate decisions
made at all planning levels. Almost all of the most highly regarded public squares
in Europe are less than 10,000 square meters; most are less than 8,000 square
meters (box 4.1). The battle for quality in cities and building projects must be won
at the very small scale.

BOX 4.1 **Enclosure and Scale of Public Spaces: Madrid Plaza Mayor Versus Nanchang Ba Yi Square**

Madrid's major civic space, the Plaza Mayor (built in the early 17th century), is a well-defined, 122 x 91 meter rectangle the size of an urban block. The square is lined with uniform houses, each with a stone arcade at the street level, three brick floors, and an attic. The streets, which existed before the square was built, lead to the square in an irregular fashion, but this irregularity is masked by the uninterrupted line of porticos at the places where these streets open onto the square (box photos 4.1.1 and 4.1.2 and box map 4.1.1). This plaza is now a major tourist attraction in Madrid.

BOX PHOTO 4.1.1 Sense of Enclosure at Madrid's Plaza Mayor

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BOX MAP 4.1.1 Street Connections to Madrid's Plaza Mayor

Source: Salat, with Labbé and Nowacki 2011.

BOX PHOTO 4.1.2 Street Conctions to Madrid's Plaza Mayor

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

Enclosure and Scale of Public Spaces: Madrid Plaza Mayor Versus Nanchang Ba Yi Square *(continued)*

Ba Yi Square, in Nanchang, China, creates a very different effect. The square lacks edge definition, with the major roads around it eliminating any sense of enclosure (box photo 4.1.3). The square fails to give a coherent order to oversized roads and disparate buildings. The square's size (515 x 255 meters, the size of a Chinese superblock) erodes human scale, compared with Plaza Mayor, seen at the same scale within a 800 meter square selection of urban fabric in box photo 4.1.4.

BOX PHOTO 4.1.3 Lack of Definition and Enclosure at Ba Yi Square, Nanchang

Source: © Serge Salat. Used with the permission of Serge Salat. Further permission required for reuse.

BOX PHOTO 4.1.4 Areas Surrounding Madrid's Plaza Mayor and Nanchang's Ba Yi Square

a. Madrid's Plaza Mayor

b. Nanchang's Ba Yi Square

Source: Urban Morphology and Complex Systems Institute. © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse.

PHOTO 4.5 **Transparency and Layering at the Barcelona Museum of Contemporary Art**

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Layering of Space

Layering of space refers to the degree to which people can see or perceive what lies beyond the edge of a street or other public space. Physical elements that influence layering of space include walls, windows, doors, fences, landscaping, and openings into midblock spaces. The Barcelona Museum of Contemporary Art (photo 4.5), designed by Richard Meier, illustrates the concept of transparency and layering by articulating two public squares and a complex composition of historic and modern architecture, materials, and volumes, with a great sense of space layering.

Whether the public environment invites or repels people depends on its degree of enclosure and transparency and the way in which the border zone is designed. Flexible boundaries in the form of transitional zones function as connecting links, making it easier physically and psychologically for people to move between in and out. Contact through experience between what is taking place in the public environment and what is taking place in the adjacent residences, shops, offices and communal buildings provides an extension and enrichment of possibilities.

Complexity

Complexity refers to the visual richness of a place. It depends on the variety of the physical environment—the number and kinds of buildings, the landscape elements, the street furniture, and human activity.

PHOTO 4.6 Plaza of the Barcelona Museum of Contemporary Art

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

Complexity is related to the number of noticeable differences to which a viewer is exposed per unit of time. Narrow buildings in varying arrangements add to complexity; wide buildings subtract from it. People need many different surfaces over which light is constantly moving in order to keep their eyes engaged. Changes in the textures, widths, and heights of buildings, as well as building shape, articulation, and ornamentation, add to complexity.

Complexity supports walking (photo 4.6). Pedestrians require a high level of complexity to hold their interest. An interesting walking network makes the walking distance seem shorter by dividing the walk into manageable stages. Crucial to determining the acceptable distance in a given situation is not only the physical distance but also the experienced distance. People find a 500-meter along an uninteresting broad arterial very long and tiring; the same walk can be experienced as a very short distance if the route is perceived in stages (Ewing and Bartolomew 2013).

Complexity is not only a physical attribute of the urban fabric.[1] It is also a social process of human interactions that is self-reinforcing (Gehl 2008). When one person does something, others often participate or observe. Individuals and events thus influence and stimulate one another. Once this process begins, the total activity is nearly always greater and more complex than the sum of the component activities.

People and events are assembled in time and space so that individual activities get a chance to grow together to become larger, more meaningful, and inspiring sequences of events. Something happens because something happens. Larger, more complex community activities develop naturally from many small daily activities (box 4.2).

Coherence

Coherence refers to a sense of visual order. The degree of coherence is influenced by consistency in the scale, character, and arrangement of buildings, landscaping, street furniture, paving materials, and other physical elements (photo 4.7). "Geometrical coherence is an identifiable quality that ties the city together through form and is an essential prerequisite for the vitality of the urban fabric" (Salingaros 2000).

BOX 4.2 Complexity and Life between Buildings

The system of squares around the Centre Georges Pompidou (a modern art museum) in Paris includes a wide, sloping square (the piazza) in front of the center's main facade; a deep square (Place Igor Stravinsky); Eglise Saint-Merri; and the Stravinsky fountain (box map 4.2.1). A third small square (Place Edmond Michelet) creates a transition between Boulevard de Sébastopol and the piazza in front of the museum. This system of three interlocking squares support many social activities, including regular performance.

BOX MAP 4.2.1 **System of Squares at the Centre Georges Pompidou, Paris**

Source: Salat, with Labbé and Nowacki 2011.

BOX PHOTO 4.2.1 **System of Squares at the Centre Georges Pompidou, Paris**

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PHOTO 4.7 Coherence of Vienna's Building Fabric

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Legibility

When faced with a new place, people automatically create a mental map that divides it into paths, edges, districts, nodes, and landmarks (Lynch 1960). *Legibility* refers to the ease with which people can create such a mental map so that the spatial structure of a place can be understood and navigated as a whole. Street or pedestrian networks that provide a sense of orientation and relative location and physical elements that serve as reference points improve legibility (photo 4.8).

PHOTO 4.8 Oslo Opera House

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

PHOTO 4.9 Linkage in New York and Singapore

Left, High Line, New York. Right, Marina Bay East Gardens, Singapore.
Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

Linkage

Linkage can be defined as features that promote the interconnectedness of places and provide convenient access between them. It refers to physical and visual connections—between buildings and the street, between buildings, between spaces, between one side of the street and the other—that unify disparate elements. Linkage can occur longitudinally along a street or laterally across a street. The fact that the possibilities for seeing other people and events is limited to a distance of 25–100 meters places great demands on the degree of linkage (Ewing and Bartolomew 2013). The High Line in New York, Marina Bay East Gardens in Singapore, and the bridge to St Paul in London (photo 4.9) are example of such linkages.

Example of Application of All Eight Design Elements

The proposed Green Triangle in Tianjin, a major port city in northeastern China, illustrates how all eight design elements could be applied. The conceptual design for the project was developed as part of a World Bank workshop in June 2014 to illustrate the concepts presented in this chapter in a real case. At this stage, it is not expected to be built.

The Golden Triangle area is located in the center of Tianjin, where green space is surrounded by a residential neighborhood to the north, mixed use to the east, and a commercial center to the south. The area has planned stations for two metro lines and a bus rapid transit line. It covers 1.6 hectares and allows for a maximum FAR of 4.1 and a maximum plot ratio of 60 percent.

The vision for the Golden Triangle it to combine new building space with green space, to turn it into a "Green Triangle" (image 4.1). The area would be highly

IMAGE 4.1 Architect's Sketches of Tianjin's Green Triangle

a. View from above

b. View from the southeast

c. View from the north
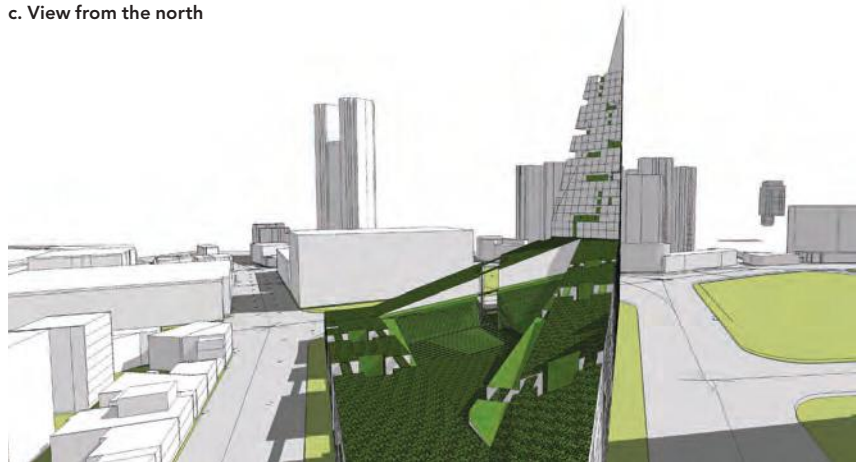
Source: Serge Salat, architect, for the World Bank.

permeable, with six openings in a medium-size block leading to an inner public space where passengers can meet. A garden roof would link the different levels. The garden roof and the inner green triangular square recreate the same amount of green space as in the original site.

The Tianjin Green Triangle's unique combination of an elevated garden promenade, a green amphitheater, and a green triangular plaza would offer the opportunity to create a reference point at the entire city scale: an urban experience associating the space of movement (transit stations) and places for people (streets, green roofs, the green amphitheater and enclosed plaza, the sharp triangular tower) as an icon of green 21st century Tianjin. The project would avoid isolated buildings, arterials, and other disconnected and inanimate objects, instead connecting people through place-making and multiple experiences in a complex sequence of movement within a structured place where people pursue a wide variety of activities.

The project's physical structure would support the social structure by linking indoors and outdoors at various levels. It would offer flowing, gentle transitions between various categories of public spaces. Its physical structure would reflect and support the desired social structure, encouraging innovation and creativity and contributing to creating high place value.

The conceptual design of the Tianjin Green Triangle embodies the eight urban design qualities for creating high place values:

1. *Spirit of place*: The triangular patterns of the project capture attention and create a lasting impression. The triangular landmark tower creates a strong image by its singularity and location in relationship to its context and to the city at large. It is a visual termination point, an orientation point, and a point of contrast in the urban setting.
2. *Enclosure*: Buildings, walls, and streets define the "Green Agora." The height of the vertical elements, which is proportionally related to the width of the space between them gives, the agora a room-like quality. The buildings become the "walls" of the outdoor triangular room, the plaza the "floor," and the sky an invisible "ceiling."
3. *Human scale*: The size, texture, and articulation of the Green Triangle's physical elements match the size and proportion of people and correspond to the speed at which people walk. Moderate-size buildings and sequences of small spaces create an intimate environment. The Green Agora is within the 100-meter limit that allows people to see everything that happens.
4. *Layering of space*: Many entryways in the Green Agora contribute to the perception of human activity beyond the street and foster interactions between indoors and outdoors. The Tianjin Green Triangle assembles people and functions in time and space. It integrates, invites, and opens up rather than close in activities.
5. *Complexity*: The project provides complex walks, split into sequences, at various levels along the edges of the Green Agora. Movement at the edge of a space makes it possible to simultaneously experience both the large space and the small details of the building facades or the spatial boundary along which one walks.
6. *Coherence*: The project displays a high level of formal and geometrical coherence, as the urban block is carved into smaller components following a set of consistent principles.

7. *Legibility*: The project's spatial structure provides a sense of orientation and relative location by physical elements that serve as reference points. The Green Triangle increases the clarity of the cityscape, the ease with which its parts can be recognized and organized into a coherent pattern.

8. *Linkage*: Tianjin Green Triangle is intensely linked by roof bridges and a continuous architectural promenade unfolding on several levels (see image 4.1, panel c). The block is divided into buildings separated by openings and united by the continuous elevated gardens and their bridges. These green connections link people and events.

Case Studies of Urban Design that Creates High Place Value

This section examines three cases studies (two from Sweden and one from Singapore). All three cases used increases in connectivity and high-quality urban design to spur green development.

High-Quality, Eco-Friendly Urban Design and Transit Connectivity in Hammarby Sjöstad, Sweden

Hammarby Sjöstad, in Stockholm, implemented an integrated approach to district planning that incorporates sustainable resource use, ecological design, and low-carbon transport (photo 4.10). Its success can be attributed to strong environmental goals that shaped the development plan, which covers land use, transportation, building materials, energy, water, and sewage.

The 160-hectare district was built on a former industrial and harbor brownfield area located on the south side of Hammarby Lake, three kilometers south of the Stockholm city center. Its flexible grid of small blocks incorporates public green space and streets designed as places for people.

Hammarby Sjöstad is an example of the conversion of a run-down industrial area into a modern, environmentally sustainable, mixed-use district with good public transit connections and high-quality urban design that embodies the eight urban qualities described in the previous section. Redevelopment of this industrial waterfront used the dynamics of place and node value increase to raise market potential value.

Planning for the redevelopment of the site began in 1996. The goal was to build a sustainable community that is twice as energy and resource efficient as a typical one. The Hammarby model (figure 4.1) is a unique eco-cycle system that systematically seeks out opportunities to reuse energy, solid waste, water, and wastewater from homes, offices, and other structures in the area in an integrated manner. It is the district's attempt at a balanced "closed-loop urban metabolism." Urban metabolism is a model to facilitate the description and analysis of the flows of materials and energy within cities. It provides researchers with a framework to study the interactions of natural and human systems in specific regions. In a circular metabolism, there is nearly no waste and almost everything is reused. (Wachsmuth 2012).

PHOTO 4.10 Use of Water at Several Scales in Hammarby Sjöstad, Sweden

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

FIGURE 4.1 The Hammarby Model
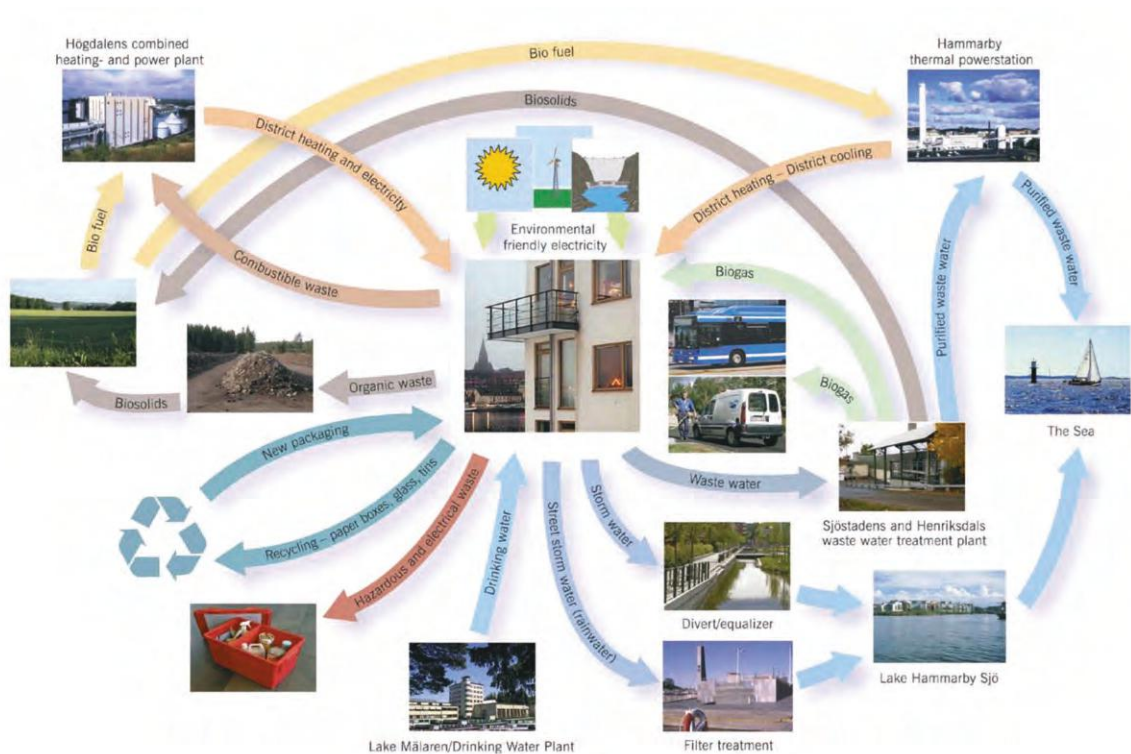
Source: City of Stockholm 2011. © City of Stockholm. Used with the permission of City of Stockholm. Further permission required for reuse.

Urban-scale density, access to multiple modes of transit, an emphasis on reduced car commuting; preservation and restoration of existing natural systems, and progressive construction and housing policies make Hammarby Sjöstad an effective demonstration of integrated planning. Through the city's forethought in land acquisition, the planning department was able to efficiently coordinate transportation, land use, and development.

Integrated transportation and land use
Hammarby Sjöstad had three transportation goals:

- Eighty percent of residents' and workers' journeys would be made by public transit, bike, or foot.
- At least 15 percent of households would have car-sharing memberships, and at least 5 percent of workplaces would have car-sharing memberships.
- One hundred percent of heavy transportation by vehicles would meet environmental zone requirements (Fränne 2007).

The district's planner recognized the importance of integrating transportation and land use planning. Expansion of the district was therefore complemented by transport investments, including increased bus service, cycle paths, pedestrian bridges, ferry service, and extension of the tram line.

Hammarby Sjöstad was designed to integrate transportation, amenities, and public spaces. The spine of the district is a 37.5-meter wide boulevard and transit corridor that connects key transport nodes and public focal points and creates a natural focus for activity and commerce (Foletta 2011). Hammarby Sjöstad's tramline was built as the main commuting traffic mode to the southern part of Stockholm. Underground parking and low parking ratios mean that cars do not dominate the urban landscape.

The planning process
The first step in planning was the development of the strategic master plan, led by architect Jan Inghe-Hagström, at the Stockholm City Planning Bureau. The plan is divided into 12 sub-neighborhoods, which are being developed in phases. A process called "parallel sketches" is used in which the city selects three to four private sector architects/planners to draw up detailed proposals for a sub-neighborhood. The city evaluates each of the sketches and combines the best features to create a master plan. The city planning and design team then prepares a design code for each sub-neighborhood in partnership with the developers and architects. This design code is included in the development agreement between the developer and the city. The design code is taken through the local authority political process in order to grant planning permission; the code provides an overview of the layout, form, and structure of each block, including key landmark buildings, public spaces, and pedestrian routes.

To provide architectural diversity, and inspire higher standards of design through competition, a consortium of developers and architects is then invited to develop each plot or individual building within the sub-neighborhood, according to the design code. More than 60 developers and 30 architects were

involved in the planning process (Foletta 2011). This participatory process helped the project achieve a high level of diversity and complexity within a coherent master plan.

Application of the eight design principles

Spirit of place has been created in Hammarby Sjöstad by the subtle use of Stockholm urban morphology, sizing, and scaling. The variety of urban tissues in Stockholm helped guide the urban design. Although Hammarby Sjöstad is located outside Stockholm's center, the design is intentionally urban rather than suburban and follows the urban fabric typology of Stockholm's center city (image 4.2), with 4 types of landscape and 5 types of public waterfront, 12 different types of urban tissue and as many street profiles (Assche and Meeus 2000). The traditional city structure of Stockholm has been combined with a new architectural style that responds to Hammarby Sjöstad's waterside context, promotes the best of contemporary sustainability technology, and follows modern principles of maximizing light and views of the water and green spaces.

Enclosure of a variety of inner spaces is subtly combined with openness and linkage by multiple water and pedestrian connections. The facades form a concave, complex, and irregular enclosure of pedestrian areas, giving a sense of rhythm, diversity, and variety to the pedestrian experience. Bridge curves give rhythm to the pedestrian journey.

IMAGE 4.2 **Urban Block Pattern of Hammarby Sjöstad, Sweden**
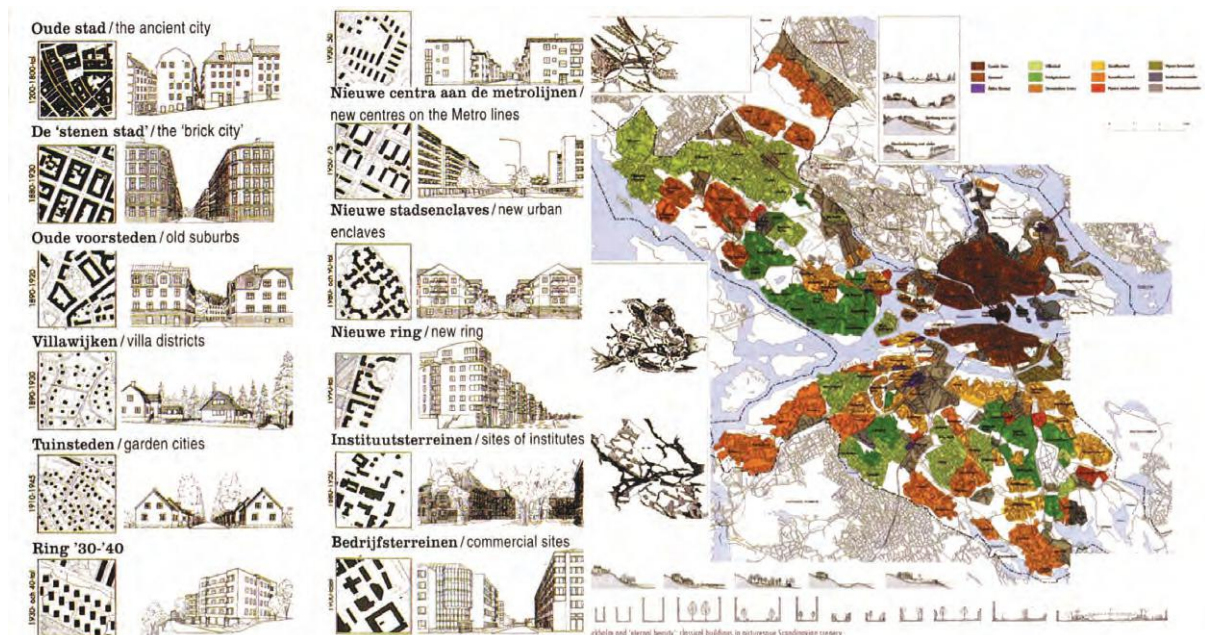
Source: Assche and Meeus 2000. © van Assche. Used with the permission of van Assche. Further permission required for reuse.

Human scale is created by an urban morphology (form and structure) using urban block patterns and sizing of the center city. The district was planned with a dense settlement structure, with four- to five-story buildings in a compact neighborhood complemented by spacious green courtyards. The design follows standards for Stockholm's center city in terms of street width (18 meters), block size (70 x 100 meters), density, and land use. City street dimensions, block sizes, building heights, and density mix are integrated with openness, waterfront views, parks, and sunlight. This design allows for both wind-shielded and sunny inner courtyards, with ample possibilities and incentives to develop inviting entrance and common courtyard greens and facilitate small-scale cultivation in micro-garden plots and small greenhouses.

Layering of space is ensured by limited building depths, recessed penthouse flats, large balconies and terraces, and large windows on water-facing facades. Most balconies overlook streets, waterfront walkways, and open spaces. Many apartments also have a semi-open block form, providing open access to the courtyards of the residential blocks.

Complexity, coherence, and *legibility* are created by the planning process. A master plan resulted from the combination of multiple sub-neighborhood plans; implementation fostered diverse designs respecting the design code.

Among the key organizing principles is the variety in the scales of development. The scale of development varies from four- to five-story buildings along the Sickla Canal and six- to eight-story buildings along the main corridors. Taller buildings facing the water are built in a classic urban style that complements the large-scale facilities and large open water areas. Large-scale, multifunctional buildings have been built along the avenue, with small-scale backstreet and courtyard houses built between the dock and the park walkway. The environment along the canals is more intimate and small-scale, with development gradually downscaled toward the shorelines (photo 4.10).

Linkage is ensured in multiple ways. The water environment adds significant links in the neighborhood. Major non-road-based links create huge areas of openness linked to building spacing and height. A network of connected parks, green spaces, and walkways runs through the district to provide a counterbalance to the dense urban landscape. Two wide bridges over a busy road have been covered with vegetation. The bridges provide both a link and a shortcut to the nature reserve just outside the city.

Enhancement of the social life of the community

Mixed-use development creates a complete and balanced community. The 200-hectare district is home to about 20,000 people (9,000 housing units) and 10,000 jobs (200,000 square meters of commercial space). It offers a wide range of educational, cultural, and recreational programs. It balances both private and public space and ensures that priority is placed on what benefits the community. High-density living promotes a greater sense of community by facilitating the development of programs and processes that promote social interaction and cultural enrichment. Family living is key to Hammarby's success, with good-quality housing and community facilities for families, including schools, community center, and churches.

The development process and market potential value

The city of Stockholm joined forces with 25 construction companies to build the district, with the district contributing 80 percent of local cost. Other funding came from two government agencies, the Swedish Rail Administration (rail transport) and the Swedish Road Administration (routing of the Southern Link ring road).

Several key features ensured an efficient development process, with a good balance between planning and market forces (Lee n.d.). The entire site is owned by a single owner. As a result, the plan could be implemented in an orderly fashion. It was based on a master plan reflecting a long-term vision. Major public funding of infrastructure was key, with power, water, and recycling facilities all put in place early. Each development zone was put out to developers and architects, who came up with solutions. Within the confines of the master plan, different developers delivered each zone, creating diversity. Requiring developers to pay for each site on a per-square-meter-of-development basis sharpened the focus on design and quality. The master plan envisaged a mix of nonresidential uses but did not impose constraints. Ground floor areas in certain key frontage zones had to be active (including shops, for example), but were flexible for the end-user. The market eventually determined what worked.

Hammarby Sjöstad is now a middle-class suburb with strong housing values (which increased by four to five times since the first parts were built). It also includes affordable housing, public rental, private rental, and privately owned properties.

Lessons learned

A holistic approach to planning, grounded in increased connectivity, high-quality design, and strong environmental goals can help shape new developments and create market potential in run-down industrial areas. These principles should be adopted as early as possible, so that they can be integrated into every part of the infrastructure early in the planning process. Achieving both coherence and a high level of complexity and diversity in the neighborhood requires a participatory process that includes all stakeholders and a discussion of possible options and their potential results within the planned district.

Transit-Oriented Development and Green Growth in Malmö, Sweden

Like Hammarby, the Bo01 district of Malmö was built on a former industrial estate and port, where the ground was polluted (map 4.2). This 18-hectare development represents the first step in the process of transforming the 160 hectares of industrial estate and port of Västra Hamnen, one of Malmö growth areas. Density is 122 people per hectare, but more than half of the development area is dedicated to open space, making Bo01 an example of an urban settlement that does not diminish quality of life for the sake of density.

Bo01, the first area of the Western Harbor being constructed (inaugurated in 2001 for the housing exhibition Bo01), combines transit-oriented development (TOD) features with green growth. Comprehensive planning for energy, water, and waste systems resulted in significant improvements, especially in energy

MAP 4.2 Structural Plan for Malmö

a. Western Harbor

b. Bo01 area
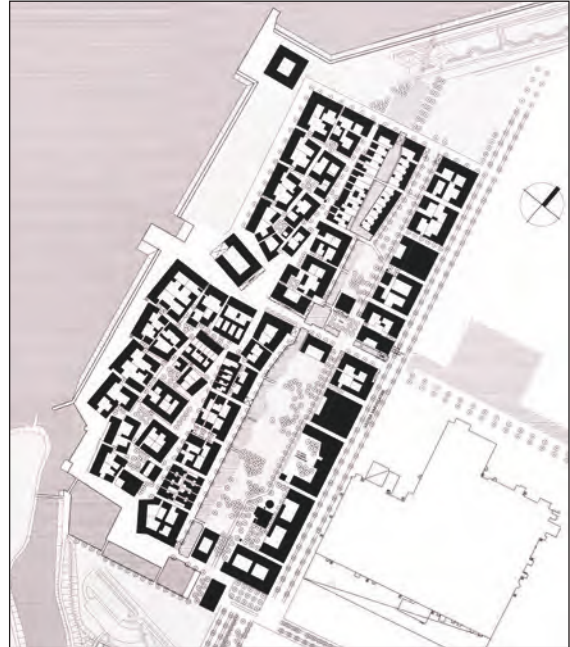
Source: © Malmö City Planning Office. Used with the permission of Malmö City Planning Office. Further permission required for reuse.

production (all of which comes from renewable sources) and solid waste management.

Bo01 inhabitants are encouraged to use environmentally friendly modes of transport. The area is car free. It is well served by paths dedicated to pedestrian and bicycle use. A little more than eight kilometers of bicycle paths extend from Bo01 through the Western Harbor. All residents of Bo01 are within 450 meters of a bus stop, and buses operate every seven minutes (City of Malmö 2006).

Malmö has more than 460 kilometers of bicycle paths. Forty percent of trips to school or work are made by bicycle, and 30 percent of all trips are by bicycle (Reepalu 2013).

Application of the eight design principles
Outstanding urban design qualities have been achieved through an innovative participatory planning process in which the city exerted control through ownership, goal formulation, and planning while involving stakeholders. The city hired Klas Tham, a well-known architect and planner, to craft the design and planning basis for Bo01 and serve as its main designer and director. Tham balanced the technological goals of the project with an overarching concern for the social environment and for elevating the aesthetic quality of the development (Austin 2013). According to Tham:

The plan has also been shaped by our ambitions: to offer an urban structure that is sufficiently robust, to meet the demands of an uncertain future (the network

structure of block city and clear borders between the public and private spaces), to provide the conditions for the essence of the city, the meeting between different people and cultures, to come about gradually (the small-scale property division of the plan, its range of different residential environments), to let cars get through, but on the terms of the pedestrians, to provide the conditions of a city environment which, over and above empathy and comprehensibility, also offer a wealth of information, mystery, surprises, and many unique and promising urban spaces; a dramatic tension between the grand and the intimate, to offer a wealth of all forms of vegetation, from the individual garden, to the sheltered, thickly wooded public canal park through the interior of the area. That is how the plan took shape. The grid has been distorted by the wind, among other things, like a fishnet hung out to dry. And, as a result, it has actually become more rational, more valuable to build, live and stroll around in. (McCollum n.d.)

Innovative planning methods that emphasized the collaboration of government, designers, and developers were created through "creative dialogues" to produce consensus on what could be accomplished under a time constraint. The result was the Quality Program (1999), a simple document outlining the minimum standards for architecture, landscaping, energy, water, waste management, and biodiversity. It included an emphasis on green space, which reinforces the master plan and resulted in diverse and effective landscapes (City of Malmö 2002). Dialogue fostered an atmosphere of collaboration and innovation. The 20 developers selected for the project committed to material, technological, environmental, and architectural quality measures before any parcel was sold. Although time-consuming, the process resulted in rapid approval of the plans developers submitted to the city (Austin 2013).

Spirit of place is created in Bo01 by the "sensory, emotional and mental nonquantifiable human aspects of design" and by "highlighting the *genius loci*—the unique identity and quality of the place—the sky, the sea, the wind, the ground—and its imageability," according to the Quality Program (1999). According to Klas Tham:

The plan has been sculpted by the grandeur of the site (the ocean, the expanse of sky, the horizon, the sunset), by very strong exposure to the wind from the west, and by the broad-meshed grid of boulevards in the district. This ensures orderliness and empathy on a grand scale and at the same time, gives space to discover a teeming, less tangible world on the inside of the large squares. (McCollum n.d.)

Water is included in park axes and as stylized streams of storm water in squares, piazzas, streets, and lanes. It creates natural limits and structures people's movement. Bridges, canals, and courtyards organize journeys with views of water. The Turning Torso Tower (see photo 4.1) acts as a landmark, creating place identity.

Enclosure of a variety of semipublic courtyards and small squares—linked by green spaces, including parks and streets—provides vitality, light, room to travel, and room to rest.

Human scale and the interaction of man with the environment are fundamental factors in the Quality Program (1999):

It is human beings and their needs that provide the starting point for all design and all planning and never, for example, the needs of motor traffic or technology…. A district needs values which cannot be measured in the traditional manner: visual and acoustic impressions, the experience of greenery and water, street

spaces with "human" proportions, and the subconscious understanding, interpretation and experience of one's surroundings in a way which interacts positively with our biological origins, even in the distinctively manmade environment of the city.

Slightly more than half of the area is open space; many social spaces were designed within a diverse landscape to create a broad range of experiences for people. Access to green areas and water, the use of daylight, and various visual impressions create a sense of well-being (photo 4.11).

Layering of space is ensured by intermediary transparent components that are open to the outside, such as porches and balconies, to ensure transitions between public and private areas. Public space is not designed as a homogenous entity in opposition to private space but as a series of intermediary semiprivate and semipublic levels.

Complexity is defined in the Quality Program (1999) as the "wealth of information, mystery, surprise, possibilities of getting lost and making accidental discoveries." It is created by irregular streets and their rich set of interconnections, visual variety, diversity in patterns, open spaces, and buildings.

The Bo01 plan develops a rhythm of moving and stopping. It is made for the slower pace of pedestrians and cyclists. Variations in the grid shield inner areas from the weather that buffets the district. Unpredictable building orientation and placement create a dynamic character, full of surprising spaces and views within a pedestrian environment.

Diversity characterizes the area. Twenty-six architectural firms designed the houses, each firm given wide freedom of expression. Twenty developers built

PHOTO 4.11 **Integration of Water Features in the Bo01 Neighborhood of Malmö, Sweden**

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

houses and apartments of different sizes and types of ownership. Bo01 created a community with the variety, detail, and diversity that elude master-planned communities with fewer participating architects, landscape architects, and developers.

The project also reveals diversity and variety in the design of its parks. The Scania Portal (Scaniatorget) includes etched pathways that allow storm water to reach the sea with an austerity and restraint reminiscent of Zen gardens. In contrast to typical seaside parks, with their hardened, protective edges, Anchor Park offers more detail and an introverted character than the dramatic views and scale of the western landscapes (Dania Park, Scania Portal, the Promenade, and Scania Park).

Coherence within this high level of diversity is ensured by a strong overarching order in the detailed development plan with "distinct territories, clear boundaries between what is to be perceived as, respectively, public and private, between semiprivate and private, between private and private" (Bo01, the City of Malmö, and Developers' Representatives 1999). The architectural design is integrated with and supportive of the structure of public spaces. The design of the facades overlooking quays, parks, and main streets proclaims the buildings as the walls of very important urban spaces. The tall houses on the block perimeter form a wind shelter around a small-scale and green interior.

Legibility in Bo01 is defined as "strong, intrinsic identity of the part and the whole—the home, the block, the street, the square, the park, the neighborhood; intelligibility of structure, form and function, facilitating participation by the local residents" (Bo01, the City of Malmö, and Developers' Representatives 1999). Urban edges ensure this intelligibility (photo 4.12). The neighborhood has a clearly defined limit, with the sea forming a natural border.

Linkage was developed at many scales. It is both formal and informal and includes a mix of streets, pedestrian walks, alleyways, squares, and water banks. As stated in the Quality Program (1999), the plan "provides many different opportunities for approaching and exploring the district. A network of axes moving through different, carefully balanced public spaces will provide oppor-

PHOTO 4.12 Legibility in the Bo01 Neighborhood of Malmö, Sweden

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

tunities for many different choices of direction and experiences." A central axis extends from the city castle toward the sea. This tree-lined avenue is the symbolic main entrance to the Western Docks; it creates visual contact between the castle and the sea. At right angles to this axis, a canal and street access link the docks in the Wihlborg area with new housing on the Bo01 site. The cross formed links and articulates four city quadrants with different characteristics and content.

Another layer of linkage is the variety of informal pathways where people can stroll and bicycle. They complement the neighborhood street pattern with a rich network of pedestrian connections. The use of these varying interior open spaces facilitates many social interactions and is of great importance in creating a character for the area as a whole.

Lessons learned

The holistic definition of sustainability by the visionary planner resulted in aesthetics and social opportunities that match the high levels of technical performance. The project supports physical and psychological health by providing immediate access to open space, walkable neighborhoods, and opportunities for social interaction. The urban environment offers natural meeting points and a well-balanced mix of housing activities, schools, and green areas, creating a vibrant community fulfilling the needs for beauty, proportion, nature, water, and safety.

The Positive Feedback Loop of High Node, Place, and Market Values in Marina Bay, Singapore

Singapore's desire to become a financial hub economy meant that it needed to build new, high-quality commercial space.[2] Urban regeneration and "breathing space" was needed in the central business district (CBRE 2012).

PHOTO 4.13 Singapore's Marina Bay Skyline from the East

Source: Chensiyuan. GNU Free Documentation.

Marina Bay became the new growth area (photo 4.13). The 360-hectare area was reclaimed during the 1970s and 1980s, in anticipation of the growth of the city center. Full development of this area is expected to more than double Singapore's office size, to 4.8 million square meters.

High node value

Marina Bay is planned as a vibrant, mixed-use district with round-the-clock activities based on sustainable development strategies. By 2018 the area will be served by four mass transit lines and nine metro stations; all locations in Marina Bay will eventually be within a five-minute walk of a public transit node. Singapore's Urban Redevelopment Agency projects that the intricate network of mass transit lines, cycling paths, and pedestrian walkways serving the district will make the need for car redundant in this part of the city. It is the first district in Singapore to be planned upfront with a network of dedicated cycling lanes. A comprehensive pedestrian network, including shady sidewalks, covered walkways, and underground and second-story links, will ensure all-weather protection and seamless connectivity between developments and transit stations. Water taxis will also operate.

High place value

To provide good connectivity and seamless extension, the development parcels were planned based on an urban grid pattern with floor area ratios of 8–25 that extends from the existing street network within the central business district. This grid creates a flexible framework with a series of land parcels that can be combined or subdivided to meet new requirements or changing demands and allow the phasing in of development.

The vision for Marina Bay is "a garden city by the bay." It is Singapore's first location to host water activities and serve as a focal point for major events. Together with the waterfront promenade and its loop of attractions and vibrant public spaces, Gardens by the Bay is playing a key role in defining the character of Marina Bay, with its leafy streetscape, lush park, and sky-rise gardens.

Gardens by the Bay is a nature park spanning 101 hectares of reclaimed land adjacent to the marina reservoir. The park consists of three waterfront gardens, the largest of which is 54 hectares. It is part of a strategy to transform Singapore from a "garden city" to a "city in a garden." The aim is to raise the quality of life by enhancing greenery and flora in the city. Gardens by the Bay includes "supertrees"—tree-like structures 25–50 meters high. These vertical gardens perform various functions, providing shade, venting hot air, and circulating cool water (photo 4.14)

High market potential value

Public sector investment has been key to the development of Marina Bay. This investment has been recouped by returns from the private sector. The Urban Redevelopment Agency has received more than $4.5 billion from the sale of land parcels (excluding proceeds from One Marina Boulevard and the M+S Marina One development site), according to estimates by CBRE (2012). Public sector investments in infrastructure have attracted local developers as well as

PHOTO 4.14 "Supertrees" in Singapore's Garden by the Bay

Source: © Serge Salat. Used with the permission of Serge Salat. Further permission required for reuse.

developers from Australia; Hong Kong SAR, China; Malaysia; and the United States. U.K. firms reportedly occupy 29 percent of the development's space, with 19 percent occupied by U.S. firms and 18 percent by Singaporean firms. Most occupants are from multinational companies headquartered in Europe (51 percent), Asia (22 percent), and North America (20 percent). Occupants include law, information technology, commodities, energy, and insurance firms as well as financial service firms.

Flexibility is an advantage for developers and corporate occupants. Development sites that are zoned white are granted high development flexibility. Developers in these zones have the autonomy to develop property for a variety of uses and to respond to changing market needs.

With a prime waterfront location, high-end specifications, and larger floor plates (the amount of rentable floor space on one floor), buildings in Marina Bay have contributed to an increase in the average market rent. Of the six office towers totaling 510,000 square meters completed between 2006 and 2012, the average pre-let commitment level upon completion was 82 percent; four of the six towers were essentially 100 percent pre-let upon completion (CBRE 2012). In 2012 more than $18 billion was invested in the development. Marina Bay looks to be one of the most lucrative investments ever in Singapore, according to CBRE.

Lessons learned

The success of the new development is based on a positive feedback loop of high node value, high place value (created by the futuristic landscaping of Gardens by

the Bay), and high market potential value. The project is a public-private partnership in which the state makes infrastructure investments and releases development sites to the private sector. Urban designs and planning objectives are articulated and achieved through conditions imposed on these sites. The fact that the Urban Redevelopment Authority is both the master planner and the place manager ensures that a central governing body is able to coordinate the infrastructural developments from concept to operation (CBRE 2012).

Notes

1   Urban fabric is the physical aspect of urbanism, emphasizing building types, thoroughfares, open space, frontages, and streetscapes.
2   This part of the chapter is based on information from Singapore's Urban Redevelopment Agency.

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Realizing Market Potential Values through High Place Value and Improved Accessibility: Hudson Yards in New York City

This case study describes the redevelopment of Hudson Yards, part of a comprehensive strategy to develop Manhattan's West Side (image 5.1) and to maintain a high level of agglomeration economy in Midtown Manhattan.[1] It analyzes the project using the 3V Framework, examining its node, place, and market potential values and describing the approach taken to capture some of the resulting increases in value.

A report released by Related Companies and the Oxford Properties Group (the project's developers) outlines the substantial economic impacts of the 11.3-hectare Hudson Yards development on New York City's economy (Appleseed 2016).[2] The development will help modernize New York's commercial office space, improve its global competitiveness, create jobs, and make major contributions to New York's GDP and city taxes (box 5.1).

The Need for More Office Space in New York City

During the 1990s, New York City's economy soared. Projections made in 2001 indicated that the city could add nearly 600,000 jobs by 2020—but that it would need more office space to do so. The projections indicated that these jobs would increasingly come from companies in the "ideas economy," where value is created by "thinking things rather than moving things" (Group of 35 2001).

To accommodate the growth in the office sector, the city estimated that it would need about 6 million square meters of new office space by 2020. Without this new

PHOTO 5.1 **Dense Vertical Cityscape in New York City**

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space, New York stood to lose thousands of jobs and the economic activity they would generate. The shift of such jobs to New Jersey and Long Island would have implications for New York and the region, with a reduction in agglomeration economies that could be generated in highly concentrated jobs areas in Manhattan.

IMAGE 5.1 Hudson Yards, Viewed from the Hudson River

Source: Rendering courtesy of Volley Studio. © Related Oxford. Used with the permission of Related Oxford. Further permission required for reuse.

BOX 5.1 Expected Impacts of Hudson Yards

More than 64 percent of the City's office space is currently in buildings that are at least 50 years old. The development of Hudson Yards is one of New York's most important responses to the demand for new office space to keep New York competitive with other global markets. Hudson Yards will bring 1 million rentable square meters of new office space—an amount greater than the total supply of office space in downtown Austin, Texas or downtown San Diego, California—into New York City's marketplace.

Hudson Yards development, once fully operational, will contribute nearly $19 billion (all figures are in 2018 dollars annually to New York City's gross domestic product, accounting for 2.5 percent of the city's GDP. Upon completion, the project will produce nearly $500 million in annual taxes for New York City.

Companies and buildings at Hudson Yards will bring more than 55,000 jobs to the new West Side neighborhood. Related and Oxford's Hudson Yards development is just one piece of the broader Hudson Yards district, which can accommodate 4.6 million square meters of development, including new park land; office, hotel, and retail space; and 20,000 apartments, including more than 5,000 affordable units. During the estimated 13-year construction period, Hudson Yards will create 7,030 full-time jobs each year, paying about $761 million in wages. Hudson Yards has been a major contributor to the recovery of New York City's construction industry, with the early years of the project (2011–14) accounting for approximately 16 percent of the total increase in construction industry employment.

No project in New York City's history has contributed as much as Hudson Yards to the Metropolitan Transit Authority (MTA), which received $1.784 billion in revenues from the project during its development and construction. Upon completion, Hudson Yards is expected to contribute $89.3 million annually to the MTA.

Source: Appleseed 2016.

