The 3V Framework

Maximizing Economic Value of TOD Station Areas by Matching Place Value, Node Value and Market Value

Serge Salat
Gerald Ollivier

CONFERENCE EDITION (MARCH 9, 2016)

© 2016 International Bank for Reconstruction and Development / The World Bank
1818 H Street NW, Washington DC 20433
Telephone: 202-473-1000; Internet: www.worldbank.org

Some rights reserved

This work is a product of the staff of The World Bank with external contributions. The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of The World Bank, its Board of Executive Directors, or the governments they represent. The World Bank does not guarantee the accuracy of the data included in this work. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of The World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Nothing herein shall constitute or be considered to be a limitation upon or waiver of the privileges and immunities of The World Bank, all of which are specifically reserved.

Rights and Permissions

This work is available under the Creative Commons Attribution 3.0 IGO license (CC BY 3.0 IGO) http://creativecommons.org/licenses/by/3.0/igo. Under the Creative Commons Attribution license, you are free to copy, distribute, transmit, and adapt this work, including for commercial purposes, under the following conditions:

**Attribution**—Please cite the work as follows: Salat Serge and Ollivier Gerald. 2016. "The 3V Framework: Maximizing Economic Value of TOD Station Areas by Matching Place Value and Market Value" "Overview Methodology. World Bank, Washington, DC. License: Creative Commons Attribution CC BY 3.0 IGO

**Translations**—If you create a translation of this work, please add the following disclaimer along with the attribution: *This translation was not created by The World Bank and should not be considered an official World Bank translation. The World Bank shall not be liable for any content or error in this translation.*

**Adaptations**—If you create an adaptation of this work, please add the following disclaimer along with the attribution: *This is an adaptation of an original work by The World Bank. Views and opinions expressed in the adaptation are the sole responsibility of the author or authors of the adaptation and are not endorsed by The World Bank.*

**Third-party content**—The World Bank does not necessarily own each component of the content contained within the work. The World Bank therefore does not warrant that the use of any third-party-owned individual component or part contained in the work will not infringe on the rights of those third parties. The risk of claims resulting from such infringement rests solely with you. If you wish to re-use a component of the work, it is your responsibility to determine whether permission is needed for that re-use and to obtain permission from the copyright owner. Examples of components can include, but are not limited to, tables, figures, or images.

All queries on rights and licenses should be addressed to the Publishing and Knowledge Division, The World Bank, 1818 H Street NW, Washington, DC 20433, USA; fax: 202-522-2625; e-mail: pubrights@worldbank.org.
# Table of Contents

Introduction ................................................................................................................. 5

1. What are node, place and market values? ................................................................. 8
   1.1. Node value ........................................................................................................ 8
   1.2. Place Value ..................................................................................................... 9
   1.3. Market Value .................................................................................................. 10
   1.4. The respective impacts of values .................................................................. 11

2. The 3V Framework ................................................................................................. 11
   2.1. Node/Place/Market Value provide a framework for pro-active TOD implementation at the urban scale ........................................................................................................... 11
   2.2. Node Value: Measuring and Dividing into 3 categories .................................. 13
   2.3. Place Value: Measuring and Dividing into 3 categories ................................. 16
   2.4. Market Value: Measuring and Dividing into 3 categories .............................. 17
   2.5. Most promising areas of development ............................................................. 19
   2.6. Case study 1-King’s Cross: in London a major place value creation around London’s major and most accessible hub ..................................................................................... 21
   2.7. Hudson Yards in New York: increasing connectivity and accessibility to a major land redevelopment ............................................................................................................................ 22

3. Implications for Chinese practitioners ................................................................. 24
   3.1. Types of TOD areas and types of policies ....................................................... 24
   3.2. TOD Strategies .............................................................................................. 26
   3.3. Increasing values ........................................................................................... 29

*Increasing Node Value* .......................................................................................... 30

*Increasing Place Value* ......................................................................................... 31

*Increasing Market Value* ...................................................................................... 34

Annex: Key Metrics .................................................................................................. 37

Key Metrics of Node Value .................................................................................... 37

Key Metrics of Place Value .................................................................................... 39

Key Metrics of Market Value .................................................................................. 42
Acknowledgements

This methodology was prepared by a team comprising Serge Salat (Urban Morphology and Complex Systems Institute) and Gerald Ollivier (World Bank). It is based on a program of activities on Transit Oriented Development under TransFORM. TransFORM is the Transport Transformation and Innovation Knowledge Platform, jointly convened by the Government of China and the World Bank, to help make comprehensive transport safer, cleaner, and more affordable for development in China, while sharing Chinese experiences with other countries.

The preparation of this methodology benefitted from the generous financial support from the Multi-Donor Trust Fund on Sustainable Urbanization led by Ellen Hamilton.

We want to thank Hiroaki Suzuki, Valerie-Joy Santos, Cuong Duc Dang (World Bank), and Robin King (WRI) for their peer review comments, Abhas Jha and Michel Kerf for their continued management support in the preparation of this document, to Paul Kriss and Binyam Reja for their guidance, and to Paul Procee for the many engaging discussions on TOD in China.

The preparation of this methodology benefitted from the many discussions with Chinese officials in the cities of Tianjin, Nanchang, Zhengzhou, Beijing, Qingyang, Shanghai, and with the China Railway Corporation, as well as discussions in South Africa and India.
Maximizing Economic Value of TOD Station Areas by Matching Place Value, Node Value and Market Value

The 3V Framework

Introduction

Over 40 Chinese cities have launched plans to develop a comprehensive mass transit system. Within the next decade, there will be about 6,000 transit stations in China. The State directive 64 (2012) on Prioritization of Urban Public Transport Development and the State Council directive 2014 (37) on Land Comprehensive Development in Supporting Railway Construction call for integrated development strategies around metro and railway stations.

Concentrating development around these stations and the 1km² areas around them offers a unique opportunity to shape the Chinese cities of tomorrow and make them more innovative, livable, efficient and inclusive. But because such mass transit systems require major investments, policy makers will have the challenging task of having to generate as much economic value out of them as possible. International experience has shown that, while the 1 km² areas around transit stations typically offers the highest level of opportunities, not all stations are equal in terms of development potential, with about 15% offering very high potential.

Understanding where, when and how potential economic value can be created requires tools that help differentiate the opportunities offered by the diverse stations in a mass transit network. This paper outlines a city level framework to equip 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 stations. Following such analysis, a city level vision for Transit Oriented Development (TOD) can emerge and be used to engage with citizens, companies and other stakeholders to refine and advance such vision, and update it on a regular basis.

Other critical TOD considerations such as inclusiveness, resilience, or freight movement also need to be integrated in such TOD vision, and will be covered in future reports. On the basis of such vision, plans can be developed to provide the necessary service infrastructure to support higher densities in priority areas and to analyze the specific economic returns of different programs, considering all related social and environmental aspects.

For residents, value is driven by the characteristics of a place (fit with personal preferences in terms of urban form, schools, access to daily amenities, walkability and bikability) and the connections between this 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 where a high agglomeration of jobs takes place. The application of TOD principles can support effectively such value creation, by strengthening quality of life at a local level, while providing for enhanced job opportunities through good connections to jobs at city level using mass transit.

This paper outlines a typology to facilitate TOD implementation at urban scale in various contexts as part of a framework which aims at: (i) identifying the economic development potential of different areas around mass transit stations in terms of type, scale, and timing considering the level of market demand; (ii) developing planning and implementation measures and prioritizing limited public resources to create such value through coordinated inter-agency measures; and (iii) communicating with private developers a vision for the city that articulates development around its mass transit network.

The economic development potential of each TOD area can be quantified using the “3V framework” proposed in this paper: Node Value (value of a node or hub according to its position in the overall transport metropolitan network), Place Value (value of an urban area according to its urban qualities), and Market Value (value of a node or hub according to its market potential, and notably the number of accessible jobs).

The 3V Framework is based on a comprehensive assessment of the node value (connectivity and accessibility of the station within the entire network), place value (amenities, schools and healthcare, type of urban development, local accessibility to daily needs by walking and biking, degree of mixed use, accessibility to jobs) and market value (density of people and jobs, number of jobs accessible in 45 minutes by transit, FARs, and land opportunities for development) of each station in a transit network. It draws on international and domestic research, applied in a Chinese context but with applicability in other context. The 3V Framework includes a typology for stations and a set of differentiated strategies.
The 3V Framework is applicable to large cities with extensive networks as well as in smaller cities with only a few mass transit lines or a bus rapid transport system. It seeks to determine the relative areas of potential within a city rather than across cities.

