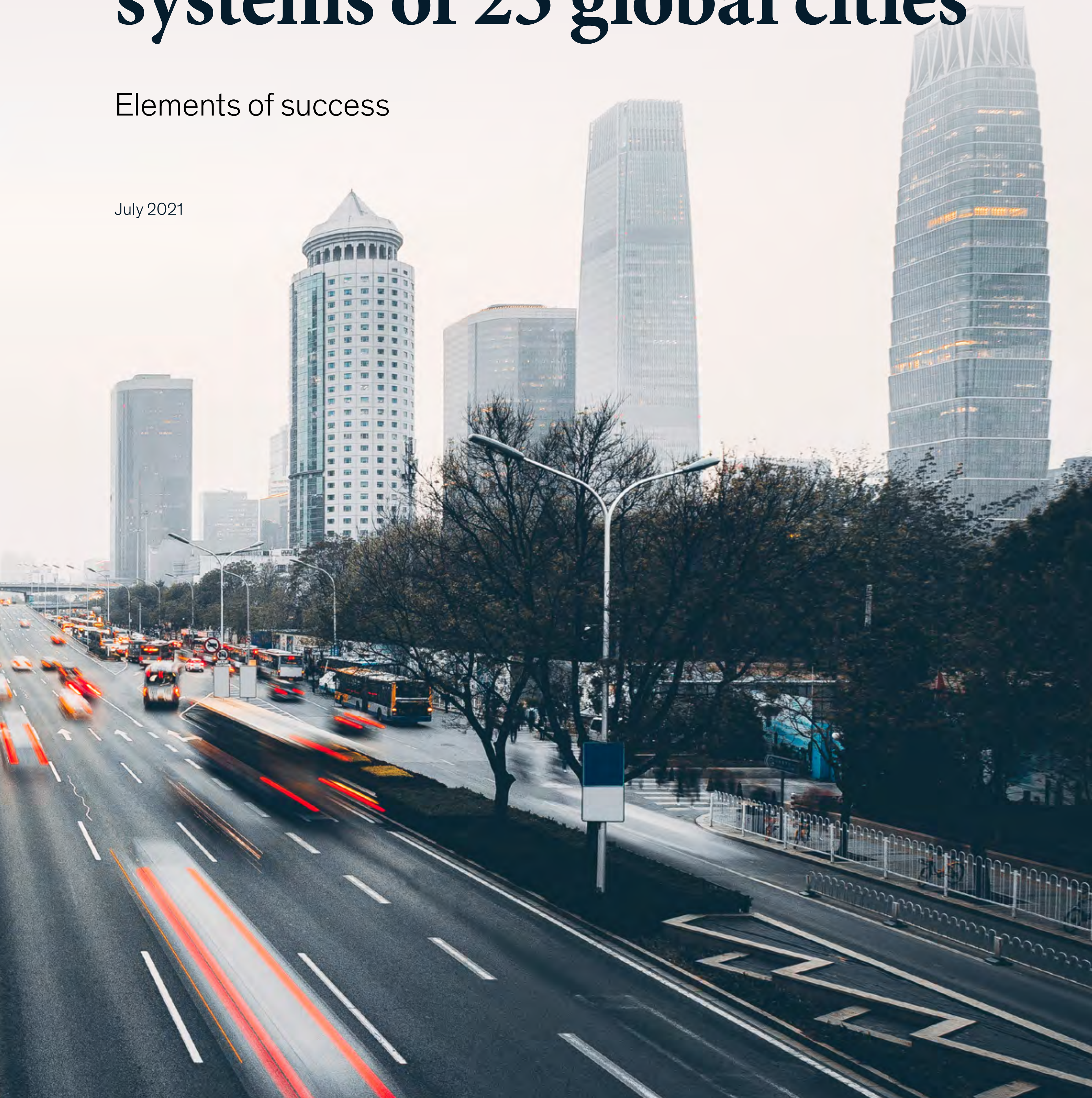
McKinsey & Company

Urban transportation systems of 25 global cities

Elements of success

July 2021



Contents

Over the three years since our previous study, city authorities across the world have implemented dozens of large-scale projects to improve the operation of their transport systems. They faced new challenges, including those related to environmental safety and development of various types of mobility. Then 2020 became a hallmark year because of the COVID-19 pandemic, which has had tremendous impact on operation of city transport systems. Accordingly, a new study has become necessary to cover the recent changes.

Like its predecessor, the new study reported here is designed to analyze, as broadly as possible, transport systems in 25 cities of the world from a user point of view and to benchmark critical aspects of their performance that have the most effect on city residents' transport needs and quality of life. It is distinguished by the special attention paid to the impact of the COVID-19 pandemic on objective transport-system metrics and residents' behavior. We offer examples of successful events and projects city authorities have implemented to deal with the pandemic.

One of the study's objectives is to review the progress achieved by city transport systems since the previous study's publication. To assure data comparability, we have left the list of examined cities unchanged. However, during the time between the two studies, the challenges faced by megapolises have changed, particularly against the backdrop of the COVID-19 pandemic. Accordingly, we have been forced to revise the list and weights of metrics under review. This has made it all but impossible to draw direct comparisons between the previous study and its current version. Nevertheless, we can compare the rate of change of metrics describing certain aspects of transport systems, such as development of road networks and improvement of fare payment systems.

The report is organized into five sections and two appendixes. Section 1 describes our research methodology, while Section 2 presents the general conclusions we have drawn upon completion of the current study. Section 3 presents transport system ratings and an assessment of changes that have occurred to them since the previous study. Section 4 provides an overview of subgroups of metrics that make up the transport system ratings, and Section 5 looks at the impact of the COVID-19 pandemic on transport systems. The first appendix contains profiles of ten cities with the most efficient transport systems, and the second offers examples of significant transport system projects implemented in various cities.

Research findings may prove interesting primarily for city mayors and heads of urban transportation agencies and companies. We hope our conclusions will be gainfully employed to make informed decisions regarding further development of city transport systems.

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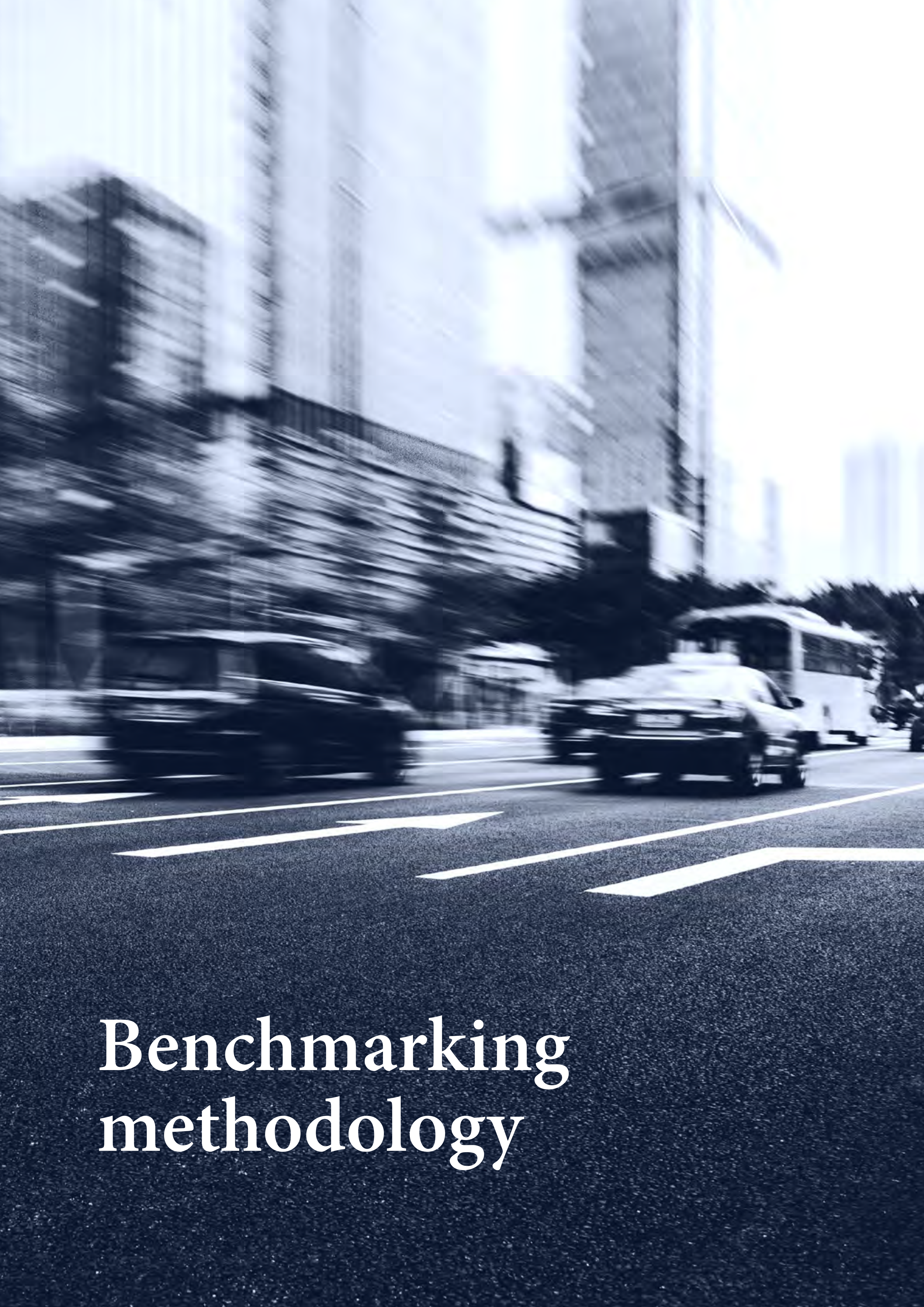


Benchmarking methodology

General description of research methodology

In our research, we sought to assess transport systems operating in some of the world's largest cities, based on a broad range of objective and comparable metrics that reflect, in their entirety, transport user experience amassed by city residents.

According to our methodology, research is generally conducted in five stages (Exhibit 1). We have identified a list of comparable cities and generated a set of analytical metrics with applicable weights. Concurrently with the processing of objective metrics, we conducted a survey among the residents of the cities being examined and compiled additional ratings for certain groups of metrics.

Selection of cities. We have consistently applied five filters, ensuring comparability of cities to be rated (by population, GRP per capita, and so on). The resultant research sample contains 25 cities.

Preparation of the list of metrics, collection of data, calculation of values. Following a thorough examination of hundreds of diverse data sources, we have identified more than 50 objective metrics, which we organized into six groups. We independently calculated more than 15 metrics, using advanced geospatial data analysis tools.

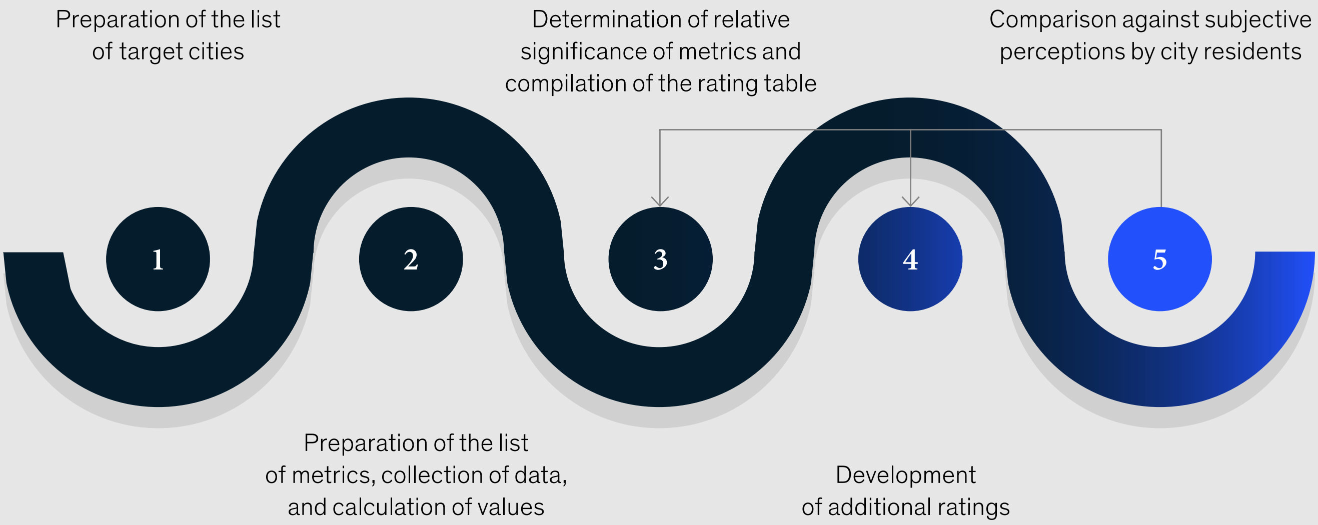
Determination of relative significance of metrics and compilation of the rating table. We interviewed more than 30 transport systems development experts and assigned weights to objective metrics and groups of metrics used in the rating. Weighted metrics were merged to produce a rating of city transport systems.

Development of additional ratings. In addition to the main rating, we made several additional ratings: by certain groups of metrics, by significance of changes affecting groups of metrics, by public- and personal-transport metrics. We used the same approach as when making the main rating, except that instead of using the full complement of objective metrics, we used only some of them, depending on the purpose of each specific rating.

Completion of a survey with the participation of about 10,000 residents of the examined cities. The respondents, city residents, were asked questions covering all relevant groups of metrics to assess perception of the current state of city transport systems and of the changes affecting those systems. The results of the survey did not have any direct impact on city positions in the rating; instead, we used them to compare the objective situation against subjective perceptions of city residents.

Exhibit 1

Research methodology



We have used the method that proved to be efficient during our 2018 study. However, it has been modified to better reflect the challenges currently faced by city transport systems across the world (Exhibit 2).

Exhibit 2

Key changes in methodology compared with the 2018 study

Methodology elements	Key changes
List of cities	Approach to city selection has remained unchanged. Shenzhen has been added to the list of examined cities.
Preparation of the list of metrics, collection of data, and calculation of values	The 5 groups of metrics (Availability, Affordability, Efficiency, Convenience, Safety and Sustainable Development) have been retained. We excluded 3 metrics due to unavailability of relevant data. More than 10 new metrics have been added to ensure a more objective assessment of city transport systems subject to contemporaneous challenges.
Determination of relative significance of metrics and compilation of the rating table	Weighting approach has not changed. Weights have been modified to reflect expert interview findings.
Development of additional ratings	Approach to compilation of additional ratings has not changed (subject to adjustments to the list of metrics and related weights).
Approach to survey completion, survey findings	The list of questions in the main part of the questionnaire has not changed. Questions have been added to the survey to reflect the impact of the COVID-19 pandemic and the level of awareness of transport projects among city residents.

Selection of target cities

Five filters were used to prepare the list of cities for examination (Exhibit 3).

Population of the city must exceed five million people, and the city must play a leading role in the national economy. GRP per capita must be more than $10,000, and the number of cars must be more than 150 per 1,000 people. The city must be mentioned in international data sources.

We applied these filters to approximately 13,800 cities across the world. The resultant list consists of 21 cities with comparable transport systems. Four more cities (Shanghai, Singapore, Berlin, and Hong Kong) were added to the list because of their perceived research relevance. Even though they had failed to clear one of the formal filters, those megapolises topped at least several international ratings reflecting the level of development of certain aspects of their transport systems.

Exhibit 3

Approach to selection of target cities

	Number of cities	Selection criteria
1	~13 800	**Size** Population of urban agglomeration is ≥5 million; city is among country's most economically significant
2	38	**Level of economic development** GRP per capita is at least $10,000
3	32	**Transport system features** Number of cars is ≥150 per 1,000 residents
4	28	**Data availability and quality** >50% of data represented in international sources[1]
5	21	**Expert assessment** Leading positions in ≥2 reviewed ratings[2] and population is >3 million
	4 additional cities	

[1] This guarantees comparability of metrics across all cities.

[2] Third-party transport system ratings include TomTom Traffic Index; The Future of Urban Mobility 2.0 (rating published by Arthur D. Little and International Union of Public Transport); Sustainable Cities Mobility Index (rating published by Arcadis); Urban Mobility Index Report (rating published by Qualcomm and consulting agency CEBR).

List of metrics reviewed

We selected five aspects of transport systems for comprehensive assessment of the level of development of city transport systems across the world. These are Availability, Affordability, Efficiency, Convenience, and Safety and Sustainable Development.

Each of those aspects encompasses objective metrics joined into logical subgroups (Exhibit 4). For example, the ticketing system is part of the Convenience group, and public-transport efficiency is part of the Efficiency group.

The main criteria governing inclusion of a metric in the research were availability of data for the examined cities, the evaluation of transport systems from a passenger's perspective, and relevance of the metric in terms of assessing one of the transport system's aspects.

We did not include certain metrics in three main cases. First, we excluded any metric that does not follow the "passenger's view" principle. For example, we do not consider the commercial efficiency of public transport for the transport operator. We also excluded data that were not available for a number of cities, so, for example, we report data on no emissions other than NO_2 and no data on the share of off-street parking. Finally, we excluded metrics that involve complex relationships between various aspects of transport systems. For example, we do not consider the integration of bus and rail transport timetables and do not estimate the optimal number of taxis taking into account the specifics of a city.

Exhibit 4

Metrics used in this analysis

Availability

Rail transport

Share of population living at a walking distance of <20 minutes from an underground station or a commuter railroad station, %

Share of workplaces located at a walking distance of <20 minutes from an underground station or a commuter railroad station, %

Road network

Share of bicycle lanes in total road network length, %

Pedestrian infrastructure cohesion index: length of pedestrian route from point a to point B compared with straight-line distance

Motorway infrastructure cohesion index (length of motorway route from point a to point B compared with straight-line distance

Road network quality index

Density of road network, km^2 per number of cars

Shared transport

Number of bicycles used in public rental systems per million people

Number of cars used in car-sharing systems per million people

External connectivity

Number of regular flight routes from city airports

Affordability

Public-transport affordability

Ratio of the cost of monthly travel card to average monthly income, %

Number of categories of reduced-fare passengers

Ratio of the cost of a 1-kilometer taxi ride to average monthly income, %

Personal-transport cost and use barriers

Ratio of the average cost of 2-hour paid on-street parking to average monthly income, %

Existence of fees imposed on car owners entering downtown area or specific city districts

Motor vehicle restrictions index (restrictions based on license plates or place of registration, prohibitive taxes or duties, mandatory availability of a reserved parking space)

Efficiency

Public-transport efficiency

Average effective public-transport travel speed during morning rush hour, kilometers per hour

Average land transport waiting time, minutes

Share of dedicated public-transport lanes in total length of road network, %

Underground-train waiting time index

Personal-transport efficiency

Average traffic flow speed during morning rush hour, kilometers per hour

Traffic congestion index: rush hour trip duration vs free-road trip duration

Morning rush hour travel time predictability index

Time lost in traffic jams: rush hour travel time vs free-road travel time, minutes

Convenience

Electronic services

Penetration rate of the most popular official transport mobile application, %

Average rating of official transport applications

Availability of Wi-Fi networks in underground cars, on buses, and at land transport stops

Availability of Wi-Fi networks or mobile internet access at underground stations

Availability of real-time public-transport traffic information on the internet

Availability of real-time public-transport traffic information on electronic screens mounted at public-transport stops

Availability of information about parking lots on the internet

Possibility to pay parking fees online

Transport operations big data analysis and personalization of communications

Possibility to pay fines online

Travel comfort

Average bus age, years

Average underground rolling stock age, years

Share of buses accessible for persons with reduced mobility, %

Share of underground stations accessible for persons with reduced mobility, %

Intermodality

Average distance from an underground station to the 3 closest public-transport stops, meters

Average time required to switch from 1 mode of public transport to another, minutes

Availability of unified public-transport navigation for passengers

Ticketing system

Availability of a universal travel card to pay fares while using multiple modes of public transport

Possibility to use remote top-up and/or remote ticketing

Possibility to use an electronic travel card available on mobile devices

Possibility to top up travel card and/or buy a ticket using a bank card

Possibility to use contactless bank cards and/or Apple Pay, Samsung Pay, or Android Pay mobile applications directly at pay gates

Possibility to use an electronic travel card to pay for nontransport services

Possibility to pay fares using biometric data

Need for registration following travel card top-up

Safety and Sustainable Development

Physical safety

Number of public-road traffic accident fatalities per million people per year

Number of underground accident fatalities per million people per year

Safety rules compliance index

Environmental safety

Availability of public-transport disinfection measures

Current diesel/petrol fuel quality standards

Average age of cars on the roads, years

Share of e-vehicles in total vehicle sales, %

Concentration of NO_2 in atmospheric air, molecules per cubic centimeter

Number of commercial vehicles registered in the city per $1 billion of city GRP (based on purchasing power parity)

Index of commercial transport-related environmental restrictions

Availability of subsidies or incentive programs related to transition to more environmentally friendly fuel, e-vehicles etc.

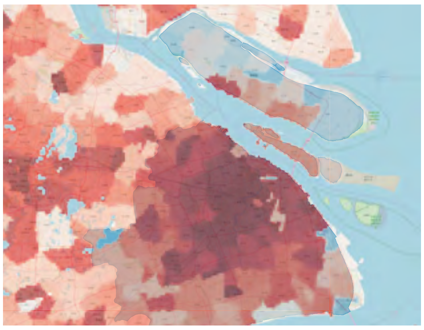
Use of geoanalytical tools

To create an objective rating of transport systems, we resorted to tools used to analyze geospatial data. With those tools, we calculated values for more than 15 metrics, because traditional open-source data collection methods are not available or are available only to a limited extent. In particular, we measured average personal motor car travel time, average taxi ride cost, average public-transport travel speed, share of population living at a walking distance of less than 20 minutes from an underground station or a commuter railroad station, road network area, and so on.

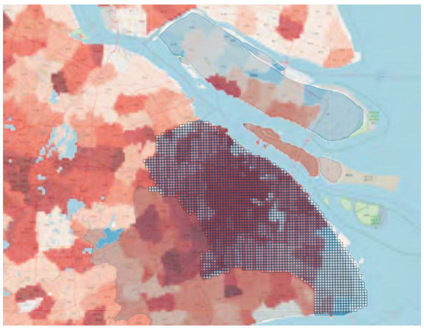
To enable calculation of those metrics, it was necessary to ensure that the areas of cities under analysis are comparable. To do that, in some cities we relied on areas specifically selected for research purposes, rather than on official city boundaries. We had to make certain adjustments: some urban agglomerations (for example, Paris) occupy areas that are in fact larger than those delimited by their official boundaries, while others (including Madrid) have official territories that greatly exceed the area of their densely populated parts. Had we failed to account for such deviations, they could have distorted our analytical findings.

Algorithm for determining city boundaries

Determination of official city boundaries. We reviewed diverse approaches applied to administrative division of each city covered by our research. For example, in Shanghai, there are various ways to measure the city's area, ranging from seven central districts (290 km^2) only partially covering the area with the highest density of population to Shanghai city area (6,341 km^2).



Calculation of population density. We divided the territory of the city into squares, each with an area of 1 km^2. For each such square, we determined relative population density and workplace concentration, based on NASA data and municipal statistics.