MAP 5.1 Office Floor Area Ratios in New York
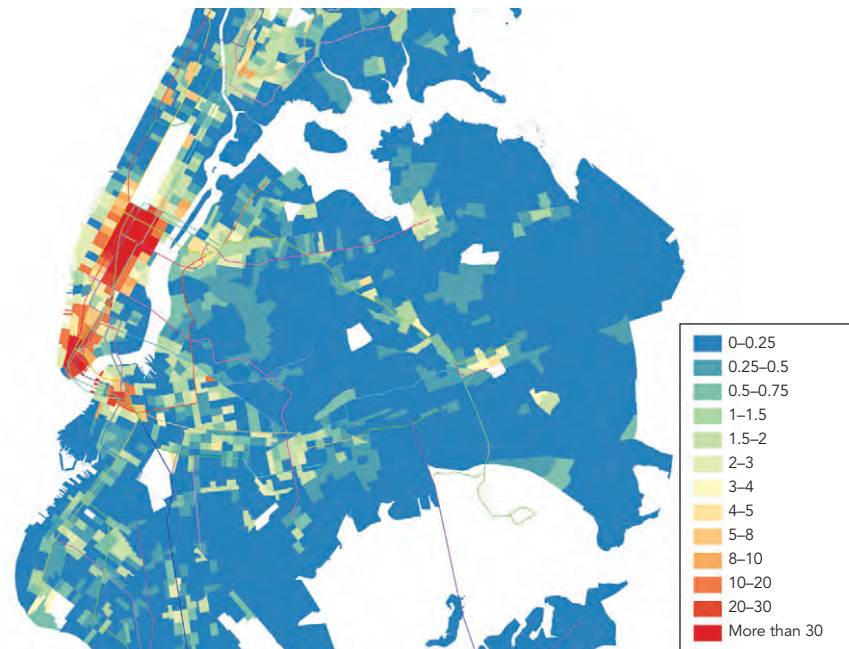
Legend:
- 0–0.25
- 0.25–0.5
- 0.5–0.75
- 1–1.5
- 1.5–2
- 2–3
- 3–4
- 4–5
- 5–8
- 8–10
- 10–20
- 20–30
- More than 30

Source: © Urban Morphology and Complex Systems Institute. Used with the permission of the Urban Morphology and Complex Systems Institute. Further permission required for reuse. Data from NYC Open Data.

The effects—including the loss of jobs and competitiveness; a reduction in tax revenues generated by Manhattan office space, a major contributor to New York's operating budget; and the environmental costs associated with changes in the patterns of commuting, with an increase in the car share—were highly undesirable.

Office floor area ratios (FARs) in New York are highly variable, with values ranging from less than 0.25 to more than 30 (map 5.1). About 60 percent of New York's office space is concentrated on 1 percent of the city's land area (9 square kilometers, out of a total of 780). The concentration of residents is lower than the concentration of jobs (map 5.2). Mathematically, the distribution of office FAR values across the urban space follows an inverse power law, with a very steep gradient of −1.7 (see appendix A).

Midtown and Downtown are New York's economic engines. The Midtown office market comprises 27.4 million square meters (44 percent of all office space in New York City). Combined with Downtown, this market totals 36 million square meters (59 percent of the total of New York City's office inventory).

The central business district (CBD) in Manhattan offered opportunities for new office space through rezoning, but there was not enough space to meet projected demand. Potential development sites are insufficient to meet future demand of 4.2 million square meters in Midtown by 2025.

To meet those needs, the Group of 35 (a group organized by a U.S. Senator and including major developers, landowners, and business officials) called for the cre-

MAP 5.2 **Residential and Office Density in Manhattan**

a. **Residential densities**   b. **Office densities**

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ation of three new and expanded CBDs: the Far West Side of Manhattan, Downtown Brooklyn, and Long Island City. An extended IRT Flushing Line would serve the new CBD on Manhattan's Far West Side, connecting the area to the Port Authority Bus Terminal, Times Square, and Grand Central Terminal. Development in the area was planned to provide at least 2 million square meters of office space.

For each location, the core strategy was to create an "urban business campus" as a catalyst for development. As private sector efforts alone were considered insufficient to produce the urban space needed for new economic growth, the strategy for each new CBD included the initiation of an urban business campus by the public sector. This strategy aimed at avoiding the initial reluctance of the private sector to consider locating in a new CBD because of the dearth of ready-to-go development sites, amenities, and business support services.

To jump-start the development process, the public sector (the City of New York and the State of New York) planned three urban business campuses, one for each new CBD. They included the following elements: 300,000–500,000 square meters of state-of-the-art office facilities; a park-like setting, with open spaces and pedestrian-friendly streetscapes; and amenities such as retail and dining establishments, business services, hotels, and entertainment venues and access to local cultural and academic resources.

The City and the State partnered to accomplish a number of tasks. They identified several blocks in the new CBD where the campuses should be located. They then assembled development sites by condemnation (appropriating property for public use), making financial contributions when necessary. They designated locations with the appropriate high-density commercial use zoning. They then solicited developers to build 300,000–500,000 square meters of new office space. Finally, they aggressively marketed projects and offered financial incentives to attract businesses to new developments.

Urban business campuses such as the one planned for Hudson Yards are expected to create a sense of place in the CBD and serve as a catalyst for ongoing private sector development efforts that will follow in adjacent areas. Some of the public sector investments will be recouped when sites are sold to private developers.

The Selection of Highly Accessible Sites for New Development

Over the centuries, New York has been able to make major public investments that trigger private market response. The grid plan of 1811 laid out the future of development for island of Manhattan at a time when few people thought development would expand north of Houston Street. Part of the success of New York is based on its ability to make strategic public investments that yield high returns long into the future.

The three areas identified by the Group of 35 Report as the future new CBDs of New York—the Far West Side, Downtown Brooklyn, and Long Island City—illustrate the strong connection between how accessible places are and how densely populated, used, and built up they are (box 5.1).[3] They benefit or will benefit from high accessibility in 30 minutes by transit by New York City residents. Some 2.8 million jobs are accessible in less than a 30-minute public transit ride from Brooklyn Heights. The Far West Side will be better connected to Midtown Manhattan by extending the No. 7 Subway to reach the same levels of accessibility as the other locations.

BOX 5.2 **Concentration of Transit Accessibility in New York City**

Transit accessibility in New York City is highly concentrated in specific areas, creating a highly efficient urban form for agglomeration economies. In a 780-square-kilometer city with 8.5 million people, 4 million jobs are located less than half a mile from a mass transit station. The high concentration of jobs in Manhattan and the dense provision of subway infrastructure in New York City have created a highly efficient urban form with an integrated labor market: 1.35 million jobs are accessible within a 30-minute transit commute including walking time (box map 5.1.1), and employers have access to 700,000 workers within a 30-minute transit commute (box map 5.1.2).

In Manhattan an average 2.6 million jobs are accessible in less than a 30-minute public transit commute (excluding walking time), and more than 75 percent of commuters use transit; more than 1 million workers are accessible within a 30-minute transit commute to an employer. The highest concentration of accessibility is in Midtown, which is undergoing rezoning at higher density: 3.3 million jobs are accessible in less than a 30-minute transit commute, and 1.6 million workers are accessible within a 30-minute transit commute on average. In comparison, in Chicago (a city of 2.7 million people), 535,000 jobs are accessible within a 30-minute transit trip and 28 percent of commuters use transit; in Los Angeles (a city of 4 million people), 567,000 jobs are accessible within a 30-minute transit trip and less than 12 percent of commuters use transit (Center for Transit Oriented Development n.d.).

BOX 5.2 **Concentration of Transit Accessibility in New York City** *(continued)*

BOX MAP 5.1.1 **Number of Jobs Accessible from Any Location in New York in Less than 30 Minutes Door to Door by Transit, Including Walking Time, 2015**
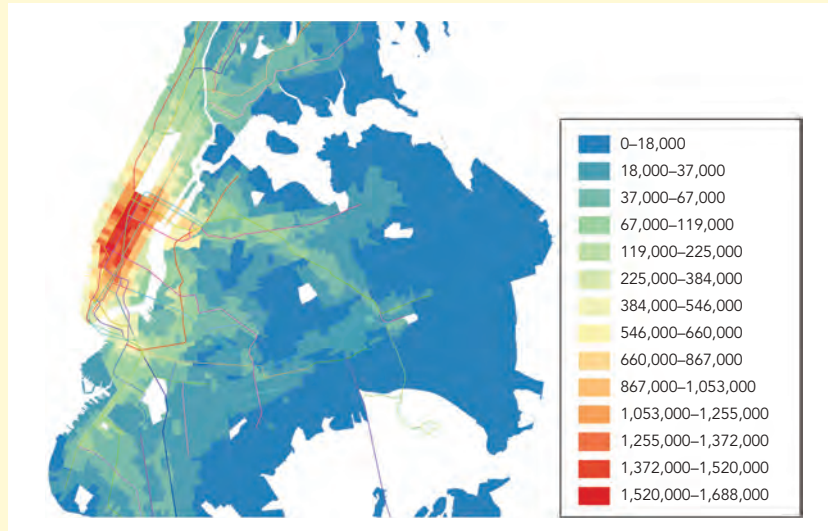
Source: © Urban Morphology and Complex Systems Institute. Used with the permission of the Urban Morphology and Complex Systems Institute. Further permission required for reuse. Data from NYC Open Data.

BOX MAP 5.1.2 **Number of People in New York Who Can Access a Given Location in Less than 30 Minutes Door to Door by Transit, Including Walking Time, 2015**
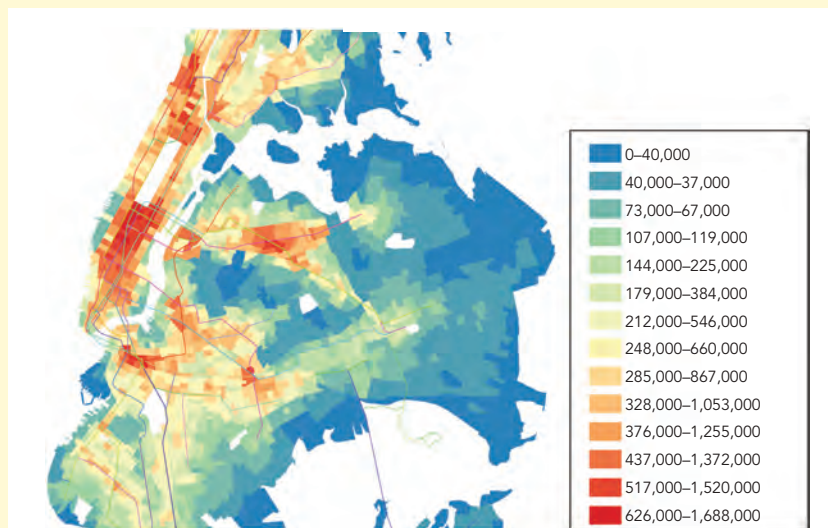
Source: © Urban Morphology and Complex Systems Institute. Used with the permission of the Urban Morphology and Complex Systems Institute. Further permission required for reuse. Data from NYC Open Data.

Selection of the three areas corresponds to the peaks of closeness centrality (the most accessible parts in the network [see chapter 2]) (map 5.3). Hudson Yards and Downtown Brooklyn are adjacent to or peaks of betweenness centrality as well. The three new CBD locations have high node value, much of which is underutilized. The strategy of the Group of 35 was to enhance their place value to boost their market potential value.

The Hudson Yards Project

Proximity to the Midtown CBD, accessibility to the regional workforce, and a vast amount of vacant and underdeveloped land make Manhattan's Far West Side an

MAP 5.3 Degree, Closeness, and Betweenness Centralities of Subway Stations in New York

a. Degree centrality
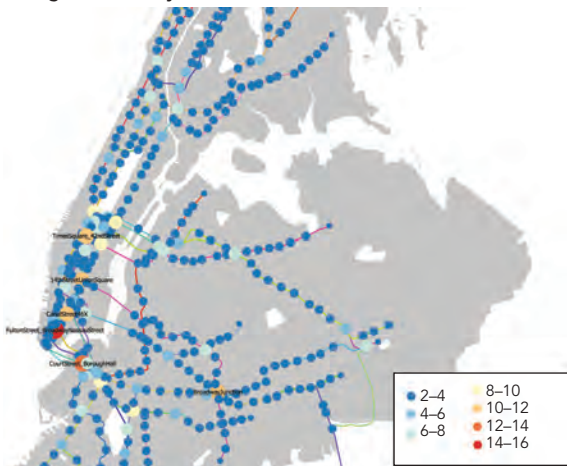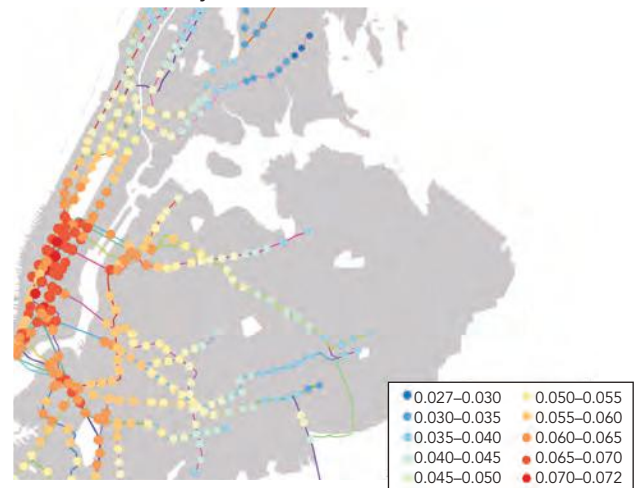
b. Closeness centrality

c. Betweenness centrality
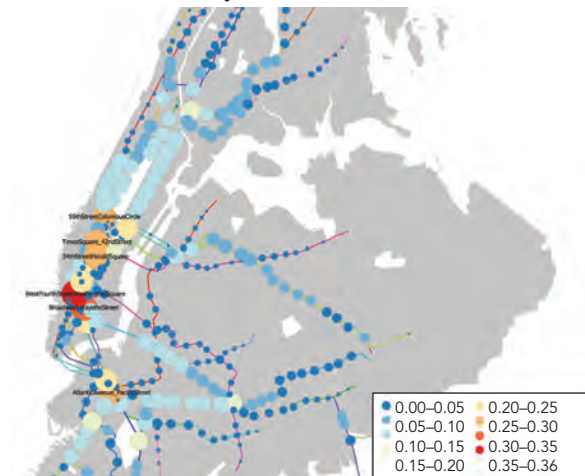
ideal location for creating a new CBD. As the Hudson Yards Master Plan Preferred Direction notes:

The planning for Hudson Yards anticipates a multi-decade-long time horizon for the redevelopment of the Hudson Yards (photos 5.2 and 5.3). This area is one of the great opportunities to secure the City's economic future in the global market place. It is anticipated that through decisive public sector actions, such as the expansion of mass transit, creation of character-defining open space, and reinvention of the area's zoning, these actions would spur the private investment that will sustain the livelihood of future generations of New Yorkers.

The Hudson Yards Redevelopment Project is a joint venture by New York City and New York State run by the Metropolitan Transportation Authority (MTA) to encourage development on Manhattan's Far West Side along the Hudson River. The project in-

PHOTO 5.2 Aerial View of the Hudson Railyards (West and East Yards)

Source: © Related Oxford. Used with the permission of Related Oxford. Further permission required for reuse.

PHOTO 5.3 Hudson Yards Worksite

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cludes rezoning of the Far West Side into a new high-density mixed-use neighborhood; extension of the No. 7 Subway; creation of new open space; and renovation of the Jacob K. Javits Convention Center. The centerpiece of the project is the development of a 11.3-hectare mixed-use real estate development by Related Companies and Oxford Properties over the John D. Cammermayer railyards (where the commuter trains that serve Long Island stay when they are not in service), split into Eastern and Western Yards. The original design of the yards foresaw the construction of a deck on top of them when market demand warrants it.

To complete the 28-acre Hudson Yards development, two platforms must be constructed to bridge 30 active Long Island Rail Road train tracks. Two subsurface rail tunnels will be used by Amtrak and New Jersey Transit. A tunnel box was constructed on the Manhattan side of the river to preserve the possibility of constructing a future trans-Hudson under river crossing. The foundations of the finished buildings extend through and rise above the platform. The platforms will cover approximately three-quarters of Eastern and Western Yards. Throughout construction, the Long Island Rail Road, Amtrak, and New Jersey Transit trains will remain operational.

The Eastern and Western Railyards will be a neighborhood with 1.6 million square meters of floor space. Half of the developed area will be open space. It is the largest private real estate development in the history of the United States and the largest development in New York City since Rockefeller Center was built, in 1939. It is expected that additional public investment in parks, mass transit, and infrastructure will turn it into one of the most livable areas of the city.

There is a precedent to the Hudson Yards project: Park Avenue. Responding to public outrage at the pollution and filth of the New York Central Railroad railyards in mid-Manhattan, in 1903 the state legislature passed a law requiring the railroad to "cover its tracks." In response, the railroad built a deck over the newly electrified tracks from Madison Avenue to Lexington Avenue, between E. 42nd and E. 56th streets. Down the middle of the deck a grand boulevard was built. It was crowned with a magnificent new train station, Grand Central Terminal. Over the next three decades, new hotels, office buildings, and apartments sprang up along Park Avenue, forming the core of what would become the world's greatest central business district. One hundred years later, the trains still run under Park Avenue, and 160,000 people earn their living in the blocks over the tracks (NYC Planning n.d).

Increasing Node Value

Public transit networks—their structure and how they connect people to people—completely change how people perceive distance and how businesses and jobs are located. Strategically located between 10th and 12th Avenues between W. 30th and W. 34th Streets, Hudson Yards is near the center of the metropolitan region.

The center of the metropolitan region offers connections to commuter rail service, the subway system, the West Side Highway, the Lincoln Tunnel, and ferries along the Hudson River. Penn Station, located nearby, is the busiest transportation facility in the United States, handling more than 600,000 New Jersey Transit, Long Island Railroad, and Amtrak passengers daily in 2015. The Port Authority Bus Terminal is the busiest such terminal in the United States, serving 200,000 passengers a day with 7,200 buses in 2015. Buses link the area to the region's three major

airports. Commuters from parts of New York and New Jersey can reach the Far West Side via ferry, with expansion plans allowing for trans-Hudson service for up to 60,000 passenger trips a day. Vehicular travelers can reach the Far West side via the Lincoln Tunnel (map 5.4).

Despite its location, Hudson Yards lacked direct mass transit connectivity west of Eighth Avenue. The development strategy entails critical infrastructure improve-

MAP 5.4 Access to Hudson Yards

a. Regional access map

b. Hudson Yards transit access map
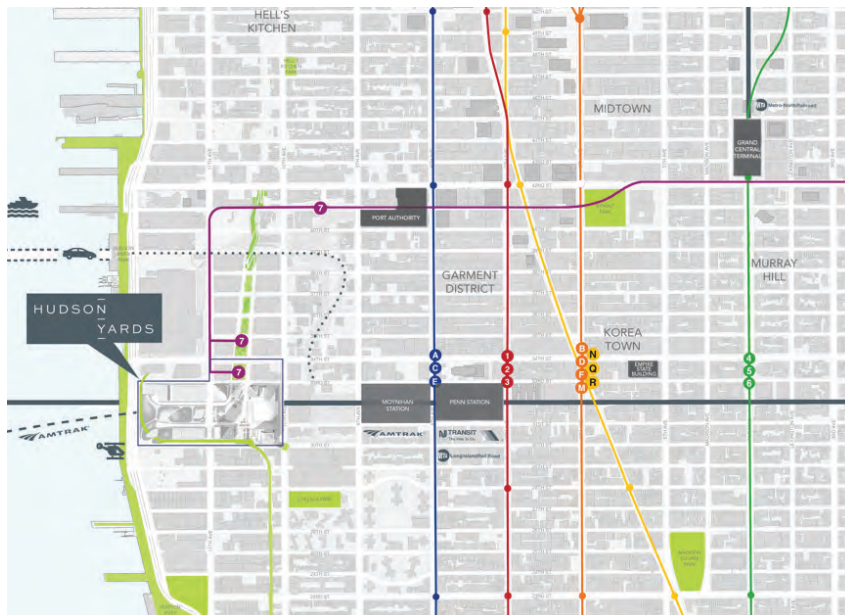
Source: © Related Oxford. Used with the permission of Related Oxford. Further permission required for reuse.

IMAGE 5.2 The New No. 7 Subway Station at W. 34th Street and 11th Avenue

Source: © Related Oxford. Used with the permission of Related Oxford. Further permission required for reuse. Image credit: BY-ENCORE.

ments to address this issue. These improvements include extending the No. 7 Subway to connect to the Port Authority Bus Terminal, and Grand Central Station; bringing Metro-North to Penn Station; mitigating traffic around the Lincoln Tunnel; and building a platform above the railyards for real estate development and pedestrian flows. The No. 7 Subway Extension west and south of its current terminus at Times Square, a $2.4 billion investment, added a new station at W. 34th Street and 11th Avenue (image 5.2).

Increasing Place Value

Numerous amenities near Hudson Yards—including Madison Square Garden, the Javits Center, and the Broadway theater district—already attract millions of visitors. The strategy for the development builds on these amenities, as well as the proximity of three parks.

Three dynamic parks and the High Line effect

Creating place value in Hudson Yards is based primarily on the design of public space. Half of the site is set aside for public open space (image 5.3).

The site connects directly with the High Line, an elevated park that quickly became the second most visited tourist attraction in New York, a dynamo for high-end real estate development, and an iconic architectural project (photo 5.4 and images 5.4–5.6). A revolutionary public space and urban revitalization project, the High Line is a plant-lined elevated parkway converted from a long-abandoned freight line snaking above the West Side of Manhattan. Designed by Diller Scofidio + Renfro, the 2.4-kilometer parkway, which sits 9 meters above street level, wraps

IMAGE 5.3 Public Square at Hudson Yards

Source: © Related Oxford. Used with the permission of Related Oxford. Further permission required for reuse.

PHOTO 5.4 New York's High Line
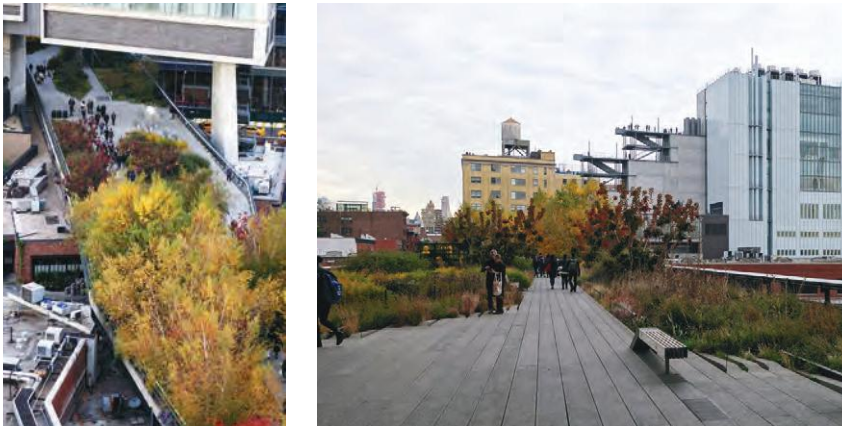
Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

around Hudson Yards as it curves toward the Hudson River, revealing sweeping waterfront views at its northern end. The High Line combines elements of the original railway with native flora and fauna. The characteristics of former tracks—flat, long, frequently running through historical areas—are appealing for various developments. New growth on the West Side can be attributed to the success of the High Line, which has spurred $2 billion of private investment, 12,000 new jobs, and 29 development projects since opening in June 2009.

The site will become one of the greenest neighborhood in the city (images 5.7 and 5.8). It connects to Hudson River Park, a five-mile long waterfront park that will

IMAGE 5.4 Hudson Yards Viewed from the High Line

Source: © Related Oxford. Used with the permission of Related Oxford. Further permission required for reuse.

IMAGE 5.5 Entrance to the High Line from Hudson Yards

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Image credit: BY-ENCORE.

provide open space, waterfront access, and walking and bicycle pathways. It is organized around the new Hudson Park and Boulevard Public Park (built at a cost of $30 million), creating a network of open space. The development also has easy access to a six-story building to host cultural activities (the Culture Shed) and a large public square (map 5.5).

IMAGE 5.6 **Hudson Yards and 520 W. 28th Viewed from the High Line**

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Image credit: visualhouse.

Mixed-use development

By 2024, when the project is completed, 125,000 people a day will work in, visit, or live in Hudson Yards. The neighborhood will include more than 1.6 million square meters of commercial and residential space, 5 state-of-the-art office towers, about 5,000 residences, a 750-seat public school, a unique cultural space, 5.6 hectares of public open space, a 175-room luxury hotel, restaurants, and more than 100 stores (image 5.9).

Smart city systems that make development connected, reliable, efficient, and responsive

Related Companies designed the area to be ready for the future: Communications will be supported by a fiber loop, designed to optimize data speed and service continuity for rooftop communications, as well as mobile, cellular, and two-way radio communications. This will allow continuous access via wired and wireless

MAP 5.5 Open Space at Hudson Yards

Source: Hudson Yards website. © Related Oxford. Used with the permission of Related Oxford. Further permission required for reuse.

IMAGE 5.7 Hudson Yards Looking West

Source: © Related Oxford. Used with the permission of Related Oxford. Further permission required for reuse.

IMAGE 5.8 Hudson Yards Looking South from the No. 7 Subway Station

Source: © Related Oxford. Used with the permission of Related Oxford. Further permission required for reuse.
Image credit: BY-ENCORE.

IMAGE 5.9 Neiman Marcus, on 10th Avenue

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broadband performance from any device at any on-site location. Whatever the disruption, Hudson Yards will have the onsite power-generation capacity to keep basic building services, residences and restaurants running. Buildings at Hudson Yards are connected through a micro grid allowing them to be heated and cooled by their own equipment or that of their neighbor.

Social diversity

Local affordability was a major concern with earlier transferrable development right schemes in New York, since commercial densification had historically paid little attention to ensuring the interest of local communities, which would suffer from rising costs and increasingly unaffordable living options. In the context of Hudson Yards, social diversity has been emphasized as a principle, even if market-rate residential units at Hudson Yards are expected to sell for $20,000–$35,000 per square meter and the retail and commercial space will be expensive.

Flexibility and development bonuses are offered to developers for providing affordable housing. Some affordable rental apartments were allocated by lottery in 2016. More affordable units might be delivered later, but Related Companies focused first on commercial development. It leased all of its properties with high-end tenants.

Increasing Market Potential Value

Responding to market demand through a well-located underutilized area

The market potential value of a station area is assessed by identifying the unrealized market value around it and estimating market demand at the city level (see chapter 2). New York City, particularly Manhattan, has strong needs for new office space in well-connected areas. Manhattan is also one of the United States' tightest housing markets, with an estimated vacancy rate of 2.87 percent in November 2015 (Carmiel 2015). People in New York City are clustered at high densities in the areas with the highest accessibility to jobs and to Manhattan in 30 minutes. According to census data, Manhattan gained about 100,000 residents between 2000 and 2014 (increasing its population from 1.54 million to 1.64 million). Demand for new housing is great and expected to grow.

The enhancements of node value and place value on the Far West Side will unleash the high market potential of the area. Increasing the connectivity of and creating jobs in Hudson Yards will be a catalyst for development of the entire Far West Side. The number of accessible jobs will increase significantly beyond the boundaries of the project itself, fostering increases in human densities (people + job densities) and land and real estate development.

The proximity to Midtown Manhattan is the most compelling market potential value asset of the Far West Side, since the area can be seen as a natural extension of this existing market, providing convenient access to clients and other business services in Midtown, and a tremendous advantage in terms of bridging the psychological barriers that affect firms' locational choices. This untapped market potential value has been unleashed through rezoning of the area. Previous zoning was for low-density industrial uses. The maximum floor area ratio of 5 was not enough to encourage private investment in commercial development.

The Far West Side has adequate space to accommodate a large-scale office district. It is a remarkably underdeveloped area of Manhattan, with 128 unbuilt lots and 27 hectares of vacant development space. After rezoning, the area can easily accommodate at least 2 million square meters of new office development, as well as other commercial, residential, and retail uses.

When preparing the Master Plan for Hudson Yards, New York City identified the vision and driving direction for the development of the overall area (the Preferred

Direction 2003), including zoning for appropriate densities and uses. This Preferred Direction directs the highest density to the areas that will most benefit from subway access—namely, the regional 42nd and 34th streets and across from the Javits Convention Center. The rezoning strategy seeks to preserve the Ninth Avenue scale by keeping the density near existing levels. The Ninth Avenue is separated from the higher density areas by a band of moderate density areas (maps 5.6 and 5.7). In 2009 the West Side Yard was rezoned.

MAP 5.6 **Hudson Yards Land Use Plan**

Source: © Hudson Yards Development Corporation. Used with the permission of Hudson Yards Development Corporation. Further permission required for reuse. Source: Hudson Yards Master Plan Preferred Direction, New York City 2003.

MAP 5.7 **Hudson Yards Master Plan, 2016**

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Flexible zoning and tax abatement

Adapted zoning in Hudson Yards sets varied FARs for predominantly commercial, mixed-use, and predominantly residential in order to introduce flexibility and capture value. Developers of commercial or residential projects in the Hudson Yards area have an opportunity to receive a zoning bonus that would allow their project to exceed the base maximum FAR (or "as-of-right") established in the zoning resolution by making a District Improvement Bonus (DIB) payment to the Hudson Yards District Improvement Fund (about $1,350 per square meter), through transfer of development rights, or through provision of inclusionary housing (image 5.10). The inclusionary housing bonus for specific parts of the development allows 10–15 percent of the development to be affordable to low-, moderate-, or middle-income families (maps 5.8 and 5.9 and image 5.11). The New York City Industrial Development Agency's (NYCIDA) Uniform Tax Exemption Policy (UTEP) also includes financial incentives, including real estate tax discounts, for commercial development projects in the Hudson Yards area (map 5.10).[4]

Financing structure for public spaces and connecting infrastructures

The cost of phase 1 infrastructure was initially estimated at $1.763 billion for the No. 7 Subway Extension, $351 million for Eastern Railyard platform, and $361 million for open space and streets (HYIC 2004). Cost estimates for phase 2 were $250 million for the No. 7 Subway 41st Street Station and $271 million for the midblock boulevard and parks. The total cost of public spaces for the 2 phases was estimated at $632 million. Total infrastructure costs for the 2 phases with the subway

IMAGE 5.10 Options to Increase Floor Area Rations Against Contributions
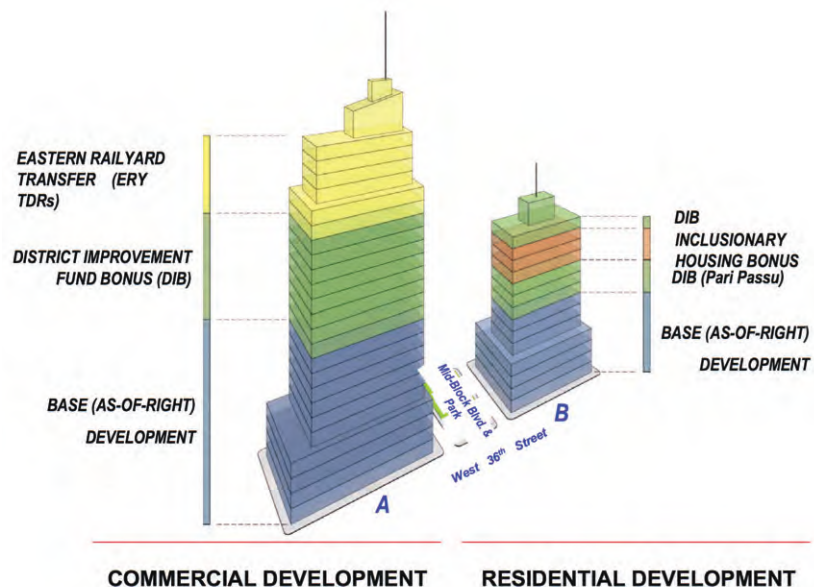
Source: Image used with permission of the New York City Department of City Planning. All rights reserved.

IMAGE 5.11 Affordable Housing Percentage Against Additional Floor Area Ratio

MAP 5.8 Inclusionary Housing Area at Hudson Yards

MAP 5.9 Uniform Tax Exemption Policy (UTEP) for Hudson Yards
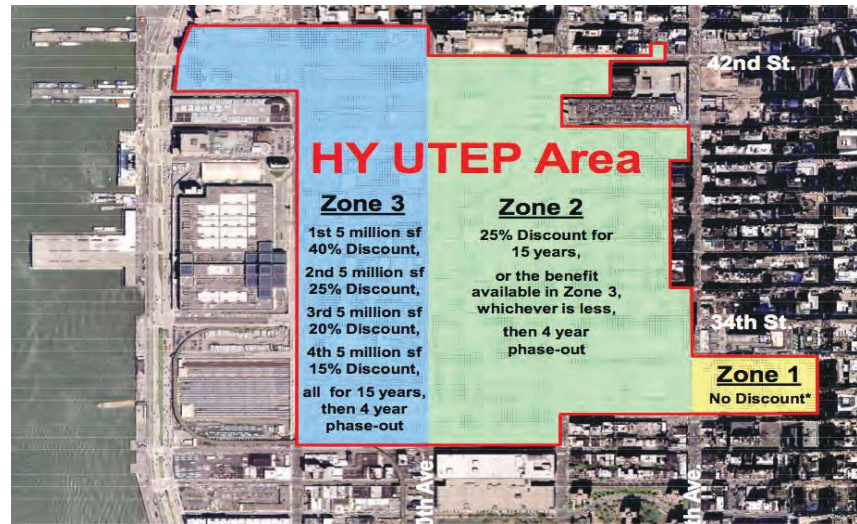
extension was estimated at about $3 billion. The new 34 St-Hudson Yards No 7 line Station opened September 13, 2015. Although a new station at 10th Avenue and 41st Street was part of the original plan, the intermediate station was eliminated in October 2007 due to cost overruns, leaving the terminal station at Eleventh Avenue and 34th Street as the only new station on the extension.

The Hudson Yards Investment Corporation (HYIC), a local development corporation, was created in 2005 under the Not-for-Profit Corporation Law of the State of New York to finance certain property acquisition and infrastructure development, including the No. 7 Subway Extension. The Hudson Yards Development Corporation (HYDC) is a local development corporation created by the city to manage and implement the project. The two corporations have separate financial statements.

HYIC collects revenues, including payments in lieu of taxes (PILOT) and district improvement bonuses from private developers and appropriation from the city; pays principal and interest on its bonds; and disburses bond proceeds to pay project costs. Its revenue streams include interest support payments by the city; PILOT; tax equivalent payments for property taxes on new residential development in the project area; district improvement bonuses against additional density; and payments in lieu of mortgage recording (PILOMRT). Under the support and development agreement between HYIC, HYDC, and the City, the City agreed to make payments, subject to annual appropriation, in an amount sufficient, together with HYIC other revenues, to pay interest on outstanding bonds (HYIC 2015).

HYIC acquired a 50 percent interest in the Eastern Railyards Transferable Development Rights (TDR), allowing developers to build larger buildings than otherwise permissible under zoning law. The proceeds received by HYIC for the sale of the

FIGURE 5.1 Projected Revenues and Debt Service Associated with Hudson Yards, 2005–35
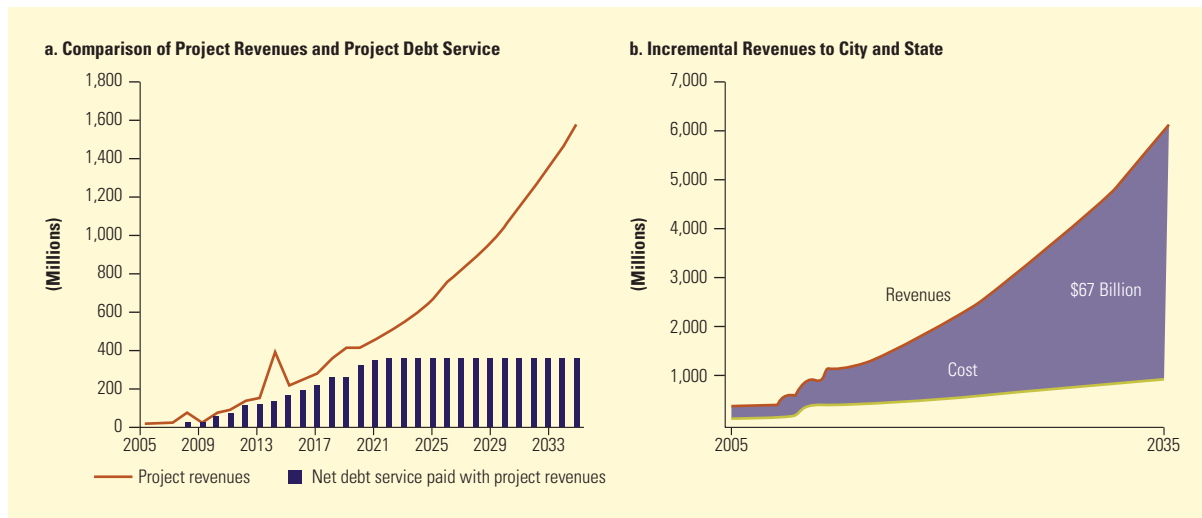
Source: Hudson Yards Development Corporation July 12, 2004. © Hudson Yards Development Corporation. Used with the permission of Hudson Yards Development Corporation. Further permission required for reuse.

TDRs up to the amount of HYIC's investment (including total purchase price and interest costs) will be used to support its operations and service its debt.

By the end of 2006, $3 billion of Hudson Yards bonds had been sold, making the project fully financed. Of this amount, $1 billion were sold in October 2011. They were rated A by S&P and Fitch, and A2 by Moody's. Another $2 billion of bonds were sold in December 2006, with similar ratings.

In 2008 the commercial real estate market crashed. The MTA started negotiations with selected developers before the crash (Related was not the first team selected; originally Tishman was selected). The real estate crash delayed the project, because developers were unable to secure financing. Eventually the City Council had to vote to pay for a few more years of debt service payments.

New development will generate various streams of revenue that are expected to cover these costs over time. It is expected that these streams of revenue will largely cover the debt service and that the project will generate cumulated incremental revenues to City and State of $67 billion between 2005 and 2035 (figure 5.1).

Notes

1   The chapter is based on public information and information from Related Companies and Oxford Properties, the developer of Hudson Yards.
2   The report, prepared by Appleseed, a New York City-based consulting firm that provides economic research and analysis and economic development planning services to government, non-profit and corporate clients, finds that Hudson Yards will be a significant contributor to New York City and Metropolitan Transportation Authority (MTA) revenues, both during and after construction.

3   A report on Paris documents the correlation between the number of people who can access a given location and the density of companies. It shows the impact of transit accessibility on firms' locational choices (Salat and Bourdic 2015). A report on London shows a similar correlation between the number of people who can access a borough in 45 minutes by transit and the employment density in the borough (GLA 2004).
4   To learn more about this program, refer to the complete NYCIDA Uniform Tax Exemption Policy (see appendix F for the Hudson Yards incentives).

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Creating High Node and Place Values: King's Cross in London

This case study shows how the dynamic power of imbalances between node and place values can trigger massive regeneration of a former industrial area, creating a major new economic node. King's Cross is a mixed-use, urban regeneration project (map 6.1) in Central London and a major transport hub. The site is an interchange station with six London metro lines, two national train stations (King's Cross and St Pancras [photo 6.1]), and an international high-speed rail line (HS1) connecting to Paris, making it the most connective hub in Central London. Investment in high-quality public space and local pedestrian connectivity and mixed-use development triggered a strong market response, raising market potential.

In 1996 strategic planning guidance for London identified King's Cross as one of five "central area margin key opportunities." It called for mixed-use development, with an intensification of densities and commercial uses close to the station, as well as urban regeneration and support to local communities, including a housing program (some of it affordable housing) and community facilities. Planners also called for maintaining and enhancing features of historic and conservation importance to create a neighborhood with a distinct character, identity, and image.

The area of opportunity for urban regeneration spanned over 27 hectares of fragmented land and old industrial buildings located on the site of former rail and industrial facilities to the north of the transport hub and in front of the two rail stations (photo 6.2). Redevelopment has involved restoration of historic buildings and new construction. The site has been regenerated and made attractive by provision of ample public spaces. The plan increases local connectivity, accessibility, and permeability, with a dense pattern of internal streets. It creates high place value,

MAP 6.1 King's Cross Master Plan

PHOTO 6.1 Transformation of St Pancras Station

Source: © John Sturrock. Used with the permission of King's Cross Central Limited Partnership. Further permission required for reuse.

PHOTO 6.2 Rebuilding of the Space in Front of St Pancras and King's Cross Stations

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with 10.5 hectares of open space, 316,000 square meters of office space, almost 2,000 residential units (42 percent of which are affordable housing), 46,400 square meters of retail and leisure space, a hotel, and educational facilities.

This chapter provides an overview of King's Cross, based on the 3V Framework. It reviews the node, place, and market potential values of the area and the approach taken to capture some of the resulting increase in value.

MAP 6.2 Accessibility of King's Cross within London and within Europe

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Increasing Node Value

King's Cross Station, in the core of London, is a major interchange station at the scale of the city, the United Kingdom, and Europe (map 6.2). It has one of the highest node values in Europe, with very high levels of connectivity and accessibility. Five international airports are within an hour, including three with direct connections to King's Cross. King's Cross is also the biggest inner-city transit interchange in London, linking 6 metro lines and 17 bus routes.

King's Cross—together with the St Pancras and Euston stations—is expected to function as the principal transit center for London. The 2004 London Plan expected that with the completion of the Channel Tunnel Rail Link-High-Speed 1 (HS1), the Thameslink 2000, and the Cross River Tram, King's Cross will become the most accessible station in Greater London. The decision in 1996 to move Britain's first high-speed railway, the Channel Tunnel Rail Link, from London Waterloo Rail Station to St Pancras provided the catalyst for landowners LCR and Exel (now DHL) to develop the King's Cross site.

The Western Concourse between King's Cross and St Pancras stations is designed as a public plaza with legibility, linkage, and transparency (photo 6.3). Like the British Museum's Great Court (photo 4.4), the space acts as an internalized exterior, where the sky is materialized by an impressive architectural structure and the façade acts as a wall.

Increasing Place Value

After the King's Cross site became an integral part of HS1 development in the late 1990s, plans to redevelop the site became a real possibility. Lack of market appetite

PHOTO 6.3 **The Western Concourse between King's Cross and St Pancras Stations**

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had postponed such plans multiple times in earlier decades. To the north of the two train stations lay 27 hectares of former rail and industrial facilities. There was thus a strong imbalance between very high connectivity about to emerge and low intensity of land use. This imbalance opened an opportunity to increase place value by redefining, reshaping, and creating value on former rail land to the north of the two stations and transforming King's Cross Square in front of the stations (photo 6.4).

King's Cross is a unique development from a planning perspective. It took almost six years to design, negotiate, and receive planning consent. Four rounds of public consultations were held, involving some 30,000 people. The developer and government listened and adapted the scheme based on feedback.

PHOTO 6.4 **The Welcoming King's Cross Square**

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

Keeping the Master Plan Flexible

Two master planning teams and four independent design review panels led to a highly tailored scheme that responded to the needs of multiple stakeholders. Planning balanced the developer's long-term aspirations to create and manage a long-term asset and the local authority's desire to integrate it into the deprived communities that surrounded the area through urban regeneration. The developer started from a blank piece of paper, built the scheme based on principles and precedents, and realized its vision in the master plan (see map 6.1).

The master plan unifies the site with a comprehensive vision, but it is flexible enough to accommodate change. This flexibility will enable King's Cross to adapt to changes in social and technological trends. Development is not functionally locked into the needs and technologies of today but has been left enough margin to evolve with needs and market shifts. Changes in the proportions of uses and transformation of buildings to respond to changes in market conditions have been integrated in a planning conceived more as a continuing process than as a once and for all exercise.

To balance this adaptability and maintain continuity, order in space, and identity, key physical aspects of the site were fixed. Streets and public spaces, the most resilient features of neighborhoods, were defined. To create visual order in space and avoid out-of-proportion construction that would obstruct views and the flow of well-defined public space, maximum and minimum building heights were fixed in various zones. These standards ensure consistency in density and scale throughout the site. To provide a sense of unity, uniqueness, and harmony while allowing for diversity and variety, design guidelines describing building techniques, materials, and how materials can be used were also established.

Planners have been careful not to be too prescriptive about the tone, character, and feel of the area. Instead, specific details of the new district have been allowed to emerge over time, aided by a master plan that allows room for flexibility, negotiation, change, and experimentation with occupiers and activities (ULI 2014).

Attracting High-Tech Companies

The high-quality development attracted Google, which spent about £650 million to buy and develop a 1-hectare site on a 999-year lease from King's Cross Central Limited Partnership, the partnership developing the site. The finished development (93,000 square meters) will be worth up to £1 billion. Several thousand staff will occupy the low-rise structure. Google's U.K. headquarters will be its largest office outside its corporate headquarters in California. The building includes 4,650 square meters of ground-floor retail. Google's presence is expected to draw other technology companies, especially small start-ups, and help bump up rents.