Case studies on Hudson Yards\(^1\), King’s Cross\(^2\), Crossrail\(^3\), Zhengzhou\(^4\) outline how such principles have been applied de facto in leading cities like London or New York and how the 3V framework could be applied in the context of cities with a rapidly developing mass transit network like Zhengzhou.

Compared to the earlier node/place model developed by Bertolini in 1999, the 3V Framework introduces several changes:

1. The 3V Framework bases the node value (or value of connectivity) on recent research about the structure of networks and the different role played by three kinds of centralities (degree, closeness, and betweenness). Since 2000, network science has considerably progressed\(^5\) and has built a body of knowledge that has been applied to subways and explains why station areas like, for example, Shinjuku in Tokyo are booming. This has important implications for public policies as it reveals that networks layouts matter for creating more or less value and that different balances between top-down planned layouts or market driven layouts like London’s Crossrail or like Tokyo’s subway developed mainly by private companies lead to different outcomes.

2. The 3V Framework separates clearly the place value (quality of the urban fabric) and the market value (market vibrancy and potential), which is useful since different agencies, policies and instruments are used to impact market and place dimensions and since decision makers can thus clearly develop specific strategies to improve one or the other. Place value and market value enhancements also take place at different stages of development - and this can lead to positive feedback loops between the two - making the split even more meaningful. The case studies on Hudson Yards and King’s Cross illustrate this well. In China, for example, it is essential to separate those dimensions so that decision makers realize that the use of superblocks result in a major loss in value.

---


\(^{2}\) See Serge Salat and Gerald Ollivier, *King’s Cross Central: In London a major place value creation around London’s major and most accessible hub*, The World Bank 2016.


\(^{5}\) With important discoveries about the structure of the Internet, of the Web, of human ADN, and of neural networks, revealing structural similarities.
The 3V Framework is useful for policy makers as it helps to clarify what type of development is more appropriate in a station area, and what are the stations that have the highest development and value capture potentials. It helps to define station types, based on the three sets of value described above. The framework presents two main interests for policy makers:

1. Building a typology of stations, which classifies the hundreds of stations of a mass transit network into sub-groups for applying different development strategies.

2. Determining the imbalances between connectivity, accessibility, place quality and market values in the same station. These imbalances create a high potential for value making creation such as creating place value around an important connective node or bringing additional connectivity to a booming area.

1. What are node, place and market values?

1.1. Node value

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 that a node offers, as well as differences in centrality and in accessibility within the network create a hierarchy between the nodes.

**Hubs**

For node value, hubs are among the most important nodes. A transport hub (also transport interchange) is a place where passengers can switch between different lines or between transport modes. Public transport hubs include large subway stations with multiple lines, train stations, rapid transit stations, bus stations, tram stations, airports. Some complex hubs combine in a single integrated multimodal station, or complex of stations, several modes: for example, Hongqiao Airport in Shanghai; or Tokyo Station, which comprises a giant underground facility linking the HSR train station to 6 subway stations. The number of lines and modes connecting in a hub defines its importance. A hierarchy of nodes comprises usually:

1. A few high-ranking complex hubs offering transfers between many lines and transport modes, which are clustered in the core of the network,

2. Secondary interchange stations connecting 2 or 3 lines, which are also mostly in city centers,

3. Many single line stations in ‘spokes’ radiating far away from the core of the network.
**Centrality**

In a network, some nodes are more central than others. For a subway network for example, centrality means that many shortest paths between all the other subway stations pass through a given station. A node with high centrality has a large influence on the location of transfers of passengers within the network.

**Accessibility**

Some nodes are also more accessible within the network. Accessibility in this sense is not defined by the local walking accessibility to the station but it means that the distance of a given station to all the other stations is smaller. In a well-organized city, jobs tend to cluster under market forces of agglomeration around the more accessible nodes within networks.

Nodes that are either strong and complex hubs, or more central, or more accessible, or combine all these qualities, have a higher value, because they tend to concentrate higher flows of passengers, like Shinjuku in Tokyo, a very important hub, which has the highest ridership in the world with 3.5 million passengers per day.

### 1.2. Place Value

Place value for residents is derived from vibrant, sustainable communities where they can access jobs, shopping and services on foot or bicycle, thus enjoying a range of benefits such as reduced transportation costs, improved access to various amenities including high-quality education, and improved public health. According to Portland Transit-Oriented Development Strategic Plan, there are three key components to vibrant communities, and hence to place value: (i) Development intensity and mix of land uses, (ii) Walkability; and (iii) Meeting future and current demand.

As for node value, place value is unevenly distributed across an urban region. Places across cities have a wide range of intensities and mix of land uses. In a typical city, many stations areas are mainly residential in nature and with low intensity, while a few stations are more jobs oriented, mixed use, and with high intensity. Walkability is also different and depends on the street patterns and on 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 that might be located in their immediate neighborhood. Street patterns with small blocks about 100-meter side and high connectivity (no cul-de sac street type) enhance local accessibility, while superblocks and gating decrease accessibility.

As place value varies widely, the types of planning, urban design, public policies and investment strategies will be different based on local station area context.
1.3. Market Value

The market value of a node is a combination of the market potential (based on economic activity and attractiveness, and on land and construction opportunities), and of real estate prices and activity.

**Economic attractiveness for developers**

Market potential depends on the economic activity and attractiveness of the place for developers and businesses. For businesses and for commercial activities, local job densities and high accessibility to other job concentrations across the urban area, and expected growth are crucial as they determine the agglomeration economies of locating around a specific station. For residential development, market potential depends greatly on the amount of jobs accessible in 30 to 45 minutes from a given location as resident want to reduce their commuting time, or at least maintain it at a reasonable level.

**Land and real estate opportunities**

Market potential depends also on overall demand for real estate development at city level, on available land opportunities, on the easiness to redevelop the land, and on the volume of construction permitted on a given land. International experience shows that when there is a high attractiveness in a given place, even where land is physically constrained such as in King’s Cross in London (26 ha) and in Hudson Yards in Manhattan (22 ha), the market develops high density programs up to 175,000 people per km² (residential + jobs) in King’s Cross and more than double this figure in Hudson Yards with mixed-use programs, provided FAR regulations are set with higher values.

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

**Market prices**

Market prices comprise land prices, real estate prices, and rent prices. They have an impact on the type of TOD development an area can support. High or increasing land and real estate prices call for high-density programs.

**Market activity**

Market activity is an important component of market value and derives from the intensity of market transactions during a sufficiently long period for residential and mixed-use (residential/commercial) land uses.
1.4. The respective impacts of values

International experience suggests that node value (high connectivity and accessibility within the network) plays a major role in core dense areas where it fosters economic and jobs concentration, and commercial real estate development. Canary Wharf with the Jubilee line extensions and King’s Cross in London are examples of these spikes of real estate value created by increased connectivity or by a major hub. Connectivity plays a less important role than place value in low to medium density areas. This explains why some of the property value drops after a mass transit system is put in place as other parameters prevail (in particular the self-selection by people). One of the key features of residential property value is the residential self-selection process (where individuals select places that fit their preferences in particular for amenities and for the presence of schools). This self-selection explains why there are large variations between the value changes (and direction) at different stations on a given line (Higgins 2015), even though all benefit from an accessibility gain. This does not contradict the general model as these stations, where place value takes over node value, are typically in the ‘long tail’ of single line stations where node value is generally weak (the strongest node values are major hubs that usually are within the core part of subway systems).

2. The 3V Framework

2.1. Node/Place/Market Value provide a framework for pro-active TOD implementation at the urban scale

China adds on the average 450 subway stations every year, and, by 2020, Beijing and Shanghai subways will respectively 1,050 km and 970 km each and will be among the longest subway networks in the world. As for all the other subway networks in China, Shanghai’s 524 subway stations in 2020 will not offer the same potential for development and value capture.

It is crucial to build a framework that allows policy makers to prioritize investments and adjust policies and regulatory planning in order to enable intensification of the development around the highest potential stations and, beyond these high potential stations, to scale TOD in a range of diverse geographic and economic urban contexts requiring specific approaches for their development. There is no ‘one size fits all’ to scale TOD in an entire city. Near-term TOD potential tends to be focused in central locations and in highly accessible hubs of the transit network where it is more feasible to achieve higher density development from a market and financial perspective.

---

6 In statistics, a long tail in a distribution of values 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 as describing the retailing strategy of selling a large number of unique items with relatively small quantities sold of each—usually in addition to selling fewer popular items in large quantities.
A wide range of TOD opportunities exist anyway outside these major TOD developments and require specific approaches.