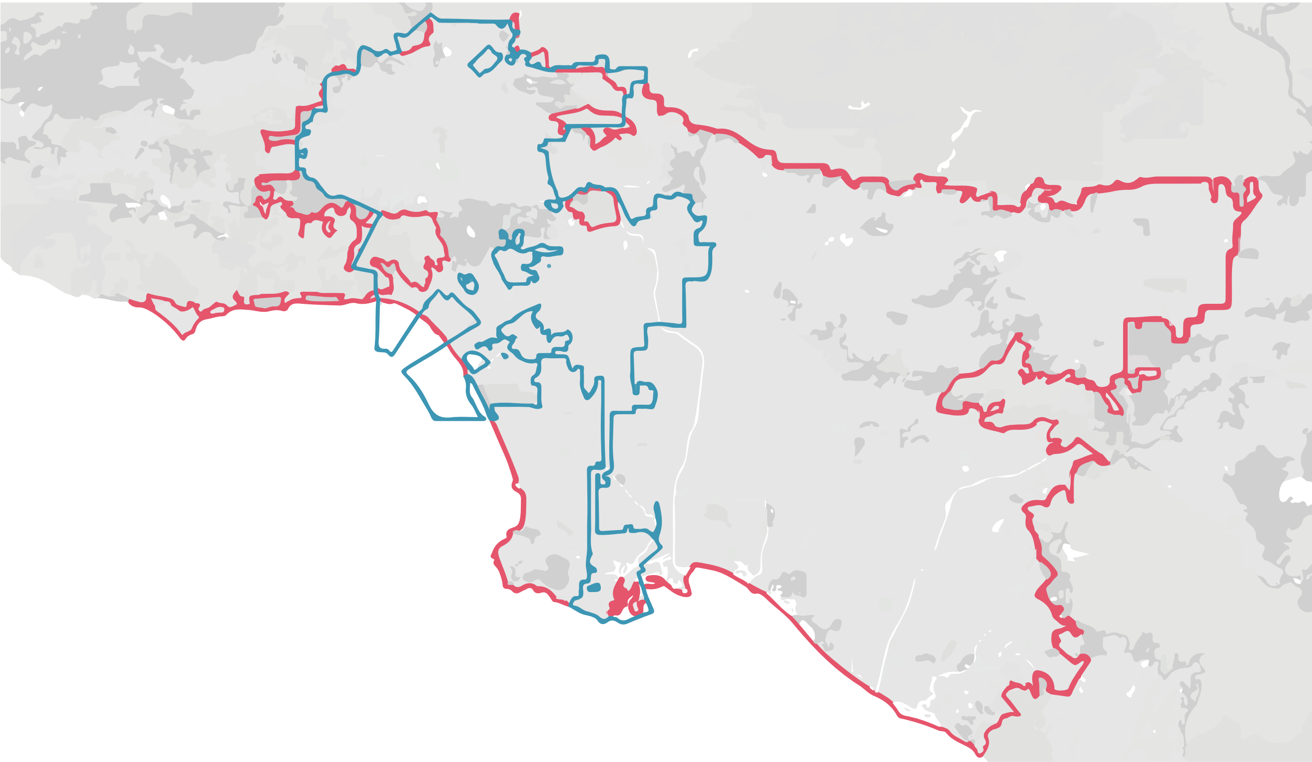


Adjustment of city boundaries for research purposes. As a result, sparsely populated areas were excluded from official city boundaries to enable comparability of all examined cities.

Therefore, we adjusted boundaries of 14 cities covered by our research:

— The boundaries of Bangkok, Hong Kong, Istanbul, Madrid, Mexico City, Moscow, Saint Petersburg, São Paulo, Shanghai, Sydney, and Tokyo were narrowed to exclude sparsely populated areas.

— The boundaries of Los Angeles, Milan, and Paris were expanded to cover not only the cities proper, but also the nearest densely populated suburbs.[1]



Having determined city boundaries, we applied geospatial analysis tools to calculate the following metrics:

— personal- and public-transport travel speed

— road network area

— share of population living and workplaces situated at a walking distance less than 20 minutes from an underground station or a commuter railroad station

These tools were also used, in part, to calculate taxi waiting times and ride costs, and to assess the quality of road infrastructure. Geoanalytical tools were applied to those metrics at the initial calculation stage. They were used to identify taxi route points (with a subsequent assessment of ride costs based on data provided by the most popular taxi-booking mobile applications) and coordinates of road infrastructure facilities. In the latter case, calculations were supplemented with expert conclusions drawn in accordance with a well-established methodology on the basis of street photographs available from cartographic services.

In one of the sections below, we will provide a detailed description of our geoanalytical methods and sample calculations of the above metrics.

[1] Here and throughout this report, references to Los Angeles mean the Los Angeles–Long Beach–Santa Ana Metro Area, references to Milan mean the Province of Milan, and references to Paris are to be construed as applying to the Métropole du Grand Paris.

Calculation of travel speed: Personal and public transport

Information on personal- and public-transport travel speed can be used to assess the overall efficiency of the city transport system. We calculated those metrics using geospatial analysis tools and data provided by cartographic services. The following paragraphs offer a simplified description of the calculation algorithm.

Calculation algorithm

Determination of each route's start and finish points. In each examined city, we identified coordinates of start and finish points for a total of 1,000 unique routes. The coordinates were derived from geospatial data on distribution of population and workplaces, while the routes reflected the paths most likely to be used by city residents to move from home to work.

Modeling of the main personal- and public-transport flows and calculation of metrics. Based on the routes identified, we charted a "heat map" featuring personal- and public-transport movement, using tools offered by cartographic services. We estimated the duration of each route, and the average travel speed during the morning rush hour. Then we weighted each route by the likelihood of it being used, obtaining average weighted travel time and speed values.

Similar methods were used to calculate certain other metrics:

- pedestrian infrastructure cohesion index (length of pedestrian route from point a to point B compared with straight-line distance)
- road infrastructure cohesion index (length of motorway route from point a to point B compared with straight-line distance)
- traffic congestion index (rush hour trip duration vs. free-road trip duration)
- morning rush hour travel time predictability index, based on measuring travel time for the same routes each day for two weeks and then calculating the mean square deviation from average ride duration

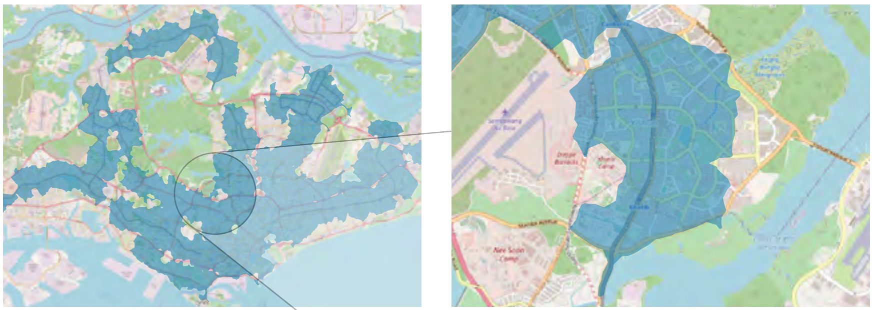
Calculation of the share of residents and workplaces near an underground station or commuter railroad station

The shares of a city's population living and workplaces situated at a walking distance of less than 20 minutes from an underground station or a commuter railroad station can be used to compare the examined cities in terms of availability of transport infrastructure. We believe that the more city residents have ready access to rail transport, the higher is the level of development of the transport system.

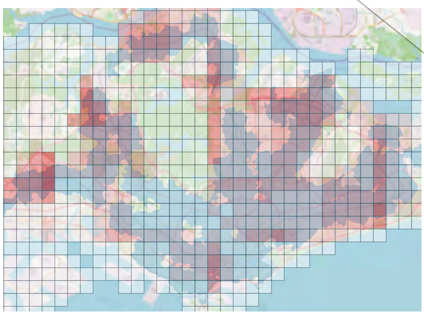
Calculation algorithm

In this study, the metric is calculated taking into consideration accessibility areas or isochrones (maximum distance that can be traveled on foot from a certain point over a given period of time). Previously, we used a simpler method: we measured fixed radii around stations. The method used in this study is described in more detail below.

Identification of underground stations and commuter railroad stations. In each city, we identified coordinates of underground stations and commuter railroad stations. To do that, we used information from popular cartographic services.



Calculation of accessibility areas (isochrones). For each coordinate, we identified a set of adjacent points that could be reached on foot within 20 minutes if traveling at a walking speed of 5 kilometers per hour.



Calculation of the share of population and workplaces covered by isochrones. To assess the share of population and workplaces within calculated areas, the population distribution grid (according to NASA data) and the workplace distribution map were superimposed on the resultant isochrones. The grid consists of squares with sides of one kilometer, and a certain population/workplace density value is set for each such square (assuming that density is the same within the boundaries of the square).

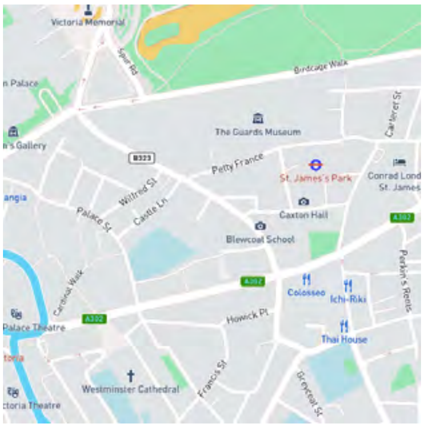
Calculation of road network area

Road network area can be used to compare cities in terms of sufficiency of existing motorways.

Unlike the less sophisticated metric of total road length, road area factors in the number of lanes, which has direct impact on road capacity and may have considerable influence on the ranking of the city. Note that instead of the ordinary road area metric, we use, for rating purposes, road area per motor vehicle registered in the relevant city.

This metric provides a more accurate picture of the state of affairs in the examined cities than the alternative (share of city area occupied with roads), as it precludes situations where cities with large forests and parks unfairly get worse rankings.

Calculation algorithm

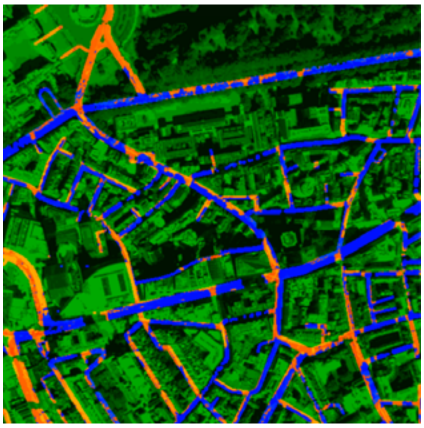


1

Create a set of city pictures. For each city, we downloaded a set of several thousand pictures ("plates"), each covering one square kilometer. Each picture was represented in two versions: a satellite image and a map provided by a cartographic service.

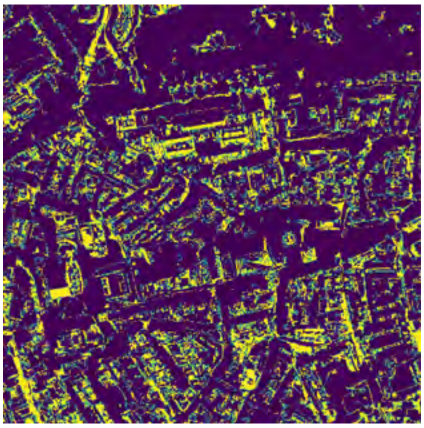
2

Make a motorway mask. Binarization of the map "plate" using a number of threshold values yielded a motorway mask sketch. Then we enhanced the mask to remove artifacts produced by inscriptions and to make sure that the final mask would cover the road on the satellite image.



3

Conduct Otsu binarization. For the part of the satellite image covered by the mask, we launched the Otsu binarization algorithm, which separated homogeneous pixels under the mask (asphalt) from other objects, such as asphalt hidden by shadows and trees.



4

Make an asphalt mask. Using the homogeneous area obtained at the previous stage, we identified the color range for asphalt pixels in the satellite image (assuming that asphalt color is relatively monotonous across the entire image). Then we selected, in all satellite images, areas falling within that color range, thus producing an asphalt mask for asphalt areas visible from the satellite (showing also similarly colored areas such as rooftops)

5

Make final road map. We superimposed the mask covering asphalt visible from the satellite on the mask from the previous stage (areas looking like asphalt and visible from the satellite) and supplemented the resultant image with the mask created at the Otsu binarization stage. The latter added to the image those sections of the roads that are not visible from the satellite. As a result, we account for the area of the roads, which would be impossible to get by using just standard cartographic data.

Survey of city residents

A survey was conducted among city residents. One of the key objectives of the survey was to compare results of the assessment of transport systems based on objective metrics with subjective opinions voiced by city residents.

We did not use survey responses as inputs for assessment of any metrics capable of affecting the final rating, but instead compared objective metrics describing transport systems with the feedback provided by city residents. Besides that, we used survey results to draw a list of most notable transport projects, analyze the link between the number of implemented projects and the level of satisfaction of city residents with changes in transport systems, and measure the impact of the COVID-19 pandemic on current and projected mobility of city residents.

About 10,000 respondents (400 from each city) took part in the survey. The survey was conducted online in local languages, and the average time required to complete the questionnaire was 15 to 20 minutes. To mitigate the risk of getting biased responses, we set quotas with respect to respondent gender, age, income level, home district, and (to eliminate sample bias in favor of, say, car owners) preferred type of transport.

Exhibit 5
Structure of city resident survey

Screening	10 questions
Assessment of specific aspects of transport systems and changes in such systems	30 questions
Awareness of transport projects implemented by city authorities	27 questions
Impact of the COVID-10 pandemic on behavior of city residents	12 questions

Weighting and final rating

Before making the final ratings, we normalized the value of each metric to 100 percent scale by assigning relative weights to metrics and groups of metrics (Exhibit 6).

Weights were assigned on the basis of results of a survey with the participation of more than 30 experts on transport systems from Europe, the Americas, and Asia.

First, the experts were asked to allocate ten points among subgroups of metrics within each group. For example, in the Affordability group, they were asked to allocate points between private-transport affordability and public-transport affordability. Then the experts assessed the relative importance of metrics in each subgroup. Based on their responses, we assigned a relative weight to each metric comprising the rating.

Upon completion of that stage, we obtained ratings of individual aspects of transport systems.

Exhibit 6
Final-rating approach

Normalize metric values to 100% scale

Determine weights for subgroups of metrics and individual metrics based on expert survey results

Compile city ratings for each of the 5 transport system aspects

Comparison with 2018 results: Approach and metrics

The present study is somewhat different from its previous version; accordingly, it would be incorrect to draw direct comparisons between the updated rating and the 2018 rating. This can be attributed to the operation of certain factors, such as expansion of the list of metrics under examination, impact of the COVID-19 pandemic on certain metrics, the fact that in some cases information had to be obtained from new sources because previously used sources could no longer produce relevant up-to-date data, and adjustment of weights based on new expert inputs.

However, some metrics have not been affected by these changes, and direct comparisons for such metrics are still possible. We have compiled a rating of such metrics based on the findings of the studies conducted in both 2021 and 2018. Then we calculated changes in city index values in the new rating versus the previous rating and normalized those changes to 100 percent scale, so that the city with the largest changes was rated at 100 percent, and the city with the smallest changes was rated at 0 percent. This produced a rating of changes in each aspect of transport system operations.

Presence of a city in the section of the main 2021 rating dealing with the relevant transport system operation aspect served as another filter.

We have included in this report only the cities that have effected the biggest changes and, concurrently, are in the top ten of the 2021 rating for the relevant aspect. We sought to highlight significant changes in the most successful cities, which can act as role models for the other cities covered by the study.

The metrics that we used to compile comparable ratings are listed in Exhibit 7.

Exhibit 7

Metrics comparable with metrics from the 2018 study

Group of metrics	Compared metrics	Metrics excluded from comparison
Availability		
Rail transport	Share of population living <1 kilometer from an underground station or a commuter railroad station	Share of population living <20 minutes from an underground station or a commuter railroad station
	Share of workplaces located <1 kilometer from an underground station or a commuter railroad station	Share of workplaces located <20 minutes from an underground station or a commuter railroad station
Road network	Pedestrian infrastructure cohesion index	Density of road network, kilometers squared per number of cars
	Road network quality index	Share of bicycle lanes in total road network length
		Motorway infrastructure cohesion index: length of motorway route from point a to point B compared with straight-line distance

Shared transport	Number of bicycles used in public rental systems per million people Number of cars used in car-sharing systems per million people	—
External connectivity	Number of regular flight routes from city airports	—

Affordability

Public-transport affordability	Number of categories of reduced-fare passengers Ratio of the cost of monthly travel card to average monthly income Ratio of the cost of a 1-kilometer taxi ride to average monthly income	—
Cost and barriers to using personal transport	Ratio of the average cost of 2-hour paid on-street parking to average monthly income, % Existence of fees imposed on car owners entering downtown area or specific city districts Motor vehicle restrictions index: restrictions based on license plates or place of registration, prohibitive taxes or duties, mandatory availability of a reserved parking space	—

Efficiency

Public-transport efficiency	Average effective public-transport travel speed during morning rush hour, kilometers per hour Share of dedicated public-transport lanes in total length of road network, %	Average land transport waiting time, minutes Underground train waiting time index
Personal-transport efficiency	Average traffic flow speed during morning rush hour, kilometers per hour Traffic congestion index: rush hour trip duration vs free-road trip duration Morning rush hour travel time predictability index Time lost in traffic jams (rush hour travel time vs free-road travel time), minutes	—

Convenience

Electronic services	Availability of Wi-Fi networks in underground cars and at underground stations, on buses, and at land transport stops Availability of real-time public-transport traffic information on the internet Availability of real-time public transport traffic information on electronic screens mounted at public-transport stops Availability of information on parking lots on the internet Possibility to pay parking fees online	Penetration rate of the most popular official transport mobile application, % Average rating of official transport applications Transport operations big data analysis and personalization of communications Availability of Wi-Fi networks or mobile internet access at underground stations
Travel comfort	Average bus age, years Average underground rolling stock age, years Share of buses accessible for persons with reduced mobility, % Share of underground stations accessible for persons with reduced mobility, %	—
Intermodality	Average distance from an underground station to the 3 closest public-transport stops, meters Average time required to switch from 1 mode of public transport to another, minutes Availability of a unified public-transport navigation for passengers	—
Ticketing system	Availability of a universal travel card to pay fares while using multiple modes of public transport Possibility to use remote top-up and/or remote ticketing Possibility to top up travel card and/or buy a ticket using a bank card Possibility to use contactless bank cards and/or Apple Pay, Samsung Pay, or Android Pay mobile applications directly at pay gates Possibility to use an electronic travel card to pay for nontransport services	Possibility to use an electronic travel card available on mobile devices Possibility to pay the fare using biometric data Need for registration following travel card top-up

Safety and Sustainable Development

Physical safety

Number of public-road traffic accident fatalities per million people per year

Safety rules compliance index

Number of underground accident fatalities per million people per year

Availability of public-transport disinfection measures

Environmental safety

Current diesel/petrol fuel quality standards

Share of e-vehicles in total vehicle sales, %

Concentration of NO_2 in atmospheric air, molecules per cubic centimeter

Average age of cars on the roads, years

Number of commercial vehicles registered in the city per $1 billion of city GRP (based on purchasing power parity)

Index of commercial transport-related environmental restrictions

Availability of subsidies or incentive programs related to transition to more environmentally friendly fuel, e-vehicles, etc

General insights and observations

Success factors for cities with sophisticated transport systems

To understand what makes the leading cities stand out from the rest and what has driven them to success, we compared their scores in all transport system operation aspects with those posted by cities in the middle (positions 11 to 18) and at the end (last seven positions) of the rating table.

Exhibit 8 shows the objective and subjective (survey) ratings of cities on the 14 measured aspects of transportation systems. Where the categories are furthest apart, middle and low performers have the most need to improve. To advance to a qualitatively new level, cities at the bottom of the rating table need to improve in the areas of availability of their transport infrastructure and intermodality, as well as expand electronic services, which have already become part and parcel of living in most of the examined cities (see the highlighted chart areas marked "A"). We believe improvement of those aspects to be a top-priority task for any city in need of a better transport system.

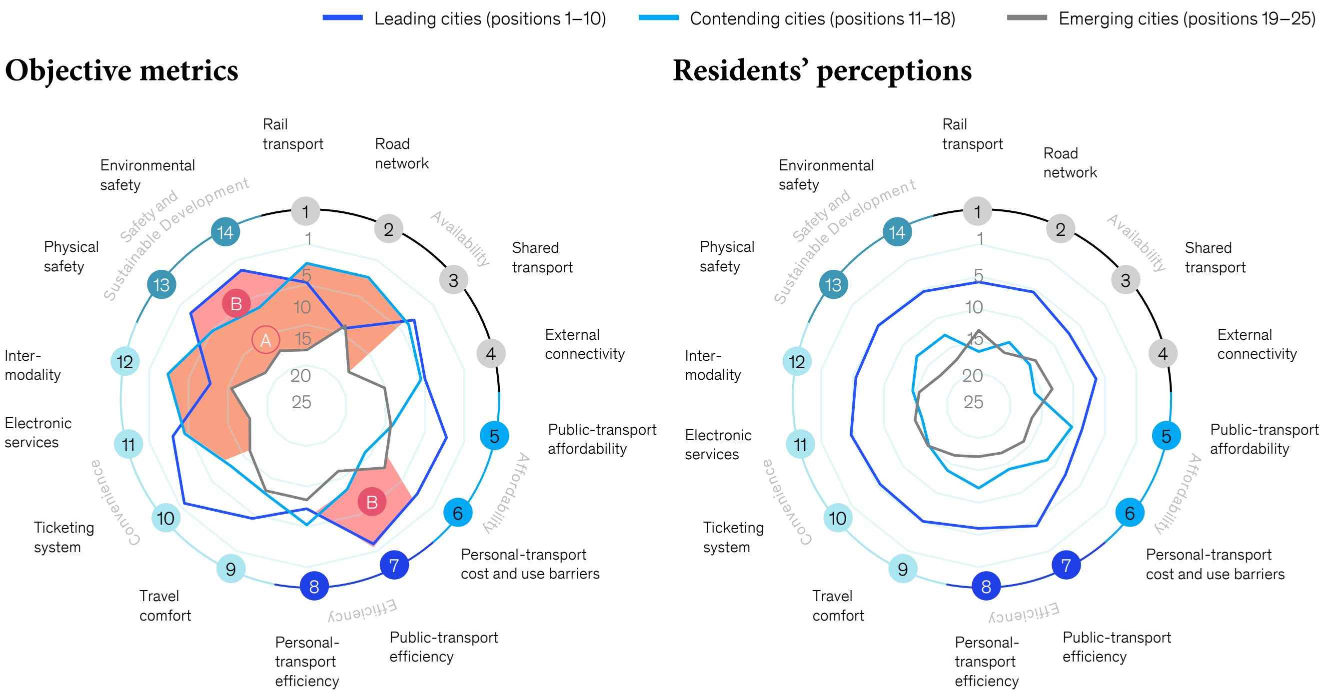
Cities desiring to rise from the middle to the top of the rating table need to painstakingly improve their ratings in Efficiency and in Safety and Sustainable Development. Superiority in these aspects differentiates the leading cities from all others (chart areas marked "B").

In the eyes of city residents, the differences between transport systems forming the middle of the rating table and those bringing up the rear are less pronounced than their common dissimilarity with transport systems operating in the leading cities. To assure that its residents have a high level of satisfaction, a city must have a truly outstanding transport system; otherwise, the difference will be hardly visible.

Exhibit 8

Transportation system ratings by city's overall level of development

Rating positions for individual aspects



Development of transport systems over the last several years

Over the last several years, all examined cities have improved their transport systems in all key aspects. This has had positive impact on popular perception of those systems.