Combining High Density with Medium-Size Buildings

High density at Kings Cross is achieved not through high-rises but through 50 medium-size buildings designed at human scale. The high density, mixed-use, infill redevelopment with an average floor area ratio (FAR) of 4.6 at block scale com-

PHOTO 6.5 Blending of Heritage and Modernity at King's Cross

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bines heritage and new buildings (map 6.3). Twenty heritage buildings are being retained and refurbished as shops and restaurants. Their color and character reflect the unique nature of the development, which blends historic and contemporary architecture (photo 6.5).

Reshaping the Image of King's Cross

Image exerts a powerful influence over site development. The density of accessible local amenities, cultural and leisure assets, and green spaces increases place value. Developing a mix of land uses contributes to a location's success and reduces the developer's risks. Mixed-use schemes are more adaptive to market changes if enough flexibility is allowed to shift uses. Such schemes allow developments to quickly establish themselves within an emerging urban neighborhood with an appealing sense of place.

According to the King's Cross Public Realm Strategy: The area in and around King's Cross has been in constant evolution and is marked by its history as one of the first "intermodal" hubs in the United Kingdom, with connected water, rail and road modes of transport. Its character reflects directly its history, forming one of the most significant groupings of early Victorian buildings in London. These existing buildings and structures have been very influential in the layout of uses across the site.

One-quarter of King's Cross is dedicated to cultural and leisure uses. The historic fabric was embedded in the plan in a sophisticated manner, rather than merely preserved. Every building has a new use and a relationship to its neighbors and the spaces in between (photos 6.6 and 6.7).

MAP 6.3 Mixed-Use Development at King's Cross

COMMITTED BUILDINGS AND OCCUPIERS

1. **URBANEST**, STUDENT HOUSING
2. **AKDN**, STUDENT HOUSING
3. **SAXON COURT**, RESIDENTIAL
4. **ROSEBERRY MANSIONS**, RESIDENTIAL
5. **RUBICON COURT**, RESIDENTIAL
6. **AKDN**, EDUCATIONAL BUILDING
7. **AKDN**, OFFICES
8. **TAPESTRY**, RESIDENTIAL, THE ENERGY CENTRE AND CAR PARK
9. **PLIMSOLL BUILDING**, RESIDENTIAL, PRIMARY SCHOOL AND FRANK BARNES SCHOOL FOR DEAF CHILDREN
10. **AKDN**, CULTURAL, EDUCATION AND HOTEL
11. **GASHOLDER NO.8**, URBAN PARK
12. **GASHOLDER TRIPLET**, RESIDENTIAL
13. **THE GRANARY COMPLEX**, CENTRAL SAINT MARTINS SCHOOL OF ART AND DESIGN
14. **MIDLANDS GOODS SHED**, WAITROSE AND OTHERS
15. **HANDYSIDE GARDENS**
16. **ARTHOUSE**, RESIDENTIAL
17. **WEST HANDYSIDE CANOPY**, EVENTS SPACE
18. **WESTERN TRANSIT SHED**, RESIDENTIAL MARKETING SUITE, KX RECRUIT, KING'S CROSS VISITOR CENTRE, ARGENT, HOARE LEA, ZONE, OFFICE AND RETAIL
19. **THE GRANARY**, UNIVERSITY OF THE ARTS LONDON
20. **REGENERATION HOUSE**, THE ART FUND, HOUSE OF ILLUSTRATION
21. **COAL DROPS YARD**, RETAIL
22. **GRANARY SQUARE**
23. **FISH & COAL**, JAMIE OLIVER GROUP, OFFICE, RETAIL
24. **FIVE PANCRAS SQUARE**, LB CAMDEN OFFICES, LEISURE CENTRE AND PUBLIC LIBRARY
25. **GOOGLE**, OFFICES
26. **TWO PANCRAS SQUARE**, OFFICES
27. **BNP PARIBAS REAL ESTATE**, SIX PANCRAS SQUARE, OFFICES
28. **ONE PANCRAS SQUARE**, OFFICES
29. **SEVEN PANCRAS SQUARE**, THE OFFICE GROUP
30. **GERMAN GYMNASIUM**, RESTAURANT
31. **GREAT NORTHERN HOTEL**
32. **PAVILION RESTAURANT AND BAR**

Source: Argent 2014b © King's Cross Central Limited Partnership. Used with the permission of King's Cross Central Limited Partnership. Further permission required for reuse.

The tranquility of the canal and the views to the Camley Street Natural Park offer a contrast with the new shops and cafes in the Coal Drops (a former coal transfer point between rail and wagons and road carts) and Granary Square. A new pedestrian bridge across Regent's Canal and other links have been created to "capitalize upon the canal's positive contribution to King's Cross and to bring life to the canal, enhance its character, wildlife value and recreational use and improve access and safety" (Argent 2002).

Creating High-Quality Public Space

The public realm is a physical and social entity that comprises the spaces between buildings and the activities happening in them. It is at the heart of the King's Cross concept:

[Public realm] means an arrangement of routes and public spaces—be it traditional streets and squares or other links and connections—to and through the surrounding city. Establishing the right framework is very im-

PHOTO 6.6 **Children Playing at Granary Square, the Canal Side Heart of King's Cross**

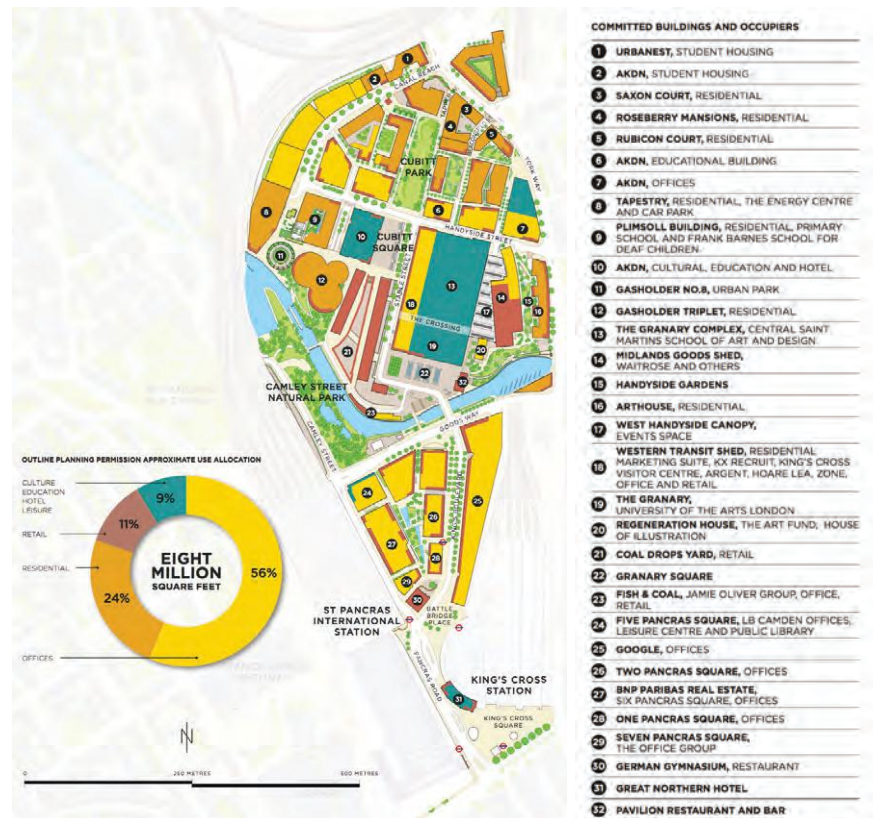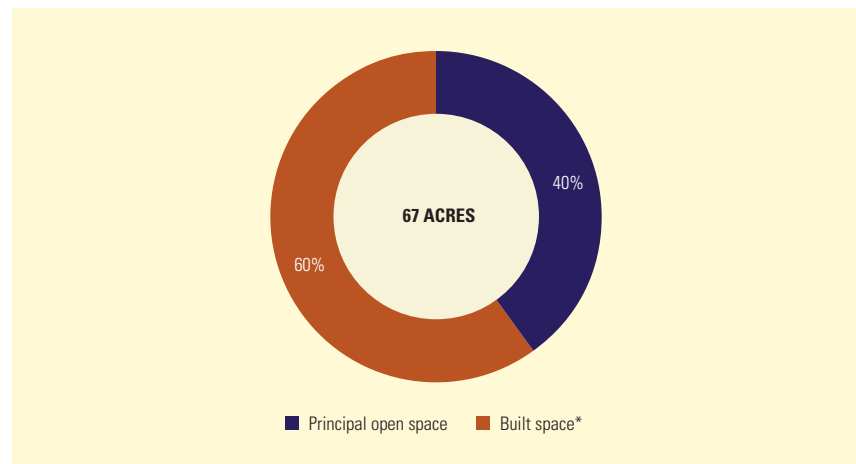*Source:* © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

PHOTO 6.7 **Regent's Canal, an Integral Part of the King's Cross Development**

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

FIGURE 6.1 Proportion of Built and Open Space at King's Cross

Source: Argent 2014b. © King's Cross Central Limited Partnership. Used with the permission of King's Cross Central Limited Partnership. Further permission required for reuse.
* Built space includes associated public spaces such as courtyards and gardens.

portant. It will provide the template, over time for buildings, new land uses and activities. (EDAW and others 2004)

The design aims at achieving an attractive and legible public realm—"a busy, thriving and exciting destination; a confluence of people and activity; an outstanding place to live, work, or just be" (EDAW and others 2004).

King's Cross Central is built around the social, functional, and symbolic importance of the public realm in providing spaces for people to meet and spend active and leisure time. The public realm is high grade, but it is not just corporate design to create high-priced rentals. It is also meant to be a part of London—open, democratic, and accessible.

In total, some £2 billion will be invested in local transport infrastructure and the public realm, including £250 million for 20 new streets, 10 new public spaces, and 5 major squares totaling 3.2 hectares. The planning team "spent a lot of time thinking about the spaces in between buildings, about how people would use those spaces" (ULI 2014). Some 40 percent of the development will be devoted to open space (figure 6.1). Some of the built space will also include public spaces, such as courtyards and gardens.

The design of King's Cross connects people to people with a continuum of outdoor areas and in some cases large indoor areas, such as the west concourse at the King's Cross Station. It encompasses streets, parks, squares, pedestrian areas, canal promenades, cycle paths, and trails as a continuum of interconnected spaces that can support a wide variety of activities. A goal is to generate pedestrian movement and activity.

King's Cross illustrates how both high-quality design and long-term management strategies help create a good public realm. The continuous flow of spaces,

PHOTO 6.8 **High-Quality Design and the Blending of Old and New at King's Cross**

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routes, and views and the vibrancy of interactions within the public realm is supported by high-quality detailing that creates a rich and constantly changing information and activity field for pedestrians. Special attention to paving, planting, orientation, light and shadow, shelter, signage, and street furniture makes spaces accessible, safe, and legible (photo 6.8).

Ensuring Unrestricted Use of the Public Realm

According to the King's Cross Central Public Realm Strategy (EDAW and others 2004):

> The traditional heart of civic life is centered on the town-square, the high-street and town-park, elements of the public realm, around which community life revolves and civic pride is focused. Civic space traditionally suggested a mode of behavior reflecting either the importance or use of the space, or the civic function of the day. Hence a town-square may be a market place one day and a place of remembrance on the next.

Argent, the developer, sought to achieve this civic meaning of the public realm by following other London examples of unrestricted use of the public realm that is owned and managed privately balancing access and quality, and managing the space with the public in focus.

Clear definition between the public realm and the private domain is provided at King's Cross with built form rather than walls, fences, or planting. Where it was desirable to limit access or use to residents or employees, features such as rumble strips, different road surface (by color or texture), pillars, and narrower carriageway were used to delimit the private space and give the impression that the area beyond is less public and more private.

Creating Active Streets

The King's Cross design creates active streets with retail stores, bars, cafes, and restaurants to keep the neighborhood lively throughout the day. All ground-floor units are, or will be, leased to these types of occupants. But the approach goes beyond individual streets within King's Cross Central. It creates a network of safe pedestrian routes that connect key sites in the development and closely connect the development with the surrounding communities in Camden and Islington (map 6.4).

The site design includes a variety of promenades for various time of day and types of people, each with a different emphasis or theme (as represented by the colors on the site map [map 6.5]). These trails integrate places for people to walk or linger. Tiered stone seating and steps cascade from Granary Square to Regent's Canal, enhancing the south-facing aspect and reinforcing the historic relationship between the canal and the Granary, the geographic heart and heritage soul of King's Cross (photo 6.9).

To the west of the site is Camley Street Natural Park (photo 6.10). Created within a relatively small space, it expresses a unique fusion between Central London's density, rich industrial archaeology, green space, and nature conservation. The focal point is a floating platform that brings architecture and nature closer together, allowing people to take in unrivalled views of both Regent's Canal and the Camley Street Natural Park. Inspired by the rocky islands off the Nordic coastline, the platform is an important new learning facility for the park.

MAP 6.4 **Active Streets at King's Cross**
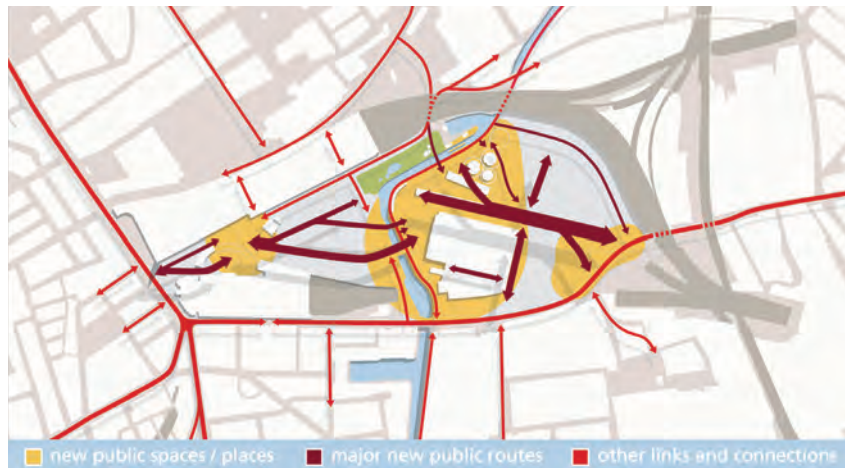
Source: EDAW and others 2004. © King's Cross Central Limited Partnership. Used with the permission of King's Cross Central Limited Partnership. Further permission required for reuse.

MAP 6.5 **Promenades at King's Cross**

Source: EDAW and others 2004. © King's Cross Central Limited Partnership. Used with the permission of King's Cross Central Limited Partnership. Further permission required for reuse.

Increasing Market Potential Value

Flexible use and a clear focus on fostering market value, have enabled value capture as shown in this section drawing on Suzuki and others (2015).

Ensuring Flexible Uses to Adapt to Market Conditions

The agreement for the redevelopment of King's Cross set floor space maximums stimulating diverse site use (table 6.1). The agreement allows for flexibility in land

PHOTO 6.9 Tiered Stone Seating and Steps Cascading from Granary Square to Regent's Canal

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

PHOTO 6.10 Floating Platform at the Camley Street Natural Park at King's Cross

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

TABLE 6.1 **Floor Space Maximums at King's Cross, by Use**

Use	Floor space (sq. m.)
Mixed-use development—total permissible	739,690
Offices	Up to 455,510
Retail	Up to 45,925
Hotels/served apartments	Up to 47,225
D1 (nonresidential institutions)	Up to 74,830
D2 (assembly and leisure)	Up to 31,730
1,900 homes	Up to 194,575

Source: Suzuki and others 2015.

uses to enable the developer to adapt to market conditions, as redevelopment is likely to take 10–15 years to complete. Use within the total floor space is allowed to vary by 20 percent; floor space allocated to one use can be traded against another, to a limited extent.

Financing and Fostering Market Potential Value

King's Cross is funded through a combination of equity, debt, and recycled revenues. Cash flow management has enabled the partnership's equity to be used across a variety of projects to create demand and interest from potential buyers. The total estimated value of the entire King's Cross project, including construction, professional fees, and interest, is expected to reach £3 billion (ULI 2014).

The partnership has made £250 million of investments in public realm infrastructure since 2009, unlocking 557,000 square meters of development. Equity funding went toward creation of the public realm, including new roads (including King's Boulevard), new public spaces (including Granary Square), a new bridge across Regent's Canal, canal side improvements, and the Energy Centre and its district heating and distribution networks. The King's Cross Central Limited Partnership also signed a £100 million construction contract with the University of the Arts, which will build a campus at King's Cross (ULI 2014).

About £300 million of debt secured since 2009 has been used to finance some of the direct construction costs of residential and office buildings. This debt package, from four leading banks, provided loans for three commercial buildings, the final phases of infrastructure, and 272 apartments. The U.K. Homes and Communities Agency provided £42 million in public funds to support affordable housing (ULI 2014).

After development, the new balance between high node value and high place value is expected to foster high market potential value, with rental and real estate performance exceeding that of London as a whole.

Capturing Value

One key land value capture technique adopted by local governments in England and Wales is of Section 106 of the Town and Country Planning Act of 1990. It

FIGURE 6.2 Stakeholders in the King's Cross Land Value Capture Scheme and Section 106 Agreements
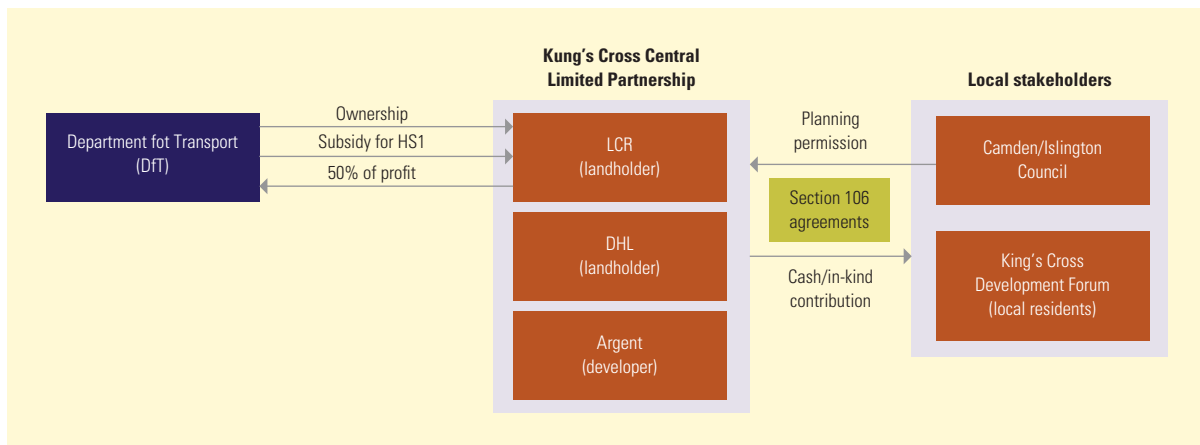
Source: Suzuki and others 2015.
Note: HS1 = High-Speed 1; LCR = London and Continental Railways.

provides a means for local authorities to negotiate agreements or planning obligations with landowners or developers in return for the granting of planning permissions to offset the negative impact of development.

Section 106 agreements have been crucial in incorporating desirable planning principles into public-private funding and property development at King's Cross. They underscore the importance of balancing interregional business marketability and local community livability with public-private partnership–based infrastructure funding and property development (Suzuki and others 2015).

Section 106 agreements include cash and in-kind contributions by the developer to the local authority (Camden Council) for local infrastructure, public space, and community services (figure 6.2). The package includes £2.1 million to create 24,000–27,000 local jobs through a construction training center and skills and recruitment center; 1,900 homes, more than 40 percent of which will be affordable housing; cash and in-kind contributions for community, sports, and leisure facilities; new green public spaces, new landscaped squares, and well-designed and accessible streets, which account for about 40 percent of the entire site; a new visitor center, education facilities, and a bridge across the canal to link streets; and cash contributions to improve adjacent streets, transit stops, and bus services (Camden Council 2006).

Under the supervision the Department for Transport, London & Continental Railways (LCR) has been mandated to maximize its long-term asset value. Its development strategy has been to use its major sites as equity to participate in joint-venture development companies that can make long-term profits through urban regeneration around HS1 stations (chiefly King's Cross and Stratford). Opportunity areas were identified and regeneration proceeded after the local authority approved the plans in 2006, with an initial target completion date of 2016.

As part of the construction of the HS1 project by LCR, the Department for Transport provided financial assistance to the then private LCR to cover part of the construction costs, the project's debts, and the operations of LCR and its subsidiaries. LCR was also granted property development rights around the King's Cross and Stratford Stations. This arrangement was to continue until the concession contract expires in 2086, at which point the assets would return to the government. Based on the 1996 arrangement between the government and LCR, the Department for Transport expected to receive half of LCR's net profit after deducting the costs for the King's Cross development scheme (Suzuki and others 2015).

The developer (Argent) was selected as a private partner in 2001. It entered into a joint collective ownership acquisition and development agreement with the landowners, in a deal that included an agreement that the land be valued following the approval of planning permission and completion of HS1. Upon valuation, Argent would have the option to acquire the land from the landowner or enter into a 50/50 partnership with it. The price paid by Argent was to be discounted based on the land open market value, with the discount increasing as the value of the land rose.

The deal incentivized Argent to optimize the value of the scheme. Under the agreement, land value would be established once the landowners (LCR and DHL) provided vacant property (which they were to do after HS1 was completed and open) and the developer completed its planning, submitted a viable business plan, and secured funding. The agreement was designed to be concluded when certainty had been delivered by all parties. The London Borough of Camden granted planning permission for regeneration in 2006, and LCR, Argent, and DHL jointly formed the King's Cross Central Limited Partnership in 2008 (Suzuki and others 2015).

A long-term development partnership was created in which Argent owns a 50 percent interest, the government-owned LCR holds a 36.5 percent interest, and DHL Supply Chain (formerly Exel) holds a 13.5 percent stake. Argent brought the backing from a large pension fund (BTPS, managed by Hermes Investment Management), essential for the private development of the site.

In 2009 the Department for Transport took over LCR, which had accumulated too much public debt in the construction of HS1. Following the concessioning of HS1, LCR was restructured into a property development and management company in 2011. A central feature of LCR's current business profile is that returns from its property interests are expected to be mainly in the form of capital appreciation over the next 5–10 years.

By March 31, 2014, six years after the actual development had started, more than 57 percent of the redevelopment project by floor area had been either completed or committed. Redevelopment continued to proceed apace, and financial contributions to LCR began. In January 2015, LCR sold its stake in the project to an Australian pension fund for £371 million, according to the company's audited statements. DHL did the same. Increases in the profit contributions and investment carrying value arose predominantly from disposal and reevaluation of investment properties. LCR also lent funds to the King's Cross Central Limited Partnership for regeneration.

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Increasing Connectivity and Economic Value along a Transit Line: Crossrail in London

In 2009, the United Kingdom and London initiated construction of Crossrail, one of the largest rail infrastructure projects in Europe. The first part of the network (the Elizabeth Line) is scheduled to open in December 2018 (map 7.1).

The new train line will deliver a much-needed increase in rail capacity—but it is much more than a new rail link. It is an infrastructure scheme that fully integrates regeneration and wider economic benefits into its business case and activities. By bringing an additional 1.5 million more people within a 45-minute transit ride from job clusters, Crossrail will increase inclusiveness and integrate more people into London job market. The project is expected to become a catalyst for urban regeneration in key locations and a driver of London's economic growth. Crossrail has spurred urban regeneration across its network of 40 stations.

This case study shows how node and place values vary along the new line, triggering different market potential and responses. The most central station areas, where job concentration and connectivity is already extremely high, are the main beneficiaries of high market potential increases. Market opportunities are also possible in fringe areas, provided the right development strategies are put in place.

London's Booming Population and Economy

London is the world's leading center for international business and commerce and one of the "command centers" of the global economy. It has the fifth-largest city economy in the world (after Tokyo, New York, Los Angeles, and Seoul) (Parilla and

PHOTO 7.1 Canary Wharf at Canada Square on the Crossrail Line

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others 2015), with gross value added of £364 billion in 2014 (£42,666 per capita). The city's economy is roughly the size of Sweden. London is projected to be the world's second most competitive city (after New York) in 2025 (Economist Intelligence Unit 2013).[1]

MAP 7.1 London's Elizabeth Line
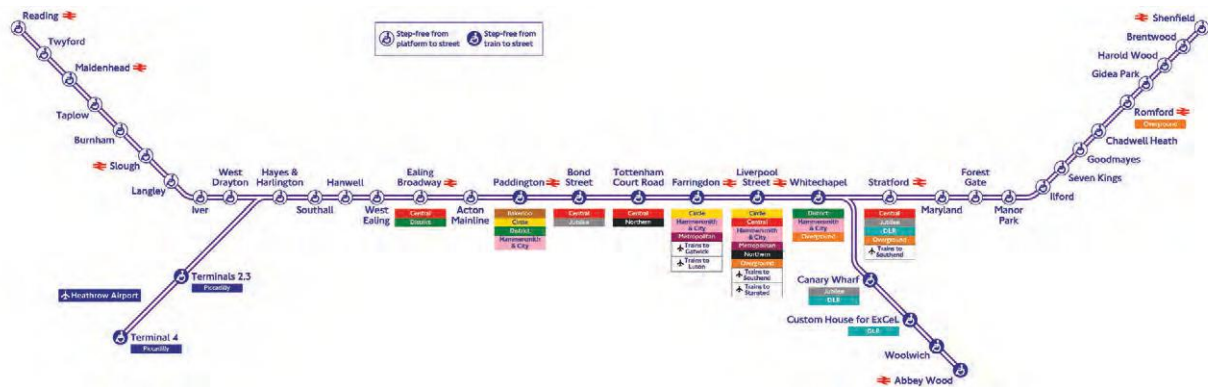
Source: © TfL. Used with the permission of TfL. Further permission required for reuse.

London's booming population is set to break the 9 million mark within the next decade. The London Plan 2016 projects that the city will add nearly 1.1 million people in working age and 900,000 new jobs by 2036. By 2050 the population could reach 13.2 million people, nearly twice its 1991 level, with 240,000 more daily travels into Central London by 2025. The projected 35 percent growth in public transit trips will put additional pressures on the transit network.

The Importance of Crossrail to London's Competitiveness and Growth

Transit acts as an enabler of economic growth for London, shaping employment concentration and agglomeration economies. The quality of the city's international connections and intracity network is a crucial component of its competitive advantage. London dominates rail travel in the United Kingdom: 62 percent of all rail journeys in the country started or ended in London in 2012/13 (GLA Economics 2016). Concentrating economic density has created agglomeration economies and increased productivity.

To remain at the top of global competitiveness, London continues investing in transit connectivity. Crossrail, scheduled to open in full in December 2019, is a new railway line running east to west through London and into the surrounding countryside. It will run over 100 kilometers of track, with a branch to Heathrow Airport. The main features of the project are the construction of 42 kilometers of new tunnels connecting stations in Central London, including a branch to Canary Wharf in east London, and the construction of 10 new stations.

Crossrail is Europe's largest infrastructure project, with a projected cost of £14.8 billion. The project is being jointly sponsored by the Department for Transport and

Transport for London (TfL). Project delivery is being managed by Crossrail Ltd., a special-purpose subsidiary of TfL. The capital cost will be recovered from riders through farebox revenues; from businesses and developers, including BAA, the Canary Wharf Group, and the City of London through direct contributions to capital costs, developer contributions, and a business rate supplement (an extra payment on some business property); and from national taxpayers through a grant from the Department for Transport.

Crossrail will deliver significant travel time reduction (up to 40 percent on some routes), a 10 percent increase in London's rail-based public transit capacity, and a 50 percent increase in capacity to the Isle of Dogs (an area in the East End of London), where the business district of Canary Wharf has the highest job density in London and in Europe, rivaled only by Wall Street and (eventually) the new Hudson Yards development in New York (see chapter 5). It will provide new transport links with the London Underground, Thameslink, the National Rail, the Docklands Light Railway, and the London Overground.

More than 200 million passengers are projected to use Crossrail annually. It will offer a direct connection between all of London's main business centers, linking Heathrow with Paddington, the West End, the City, and Canary Wharf. According to GVA (the largest independent property agency in the United Kingdom), the improvements in travel times, the quality of passenger experience, and the frequency of rail service will have significant impacts on London's economic performance and new residential and commercial investment, through a transformational effect on key locations along the route.

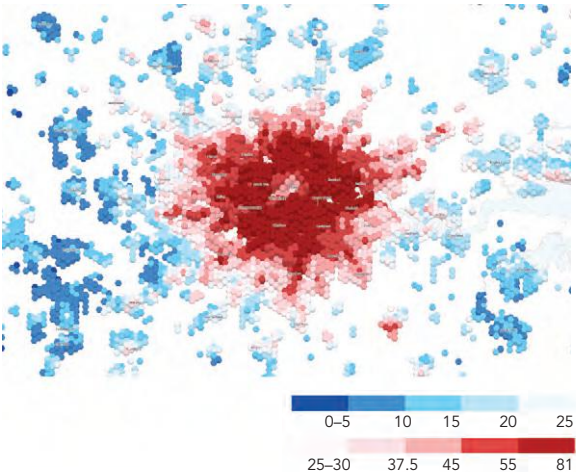## Increasing Node Value by Reinforcing Highly Connective Hubs in Central London

London's public transit system has been central in shaping a radial monocentric city with a high concentration of hubs in the core.[2] Its network has guided and constrained the city, with public transit networks central to growth during the 19th and first half of the 20th century.[3]

Map 7.2 shows the percentage of commuting trips made by public transit, according to place of residence (panel a) and destination (panel b). High transit accessibility to the city center has fostered a highly concentrated distribution of jobs in the city hypercenter, with a more dispersed pattern of residential density. The result is that two-thirds of commuting flows originate or terminate in Outer London.

Two main mechanisms drive node value in London: the concentration of transit hubs in the core of the city where most employment and GDP creation takes place, and accessibility patterns that are highly concentrated in the core of London. Map 7.3 shows how the three network centralities used in the 3V Framework are concentrated in Central London (chapter 2). The highest levels of centrality—and thus accessibility—within the network and the greatest growth potential are around the Circle Line and along the Central Line, defining Central London. The density of stations is higher in the western part of Central London, where one third of London's jobs are located.

MAP 7.2 Percentage of Commutes Made by Public Transit, by Place of Origin and Destination

a. By place of origin

b. By destination
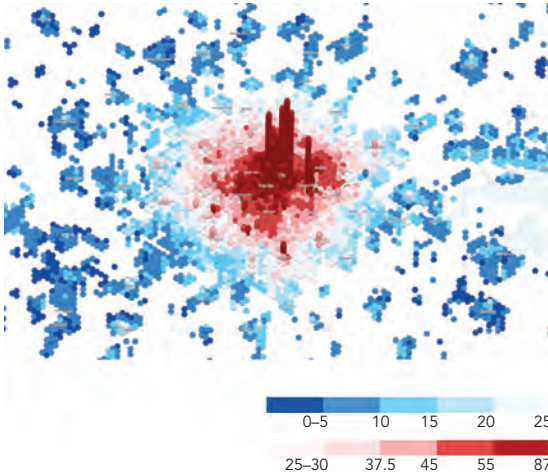
| 0–5 | 10 | 15 | 20 | 25 |
| 25–30 | 37.5 | 45 | 55 | 81 |

| 0–5 | 10 | 15 | 20 | 25 |
| 25–30 | 37.5 | 45 | 55 | 87 |

Source: © Duncan A. Smith, CASA, Bartlett UCL, Luminocity, Urban density and dynamics explorer. Used with the permission of Duncan A. Smith. Further permission required for reuse. Data Source: Census 2011, Crown © Office for National Statistics. Table WP703EW, Workplace Zone.
Note: The height of the grid cells indicates resident population (panel a) and employment (panel b) densities in 2011. People who work at home are excluded from the totals.

MAP 7.3 Degree, Closeness, and Betweenness Centralities in the Underground in Central London

a. Degree centrality
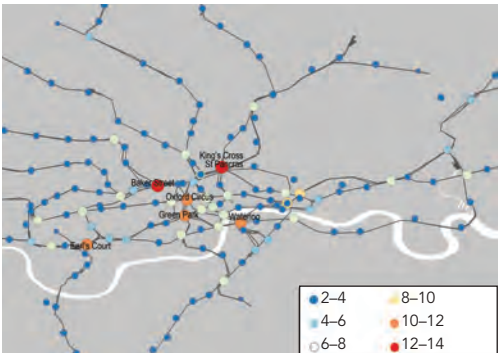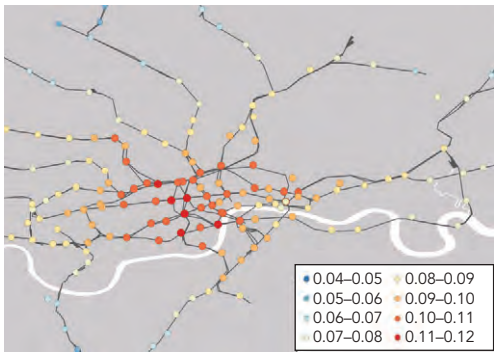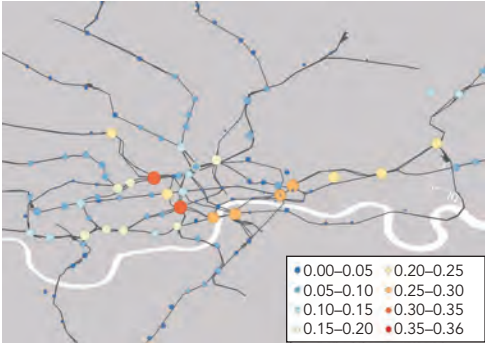
b. Closeness centrality

2–4	8–10
4–6	10–12
6–8	12–14

0.04–0.05	0.08–0.09
0.05–0.06	0.09–0.10
0.06–0.07	0.10–0.11
0.07–0.08	0.11–0.12

c. Betweenness centrality

0.00–0.05	0.20–0.25
0.05–0.10	0.25–0.30
0.10–0.15	0.30–0.35
0.15–0.20	0.35–0.36

Source: © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse.

Crossrail stations within the area defined by the Circle Line will increase the importance, centrality, and accessibility of Central London's major hubs. Crossrail station interchanges with existing tube stations and High-Speed 1 (HS1) stations will create very high node values, calling for further urban development to align place value with the very high node values of the most central stations. Main hubs, where jobs are already concentrated, will have more connections and will concentrate more lines after Crossrail. These major hubs at the top of London's transit system hierarchy are in close proximity. Crossrail will also create a new direct connection between the National Rail networks running into Paddington and Liverpool Streets; passengers will no longer have to change at the termini of the National Rail routes.

Crossrail is expected to have three main benefits:

- It will relieve overcrowding on existing Tube and train services by adding 10 percent extra rail capacity for London, the largest single increase in London's transport capacity since World War II.
- It will strengthen links to key financial centers (Heathrow, the West End, the City, and Canary Wharf) to support London as a world city and bring an additional 1.5 million people within 45 minutes commuting distance of London's key business districts.
- It will reduce travel times into and across London, with reliable and efficient service and 24 trains per hour at peak times through Central London.

Increasing Place Value through Place-Making, Redevelopment, and the Public Realm

Crossrail delivers integrated designs for stations, above-station developments, and public spaces.[4] Each element complements the others to create places and transform spaces.

Crossrail Limited, which is tasked with delivering the new railway, coordinates master planning of public realm improvements around stations. The aim is to ensure that these improvements are integrated with existing and planned improvements in the wider area and reflect other planned uses. Master plans are developed with key stakeholders, including local authorities and private developers. The approach recognizes that passengers will judge the success of the railway not only by the service and the stations but also by their overall experience arriving at and departing from stations.

Crossrail's approach to public spaces aims at making the areas outside stations work effectively as transport interchanges, getting people to the next stage of their journey by bicycle, foot, bus, or taxi and being an attractive and pleasant public space to spend time in. The designs aim to be adaptable and sustainable, so that their use can change over time. All Crossrail stations will be accessible from street to platform, safe, and secure.

The station area designs also aim to retain the identity, diversity, and characteristics of local areas, giving confidence to local communities and potential investors (photo 7.2). Toward that end, boroughs (local administrative units) play a vital part in raising funds for the designs, to ensure that such design will spread improvements and regeneration impacts. The designs were produced in collaboration with Crossrail, local authorities, TfL, and (on Crossrail's surface section) Network Rail.

PHOTO 7.2 Quality Space at Jubilee Place at Canary Wharf
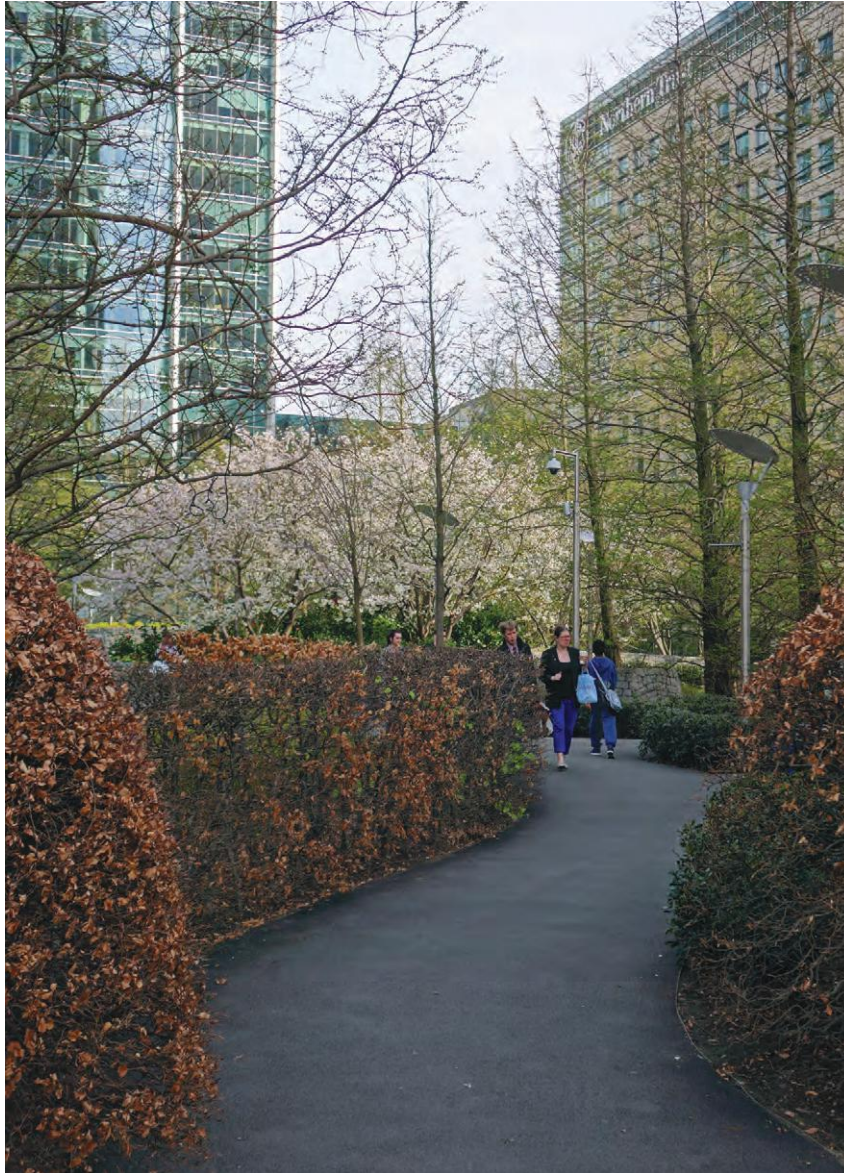
Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

By March 2014 urban realm designs had been completed for 31 stations, including 27 in the London area and 4 outside London. They covered more than 100,000 square meters of improved public space at 40 sites—the equivalent of 19 Leicester Squares. The "Crossrail effect" is already happening in the center of London, at locations such as the east end of Oxford Street, while developers are also showing interest in outer London locations such as Abbey Wood and Southall.

The funding required to implement the designs will be obtained from a variety of sources, a principle agreed to by all the partners at an early stage. Crossrail estimates the total cost of the urban realm improvements outside every station on the route at £129 million. The target is to raise and implement £90 million of improvements by Crossrail's opening. The funding will be split between Crossrail, TfL, and third parties (principally local authorities through developer contributions).

London property value analysts widely recognize that a driving force behind Crossrail's ability to support development activity and property market values is investment in the extent, configuration, and quality of public space immediately around each station. According to GVA, the new stations, developments above the stations, and planned urban realm improvements have the potential to redefine Crossrail's stations as the centers of the communities they serve, as attractive places with entertainment, public art, restaurants, and public spaces—places to spend time in, not just to pass through.

Examples of urban realm improvements along Crossrail line moving west to east are outlined below. They show how place value can be enhanced areas contexts.

Maidenhead

Maidenhead Station, on the west end of the line, is a gateway to a town through which about 3.5 million people pass each year. The main proposal includes creation of a new landscaped station plaza with a water pool acting as a focal point

IMAGE 7.1 Water Pool Focal Point at Maidenhead Station

Source: © Crossrail Ltd. Used with the permission of Crossrail Ltd. Further permission required for reuse.

that will animate the space and encourage people to linger (image 7.1). Tree planting, high-quality paving materials, sensitive lighting, and seating will help provide a positive experience for passengers arriving by rail.

Paddington

Paddington is a historical Central London railway terminus and Underground station. It is a busy complex served by four underground lines: Bakerloo, Hammersmith & City, District, and Circle. Crossrail will increase the ranking of Paddington as a major London hub.

An interim improvement scheme has been completed on the canal side outside the new Hammersmith and City Line entrance on Departures Road, opposite the Crossrail entrance. A permanent urban realm design scheme aims to complete the waterside public space within the Paddington Basin (image 7.2). Crossrail antici-

IMAGE 7.2 **Urban Realm at Paddington Station**

Source: © Crossrail Ltd. Used with the permission of Crossrail Ltd. Further permission required for reuse.
Note: Architect's impression of urban realm proposal at Paddington station (panel a) and canal side urban realm (panel b). Urban Realm Designers: Gillespies/Weston Williamson/URS.

pates that "it will establish a clear, safe and accessible towpath alongside the canal, station entrance and office development, which will be built over the entrance. This will aid pedestrian movements and wayfinding from station exits and surrounding developments while maintaining the character and quality of the area by respecting the historical industrial character of the Basin" (Crossrail 2015b).

Crossrail has also obtained planning consent from the Westminster City Council to build a 32,000-square meter development at Paddington Triangle (image 7.3).

IMAGE 7.3 New Development at Paddington Triangle

Source: © Crossrail Ltd. Used with the permission of Crossrail Ltd. Further permission required for reuse.
Note: Architect: Grimshaw.

IMAGE 7.4 Integration of Surrounding Area at Bond Street Station

Source: © Crossrail Ltd. Used with the permission of Crossrail Ltd. Further permission required for reuse.
Note: Architect's impression of urban realm proposal. Urban realm designers: John McAslan & Partners. WSP/Publica.

Bond Street

Bond Street is a major historic retail street in London. The new urban realm design for Bond Street West takes into account an increase in pedestrian use. It sensitively integrates the new Crossrail station entrance with the surrounding environment. Proposals for Bond Street East will provide ample area for pedestrians, creating a prominent and generous forecourt to the station entrance. High-quality granite paving will extend into the station concourse. Four diagonal crossing points will be introduced on Hanover Square with adjacent footways in matching materials. Cycle parking will be provided at several locations in the square (image 7.4).

Tottenham Court Road

Tottenham Court Road Station will link the West End to Canary Wharf in 12 minutes, Stratford in 13 minutes, and Heathrow in less than 30 minutes. It will cut travel times in half in some cases.

Crossrail is investing £1 billion to transform the station, making it the biggest transport investment in the West End in decades. Built more than 100 years ago as two separate Tube stations, Tottenham Court Road was not designed to cope with the almost 150,000 passengers a day who now travel through the station. Alongside the upgrade of the existing Tube station, Crossrail is building a new station the length of three football fields, four floors underground.