A TOD typology is a powerful tool to prioritize where and when to make investments, determine the types of investments that are appropriate in varying transit communities, and guide the timing and scale of those investments. A TOD typology provides a means of classifying and differentiating the many transit communities throughout a city by grouping them based on key shared characteristics.

Typologies have seen a variety of uses in different regions. Denver developed a TOD typology to provide a vision for the density and land use mix that would be appropriate in each of the city’s existing and planned light rail station areas. The typology was a guide for subsequent detailed station area planning studies. In Baltimore, a typology was developed to identify and assign station area investment needs to a broad range of TOD actors and stakeholders. This typology was folded into a broader TOD Strategic Plan that has enabled Baltimore to more systematically fund transit-supportive projects, rather than continuing the historic practice of investing in a less effective, piecemeal fashion.

The 3V Framework that is proposed in this paper generalizes previous international approaches based either on node/place model (Bertolini 1999) or on a market/place model (Portland and Baltimore typologies) by identifying the three different values that characterize a transit station: node value, place value, and market value. This allows capturing all the potential of development created by the interplay of these values. This Framework provides an analytical method to classify the transit stations according to their potential to foster economic concentration and land value increases. It aims at strategizing about ways to encourage the development of high performing communities around transit stations and to build transit systems that maximize development potential. The methodology generates new tools for economic development.

Left: 3V framework. Right: Synchronization of high peaks of node value (major connecting hubs) with high quality place making creates spikes of market value. An example is King’s Cross in London or Hudson Yards in NYC.
The 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.

The three values are unevenly distributed among stations. Some stations are important interchanges between different subway lines and different transport modes. Some stations are in extremely high property values areas. These stations will offer high potential for new developments and high value capture potential. Other stations offer much less value increase potential because they are in suburban areas, with a less vibrant real estate market and are not densely connected to the rest of the network. These different types of stations require different types of development strategies, different investments and different policy instruments.

The following three sections describe the methodology for measuring each value for a given node and then divide each of these values into three categories for defining the most appropriate TOD policy to enhance the different values.

2.2. Node Value: Measuring and Dividing into 3 categories

Measuring Node Value

Transit and infrastructure networks are key for urban development forces of agglomeration and land value capture potentials. Increases in connectivity and accessibility increase the market value of places. Node value is the value a station acquires through its location in the network. Different network organizations create different distributions of node values. Value derives from two main location advantages within a network: connectivity and accessibility, which play complementary roles but are slightly different. The organization of the network influences strongly the connectivity and accessibility of the nodes.

A few key metrics can capture the value of a node within a transportation network: ranking in the hierarchy of hubs, connection to higher and lower scales networks, accessibility, intensity of the node activity. These four metrics allow considering both the diversity and intensity of the connectivity in a given node.

**Ranking in the hierarchy of hubs (or transfer stations)** describes the number of connections to different lines that are present in a given node. For example King’s Cross in London connects 6 subway lines. Shanghai subway network will have 95 transfer stations, among which 16 with 3 lines of more. International experience shows that interchange stations have a higher development potential than single line stations.
Diversity of connectivity refers to the number and variety of different transportation modes that a station connects, and to the range of scales that it connects. The more a station in a subway network allows interchange between different lines, the more it offers options and variety of choices, including connection to other modes such as buses and HSR, the higher the connectivity of this station is. A station that can be reached by bus (through several buses lines, and that offers passengers the choice between several subway lines, and a seamless connection to a train station or several train stations, for example HSR and intercity trains, is clearly more connective than a station isolated in a single line.

Nodal Accessibility here is not defined by the local pedestrian accessibility to the station within a radius of 500 m or 800 m but by the accessibility to or from the node at city scale.

Intensity of the node activity captures the strength of the flows of traffic in a node. It can be described by the frequency of departures of public transportation and/or by the ridership of the node, which when available, is a comprehensive measure of the activity of the node. For example King’s Cross ridership in London is 140,000 commuters per day, while the ridership of Shinjuku Station, the highest in the world, is 3.5 million passengers per day.

An index of node value can be built with a weighted sum of the previous characteristics (see example of Zhengzhou).

Dividing Node Value into 3 categories

Node value is higher in network cores than at their periphery. In network cores, the high density of stations allows to interconnect them into dense clusters around major hubs. This is not possible at the periphery of the network due to the increasing spacing between stations with the distance from the city core.

Station density is not equally distributed across subway networks and this has important impacts on node value. The density of stations decreases with the distance to the core of the city with a sharp change in density at the limit of the city core. For example, Benguigui and Daoud (90) have shown in Paris that at locations close to the center (and up to 6.5 km from the center of Paris) the number of urban rail stations is proportional to R² (where R is the distance to the center). As the surface increases, the number of stations increases and the density of stations remains constant. This ensures accessibility at less than 400 meters for all residents. Quite the opposite, beyond 6.5

---

7 It can be measured by several complementary criteria:
- Between-ness centrality ranks the nodes according to the number of shortest paths between all other nodes that pass through this node.
- Distance to all the other nodes in the network has also been used to rank nodes.
These calculations require using graph theory tools to analyze the network.
km, there is a sharp decrease in the number of stations, which is now proportional to $R^{1/2}$. This sharp decrease corresponds to two different systems, the subway and the suburban rail. The suburban rail is a network with a very low density (its density in function of the distance is proportional to $R^{-1.5}$).

Other recent works have generalized this result and shown that large subway networks converge towards similar shapes. The authors have studied the temporal evolution of the structure of the world’s largest subway networks including Beijing, Shanghai, Tokyo, Seoul, London, Paris, and New York. They have shown that all these networks converge towards a shape that shares similar generic features despite their geographical and economic differences. This shape is made of a core with branches radiating from it. For most of these networks, the average number of links per station within the core has a value of order 2.5 and the proportion of transfer stations with 2 lines in the core is larger than 60 per cent. The authors have generalized the previous result about Paris with spatial measures of the number of stations at a given distance to the city center. They have found in all the studied subways, like in Paris, a first regime where the number of stations grows as $R^2$ followed by another regime with different exponents. The first regime corresponds to a uniform core, while the second regime is controlled by the spacing between stations along the branches of the network extending outwards.

We have thus a first division between 2 categories of stations (core and suburban). Research by the Urban Morphology Institute has gone further: it has shown in Paris and London that the number of lines per station and the ridership per station follows a mathematical distribution. If ordered by rank from the most connected and active station to the last, the number of lines per station and the number of passengers are proportional to the rank elevated at an exponent. These distributions are known in economy as Pareto distributions and have initially been used to describe inequalities. They show a few high values, some intermediary values, and what is called a ‘long tail’ of low values. In urban rail systems, the ‘long tail’ corresponds to suburban stations, while the few high values correspond to the major hubs, the intermediary situation corresponds to the stations that are in an urban context but are not major hubs. Many of them are transfer stations with 2 lines.

---


10 Pareto distributions comprise a few high values and a “long tail” of many low values.
The convergence of transit networks using metro or other form of mass transit towards this shape with hubs and spokes allows dividing the node value into 3 categories:

1. **Highly Connective Hubs** rank high both in connectivity and in intensity and dominate the system with a high concentration of passenger flows.

2. **Core Transfer Stations** are transfer stations with 2 lines or more concentrated in the city core.

3. **Urban and Suburban ‘Long Tail’ of Single Line Stations** belong mostly to the branches of the urban rail system extending outwards in the suburbs.

### 2.3. Place Value: Measuring and Dividing into 3 categories

#### Measuring Place Value

A few key metrics of intensity and diversity of land uses and of urban form can measure the place value of an area.

**Mix-use:** Areas with commercial urban amenities such as restaurants, groceries, and specialty retail allow residents to complete daily activities. Diversity of uses can be measured by various metrics.

**Density of social infrastructure (amenities):** Schools, healthcare and more generally social infrastructure, when concentrated in a compact area or easily accessible, increase place value.

**Compactness:** Locating conveniently the various activities and uses close together, minimizes the time and energy required to reach them and maximizes the potential for interaction, which in turn increases place value and minimizes infrastructure costs and breaks in the urban fabric created by road infrastructures.

**Physical Form and Pedestrian Scale:** Small block sizes about 100 m side with vibrant edges (facades on the perimeter with businesses) promote more compact development and walkability.

**Street patterns:** Connected street patterns with a 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.

---

11 Curitiba BRT network shows this type of shape as well.
**Pedestrian/Bicycle Connectivity:** Access to sidewalks and low-stress bikeways encourages many more people to walk or cycle to transit and neighborhood destinations.

An index of place value can be built with a weighted sum of the previous characteristics.