Efficiency metrics have demonstrated the most impressive growth, in part a result of the impact of the COVID-19 pandemic. Our study shows that some of the changes may persist during the post-pandemic period. Availability metrics have sustained the least change, as this aspect requires the most significant capital investments and lengthy implementation.

Cities at the bottom of the rating table have been developing relatively faster, gradually catching up with the leaders. This is partially attributable to the low base effect: underperformers retain the possibility to carry out reforms that do not require massive financial outlay or time expenditure. Emerging cities have posted the largest improvement in metrics related to efficiency and ease of use of transport systems.

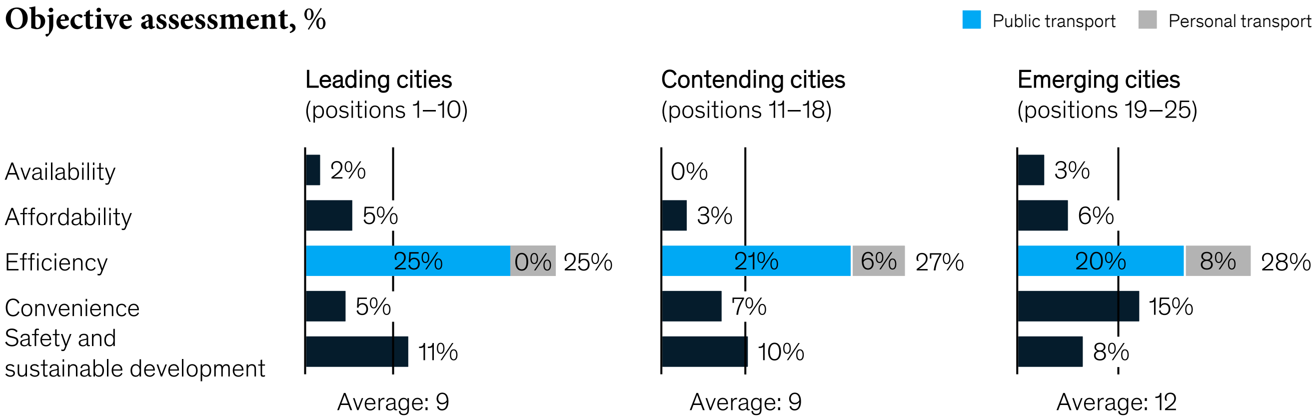
City residents have noticed those changes. In the cities at the bottom of the rating table, the level of satisfaction with transport systems has increased more than in the other cities (0.86 points, versus 0.53 to 0.81 points).

Exhibit 9

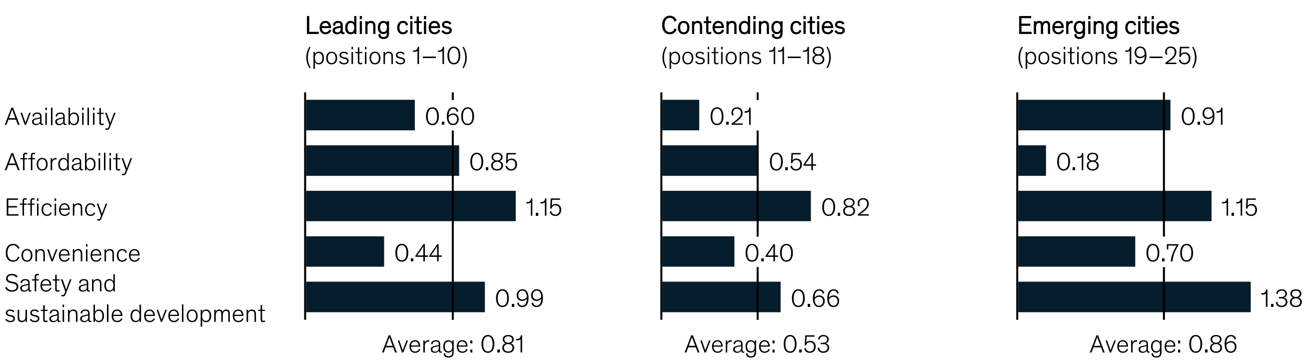
Changes in cities depending on their overall level of development

Changes by groups of metrics

Objective assessment, %



City residents' level of satisfaction with the current situation,[1] scale of –10 to +10



[1] Change in current level of satisfaction of city residents, based on survey results.

Projects implemented by cities in various areas

Since the publication of the previous version of this report in 2018, the examined cities have implemented hundreds of projects designed to enhance their transport systems. Those projects cover various areas, including public-transport infrastructure development, digitization of transport system processes, and expansion of pedestrian and cycling infrastructure.

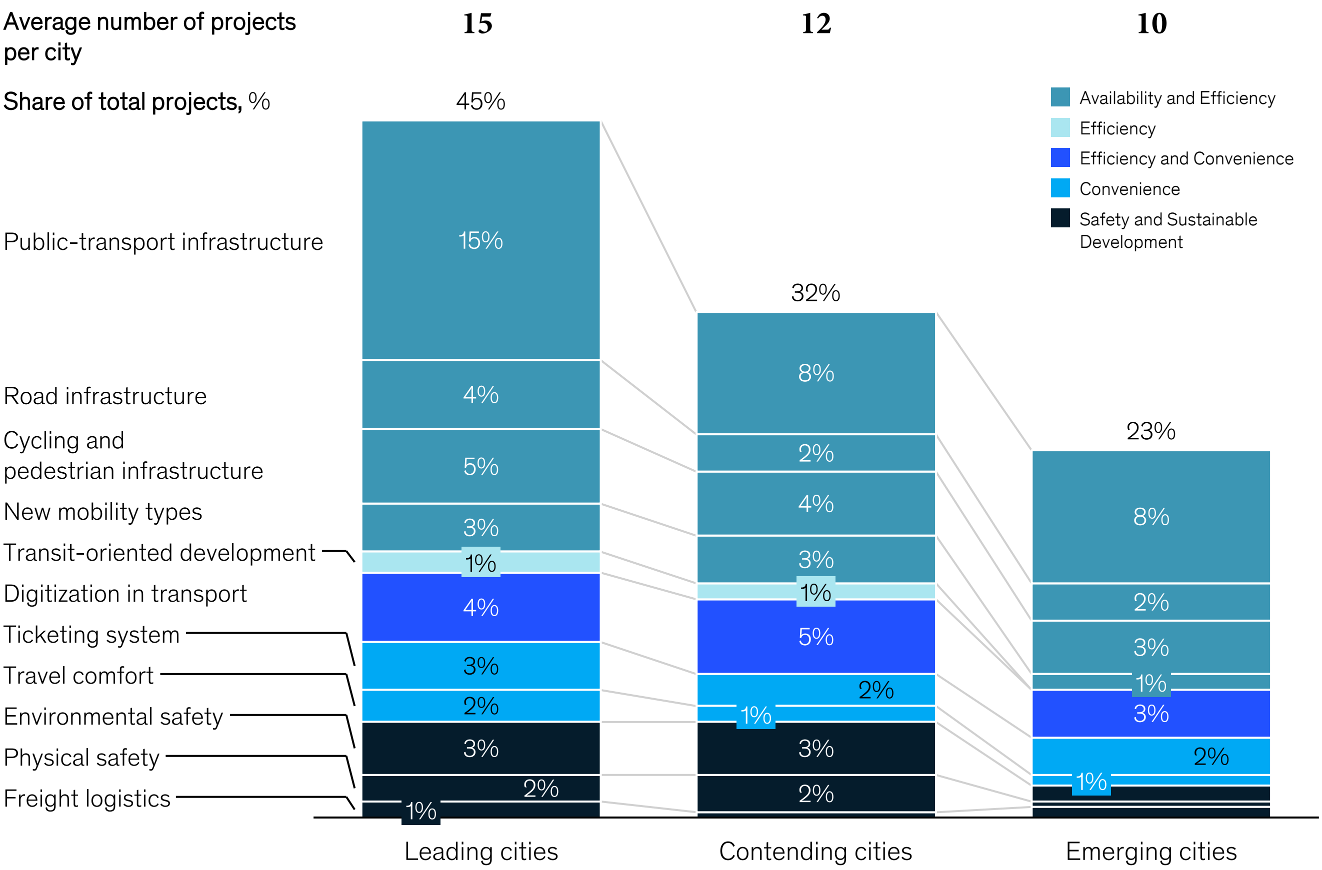
On average, top ten cities implemented more projects than the other cities covered by the study. We believe that this activity is largely responsible for their leader status.

The nature of projects and the tasks they pursued differ subject to the position in the rating table (Exhibit 10). Thus, leading cities implemented more transport infrastructure development projects: their share reaches 24 percent of all projects, versus 13 percent for emerging cities, possibly due to budget constraints or the complexity of such projects. In addition, cities at the bottom of the ratings rarely implemented projects related to safety and sustainable development, which may explain their weaker performance in this area.

The impact from implementation of such projects is not always comparable in terms of significance. Infrastructure projects designed to boost transport accessibility are usually rather local and, accordingly, have moderate impact on the overall Availability metric. In contrast, digitization projects may affect the entire transport system, producing a more significant observable impact on Convenience metrics.

Exhibit 10

Types of projects implemented in cities, by city categories



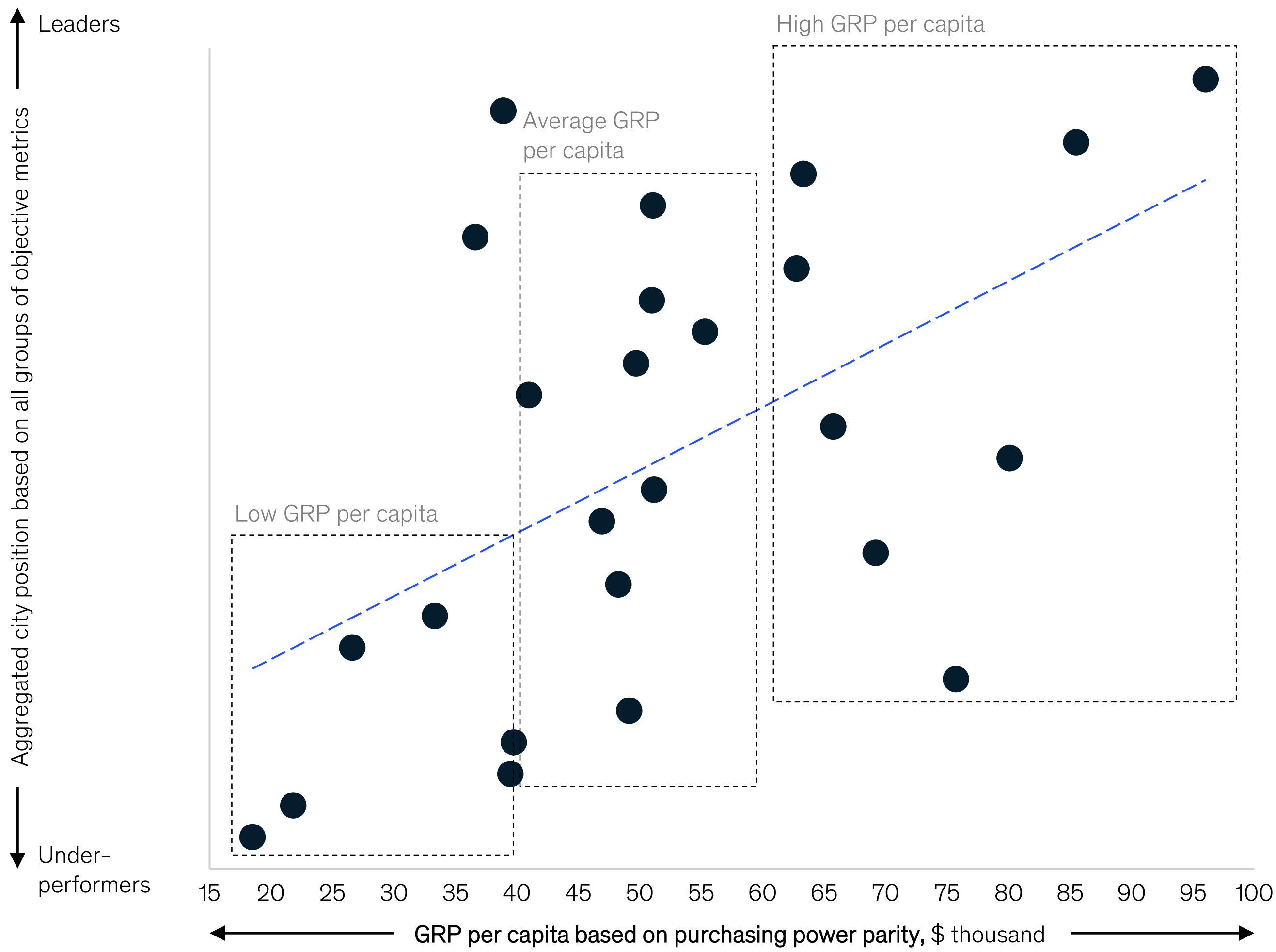
Correlation between transport system sophistication and city wealth status

We compared general scores assigned to cities in all groups we studied and the cities' GRP per capita based on purchasing power parity. As in the previous study, we discovered that, with rare exceptions, there is a positive correlation between a city's wealth status and the level of its transport system sophistication. Wealthier cities have more resources to improve their transport systems and, on average, occupy higher positions in score sheets for various groups of metrics.

Exhibit 11 features the cluster of developing cities whose transport systems are still lagging behind those of cities at the top of the rating table. Another notable cluster includes high-GRP cities which are actively investing in development of their transport systems, gradually strengthening their leadership. Between them, there lies a cluster comprising average-GRP cities (USD 40,000-60,000 thousand per capita) where transportation sophistication levels vary greatly, with the gap between highest- and lowest-rated cities being as wide as 20 positions. This means that, while having comparable financial resources, those cities take completely different approaches to their transport systems.

Exhibit 11

Correlation between objective results and city wealth status



Sustainable development index

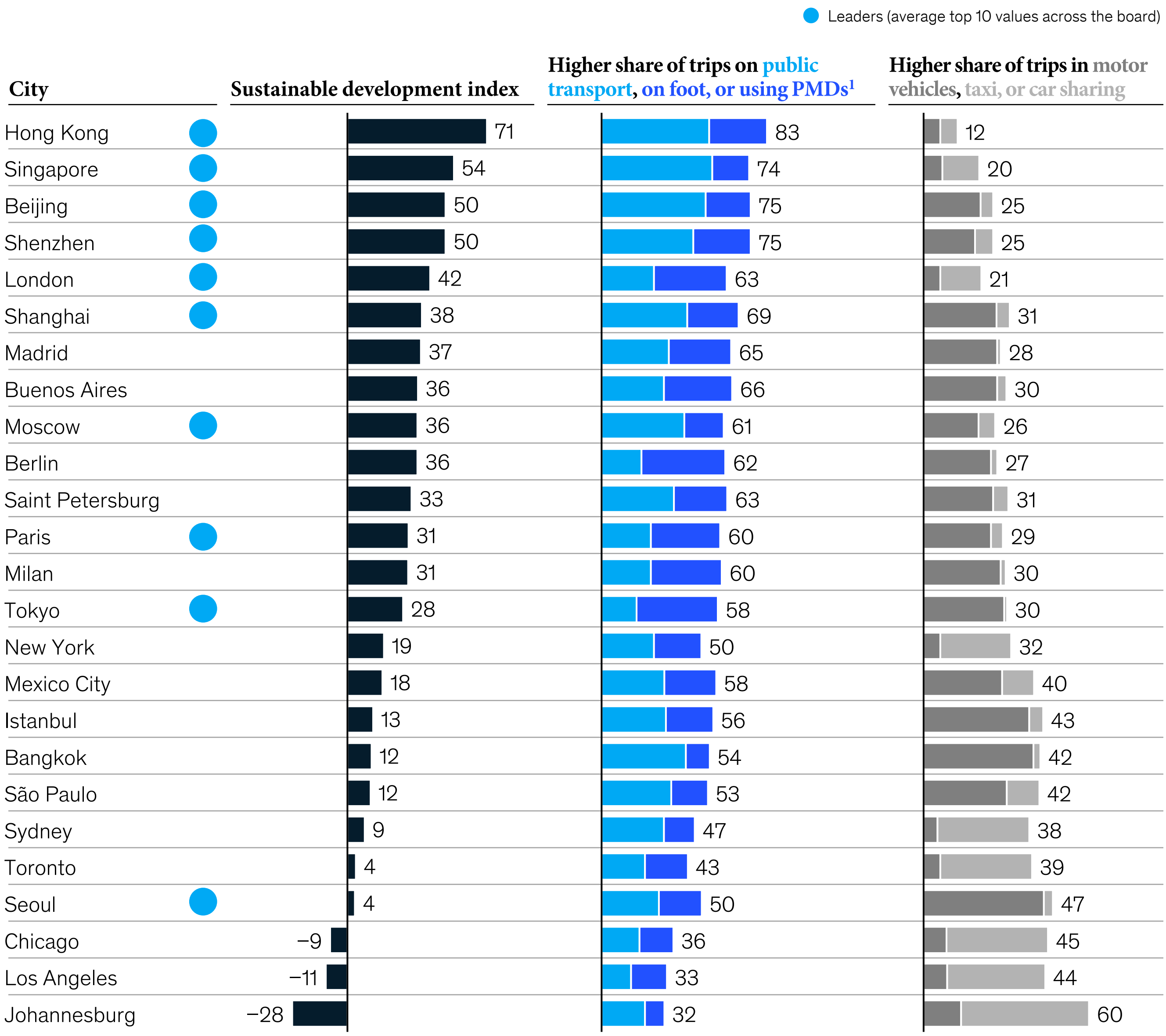
We calculated sustainable development index values based on resident survey data. The index is measured as the difference between the share of respondents who have, over the last several years, increased the use of public transport and personal mobility devices (including walking on foot) and the share of those who have increased the use of motor vehicles.

In most cities, transport systems are progressing toward sustainable development. On average, their residents indicate that over the last several years, they have been using public transport and personal mobility devices more frequently, thereby reducing the load on the road network.

There is a clear correlation between sustainable development indexes of certain cities and the level of sophistication of their transport systems, including public transport and personal mobility infrastructure (Exhibit 12). In those cities, residents may be prompted to switch over to public transport because it is more convenient than using personal transport.

Exhibit 12

Sustainable development index and its components



[1] Personal mobility devices.

Correlation between objective results for city and public perceptions of city

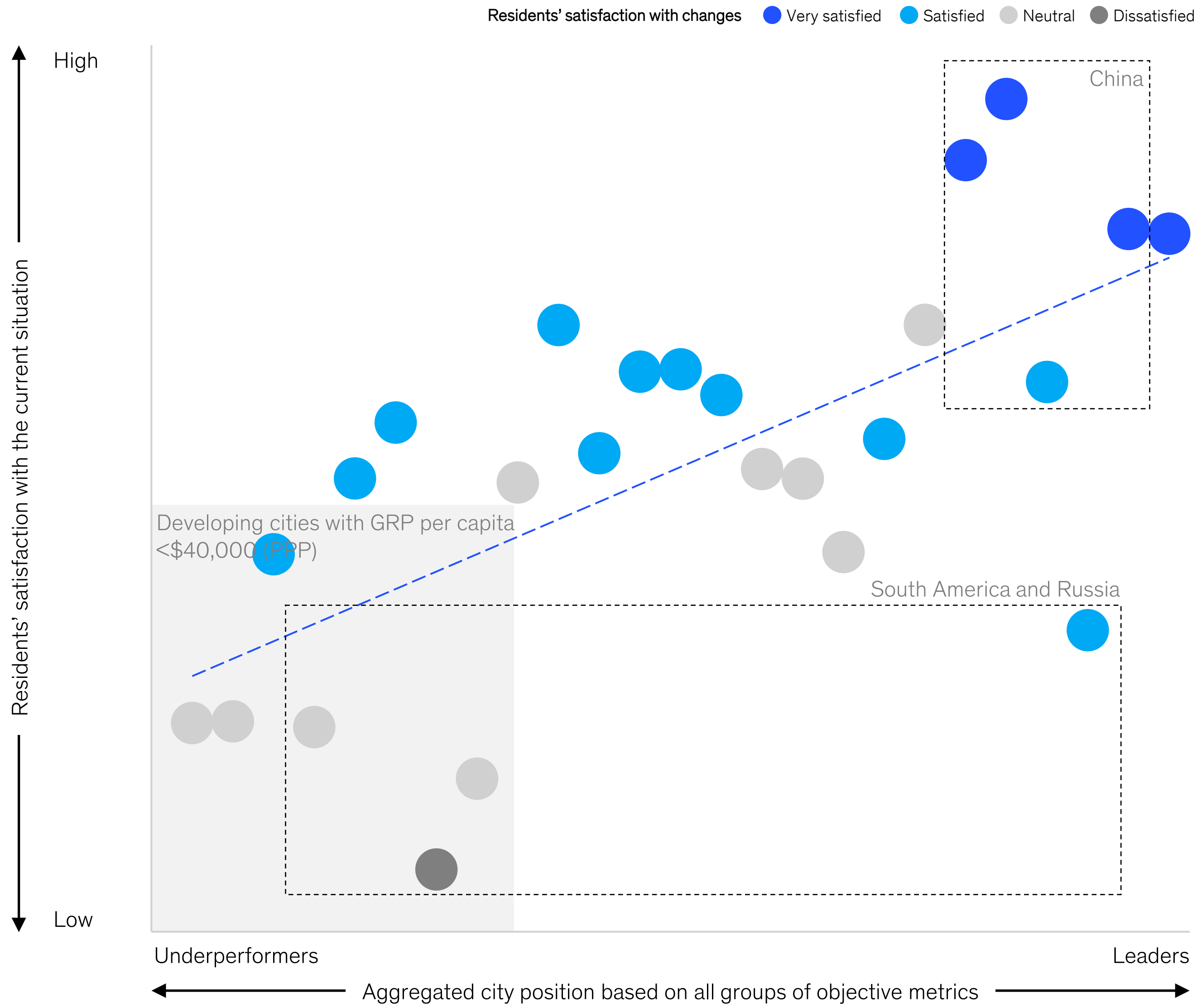
On average, public opinion in the examined cities reflects actual achievements of their transport systems: the higher the city's average rating, the higher residents' level of satisfaction with the current situation (Exhibit 13).

In some cities, though, public perceptions strongly diverge from objective metrics. In certain cities in Asia, residents' level of satisfaction with transport systems is higher than might be expected based on objective metrics. Conversely, in certain cities in Latin America, residents are dissatisfied with objectively sound transport systems.

In addition, we have analyzed residents' level of satisfaction with changes that have occurred over the last several years. Cities with the highest levels of satisfaction with the current situation have also expressed the most satisfaction with changes.