MAP 7.4 **Four-Site Strategy for Developing Tottenham Court Road**
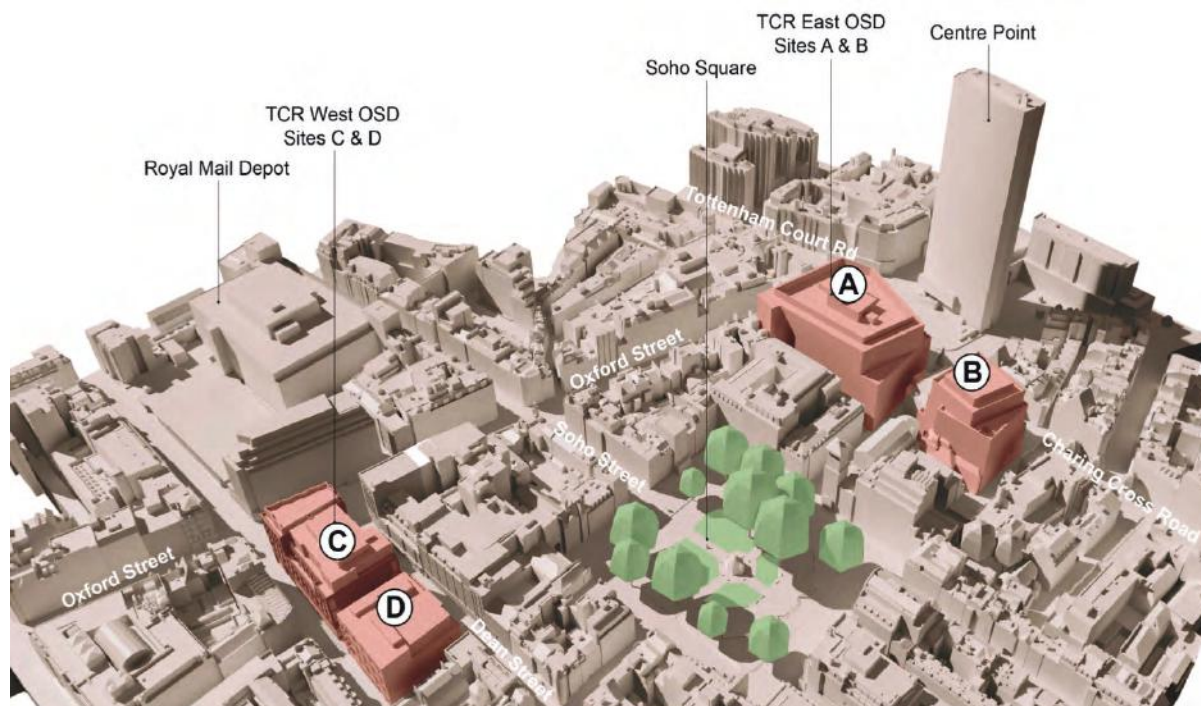
Source: © Crossrail Ltd. Used with the permission of Crossrail Ltd. Further permission required for reuse.

Planning approval has been granted for above-site development at Tottenham Court Road that will cover four blocks. It includes the first new West End theater in more than a decade and 50,000 square meters of high-quality retail, office, and housing space (map 7.4). Over Station Development (OSD) above Crossrail's integrated ticket halls at Dean Street and Charing Cross Road will create a modern new space in this part of London (image 7.5)

Plans include a new public piazza around Centre Point, creating a distinctive new West End landmark (image 7.6). A new open pedestrian space linking Soho

IMAGE 7.5 Over Station Development at Tottenham Court Road West/Dean Street

Source: © Crossrail Ltd. Used with the permission of Crossrail Ltd. Further permission required for reuse.
Note: Architect: Hawkins Brown.

IMAGE 7.6 New Pedestrian Plaza below Centre Point Tower in London's West End

Source: © Crossrail Ltd. Used with the permission of Crossrail Ltd. Further permission required for reuse.
Note: Design team: Atkins/Gillespies/AHMM.

Square and Charing Cross Road will provide new views of the square and of St Patrick's Church, among other open spaces.

Liverpool Street East

Liverpool Street Station is a key gateway to the City of London (also known as the Square Mile), Europe's leading financial center. It is a destination for 73 million people a year who use the Underground and 63 million who use the national rail on their way to work, as visitors to the City, or en route to the nearby areas of Spitalfields and Shoreditch. The compactness and density of the Square Mile means that walking is the best way to move around the City. The arrival of Crossrail will see significant increases in pedestrian movements and other transport modes to get to and from the station (image 7.7).

IMAGE 7.7 Pedestrian Walkway at Liverpool Street East

Source: © Crossrail Ltd. Used with the permission of Crossrail Ltd. Further permission required for reuse.
Note: Architect's impression. Urban realm designers: Urban Movement/Mott MacDonald.

Whitechapel

The refurbished entrance to the station on Whitechapel Road will see a larger forecourt with distinctive paving (image 7.8). Improvements to the area include the pedestrianization of Court Street, with the raising of the carriageway to create a safer walking route.

IMAGE 7.8 Refurbished Entrance to Whitechapel Station

Source: © Crossrail Ltd. Used with the permission of Crossrail Ltd. Further permission required for reuse.
Note: Architect's impression. Urban realm designers: BDP/Hyder.

Abbey Wood

The arrival of Crossrail is a catalyst for the regeneration of Abbey Wood. The new station will act as an "urban bridge" by providing a direct and accessible link between the areas to the north and south of the station. As part of the wider urban realm proposals, Harrow Manor Way will be transformed from a four-lane urban motorway to a more traditional road with pavements and dedicated cycle lanes. It will link southbound bus stops to the station via a new pedestrian crossing (image 7.9).

IMAGE 7.9 Regeneration of Abbey Wood

Source: © Crossrail Ltd. Used with the permission of Crossrail Ltd. Further permission required for reuse.
Note: Architect's impression. Urban realm designers: Urban Movement.

Canary Wharf

Canary Wharf (photo 7.3) has the highest density of jobs and office space in London, with about 105,000 jobs on 28.8 hectares (an average gross built density of office space of 7.4). Its history over the past 20 years provides an example of the role of investment in public transit and in place-making supporting and sustaining economic growth. The three-value interplay is prevalent at Canary Wharf: Place-making and a 50 percent increase in transit capacity are expected to allow a doubling of office space in London's fastest-growing business center.

The Docklands, once part of the Port of London in east and southeast London, experienced rapid expansion with the extension of the Jubilee Line, in 1999, enabling current employment levels to be reached; the previous transport systems would not have been able to cope with the number of passengers who now commute to Canary Wharf on the Jubilee Line. The combination of connectivity with high quality public realm allowed a former industrial site to be transformed into a booming business district.

In 1985, SOM, an architecture, engineering, and urban planning firm, began work on a master plan for Canary Wharf, which called for transforming a derelict industrial area into a thriving financial district. The master plan established a clear urban framework of streets, public squares, and green space. SOM worked with local artists and landscape architects to create memorable and functional gardens, plazas, fountains, shopping arcades, and waterfront promenades. It also enhanced

PHOTO 7.3 High-Quality Space at Canary Wharf

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

PHOTO 7.4 Connecting Canary Wharf through the Jubilee Line Station
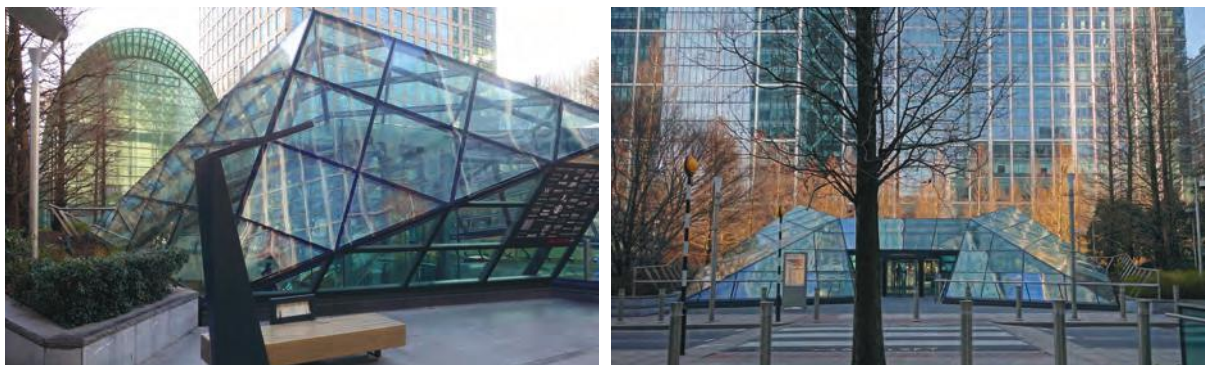
Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

tree-lined boulevards (photo 7.5). To establish aesthetic continuity, SOM proposed that design elements such as cornice lines, stone bases, and street furniture be consistent throughout the site.

The Canary Wharf Crossrail Station (photo 7.6) will cut travel time to the City (Liverpool Street) from 21 minutes to 6 minutes, with a train every five minutes at

PHOTO 7.5 Memorable Green Space at Canary Wharf

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

PHOTO 7.6 Iconic Crossrail Station at Canary Wharf

Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.
Note: Architectural design: Norman Foster.

peak time in each direction. It will trigger high agglomeration economies between the two densest and fastest-growing economic cores of London. Travel time to Paddington will be cut by from 33 to 17 minutes; travel time to Heathrow will fall from 55–90 to 39 minutes.

The 250-meter-long station being built for £500 million is surrounded by the water of the West India Quay dock. Designing a station to be built 18 meters below water level presented significant design challenges but resulted in optimum access to and through the Canary Wharf Estate while retaining a navigable channel for boats within the dock. The station and proposed retail and park areas will be seven floors high. Retail areas are planned for three of the seven floors, along with a landscaped garden, restaurant, and community facility on the top floor.

The development includes a timber lattice roof and rooftop garden level that sit above the three-story retail development (photo 7.7). It lets in light and rain for natural irrigation. Sustainably sourced beams provide a warm, natural counterpoint to the glass and steel towers of Canary Wharf.

The decision to expand Canary Wharf eastward allowed the developer to build up to 3,610 new homes, 1.9 million square meters of office space, 35,000 square meters of retail floor space, a community center, and a network of public squares, with a public space of 3.6 hectares in the first stage. The new office space will be designed to accommodate the technology media and telecommunications sector, as well as financial and professional services firms. The new station acts as a bridge between two communities, Canary Wharf Estate and Poplar, to the north. The extension will offer high street retail units to complement Canary Wharf's existing retail offer. It will also include affordable housing, substantial new green parks and dockside walks, a library, a large surgery, a school for 420 children, a community sports hall and community spaces.

PHOTO 7.7 Lattice Roof at Canary Wharf Station

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Increasing Market Potential Values, Particularly at Key Locations

London generates approximately 22 percent of Britain's GDP (City of London Corporation 2011). It shifted to a mostly service-based economy earlier than other European cities. Currently, more than 85 percent of the employed population (3.2 million) of Greater London works in service industries.

London's economic advantage lies in its extremely dense employment clusters. Its highest-value economic activity occurs in agglomerations of banking, insurance, financial, professional and business services, and creative industries. For businesses in these sectors, proximity to each other creates more opportunities for specialization in client and labor markets as well as increased potential for knowledge-sharing. Such agglomeration makes London significantly more productive than the United Kingdom as a whole.

In an advanced service economy, such as London, local job densities and accessibility to jobs are key components of market potential value. The more accessible

PHOTO 7.8 Integrated Economic Concentration and Transit Accessibility at Canary Wharf
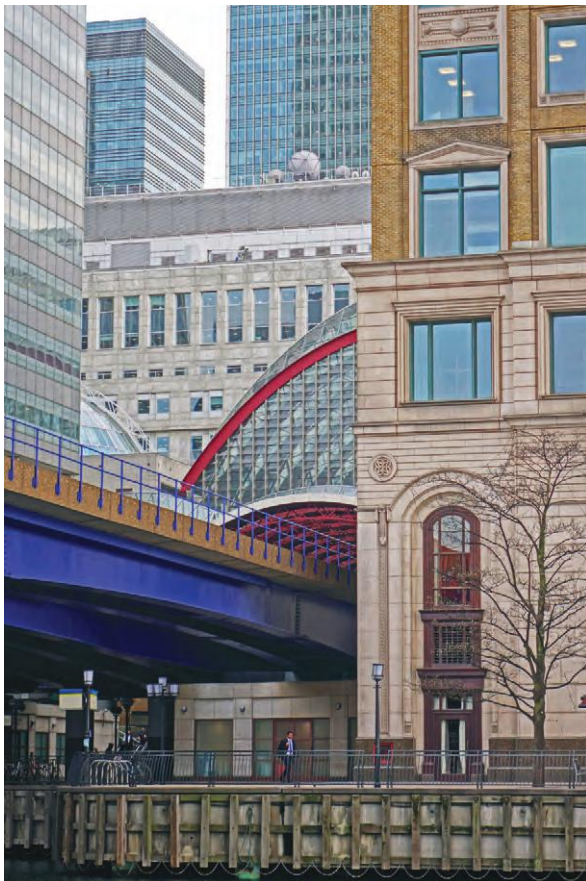
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a place is, the more it concentrates jobs. Employment has been declining significantly in Outer London, while increasing in Inner London and its densest areas. In contrast, in the City of London, density increased 30 percent in 10 years. Extremely high job density can be achieved only with an extensive network of transport connections and a high density of transport hubs in the center (photo 7.8).

Two-thirds of Greater London's GDP is produced on 20 percent of its land area (Inner London). Fifty-six percent of all private sector jobs in Greater London are located in Inner London.[5] Most of Inner London's economic activity is concentrated in 10 percent of its area, in Central London. Central London concentrates 1.5 million jobs, 30 percent of Greater London's employment, in about 30 square kilometers, or 2 percent of London land space (map 7.5 and Figure 7.1).[6]

A report by Colin Buchanan and Partners analyzes the impact of the number of people accessible within 45 minutes on employment densities in specific London locations (GLA 2004). It concludes that as accessibility increases, employment density can increase. Employment density by borough in London is correlated with the number of people that can access the borough in 45 minutes by transit. Firms locate where they can access a large number of people and other firms; people locate where they can access a large number of jobs opportunities.

Within the spike of wealth and economic might of Central London—the highest in Europe—the City of London stands out. In a 3 square kilometer area that represents just 0.2 percent of Greater London, the City generated £45 billion in

MAP 7.5 Employment Density in Greater London, 2014
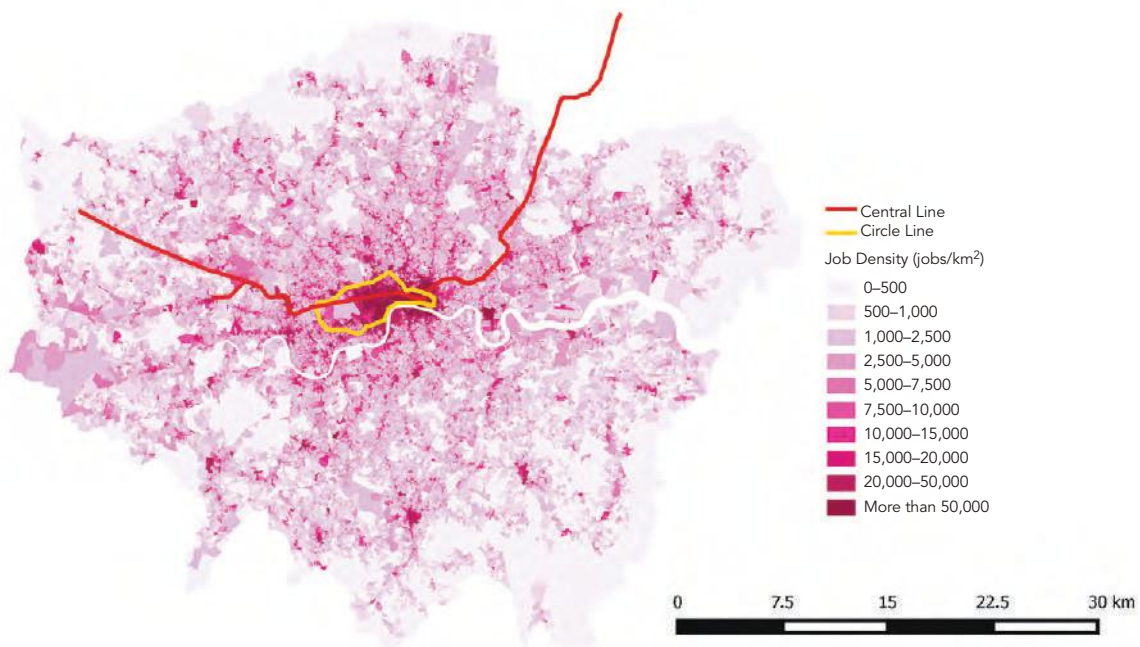
Source: © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse. Data are from the London Datastore, Greater London Authority.

FIGURE 7.1 Distribution of GDP in London in 2014
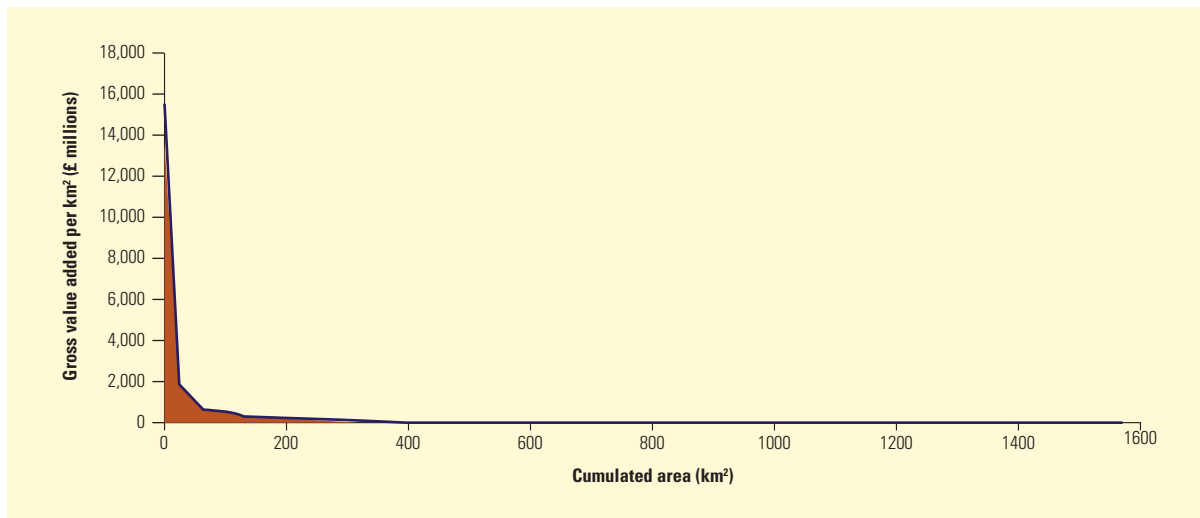
Source: Salat and Bourdic 2015. © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse. Data are from the London Datastore, Greater London Authority.
Note: Figure shows borough-level granularity, ranked from most productive to least productive, follows a Pareto distribution of exponent –0.9 (see appendix A).

economic output in 2014, equivalent to 14 percent of London's output and 3 percent of the United Kingdom's output.

London's high-density specialized clusters benefit from agglomeration advantages: knowledge-sharing spillovers, shared specialized labor markets, and economies of scale in markets for clients, customers and intermediate inputs. Advanced services are concentrated in Central London at high density. Jobs in finance and business jobs, information and communications technology (ICT), creative industries, science and engineering, and research and development represent about 25 percent of Greater London jobs. Different service industry types follow different patterns of concentration and different spatial dynamics (map 7.6).

Changes in employment density have a strong impact on market potential values. Spatial concentration of jobs increased between 2000 and 2010 (Smith 2012), fostering high market potential values in Central London. Densities have increased in already dense areas (map 7.7 and photo 7.5). Over the next 10 years, agglomeration trends are expected to continue to drive economic growth in the City of London, which is projected to grow at an average rate of 2.8 percent a year. Employment (estimated at 396,800 in 2014) is projected to reach 435,700 by 2025, and productivity is projected to rise by 1.9 percent a year through 2025.

Housing prices in Greater London
Housing in the United Kingdom is worth about £6 trillion (Savills 2016). The distribution of housing assets is very uneven. Housing in Inner London is worth a third more than all the housing in Wales and Scotland put together (Stringer 2014). This concentration of housing property value derives from the differences in accessibil-

MAP 7.6 Employment Density in Greater London by Sector

Finance and business: 667,000 jobs (13.4 percent of total)

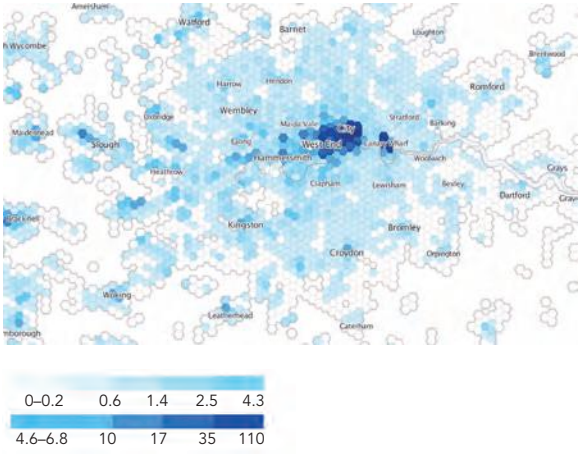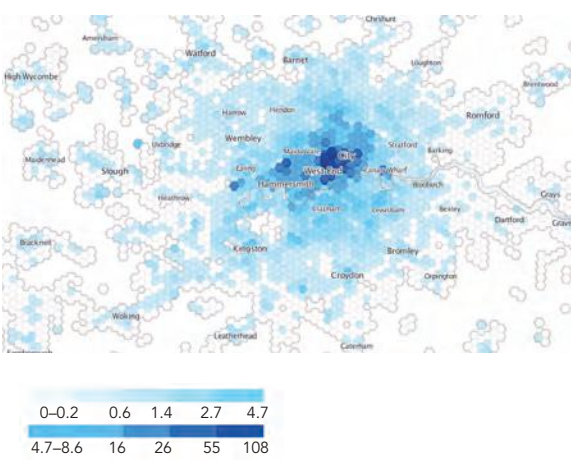| 0–0.75	2	5	10	17.5
17.5–35	63	130	300	560
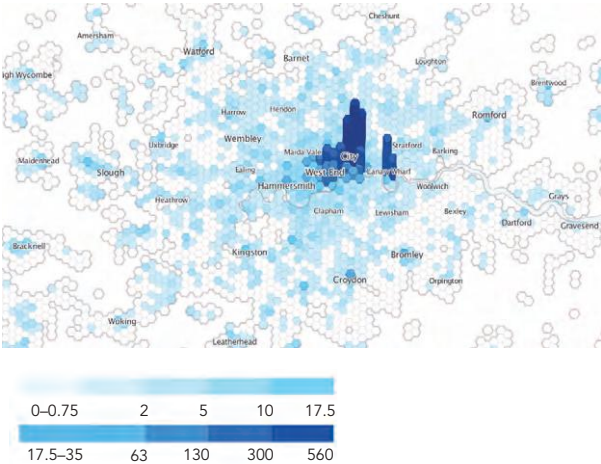
Information and technology: 208,000 jobs (4.2 percent of total)

0–0.2	0.6	1.4	2.5	4.3
4.6–6.8	10	17	35	110

Creative industry: 248,000 jobs (5 percent of total)

0–0.2	0.6	1.4	2.7	4.7
4.7–8.6	16	26	55	108

Science and technology and research and development (R&D): 114,000 jobs (2.3 percent of total)
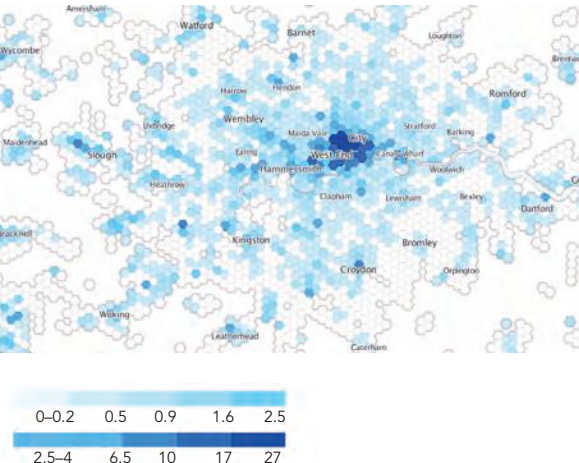
0–0.2	0.5	0.9	1.6	2.5
2.5–4	6.5	10	17	27

Source: © Duncan A. Smith, CASA, Bartlett UCL, Luminocity, Urban density and dynamics explorer. Used with the permission of Duncan A. Smith. Further permission required for reuse. Data Source: Census 2011, Crown © Office for National Statistics 2014. Table WP606EW, Output Area.
Note: Grid cell = 1 square kilometer. Classification of industries is based on minor occupation groups from 2011 census.

ity from and to Central London, where London jobs and GDP creation are concentrated (map 7.8). A study by Knight Frank shows that 91 percent of tenants in London want to live within 1 kilometer of a transport link (Knight Frank 2015).

Office density and rent in London
London office market is complex and made of highly specialized established and emerging subcenters. Five major business districts (the City, Westminster, Canary Wharf, Camden and Islington, and Lambeth and Southwark) represent less than 5 percent of Greater London but concentrate 75 percent of its office space.

MAP 7.7 Change in Employment Density in Greater London between 2001 and 2011

Jobs per hectare change

−105 – −50	−20	−10	−1	+2

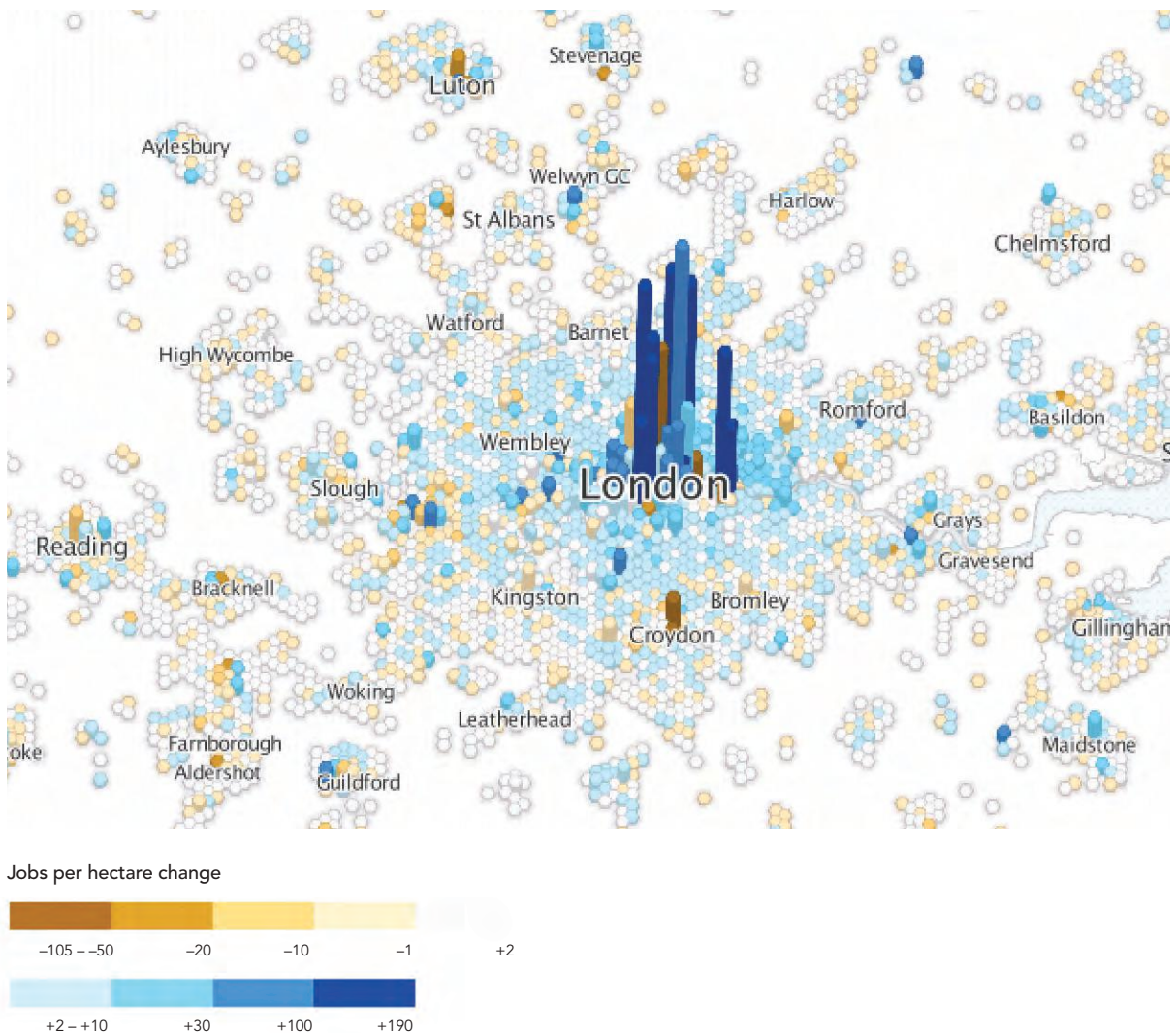|				
+2 – +10	+30	+100	+190	

Source: © Duncan A. Smith, CASA, Bartlett UCL, Luminocity, Urban density and dynamics explorer. Used with the permission of Duncan A. Smith. Further permission required for reuse. Data Source: Census 2001 & 2011, Crown © Office for National Statistics. Data scale Output Area & Workplace Zone.
Note: Grid cell = 1 square kilometer. Height of cells displays employment density in 2011. Largest increases in job density occurred in densest cells.

London office prices are strongly correlated with transit access to jobs, transit access to people, and the historical quality of the urban fabric (measured by the proportion of buildings placed on the Statutory List of Buildings of Special Architectural or Historic Interest) (Smith 2012). Accessibility variables are the most influential. Prices are higher in West London than elsewhere because of it connectivity (particularly to Heathrow Airport) and prestige, which stem from its impressive urban realm and high-quality historic architecture.

MAP 7.8 Median Price Paid for a Home in London, 2013
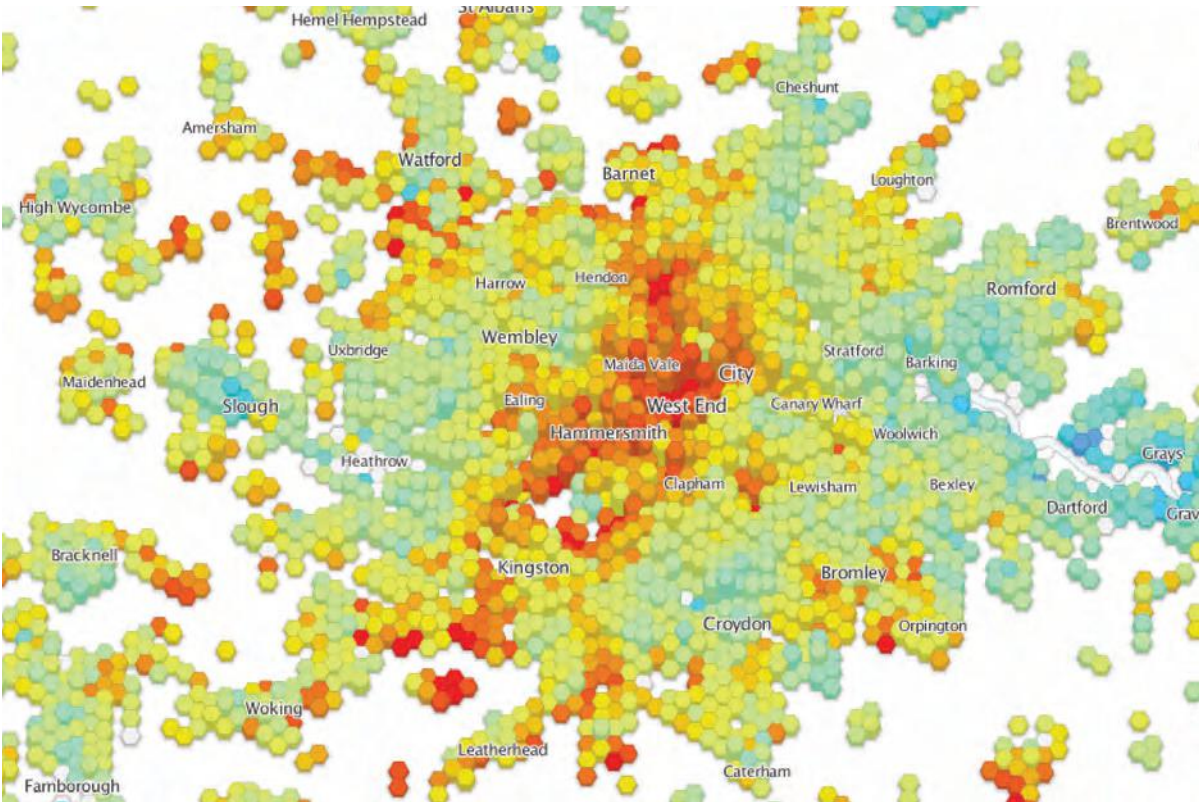
House prices, median price paid 2013, £
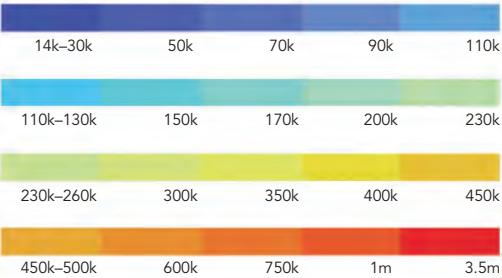
14k–30k	50k	70k	90k	110k
110k–130k	150k	170k	200k	230k
230k–260k	300k	350k	400k	450k
450k–500k	600k	750k	1m	3.5m

Source: © Duncan A. Smith, CASA, Bartlett UCL, Luminocity, Urban density and dynamics explorer. Used with the permission of Duncan A. Smith. Further permission required for reuse. Data Source: Crown © Land Registry England and Wales 2014 Price-Paid open data, unit postcode.
Note: Grid cell = 1 square kilometer. Cell heights show residential population density. Shared ownership and right-to-buy transactions are excluded.

High prices in the West End are also linked to urban development dynamics. Urban development in London between 2000–10 experienced massive intensification, with the construction of 8 million square meters of new office space, leading to a total of 26.4 million square meters of office space in 2010. Development was restricted in the West End for policy and heritage reasons. Rapid expansion in the City of London and Canary Wharf initially led to a softening of prices (Smith 2012).

MAP 7.9 Office Density and Rents in London

a. Office density 2000 and rent 2003
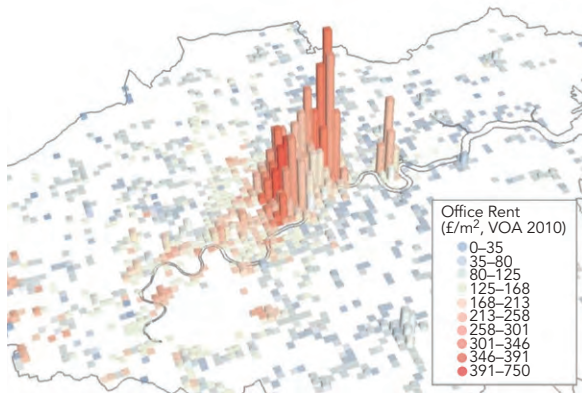
b. Office density 2010 and rent 2008

Office Rent
(£/m², VOA 2010)
0–35
35–80
80–125
125–168
168–213
213–258
258–301
301–346
346–391
391–750
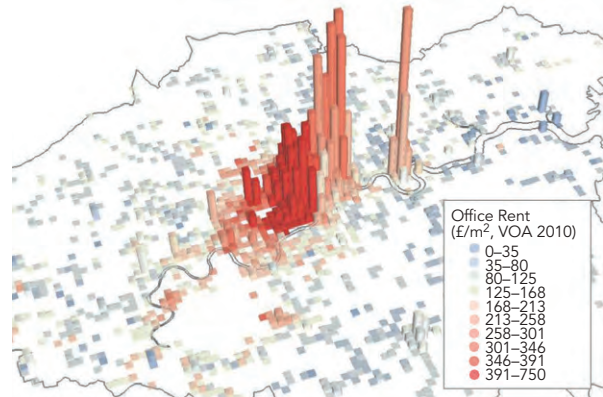
Source:© Duncan A. Smith, CASA, Bartlett UCL. Used with the permission of Duncan A. Smith. Further permission required for reuse.
Note: This visualization was created at CASA UCL using ArcGIS. The data come from the Valuation Office and the Greater London Authority. Computation on 500-meter cells. Height shows office density (number of square meters of office floor space per cell), color shows rent.

The different office markets follow different patterns of firms clustering and specialization. Higher rents in the West End than in the City and Canary Wharf have not led to businesses migration. Firms in the City are highly specialized in finance, with linkages between banks, insurance, management consultancy, accounting, legal services, and fund asset management. Firms in the West End are more di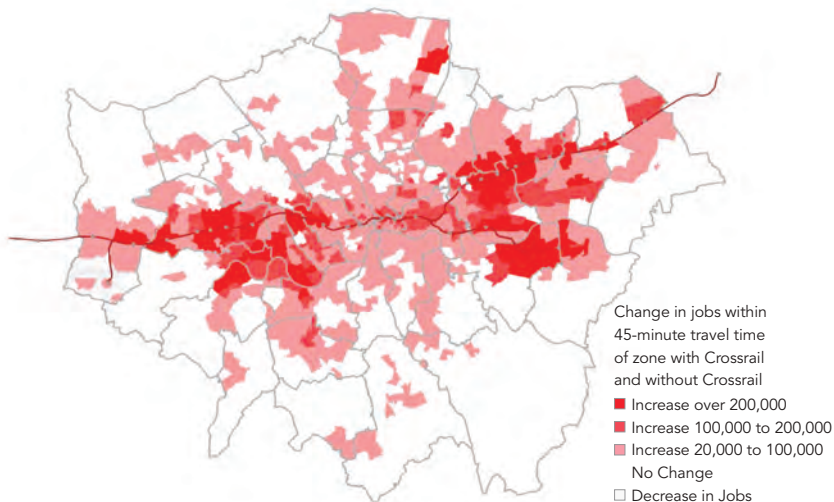versified, with creative industry clusters. The London office market is thus made of submarkets with very high local specialization (Smith 2012). Development trends reinforce patterns of firm clustering. The division between east and west is growing, with development having different effects on prices (map 7.9).

Differential effects of Crossrail on market potential

Real estate prices around station areas will not benefit equally from the increase in connectivity.[7] The complex spatial structure of London real estate markets explains the different market potential values along the Crossrail line. In addition to the dynamic interplay of node and place value enhancements, markets have their own logic (demand and supply, market vibrancy) that must be taken into account in devising transit-oriented development (TOD) spatial strategies. This section analyzes both the overall effect of Crossrail and the differentiated effects on market potential along the line.

Crossrail will bring an additional 1.5 million people within a 45-minute commuting distance of London's key business districts (the West End, the City, and Canary Wharf) (map 7.10). It will create direct connections to Heathrow Airport for Central and East London and increase the interchange roles of Farringdon and Stratford. It will decrease travel times between Canary Wharf and the City, strengthening the role of Liverpool Station as a major interchange connecting seven railway lines with trains to Southend and Standsted. Crossrail will also link new emerging centers in Inner London to the major established centers. It will enable the regeneration of areas around stations along its route by increasing accessibility with shorter travel

MAP 7.10 Projected Impact of Crossrail on Accessibility to Jobs

Change in jobs within
45-minute travel time
of zone with Crossrail
and without Crossrail

■ Increase over 200,000
■ Increase 100,000 to 200,000
■ Increase 20,000 to 100,000
   No Change
□ Decrease in Jobs

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times and giving employers located along the route better access to a larger, more highly skilled labor market. It will likely attract new private sector development and increase employment densities near Crossrail stations. More than 100,000 additional jobs could be created across the Thames Gateway, with Crossrail directly serving Custom House, Woolwich, and Abbey Wood and improving connections to other networks in the area (Crossrail 2011).

A property impact study covering the period 2012–21 reached the following conclusions (Crossrail and GVA 2012):

- Crossrail is already having an impact on investment decisions. At many locations it will be influential in supporting and accelerating new development.
- Crossrail could help create additional residential and commercial value of as much as £5.5 billion along the route between 2012 and 2021.
- Crossrail will support the delivery of more than 57,000 new homes and 3.2 million square meters of commercial office space that have been identified for development within 1 kilometer of stations along the route.
- Commercial office values around Crossrail stations in Central London will increase as a result of Crossrail over the next decade, with an increase of 10 percent above a rising baseline projection. Residential capital values immediately around stations in Central London will rise by about 25 percent, and values in the suburbs will rise 20 percent above the rising baseline projection in the period.
- Urban realm improvements and the development of new schemes above Crossrail stations will act as a highly visible and beneficial driver for further development activity; the intensification of use; and in several areas, such as Farringdon, significant change.

Crossrail will have a transformative effect on the property market and development activity over time. This overall increase will not be evenly distributed.

Along the length of the entire line, from Maidenhead to Shenfield, prices within a short walk of stations rose only 5 percent more than the local market between 2008 and 2014, gaining 43 percent on average. Some areas saw prices soar, however. In Central London, Farringdon and Paddington outperformed the local market by about 24 percent. Average prices within a 10-minute walk of stations in Central London rose 57 percent, according to analysis by the London estate firm Knight Frank, while prices close to the Bond Street Station rose 82 percent, the largest increase along the route (Knight Frank 2015).

The most significant improvements can be expected to occur where large changes in connectivity coincide with major development opportunities. Within Central London, heritage constraints will limit the development response to increased transport capacity in the West End. In the City a more liberal planning regime should allow densification where connectivity is improved.

Crossrail and Thameslink will create a new and highly significant transport interchange at Farringdon, where increased connectivity will vastly enhance development and job potential (CB Richard Ellis 2009). The impact of transport change will be most dramatic in fringe locations, where opportunities for development are plentiful. In markets such as the Isle of Dogs, Stratford, and Paddington, transport will play a leading role in the transformation of property markets. The stations along the Crossrail route where property prices have outperformed the market are the ones located in Central London where both jobs and connectivity are highly concentrated (map 7.11).

The greatest changes to the property market are expected to be in East London. The stock of office space in the Isle of Dogs could double by 2020, with Crossrail as key driver. It will provide direct access to Heathrow and West London for the first time, as well as improved access to Central London. The

MAP 7.11 Property Price Performance along the Crossrail Route
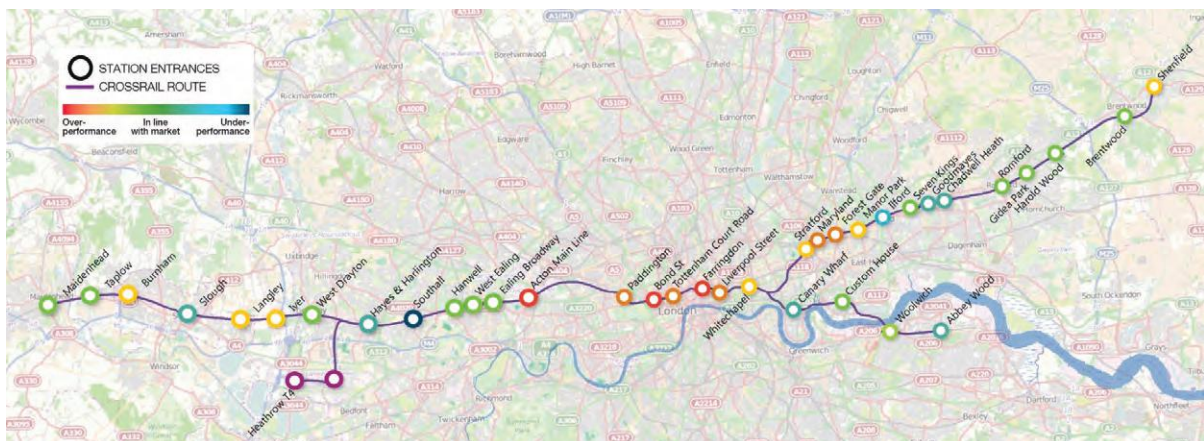
Source: JLL Residential Research 2015. © JLL. Used with the permission of JLL. Further permission required for reuse.

increasing importance of London City Airport will also be a stimulus. Crossrail will also play a key role at Stratford, where it will create a direct link to the City and the West End (HS 1 has already put Stratford on the international rail network).

The Paddington office market could also double in size by 2020. Skylines could be reshaped at King's Cross, Euston, Victoria, and Southbank, as developers seek to capitalize on the existing quality of transport connections and improvement to existing networks.

Building a typology of nodes along Crossrail

According to GVA, Crossrail will reinforce the central spikes of high node and market potential values, a phenomenon that occurred in Seoul in 1998 after completion of the second phase of its subway. Given the strength of existing Central London office groupings, Crossrail is unlikely to create new markets or major locations of new demand in its own right, but it will be instrumental in reinforcing and strengthening office clusters and supporting demand in established locations. Maintaining values in high value areas can be as important as increasing them in more modestly priced locations.

According to CB Richard/Ellis 2009, Crossrail will create new opportunities and risks for both core and fringe markets (table 7.1). The current transport system favors core markets within London, because these markets evolved where transport links were good and transport improvements were made to improve access to them. Given that these areas are already well endowed with transport links, the effects of improved transport will be incremental.