**Dividing Place Value into 3 categories**

1. **Suburban:** Suburban areas are generally non-transit areas or areas close to transit without possessing the urban character that would best support it. 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 on large areas of land (either residential, or industrial or business parks, with no mixed use). Typical Chinese new developments at city edge with superblocks, large arterials, and only one function) belong to this category.

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

3. **Intense Urban:** In Intense Urban Areas, the combination of a high diversity and intensity of uses, with high economic concentrations makes these areas the most likely to support a transit lifestyle.

2.4. **Market Value: Measuring and Dividing into 3 categories**

**Measuring Market Value**

The Market Value metrics provides a rough measure of TOD development feasibility and return on investment based on local real estate conditions. It depends on the overall demand for additional real estate at a city level. Market value can be measured with a weighted combination of:

**Density of people and jobs:** The number of residents and workers in an area and the balance between jobs and working age population has a direct correlation with the attractiveness of the area for residents and businesses and thus with the development of a strong real estate market.

**Forecasted rate of growth in human density:** Such forecasted growth indicate the expected evolution of different areas within the city. It is typically forecasted as part of urban mobility plans or mass transit development plans.

**The number of accessible jobs within 45 minutes by transit** is key for the development
potential of the area as it measures its attractiveness for residents and for companies, which want strong linkages with other dense nodes of jobs within the urban region.

**FARs:** High FAR supports a high density of people and jobs and a high volume of construction. These FAR can be adapted to the different uses with higher FAR for commercial uses and lower FAR for residential uses.

**Land and real estate opportunities:** Land opportunities are the amount of un-built land adjacent to the station in a radius of 500 meters for the highest premium and between 500 meters and 1 kilometer for the lower premium. Real estate opportunities are the amount of additional m² of floor space that can be built on land adjacent to the station. Real estate opportunities are the difference between maximum floor space that can be built within regulatory FAR and existing built floor space.

Where available market prices (land, real estate, rents) and volume of transactions provide useful indications of the state of the market, but are not used in the index to avoid correlation with other variables. They should be appreciated, when data are available, on a decade-long time frame that enables the sales transactions to span several market cycles, offering a more long-range look at performance, and consider the overall demand for additional real estate at city level.

**Dividing Market Value into 3 categories**

This typology (used in Portland) divides Market Value into three categories: Limited, Emerging and Strong.

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

**Emerging:** these are areas that have limited to moderate real estate market conditions and where 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, since land and development costs are not elevated (as in Strong market areas) and small investments may catalyze further market investment.

**Strong:** these are areas where market conditions are already ripe or ripening, TOD investments should focus on improving urban living infrastructure (amenities) and developing prototype developments.

This approach is not predictive of the financial feasibility of a new development in any given
category, but rather it provides a relative sense of how any individual station area performs relative to the city.

### 2.5. Most promising areas of development

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.

The 3V Framework allows policy makers to assess development potential in a pro-active and dynamic way. Not only are the values of stations unevenly distributed, but also the different types of values for each station may differ greatly.

TOD is a strong planning policy to balance the node-place-market properties and develop effective land-use strategies through fully exploiting synergies between transportation, real estate, and retail-related services. TOD is the key to turn node-place dynamics into success stories such as King’s Cross in London and Hudson Yards in New York. It is worth taking an active attitude towards imbalances, since they can unleash development potentials at all scales.

Bertolini (1999) has introduced a node-place model similar to the one we propose but without explicit consideration of market values that have been further developed in public policies in the US such as in Portland and Baltimore. According to Bertolini 2011, the basic idea is that improving the transport provision (or the node value) of a location will, by improving accessibility, create conditions favorable to the further development of the location. In turn, the development of a location (or an increase in its place value) will, because of a growing demand for transport, create conditions favorable to the further development of the transport system. Bertolini model highlights the dynamic potential of imbalances.

---

12 The node-place model of Bertolini (1999) is supported by the reasoning on the transport land use feedback cycle (Giuliano 2004; Meyer and Miller 2001; Wegener and Fuerst 1999) and aims at further exploring the underlying relationships, with a focus on station areas.
The potential of nodes derived from Bertolini (1999) can be classified as follows. We have added market value potential to the description:

1. **Balance**: node and place are both strong. Transportation infrastructures and local land use profile support each other. This creates the maximum market value.

2. **Stress**: intensity and diversity of infrastructures and activity of land use come close to maximum. “Stressed” station areas have a very strong position on both the node and place scales. Further development in these areas can become problematic as multiple claims on the limited amount of space can easily cause conflicts. The attractiveness of these places might anyway be so strong that they keep on developing although looking saturated. This is the case of Shinjuku in Tokyo, already having by far the highest ridership in the world, to which a new line is added with new real estate development happening.

3. **Dependence**: There is no competition for free space, and the demand of infrastructures is low. There is no need for further development of infrastructures due to the lack of local potential for an increase in market value. Both the node and the place values are relatively so weak that factors other than internal node-place dynamics (e.g. subsidization) must intervene in order for the area to sustain itself.

4. **Unbalanced node**: the supply of infrastructures is relatively stronger than the activity of land use. There is a potential of development in enhancing place value that will derive market profit from the over-supply of connecting infrastructure. An example of this is King’s Cross in London.

5. **Unbalanced place**: the activity of land use is more intense in relation to the supply of infrastructures. Local development potential should be encouraged by provision of supportive infrastructure increasing connectivity. An example of this is Hudson Yards in New York where the
intense real estate development called for an extension of subway line 7. Higher connectivity will encourage already existing economic activity and increase further market value potential.

King’s Cross in London was an unbalanced node. The case study demonstrates that creating place value with public realm and a mixed-use program around a major hub fosters high market values. Hudson Yards in New York could have been an unbalanced place. The case study demonstrates that a major high-density and mix-use land redevelopment calls for increased connectivity that can be financed by real estate development through innovative financing mechanisms.

2.6. Case study 1-King’s Cross: in London a major place value creation around London’s major and most accessible hub

Left: King’s Cross is a major interchange station in London, at the scale of the city, of UK, and of Europe. Right: A mixed-use high-density program, with 40 percent of the land for high-quality public space is under development to the north of the station. Source: Argent St George. King’s Cross Overview

A station like King’s Cross in London has one of the highest node values in Europe with a very high level of connectivity and accessibility. King’s Cross connects people to people and businesses through scales, from the European scale, to the British scale, the London scale, and the borough scale. This interchange connects six metro lines in addition to two rail stations for domestic and international rail with unrivalled connectivity (Northeast, Scotland, commuter services to north London for King’s Cross station; Midland main line, and Eurostar HSR to Paris and Amsterdam for St Pancras). Five international airports are within an hour including three with direct connections. King’s Cross is also one of the busiest routes for buses (17 routes). Its ridership is up to 140,000 commuters, visitors and residents per day. Crossrail, a major subway extension in London, will further increase the connectivity of King’s Cross by adding more than 200,000 more jobs accessible in less than 45 minutes transit. To the north of the two train stations, there were 27
ha of undeveloped land. Thus there was a strong imbalance between a very high connectivity and a low intensity of land use. This imbalance created a strong potential for matching the high connectivity with a high place value by redefining, reshaping and creating value on former rail land to the north of the two stations.

Under the supervision of the Department for Transport (DfT), London and 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 (High Speed 1) stations—chiefly King’s Cross and Stratford. For King’s Cross, the developer—Argent—was selected as a private partner in 2001. The London Borough of Camden granted outline planning permission for regeneration in 2006, and LCR, Argent, and another landholder—DHL—jointly formed the King’s Cross Central Limited Partnership in 2008, which became the single land owner and developer around King’s Cross.

2 billion £ (RMB 21 billion) will be invested in the creation of public realm, with 20 new streets, 10 new public spaces, including 5 squares totaling 3.2 ha. 40 % of the site is high quality public space while 60 % of the land supports 280,000 m² of new workspace, 46,000 m² of retail, bars, restaurants and leisure facilities, 2,000 new homes, a new university, and educational, hotel, and cultural facilities. By 2020, up to 50,000 people will be living, studying, working in King’s Cross, which represents a peak of human density (residential + jobs) of nearly 200,000 people per km². Google has spent about 650 million £ (RMB 6.8 billion) to buy and develop a 1 ha site. The finished development will be worth up to 1 billion £ (RMB 10.5 billion). Google presence is expected to draw other technology companies to King’s Cross - especially small start-ups - and help bump up rents. After development, the new balance between a high node value and a high place value is expected to foster a high market value with a rents and real estate performance higher than the rest of London.