Exhibit 13

Correlation between public perceptions and the objective situation



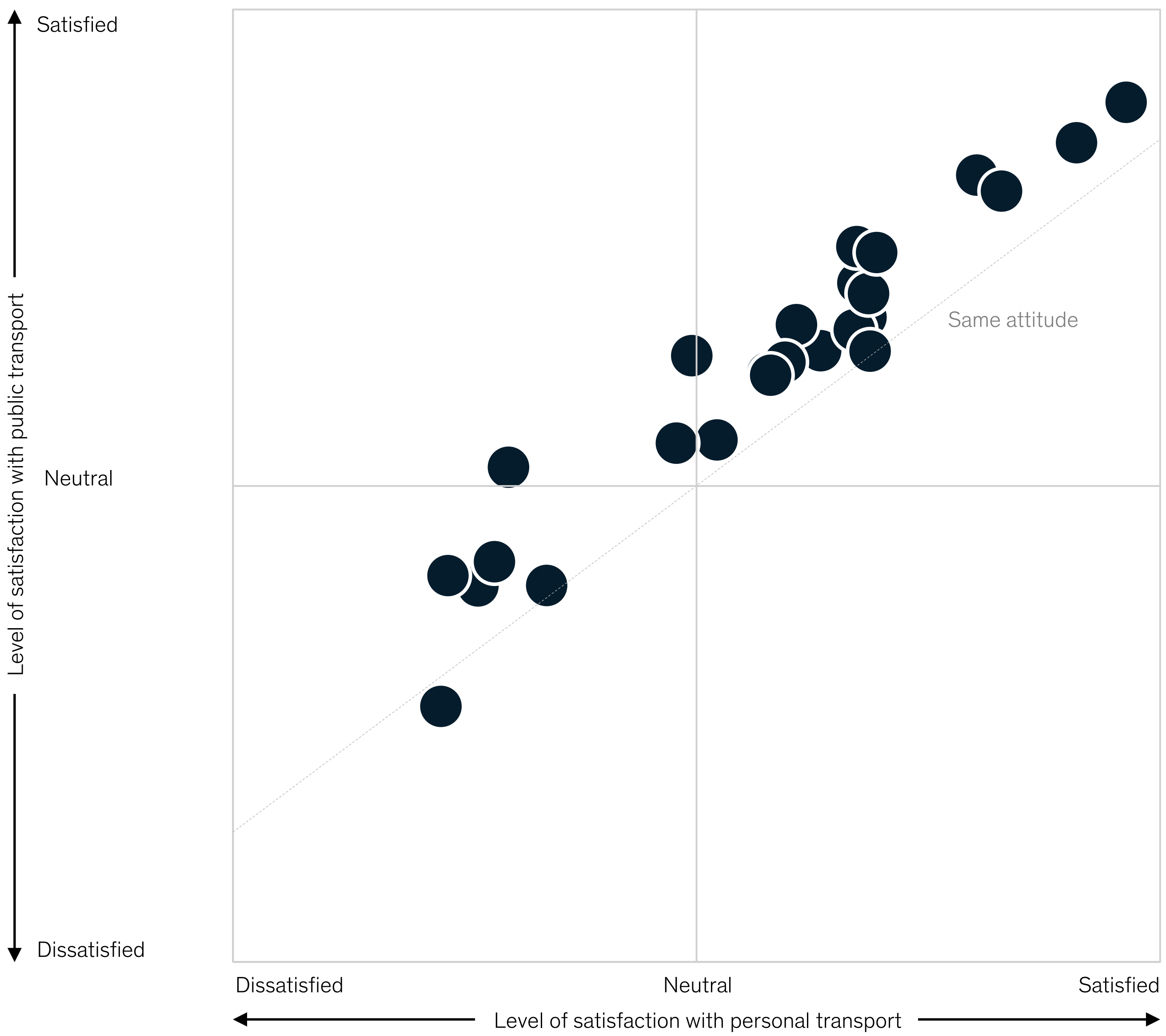
City residents' satisfaction with public and personal transport

We looked at how residents' level of satisfaction relates to metrics describing various modes of transport, including public transport and personal transport. Generally, there is a strong correlation between the scores assigned to public transport and personal transport (Exhibit 14). With several notable exceptions, if residents are satisfied with the state of public transport in the city, they are satisfied with the state of personal transport, and vice versa.

Three cities fall out of this pattern: Istanbul, Moscow, and Bangkok. In those cities, the residents are satisfied with public transport but rather dissatisfied with the state of personal transport. Those perceptions are not always fully consistent with the objective situation in the relevant cities. Istanbul ranks higher in terms of personal-transport use than in terms of public-transport use.

Exhibit 14

Public and personal transport: Public perceptions



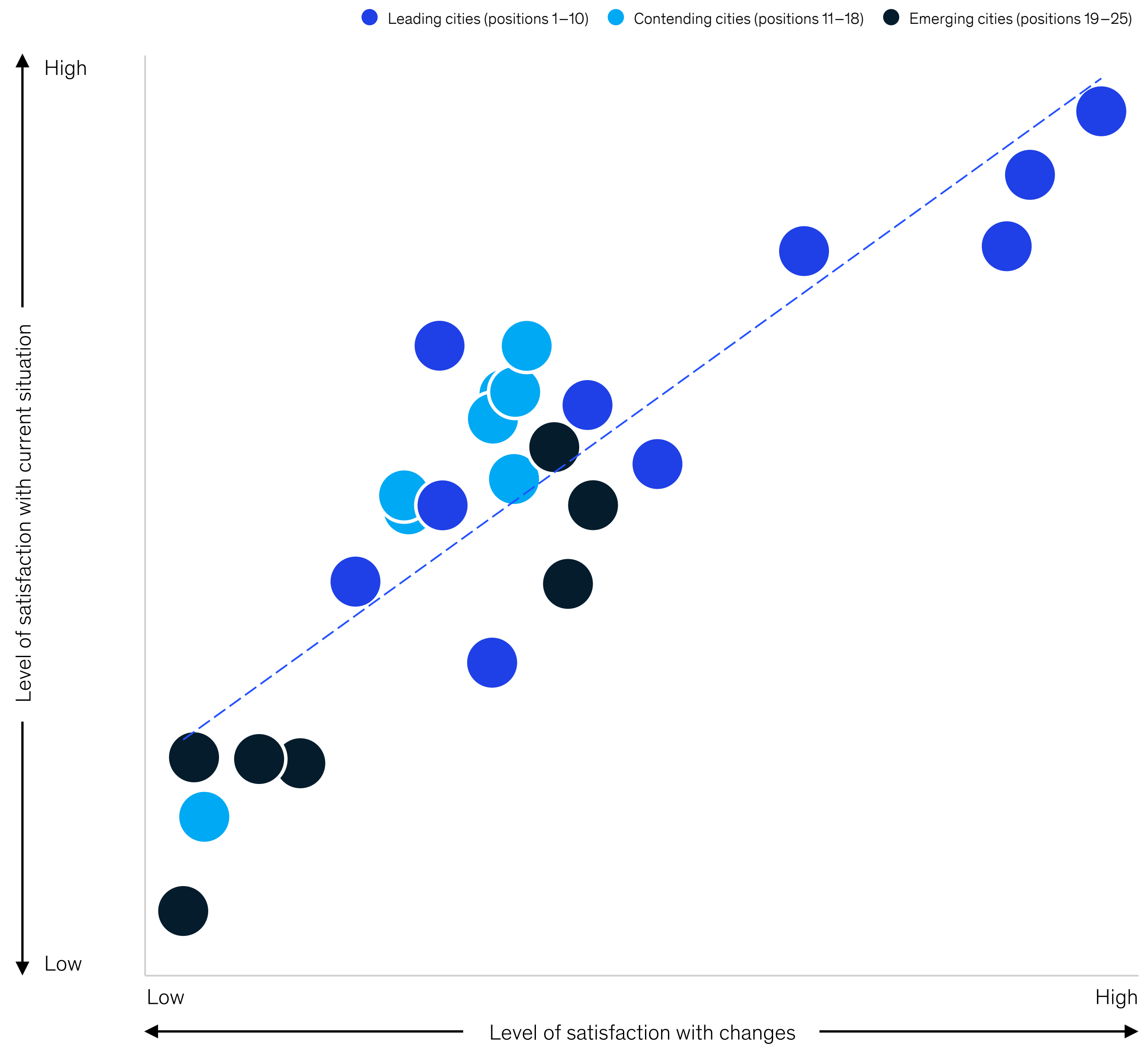
City residents' perception of changes

We looked at how city residents' level of satisfaction with changes that have occurred over the last several years depends on their perception of the current situation in their megapolises. We also assessed changes in the objective metrics posted by cities in all groups.

Assessment of the current situation in a city is closely linked to the level of satisfaction with changes: the more people are satisfied with the current situation, the better is their perception of changes that have occurred over the last several years (Exhibit 15). Residents of top-ranked cities are satisfied with both the current situation and the recent changes. Conversely, residents of emerging cities, as a rule, are less happy with the current situation and the recent changes.

Exhibit 15

Correlation between subjective assessment of the current situation and assessment of changes



City residents' views of metrics' importance

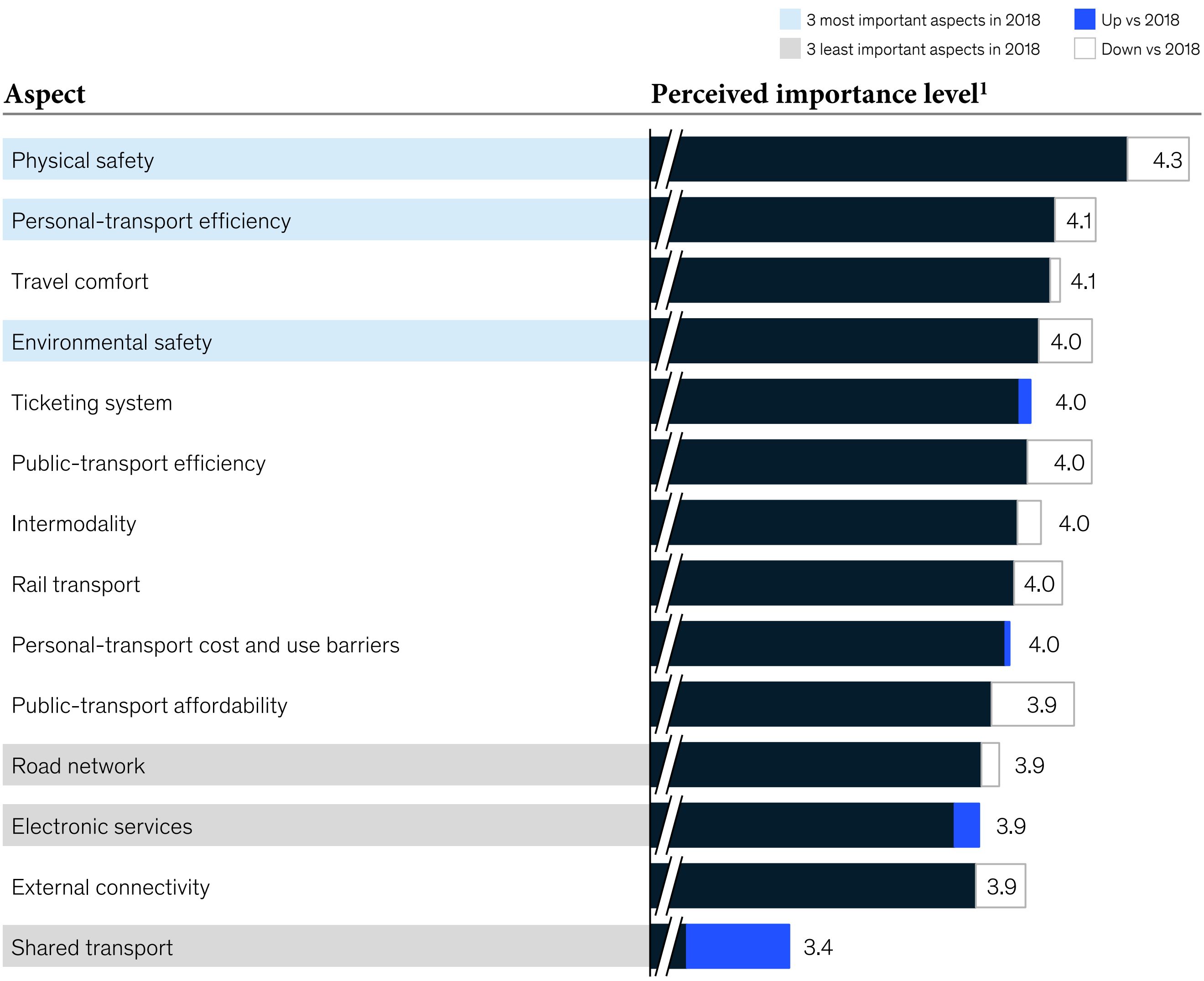
We compared the importance of aspects of transport systems as perceived by city residents participating in the current and previous studies. The current study reveals an averaging trend: aspects perceived as critical during the previous study are now described as less significant, and the aspects previously perceived as the least important have gained some significance (Exhibit 16).

Survey respondents in the previous study identified physical safety and environmental safety as critical. In the current study, they have become less significant but have retained their positions in the five most important aspects.

Respondents in the previous study identified shared transport, electronic services, and road network as least important. In the current survey, city residents describe them as more important, but they remain among the five least important aspects.

Exhibit 16

Importance ratings of transportation aspects, 2021 and change vs 2018



[1] On a scale from 1 to 5 where 1 = least important and 5 = most important.

Perceptions of transport system elements

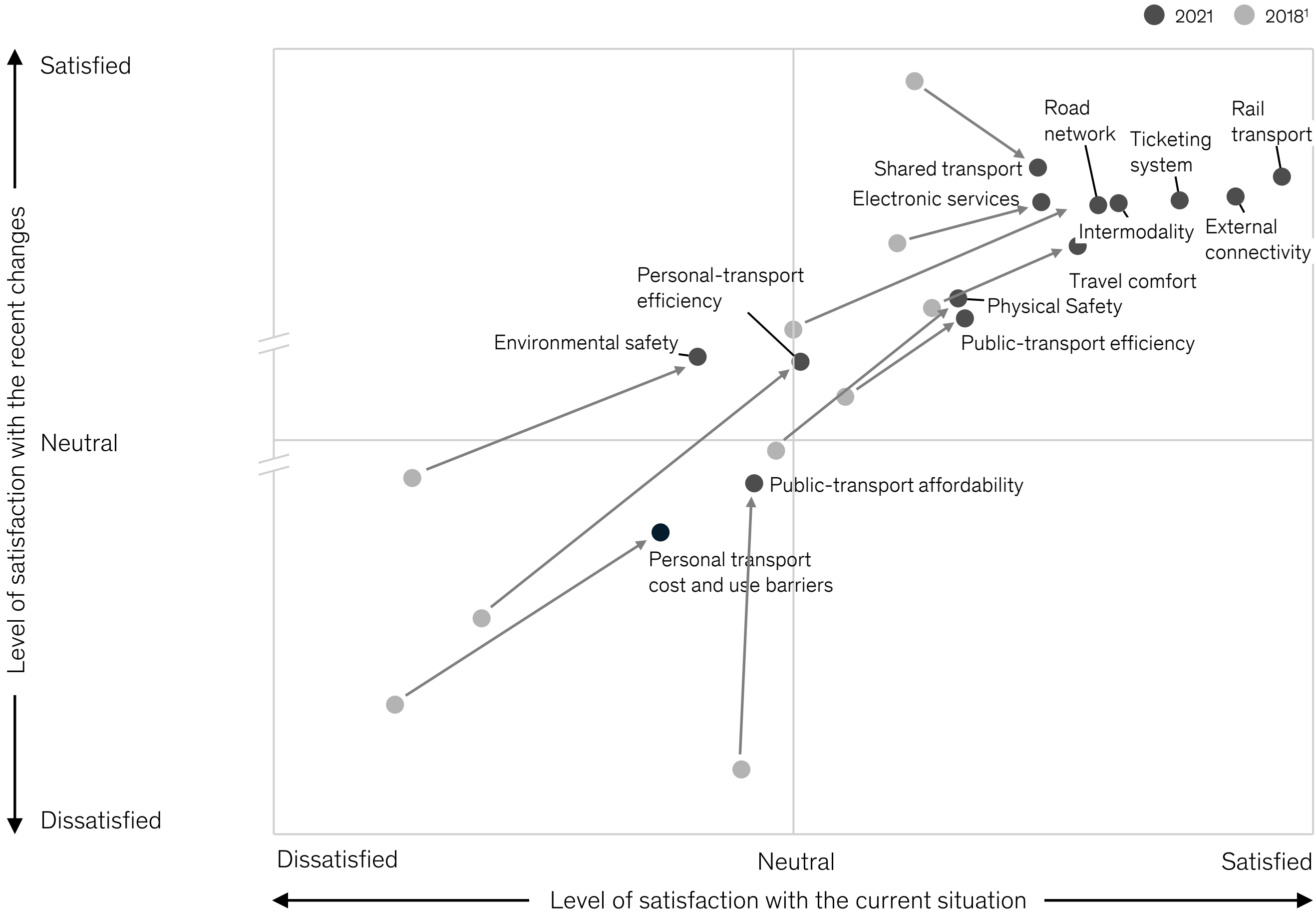
We analyzed general patterns that shape residents' perception of various elements of transport system operations in the examined cities. At the level of individual subgroups, there is a positive correlation between satisfaction with the current situation and satisfaction with the recent changes. Therefore, as with general metrics, city residents perceive that a positive state of affairs in any given aspect is a consequence of positive change, and vice versa (Exhibit 17).

City residents perceived four transport system aspects as neutral or negative: public-transport affordability, personal-transport cost and use barriers, personal-transport efficiency, and environmental safety. Since the previous study, city residents' level of satisfaction with both the current situation and the recent changes has increased in all those aspects. Notably, city residents, on average, remain rather dissatisfied with Affordability metrics. Despite the positive changes, city residents still regard all these areas as fraught with problems.

Rail transport, external connectivity, and ticketing system received the highest scores in both the current and previous studies. City residents' level of satisfaction with these aspects is quite high, and they note positive changes that have occurred over the last several years.

Exhibit 17

Average level of satisfaction with current situation and recent changes



[1] Changes in the level of satisfaction with the current situation and the recent changes exceed 30% of the overall range of values for all metrics shown.

Correlation between satisfaction levels and perceived importance of metrics

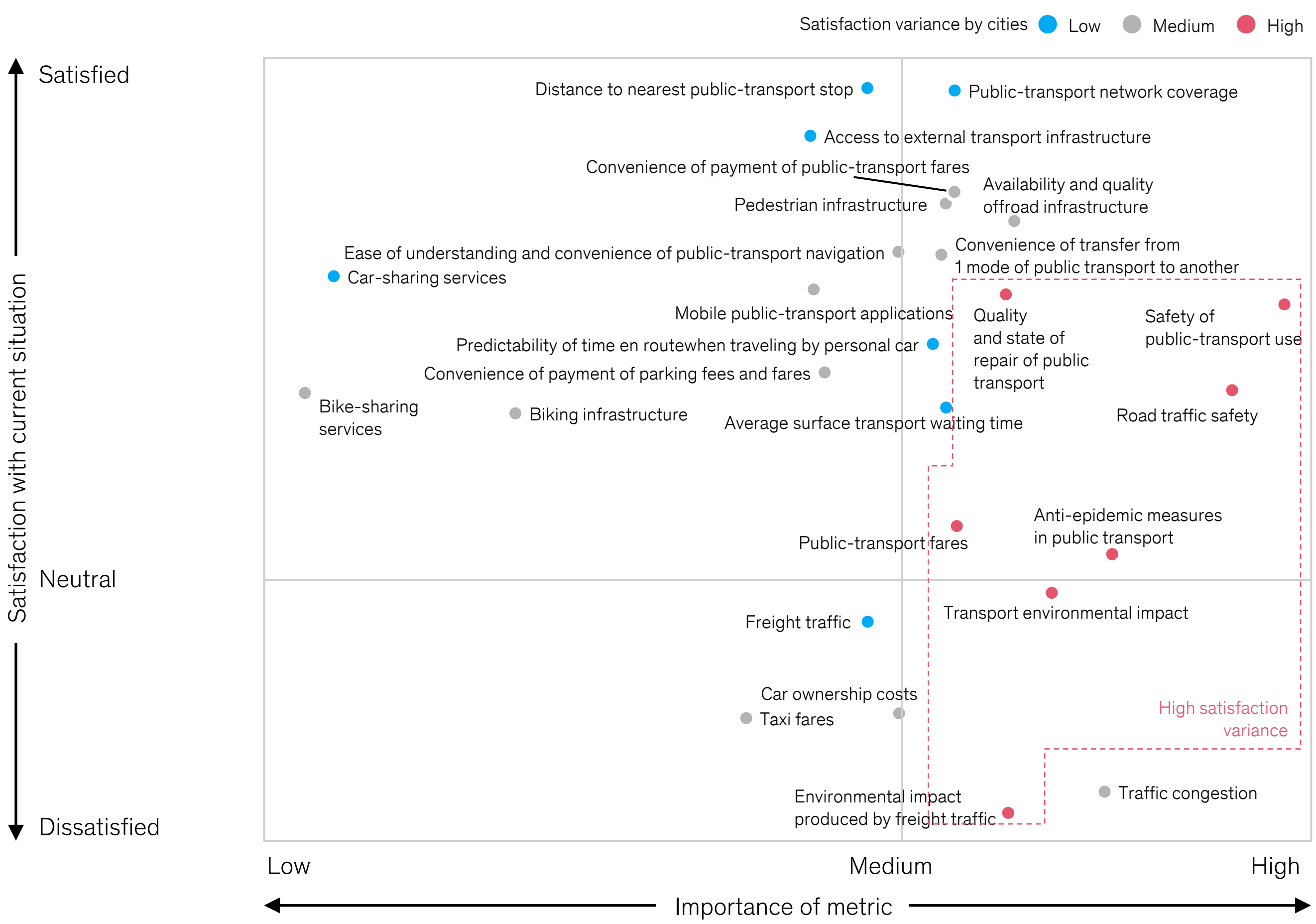
We looked at whether city residents' level of satisfaction of with various metrics depends on their subjective perception of importance of such metrics for the state of the urban transport system. Metrics that respondents deemed to be the most important and with which they are most satisfied include those related to safety, anti-epidemic measures, quality and condition of public transport, and availability and quality of road infrastructure (Exhibit 18). Typical city residents identify those parameters as important and are generally satisfied with the situation in the relevant areas.

Examples of metrics characterized by high perceived importance and low level of satisfaction are environmental impact produced by transport, including freight transport, and traffic congestion. In addition, these metrics display average-to-high variance of satisfaction levels, meaning that there exist major differences between cities in that respect. In some cities, relative satisfaction is at an even lower level.

Other metrics are classified as below average in terms of importance but are considered most problematic: are taxi fares, car ownership costs, and freight traffic on public roads.

Exhibit 18

Perception of individual metrics' importance and satisfaction with current situation



We also analyzed the recent changes in terms of objective metrics describing the aspects under review. Generally, over the last several years, most metrics have significantly improved (Exhibit 19). The metrics that city residents perceive as the most important have changed as follows: predictability of travel time has improved, surface transport waiting times have decreased, public-transport trips have become more affordable, and traffic safety has increased.