By comparison, fringe locations (where provision of new transport infrastructure will create an imbalance between a higher node value and a comparatively low place value) benefit from the transformational effects of new links and increased capacity. The risk to fringe markets is that increased transport capacity at the core reinforces agglomeration effects that further strengthens its position relative to the periphery. These risks are counterbalanced by the possibility of benefiting from the boost to the profitability of potential developments.

TABLE 7.1 Opportunities and Risks in Core and Fringe Markets

	Opportunities	Risks
Fringe Markets	• Accelerates the willingness of tenants to consider alternative locations • Increases demand for office space in non-core locations, helping to establish new and emerging markets	• Reinforces agglomeration effects that further strengthen core markets • Results in an intensification of established markets
Core Markets	• Increases employment and boosts the demand for office space • Increases agglomeration effects, generating productivity improvements and allowing higher rents to be achieved	• Weakens the relative strength of established clusters and connectivity advantages • Increases the willingness of firms to move to non-core

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FIGURE 7.2 Connectivity and Development Potential of Stations along the Crossrail Route
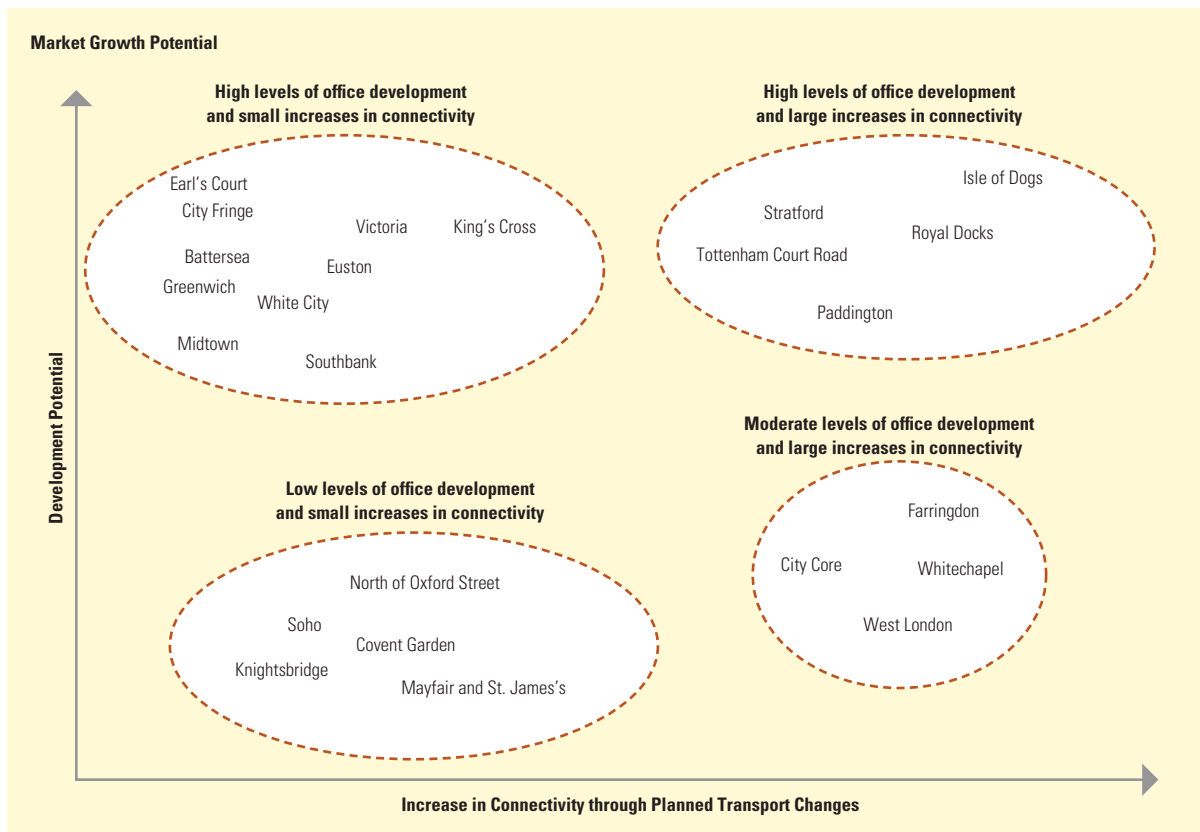
Source: Siebrits 2009.© CBRE. Used with the permission of CBRE. Further permission required for reuse.

CB Richard Ellis proposes a typology based on connectivity (node value increase) and development potential (place and market potential value increase) (figure 7.2). The greatest growth potential is where high levels of office development match high increases in connectivity.

Halfway through the construction process, some neighborhoods are already seeing benefits from incoming stations, while others have yet to do so. Although Crossrail will spur economic growth mainly by reinforcing the core advanced service economy nodes, such as Canary Wharf, there are development opportunities for a variety of communities along the route, provided they adopt the right development strategies.

Development of less central stations requires careful planning. In particular, surface-level transport interchanges must fully integrate different transport modes in a seamless way. Cycling and pedestrian access and the approach to the station have major impacts on station use and perception, for example. High-quality station and public realm design plays a major role in attracting investment, improving perception and community amenities, and gaining or retaining retailers. In particu-

lar, new streets connecting to stations should be phased in with other developer initiatives, so that works can be combined. Financing alternatives should be explored if developer contributions are not phased in in tandem with station works.

Plans need to allow for flexibility and adaptation to changes in demand. Some areas will take longer to benefit. The character of some places will change—from town center to residential, industrial to commercial, quiet to busy, or any number of shifts. Such transformation calls for a long-term view from all parties involved, built on a partnership with transit agencies and local authorities to develop high-quality plans that can deliver social as well as financial returns.

Crossrail's experience in fringe stations shows that TOD can achieve even more in terms of station-area regeneration and its effect on local economies and social inclusiveness if consideration is given to the nonrail aspects of infrastructure programs from the outset. A recommendation is to build or increase skills and employment services, especially in areas where connectivity is opening new opportunities for job creation.

Crossrail has prepared integrated designs for 12 major property developments over and around its key Central London stations (Crossrail 2015a). Development plans cover more than 280,000 square meters of high-quality office, retail and residential space. The receipts from property developments are targeted to generate income of approximately £500 million as part of the core Crossrail funding strategy. Crossrail and its partners have gained planning consent for the majority of the schemes; the last few planning applications have been submitted.

Benefit to Cost Ratio and Economic Benefits of Crossrail

Benefit to Cost Ratio

The conventional economic appraisal of a transport project focuses on factors such as travel time savings and travel quality benefits, assessing them against the total cost of the project. Such appraisals have long been used to assess the relative attractiveness of different transport projects by assigning monetary values to benefits and costs for Crossrail. This analysis yields a benefit to cost ratio of 2.59 based on a U.K. value of time and ratio of 3.64 using a London specific value of time (table 7.2). The project thus generates substantial net transport economic benefits. More than 40 percent of these benefits are associated with the increase in the capacity of London's congested transport network to meet the existing and future transport needs of London (Crossrail 2011).

Wider Economic Benefits

The conventional appraisal methodology considers only the direct transport benefits and costs. But a major project such as Crossrail will generate economic benefits that are not included in a standard benefit-cost calculation. The Department for Transport identifies four components of these wider economic benefits: move to more productive jobs, pure agglomeration, increase in labor force participation, and impacts on imperfect competition.

TABLE 7.2 Estimated Benefits and Costs of Crossrail (billions of £)

Component	Transport for London (London value of time)	Department for Transport (U.K. value of time)
User benefits		
Time savings	9.1	6.6
Congestion relief	7.3	5.3
Other	0.5	0.5
Indirect tax revenue	−1.4	−1.4
Total user benefits	15.5	11.0
Costs		
Capital expenditures	−8.0	−8.0
Operations and maintenance	−3.6	−3.6
Revenues	7.4	7.4
Other	0.2	0.2
Total user costs	−4.2	−4.2
Net present value	11.2	6.7
"Conventional" benefit-cost ratio	3.64	2.59

Source: Crossrail 2011.
Note: Figures are present values based on first quarter 2002 prices.

Crossrail will have a substantial effect on the U.K. economy. According to Ian Lindsay, Land and Property Director, at the peak of construction, Crossrail will directly employ about 10,000 people. Supply chain benefits in the United Kingdom are projected to be three times higher than actual investments. More than 1,000 contracts have already been put out to bid, and 90 percent of the budget is being spent in the United Kingdom. Crossrail is aiming to leave a skills legacy by reinvigorating tunneling and underground construction skills in the United Kingdom (Lindsay 2012).

Crossrail supports a transport system that is an engine for economic growth. Improved public transit is one of the major prerequisites for attracting more jobs and residents, delivering and facilitating the growth forecast in *The London Plan 2016* (City of London 2016). More than 35 percent of future employment growth in London is expected to be located in areas well served by Crossrail services (the West End, the City, and Canary Wharf). Like Hudson Yards in New York (see chapter 5), Crossrail is a central component of a strategic planning policy aiming at reinforcing the existing high concentration of jobs in the core city to reap the highest possible agglomeration economies.

Notes

1 This chapter does not account for any effect Brexit may have on the concentration of advanced services in London.
2 Public transit include bus, coach, metro, tram, train, and river bus trips.
3 Railways first arrived in London in 1836. Most initial developments were intercity. The 1846 Royal Commission on Railway Termini prevented train lines from entering Central

London, resulting in a ring of disconnected stations; the ban stimulated a market for interconnections and development of the underground (Levinson, Giacomin, and Badsey-Ellis 2016). Both surface rail and underground networks expanded together, producing both competition and synergy between the two modes. Transportation development played a significant role in suburban expansion, with railway companies forming business relationships with property developers, in some cases acting as property developers themselves.

4   This section draw on materials from Crossrail.

5   Although it is the richest area in Europe, Inner London is not uniformly rich: There is a strong divide between West and East. Inner London West produces twice the gross value added of Inner London East on less than one-third its area. Inner London West has GDP per capita 3.6 times higher than Inner London East. This division between East and West is growing, as reflected in the price of office space.

6   Greater London covers 1,572 square kilometers and has a population of 8.2 million people; Inner London covers 319 square kilometers and has a population of 3.2 million people; Central London (based on London Plan) covers 30 square kilometers; the City of London covers 2.9 square kilometers and has a population of 8,000, reflecting its role primarily as an economic center. Population data are based on the 2011 census.

7   This part of the chapter draws on Crossrail and GVA (2012).

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8

Integrating the Space Economy with Transit-Oriented Development: Increasing Economic Efficiency and Social Inclusiveness in Zhengzhou

This case study widens the geographical scope of the 3V Framework to the scale of a large city (Zhengzhou).[1] It analyses the impact of the first six planned subway lines (map 8.1), examining development potential of 21 stations along the city's Line 3 in detail. It shows how the 3V Framework can help develop a long-term vision for the most efficient shape of densities (people, job, and economic) to increase economic growth and productivity while decoupling economic growth from infrastructure costs and energy use. It highlights how to devise local strategies for urban development around specific transit nodes, taking into account their node, place, and market potential values. It also shows how the approach to transit-oriented development (TOD) used in highly efficient cities can be applied in rapidly growing cities, particularly in China.

This chapter makes recommendations at three levels:

- At the metropolitan level, it recommends integrating Zhengzhou's space economy and labor market with transit, in order to foster economic growth through agglomeration and increase productivity, competitiveness, and inclusiveness.
- At the network level, it recommends increasing accessibility by matching economic and people densities with the most accessible and central parts of the subway network.
- At the local level, it recommends increasing place and market potential values in order to reap the benefits of land value capture finance.

MAP 8.1 **First Six Subway Lines in Zhengzhou**
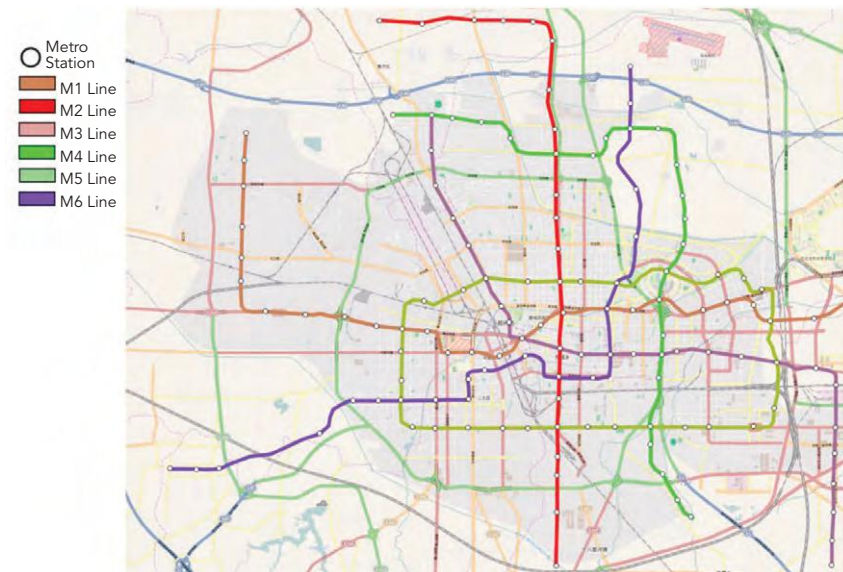
Source: Document prepared by the World Bank from data from Zhengzhou City Planning.

Importance of Zhengzhou

Zhengzhou is the provincial capital of Henan Province in central China. The city—one of the eight great ancient capitals of China—lies on the southern bank of the Yellow River. As a prefecture-level city, it serves as the political, economic, technological, and educational center of this large province (home to more than 94 million people).

Zhengzhou is a major transportation hub, located at the intersection of the Longhai Railway and the Beijing-Guangzhou Railway. The high-speed railway network provides service from the city to Beijing, Nanjing, Xi'an, Wuhan, and Shanghai. The new high-speed railway station (the Zhengzhou Dong Station) is one of the largest in Asia. Because of its strategic location, Zhengzhou is increasingly attracting domestic and international investment as well as migrants, transforming the city into one of China's large economic centers (EIU 2012). GDP per capita of Zhengzhou was Y77,217 in 2015.

Zhengzhou has a population of 9.6 million inhabitants and an area of 7,446 square kilometers. Its urban population of 6.4 million live on 1,010 square kilometers, including a built-up area of 438 square kilometers, according to the municipal government. It is the second-largest city in central China, after Wuhan.

Metropolitan-Level Transit-Oriented Development in Zhengzhou

The National Development and Reform Commission approved the plans for Zhengzhou Metro Lines 1 and 2 in February 2009. This rapid transit rail network will serve both the urban and suburban districts of Zhengzhou. The subway

extension will increase the productivity, livability, and attractiveness of the city for businesses and investors.

To transform connectivity and accessibility enhancements into increases in GDP, it is essential to coordinate the intensity of land use around transit stations and economic plans (UN-Habitat 2015). Cross-country experience suggests that the intensity of land use should not be evenly distributed across the city but should peak where transit accessibility to jobs is greatest. Firms locate where they can increase their productivity through agglomeration and localization effects. Zoning policies should allow for and promote densification of the most accessible areas.

Shaping densities (people and jobs) based on transit accessibility and connecting people to jobs in a seamless, integrated way though many modes (planes, high-speed rail, regional trains, subways, buses) and across many geographical scales is essential to boost economic development, make most efficient use of resources, and minimize infrastructure cost. Seamless integration of scales and modes should be ensured at efficient and compact interchange hubs, which provide good opportunities for urban development if neighborhoods are permeable, pedestrian oriented, and vibrant.

Economic and Human Densities in Zhengzhou

Zhengzhou's economy is concentrated (map 8.2). The concentration of GDP is similar to London's and follows the Pareto principle (20 percent of the urban land

MAP 8.2 Geographic Distribution of GDP in Zhengzhou, 2009

GDP per km^2 (100 million Y per km^2)

Less than 2.00
2.01–5.00
5.01–10.00
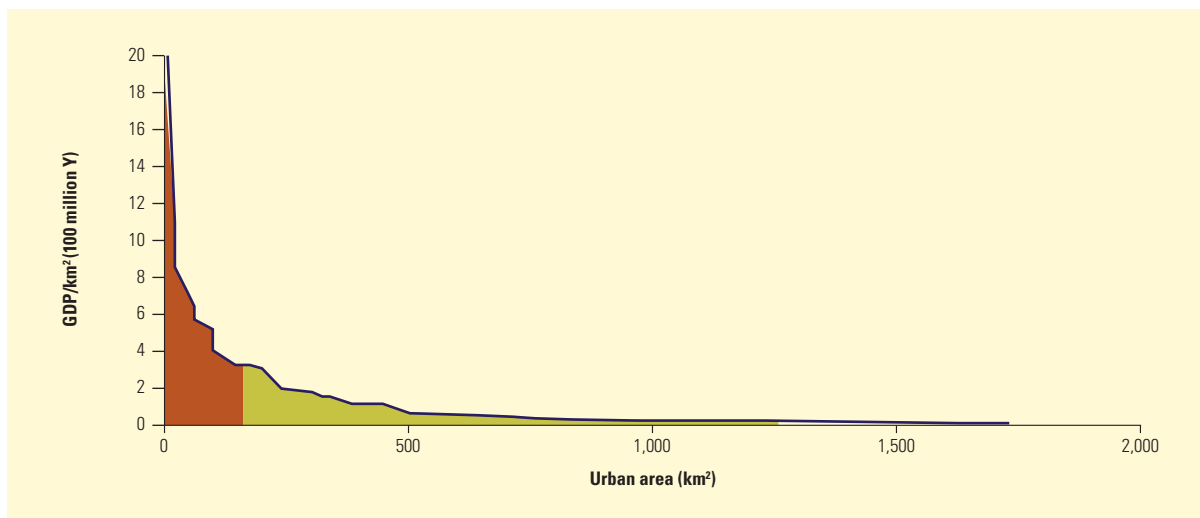10.01–20.00
More than 20.00

Source: Urban Morphology and Complex Systems Institute 2016, based on data from Zhengzhou census.

MAP 8.3 Projected Changes in Human Density in Zhengzhou between 2009 and 2030

−50–0%

0–25%

25–50%

50–75%

75–100%

100–150%

150–200%

200–300%

300–500%

More than 500%

Source: Urban Morphology and Complex Systems Institute 2016, based on data from traffic study.

produces 80 percent of the city's GDP) (figure 8.1). This pattern is efficient and considered a valuable asset in global cities, because concentrated areas with high productivity are economic engines for the entire city that ensure a city's global competitiveness and attractiveness. GDP density in Zhengzhou in 2009 follows an inverse power law distribution of exponent −0.89 (for an explanation of power law distribution, see appendix A).

Map 8.3 shows the projected decrease in human density (people and jobs) at the city core (areas marked in blue) and the increase at the disconnected periphery.

FIGURE 8.1 Geographic Concentration of GDP in Zhengzhou, 2009

Source: Urban Morphology and Complex Systems Institute 2016, based on data from Zhengzhou census.
Note: Eighty percent of Zhengzhou's GDP is concentrated on 21 percent of its urban area (red area); 20 percent of its GDP is sprawled over 79 percent of its urban area (green area).

MAP 8.4 Projected Changes in Human Density around Zhengzhou Subway Stations between 2009 and 2030

■	–50–0%
■	0–25%
■	25–50%
■	50–75%
■	75–100%
■	100–150%
■	150–200%
■	200–300%
■	300–500%
■	More than 500%
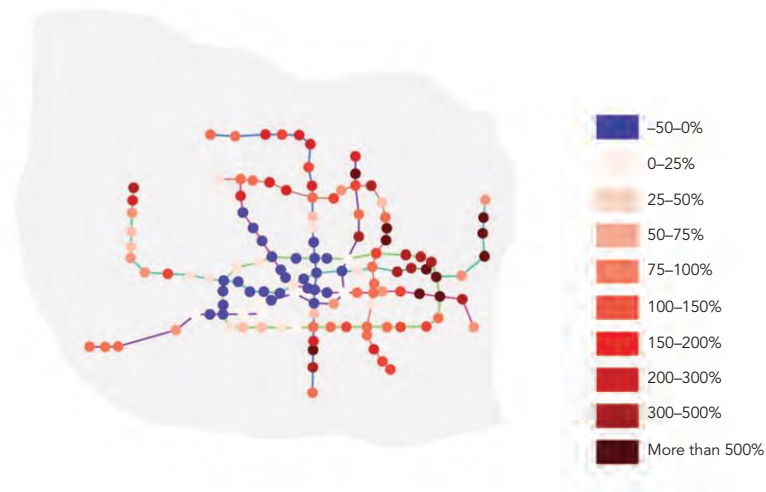
Source: Urban Morphology and Complex Systems Institute 2016.

The projected scattering of people and jobs across a vast territory may reduce the city's strong agglomeration effects.

Current planning does not foster a concentration of economic and residential densities around the most central parts of the subway network (map 8.4). Indeed, the city's decentralization policies are projected to reduce densities in the most central and accessible places within the city core while relocating people and activities to peripheral zones that are less accessible—the opposite approach from that of New York and London. Such transformation would lead to a less efficient form of land use and transit integration.

This evolution would be accompanied by increasing imbalances in the jobs to residents ratio, with an increase in large mono-functional industrial zones in peripheral locations with weak connections to subway lines. As a result, Zhengzhou's competitiveness and attractiveness for businesses would decline and travel times increase. Labor markets may become fragmented, reducing agglomeration economies and global welfare.

Instead, learning from the previous case studies, planning could match intensity of development across Zhengzhou with accessibility to people, jobs, and commercial space within 30 minutes by public transit, reinforcing already dense and accessible areas (which have higher potential for growth) rather than dispersing development with decentralization policies and new towns. It would require adjusting plans to allow better matching of increases in human densities with the increase in the number of accessible jobs delivered by the investment in new subway lines. Increases in connectivity and accessibility would lead to real estate growth and land values increases that could be partly captured by the public sector to pay for public investment and foster further local development. A new zoning system that differentiates floor area ratios (FARs) and land uses based on transit accessibility would allow Zhengzhou to develop a strategic TOD plan integrating

economic, transportation, and land use planning.[2] A match between jobs and transit would allow for a stronger integrated approach to spatial planning.

Residential and job densities in Zhengzhou are currently similar to those in competitive global cities such as Paris, London, and New York. Population density is high in central areas and low at the periphery (figure 8.2 and map 8.5), following an inverse power law of exponent –0.945 (see appendix A).

FIGURE 8.2 Population Distribution across the Zhengzhou Metropolitan Area, 2012
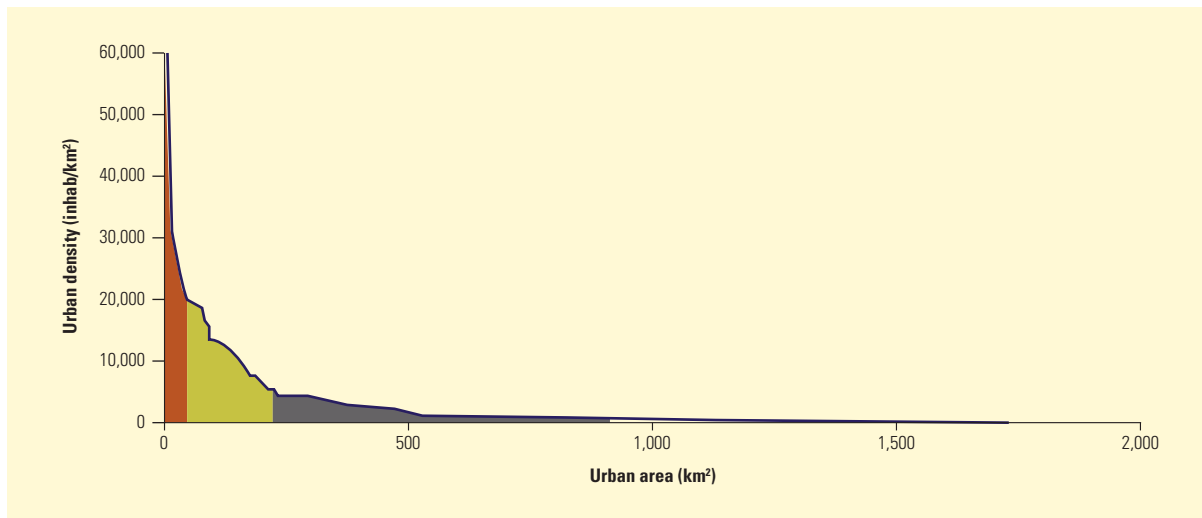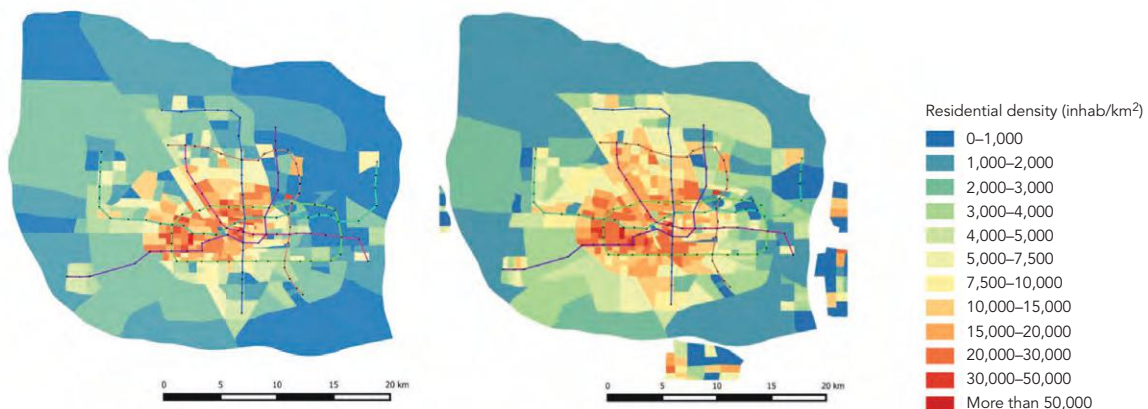

Note: Red area: 33 percent of the population (1.8 million inhabitants) lives on 2.5 percent of the metropolitan area (44 square kilometers). Density is more than 20,000 people per square kilometer, with an average density in the hypercore of 41,000 people per square kilometer. Green area: 30 percent of the population (1.6 million) lives on 6.5 percent of the metropolitan area (109 square kilometers). Density is 5,000–20,000 people per square kilometer, with an average density of 14,700 people per square kilometer. Grey area: 37 percent of the population (1.9 million) lives on 91 percent of the metropolitan area (1,570 square kilometers). Density is less than 5,000 people per square kilometer, with an average density of 3,300 people per square kilometer.

MAP 8.5 Residential Density in Zhengzhou, 2009 and 2030

a. 2009

b. 2030

Residential density (inhab/km²)
- 0–1,000
- 1,000–2,000
- 2,000–3,000
- 3,000–4,000
- 4,000–5,000
- 5,000–7,500
- 7,500–10,000
- 10,000–15,000
- 15,000–20,000
- 20,000–30,000
- 30,000–50,000
- More than 50,000

Source: Urban Morphology and Complex Systems Institute 2016, based on data from traffic study.

MAP 8.6 Residential Density around Subway Stations in Zhengzhou, 2009 and 2030

a. 2009

b. 2030

Residential density (inhab/km²)

- 0–1,000
- 1,000–2,000
- 2,000–3,000
- 3,000–4,000
- 4,000–5,000
- 5,000–7,500
- 7,500–10,000
- 10,000–15,000
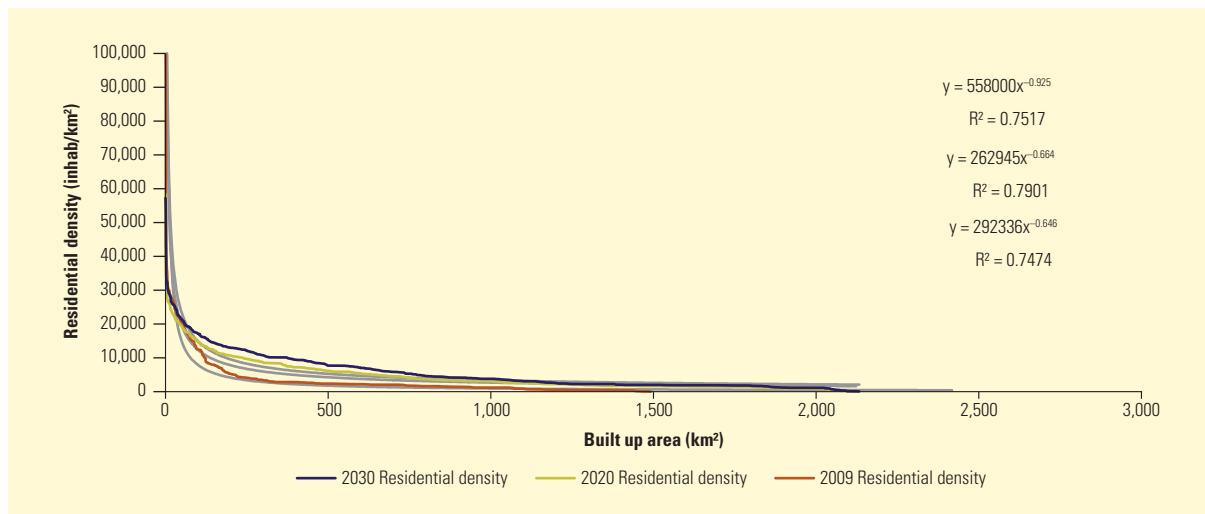- 15,000–20,000
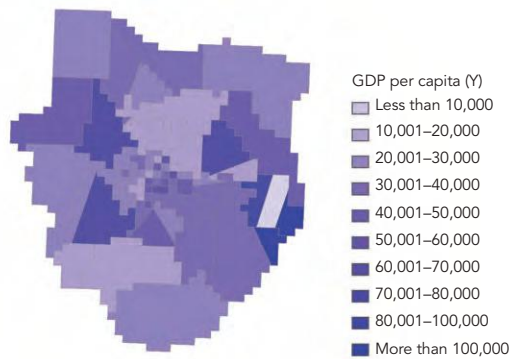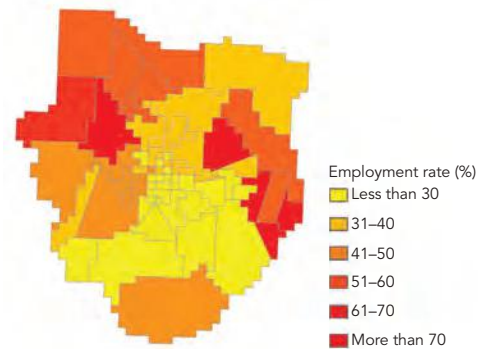- 20,000–30,000
- 30,000–50,000
- More than 50,000

Source: Urban Morphology and Complex Systems Institute 2016, based on data from traffic study.

The projected distribution of residential densities reveals a progressive increase, but large dense areas remain with little access to the subway network (map 8.5). Residential density is highly concentrated in 2009 (inverse power law exponent of –0.92). It is projected to become more smoothly distributed beginning in 2020 (inverse power law exponent of –0.66)—a development that reduced urban efficiency (figure 8.3).

Residential density within a 500-meter radius of subway stations reveals a strong imbalance between the western and eastern parts of the city (map 8.6). This imbalance will structure value, with a cluster of high residential density stations within the western part of the loop line.

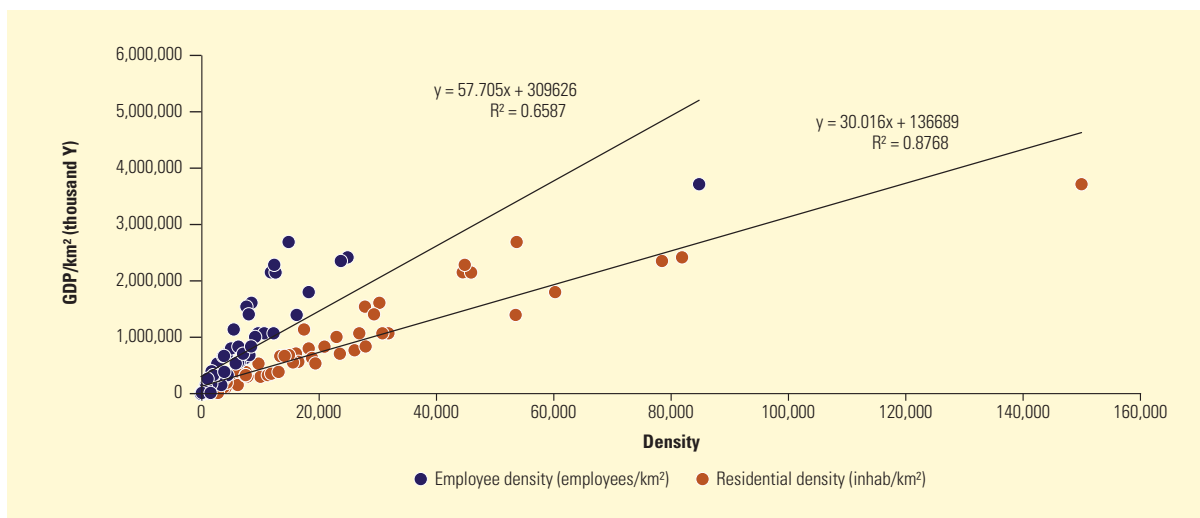**FIGURE 8.3 Residential Density in Zhengzhou, 2009, 2020, and 2030**

$y = 558000x^{-0.925}$

$R^2 = 0.7517$

$y = 262945x^{-0.664}$

$R^2 = 0.7901$

$y = 292336x^{-0.646}$

$R^2 = 0.7474$

2030 Residential density   2020 Residential density   2009 Residential density

MAP 8.7 GDP Per Capita and Employment Rate in Zhengzhou, 2009

a. GDP per capita

b. Employment rate

GDP per capita (Y)
- Less than 10,000
- 10,001–20,000
- 20,001–30,000
- 30,001–40,000
- 40,001–50,000
- 50,001–60,000
- 60,001–70,000
- 70,001–80,000
- 80,001–100,000
- More than 100,000

Employment rate (%)
- Less than 30
- 31–40
- 41–50
- 51–60
- 61–70
- More than 70

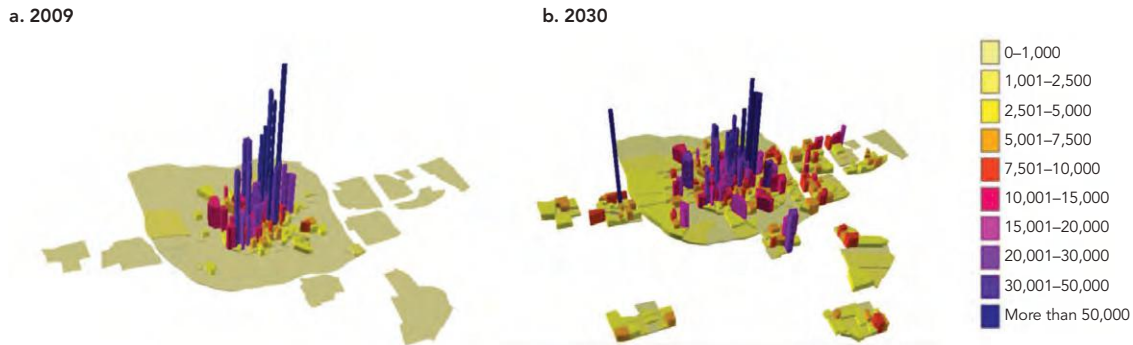*Source:* Urban Morphology and Complex Systems Institute 2016, based on data from census.

GDP per capita and the employment rate are highest in four peripheral districts (map 8.7). This pattern reflects zoning that concentrates employees and industrial zones in districts with few residents.

The correlation between residential and economic densities demonstrates strong agglomeration economy effects (figure 8.4). They may be jeopardized by the spreading out of jobs across a vast territory (map 8.8). The analysis reveals a drop in the concentration of jobs under the impact of decentralization policies (figure 8.5), with the exponent of the power law falling from 1.51 to 0.74.

Analysis of job densities within a 500-meter radius of subway stations confirms the structural imbalance between the western part of the city and the eastern part.

FIGURE 8.4 Correlation between Residential and Economic Densities in Zhengzhou, 2012

$y = 57.705x + 309626$
$R^2 = 0.6587$

$y = 30.016x + 136689$
$R^2 = 0.8768$

- Employee density (employees/km²)
- Residential density (inhab/km²)

Source: Urban Morphology and Complex Systems Institute 2016.

MAP 8.8 Job Density in Zhengzhou, 2009 and 2030

a. 2009   b. 2030

Legend:
- 0–1,000
- 1,001–2,500
- 2,501–5,000
- 5,001–7,500
- 7,501–10,000
- 10,001–15,000
- 15,001–20,000
- 20,001–30,000
- 30,001–50,000
- More than 50,000

Source: Urban Morphology and Complex Systems Institute 2016.

FIGURE 8.5 Concentration of Jobs in Zhengzhou, 2009 and 2030
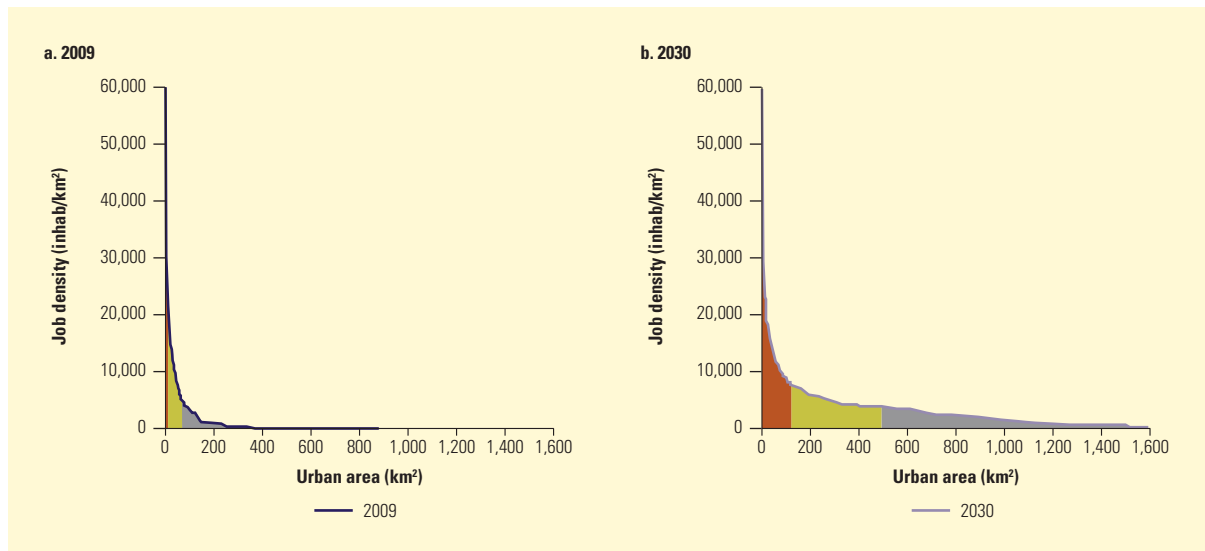
Note: In panel a: Red area: One-third of jobs are located on 1 percent of the built area (14 square kilometers); density is more than 20,000 jobs per square kilometer. Green area: One-third of jobs are located on 6 percent of the built area (44 square kilometers); density is 6,500–20,000 jobs per square kilometer. Grey area: One-third of jobs are located on 93 percent of the built area (809 square kilometers); densities are less than 6,500 jobs per square kilometer. In panel b: Red area: One-third of jobs are located on 6 percent of the built area (123 square kilometers); density is more than 7,700 jobs per square kilometer. Green area: One-third of jobs are located on 19 percent of the built area (305 square kilometers); density is 3,900–7,700 jobs per square kilometer. Grey area: One-third of jobs are located on 75 percent of the built area (1,163 square kilometers); density is less than 3,900 jobs per square kilometer.

Densities increase over time, but the imbalance remains. Jobs are decentralized, not clustered around subway stations. The projected decrease in density in the most connected part of the city will reduce market potential value in the urban center without creating strong market opportunities in the periphery, because areas planned for expansion are poorly connected to the subway network (maps 8.9

MAP 8.9 **Job Density around Subway Stations in Zhengzhou, 2009 and 2030**

a. 2009   b. 2030

Job density (jobs/km²)
- 0–1,000
- 1,000–2,000
- 2,000–3,000
- 3,000–4,000
- 4,000–5,000
- 5,000–7,500
- 7,500–10,000
- 10,000–15,000
- 15,000–20,000
- 20,000–30,000
- 30,000–50,000
- More than 50,000

Source: Urban Morphology and complex Systems Institute 2016, from data from traffic study.

MAP 8.10 **Disconnect between Projected Growth in Job Density between 2009 and 2030 and Subway Stations in Zhengzhou**

Job density Growth 2009–2030
- –50–0%
- 0–25%
- 25–50%
- 50–75%
- 75–100%
- 100–150%
- 150–200%
- 200–300%
- 300–500%
- More than 500%

Source: Urban Morphology and Complex Systems Institute 2016, based on data trom traffic study.
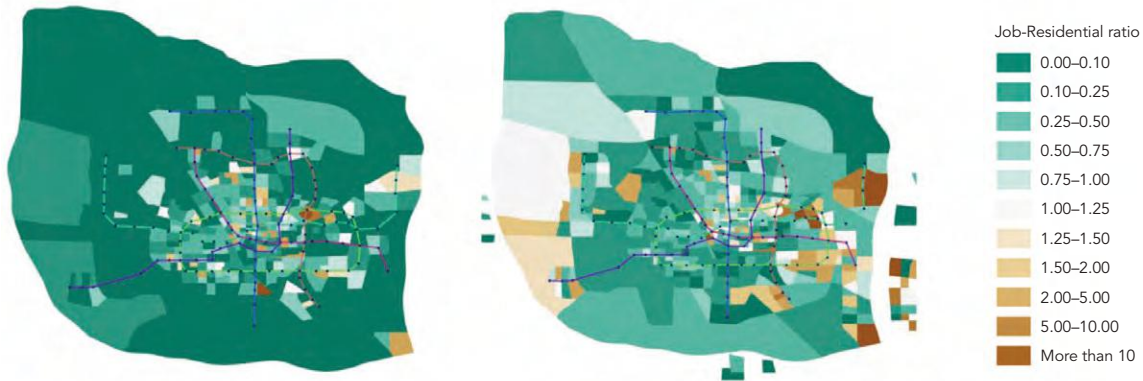
and 8.10). Job growth is expected to occur mostly in the periphery, in some cases in large, disconnected zones.

Large industrial zones will increasingly be scattered in peripheral locations and weakly connected to subway lines (maps 8.11 and 8.12). Their growth implies large increases in transport needs, mostly by road transport. The number of stations in the eastern part of the city with very high proportions of jobs to residents will grow, reflecting the increase in mono-functionality.
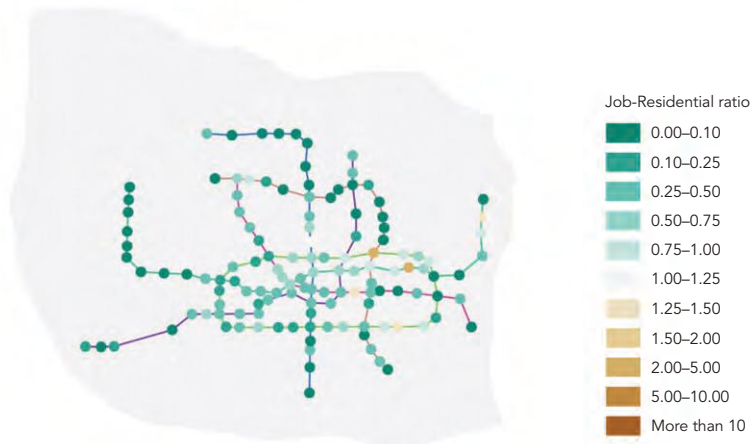
MAP 8.11 Jobs to Residents Ratio in Zhengzhou, 2009 and 2030

a. 2009   b. 2030

Job-Residential ratio

- 0.00–0.10
- 0.10–0.25
- 0.25–0.50
- 0.50–0.75
- 0.75–1.00
- 1.00–1.25
- 1.25–1.50
- 1.50–2.00
- 2.00–5.00
- 5.00–10.00
- More than 10

Source: Urban Morphology and Complex Systems Institute 2016, based on data from traffic study.

**MAP 8.12 Jobs to Residents Ratio in 500-Meter Catchment Area around
Subway Stations in Zhengzhou, 2030**

Job-Residential ratio

- 0.00–0.10
- 0.10–0.25
- 0.25–0.50
- 0.50–0.75
- 0.75–1.00
- 1.00–1.25
- 1.25–1.50
- 1.50–2.00
- 2.00–5.00
- 5.00–10.00
- More than 10

Source: Urban Morphology and Complex Systems Institute 2016, based on data from traffic study.