2.7. Hudson Yards in New York: increasing connectivity and accessibility to a major land redevelopment

New York City envisions the creation of 440,000 new jobs requiring 12 million m² of new office space. The City Planning policy is to concentrate these jobs in the core areas of the city and as much as possible in Manhattan in order to increase agglomeration effects in an advanced service provider economy.

Hudson Yards, one of the last large pieces of unemployed land in Manhattan will be massively redeveloped and is expected to cluster in a very limited area 20 % of the jobs growth of New York (88,000 jobs). Hudson Yards project in New York could have presented a form of imbalance between the place, market and connectivity values as the area was poorly connected. The project
of redevelopment of the 22 ha of the yards (less than 500 m by 500 m) achieves an average FAR of 20 at the scale of the entire site (including streets and green spaces), which is an extremely high figure. According to NYC DCP, the Hudson Yards zoning district was planned to include up to 2.4 million m² of new office development, 20,000 units of housing, including 5,000 affordable units, 186,000 m² of retail and 279,000 m² of hotel space.

In spite of its verticality the project respects the Manhattan grid of about 36 small and elongated blocks 60 meters wide and 180 meters long that create a densely connected pedestrian scale urban fabric. The project even increases the connectivity and local accessibility by cutting through the blocks with a wide urban garden crossing diagonally all the depth of the site. A great effort has been undertaken to create high quality public space.

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 established in the Zoning Resolution by making a District Improvement Bonus (DIB) payment to the Hudson Yards District Improvement Fund (about US$ 1,350 per m²). The District Improvement Fund will be used by the City to help finance density-ameliorating infrastructure improvements in the Hudson Yards area, including the No. 7 Subway Extension and new parks and open space. Cost estimates of infrastructure for phase 1 are 1.7 billion US $ for No. 7 subway extension, 350 million US $ for eastern rail yard platform, and 360 million US $ for open space and streets. Costs estimates for phase 2 were 250 for No. 7 Subway 41st street station and 270 million US $ for mid-block boulevard and parks. Total cost of public spaces is 630 million US $ while total infrastructure cost with subway extension is around 3 billion US $. New development will generate various streams of revenue that cover these costs. It is expected that these streams of revenue will largely cover the Project Debt service and that the overall project will generate cumulated incremental revenues to City and State of 67 billion US $ between 2005 and 2035.
Without the No.7 Subway Extension the project would have created an imbalanced area with a high place value, an extremely high property value and concentration of economic density, and a low connectivity. Thus the No.7 Subway Extension was decided and designed in such a way that every place in Hudson Yards will be at less than 10 minutes walking from the new station. By extending the subway line, New York Department of City Planning transformed Hudson Yards in a highly integrated 500 m by 500 m TOD neighborhood.

3. Implications for Chinese practitioners

3.1. Types of TOD areas and types of policies

Overlaying node value, place value, and market value characteristics creates 3 times 9 distinct areas types that call for different approaches for public policies and timing of investments. This classification is the first step in an investment strategy at city scale. Many of the place types face similar challenges and would benefit from similar investments strategies. The 9 types in each matrix are grouped into 3 clusters (an approach similar to Portland strategy). The types on the diagonal are balanced types, from dependent needing infill, to median needing intensification, to major nodes that can support transformation. The most promising types are the unbalanced ones outside the diagonal with a great potential for transformation such as the massive redevelopments in King’s Cross, and in Hudson Yards. King’s Cross is a highly connective hub in an urban setting, which through transformation moved from an emerging market value to a very strong market value. Hudson Yards has a high market value (last large land opportunity in Manhattan), which through transformation will become an intense and connected urban place. These matrices are not to be considered as static descriptions but as dynamic tools to look at the levels of possible transformations of the different TOD areas.
3.2. TOD Strategies

Scaling up TOD at metropolitan region level

All TOD investments should take a comprehensive view of programs and policies that can help realize the full range of TOD benefits. These comprehensive strategies will include investments in human capital, neighborhood services and business development, and may well improve an area’s long-term prospects for TOD. The 3V Framework integrates the different aspects and scales of urban development. Such integration fosters the interactions and coherence between scales and the interactions between people, and between people, companies and markets through different scales.

Scaling up TOD at metropolitan region level will require changes to occur in a range of geographic and economic contexts, rather than just in core, urbanized areas. Many suburban stations have limited near term market rate development potential, but have substantial land opportunities. Chinese cities more suburban stations have low densities and significant developable land, which can accommodate urban growth through infill.
There are significant challenges\textsuperscript{13} to the effective implementation of TOD in China. These include an incomplete understanding of TOD, conflict between current planning regulations (in particular at national level) and TOD planning techniques requiring close focus on pedestrian oriented design and mixed land use, economic incentives that support urban expansion rather than densification and urban renewal, and lack of solutions to internationalize the economic benefits and finance the supporting infrastructure for higher densities. In particular regulatory barriers to subdivide land and redevelop superblocks with more flexible mix use programs or the lack of dense and connected street patterns and of retail and service amenities have hindered accessibility to mass transit and reduced the vibrancy of neighborhoods. In addition while redevelopment will bring higher market returns, it requires upfront costs that the market is reluctant to cover.

This raises many issues for the redevelopment of TOD neighborhoods in Chinese cities outside the core areas. The ‘long tail’ of single line station neighborhoods outside the core areas needs significant infrastructure improvements in order to promote urban style development, biking, walking, and transit use.

Additionally, station area planning and implementation efforts are needed in outlying station areas. TOD investments are intended to stimulate a market response, but many other critical investments and/or incentives are needed, leading up to development or concurrent with it.

**Synchronizing Place Value, Node Value and Market Value**

The synchronization of place value, node value and market value has a very strong leverage, with strong feedback loops: higher place, node and market values induce higher economic value which in return feeds place and node value, because more and more opportunities emerge and investments become more profitable. The 3V Framework is a virtuous circle.

\textsuperscript{13} Ruishan Zheng and Jinhua Zhao, *Establishing TOD on the Ground: Case-Based Analysis of Implementing TOD in China* (2015). TRB.
New development is a fundamental way to improve the vibrancy of station areas, but the potential to attract investment is clearly predicated on both neighborhood market conditions and regional market demand. Key questions are:

- Is there land available for development?
- Is there the potential for some uses to transition to others?
- Are there opportunities to intensify existing residential or employment concentrations?
- Is there development happening now?
- Are values going up quickly?
- Is there a lot of transaction activity?

**Implement differentiated strategies**

The Framework makes it possible to: (1) assess the structure of transit networks on the city scale, and identify which transit nodes have the highest development potential; (2) to assess where to improve the place value (e.g. around high potential transit nodes) and implement infill and intensification strategies; (3) to increase market value while adapting intensity of development to the market potential of each node. The Framework provides differentiated strategies according to the relative levels of the different values. Depending on their TOD and market potential, we can define 3 types of implementation strategies:

- **Infill**
- **Intensification**
- **Transformation**

**Infill** is mainly for dependent nodes in suburban neighborhoods with single transit lines and low value market. The strategy there is to:

- Promote long term planning
- Increase activity levels and transit service through increased densities
- Plan and fund multimodal transportation system
- Plan for maintaining equity in vulnerable or challenged communities

**Intensification** is for emerging station areas in urban neighborhoods with interchanges and emerging markets. The strategy there is to:

- Invest in catalytic TOD projects to prime and push the market
- Promote development oriented planning
- Evaluate and address missing multimodal connections and accessibility
Transformation is the strategy to be applied in major hubs where creating a high level of place value through job concentration and good urban design with major investments in public spaces can create high peaks of land and real estate value.

- Invest in aggressive TOD projects to push the market
- Significantly higher densities and lower parking ratios
- Innovative building types and advancements in urban design & living, employment uses and destination
- Encourage affordable or work force housing
- Foster increased transit service, capacity and amenities to support intensity of uses

3.3. Increasing values

Aside from the strategy in section 3.2, several levers are available to increase node, place and market value as summarized in the table below and explained through examples in the rest of this section.