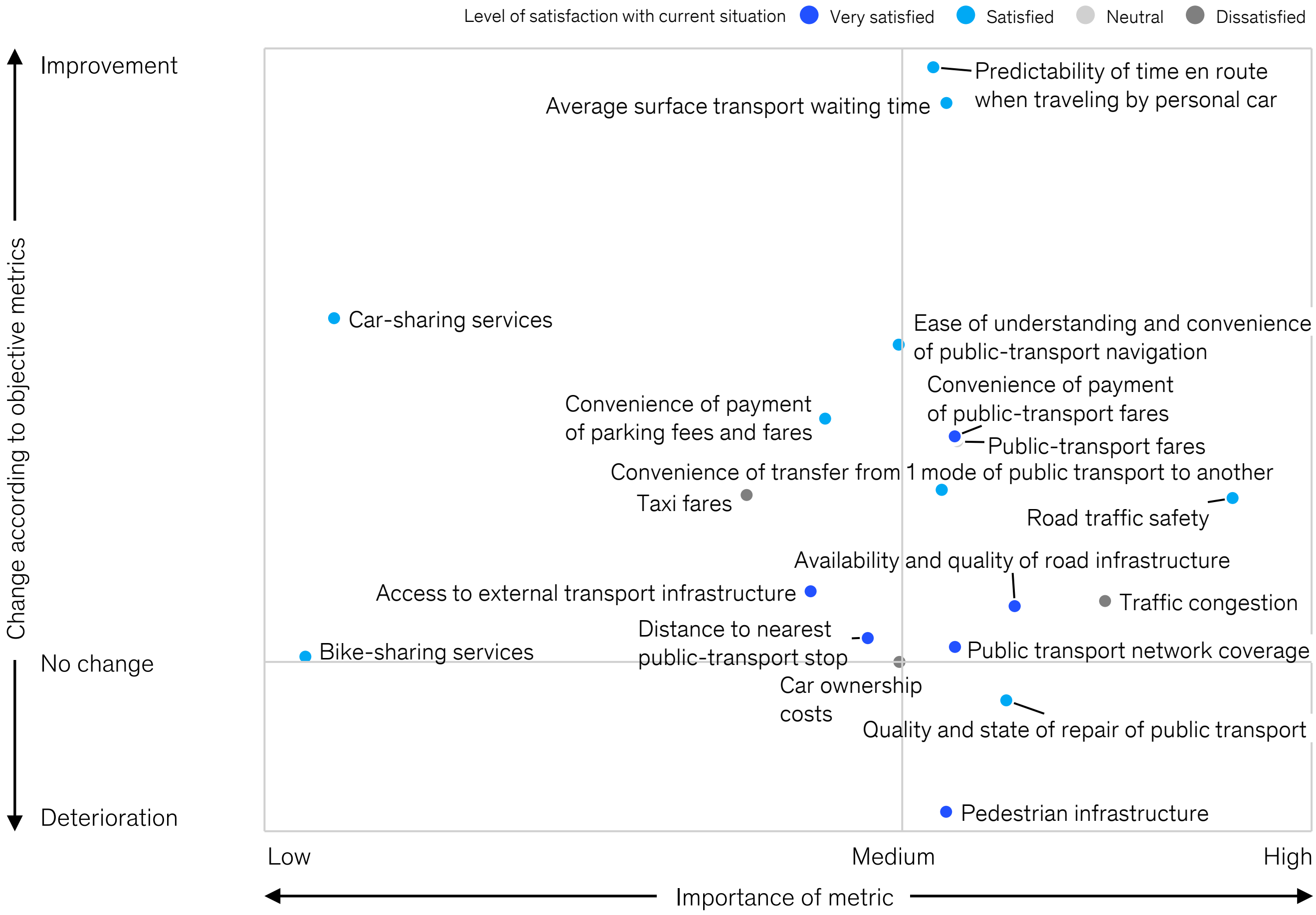
However, for some metrics, the changes have been relatively small. This is especially true for pedestrian infrastructure and for the quality and state of repair of public transport. Cities need to pay more attention to such metrics with due regard to their significance for the residents.

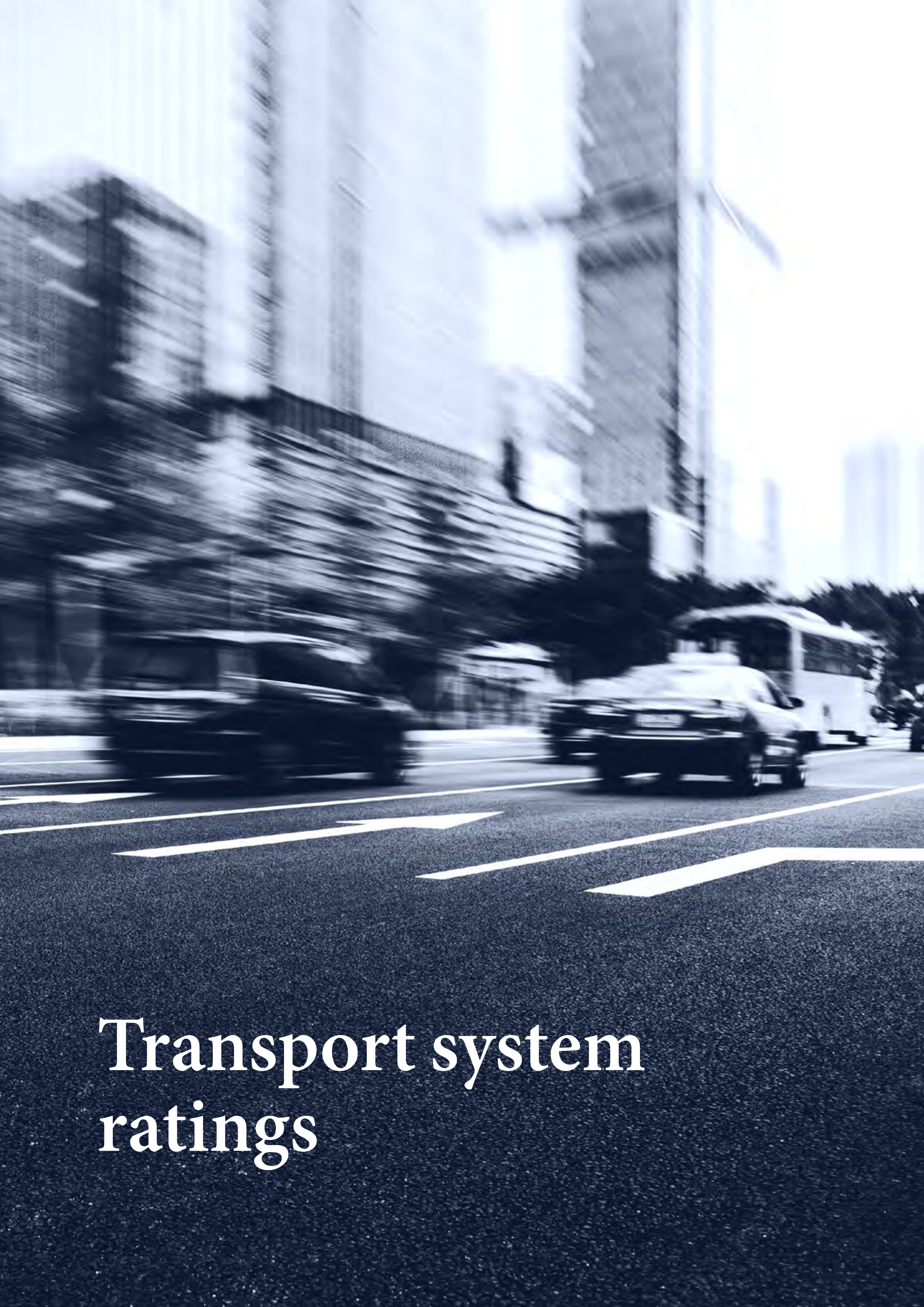
As for the metrics generally causing the most dissatisfaction, over the last several years there has been some improvement in, for example, availability of public transport and taxis. City authorities need to keep residents informed of all positive changes and continue their efforts to improve public perceptions in those areas. Over the last several years, there has been little improvement in terms of reducing car ownership costs and overall traffic congestion; accordingly, city authorities need to focus on those aspects.

Taking into consideration the need to reduce traffic congestion, it is highly likely that additional restrictions on the use of personal motor vehicles will be introduced in the next several years. To improve public perception of those aspects, city authorities must score tangible successes and clearly articulate their policies.

Exhibit 19

Changes in objective metrics relative to their perceived importance





Transport system ratings

Ratings based on Availability metrics

Availability
Rail transport
Road network
Shared transport
External connectivity

The Availability Index comprises a set of metrics for assessment of variety of travel modes that can be used by city residents.

The index describes availability of rail transport, road network, shared transport, and connectivity of the city with other cities in terms of air destinations.

The three cities with the highest Availability Index values are London, Paris, and Madrid (Exhibit 20). The British capital has the largest number of available air destinations; during the pre-COVID era, Heathrow Airport supported flights to more than 450 domestic and international destinations. In addition, London is one of the world's leaders in terms of road network availability. For example, it boasts a very high share of biking lanes in total road length, with total length of biking lanes in London having increased by more than 30 percent over the course of three years.

Paris is holding the second position, with only external-connectivity values being significantly below those posted by London. Paris is ahead of London in terms of pedestrian infrastructure cohesion (in the road network subgroup), meaning it has a ramified road network, making it possible to walk from point a to point B without losing much time compared with walking along a straight line.

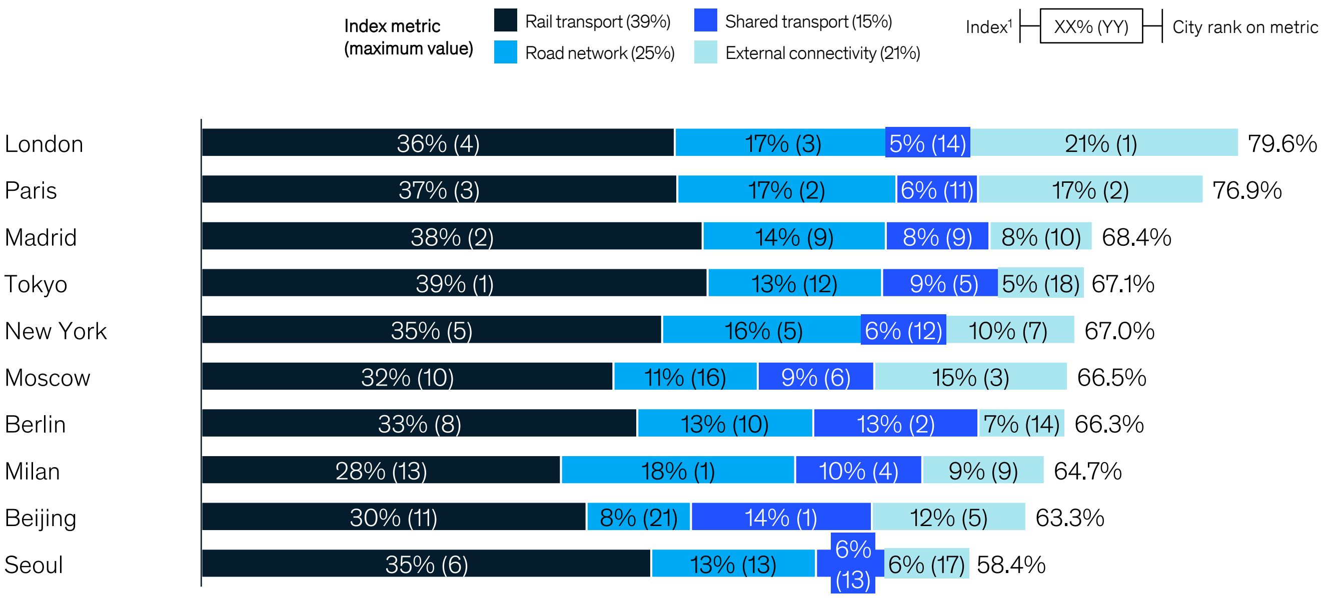
Madrid, in the third place, has excellent car-sharing metrics vis-à-vis other leading cities (840 cars per million people, ranked fourth in the all-cities ranking). Besides, the city has an extensive rail transport network, with only Tokyo having a modest advantage in that respect; in both cities, about 91 percent of the population live within a 20-minute walk from underground and commuter train stations.

An ideal city in terms of Availability would be a combination of London (for external connectivity), Tokyo (rail transport network), Milan (road network), and Beijing (number of bicycles and motor cars available from shared transport services).

Exhibit 20

Ten leading cities for Availability

Index[1] (city rank on metric)



[1] Components may not sum to total because of rounding.

Availability change rating, 2018–20

Cities with best scores in the Availability group have bested their rivals in terms of the number of implemented rail infrastructure projects, considerably improved the quality of their road networks, increased shared-transport availability, and taken steps to boost external connectivity.

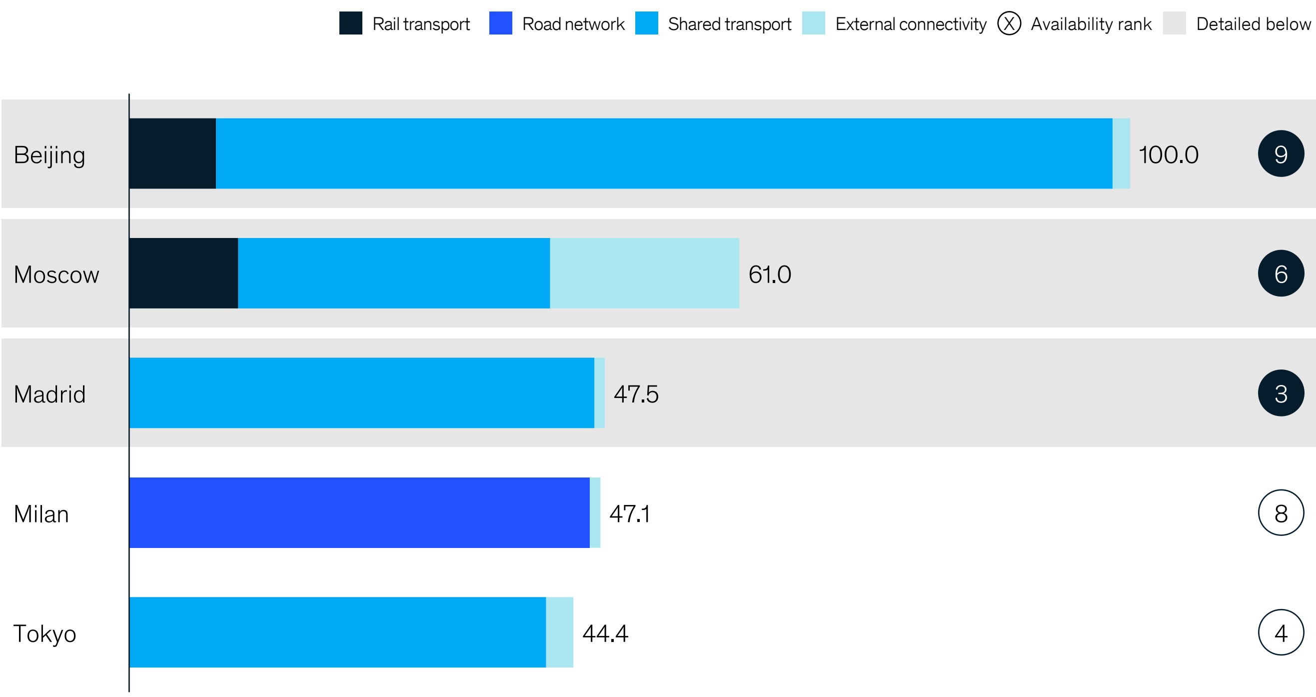
The key changes include the opening of new city railway and underground stations (rail transport category) and improvement of road infrastructure (road network). Shared-transport scores were determined by the rate of growth of the number of rental bicycles and cars provided by car-sharing services, while external-connectivity scores depended on the number of destinations served by city airports.

The leading cities with the highest change scores are Beijing, Moscow, and Madrid (Exhibit 21). Transformations carried out over the last several years have propelled Moscow into the top ten of the Availability index. The other cities have reaffirmed their leading positions.

Change leaders have demonstrated the most impressive growth in the shared-transport category.

Exhibit 21
Leading cities with top improvements in Availability Index

Change index (maximum change = 100)



Beijing

Beijing has become the absolute change leader in the Availability group. This success is based on improvements in the rail transport and shared-transport subgroups (where the city's improvement ranks fourth and first, respectively).

Beijing remains one of the cities investing massively in rail infrastructure. As a result, rail transport availability for city residents has increased by four percentage points versus 2018. Three new underground lines have been opened over the last several years.

The city has completed construction of a high-speed railroad linking it to Hong Kong. Work was carried out in several stages, ending in 2018. The overall length of the line is 2,439 kilometers, a distance the train covers in less than nine hours. Trains run daily.

The project was part of a long-term plan to join 11 cities into a large economic cluster, using the advantages offered by efficient logistics.

Beijing remains a global leader in shared transport. Over the last several years, the number of cars provided by the city's car-sharing companies has increased dramatically. In addition, city residents can still use a huge fleet of bicycles offered for rent. The number of bicycles available for rent has stabilized at 0.9 million; no other city in the world can boast such a large fleet.

High-speed train connecting Beijing and Hong Kong

Moscow

Moscow has secured top ranking in improvement in several subgroups, including rail transport (where it ranks fifth), shared transport (sixth), and external connectivity (first). The city has the fourth-best change score in the Availability group.

Over the last several years, Russia has been heavily investing in development of its railway infrastructure, including the underground, to make that mode of transport more accessible to city residents where they live and work. New surface lines linking the city with Moscow Region destinations have been built within the framework of the Moscow Central Diameters (MCD) project. The overall length of the first two diameters (60 stations) is 132 kilometers.

In addition, the city has opened the first sections of the Large Circle Line, a new 70-kilometer underground line, one of the world's largest underground construction projects. The line will help reduce passenger flows currently served by Moscow Metro. The new line will have a total of 31 stations, of which ten have already been opened.

In addition, the new Nekrasovskaya Metro Line has been launched. As a result, another 700,000 people have gained access to Moscow Metro, while passenger traffic through other lines is going to decrease.

Shared transport is posting robust growth rates in Moscow. The total number of bicycles that can be rented from the city's Velobike service has increased from 1,000 to 6,500. Electric-scooter rental services have emerged, offering a total of 5,000 vehicles. Car-sharing fleets have posted a considerable increase from 6,500 cars to 30,000 cars (prior to the COVID-19 pandemic). In the case of car sharing, the growth can be attributed to successful development of private operators such as Yandex.Drive and Delimobil.

Since 2018, Moscow has implemented several large-scale projects designed to upgrade its airport infrastructure, bringing the number of destinations with daily flights from 295 to 345. The city has taken steps to improve service quality and passenger safety. For example, Domodedovo has become Russia's first airport to deploy baggage storage robotization systems and automated turnstiles; the air haven is currently testing a face recognition system.

MCD train at a station in Moscow

Madrid

Madrid has shown improvements in the shared-transport and external-connectivity subgroups (putting it in third and 15th places, respectively), bringing the city's change score up to eighth place in the Availability ranking.

Madrid channels considerable investments into expanding the use of personal-mobility devices. About 3,000 bicycles were purchased and 50 new bike rentals opened in 2020 alone. City authorities hail projects designed to support shared-transport development. For example, recently city residents were granted access to 4,800 electric bikes offered for rent by private operators.

Bike rental station in Madrid

Ratings based on Affordability metrics

Affordability

Public-transport affordability

Personal-transport cost and use barriers

The Affordability Index shows the relative weight of costs associated with various modes of transport.

It comprises two metrics: public-transport affordability and personal-transport cost and use barriers.

The rating is topped by Asian cities: Singapore, Shenzhen, and Seoul (Exhibit 22). Their common feature is the relative inexpensiveness of public transport. Also, in each of those cities, authorities take steps to incorporate into car ownership costs certain additional expenses borne by society as a result of personal car use: environmental and health impact, time lost in traffic jams, use of additional space, and so on.

Singapore is holding the first place. It has one of the lowest ratios of the cost of a one-kilometer taxi ride to average monthly income, as well as a well-balanced ratio of the cost of a monthly public-transport travel card to average monthly income. In addition, car owners pay a special fee when they enter areas with high traffic congestion.

The number-two city is Shenzhen. Like Singapore, it has managed to balance public-transport availability with constraints on the use of personal motor vehicles, thereby earning a high rating.

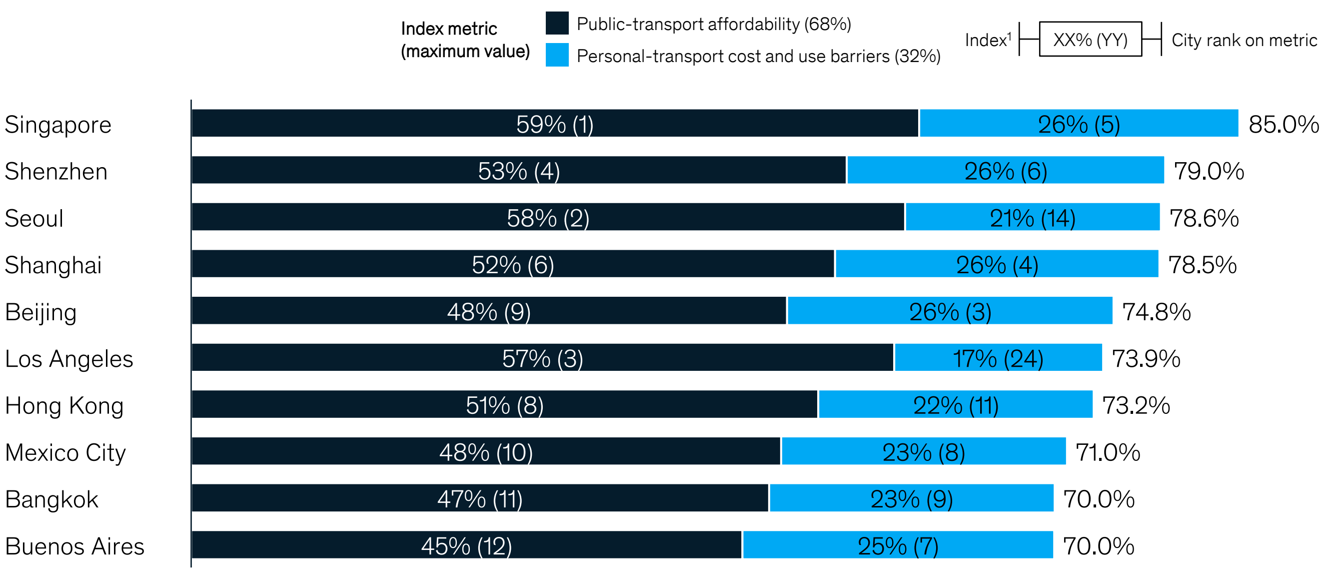
Seoul, in third place, has introduced a traffic-congestion penalty and limited the number of parking spaces, with pricing policy as the key occupancy control tool. At the same time, public transport remains widely available.

To be rated as "ideal" in Affordability, a city must have a high score for public-transport affordability. In addition, personal transport's impact on the megapolis must be reflected in car ownership costs. For example, the cost of a monthly public-transport travel card and taxi ride must constitute a smaller share of average monthly income, as in Los Angeles, and certain categories of city residents must be offered rides at reduced fares. Also, the city must introduce reasonable constraints on personal car ownership to reflect the additional costs borne by the society, as done in a number of cities in Asia, including Singapore.

Exhibit 22

Ten leading cities for Affordability

Index[1] (city rank on metric)



[1] Components may not sum to total because of rounding.

Change ratings for Affordability, 2018–20

Cities emerging as change leaders in the Affordability group have either increased public-transport affordability or introduced new barriers on personal-transport use.