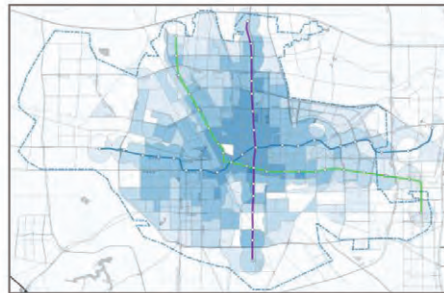## *Impact of Transit-Oriented Development on Improved Job Accessibility in Zhengzhou*

Li and others (2016) examined the average percentage of jobs accessible from each location within 45 minutes' travel time by public transit, walking, and biking weighted by the population for different land use and transport investments.[3] They showed that a significant increase in average job accessibility can be achieved when two complementary policies are combined: (a) a multimodal transit system that includes a well-developed subway network, supplemented by

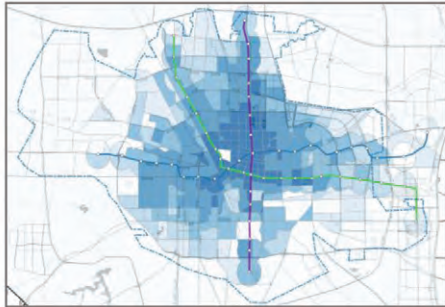**MAP 8.13 Accessibility to Jobs in Zhengzhou under Different Scenarios**
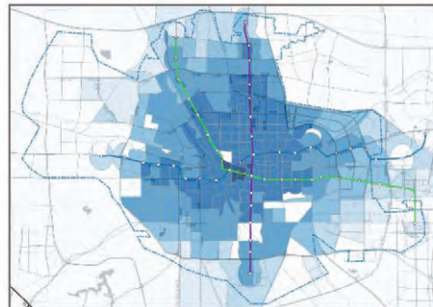
a. Line 1, 2 and 3 and walking

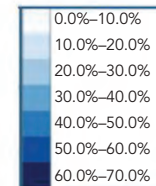**b. Scenario a plus buses**

c. Scenario b plus transit-oriented development

d. Scenario c plus bicycle access

Percent of jobs accessible
within 45 minutes by
public transit

	0.0%–10.0%
	10.0%–20.0%
	20.0%–30.0%
	30.0%–40.0%
	40.0%–50.0%
	50.0%–60.0%
	60.0%–70.0%

Source: Li and others 2016.

buses and bicycle access, and (b) densification at high levels around subway stations. Both social inclusiveness and labor market integration increase under such scenarios.

Map 8.13 shows the share of jobs than can be accessed by public transit, walking, and biking to within 45 minutes by people in Zhengzhou. In the first scenario, which includes only metro lines 1, 2, and 3 (panel a), people have access on average to 12 percent of the jobs. Adding the bus network increases the share to 28 percent (panel b). Doubling the concentration of jobs and residents within an 800-meter radius of metro stations (the TOD scenario) increases the share to 39 percent (panel c). Also ensuring good bike access to the stations (through improved bike lanes and secured parking facilities, for example) increases the share to 46 percent (panel d).

Node Value along Line 3

Node value is the value a station acquires through its location in the network. Different network organizations create different distributions of node values. The shape of transit and infrastructure networks strongly affects agglomeration and the potential for land value capture. Increases in connectivity and accessibility increase the growth potential and the market potential value of urban places.

Line 3 has 21 stations, crossing some of the densest parts of Zhengzhou in the central northwest quadrant of the city and linking them to the east of Zhengzhou (map 8.14).

Centralities in subway networks play an important role in structuring node values. The northern part of the loop line, Line 5 (in red in map 8.15), and the major interchanges between lines stand out in terms of betweenness centrality (many different routes pass through the station). As in global cities (Tokyo, London) or large Chinese cities (Shanghai), the loop line in Zhengzhou has high betweenness centrality, linking the core and the spokes. Stations with high betweenness centrality capture large flows of passengers and thus have high market development potential. Centrality
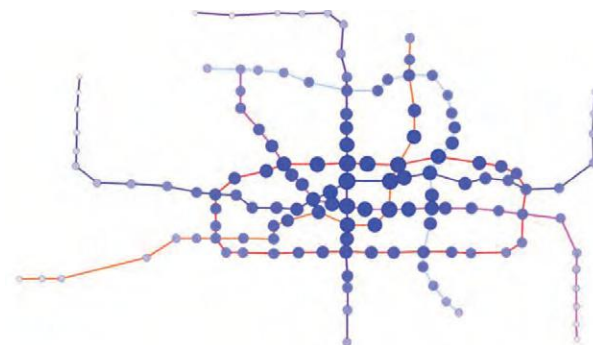
MAP 8.14 First Phase of Zhengzhou Line 3
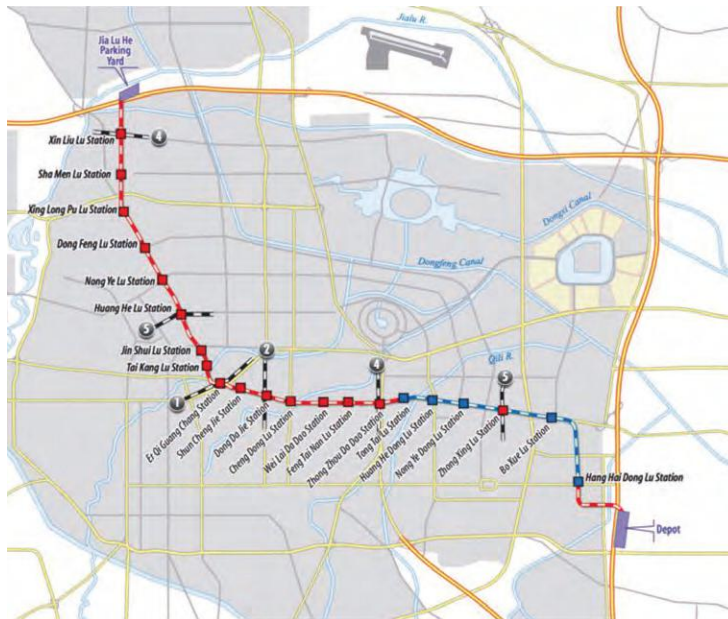
Source: World Bank 2014.

MAP 8.15 Closeness and Betweenness Centrality of the Zhengzhou Subway System

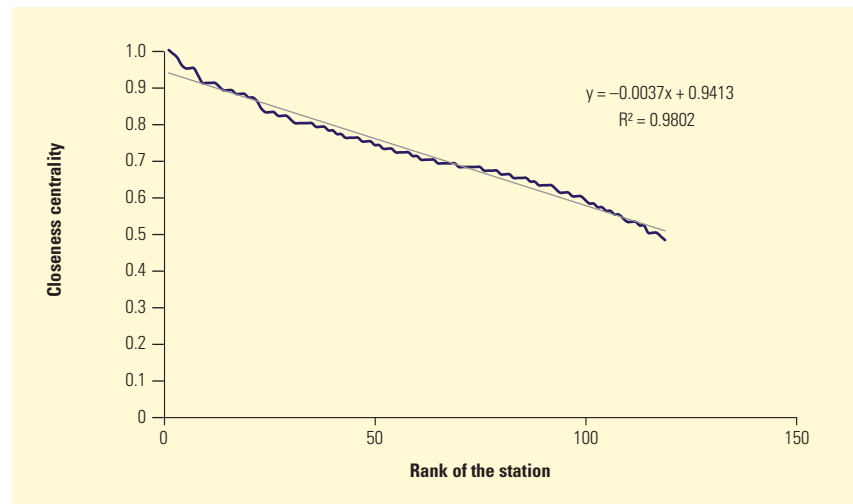a. Closeness centrality

b. Betweenness centrality

Source: Urban Morphology and Complex Systems Institute 2016.

analysis is based on the network including six lines by 2020. The central part of Line 3 (in pink in map 8.15) has good closeness centrality (stations are close to other stations in the network) but weak betweenness centrality, except when it crosses Line 5.

Closeness centrality does not display a steep gradient (figure 8.6). Its values do not decrease according to an inverse power law but linearly. In contrast, the distribution of betweenness centrality follows an inverse power law (with an exponent of –0.72 in Zhengzhou), both for the entire system and for Line 3 (figure 8.7).

FIGURE 8.6 **Distribution of Closeness Centrality of the Zhengzhou Subway**

$$y = -0.0037x + 0.9413$$
$$R^2 = 0.9802$$

Note: Blue line indicates the closeness centrality of stations. Grey line is the regression line.

FIGURE 8.7 **Distribution of Betweenness Centrality of the Zhengzhou Subway Network**

$$y = 2.9046x^{-0.726}$$
$$R^2 = 0.8305$$
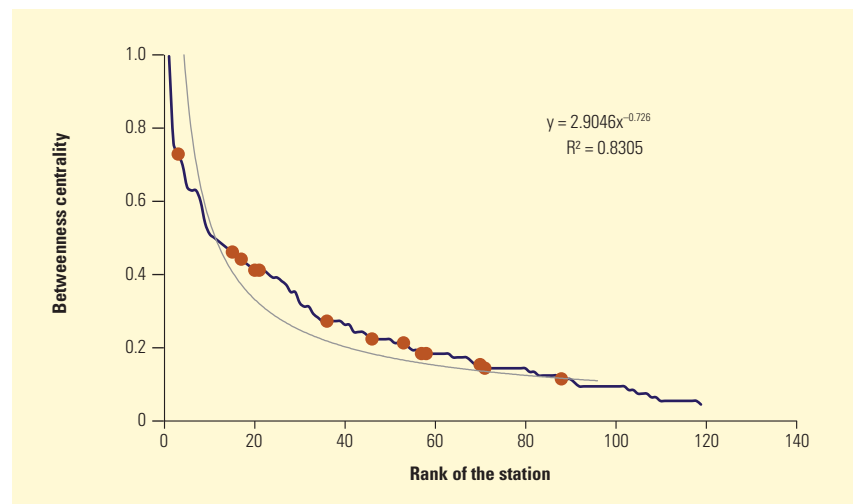
Source: Urban Morphology and Complex Systems Institute 2016.
Note: Red dots indicate stations on Line 3. Grey line indicates the entire system.

The Node Value Index

The node value index is created from three subindexes based on daily ridership, centrality, and intermodal diversity.

- Daily ridership (in 2021 and 2028) is the current and projected traffic of each station.
- Centrality describes the accessibility of each station within the network and the number of routes passing through it. It is measured as a composite index of three types of centralities explained in Chapter 2, calculated at the scale of the entire network.
- Intermodal diversity describes the number of other transit modes at walking distance from the station.

Each metric was normalized in a subindex (with 1 as the highest value). The composite index is the mean of the three subindexes.

Subindex 1: Daily ridership

Data on ridership were extracted from a study of projected inbound traffic at stations in 2021 and 2028 for Line 3. Ridership is highest at strong, central attractive destinations, such as Er Qi Guang Chang and Dong Da Jie, and at interchange stations, notably stations that connect to loop Line 5, which have high betweenness centrality (figure 8.8).[4]

FIGURE 8.8 **Daily Ridership Subindex at Line 3 Stations**
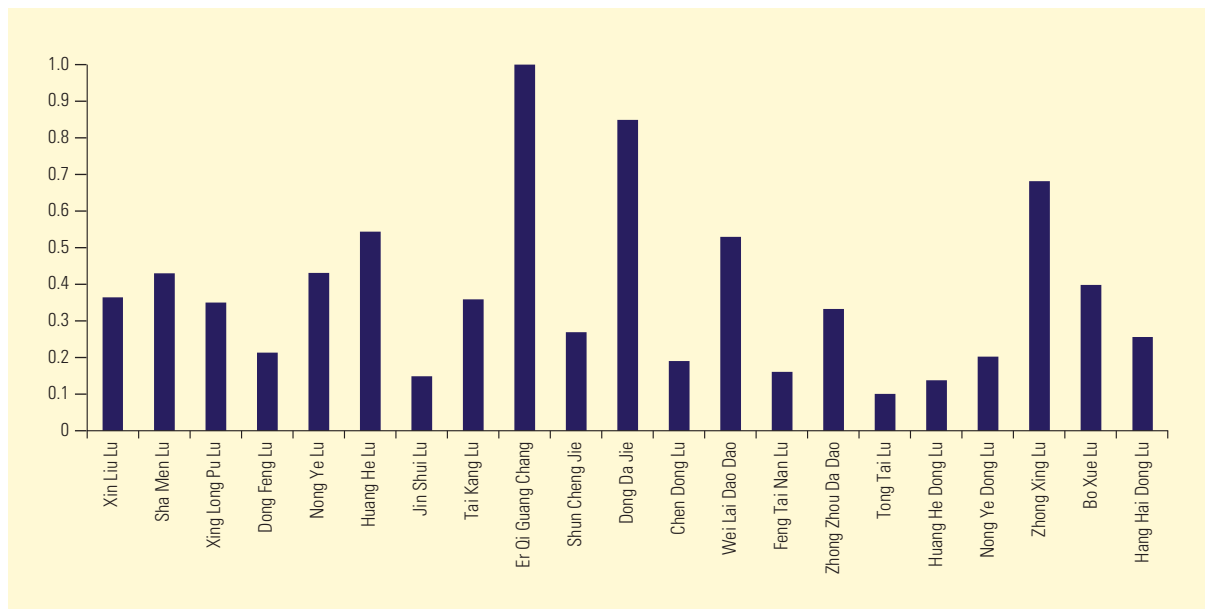
Source: Urban Morphology and Complex Systems Institute 2016.
Note: To give more weight to the long-term future potential of each subway station, the 2028 ridership is given twice the weight of 2021 ridership in calculating the subindex. Stations are ordered from west to east.

Daily ridership follows an inverse power low distribution (with a coefficient of –0.7) (figure 8.9). This hierarchical property of ridership (also evident in Paris and London) makes this indicator an excellent candidate to calculate the node value index.

FIGURE 8.9 **Inverse Power Law Distribution of Subway Ridership in Zhengzhou 2021 and 2028**

$y = 81606x^{-0.69}$
$R^2 = 0.87274$

$y = 139737x^{-0.729}$
$R^2 = 0.88961$
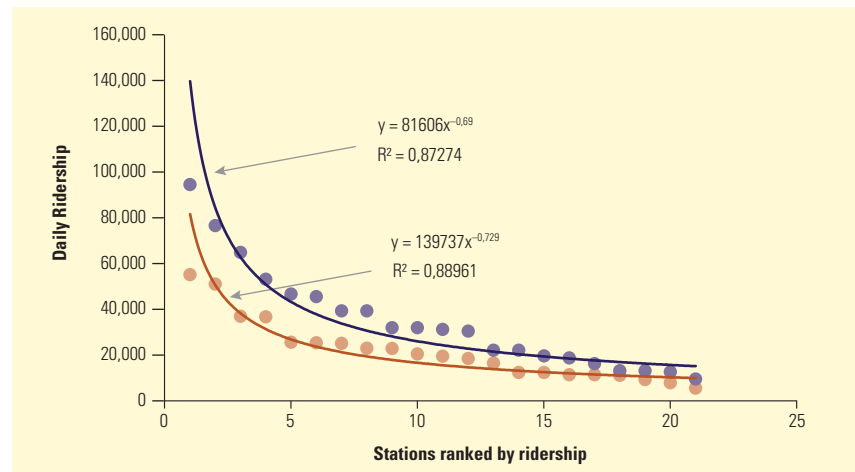
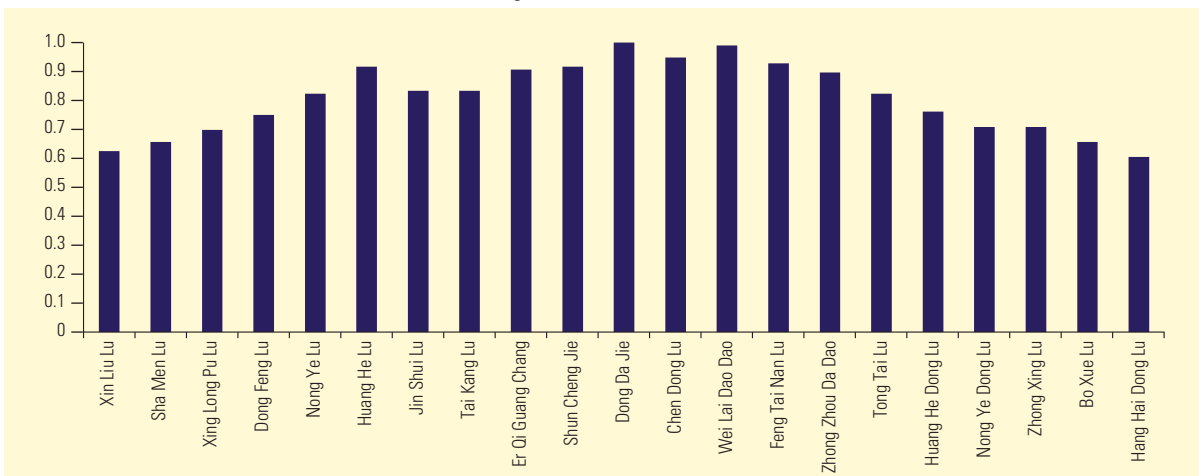*Source:* Urban Morphology and Complex Systems Institute 2016.
Note: Blue arrows points to ridership in 2021; red arrow points to ridership in 2028.

Subindex 2: Centrality

Centralities for Zhengzhou Line 3 were calculated for the entire Zhengzhou subway network. The subindex is a weighted average of degree centrality, closeness centrality, and betweenness centrality.

Figure 8.10 shows the normalized closeness centrality index for Line 3 stations. It shows differences between core stations and spoke stations.

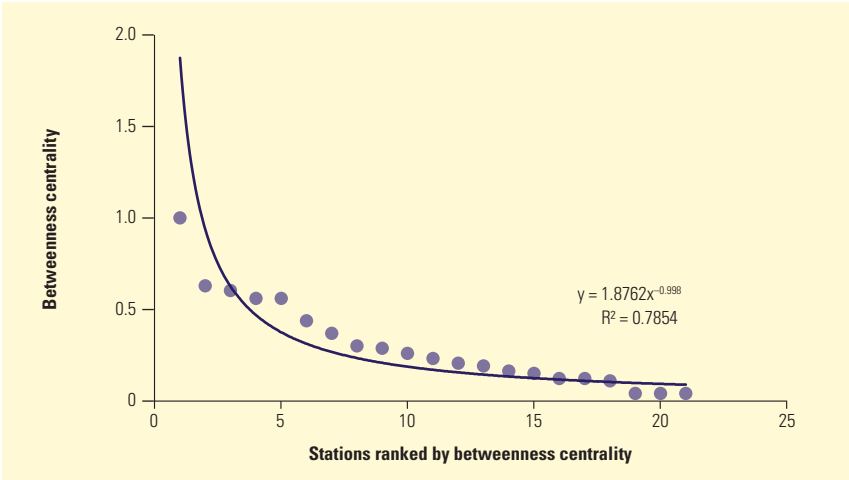**FIGURE 8.10** **Normalized Closeness Centrality Subindex of Line 3 Stations**

Source: Urban Morphology and Complex Systems Institute 2016.
Note: Stations are ordered from west to east.

Betweenness centrality has a steep gradient, distributed according to an inverse power law for both the entire network and Line 3 (figure 8.11).

FIGURE 8.11 Ranking of Betweenness Centrality of Line 3 Stations

$y = 1.8762x^{-0.998}$
$R^2 = 0.7854$

Source: Urban Morphology and Complex Systems Institute 2016.
Note: The distribution of betweenness centrality for Line 3 follows an inverse power law with a coefficient of −1.

Figure 8.12 shows the normalized index of betweenness centrality of stations on Line 3. It shows higher values for stations connecting Line 3 with Line 5.
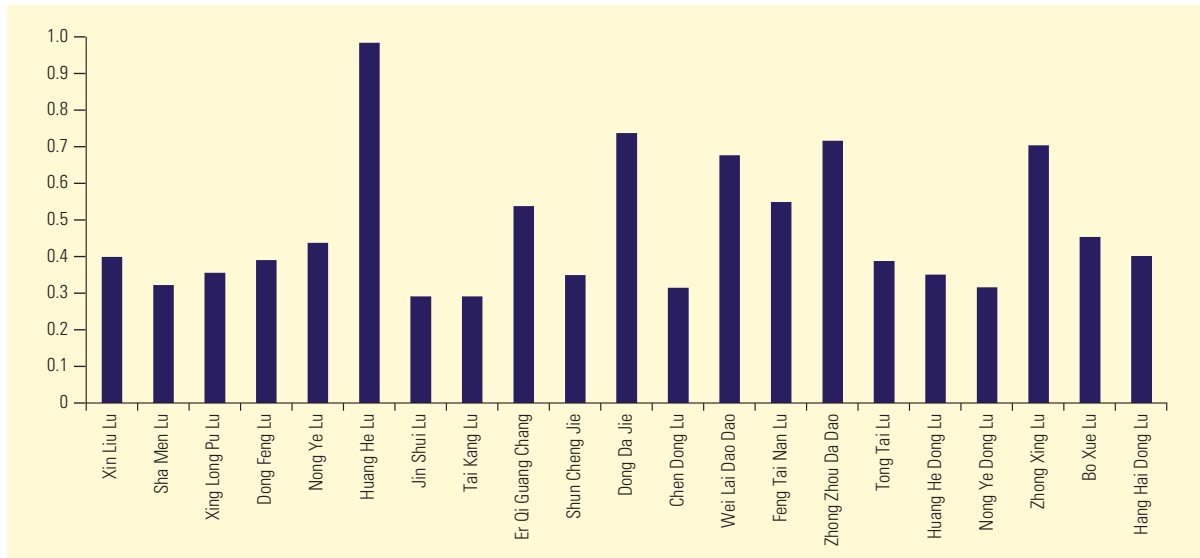
FIGURE 8.12 Normalized Betweenness Subindex of Line 3 Stations
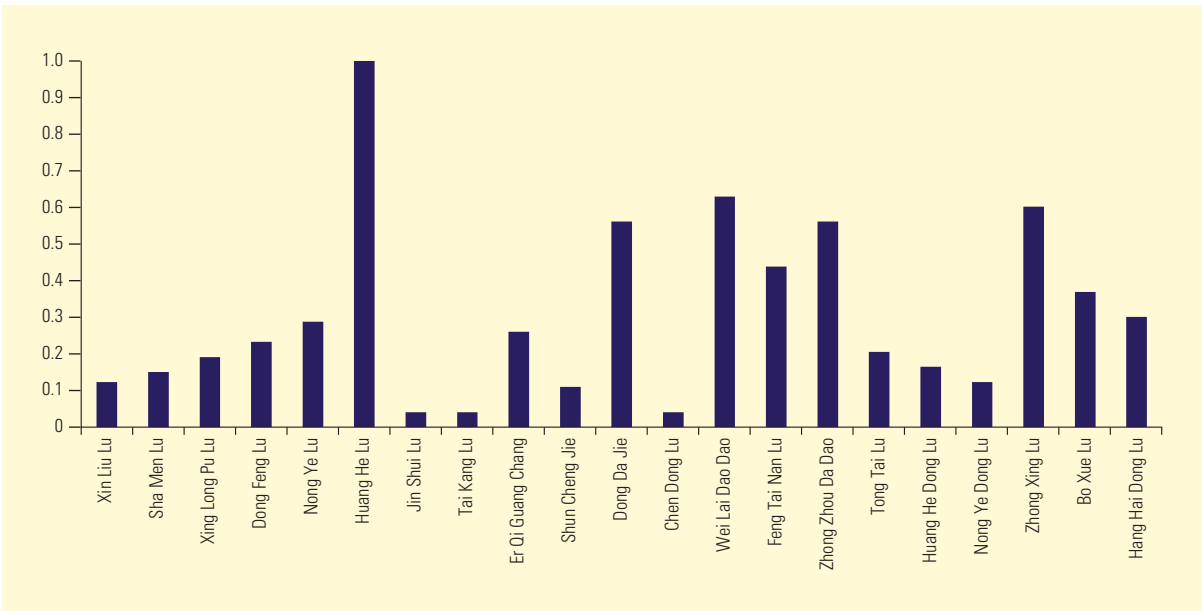
Source: Urban Morphology and Complex Systems Institute 2016.
Note: Stations are ordered from west to east.

Figure 8.13 gives the aggregated centrality index, a weighted average of degree (0.2), closeness (0.2), and betweenness (0.6) centrality.[5] Figure 8.14 shows the rankings of the stations.

FIGURE 8.13 **Aggregated Centrality Subindex for Line 3 Stations**

Source: Urban Morphology and Complex Systems Institute 2016.
Note: Stations are ordered from west to east.

The aggregated subindex of centrality follows an inverse power law (figure 8.14). The strong betweenness hierarchy is muted by the more linear closeness centrality.

FIGURE 8.14 **Ranking of Line 3 Stations by Subindex of Centrality**

$$y = 1.1106x^{-0.423}$$
$$R^2 = 0.9572$$

Source: Urban Morphology and Complex Systems Institute 2016.
Note: Stations are ordered from west to east.

Subindex 3: Intermodal diversity

Intermodal diversity captures the number of complementary modes (bus and bus rapid transit routes) that are within walking distance from a station. Figure 8.15 shows higher intermodality at the city center than at the periphery.
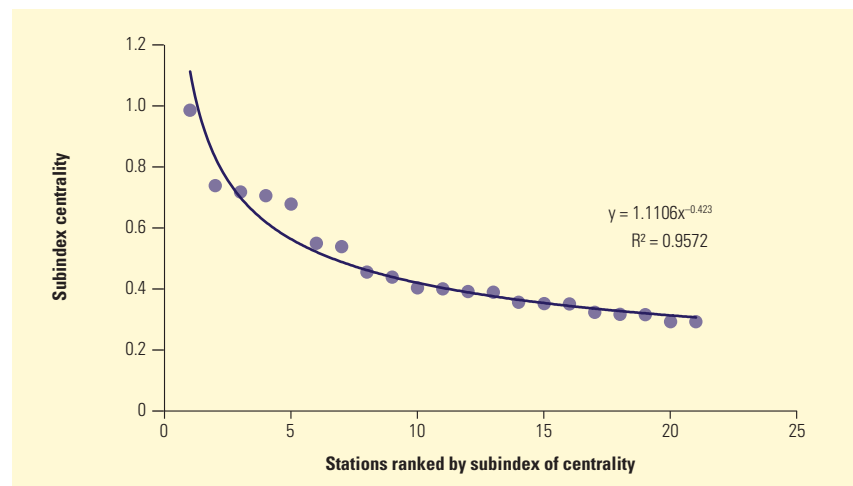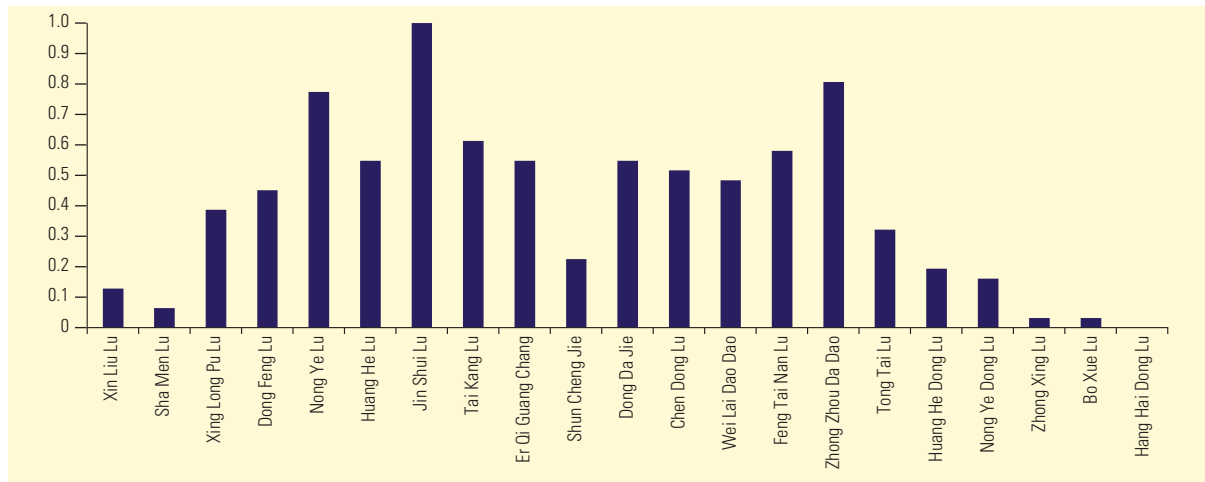
FIGURE 8.15 Normalized Intermodality Subindex of Line 3 Stations

Source: Urban Morphology and Complex Systems Institute 2016.
Note: Stations are ordered from west to east.

Comparison of node value subindexes reveals imbalances in connectivity (figure 8.16). The station with the highest ridership (Er Qi Guang Chang) has a

FIGURE 8.16 Subindexes of Daily Ridership, Centrality, and Intermodal Diversity
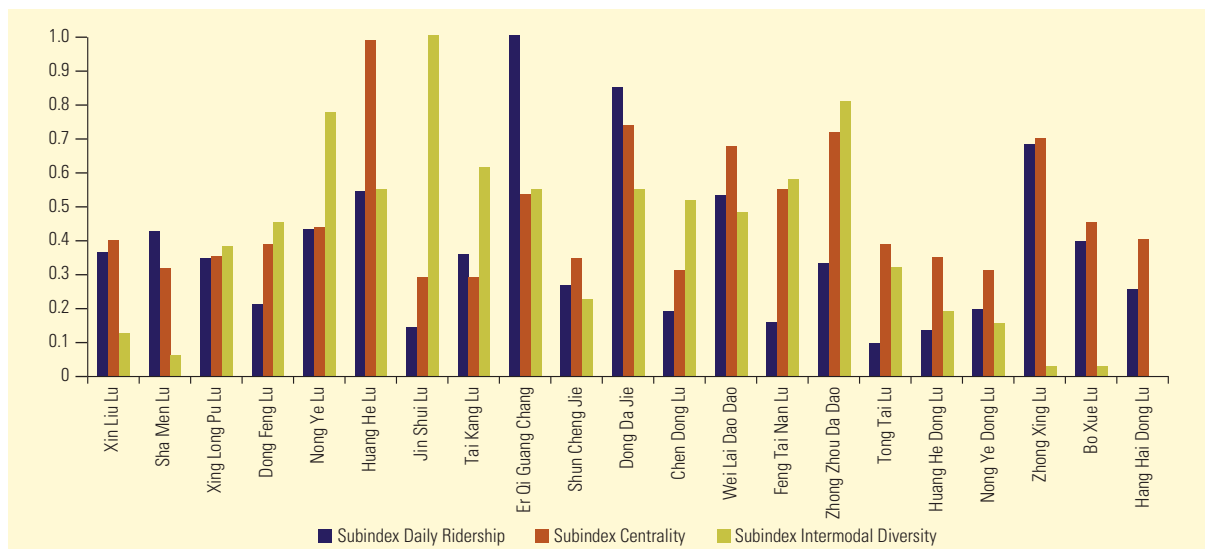
Source: Urban Morphology and Complex Systems Institute 2016.
Note: Stations are ordered from west to east.

moderate value of intermodality, whereas a station with high centrality and ridership, such as Zhong Xing Lu, has currently almost no intermodal diversity (reflecting its location in an area of underdevelopment). Peripheral stations have less intermodality than more central stations. The interplay of the different structural properties of the three centralities constitutes a subframework for analyzing the dynamics of node value.

Aggregated node value index ranked by hierarchical order reveals that a hierarchical structure is maintained but is dampened by the misalignments of traffic and intermodality with centralities (figure 8.17).
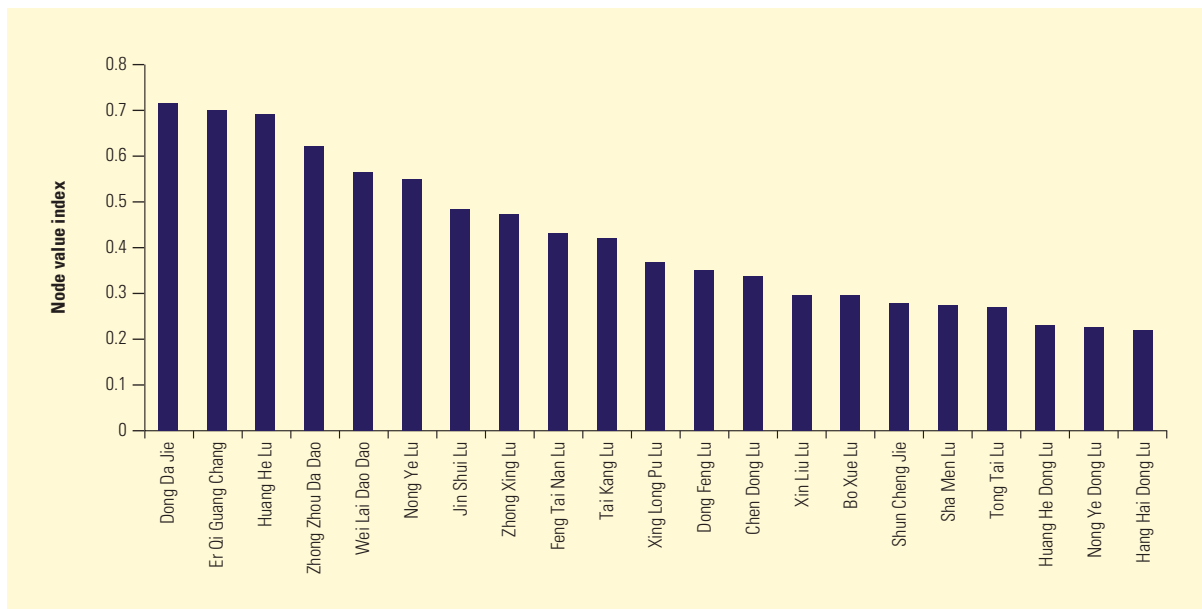
FIGURE 8.17 Aggregated Node Value of Line 3 Stations

Source: Urban Morphology and Complex Systems Institute 2016.

Increasing Node Value

In global cities with highly efficient transit networks, the centrality index is highest in the central part of the city. Zhengzhou could increase the hierarchy of stations along Line 3 by increasing the importance of central hubs and the number of lines and modes they connect and interconnecting neighboring stations into clusters.

Three planning approaches increase node values and thus the development potential of station areas:

- *Increasing the number of hubs and the number of lines and modes they connect in a dense network core.* Different network organizations shape land uses and land values differently. Networks that concentrate lines at focal points, interconnecting many lines and transportation modes, shape land prices and economic concentrations in a "spiky" way, with high peaks of value concentra-

tion. In contrast, a "flat" network—one that has no major hubs and no dense concentration of lines in a core—does not offer strong opportunities for capturing high land values around stations.

- *Interlinking neighboring stations into clusters.* An important property that enhances the connectivity of networks and the value of their nodes is clustering (establishing dense links between neighboring stations). This density of links creates many triangles between neighboring stations and tightly connects the network, offering passengers varied possibilities of interchange.
- *Increasing accessibility within the network.* Highly successful subway extensions (such as the addition of four lines in Seoul) cluster a large number of highly accessible stations in the network core, which concentrates density and economic activity.

Coordinating Node Values with the Intensity of Land Use

The projected decentralization of people and jobs is likely to reduce the match between the centrality of subway stations and residential and job densities in station catchment areas. To reap the opportunities created by the network extension, planners could coordinate the intensity of land use and economic policies in three ways:

- Encourage development at major interchanges (highest degree centralities), at the most accessible stations of the network (highest closeness centrality), and at stations that are major articulations of the network (highest betweenness centrality).
- Moderate development in areas that are less accessible within the network.
- Discourage development in areas that are more than 1 kilometer from a subway station.

Zoning policies can be fine-tuned to coordinate transit infrastructure provision and land use development. FARs are an effective way to achieve optimal land use intensity. They should be set at different levels depending on uses and accessibility. Seoul set FARs as high as 10 for commercial uses around the most connected and central transit stations, at 2–4 for mixed residential and business areas, and at 1–2 for residential uses. Uses are defined with fine granularity, depending on proximity to and importance of transit stations (see box 1.8). FARs should include flexibility for transferring them between uses based on market changes, allowing the private sector to adjust the intensity of development to market needs.

Place and Market Potential Value along Line 3

Zhengzhou's planning is based on superblocks. Arterials over many subway routes are 60 meters wide; some are as wide as 100 meters (with additional setbacks). Street intersection densities (the number of intersections per square kilometer) around subway stations are low in new areas, as in most Chinese cities. Most superblock areas have fewer than 10 intersections per square kilometers—a fraction of the 80–100 recommended by UN-Habitat (2013). Street intersection density

reflects important properties of local accessibility to stations, the permeability and openness of the neighborhood, and the quality of the urban and social fabric. It is highly correlated with block size. Street lengths in Line 3 station areas are also well below the 18 kilometers of streets per square kilometer UN-Habitat recommends.

Place value for residents derives from vibrant, sustainable communities where they can access jobs, shopping, and services on foot or bicycle and enjoy a range of benefits, such as reduced transportation costs; easier access to amenities, including high-quality education; and improved public health. Like node value, it is unevenly distributed. In a typical city, many station areas are mainly residential, and a few are more job-oriented and mixed-use.

Walkability also differs across areas. It depends on street patterns and the design of streets as places for people. Street patterns determine not only whether residents and workers can access rail and bus transit but also whether they can access shopping, jobs, and services in their neighborhood. Street patterns with small blocks (about 100 meters per side) and high connectivity (no cul-de-sacs) enhance local accessibility. Superblocks and gating decrease accessibility.

Place Value along Line 3

The place value index is built from two subindexes: street intersection density and the diversity of land use. Diversity of land use is a measure of mixed use in the area surrounding the station. Each subindex was normalized (with 1 as the highest value). The composite index is the mean of the two subindexes.
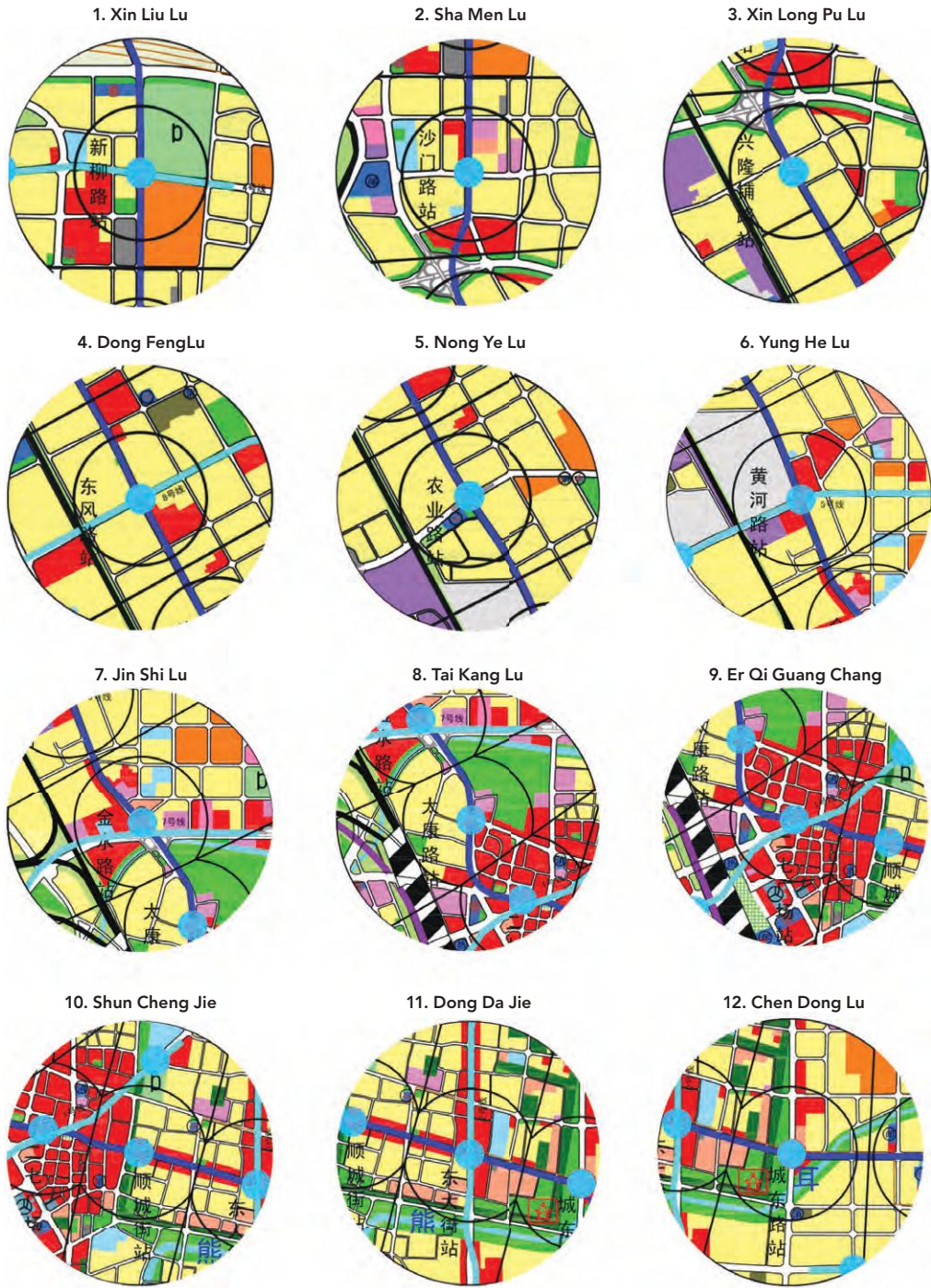
The subindex of intersection density reveals low intersection densities almost everywhere along the line except in the city center, with a peak in the historical part of Shun Cheng Jie. Intersection densities are below 10 almost everywhere and as low as 6 in Dong Feng Lu and Hang Hai Dong Lu. The peak is 50, at Chung Cheng Jie, followed by 40 at Er Qi Guan Chang, but even these densities are low compared with the 80–100 recommended by UN-Habitat (2013)

Diversity was estimated within a 1-kilometer area of each station (map 8.16) using a color analysis method applied to the regulatory plan color codes (see Shannon entropy in appendix B). Weak values capture large-scale mono-functional residential developments or warehouses in the eastern part of Zhengzhou; they have low street intersection densities. High values characterize more vibrant neighborhoods in the central part of the city. The western part of the city is more diversified than the newly developed eastern part, which is strictly zoned. As the diversity calculation is based on the regulatory plan, it tends to reflect expected future diversity rather than current use.

The interplay of land use and intersection densities and their discrepancies could guide public policies. Increasing land use diversity in the east should be accompanied by increasing street density and local connectivity.

The aggregated place value index maintains the pattern of higher place value in the historic central parts of the city, although the effect is dampened by planned land use (figure 8.19).