<table>
<thead>
<tr>
<th>Node Value</th>
<th>Place Value</th>
<th>Market Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Increase number of hubs and number of lines/modes they connect to</td>
<td>● Increase compactness (proximity to existing urban activity and short travel time to main destinations)</td>
<td>● Increase residential density</td>
</tr>
<tr>
<td>● Interlink neighboring stations into clusters</td>
<td>● Increase diversity of uses</td>
<td>● Increase job density</td>
</tr>
<tr>
<td>● Increase accessibility within the network for all</td>
<td>● Increase concentration of commercial, cultural and education amenities</td>
<td>● Increase human density</td>
</tr>
<tr>
<td></td>
<td>● Design neighborhood that promote walking and biking</td>
<td>● Increase diversity of land parcels to create a vibrant land market</td>
</tr>
<tr>
<td></td>
<td>● Create vibrant public realm</td>
<td>● Increase social diversity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Allow for vertical separation of development rights</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Increase FARs</td>
</tr>
</tbody>
</table>

Addressing Imbalances between those values
Increasing Node Value

Increase the number of hubs and the number of lines and modes they connect in a dense network core

Networks structures are different. Some networks have more hubs than others and interconnect more neighboring stations with criss-cross lines. These different 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 land prices and economic concentrations in a ‘spiky’ way with high peaks of value concentration. On the contrary, if a network is ‘flat’ in terms of hierarchy, that-is if the network has no major hubs and no dense concentration of lines in a core, it will not offer strong opportunities for capturing high land values around stations.

As efficient urban spatial organizations require concentrating production factors to create forces of agglomeration, the more hierarchy a network presents, the better it is for shaping land uses in a productive way for economic growth. Transit network structures in cities like London, Tokyo and Seoul, determine how concentrated population, jobs and economic densities will be. The spatial development strategy of cities like Tokyo, Seoul, and London is to create first this hierarchy of hubs in the transit network and then to associate public and private investment to create high place value around these nodes.

London major extension of the subway network in many decades, Crossrail, connects all the most important nodes of economic and jobs concentration in London. Many of the stations along the line are already important hubs. Crossrail increases their connectivity by adding a new line to these interchanges and in one case by allowing the integration of two stations, Euston Square and King’s Cross, increasing even more the connectivity of one of the most connected stations in Europe.

The development of Tokyo urban rail system has fostered a highly interconnected network. The success of the Japanese programs of land value capture is based on adding lines that increase the interconnectivity of the network. Tokyo 48 urban rail and subway companies are mostly private and derive a large part 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.

The distribution of subway lines between stations in China comprises generally much less high-ranking nodes than in subways that have evolved under market forces and over long periods of time like London or Tokyo subways. London and Tokyo subway organizations are very similar: two circle lines (23 km long in London, 33 km long in Tokyo) create a very compact poly-centricity
with high-ranking hubs where public policies have fostered high intensity development.

**Interlink neighboring stations into clusters**

An important property that enhances the connectivity of networks and the value of their nodes is clustering, that is the density of links between neighboring stations. This density of links creates many triangles between neighboring stations and tightly connect the network, offering passengers varied possibilities of interchange.

**Increase accessibility within the network**

Highly successful subway extensions such as the addition of four lines in Seoul have clustered in the network core a high number of highly accessible stations, which concentrated density and economic activity. Enhancing node value through accessibility pushes market value at considerable heights. Accessibility increase, through node value transformation resulting from extensions of subway systems, has fostered real estate development and jobs concentration in London Canary Wharf with Jubilee line extension. In Seoul, accessibility increase with the second phase of construction of the subway fostered the development of Gangnam-ku. This relatively low developed neighborhood became first a high-class residential area, and then a magnet for high-tech and advanced service provider companies. The result of the accessibility increase and of the place development is a land value, on 40 km\(^2\), which rivals with the land value of Busan, the second city in Korea. Combined with the neighboring districts of Seocho and Songpa, Greater Gangnam Area account for almost 10% of land value of the entire country\(^{14}\). Such network level approach needs to be supported by increased service levels and service integration.

**Increasing Place Value**

**Increase compactness**

Locating conveniently the various activities and uses close together, minimizes the time and energy required to reach them and maximizes the potential for interaction, which in turn increases place value and minimizes infrastructure costs and breaks in the urban fabric created by road infrastructures.

Compactness can be applied to a neighborhood scale, resulting in spatial integration by good walking and cycling connectivity and orientation toward transit stations. At the scale of a city, being compact means being integrated spatially by public transit systems. The two performance objectives for compactness focus on the proximity of a development to existing urban activity, and

---

short travel time to the major trip generators, in the central and regional destinations (ITDP TOD Standard).

**Increase diversity of land uses**

Trip lengths are reduced by providing diverse and complementary uses combined within same or adjacent blocks. There is consensus that diversity and mixed land use are necessary conditions for clustering of economic activity and promoting walking and non-motorized travel. Mixed land use tends to reduce amounts of vehicular movement and enable walking more than settlements characterized by high degrees of mono-functionality.

Mixed use on the neighborhood scale rests upon a mix of housing buildings, office buildings, shops and urban amenities. It has beneficial impacts on transportation patterns, by decreasing the average travel distances. Non-motorized commuting (cycling and walking), the presence or absence of neighborhood shops can be even more important than urban density. The presence of shops and workplaces is also associated both with relatively low vehicle ownership rates and relatively shorter commuting distances among residents of a mixed-use neighborhood. At the block and building scale, mixed use consists in developing small-scale business spaces for offices, workshops and studios on the ground floor of apartment blocks and home-working premises. This option increases the area’s vitality and is a way of achieving an attractive urban environment.

**Increase concentration of commercial, cultural, education**

High quality transit-oriented neighborhoods are vibrant, sustainable communities. Residents of TOD access jobs, education, shopping and services on foot, bicycle or transit, thus enjoying a range of benefits such as reduced transportation costs, improved public health and more stable property values. Japanese railway realized the value early on of integrating mass leisure facilities along rail lines and have since done so as part of their practice to create a sense of community, attractive environment and stimulate balanced transit flows.

**Design neighborhoods that promote walking**

Walking is the most natural, affordable, healthy and clean mode of travel for short distances, and a necessary component of the vast majority of transit trips. As such, walking is a fundamental building block of sustainable transport and of high place value. Walking is, or can be, the most enjoyable and productive way of getting around provided that paths and streets are populated and desired services and resources conveniently located (ITDP TOD Standard).

Walkability is enhanced by dense networks of streets and paths. Blocks sizes and street patterns

---

15 Integrated Station-City Development (2013). Architecture and Urbanism
determine not only whether residents and workers can access rail and bus transit, but also whether they can access the shopping, jobs, and services that might be located in their immediate neighborhood. Block sizes are a good proxy for the walkability of a neighborhood, and small block sizes have a demonstrated correlation with reducing vehicle miles traveled. The size of the urban block in Chinese cities is generally 4 times larger (side of 400 m instead of 100 m) than what corresponds to sustainable urban design. A 400 m side urban block size locks Chinese cities into automobile dependence and prevents further plot subdivision inside the block due to land market regulations.

There are a certain number of thresholds in block sizing and street mesh sizing that differentiate pedestrian cities, TOD cities, and car-dependent cities. Japanese cities with an average distance between intersections of 50 m (even in modern Tokyo) are highly pedestrian cities. European 19th century cities as well as the historical core of American cities and some Asian cities like Hong Kong SAR, China present average distances between intersections from 100 to 150 m. This is the TOD planning sizing. Manhattan for example with urban blocks of 60 m x 180 m presents an average distance between intersections of 120 m, identical to the hyper center of historical Paris. Manhattan on the North South direction presents an average distance between intersections identical to an European Medieval city and in the East West direction an average distance between intersections of 180 m a little bit higher than most European 19th century cities; that makes Manhattan a most walkable city rooted both in the best of European history and adapted to the 21st century.

**Create vibrant and active pedestrian public realm**

Walking is attractive and safe, and can be highly productive when sidewalks are populated, animated and lined with useful ground-floor activities and services such as storefronts and restaurants. In turn, being closer to passing pedestrians and bicyclists increases the exposure and vitality of local retail. *Visually Active Frontage* measures the opportunities for visual connection between sidewalks and the interior ground floors of adjacent buildings. Similarly, *Physically Permeable Frontage* measures active physical connections through the block frontage via entrances and exits to and from storefronts, building lobbies, courtyard entrances, passageways, and so on (ITDP TOD Standard).

**Reduce roadway area**

High quality places such as Paris intra-muros or Manhattan make the use of cars unnecessary. In spite of a very wealthy population and extremely high real estate prices in Paris intra-muros, the rate of ownership of cars is extremely low because people find cars unnecessary and inconvenient. 55% of Paris intramuros households do not own a car. According to the last Census data, only 1.4 million households in the City of New York out of the total 3.0 million owned a car. Within the five boroughs, ownership is lowest in Manhattan, with only 23% of households owning a car, followed by Brooklyn and the Bronx, with 44% and 46% respectively. In contrast, a large majority of households in Queens (64%) and particularly in Staten Island (84%) own at least one car. These
overall ownership rates for City residents are notably different than that of the US, where 92% of all households own at least one car and 20% report owning three or more vehicles.