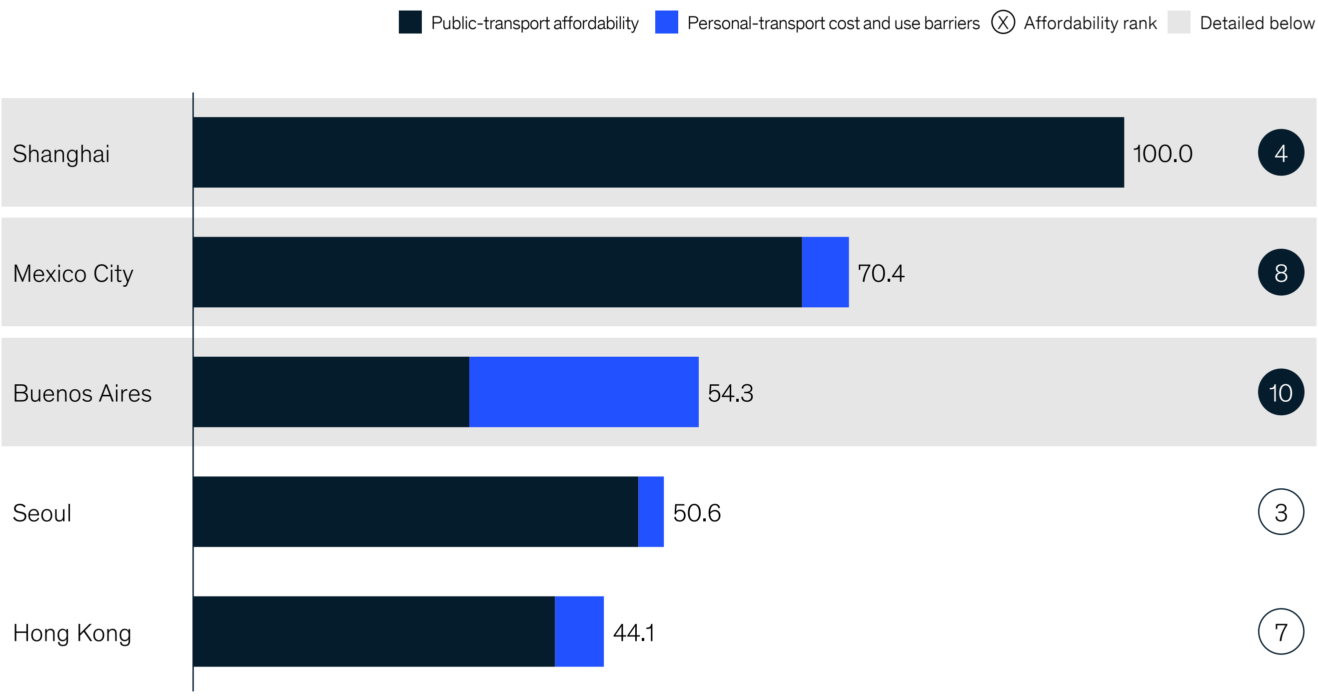
In the public-transport affordability subgroup, city authorities implemented various projects to support low-income residents, launched new and cheaper trip services, and reduced effective public-transport fares by ensuring that income grew at a rate higher than the fare indexation rate. In personal-transport cost and use barriers, cities achieved improvement by imposing new restrictions on the use of personal motor vehicles and reducing the availability of this travel mode relative to others.

The leading cities with the highest change scores are Shanghai, Mexico City, and Buenos Aires (Exhibit 23). Changes have enabled Shanghai and Mexico City to join the list of the best performers, while Buenos Aires reaffirmed its leadership. Public-transport affordability made the weightiest contribution to the overall change.

Exhibit 23

Leading cities with top improvements in Affordability Index

Change index (maximum change = 100)



Shanghai

Shanghai has shown strong improvement in public-transport affordability. The city maintains low bus and underground fares. That and growing resident incomes enable Shanghai to improve its position in the overall rating. Taxi fares remain competitive because of continued rivalry between private companies. For example, Didi, one of the largest taxi aggregators in China, has launched Huaxiaozhu, a new service targeting young customers and offering relatively low fares.

The city is actively testing self-driving taxi technologies. Didi has been offering those services in certain districts since 2020. By expanding self-driving transport, Shanghai can make transport even more affordable for its residents.

Over the last several years, the city has avoided the need to impose new major restrictions on the use of personal transport. The existing restrictions, however, are already quite onerous. If a car is registered outside of Shanghai, it is barred from entering certain city districts. There are certain limitations on acquisition of motor vehicles by nonpermanent residents.

The average taxi fare in Shanghai currently stands at about $0.50 per kilometer

Mexico City

Mexico City's metrics have improved because of its balanced development. The city occupies top positions in change ratings for both Affordability subgroups.

As for public-transport pricing policy, the city has not increased fares in local currency for several years, making transport services more affordable to residents. In 2013, underground fares were raised from three to five pesos, bringing the number of trips down. The fare has not changed since then. In addition, taxi services have become much more affordable.

As for personal transport, the city is expanding the use of paid parking lots, which makes private car ownership more expensive.

Mexico City residents have noted that transport Affordability has improved. The level of satisfaction with public-transport affordability has increased by 6 percent. Incidentally, despite the ongoing limitations on the use of personal transport, the level of satisfaction with its Affordability has risen 10 percent

The fee for using a parking lot in Mexico City for two hours is $0.90

Buenos Aires

Buenos Aires is the change leader in personal-transport cost and use barriers. The city also holds a top position in the public-transport affordability subgroup.

The capital of Argentina continues to develop a system enabling proper measurement of motor vehicles' environmental impact. The city has created a system of paid parking lots, and a special fee has been charged since 2018 for entry to downtown areas with excessive traffic. Drivers entering those areas between 11:00 and 16:00 on workdays must pay an annual fee of $77.

In public transport, the availability of Buenos Aires taxi services is growing, with the city going up four notches in the rating table for that metric. This can be attributed to successful development of aggregator services, which recently emerged in the city. For example, Uber came to Buenos Aires only in 2016.

The total number of taxis in Buenos Aires stands at about 40,000, with Uber boasting the most drivers and customers

Ratings based on Efficiency metrics

Efficiency

Public-transport efficiency

Personal-transport efficiency

The Efficiency Index shows how fast and predictably one can move around the city.

In particular, the index comprises metrics for traffic congestion and helps assess its impact on travel times.

The highest index values have been recorded by Moscow, Shenzhen, and Singapore (Exhibit 24). Moscow is holding the first place: it has high public-transport efficiency (ranking first in the subcategory), while in terms of personal-transport efficiency, it lags behind the other examined cities. Moscow is one of the top three cities in terms of underground waiting time, public-transport travel speed during the rush hour (about 21 kilometers per hour), and share of dedicated lanes (6.5 percent, versus 2.3 percent on average for all examined cities).

Shenzhen is only slightly behind Moscow. It has wound up at the top of the rating because it has the highest share of dedicated bus lanes in total road length and the highest predictability of travel time during the rush hour (putting it in second place in the personal-transport efficiency subcategory).

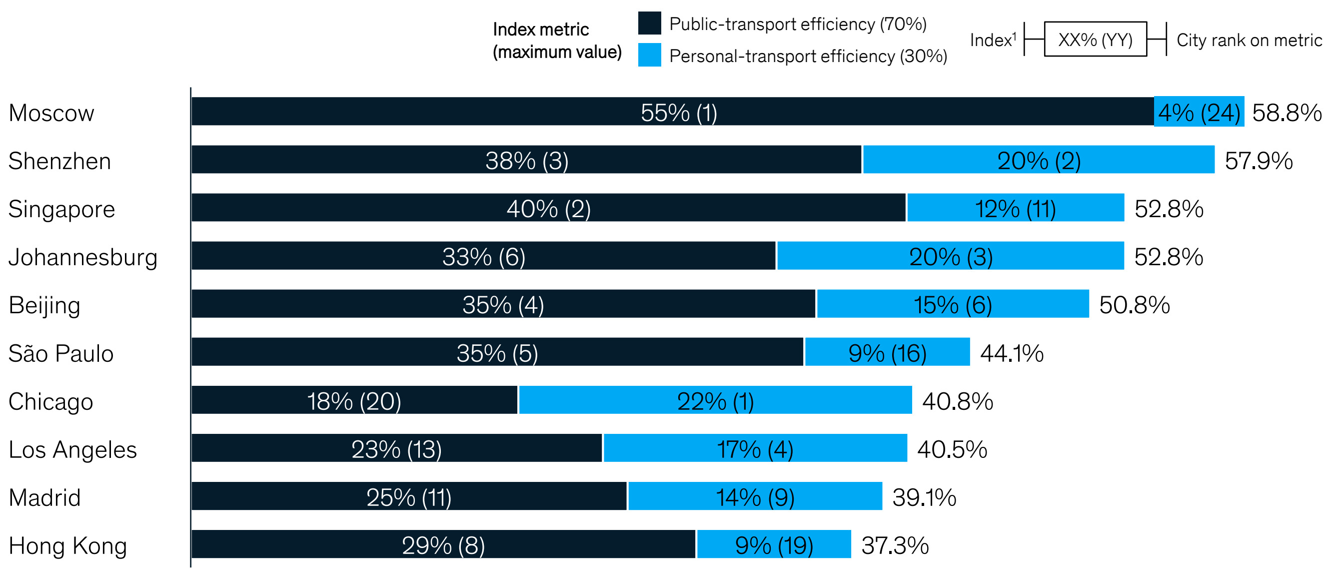
Third-ranked Singapore also scores high in public-transport efficiency (making it number two in the subcategory), while also demonstrating leading results in personal-transport travel speed during rush hour (fifth) and deviation of travel time during rush hour (seventh).

An “ideal” city with the most efficient transport system would have the following characteristics: an extensive network of dedicated public-transport lanes (as in Shenzhen and Moscow); a possibility to predictably reach the point of destination, especially during the rush hour (as in Beijing); minimal underground waiting time (as in Moscow); and high travel speed during rush hour (as in Chicago).

Exhibit 24

Leading cities for Efficiency

Index[1] (city rank on metric)



[1] Components may not sum to total because of rounding.

Change ratings for Efficiency, 2018–20

Cities that have become change leaders in Efficiency managed to boost public-transport and personal-transport performance.

To improve public-transport operations, they created dedicated bus lanes and took steps to reduce traffic congestion. Personal-transport efficiency increased through the operation of three key factors: proactive steps taken by city authorities to make car purchase less attractive for residents, completion of road construction or modernization projects, and reduction of population mobility as a result of the COVID-19 pandemic.

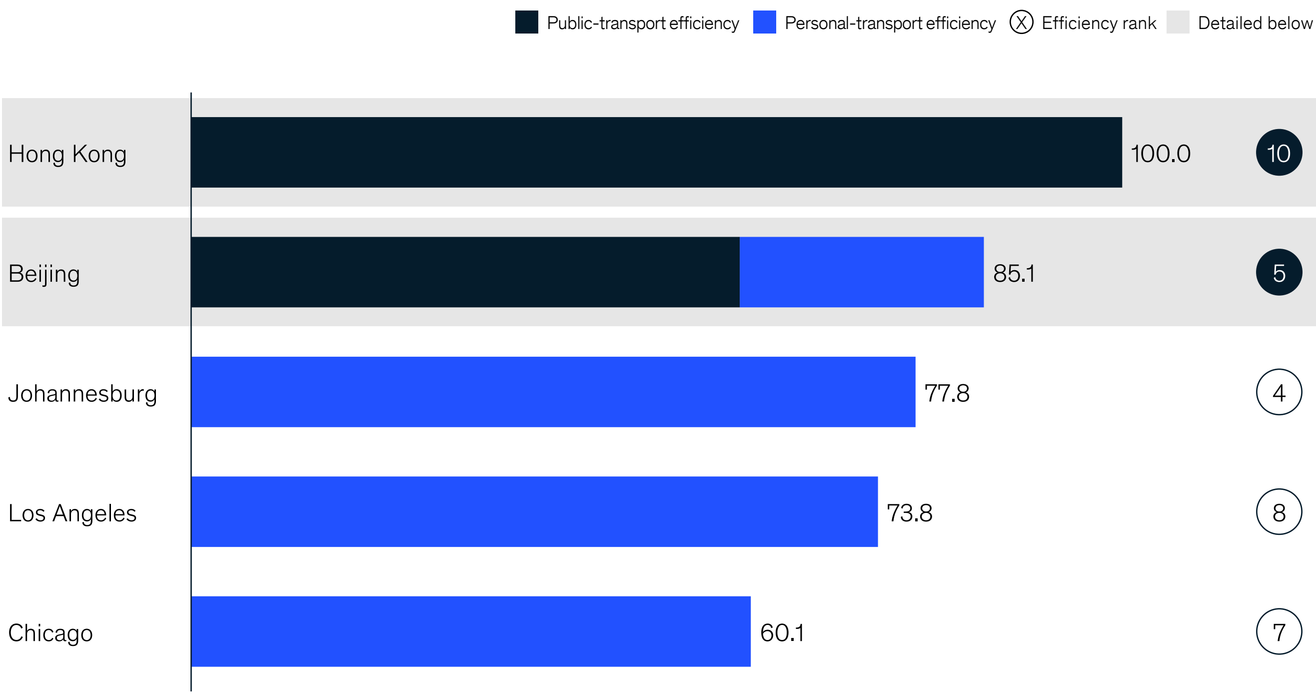
When modeling certain metrics, we "cleanse" them to account for the impact of the pandemic. However, our survey shows that residents of many examined cities (with the exception of Johannesburg, Buenos Aires, and Singapore) expect to retain reduced levels of mobility past the pandemic. Therefore, the impact generated by reduced traffic congestion is likely to persist in the future, at least in part.

The leading cities with the highest change scores are Hong Kong, Beijing, and Johannesburg (Exhibit 25). Transformations have placed Hong Kong, Beijing, and Los Angeles in the top ten of the group, while Johannesburg has greatly improved its position, rising five places in the rating table. Hong Kong and Beijing have secured leadership by improving public-transport efficiency, with improved personal-transport efficiency being the key driver for the other cities.

Exhibit 25

Leading cities with top improvements in Efficiency Index

Change index (maximum change = 100)



Hong Kong

Hong Kong has become a change leader because of its great improvements in the subcategory of public-transport efficiency, where it is holding the top rank.

The increase in the efficiency of public transport in Hong Kong is directly related to two parameters. The average speed of public transport during peak hours has almost doubled, and the waiting time for surface transport has been significantly reduced, from eight minutes to five.

Also, a project to build the Tuen Ma Line is under way in Hong Kong. The Tuen Ma Line will be the longest railway line in Hong Kong at 56 kilometers and 27 stations, connecting the Ma On Shan Line and the Western Railway Line, including a number of interchange stations between the existing railway lines to further expand the railway network. The opening of the first section took place in February 2020. The first phase of the Tuen Ma Line, which includes one expanded and two new stations, is estimated to carry 80,000 passengers daily while boasting new anti-vandalism features.

The average waiting time for a bus in Hong Kong is five minutes

Beijing

Beijing has become a change leader in this group by improving its position in public-transport efficiency. China's capital takes the second position in this subgroup.

Both public- and personal-transport travel speed in the city have increased, while waiting time for surface transport has decreased. This can be attributed, among other things, to creation of dedicated bus lanes. City authorities note that travel speed is growing because of the ongoing development of rail infrastructure and personal mobility devices.

In addition, the city continues to expand its motor vehicle infrastructure, which is likely to increase motor vehicle connectivity and travel speed. Construction of the seventh ring road with a total length of about 1,000 kilometers was completed in 2018. It joins the Beijing with adjacent cities, with 38 kilometers of the road traversing Beijing.

City residents have appreciated improvement of metrics in this group: their satisfaction has risen 17 percentage points.

The length of bus lanes increased by 650 kilometers in Beijing

Ratings based on Convenience metrics

Convenience
- Electronic services
- Travel comfort
- Intermodality
- Ticketing system

The Convenience Index assesses the convenience of transfers from one mode of transport to another, level of ticketing-system development, electronic-services penetration rates, internet access during the trip, and share of buses and underground stations accessible to passengers in wheelchairs.

The leading cities in the Convenience category are Toronto, Hong Kong, and Singapore (Exhibit 26). Toronto comes first with its superior travel comfort metrics: city underground rolling stock is new, and the share of buses accessible to passengers in wheelchairs reaches 100 percent.

In second-ranked Hong Kong, the city bus fleet is rather young, the underground uses new rolling stock, and the share of underground stations accessible to passengers in wheelchairs is very high. City authorities have launched a project designed to boost underground and bus mobility: elevators and ramps have been installed at 90 of 93 underground stations. In addition, the city has purchased new low-floor buses. Hong Kong boasts the shortest average distance from underground station to the nearest surface public-transport stop.

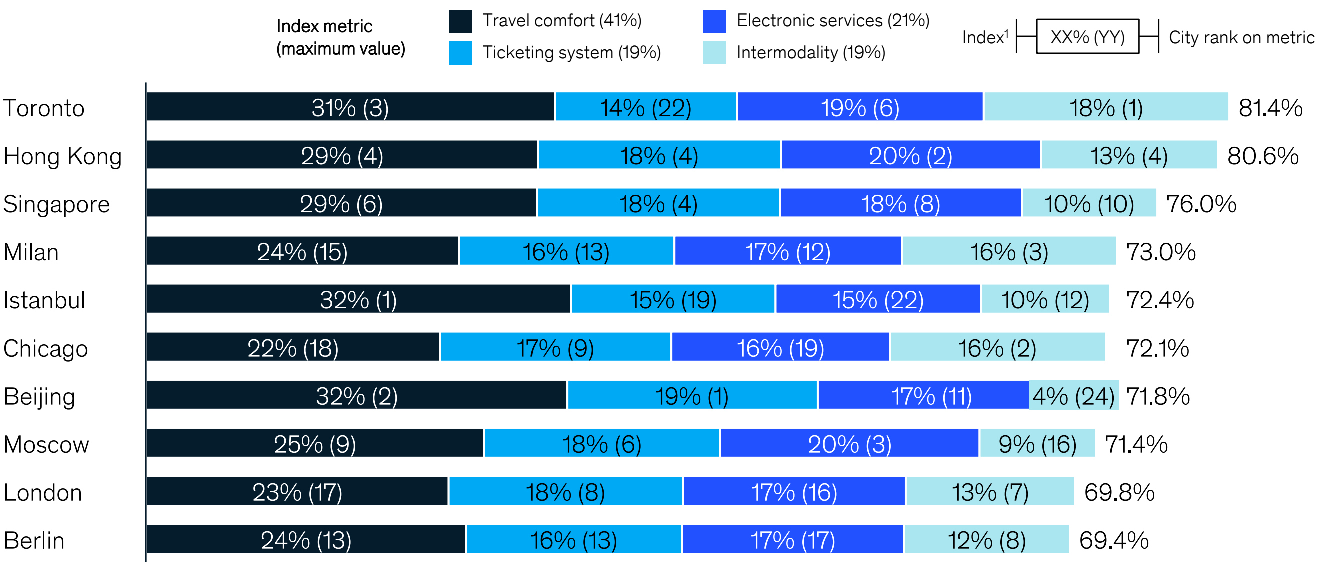
Singapore's presence in the top three is attributable to the fact that most of its metrics are above average: the city is developing various aspects of its transport systems at an even pace. Thus, over the last three years, it has increased the share of underground stations accessible to disabled passengers, and public transport is offering improved internet access, with buses and stops being equipped with Wi-Fi modules.

An "ideal" city for Convenience would be one that deploys new technologies, offers convenient city-resident interaction mechanisms based on the use of mobile applications (to verify and pay fines and penalties, plan routes, etc.), provides passengers with continuous access to high-speed internet, minimizes fare payment efforts (e.g., through implementation of biometric technologies, as in Beijing and Shanghai), and regularly upgrades its transport fleets (as in Moscow, Istanbul, and Toronto).

Exhibit 26

Ten leading cities for Convenience

Index[1] (city rank on metric)



[1] Components may not sum to total because of rounding.

Change ratings for Convenience, 2018–20

Change leadership in the Convenience group comes from offering superior travel comfort to public-transport passengers, implementing of new ticketing technologies, developing electronic services, and improving intermodality metrics.

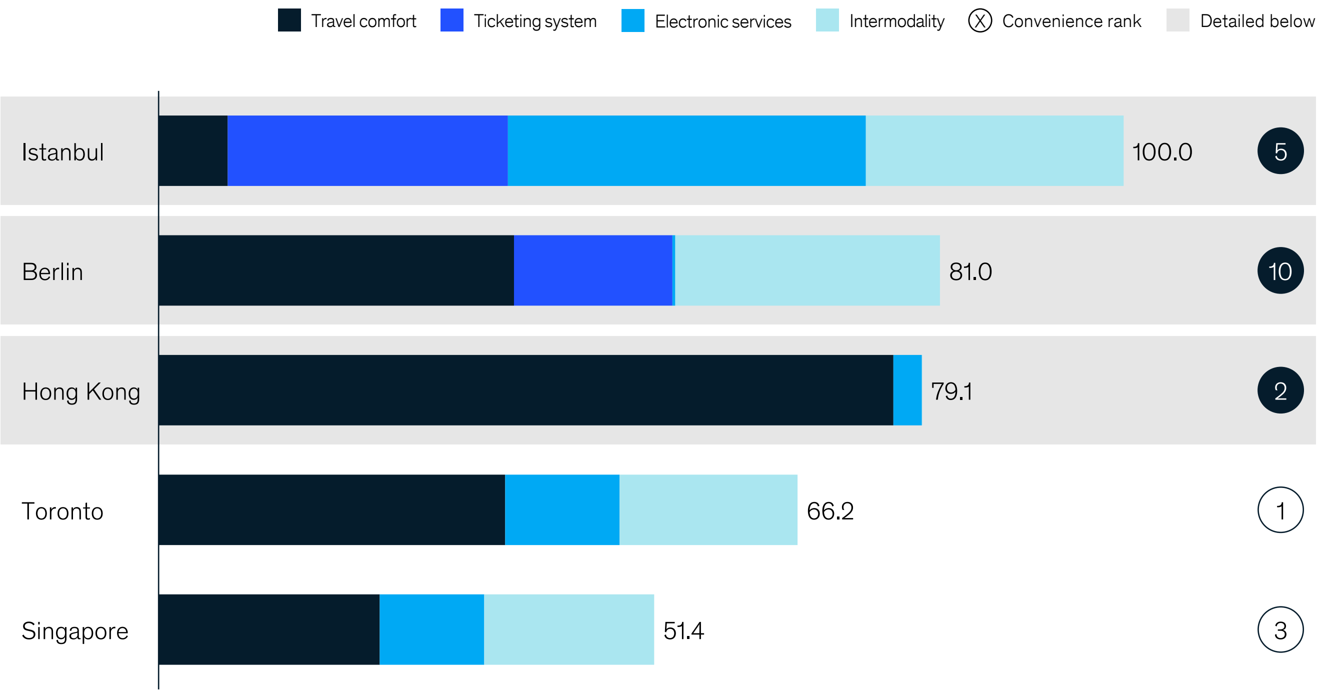
Improvement of metrics in the travel comfort subgroup is explained by completion of projects designed to upgrade bus and underground car fleets and higher mobility of passengers using wheelchairs. Improvements in the ticketing system subgroup can be attributed to implementation of new payment methods and expansion of transport card functionality. To expand electronic services, cities launched applications that can be used to schedule routes for multiple modes of transport, track bus arrival times, and top up transport cards online. Intermodality metrics increased as a result of opening conveniently placed public-transport stops, enabling passengers to spend less time switching to another mode of transport, and upgrading city navigation systems.

The leading cities with the highest change scores are Istanbul, Berlin, and Hong Kong (Exhibit 27). Having completed their respective transformation programs, Berlin and Istanbul made it to the top ten of the group, while Hong Kong rose to second place in the ranking table. Singapore went up by five notches and is now ranked third, while Toronto has retained its leadership. In all leading cities except Istanbul, travel comfort metrics have sustained massive changes.

Exhibit 27

Leading cities with top improvements in Convenience Index

Change index (maximum change = 100)



Istanbul

Istanbul has become a change leader by securing improvements in multiple subcategories. The city has taken the top ranking in the subcategories of ticketing system, electronic services, and intermodality.