MAP 8.16 Land Use around Line 3 Stations

1. Xin Liu Lu

2. Sha Men Lu

3. Xin Long Pu Lu

4. Dong FengLu

5. Nong Ye Lu

6. Yung He Lu

7. Jin Shi Lu

8. Tai Kang Lu

9. Er Qi Guang Chang

10. Shun Cheng Jie

11. Dong Da Jie

12. Chen Dong Lu

MAP 8.16 **Land Use around Line 3 Stations** (continued)

13. Wei Lai Da Dao   14. Feng Tao Nan Lu   15. Zhong Zhou Da Dao

16. Tong Tai Lu   17. Huang He Dong Lu   18. Nong Ye Dong Lu

19. Zhong Xing Lu   20. Bo Xue Lu   21. Hang Hai Dong Lu
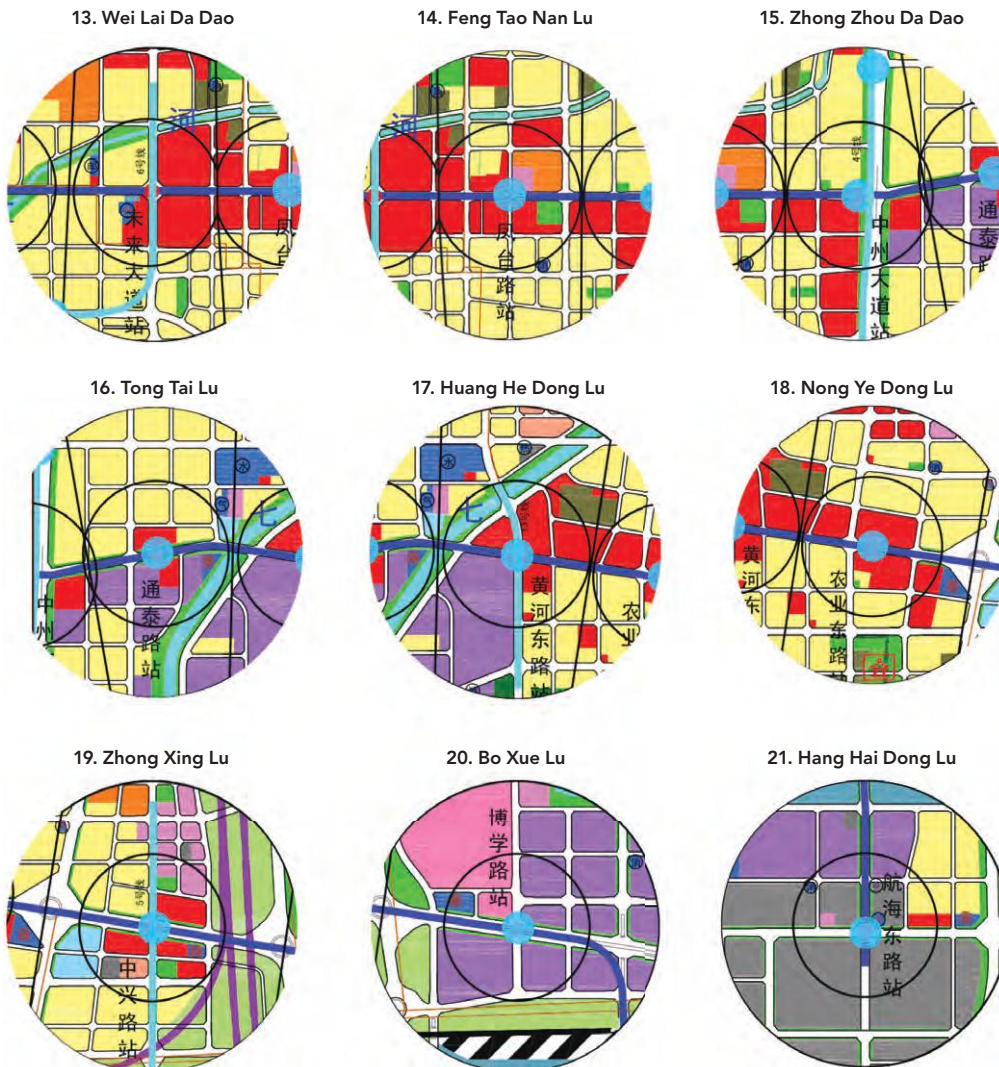
Source: World Bank, based on data from the Zhengzhou City Planning.
Note: Regulatory plan color codes: Yellow: Residential. Red: Commercial and office. Grey: Industry in economic development zone and e-business. Blue: Municipal utility. Violet: Warehouse. Pink: Government office. Orange: Schools and education and research institutes. Light orange: Library or museum. Light salmon (stations 11 and 12): School.

FIGURE 8.18 Intersection and Land Use Diversity Subindexes of Line 3 Stations
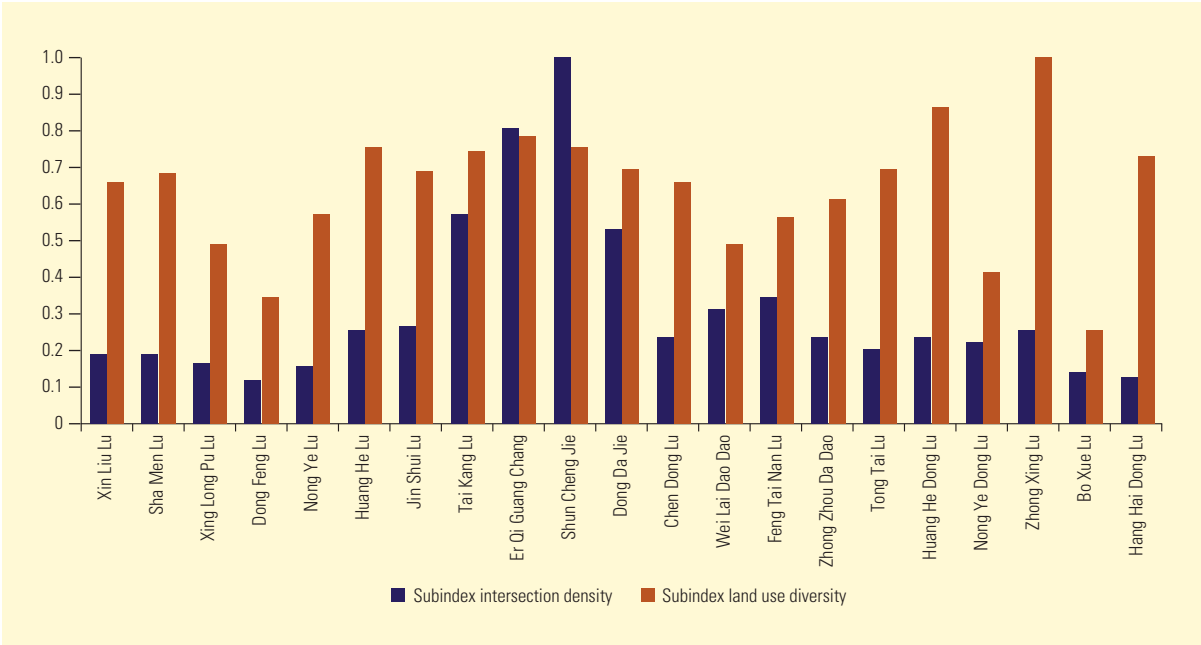
Source: Urban Morphology and Complex Systems Institute 2016.
Note: Stations are ordered from west to east.

FIGURE 8.19 Aggregated Place Value Index of Line 3 Stations
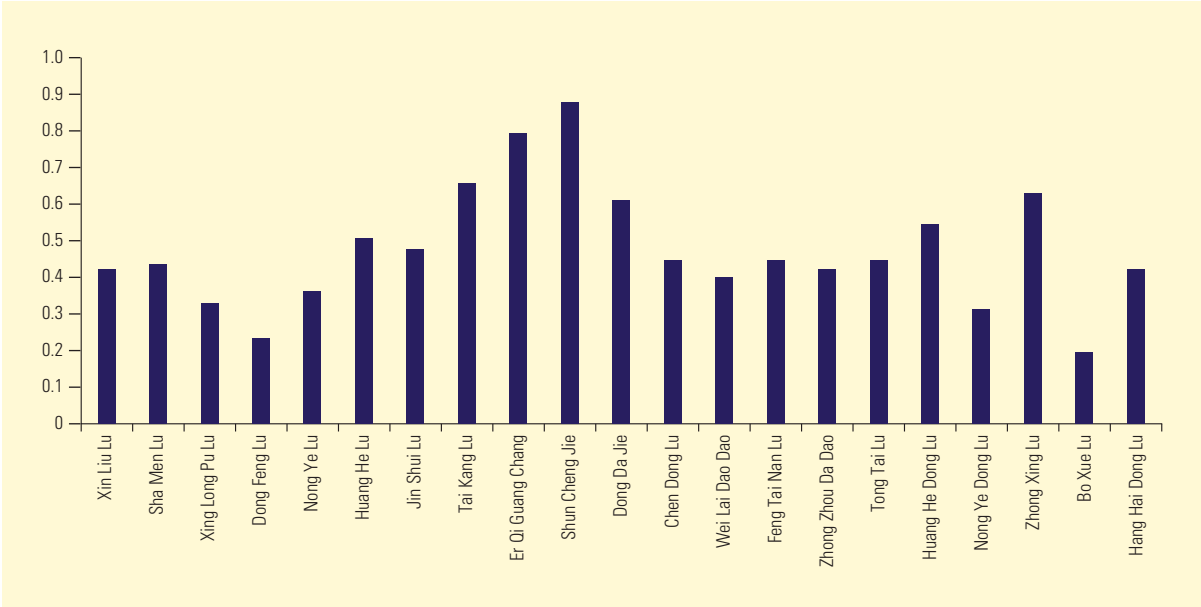
Source: Urban Morphology and Complex Systems Institute 2016.
Note: Stations are ordered from west to east.

Recommendations for Increasing Place Value

Mixed-use development promotes a variety of compatible land uses and functions and provides a mix of residential, commercial, and community infrastructure in neighborhoods while reducing the demand for commuter travel. Transforming superblocks into communities with a better mix of uses, ensuring a wider ranging of building types and sizes, creating a finer mesh of streets with better connectivity, and building a better-defined and more vibrant public realm would increase place value in Zhengzhou.

Market Potential Value along Line 3

The market potential value index in this study is built from three subindexes that reflect the demand side of market potential value: human density, the job to resident ratio, and growth potential:

- Human density (the number of residents and jobs per square kilometer) is an indication of how economic potential and concentration of interaction and activity vary along the line.
- The jobs to residents ratio provides an indication of the level of economic mono-functionality of the station environment.[6]
- Growth potential is the rate of growth of human density between 2009 and 2030. It is a proxy for market growth and market opportunities.[7]

Each metric was normalized in a subindex (with 1 as the highest value). The composite index is the mean of the subindexes.

Human density around transit nodes in 2009 reveals a pattern of concentration within the centerwest quadrant (map 8.17). The subindex peaks at Shun Cheng Jie and Dong Da Jie (figure 8.20).

MAP 8.17   **Subindex 1: Human Density around Transit Stations in Zhengzhou, 2009**

Human density (inhab & jobs/km²)
- 0–1,000
- 1,000–2,000
- 2,000–3,000
- 3,000–4,000
- 4,000–5,000
- 5,000–7,500
- 7,500–10,000
- 10,000–15,000
- 15,000–20,000
- 20,000–30,000
- 30,000–50,000
- More than 50,000

Source: Urban Morphology and Complex Systems Institute 2016.

FIGURE 8.20 Subindex 1: Human Density around Line 3 Stations, 2009
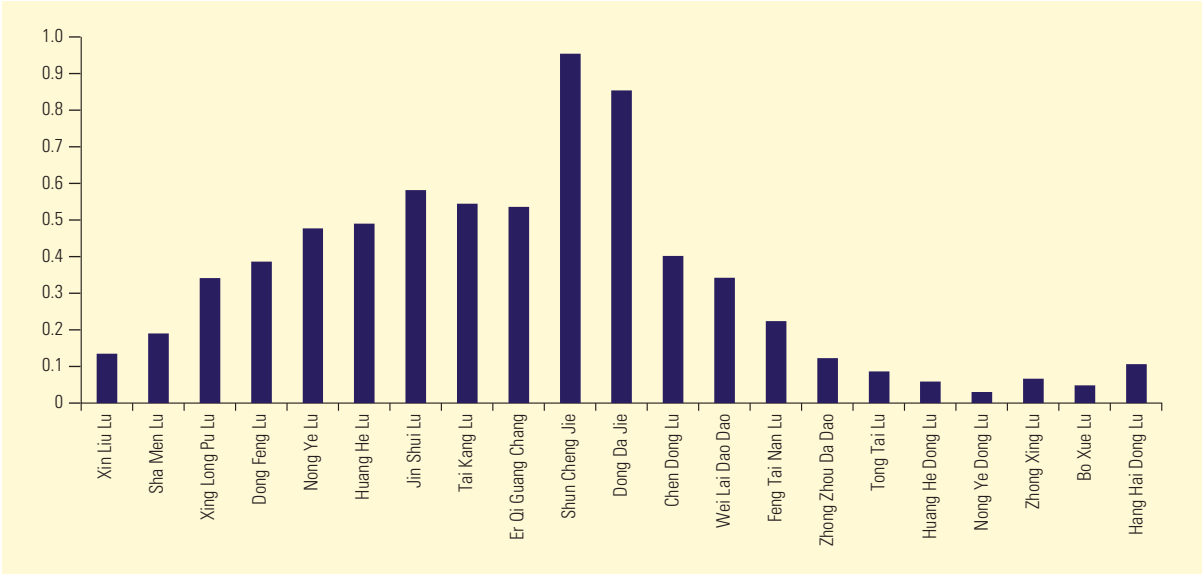
Source: Urban Morphology and Complex Systems Institute 2016.
Note: Stations are ordered from west to east.

The jobs to residents ratio indicates that the center-west quadrant has a better alignment of jobs around transit stations than the eastern part of the city (figure 8.21).

FIGURE 8.21 Subindex 2: Jobs to Residents Ratio around Line 3 Stations

Source: Urban Morphology and Complex Systems Institute 2016.
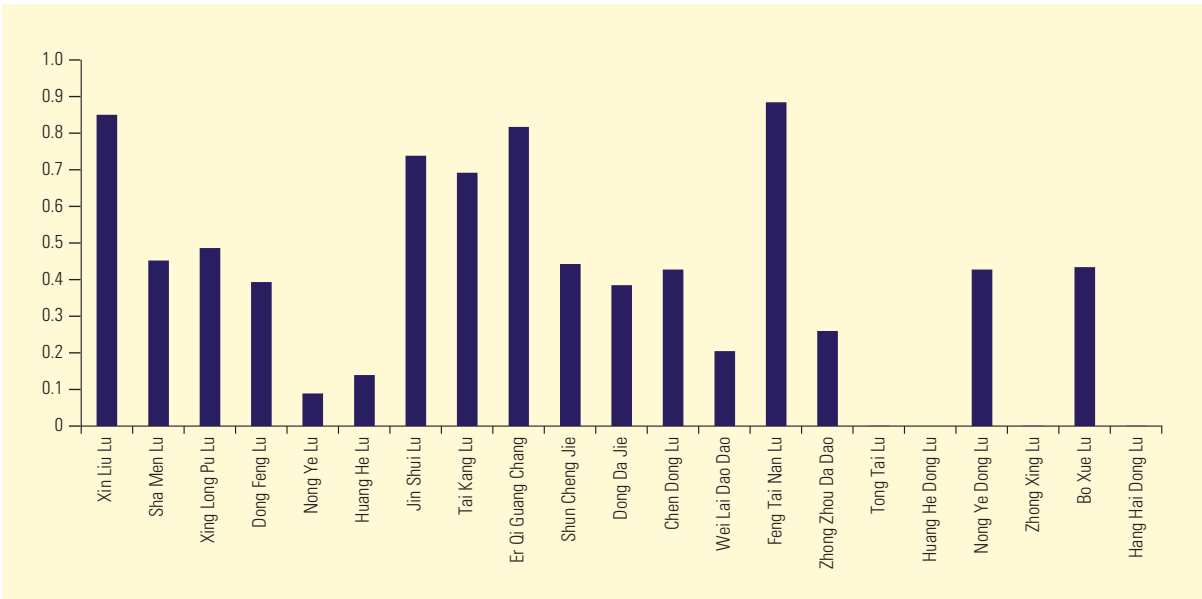*Note:* Stations are ordered from west to east.
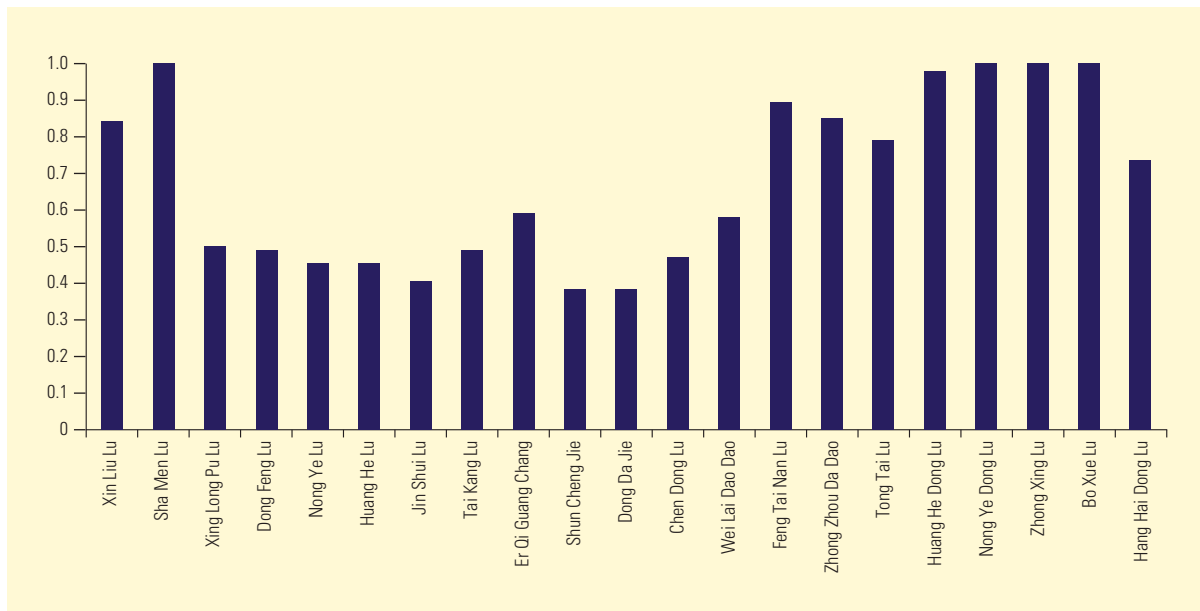
FIGURE 8.22 Subindex 3: Growth Potential around Line 3 Stations

Source: Urban Morphology and Complex Systems Institute 2016.
Note: Stations are ordered from west to east.

The index of growth potential reveals a shift toward the east away from more central and more connected nodes (figure 8.22). The shift partly reflects development around the new high-speed rail station in Zhengzhou East.
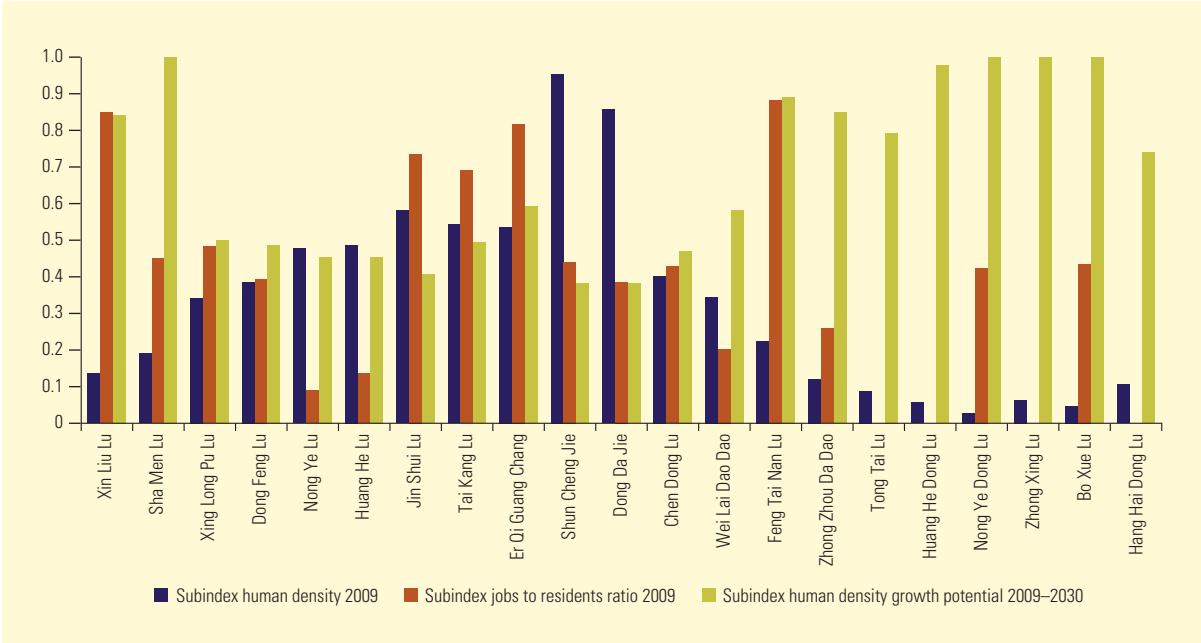
Comparison of subindexes shows the contrast between 2009 and 2030 in terms of the human density and the jobs to residents ratio. Both indicators have well aligned values in 2009 that foster high market potential values. By 2030 the projected shift to the east as a result of the development of the HSR Zhengzhou East is projected to lead to a more spread out market potential (figure 8.23) across stations (figure 8.24). It does not peak strongly in the center and does not take off in the eastern part of the city.

Recommendations for Increasing Market Potential Values

The following strategies would foster TOD in the 800-meter radius around key stations, likely increasing their market potential value:

1. *Increase the density of people and jobs in key station areas.* The number of residents and workers in an area and the balance between jobs and the working-age population is correlated with the attractiveness of the area for residents and businesses and thus with the development of a strong real estate market. Such densification is particularly relevant in stations with high node values.
2. *Increase FARs around key stations.* In TOD projects, local authorities often raise FARs to facilitate densification and generate revenue streams that can be captured to finance infrastructures (transit and public spaces). Commercial FARs

FIGURE 8.23 Subindexes of Human Density, Job Resident Ratio, and Human Density Growth Potential around Line 3 Stations

■ Subindex human density 2009   ■ Subindex jobs to residents ratio 2009   ■ Subindex human density growth potential 2009–2030

Source: Urban Morphology and Complex Systems Institute 2016.
Note: Stations are ordered from west to east.

FIGURE 8.24 Aggregated Market Potential Value Index around Line 3 Stations

Source: Urban Morphology and Complex Systems Institute 2016.
Note: Stations are ordered from west to east.

around stations should be raised. Residential FARs could be raised, albeit at lower than commercial FARs.

3. *Increase the diversity of land parcel sizes to create a vibrant land market*. Diversity of land parcel sizes can meet future demand and create an adaptive city. Urban development in China is based on 400 square meter superblocks, the current unit of land sales to developers. This contrasts sharply with the smaller unit of land sales found in other large cities outside China (see chapter 4). Smaller block size fosters an active land market with potential for mixed use.

Interplay of Node, Place, and Market Potential Values

By improving accessibility, improving the node value of a location creates conditions favorable to the further development of the location. Because of growing demand for transport, an increase in place value creates conditions favorable to the further development of the transport system.

Of the 21 Line 3 stations, only 2 have "high" place value (figure 8.25). (These values are relative. The medium values are low by international standards, as most

FIGURE 8.25 **Relationship between Node and Place Values around Line 3 Stations**
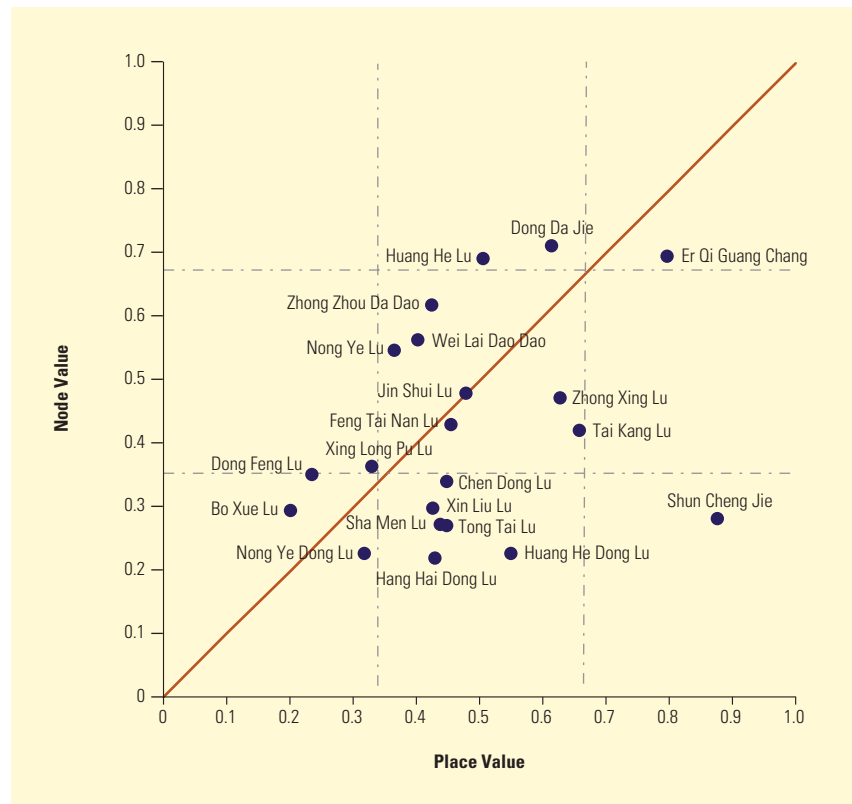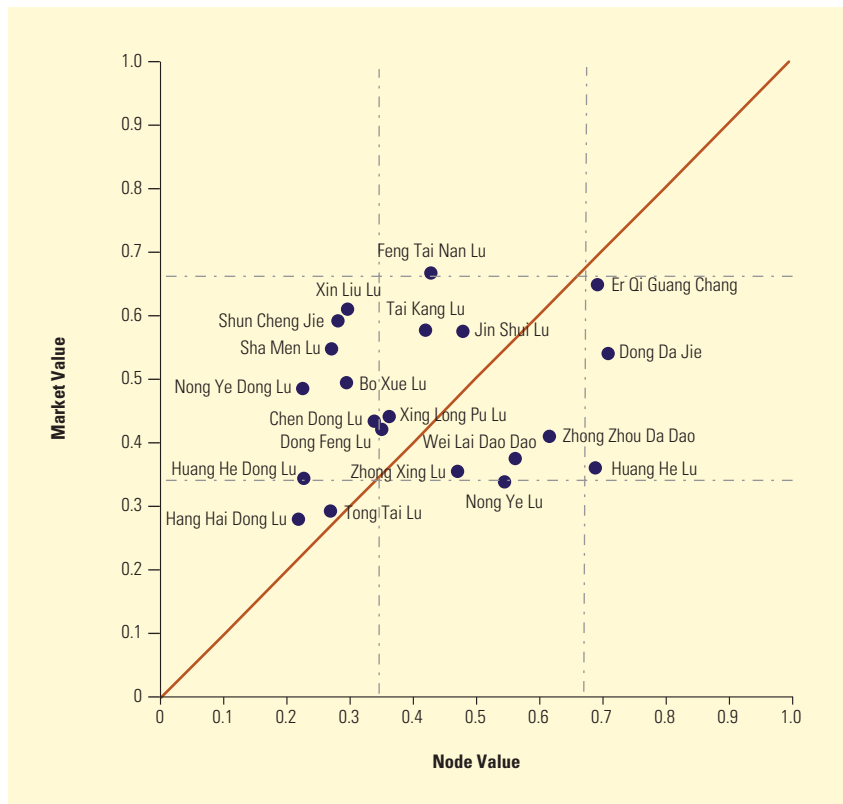

Source: Urban Morphology and Complex Systems Institute 2016.

of the station surroundings are based on superblocks with low intersection density, leading to reduced accessibility to stations.) Er Qi Guang Chang stands out as a place of high value and high potential in terms of node value, connectivity, and diversity. Zhong Zhou Da Dao, Huang He Lu, and Dong Da Jie Da Jie stand out in terms of node value; their medium place value should be enhanced.

Figure 8.26 reveals strong imbalances between market potential and node values. Er Qi Guang Chang stands out in terms of both values. Most market potential value is moderate, with little alignment with node value. Stations with higher node values have lower market potential values than stations with lower node value on the periphery of the network. This pattern is the likely result of decentralization policies that do not align land use intensity and transport and may not let the market shape the distribution of densities based on accessibility. Growth should occur as a priority in more connected stations (below the 45-degree line) rather than in less connected stations (above the 45-degree line) requiring planners to think about alternative spatial scenarios of growth.

The relationship between market potential and place value shows the same type of imbalance (figure 8.27). Er Qi Guang Chang and Shun Cheng Jie stand out in

FIGURE 8.26 **Relationship between Market Potential and Node Values around Line 3 Stations**

Source: Urban Morphology and Complex Systems Institute 2016.

FIGURE 8.27 **Relationship between Market Potential Value and Place Value around Line 3 Stations**
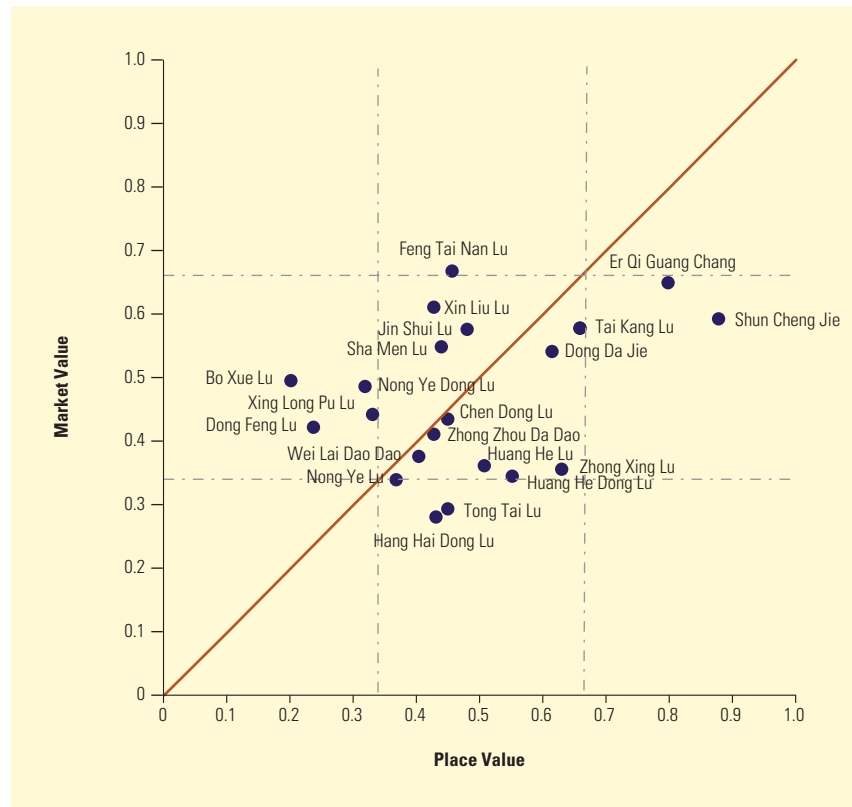
Source: Urban Morphology and Complex Systems Institute, 2016.

terms of place value but remain below their potential in terms of market potential value, because planning does not incentivize development around these stations.

Recommendations

A functional and cost-effective transit infrastructure—one that gets commuters to and from work efficiently—is a fundamental prerequisite of a thriving business environment in a large city. Another is a set of economic and housing policies that match transit accessibility, jobs, and housing and clusters companies in places accessible by large numbers of people, in order to broaden the choice of affordable housing locations.

The 3V Framework helps planners meet these two prerequisites by allowing them to prioritize investments and adjust policies and regulatory planning in order to intensify development around the highest potential stations and to define strategies in diverse economic and urban contexts. TOD can unlock a new wave of urban productivity in Zhengzhou if land use policies that encourage higher densities of jobs and people in areas with good transit accessibility are put in place. This

integrated planning approach would involve a shift to more compact, connected, and coordinated urban growth, with land development intensities aligned with transit networks accessibility.

Creating Transit-Oriented Districts Near the Center

The urban core is the most efficient place for concentrating jobs; doing so fosters agglomeration and localization economies. Dispersing economic growth to the periphery creates inefficiencies, because networks cost more per capita at the periphery and economic output per capita and per serviced land decreases when development occurs far away from the urban core (Salat 2016).

Fostering growth at the center requires appropriate regulations for block size, FARs, and coverage ratios. TOD zoning at the Zhengzhou master plan level could establish a minimum density for jobs and housing for the station catchment area. The regulatory plan could support the redesign of TOD communities by:

- creating a more walkable street network, with denser and more connected street patterns (80–100 intersections per square kilometer), narrower streets, reduced or eliminated setbacks, and streetscapes designed for people
- establishing urban design standards at the small block rather than the super-block level
- fostering mixed-use districts that are walkable and bikable, with transit-oriented street and circulation systems and high densities of population and jobs. Within these districts, areas close to major transit stations would have higher densities and land-use standards, allowing the municipality to capture some of the value of the investment in transit infrastructure.

Adopting Different Strategies for Different Types of Stations

The 3V Framework allows policy makers to assess the development potential of station areas in a proactive and dynamic way. All nodes in a network are not equal. Node and place values are unevenly distributed across Zhengzhou and along Line 3. Some stations, such as Er Qi Guang Chang, score high in node and place value. International experience suggests that such stations could play a major role in fostering economic and job concentration and commercial real estate development.

The imbalances between values create development opportunities. At many stations, the supply of new infrastructure is stronger than the activity of land use; there is potential to enhance place value to derive market value from the current oversupply of connecting infrastructure. At other stations, greater connectivity will encourage economic activity and increase market potential value.

The 3V analysis identifies which type of development is more appropriate in a station area and which stations have the highest development and value capture potential. It helps define station types based on node, place, and market potential values. Zhengzhou's policy makers can use the framework to (a) build a typology of stations that classifies them into subgroups for applying different development

strategies and (b) identify the imbalances between connectivity, accessibility, place quality, and market potential values at stations. Identification of such imbalances enables the relevant land, economic development, and transport agencies to develop multiagency solutions.

Capturing Value

Increases in connectivity and accessibility will increase land value in subway catchment areas. This value can be captured to create a positive feedback loop for financing infrastructure, enhancing the public realm, and building inclusionary housing (see chapter 3).

Notes

1   This chapter is based on projections made as part of the traffic modeling for Line 3 of the Zhengzhou subway (for which the World Bank provides part of the financing); the Zhengzhou master plan; detailed control plans with land use, floor area, coverage ratios, 3D renderings of the urban fabric, technical specifications of station designs; population and jobs data by census tracts and within the polygons of the traffic study and forecasts for 2020 and 2030; and GDP data by subdistrict. It benefitted from discussions with Zhengzhou planning bureau and transportation bureau and from field visits to each of the 21 sites of the planned stations.

2   The FAR (also known as floor space ratio [FSR], floor space index [FSI]) is the ratio of a building's total floor area (gross floor area) to the size of the piece of land upon which it is built.

3   Calculated as:

$$\frac{\sum_{location} \left(\dfrac{number\ of\ jobs\ accessible\ from\ each\ location}{total\ jobs\ in\ the\ city} * population\ in\ each\ location \right)}{Total\ Population} \times 100\%$$

4   Ridership is aligned but not directly correlated with structural properties of the network (correlation was tested). It is thus valid to keep the traffic and centralities as separate subindexes for buildin he centrality index.

5   In more complex networks with high-ranking hubs, such as London and Tokyo's, weighting could give higher weight to degree centrality.

6   The maximum value of the subindex is 1. As some places (industrial zones) have more than 1 job per resident and others (residential neighborhoods) have far less than 1 job per resident, the subindex was normalized between 0 and 1 with a lognormal function in order to give values below 1 to mono-functional neighborhoods (either excessively job or resident oriented).

7   This value was normalized between 0 and 1 with a log function calibrated to have 0.5 for zero growth, values below 0.5 for decreases in density, and 1 for a 200 percent increase, with a cut-off beyond 200 percent.

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Conclusions

Cities that effectively integrate transportation and land use reduce traffic congestion, promote business, improve public services, and boost revenues. Such cities are more livable, economically competitive, and environmentally and socially sustainable than other cities.

Transit-oriented development (TOD) contributes to shaping urban forms in order to increase access to transit and access to jobs by transit. Managed well, it can unlock land for affordable housing and more inclusive urban growth by reducing the burden of transportation costs on poor, low and middle income households.

Cities that grow efficiently around transit lines—such as Tokyo, Singapore, Hong Kong SAR, China, London, and New York—are strategically planned with a long-term vision of the evolution of their spatial structure. This vision factors in long-term population and economic growth. It is turned into master plans with 15- to 20-year horizons that are reviewed every 5 years. These master plans detail land use with a high level of granularity, setting variable intensities of development and allocation of uses at the scale of small urban blocks of about one hectare. They have built-in flexibility in zoning codes and incentives that allow some variation to planning and design parameters. Land supply is planned in tandem with market demand and cycles.

The 3V Framework helps policy makers integrate transport planning and land use across different geographical scales, from metropolitan to local. It helps identify areas of opportunity where the combination of high connectivity and the potential for redevelopment and regeneration of the urban (and in some cases social) fabric will generate market response from the private sector, initiating a positive feedback loop of local urban growth and value capture finance. It is applicable not only to areas with the highest growth potential but also to areas with less potential but more land opportunities. As the case studies demonstrate, by creating and capturing higher land values around urban transit stations and corridors, cities can recoup some of the costs of building, operating, and maintaining mass transit systems, as well as support TOD in ways that make them more appealing places to live, work, and do business.

The methodology includes an analysis of transit networks. It integrates market demand and supply analysis with more traditional node/place models. Consideration of market response is essential for transitioning toward more sustainable urban growth, particularly in rapidly growing cities, where the integration of the space economy is crucial for economic success.

Opposite page:
Thanks to its livable and accessible high densities, Paris is the second global real estate market after London.
Source: © Françoise Labbé. Used with the permission of Françoise Labbé. Further permission required for reuse.

The 3V Framework is an instrument for tailoring, with a high granularity, intensities of development to different levels of transit accessibility and to different local contexts. It acknowledges the wide variations in densities of jobs and residents and in accessibility across the urban space. It comprises both a vision of the metropolitan urban shape that is most efficient for inclusive economic growth and actionable differentiated local strategies for specific development around transit stations. As such, it is particularly well adapted to contribute to integrated planning that articulates a long-term vision and local plans and integrating transportation infrastructure investment and land use planning.

Above all, the 3V Framework is a tool for developing options for rapidly growing cities. The World Bank plans to apply it in various contexts, including India and Latin America. The Framework is not limited to investments in subway networks; it can be applied to other kinds of mass transit networks, such as bus rapid transit.

Implementing the framework involves a long-term strategic vision and a process of actions and investments. The process should be able to adapt to the dynamic, evolving, and complex nature of cities and be able to continuously update the vision, as required by changing conditions and market response.

This shared vision—and the engagement of multiple stakeholders in its implementation—drive spatial, social, and economic transformation. Key to success is coordinating across scales and sectors, integrating a multiplicity of actions and initiatives that will reinforce one another, implementing the vision with milestones and indicators, and being highly granular and contextual.

# Appendix A Power Laws in the Distribution of Urban Values, Network Centralities, and Commuting Flows

Network science has discovered that networks (neural networks, natural networks, transit networks, the Internet) have a strict architecture that is captured by a few simple mathematical regularities (inverse power laws). These formulas represent a novel perspective from which to understand the interconnected urban world and the relationship between transit network layouts and people, jobs, and economic concentrations.

Urban values such as the ones used in the 3V Framework are not distributed evenly or randomly through urban space but according to identifiable mathematical patterns. The 3V Framework is not just an empirical method; it derives policy making from the underlying order of urban space and urban connectivity, as described below.

Power Laws in the Distribution of Values across Urban Space

Inverse power laws govern demographic densities in cities.[1] Research by the Urban Morphology and Complex Systems Institute (Salat 2016, 2017) documents the presence of power laws at the intra-urban scale, where they order the patterns of most urban values and their distribution across urban space. An inverse power law distribution does not have a central peak, like the familiar bell curves found in statistics. It is a continuously decreasing curve, indicating that many small observations coexist with a few large ones in a highly structured mathematical way that relates the large, the intermediate, and the small (figure A.1). This relationship characterizes variables such as density, centrality, connectivity, and accessibility.

In a city, for example, the density of jobs is high in a few locations, medium in a moderate number of locations, and low in a large number of locations. The frequency of a component of size x is proportional to the inverse of its size at an exponent m characteristic of the system. The relative frequency of each type is determined by the mathematics of the rank size distribution: the size of any urban

FIGURE A.1 **Typical Power Law Distribution**
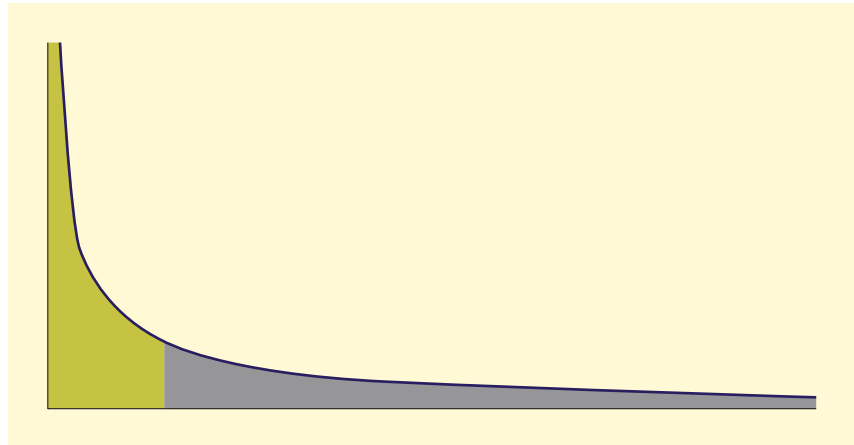
component (density, accessibility, connectivity) is related to its rank within the distribution. The higher m, the steeper the gradient between the few high values and the many low values.

Inverse power laws are a measure of inequality or hierarchy in systems (Pumain 2005). They were first introduced in economics by Vilfredo Pareto (1906). The Pareto distribution is a power law probability distribution that is used to describe social, scientific, geophysical, actuarial, and many other types of phenomena. Pareto originally used it to describe the allocation of wealth in society, where a small proportion of the population owns a large portion of wealth. He also used it to describe the distribution of income.

The Pareto distribution can be observed in GDP density across urban space: The same spatial distribution of GDP characterizes both London and Zhengzhou, despite huge differences in their socioeconomic structures. An inverse power law of exponent –0.90 characterizes both, indicating a high level of concentration of GDP in a few areas. The distributions of jobs is similar in Paris, London, and New York (with exponents of –1.0). In contrast, the exponent is –0.89 in Zhengzhou and –0.94 in Shanghai, reflecting decentralizing policies.

This idea is sometimes expressed more simply as the Pareto principle or the 80–20 rule, which says that 20 percent of the population controls 80 percent of the wealth.[2] In terms of urban space, it means that 20 percent of urban land produces 80 percent of urban GDP. This pattern explains the economic break-up point of sprawling: When a city expands at low density, infrastructure costs for servicing the land remain high per capita while the contribution to urban GDP becomes negligible (Salat 2016; Salat, Bourdic, and Kamiya 2017).

Recent research shows that inverse power laws govern the distribution of degree and closeness centralities in transit networks; GDP; densities of jobs, people, and amenities; energy intensity (energy used per unit of urban land) and productivity (gross value added created per unit of energy used); as well as many other ur-

ban characteristics (Salat 2017). The ubiquity of power laws in urban space derives from power laws in networks. Cities can be described as networks from which locations emerge.

Power Laws in Network Centralities and Commuting Flows

This section looks at properties of subway networks and commuting flows that underlie the clustering of stations based on their node values from a graphs theory perspective (see Barabasi and Albert 1999 and Barabasi 2005).

Power Laws in the Core-and-Branches Structure of Subway Networks

Efficient subway layouts in global cities appear to converge toward a similar layout (Roth and others 2012). The structure of the world's largest subway networks—including Beijing, Shanghai, Tokyo, Seoul, London, Paris, and New York—share similar generic features despite these cities' geographical and economic differences. This shape is made of a core with branches radiating from it. Densely interconnected by crisscrossing lines, the core has a spatial extension of about five kilometers, because it would be too costly to maintain a high density of stations beyond this radius. Beyond this radius are (lower-density) branches. The density of stations with distance to the city center sharply decreases and follows an inverse power law of the form $R^{-1.6}$, where R stands for radius. For most networks, the average number of links per station within the core is about 2.5, and at least 60 percent of stations at the core serve at least two lines. In all the studied subways, the number of stations grows by a factor of R^2 at the core. Beyond the core the density of stations decreases very quickly with distance from the core, with the number of stations growing at only $R^{0.5}$.

## *Power Laws in the Distribution of Centrality Values*

In graph theory and network analysis, indicators of centrality identify the most important vertices within a system. Applications include identifying the most influential people in a social network, key infrastructure nodes in the Internet or urban networks, and superspreaders of disease.[3]

Centrality indices are answers to the question "What characterizes an important vertex?" For mass transit networks, degree centrality, closeness centrality, and betweenness centrality best capture the centrality of stations.

Degree centrality

Historically first and conceptually simplest is degree centrality, defined as the number of links at a node. Hubs dominate the structure of all networks in which they are present. They create short paths between any two nodes in the system.