In high-value places, personal motor vehicles become largely unnecessary in day-to-day life. Walking, cycling and the use of high-capacity transit are easy and convenient, and can be supplemented by a variety of intermediary transit modes and rented vehicles that are much less space-intensive. Scarce and valuable urban space resources can be reclaimed from unnecessary roads and parking, and can be reallocated to more socially and economically productive uses (ITDP TOD Standard). The land occupied by motor vehicles is minimized.

*Develop safe and complete cycling networks*

Cycle friendliness enhances place value and is strongly promoted in Amsterdam and Paris. Cycling is an emission-free, healthy and affordable transport option that is highly efficient and consumes little space and few resources. It combines the convenience of door-to-door travel, the route and schedule flexibility of walking, and the range and speed of many local transit services. The key factors encouraging cycling are the provision of 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 TOD Standard). Bicycles do not take up much space but still require secure parking and storage. Cycling can be an attractive travel option only to the extent that cycle racks is available at destinations, and that bicycles can be secured within private premises at night and for longer periods (ITDP TOD Standard).

*Increasing Market Value*

*Increase residential density*

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 (ITDP TOD Standard). Cities can stimulate such increased density around stations by adjusting their land use plans.

High residential density does not imply vertical urban forms. Seven floor high intra-muros Paris, where high-rise is prevented by strict regulation achieves the same residential density as Manhattan: 21,000 inhabitants per km² on the average with a several districts at 40,000 inhabitants per km², meaning densities that are much higher than in vertical Chinese urban forms. High residential density does not mean that the city must grow vertically: this achieves low densities due to inefficient land use with a lot of urban land left empty or occupied by oversized road.
infrastructures. It means that the city must grow in a more compact form with traditional small size, medium rise, perimeter blocks that are the most efficient way to use urban land.

**Increase jobs density**

Jobs density feeds economic productivity. Across the U.S., 50% of the variation in economic productivity per capita can be explained by job density. A doubling of employment density in U.S. cities corresponds to a 6% increase in hourly labor productivity. A study including 261 Chinese cities shows that economic productivity in China increases by 8.8% with a doubling of employment density. Job and business density is key to economic sustainability: reaping the benefits of agglomeration economies, increasing economic productivity and fostering innovation.

Concentration of economic activity in particular locations enables firms to reap economies of scale and scope, and bring talented people together to share ideas and innovate. Economic density is GDP per square kilometer. Dublin, London, Paris, Singapore, and Vienna ranked at the top of the densest cities in the world in 2005, with more than US$ 200 million in GDP per square kilometer. Tokyo-Kanagawa, New York–New Jersey, Oslo-Akershus-Vestfold, and Vienna-Mödling were the densest grid cells of 1° longitude by 1° latitude, producing GDP per square meter in excess of US$30 million (World Bank 2009).

**Increase human density and employment rate**

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

Employment rate is the rate of employment of the working age population in the district. It gives an indication of the level of employment of the district and of the degree of integration of its population in the urban economy. These two densities are key socio-economic components of place value.

---


**Increase social diversity**

The integration of social diversity within large redevelopment creates an opportunity for more balanced urban development that relieves gentrification pressures, and increase the public buy-in for TOD. The availability of affordable housing in dense TOD areas broadens access to opportunities, in particular access to jobs or better schooling. By avoiding the relocation of individuals far away from job prospects it also better balances transit ridership. The use of FAR bonuses against provision of affordable housing (see Hudson Yards case study) enables the combination of value creation for developers with greater equity.

**Increase diversity of land parcel sizes to create a vibrant land market**

Diversity of land parcel sizes can meet future demand and creates an adaptive city. Chinese current urban development is based on large superblocks (400 meter side) that are the current unit of land sales to developers. This contrasts strongly with the 80 times smaller unit of land sales (200 m²), which has been the original basis of Manhattan land market. Manhattan now shows a huge diversification of land plot sizes, and plot intensity of development. On an area of 60 km² (the size of Manhattan), taking into account the much larger road surface in Chinese urban planning, there would be initially 300,000 units of land sale in Manhattan compared to 250 in a Chinese New Town. The fine grain of plot and land market fosters an active land market with a great potential of future mix use. Over time, plots of land in Manhattan have consolidated but still 40 % remain with the initial sizing of 2 centuries ago, while very few occupy whole urban blocks. Studies (Salat 2015) have shown that the sizing of land parcels in vibrant cities and in high value neighborhoods follow mathematical regularities that reflect optimal distributions.

**Increase FARs near stations**

In TOD projects, local authorities often reset the FAR at higher values for allowing densification and generate revenue streams that can be captured to finance infrastructures (transit and public spaces). Commercial FAR can be reset at high values in the immediate proximity of the station while residential FAR may be reset at lower values than the commercial FAR.
Annex: Key Metrics

These Key Metrics do not constitute an entire assessment system for TOD desirable features. They aim at capturing in an automatized and synthetic way the essential data necessary to build the 3 Value indexes and plot them in matrixes from data that are usually geo-referenced in urban GIS.

Key Metrics of Node Value

A few key metrics can capture the value of a node within a transportation network: ranking in the hierarchy of hubs, diversity of connectivity (connection to higher and lower scales networks), network accessibility, and intensity of the node activity. These four metrics allow considering both the diversity and intensity of the connectivity in a given node.

**Ranking in the hierarchy of hubs in a subway network** describes the number of connections to different subway lines that are present in a given node. A station that offers multiple connections will have a larger development potential than a station that does not.

**Metrics: an index of centrality is “degree centrality” in the network (that is the number of transit lines in a station).**

**Example**

The Metro Station République in Paris has a degree centrality of 5 (5 metro lines are crossing), whereas most of surrounding stations have a degree centrality of 1.
**Diversity of Connectivity** refers to the number and variety of different transportation modes that a station connects, and to the range of scales that it connects. The more a station in a subway network allows interchange between different lines, the more it offers options and variety of choices, including connection to other modes such as buses and HSR, the higher the connectivity of this station is.

**Metrics:** number of different transit modes that are accessible within walking distance from a node.

*Example: Around the Métro Station République, 11 alternative transit modes are accessible within walking distance, including: 5 metro lines, 4 bus lines, 2 bike sharing facilities*

**Network Accessibility** is not defined here by the local pedestrian accessibility to the station within a radius of 500 m or 800 m but by the accessibility to or from the node at city scale. It can be defined by the betweenness centrality that ranks the nodes according to the number of shortest paths between all other nodes that pass through this node. Betweenness centrality captures the geographical distribution of attractive travel paths between each pair of transit nodes across the network. It quantifies to what extent a transit node is located 'at the crossroads' of the public transport network. It is calculated with the following formula, with $\sigma_{ij}$ the total number of shortest paths from node i to j and $\sigma_{ij}(k)$ the number of those path that pass through the station k.

$$\text{betweenness}_{node \, i} = \sum_{i \neq j \neq k} \frac{\sigma_{ij}(k)}{\sigma_{ij}}$$

*Example: map of metro stations betweenness centrality in the North-East of Paris*

**Intensity of the node activity** captures the strength of the flows of traffic in a node. It can be described by the frequency of departures of public transportation and/or by the ridership of the node, which when available, is a comprehensive measure of the activity of the node.
**Metrics: Frequency of departures of public transportation**

*Example:* During rush hour at the Métro station République, one metro is leaving the station every 24 seconds in average, and one bus every 2 minutes

**Metrics: Station entering traffic, equal to the number of passengers entering a station per year.**

*Example:* Metro Station République in Paris has an entering traffic of 16.9 million passengers per year, whereas its direct neighboring station (Métro station Temple) has a entering traffic of 1.2 million passengers per year.

An index of Node Value can be built with a weighted sum of the previous metrics.

**Key Metrics of Place Value**

A few key metrics of intensity and diversity of land uses and of urban form can measure the place value of an area.

**Density of social infrastructure (amenities):** Schools, healthcare and more generally social infrastructure, when concentrated in a compact area or easily accessible, increase place value. High-quality transit-oriented neighborhoods are vibrant, sustainable communities. Residents of TOD access jobs, shopping and services on foot, bicycle or transit, thus enjoying a range of benefits such as reduced transportation costs, improved public health and more stable property values.

**Metrics: Number of cultural, education and health services within a radius of 800 m from the station.**

*Example:* Social infrastructure around transit nodes (G) can be at metropolitan scale (major hospital, university, major cultural facility), at local scale (local schools and health care) or non-existent. These 2 station neighborhoods around 2 stations of the new Grand Paris Express line 15 have different types of social infrastructure: Créteil...
I’Échat offers major metropolitan infrastructure (black and grey areas) including university facilities, while Châtillon-MontroUGE offers smaller local social infrastructure (brown areas). Other stations offer little or no infrastructure.