It improved the ticketing system by increasing the number of city locations where passengers can pay the fare using bank cards, making it even easier to use public transport. The Istanbulkart city transport card is fully integrated in a mobile application featuring a new option to pay by scanning the QR code (a function currently available at some but not all public-transport stations).

Over the last several years, the quality of electronic services has notably improved in Istanbul. It has become possible to learn the location of city buses online. The official Ulasim Asistani application enables the use of multiple modes of transport, including buses, underground, railways, water transport, and taxi. In addition, users can build routes for their personal motor vehicles and for pedestrian or bicycle trips.

Following the opening of new public transport stops, the average distance between stops and underground stations has decreased, as has the time required to switch from one mode of public transport to another.

Multiple improvements have affected satisfaction ratings assigned by city residents when assessing the aspects described by the metrics comprising this group. In particular, the overall satisfaction level has reached 86 percent, versus 76 percent noted in the previous study.

Istanbulkart can be purchased from a dispensing machine for six liras

Berlin

Berlin has become a change leader because of improvements in travel comfort (where it ranks third), ticketing system, and intermodality (second). Over the past three years, the results for these subgroups have increased significantly.

Since 2018, Berlin has been purchasing new electric buses, an investment that has reduced the average age of the bus fleet by two years. The number of metro stations accessible to people in wheelchairs has increased by 20 percent.

For car owners, a new service called Park Now allows drivers to track the congestion of parking spaces and choose available ones. a transport app with the ability to buy tickets online also has been launched: in 2020, 20 percent of public-transport tickets were sold through the BVG Ticket and BVG Fahrinfo apps.

BVG Ticket, an additional app to BVG Fahrinfo, was launched in Berlin in 2018

Hong Kong

Hong Kong has become a change leader because of improvements in travel comfort, a subgroup in which it is ranked first. Travel comfort improvements can be attributed to the recent upgrade of the city bus fleet and reduction of its average age to seven years. In the course of the upgrade, the share of buses that can be used by persons with reduced mobility has significantly increased.

Electronic-service improvements are related to expansion of Wi-Fi coverage in underground trains and emergence of new services. Hong Kong Mobility gives an overview of pedestrian routes across the city. City residents have noted that the biggest changes have occurred in this area, with the level of satisfaction up by four percentage points (more than in other groups of metrics).

Road network data prepared by the Hong Kong University include information about 2,000 pedestrian bridges, 400 pedestrian tunnels, and underground crossings where no additional fee is charged.

Double-decker buses first appeared in Hong Kong streets in 2010; since 2017, all buses have been modified to meet the needs of persons with reduced mobility

Ratings based on Safety and Sustainable Development metrics

Safety and Sustainable Development

Physical safety

Environmental safety

The Safety and Sustainable Development Index describes the safety level of city travel and the current environmental situation. The index comprises two groups of indicators: one related to physical safety and the other for environmental safety.

The three top-ranked cities in this category are Singapore, Sydney, and Hong Kong (Exhibit 28). The cities topping the rankings have very similar performance levels for environmental protection; the key differences between them are observed in the domain of physical safety.

Singapore's leadership can be attributed to the high level of physical safety related primarily to superior road safety rules compliance record and steps taken to disinfect public transport during the COVID-19 pandemic.

Sydney ranks second, slightly behind Singapore, with strong environmental-safety performance. In particular, Sydney is one of the three cities with the best levels of NO_2 concentration in the atmospheric air (about 19 milligrams per cubic meter) and number of trucks relative to GRP (about 330 units per million US dollars of GRP).

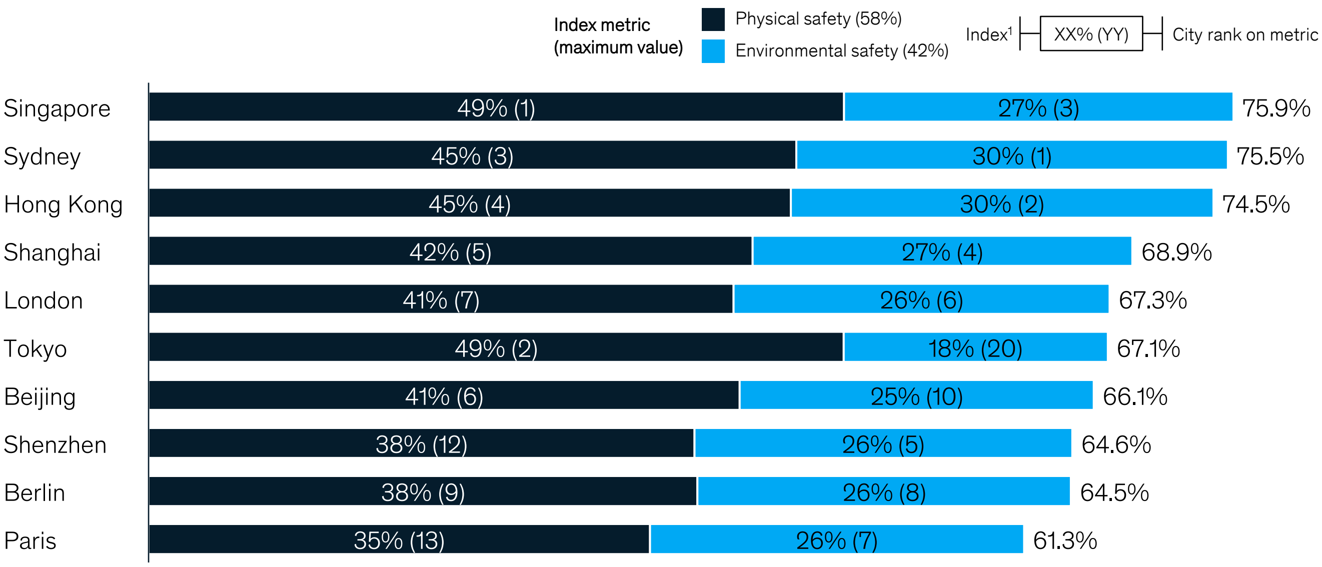
Third-ranked Hong Kong closely follows. The city is slightly behind Singapore with regard to physical safety. Hong Kong has demonstrated second-best environmental-safety performance as Chinese authorities have imposed more stringent car-exhaust requirements (the current standard is Euro 6). The city also sells a high amount of e-vehicles (14 percent of total vehicle sales, putting it in fourth place).

An "ideal" city would be like Singapore in terms of physical safety, like Hong Kong in terms of environmental standards for vehicles, and like Sydney in terms of air pollution and number of trucks.

Exhibit 28

Ten leading cities for Safety and Sustainable Development

Index[1] (city rank on metric)



[1] Components may not sum to total because of rounding.

Change ratings for Safety and Sustainable Development, 2018–20

Change leaders in the Safety and Sustainable Development group have improved city travel safety and environmental situation in their respective cities.

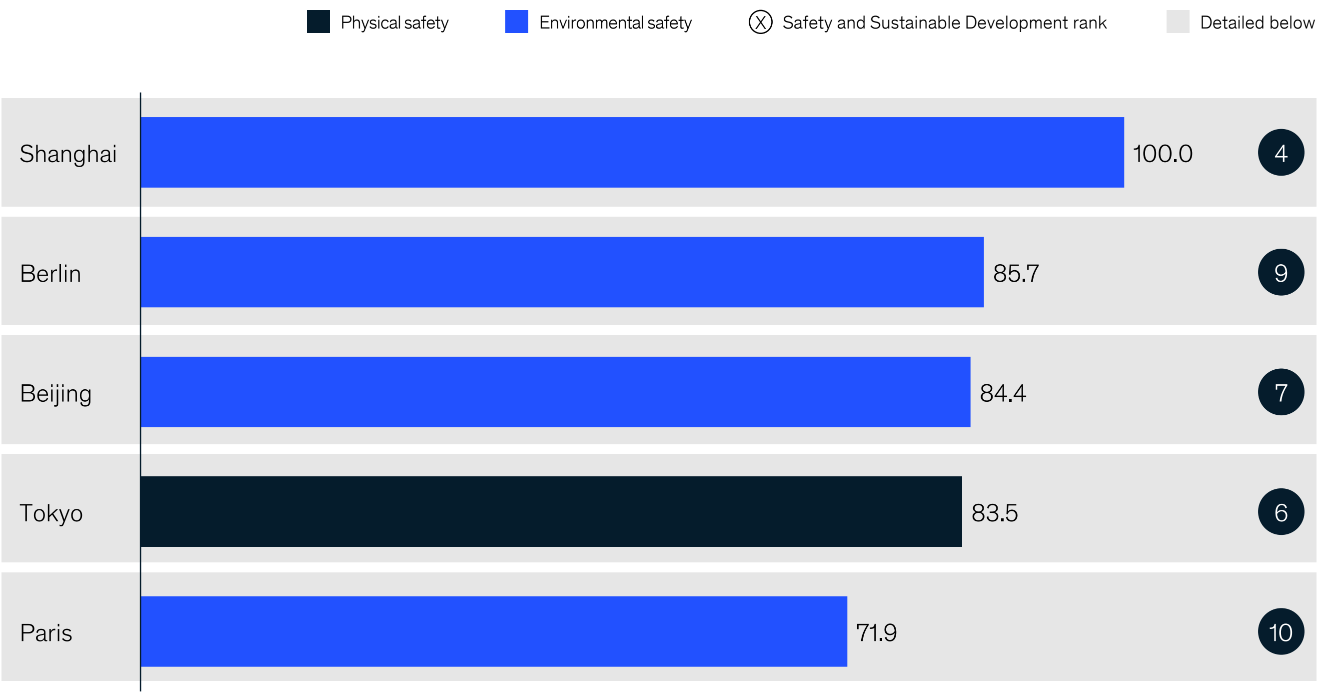
In the physical-safety subgroup, changes were related to the reduced number of road and underground fatalities, as well as active efforts designed to ensure compliance with safety requirements. In the environmental-safety subgroup, improvements were driven by measures designed to reduce environmental pollution, imposition of more stringent restrictions on the use of petrol and diesel engines, and growth in the share of electric vehicles in total vehicle sales.

Change leaders in this rating are Shanghai, Berlin, and Beijing (Exhibit 29). Transformations have enabled Shanghai to move up four levels in the rankings to take fourth place. Shanghai has gone up three levels to the sixth rank. All the leading cities except Tokyo have improved their rating positions primarily due to their better environmental-safety performance.

Exhibit 29

Leading cities with top improvements in Safety and Sustainable Development Index

Change index (maximum change = 100)



Shanghai

Shanghai has become a change leader by increasing the level of environmental safety. The city has earned the best improvement score in this subgroup.

This can be attributed in particular to the growing number of more environmentally friendly motor vehicles. Since 2021, only motor vehicles that comply with the China 6 environmental-safety standard (approximately consistent with the Euro 6 standard) will be permitted for sale in Shanghai and other Chinese cities. The share of vehicles with superior environmental characteristics in total sales has been quite substantial for some time already. In addition, Chinese cities are leaders in the development of electric vehicles (EVs). Shanghai has the highest share of electric car sales.

Another cause of improvement is the general initiatives designed to increase the cost of ownership of motor vehicles and reduce their total number (presence of toll roads in the city, restrictions by car plate or place of car registration, preventive tax or license on car acquisition). Those measures have contributed to the reduction of NO_2 concentration in atmospheric air by 4 percent over the last several years. This has largely become possible because of a sizable decrease of emissions by motor vehicles.

Residents' overall level of satisfaction with metrics in this subgroup has increased by 15 percentage points.

EVs hold a 19 percent share of total vehicle sales in Shanghai

Berlin

Berlin has become a change leader because of improvements in parameters connected with the level of environmental safety.

The biggest changes in the city are associated with the development of electric transport. Over the past three years, Berlin has significantly increased the share of electric cars in total sales (from 1.6 percent to 13 percent).

The support of the authorities contributes to the growth of sales of electric vehicles. Subsidies are allocated to cover part of the cost of an electric car, there is a reduced tax rate on sales for organizations, and the transport tax is abolished for owners of cars in a high environmental class. In addition, a project is being implemented to upgrade the bus fleet with electric buses. In some areas, the movement of vehicles in a low environmental class is prohibited. The low-emission zone covers the center of Berlin inside the S-Bahn.

The city authorities of Berlin have set a goal to completely upgrade the bus fleet with zero-emission buses by 2030

Beijing

Improvement of Beijing's ranking also is attributable to positive changes in the area of environmental safety. China's capital city has taken third place in this subgroup.

Only China 6–compliant motor vehicles are permitted for sale in Beijing. In addition, there are several restrictions on ownership and use of personal motor vehicles.

Over the last several years, NO_2 concentration in atmospheric air has decreased by 3 percent. Beijing, like other Chinese cities, has a high share of electric-car sales: 16 percent. This, among other things, has contributed to residents' satisfaction: the metrics comprising this subgroup increased by 25 percentage points.

Number of annual vehicle registrations in Beijing is up to 100,000

Tokyo

Tokyo has secured change leadership in this group by improving its standing in the physical-safety subcategory, where it is ranked number two among all examined cities.

The authorities of the Japanese capital are taking systemwide steps to improve road safety. Over the last several years, they have conducted a series of information campaigns to attract popular attention to that issue and arranged for the use of smart transport systems to analyze available information. As a result, the number of road fatalities has decreased, while the index for traffic rules compliance has increased.

To make the city even safer, steps are being taken to reduce motor vehicle traffic, including toll management measures. It is anticipated that these restrictions were tightened during the Olympics.

Eighty-nine percent of city residents have noted that they are satisfied with the level of physical safety. This is the fifth-best result among all examined cities.

Tokyo has one of the lowest road fatality levels: 9.6 fatalities per million people

Paris

In the first half of 2020, the authorities of Paris announced a project called "The 15-Minute City," which involves reducing the number of private cars in the city, turning the streets into pedestrian streets, and creating "children's streets" near schools. On some streets, this mode is valid at certain hours (children's streets at the beginning and end of the school day); on others, constantly. The journey time on foot or by bike to the nearest most important infrastructure facilities will be no more than 15 minutes.

Green spaces and playgrounds will substitute for parking spots. By 2024, the city plans to reduce the number of street parking spaces by 72 percent or 60,000 (out of 83,500 parking spaces). The remaining seats will be reserved for residents, employees of organizations, and the disabled (the number of seats for the disabled is not reduced).

In addition, Paris is already implementing a project that allows only pedestrians, public transport, and taxis to move along some city streets. As of this writing, this project involves Rue de Rivoli, the Porte d'Orléans, Boulevard Saint-Michel, Rue Saint-Jacques, and the Etoile Tunnel.

Rue de Rivoli is one of the central and the most congested streets in Paris. On May 11, 2020, the authorities completely restricted the movement of personal vehicles on it, allowing only walking, cycling, and movement on public transport and taxis. (Residents are allowed to drive their own car.) At the entrance to this area are terminals that filter the traffic flow to prevent the entry of unauthorized vehicles.

In 2020, 50 kilometers of roads in Paris were transformed into pedestrian and bicycle roads on a permanent basis

City ranking based on public-transport use

Two separate sub-rankings were made for public and private transport, based on selection of the parameters relevant only for the respective modes.

The assessment of public transport was based on the following groups of metrics: rail transport availability, public-transport affordability, public-transport efficiency, most of the Convenience metrics, and physical safety in public transport.

The three top-ranked cities are Singapore, Moscow, and Beijing (Exhibit 30). First-place Singapore has above-average values in some key metrics. In particular, it rates high in terms of Efficiency (third-best surface public-transport waiting time), Affordability (second-best ratio of cost of one-kilometer taxi ride to average monthly income), and Safety (third-best number of public-transport fatalities).

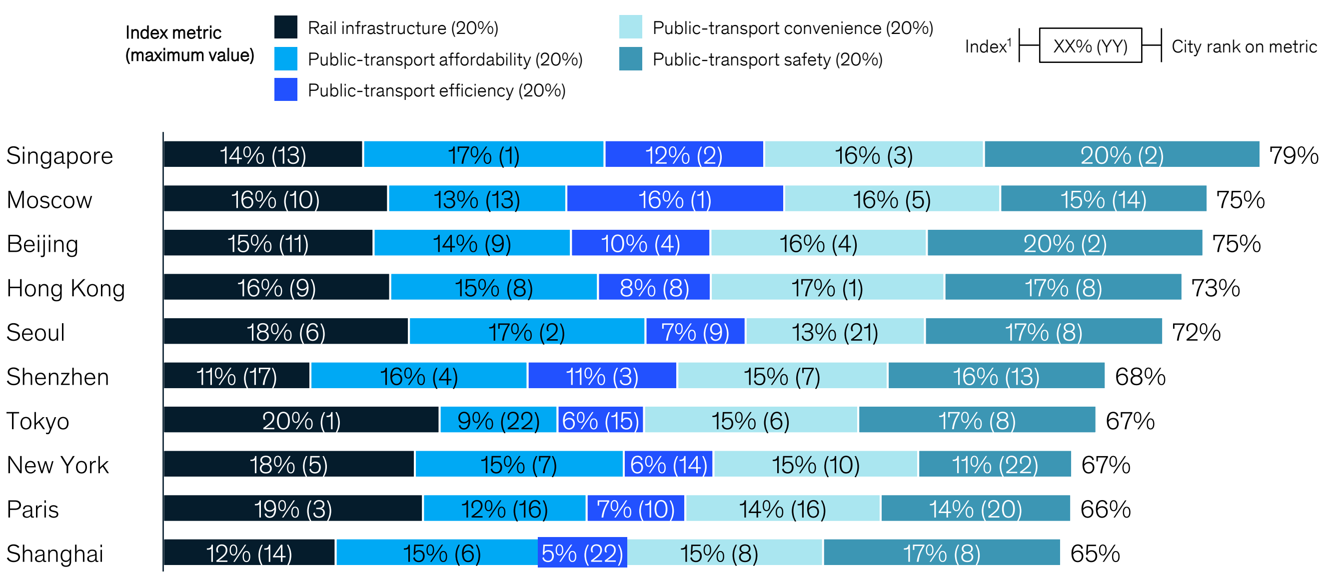
Moscow ranks second, largely because of the high efficiency of its public transport: a large share of public-transport dedicated lanes and high travel speed during the rush hour. The city's bus fleet is rather young (with average bus age of five years), and both surface and underground transport have high rates of internet penetration.

Beijing, ranked third, has the highest levels of public-transport safety. For example, it is one of the four cities with the most efficient disinfection measures taken during the COVID-19 pandemic. Public transport in the Chinese capital also is very efficient, with the share of dedicated lanes reaching 9.4 percent, versus 2.3 percent on average for the other examined cities. Metrics for travel comfort metrics also are quite high: the city has the youngest underground rolling stock among all examined cities (average age, five years). In addition, the ticketing system is very convenient. For example, in Beijing it is possible to pay the fare using biometric technologies, and the Beijing travel card can be used to pay fares in other cities.

Exhibit 30

Ten leading cities for public-transport use

Index[1] (city rank on metric)



[1] Components may not sum to total because of rounding.

City ranking based on personal-transport use

The index of personal-transport use comprises the following groups of metrics: road infrastructure availability and quality, private-transport affordability, private-transport efficiency, online services for private-vehicle users, and road safety. In this analysis, unlike for the rest of the report, we scored private-transport affordability from the user's point of view: "the cheaper the better" reflects the preferences of car users.

The top-ranked cities for personal transport are Los Angeles, Chicago, and Madrid (Exhibit 31). Los Angeles comes out on top because it enjoys high-quality road infrastructure (89 of 100 points) and is one of the leaders in terms of cost of using personal transport (primarily due to low parking fees, averaging about $4 per two hours). Los Angeles is characterized by high travel speed during the rush hour: more than 50 kilometers per hour). This is largely because the agglomeration has an extensive network of high-speed highways.

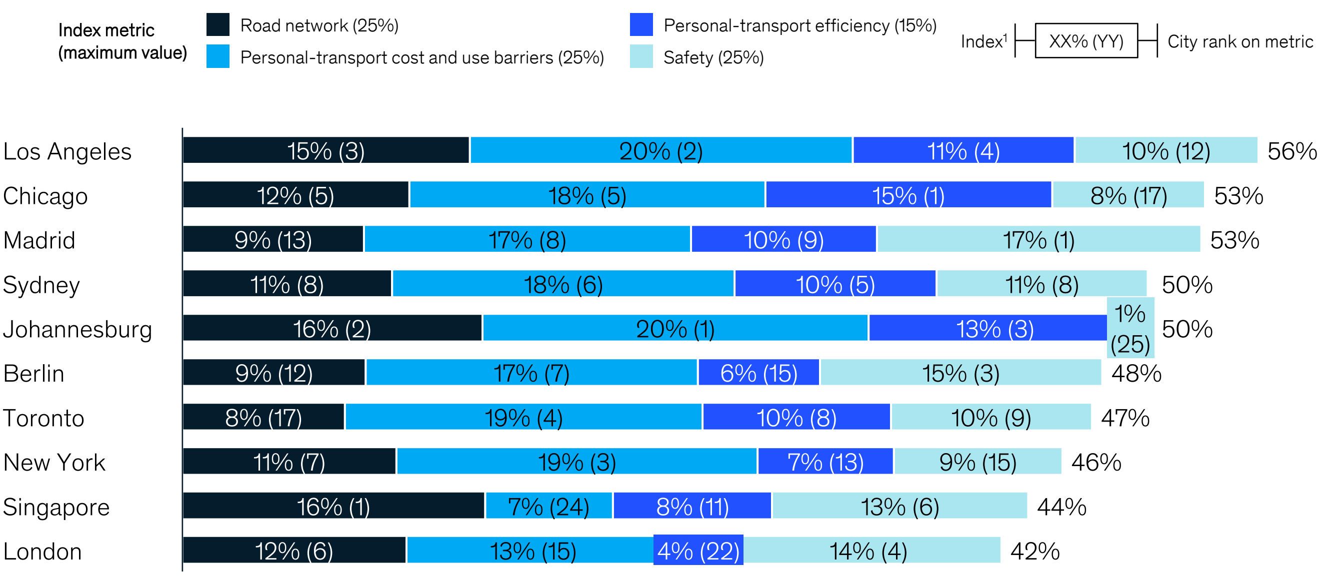
Chicago ranks second. The city has reached this position due to steadily high scores on most metrics under review. Its main difference from the other cities lies in personal-transport efficiency. Chicago is the leader in this group of metrics, as it has one of the highest motor car travel speeds during the rush hour: more than 40 kilometers per hour.

Madrid has taken the third position, largely because of the city's leadership in road safety. Madrid has one of the lowest road fatality levels, which is consistent with very sophisticated legislation designed to maintain road safety. Madrid authorities are actively working on reducing noxious environmental emissions: they have restricted entry in downtown areas during certain times of the day for some categories of vehicles.

Exhibit 31

Ten leading cities for personal-transport use

Index[1] (city rank on metric)



[1] Components may not sum to total because of rounding.

Analysis of specific aspects of transport systems

Rail transport

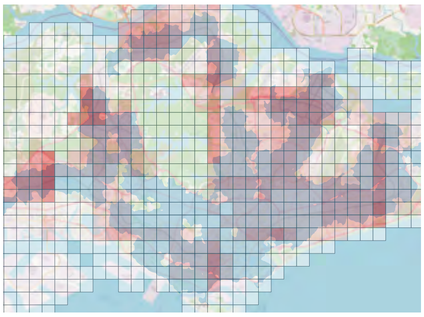
To measure rail transport availability, we assessed pedestrian coverage of underground and commuter train networks. The index of rail transport availability is based on the share of population residing within 30 minutes' walking distance from the nearest underground or commuter train station and the share of workplaces located at the same distance. When measuring both metrics, we took into consideration the existence of actual pedestrian routes that can be used to reach the relevant stations.