In most networks, most nodes have only a few links, and a few big hubs have a very large number of links. The links connecting the smaller nodes are not sufficient

FIGURE A.2 Degree Centrality of Paris Stations in 2030
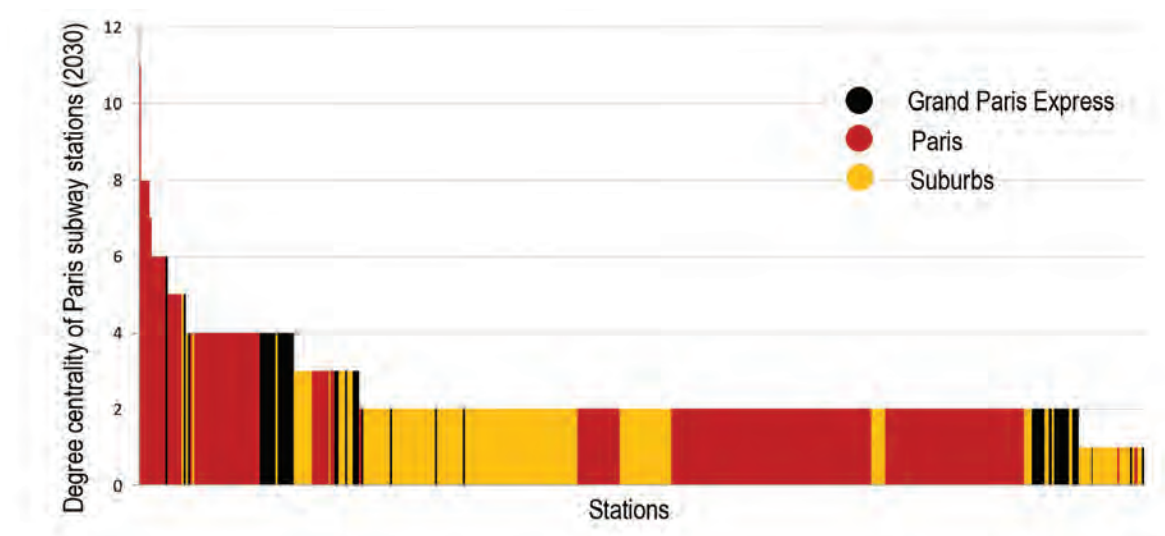
Source: Salat and Bourdic 2015. © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse
Note: Figures reflect centrality after the opening of the 67 new stations and 200 kilometers of new lines of the Grand Paris Express.

to ensure that the network is fully connected. It is the large hubs that make networks work.

Once the Grand Paris Express is built, the Paris metro will have a few hubs in the hypercore of the network with many connections, including four stations with six or more connections (figure A.2). These stations will be located in parts of the city where one third of jobs are agglomerated. The system will also have a long tail of single-line stations (degree centrality of 2).

Closeness centrality

The farness of a node *x* is defined as the sum of its distances from all other nodes; its closeness is defined as the reciprocal of its farness. The more central a node is, the shorter its total distance from all other nodes.

Stations in the network core in Paris are closer to other stations than are stations outside the core (figure A.3). Closeness centrality decreases linearly, not according to an inverse power law.

Betweenness centrality

Betweenness centrality quantifies the number of times a node acts as a bridge along the shortest path between two other nodes. It was introduced as a measure for quantifying the control of one person over communication between other people in a social network. Vertices that have a high probability of occurring on a randomly chosen shortest path between two randomly chosen vertices have a high level of betweenness.

FIGURE A.3 Closeness Centrality of Paris Subway Stations in 2015
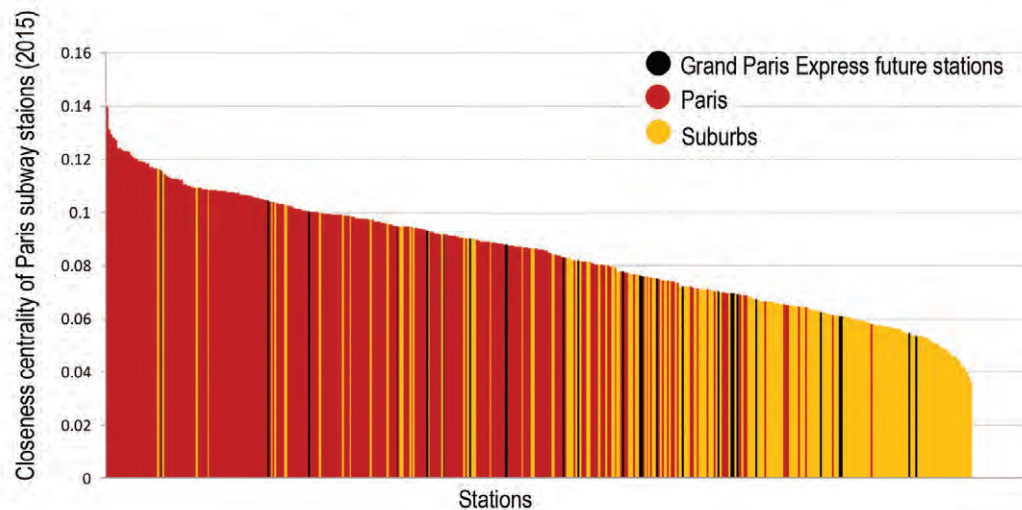
Source: Salat and Bourdic 2015. © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse.
Note: Figures reflect centrality after the opening of the 67 new stations and 200 kilometers of new lines of the Grand Paris Express.

A subway station with high betweenness centrality has significant influence on the transfer of passengers through the network (assuming that passengers follow the shortest paths). These stations areas have high development potential, as demonstrated by stations along Tokyo's Yamanote Line.

FIGURE A.4 Betweenness Centrality of Paris Subway Stations in 2015
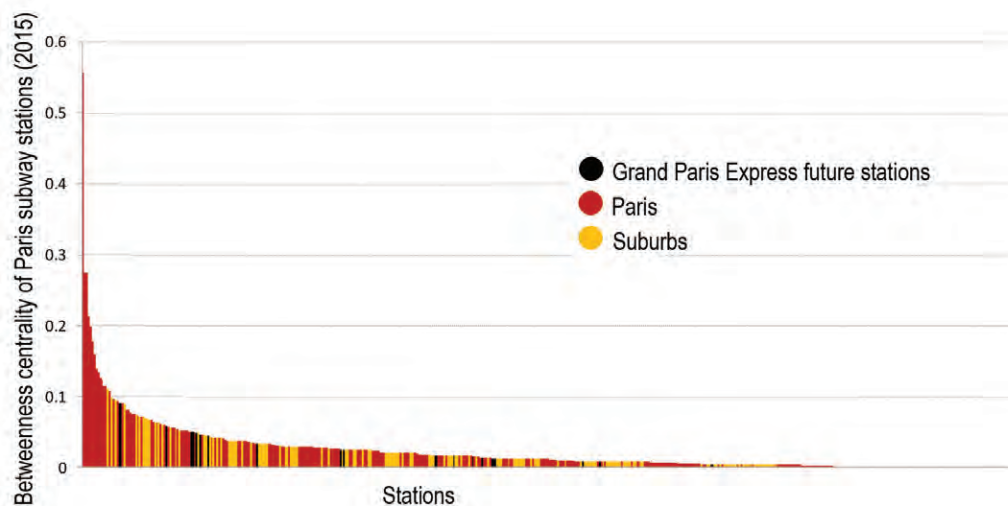
Source: Salat and Bourdic 2015. © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse.
Note: Figures reflect centrality after the opening of the 67 new stations and 200 kilometers of new lines of the Grand Paris Express.

As in London, New York, and Tokyo, the distribution of betweenness centralities in Paris follows an inverse power law of exponent −1 (figure A.4), suggesting a universality class (a collection of mathematical models that share a single scale invariant limit). Although cities may differ dramatically at small scales, their behavior becomes increasingly similar as the limit scale is approached. In particular, asymptotic phenomena such as critical exponents will be the same for all cities in the class (notably for the density distribution of jobs and the betweenness centralities of their subway networks).

Box A.1 illustrates the relationships between betweenness centrality in urban rail networks and local urban growth in London.

BOX A.1   **Promoting Urban Growth through Transit: London's Circle Line**

The 1846 Royal Commission on Railway Termini prevented trains from entering Central London (an area of about 32 square kilometers). The result was a ring of disconnected stations, which stimulated a market for interconnections and the development of the underground. Surface rail and underground networks expanded together, producing both competition and a high degree of complementarity between the two modes.

From the linkage between the train stations, the Circle Line was born, in 1884. Before December 13, 2009, Circle Line trains travelled in both directions around a simple loop with 27 stations and 20.75 kilometers.

Box map A.1.1 shows the route of the Circle Line since December 13, 2009 and the London boroughs it serves. The line serves the highest concentration of wealth in Europe. Its 27 kilometers serve

BOX MAP A.1.1 **London's Circle Line**

Source: http://www.wikiwand.com/en/Circle_line_(London_Underground).

36 stations, including most of London's main line railway terminals. Most of the route and all of the stations are shared with the District, Hammersmith & City, and Metropolitan lines. The Circle Line and the Hammersmith & City line combined host more than 114 million passenger journeys a year.

The hierarchy of betweenness centrality in London follows an inverse power law of exponent – 1.15. The Circle Line has the highest peaks of betweenness centrality in London (box map A.1.2). This network layout created strong hubs, which became high peaks of economic density, job concentration, and land and property values. The evolution of London's public transportation network shaped the spatial and economic growth of the urban region, with a strong concentration in the center, along a ring of highly connective transfer hubs.

BOX MAP A.1.2 Betweenness Centrality of London Subway Stations in 2015

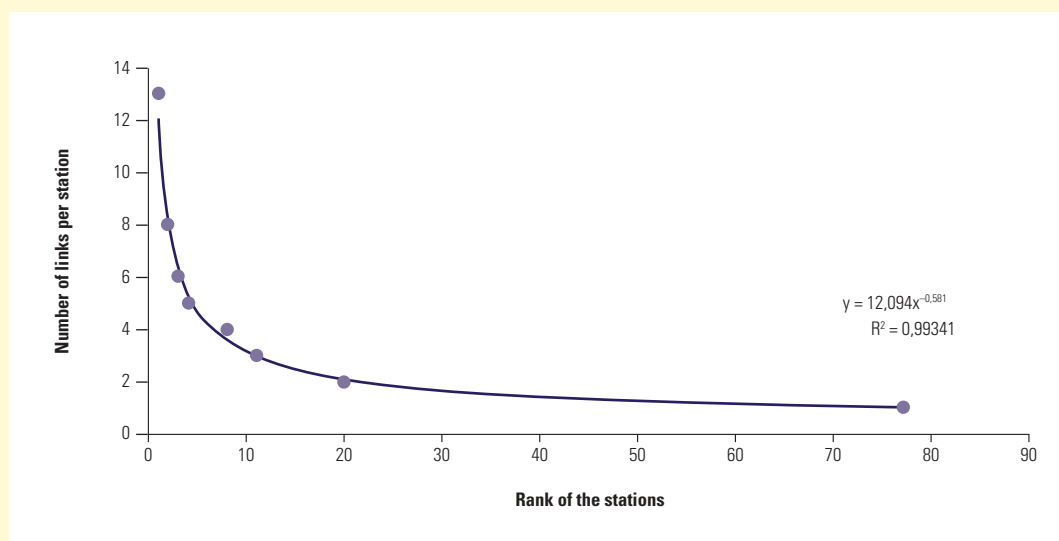*Source:* © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse.

Box figure A.1.1 shows the hierarchy of connectivity along the Circle Line. The higher exponent on the Circle Line (0.58) than on the London system as a whole (0.31) shows that inequality between hubs is more intense at the core of the subway system, where high connectivity is concentrated.

The Circle Line is extremely well connected. It will become even better connected after the opening, in 2018/2019, of Crossrail 1. In the longer term, High-Speed 2 (HS2) is expected to transform Euston and King's Cross-St Pancras into the United Kingdom's largest mega rail hub, as rail passengers will be able to interchange between HS2 and Crossrail 2 (under consideration) at Euston. This intensity of connectivity offers excellent opportunities for urban development around train stations.

BOX FIGURE A.1.1 **Degree Centrality along the Circle Line in 2015**

$$y = 12{,}094x^{-0.581}$$
$$R^2 = 0{,}99341$$

Source: Salat and Bourdic 2015. © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse.
Note: Figure includes loop-only and transfers to train stations.

Power Laws in the Distribution of Commuting Flows

Research by the Urban Morphology and Complex Systems Institute (Salat and Bourdic 2015) shows that ridership per station in Paris and London and the structure of commuting flows follow the same mathematical distribution. Power laws also describe passenger flows and the intensity of commuting routes. Traffic in London's tube stations in 2010 follows an inverse power law of exponent –1, with a concentration of traffic in highly connective hubs corresponding to the train stations.

The distribution of the number of commutes per commuting line (all modes considered) between home and work in Paris (map A.1) reveals an inverse power law of exponent –0.65 (figure A.6).

FIGURE A.5 **Distribution of Traffic Volume at London Subway Stations**

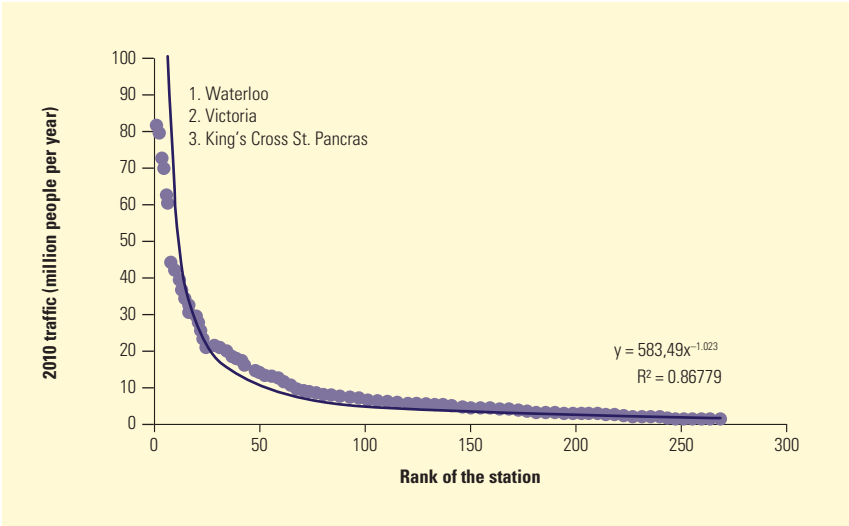*Source:* Salat and Bourdic 2015. © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse. Based on data from the London Datastore, Greater London Authority.

MAP A.1 **Number of Commutes per Commuting Line in Paris**
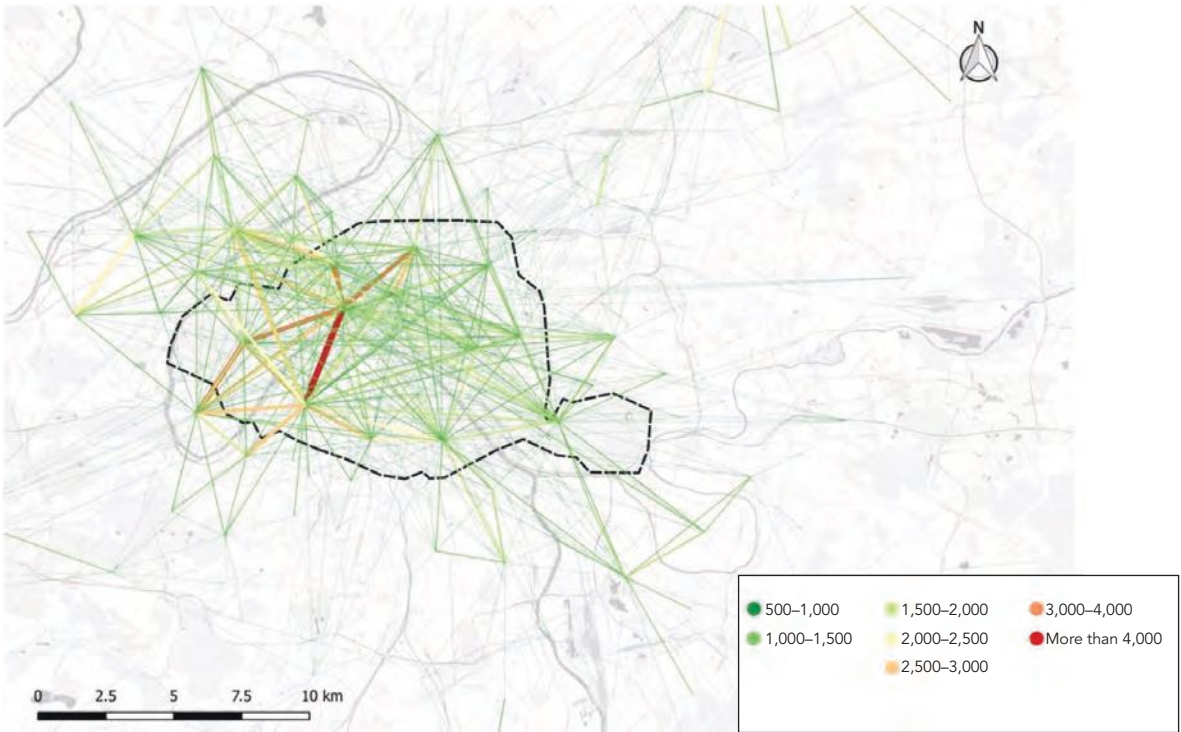
Source: Salat and Bourdic 2015. © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse.

FIGURE A.6 Distribution of Traffic Volume along Paris Commuting Lines

Source: Salat and Bourdic 2015. © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse.
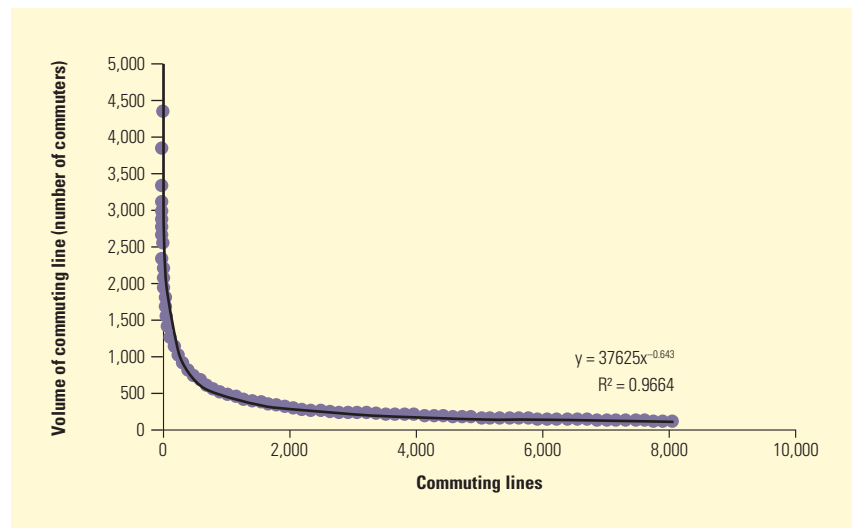
Notes

1 For a discussion of inverse power laws, see Cheshire (1999), Rose and Resnick (1980), Xavier (1999), Blank and Solomon (2000), Eeckhout (2005), Soo (2005), Rose (2006), and Salat and Bourdic (2011).
2 Empirical data show that 67 percent of London's GDP is produced in 20 percent of London's area. In contrast, 80 percent of Zhengzhou's GDP is produced in 20 percent of Zhengzhou's area. The difference comes not from the distribution, which is identical, but from the size of the cities. The long tail of low values of GDP per square kilometer at the urban periphery makes a weak contribution to the GDP. Thus, if the city expands, the proportion of its urban land that does not contribute significantly to its GDP will expand accordingly and GDP will appear more concentrated in the simplified version of the Pareto principle. Only the complete Pareto description, with the exponent of the power law, captures the distribution. It reveals striking structural similarities different cities.
3 Centrality concepts were first developed in social network analysis; many of the terms used to measure centrality reflect their sociological origin.

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Appendix B Subindexes for Estimating Node, Place, and Market Potential Value of Stations

Table B.1 summarizes the key subindexes that can be used to estimate the node, place, and market potential values of stations. Selection of subindexes, particularly for market potential value, depends in part on the availability of data. All subindexes are normalized to a 0–1 scale, as shown in the example of Zhengzhou (see chapter 8).

TABLE B.1 Subindexes for Estimating Potential Node, Place, and Market Value of Stations

Type of value/subindex	Measure	How to calculate	Example
Node			
Subindex 1.1: Degree centrality	Number of mass transit links at a station	Calculated at the network level using graph analysis software. Each direction counts as a link.	London (see map 2.1)
Subindex 1.2: Closeness centrality	Average distance (in terms of number of links) from a station to every other station in the network	Calculated at the network level using graph analysis software. Measured by dividing 1 by the average shortest path from a station to all other stations in the network.	London (see map 2.2), Zhengzhou (see figure 8.10)
Subindex 1.3: Betweenness centrality	Extent to which a transit node is located at the crossroads of the public transport network	Calculated at the network level using graph analysis software. Calculated as $$betweenness_{node\,i} = \sum_{i \neq j \neq k} \frac{\sigma_{ij}(k)}{\sigma_{ij}}$$ where σ_{ij} is the total number of shortest paths from node i to j and $\sigma_{ij}(k)$ is the number of those paths that pass through station k.	London (see map 2.3), Zhengzhou (see figure 8.12)
Subindexes 1.1–1.3 are combined into a single (weighted-average) centrality index.			
Subindex 1.4: Daily ridership	Strength of flows of traffic in a node	Daily number of passengers entering a station, excluding passengers not stopping.	Zhengzhou (see figure 8.8)

TABLE B.1 Subindexes for Estimating Potential Node, Place, and Market Value of Stations *(continued)*

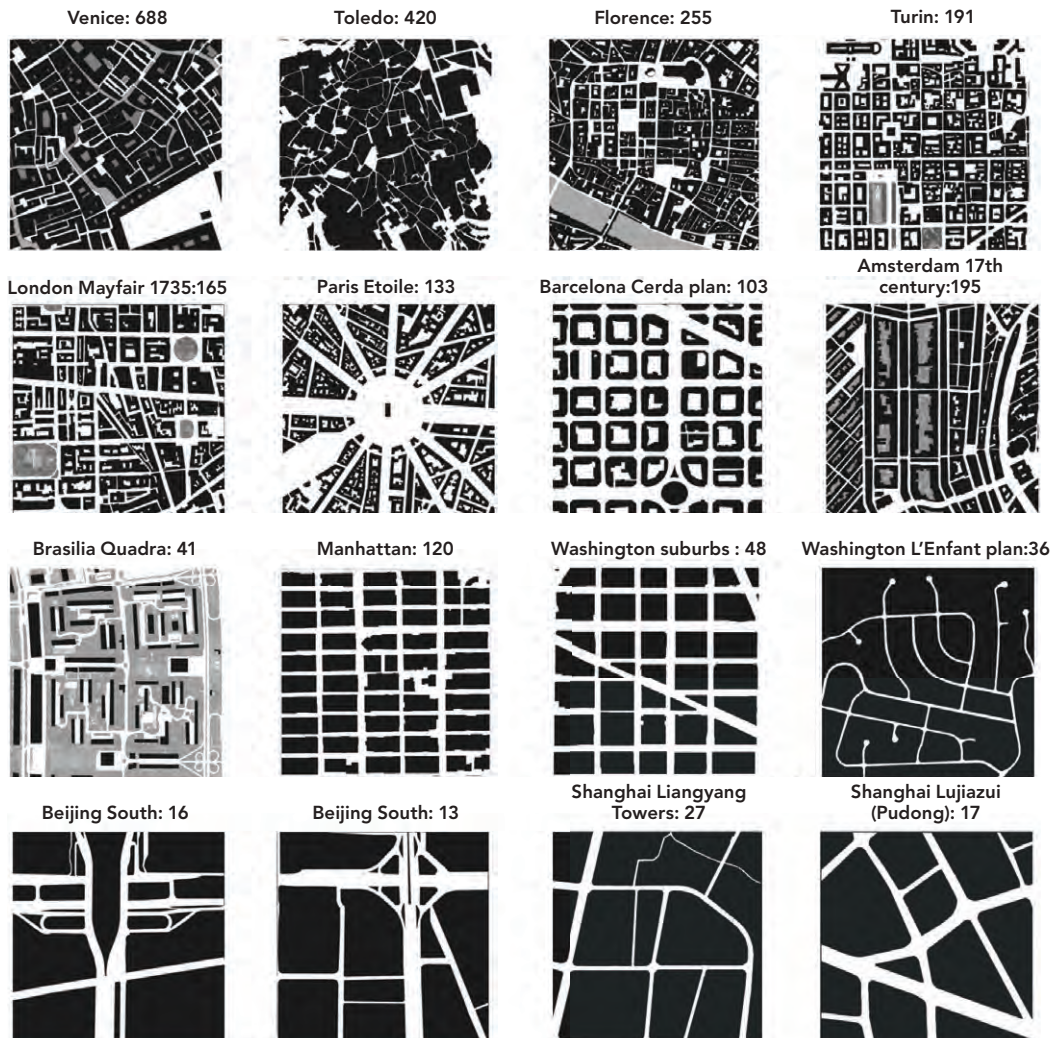| Type of value/subindex	Measure	How to calculate	Example
Subindex 1.5: Intermodal Diversity	Number of complementary transit modes connecting to a station	Number of lines of different transit modes accessible within walking distance of a station.	Zhengzhou (see figure 8.15)
The centrality subindex, subindexes 1.4 and 1.5, are combined into a single (weighted-average) node value.			
Place			
Subindex 2.1: Density of street intersections	Number of intersections per square kilometers within an 800-meter radius of each transit station	Calculated through street GIS shapefiles/ software, such as ArcGIS or QGIS on an area with an 800–meter radius centered on the station or on a square measuring 800 x 800 meters centered on the station.	Zhengzhou (see figure 8.18); example 1 below
Subindex 2.2: Local pedestrian accessibility	Proportion of a an area of 800-meter radius around a station that is actually reachable in a 10-minute walk	Calculated using open sources software Open Trip Planner Analyst and OpenStreetMap to determine the proportion of the 800-meter radius around the station that is reachable by foot within 10 minutes.	Example 2 below
Subindex 2.3: Diversity of uses	Number of types of land use in a dataset	Calculated using the Shannon entropy formula: $$Entropy = -\frac{\sum_{i=1}^{N} \frac{p_i}{p_N} \log\left(\frac{p_i}{p_N}\right)}{\log N}$$ where *i* is the type of use (commercial, community, residential, industrial); *N* is the number of uses; p_i is the area dedicated to use *I*; and p_N is the area of the cell dedicated to any use. The value of a diversity index increases when the number of types increases and evenness increases. For a given number of types, the value of a diversity index is maximized when all types are equally abundant.	Zhengzhou (see figure 8.18)
Subindex 2.4: Density of social infrastructure within 800 meters of the station	Number of cultural, educational, and health services within a radius of 800 meters from the station	Calculated by dividing the number of social infrastructure facilities within 800 meters of a station. Georeferenced points of interest are increasingly collected in cities and can be used as a basis for such calculation.	
The four place subindexes are combined into a single (weighted-average) place value.			
Market potential			
Demand			
Subindex 3.1: Human density	Number of people and jobs per square kilometer around the transit station within a catchment area of 800-meter radius	Calculated based on population and job data available through census or transport model developed for metro lines.	Zhengzhou (see figure 8.20); Paris (see example 3 below)

TABLE B.1 Subindexes for Estimating Potential Node, Place, and Market Value of Stations *(continued)*

Type of value/subindex	Measure	How to calculate	Example
Subindex 3.2: Jobs/residents ratio	Jobs/residents ratio within 800-meter radius of each station	Calculated based on population and job data available through census or transport model developed for metro lines.	London; Zhengzhou (see figure 8.21)
Subindex 3.3: Human density growth potential	Forecasted rate of population and job growth over 10–20 years within 800-meter radius of each station	Calculated based on population and job data available through census or transport model developed for metro lines.	Zhengzhou (see figure 8.22)
The three demand subindexes are combined into a single (weighted-average) market potential value if other subindexes are not available.			
Subindex 3.4.1 Social composition of the neighborhood	Average or median income	Calculated based on population data available through census or transport model developed for metro lines.	Paris (see example 4 below)
Subindex 3.4.2: Social composition of the neighborhood	Percentage of managers in labor force	Calculated based on population data available through census.	Paris (see example 4 below)
Subindex 3.5: Number of accessible jobs by transit	Number of accessible jobs within 30 minutes by public transit and foot	Calculated with open source software Open Trip Planner Analyst based on population data available through census or transport model developed for metro lines.	
Supply			
Subindex 3.6: Real estate opportunities	Developable land and developable floor space around each subway station within a radius of 500 meters for the highest market premium and between 500 meters and 1 kilometer for the lower market premium	Calculated by comparing GIS map of built densities with a map of regulatory floor area ratio (FAR) and by subtracting existing built floor space from maximum floor space that can be built within the regulatory FAR.	Singapore (see example 5 below)
Market vibrancy			
Subindex 3.7: Dynamics of real estate development	Additional square meters built around stations during past decade	Obtained from local public planning agencies or agencies monitoring real estate activity	Paris (see example 6 below).

Example 1 Density of Street Intersections

Connected street patterns with a high density of street intersections promote accessibility and walkability. UN-Habitat recommends a density of at least 80–100 intersections per square kilometer. A high density of intersections is also a good proxy for block size. Small block sizes (about 100-meter sides) with vibrant edges (facades on the perimeter with businesses) promote more compact development and walkability. The higher the density of intersections, the smaller the blocks are. This indicator captures block size, the "granularity" of the urban fabric, the diversity of paths around the transit station, and local accessibility. Map B.1 shows examples of street intersection density for squares measuring 800 x 800 meters.

MAP B.1 Number of Street Intersections per Square Kilometer in Selected Cities

Venice: 688   Toledo: 420   Florence: 255   Turin: 191

London Mayfair 1735:165   Paris Etoile: 133   Barcelona Cerda plan: 103   Amsterdam 17th century:195

Brasilia Quadra: 41   Manhattan: 120   Washington suburbs : 48   Washington L'Enfant plan:36

Beijing South: 16   Beijing South: 13   Shanghai Liangyang Towers: 27   Shanghai Lujiazui (Pudong): 17

Source: Salat, with Labbé and Nowacki 2011. © Serge Salat. Used with permission of Serge Salat. Further permission required for reuse.

Example 2 Local Pedestrian Accessibility

An *isochrone* is a curve that shows equal travel times. Isochrones are critical because how long it takes to get somewhere is more relevant than how far away it is. Isochrones have been used for more than 130 years in science and transport planning to understand the relationship between movement and time. Isochrone maps can include a combination of transport modes or focus on just one mode.

Walking isochrones map walkable catchments or "pedsheds." They provide insight into the permeability of a neighborhood, as well as an understanding of accessibility to public transport, jobs, and services.

Map B.2 illustrates how superblocks reduce accessibility around subway stations in Tianjin, a major port city in northeastern China. The green circle displays the theoretical maximum accessibility within an 800-meter radius. Because of superblocks, only 50–65 percent of the 800-meter radius area is accessible by foot. The Liu Yuan Station area has 4.4 kilometers of streets per square kilometer, far below the minimum length of 18 recommended by UN-Habitat; within an 800-meter radius circle, the average block surface is 103,300 square meters, and the density of intersections is 7. This density is just 1/11th–1/15th the density recommended by UN-Habitat and international best practice. The Golden Triangle Station area, the most accessible and permeable station in Tianjin, has a street density of 11.2 per square kilometer; within an 800-meter radius circle, the average block surface is 22,400 square meters and the density of intersections is 48. The Tu Cheng Station area has a linear density of 5.8 per square kilometers; within an 800-meter radius, the average block surface is 74,250 square meters, and the density of intersections is 9.

The subindex measures the percentage of the 800-meter radius area that can be reached within a 10-minute walk (area in green).

MAP B.2 Ten-Minute Walk Isochrones within 800-Meter Radius of Three Subway Stations in Tianjin, China

a. Liu Yuan Station   **b. Tu Cheng Station**   **c. Golden Triangle Station**
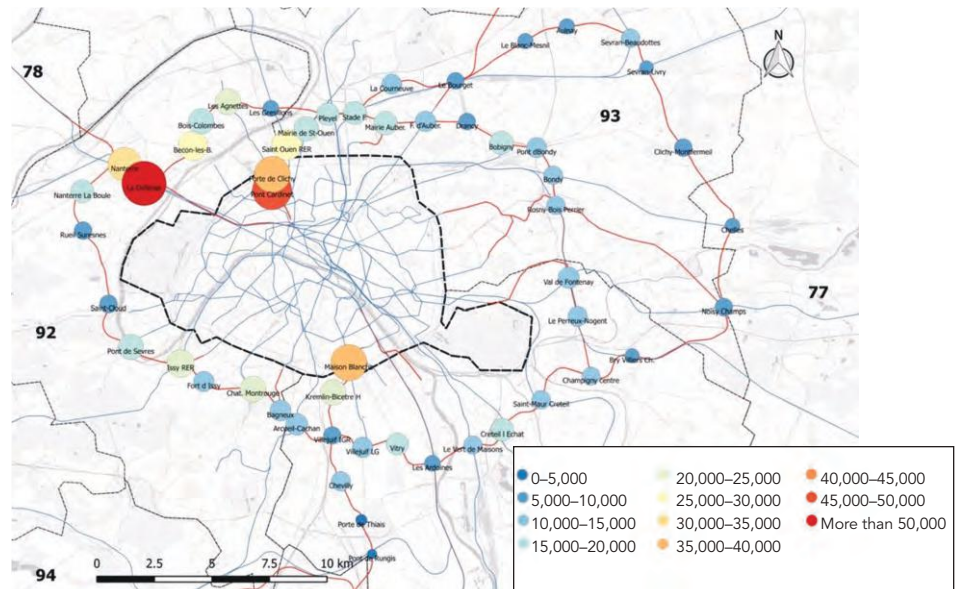

Source: Urban Morphology and Complex Systems Institute for the World Bank 2016.
Note: Red: Accessibility at 200 meters. Yellow: Accessibility at 400 meters. Green: Accessibility at 800 meters. The green area is used to measure the subindex.

Example 3 Human Densities

Human density along the subway lines that will be built as part of the Grand Paris Express varies by a factor of more than 10, from less than 5,000 to more than 50,000 (map B.3).

MAP B.3 Estimated Human Densities (People + Jobs) along Planned Grand Paris Express Stations
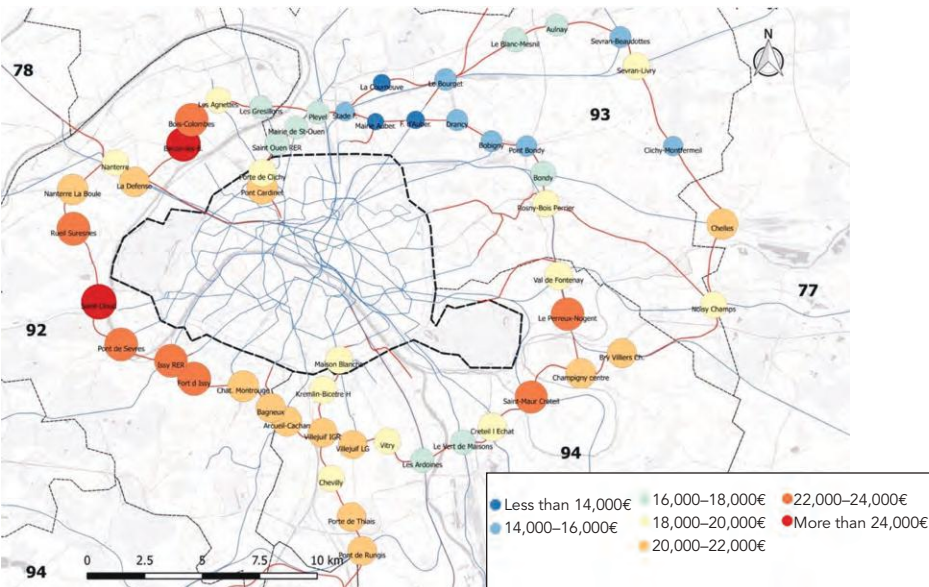

Source: Salat and Bourdic 2015. © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse. Data from INSEE.

Example 4 Median Incomes

Map B.4 shows median incomes per unit of consumption (a measure used by the Organisation for Economic Co-operation and Development [OECD] to reflect the composition of households) along the new subway lines being built as part of the Grand Paris Express. It shows lower values in the northeast quadrant.

MAP B.4 Estimated Median Income per Unit of Consumption along Planned Grand Paris Express Stations, 2011
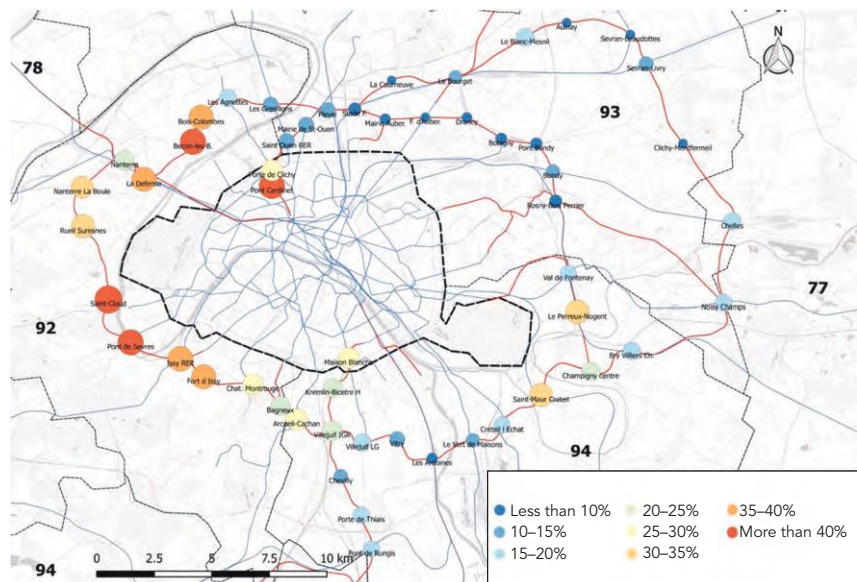

Source: Salat and Bourdic 2015. © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse. Data from INSEE.

Example 5 Percentage of Managers

Map B.5 shows the percentage of managers in the labor force along the subway lines being built as part of the Grand Paris Express. It shows a strong concentration of managers in the west, near the core of the historic city (Paris intra-muros). Multicriteria analysis by Salat and Bourdic (2015) shows that these areas have the highest market potential.

MAP B.5 Percentage of Managers in the Labor Force along Planned Grand Paris Express Stations

Source: Salat and Bourdic 2015. © Urban Morphology and Complex Systems Institute. Used with permission of UMCSII. Further permission required for reuse. Data from INSEE.

Example 6 Floor Area Ratios

Table B.2 presents the ranges of FARs applied in various cities. Based on those ratios, the potential for development can be estimated.

Map B.6 presents FARs along Singapore's Orchard Road. FARs in Singapore along Orchard Road, one of Singapore main commercial roads, are set higher (4.2–5.6) close to subway stations and are zoned for commercial uses (in dark blue) and offices (in violet) on small blocks; 100 meters away from the transit line, FARs are lower (1.4–2.8). Some blocks in light blue are residential and commercial with FARs of 4.2–5.6.

TABLE B.2 Floor Area Ratios by Type of Land Use in Selected Cities

	Tokyo		Hongkong		Singapore		New York		Seoul		average min.	average max.
	minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum	minimum	maximum		
all residential					1.4	11.2			1.0	7.0		
low-density residential	0.5	2.0	0.2	3.0			0.5	1.65	1.0	7.0	0.72	4.97
medium-density residential	1.0	5.0	0.67	5.0	1.4	11.2	0.78	7.2	1.0	7.0	1.0	7.1
high-density residential	1.0	5.0	6.5	10.0	1.4	11.2	0.99	12.0	1.0	7.0	2.0	9.0
commercial (office+retail)	2.0	13.0	3.5	12.0	1.4	12.6	0.78	15.0		15.0	1.9	13.5
industrial	1.0	4.0	1.0	12.0	1.0	3.5	1.0	10.0		4.0	1.0	6.7
mixed use	1.0	5.0			1.4	25.0	0.78	10.0		7.0	1.1	11.8

Source: World Bank and Chreod Ltd 2015.

**MAP B.6 Floor Area Ratios along Singapore's Orchard Road**
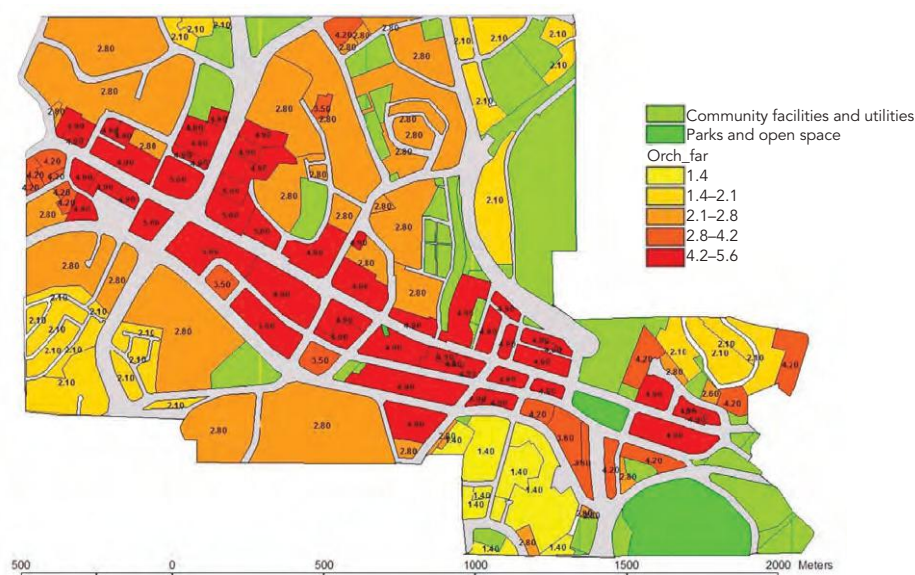
Source: Bertaud 2008. © Alain Bertaud. Used with permission from Alain Bertaud. Further permission required for reuse.

Example 7 Dynamics of Real Estate Development

Map B.7 shows the market dynamism of Paris's northwest quadrant. It lies in contrast to the lagging eastern part of the city.

**MAP B.7 Increase in Construction Programs between 2000 and 2012
around Planned Grand Paris Express Subway Stations**
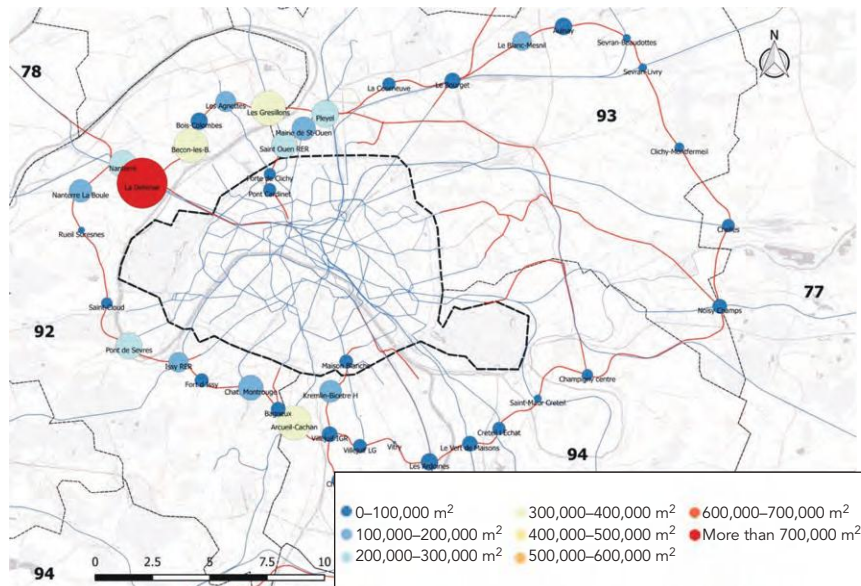
Source: Salat and Bourdic 2015 © Urban Morphology and Complex Systems Institute. Used with the permission of UMCSII. Further permission required for reuse. Data from Atelier Parisien d'Urbanisme (APUR) and Direction Régionale et Interdépartementale de l'Equipement et de l'Aménagement d'Ile de France (DRIEA).

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Imagine a city that is more competitive, with higher-quality neighborhoods, lower infrastructure costs, and lower CO_2 emissions per unit of activity. This city has lower combined transportation and housing costs for its residents than other cities at similar levels of economic activity. Its residents can access most jobs and services easily through a combination of low-cost public transport, walking, and cycling. Its core economic and population centers are resilient to natural hazards. It is able to finance improvements to public space, connectivity, and social housing by capturing value created through integrated land use and transport planning. Such a vision has never been more relevant for rapidly growing cities than it is today. Transit-oriented development (TOD) can play a major role in achieving such a vision.

Based on an observation of methodologies applied in different countries, the World Bank's Community of Practice on Transit Oriented Development has developed a methodology called the 3 Value (3V) Framework, which outlines a typology to facilitate TOD implementation at the metropolitan and urban scale in various contexts. The 3V Framework equips policy and decision makers with quantified indicators to better understand the interplay between the economic vision for the city, its land use and mass transit network, and urban qualities and market vibrancy around its mass transit stations.

This book provides examples of approaches taken by cities like London and New York to align their economic, land use, and transport planning to generate jobs and high value. We hope the book will help readers develop a coherent vision, policies, and strategy to leverage the value created through enhanced connectivity and accessibility and make cities even more appealing places to live, work, play, and do business.