For Créteil I’Échat and Châtillon-Montrouge, the index is a weighted sum of the number of metropolitan scale and local scale social infrastructure with a weight 3 for metropolitan scale facilities and 1 for local scale.

Source: APUR

Diversity of uses: Diversity of uses creates an adaptive city with a wide variety of land uses. Areas with commercial urban amenities such as restaurants, groceries, and specialty retail allow residents to complete daily activities.

Metrics: A diversity index is a quantitative measure that reflects how many different types there are in a dataset, and simultaneously takes into account how evenly the basic entities are distributed among those types. The value of a diversity index increases both when the number of types increases and when evenness increases. For a given number of types, the value of a diversity index is maximized when all types are equally abundant.

Example

The local diversity of land use is calculated using a Shannon entropy formula, taking into account commercial use, community use (health, education, public services), residential use and industrial use. The entropy of each urban area is calculated with the following formula, with i corresponding to a type of use, N the number of uses (here equal to 4), $p_i$ the area dedicated to use i and $p_N$ the area of the cell dedicated to any use:

$$Entropy = \frac{\sum_{i=1}^{N} \frac{p_i}{p_N} \log \left( \frac{p_i}{p_N} \right)}{\log N}$$
The urban areas encompassing the four types of uses have an entropy close to 1. The urban areas with one single use display very low entropy, close to zero.

Diversity of land use (Shannon entropy) along a BRT transit corridor in Johannesburg. Source: Urban Morphology Institute

**Street patterns and block sizes**

Connected street patterns with a 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. A high density of intersections is also a good proxy of size block. Small block sizes about 100 m side 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 gives thus in one single measure a synthetic indication about block sizes, the “grain” of the urban fabric, the diversity of paths around the transit station, and the local accessibility.

**Metrics: number of intersections per km².**

Example: The number of intersections in a 800m radius around Metro station République in Paris is 67 intersections per km², compared to 23 per km² around station Torcy in the suburbs of Paris.
An index of place value can be built with a weighted sum of the previous characteristics.

**Key Metrics of Market Value**

Key Market Value metrics provides a rough measure of TOD development feasibility and return on investment based on local real estate conditions. Market value can be measured with a weighted combination of:

**Density of people:** The number of residents in an area has a direct correlation with the possibility of creating a vibrant mixed-use community.

*Metrics: number of people per km² around the transit station within a catchment area of 800 m radius*

*Example: in a 800m radius circle around King’s Cross Saint Pancras tube station, residential density is of 10,930 inhab/km².*
**Density of jobs:** Jobs density feeds economic productivity. Concentration of economic activity in particular locations enables firms to reap economies of scale and scope, and bring talented people together to share ideas and innovate.

**Metrics:** number of jobs per km$^2$ around the transit station within a catchment area of 800 m radius.

*Example: in a 800m radius circle around King’s Cross Saint Pancras tube station, job density is 24,800 jobs/km$^2$. It will be tripled with the new development under construction in the north of the 2 stations.*

**Forecasted rate of growth in human density:** Such forecasted growth indicate the expected evolution of different areas within the city. It is typically forecasted as part of urban mobility plans or mass transit development plans.

**Metrics:** Forecasted rate of growth in human density.
Number of accessible jobs within 45 minutes by transit: accessibility to jobs is key for the development potential of an area as it measures its attractiveness for residents and for companies which want strong linkages with other dense nodes of jobs within the urban region.

**Metrics: Number of jobs accessible within 45 minutes commuting by transit.**

![Diagram showing mapping accessibility in 45 minutes (isochrones) from subway station Pont de Sèvres in Paris before Grand Paris Express extension of the subway (in orange) and after (in red). The number of jobs within the isochrone (accessible in 45 minutes) increases substantially to reach about 4.2 million jobs from all the stations of the new subway lines.](image)

Source: DRIEA

FAR: The measure of a development’s land use intensity is the Floor Area Ratio (FAR). It is calculated by dividing the total Gross Floor Area (GFA) of the buildings in the development by the area of the land. High FAR supports a high density of people and jobs and a high volume of construction. These FARs can be adapted to the different uses with higher FAR for commercial uses and lower FAR for residential uses. Densification optimizes land use and transit capacity. The maximum recommended distance to the nearest high-capacity transit station for a transit-oriented development is defined as 1 kilometer, a 15- to 20- minute walk. Moreover, by building at higher densities closer to the transit station, a development can maximize the number of people and services that can easily be reached by a short walking distance (ITDP TOD Standard).
Metrics: Floor Area Ratios for different land uses

Example: higher FAR around transit stations and in business districts in Seoul.

Around the central cluster of subway nodes in Seoul CBD, FAR is between 4 and 10 or higher (in red).
Adjacent to these intense predominantly business areas, mixed use areas have a FAR between 2 and 4 (in yellow).
Adjacent to the business and mixed-use, predominantly residential areas have a FAR between 1 and 2 (in light green).
Areas in green in this map are essentially green space (FAR below 1). Source: Alain Bertaud

Real estate opportunities: Real estate opportunities are the amount of additional m² of floor space that can be built on land adjacent to the station in a radius of 500 meters for the highest premium and between 500 meters and 1 kilometer for the lower premium.

In a simplified approach this metric can be extracted automatically for all the stations of the network from a GIS map of existing built densities compared to a map of regulatory FAR by subtracting existing built floor space from maximum floor space that can be built within regulatory FAR.

In a more detailed approach, this metric can be calculated with a more fine resolution as in the 2 examples below for high areas of opportunity.

Metrics: Additional m² of floor space that can be built on land adjacent to the station taking into account existing built space and maximum built space resulting from regulatory planning.
Example 1: Real estate opportunity within the 27 ha north of London King’s Cross-St Pancras station

Initially, the site contained only a few historical buildings that have been retrofitted. The regulatory FAR was set to 4.5 on the average in the built footprint (coverage of 60% of the site leaving 40% for streets and public spaces) and of 2.6 at the scale of the entire site (including streets and public spaces), resulting in a real estate opportunity of 720,000 m² of new floor space split into different uses with a dense fabric of medium scale and medium height buildings. Source: GOOGLE and Kings Cross Overview

Example 2: Real estate opportunity in New York Hudson Yards 22 ha

Adapted zoning in Hudson Yards sets varied FAR for predominantly commercial, mixed use, and predominantly residential with a range between base and maximum FAR, in order to introduce flexibility and capture value. Developers which want to build over base FAR and up to maximum FAR (for example between base FAR 10
and maximum FAR 33 in the densest blocks, can do so by paying bonus payments into zoning-based District Improvement Fund (DIF). This creates an additional real estate opportunity and allows for demand driven development. The real estate potential up to 2035 is 2.5 million m² office floor space, 1.13 million m² residential space, 135,000 m² hotel space, and 630,000 m² retail space, totaling 4.4 million m². The average maximum FAR at the scale of the entire site (including streets and public spaces) is 20. This extremely high figure is 7.6 times higher than in King’s Cross. On a similar size plot of land, the differences in FAR create a much higher real estate opportunity in New York, resulting in high-rise urban forms in a compact layout with public spaces. Source: HYDC (Hudson Yards Development Corporation), The Hudson Yards Project – Rezoning & Financing, Fall 2012 (adapted from NYC Planning, Hudson Yards Graphical Zoning Presentation)

**Market prices and volume of transactions:** Where available market prices (land, real estate, rents) and volume of transactions provide useful indications of the state of the market, but are not used in the index to avoid correlation with other variables. They should be appreciated, when data are available, on a decade-long time frame that enables the sales transactions to span several cycles of sales and dampen fluctuations. According to the available data one of the following metrics may be used. To automatize calculation of the potential of stations on GIS, they should be previously mapped in a GIS platform.

**Metrics:** Land value data and historic land market transactions

**Metrics:** Real estate value data and historic real estate market transactions

**Metrics:** Rent value data and historic rent market transactions

**Example:** Historic rent market transactions at Canary Wharf in London. Jubilee line extension added £1.9 billion in value at Canary Wharf

Canary Wharf is often cited as a prime example of how transport changes can transform a location. Enhancement of connectivity and accessibility has already significantly increased market value. CBRE found the rental discount of the City vs. Canary Wharf closed c.3-4 years in advance of the actual opening of the Jubilee line extension.

Source: CBRE; Drivers Jonas Deloitte.