Among the examined cities, the three top-ranked cities for rail transport availability leaders are Tokyo, Madrid, and Paris (Exhibit 32). In those cities, rail transport pedestrian availability areas cover more than 80 percent of total population and more than 94 percent of total workplaces.

In most examined cities, residents are satisfied with rail transport availability, and satisfaction levels are generally consistent with objective metrics. However, in some leading cities, including Tokyo, Paris, and Buenos Aires, the level of satisfaction with the transport system proved to be much lower than it should be based on objective metrics.

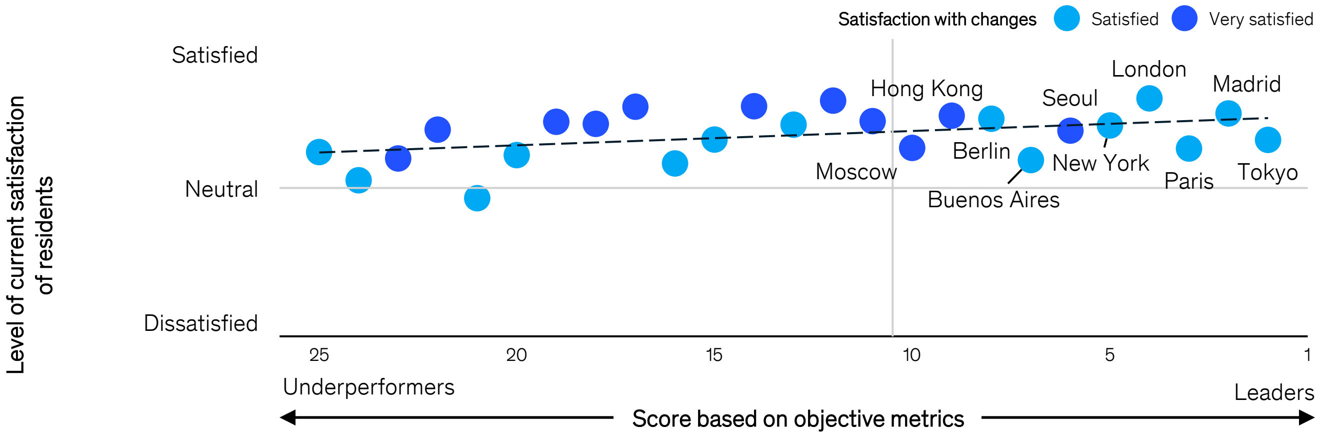
We also see that, with the exception of Moscow, Hong Kong, and Seoul, the level of satisfaction with changes in the cities with the best objective metrics is somewhat lower than in the midranked cities (such as Singapore, Sydney, and Shanghai). This assumption is supported by data on large-scale projects in those cities. For example, Sydney's first underground line (13 stations) was opened in 2019. Its launch became a landmark event: implementation of the construction project took three years. The line is part of a bigger project envisaging construction of an underground network capable of carrying up to 40,000 passengers per hour. It is expected that all 31 stations will have been opened in 2024.

Availability
Rail transport
Road network
Shared transport
External connectivity



In this geospatial analysis of Singapore, rail transport covers 83 percent of city's total population

Exhibit 32
Perception and reality: Rail transport availability



Road network

The road network assessment was based on metrics critical for various types of users, including motor vehicles, surface public transport, cyclists, and pedestrians. The road network index comprises five metrics: road network area per motor vehicle, motor vehicle infrastructure cohesion index, pedestrian infrastructure cohesion index, road network quality index, and share of bicycle lanes in total road network length.

The top-ranked cities for road network development are Milan, Paris, and London (Exhibit 33). In those cities, the road network is best adapted to the needs of various road traffic participants: the motor vehicle infrastructure cohesion index does not exceed 1.48, and the pedestrian infrastructure cohesion index does not exceed 1.45.

Residents of the cities in the upper half of the ranking table are satisfied with the current situation and take a positive view of relevant changes. Residents of the remaining cities have a neutral or negative attitude toward the current state of their road networks.

Generally, objective and subjective assessments are correlated, with some notable exceptions. For example, city residents in Asia have a propensity to assess the state of the road network more positively, while people in Latin America and Africa take a more skeptical view.

Availability

Rail transport

Road network

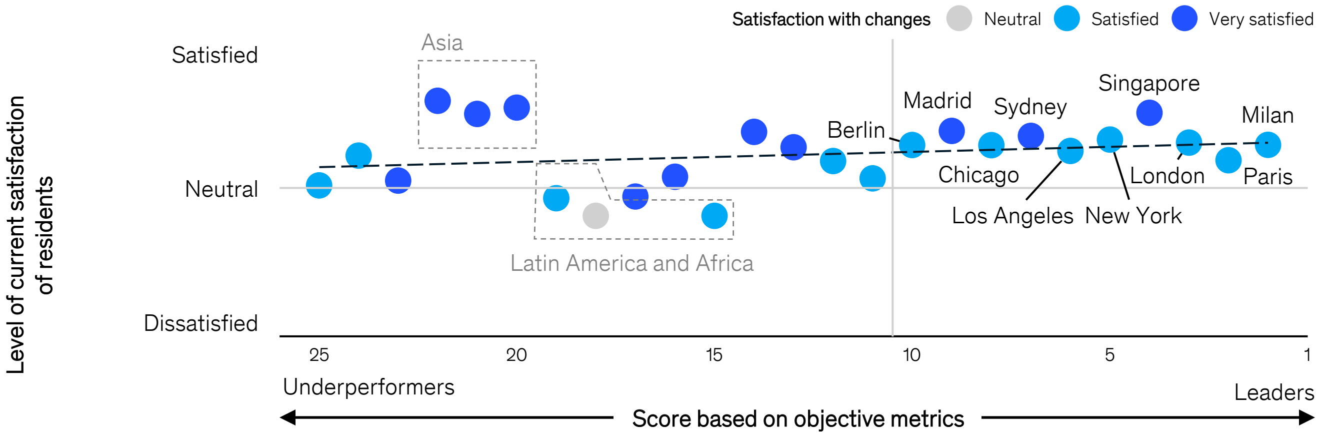
Shared transport

External connectivity

Tokyo has the largest road network area per motor vehicle (68 square meters). The picture shows the downtown area between the Tokyo Imperial Palace and the Sumida River

Exhibit 33

Perception and reality: Road network



Shared transport

Over the last several years, the role of shared transport has increased significantly, as has its availability to city residents. The shared-transport index comprises two metrics: the number of cars used by car-sharing services and the number of bicycles used by public bicycle rentals. Both indicators were scaled per million people to enable a comparison of cities of different sizes. Limits were set on the maximum useful number of motor vehicles and bicycles to make sure that they support demand without creating excessive load on the city transport system.

Shared-transport leaders among the examined cities are Beijing, Berlin, and Shanghai (Exhibit 34). In those cities, there are more than 500 rented cars and more than 3,000 rented bicycles per million people.

Objective metrics observed in the cities are generally consistent with public perceptions. However, residents of Berlin display a lower level of satisfaction with the current situation than might be expected based on objective data.

In almost every city, residents note that large changes have occurred over the last several years. Residents of the cities in the top half of the ranking table based on objective metrics in this subgroup are also satisfied with the current situation. The only exception is Moscow, where residents say there are not enough bicycle rentals in the city, although people note improvements in that area. Still, Moscow has considerably expanded its bicycle rental network: about 2,900 new bicycles have been purchased over the last three years, and 119 new bicycle rental stations have emerged in 2020 alone.

Availability

Rail transport

Road network

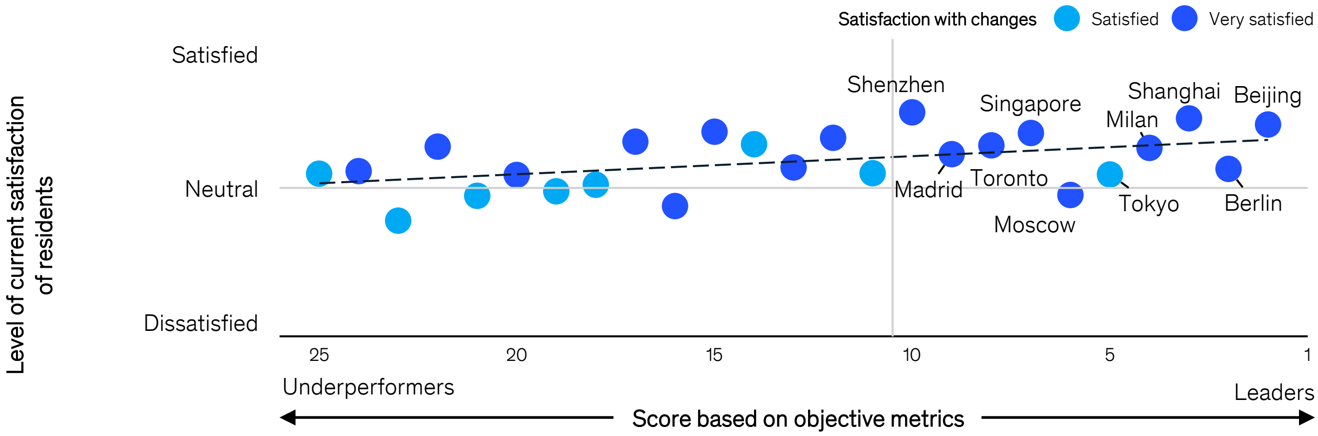
Shared transport

External connectivity

More than 5,000 bicycles per million people are available for rent in Beijing

Exhibit 34

Perception and reality: Shared transport



External connectivity

To assess external connectivity, we used the number of destinations served by each city's airports.

External Connectivity leaders among the examined cities are London, Paris, and Moscow (Exhibit 35). Airports of those cities serve more than 300 domestic and international destinations.

In addition, we note a positive correlation between the objectively measured level of external connectivity and the level of satisfaction with that aspect: as external connectivity improves, so does city residents' satisfaction. Moscow and Paris are the two exceptions in that respect among the leaders. In those capitals, residents' level of satisfaction with the current situation is lower than in many other cities, despite the high objective metric.

This assumption is supported, among other things, by the Charles de Gaulle Airport modernization project. It involved a massive upgrade of Terminals 2B and 2D and of waiting areas of the busiest Terminal L and the construction of a passage joining Terminals 2B and 2D, enabling a passenger flow increase to 80 million people per year. Yet Paris has, with London, posted the lowest level of satisfaction with changes among the leading cities.

Availability

Rail transport

Road network

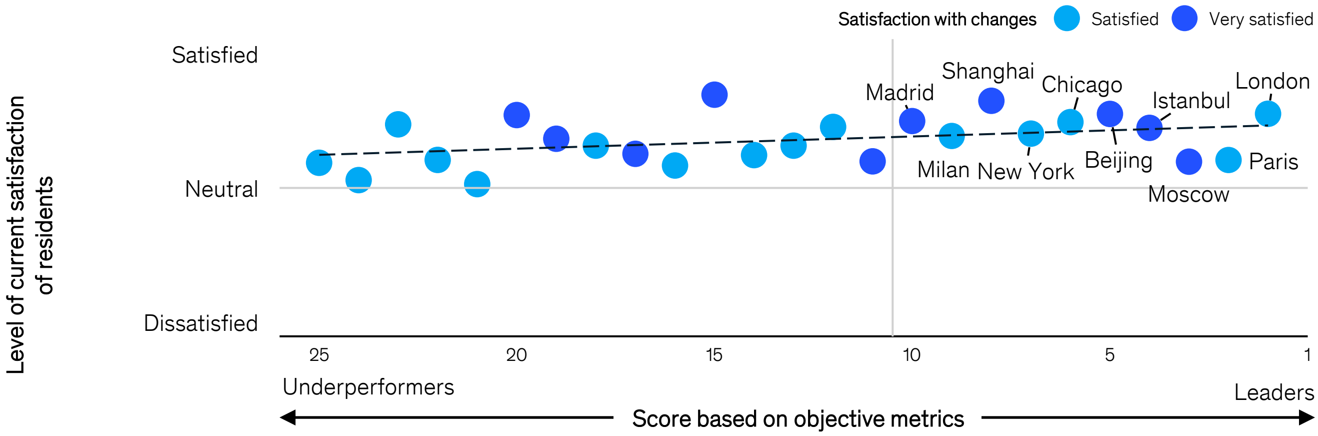
Shared transport

External connectivity

London has the largest number of daily flight destinations: more than 450

Exhibit 35

Perception and reality: External connectivity



Public-transport affordability

To assess public-transport affordability, we looked at monthly travel card prices and taxi fare per kilometer relative to average individual income level of city residents and at the number of passenger categories entitled to fare discounts.

The leaders in public-transport affordability among the examined cities are Singapore, Seoul, and Los Angeles (Exhibit 36). Seoul has the lowest monthly travel card price relative to individual income, while Singapore has the second-lowest taxi fares relative to individual income. Los Angeles demonstrates "even" results—that is, without extremes in any one aspect.

City residents' attitudes about public-transport affordability are generally rather negative, and that attitude is typical for most cities. Moreover, residents of a third of all examined cities are dissatisfied with changes in that area. a high level of satisfaction with changes is noted in only four cities, of which three are in China. Seoul stands out among the leaders: its residents are dissatisfied with the current situation despite the city's good performance based on objective metrics.

Affordability

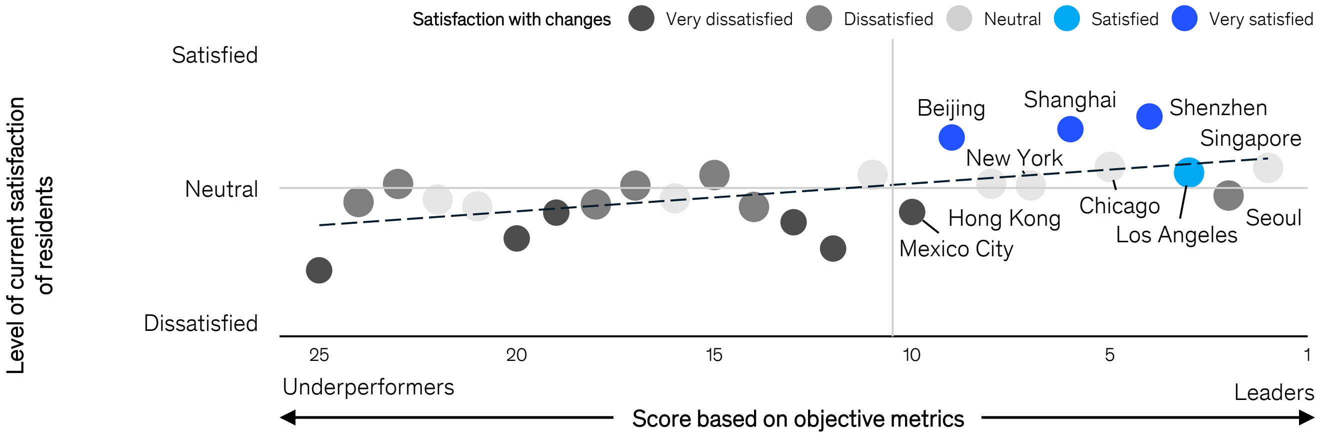
Public-transport affordability

Personal-transport cost and use barriers

In Singapore, the taxi fare per kilometer is $0.60

Exhibit 36

Perception and reality: Public-transport affordability



Personal-transport cost and use barriers

This index of personal-transport cost and use represents the costs associated with the use of personal transport and the restrictions imposed on its owners in the examined cities. It takes into account the following factors: existence of fees charged for entering the city or specific districts, ratio of average two-hour parking fee to average individual income level, and total number of restrictions related to owning a motor vehicle (requirement to have a parking space, additional car purchase tax, etc.). The highest ratings went to cities where the real costs associated with personal-transport ownership are determined from a public perspective and financial barriers on the use of such transport are imposed subject to such costs.

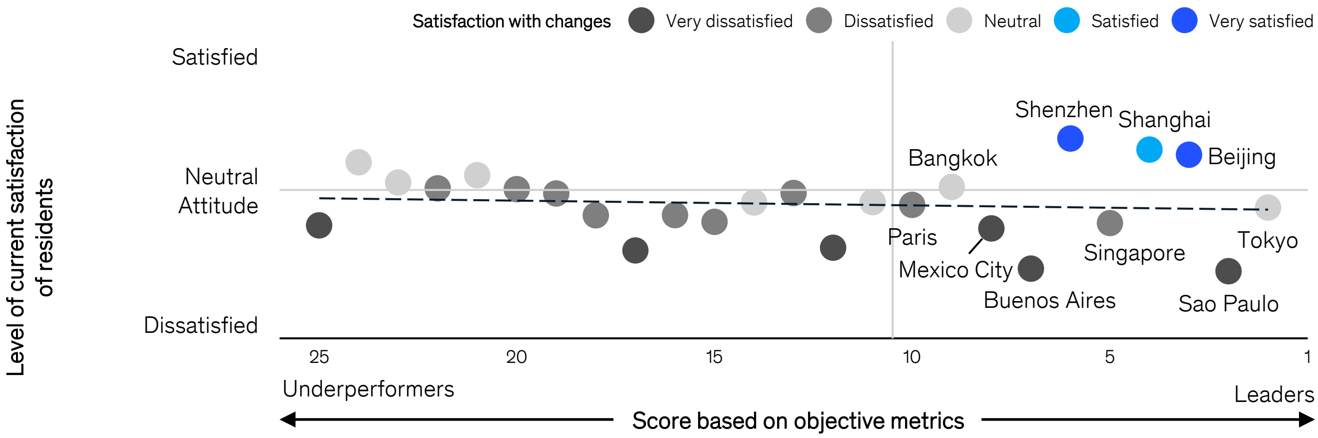
The leaders in personal-transport cost and use barriers among the examined cities are Tokyo, São Paulo, and Beijing (Exhibit 37). In São Paulo, the two-hour parking fee relative to average individual income level is the highest among examined cities. Tokyo and Beijing have imposed onerous restrictions on personal-transport owners. The capital of Japan is the only city covered by our study where anyone wishing to purchase a motor car must have an individual parking space. Beijing regularly holds license plate acquisition lotteries. However, at the end of 2020, the Chinese government called on city administrations to relax those restrictions in order to support the local automotive industry and help it overcome the aftermath of the COVID-19 pandemic. Beijing authorities responded by adding to the lottery pool another 20,000 license plates for hybrid vehicles and EVs.

Objective metrics of the examined cities are inversely correlated to subjective perception of the current situation by city residents. This is logical, as they are forced to pay for the right to use their personal transport over and above its purchase price. In US cities, the level of satisfaction is above average, even though restrictions are among the least stringent among the examined cities. Chinese cities stand out, as the level of satisfaction with the current situations and its recent changes is rather high despite the existence of considerable restrictions.

London has the highest parking fees among the examined cities: about $12 for 2 hours

Exhibit 37

Perception and reality: Personal-transport cost and use barriers



Public-transport efficiency

Efficiency

Public-transport efficiency

Personal-transport efficiency

The public-transport efficiency index shows the speed and predictability of movement across the city. It comprises the following metrics: average public-transport travel speed during the morning rush hour, average surface transport waiting time, underground-train waiting time index, and share of dedicated public-transport lanes in total road network length.

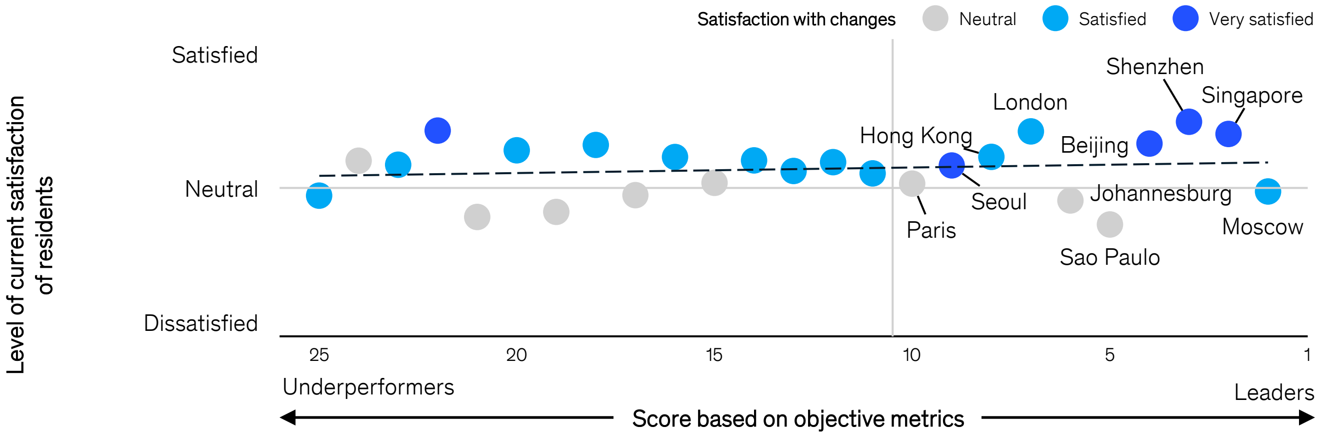
Public-transport efficiency leaders among the examined cities are Moscow, Singapore, and Shenzhen (Exhibit 38). Moscow has the third-best average public-transport travel speed during the rush hour and, together with Shenzhen, is part of the top three in terms of the share of dedicated bus lanes. About 100 kilometers of dedicated lanes have been put in operation in the Russian capital over the last three years, and this is one of the reasons for the high average public-transport travel speed noted in our study. Singapore has demonstrated excellent surface transport waiting times, ranking third for this metric.

City residents' level of satisfaction of and the objective results posted by the cities in this subgroup are generally positively correlated. In most leading cities, residents are satisfied or very satisfied with improvements in public-transport efficiency. Moscow is a notable exception from that rule: despite its star-quality objective performance, Muscovites' level of satisfaction with the current situation is rather low. Johannesburg and São Paulo are similar in that their residents have failed to notice significant changes and see the current situation in a more negative light than residents of most other cities.

The length of dedicated bus lanes in Shenzhen is 1,057 kilometers

Exhibit 38

Perception and reality: Public-transport efficiency



Personal-transport efficiency

To assess personal transport efficiency, we have used the following metrics: average traffic flow speed, time en route predictability index during the morning rush hour, traffic congestion index, and time lost in traffic jams per motor vehicle trip.

Personal-transport efficiency leaders among the examined cities are Chicago, Shenzhen, and Johannesburg (Exhibit 39). In Chicago, the traffic congestion index is one of the lowest, while travel speed is one of the highest, reaching 40 kilometers per hour, versus an average 28.6 kilometers per hour for all examined cities. This is one of the reasons why Chicago has one of the lowest indicators of time lost in traffic jams (about three minutes on average). As for the other leading cities, Shenzhen has a high index for time en route predictability during the morning rush hour, and Johannesburg boasts high average personal-transport travel speed during the rush hour (46 kilometers per hour).

We note a strong positive correlation between objective personal-transport efficiency metrics and city residents' level of satisfaction with that aspect. One notable exception is Buenos Aires, where residents have a rather low level of satisfaction with both the current situation and the recent changes.

In addition, unlike in the other subgroups of metrics, this one has a rather high share of respondents who fail to note occurrence of any changes over the last three years. This may testify to the fact that traffic congestion in the examined cities is still high, and that remains a concern for city residents. Indeed, the average traffic congestion index for all cities has increased from 1.39 in 2018 to 1.43 in 2021.

Efficiency

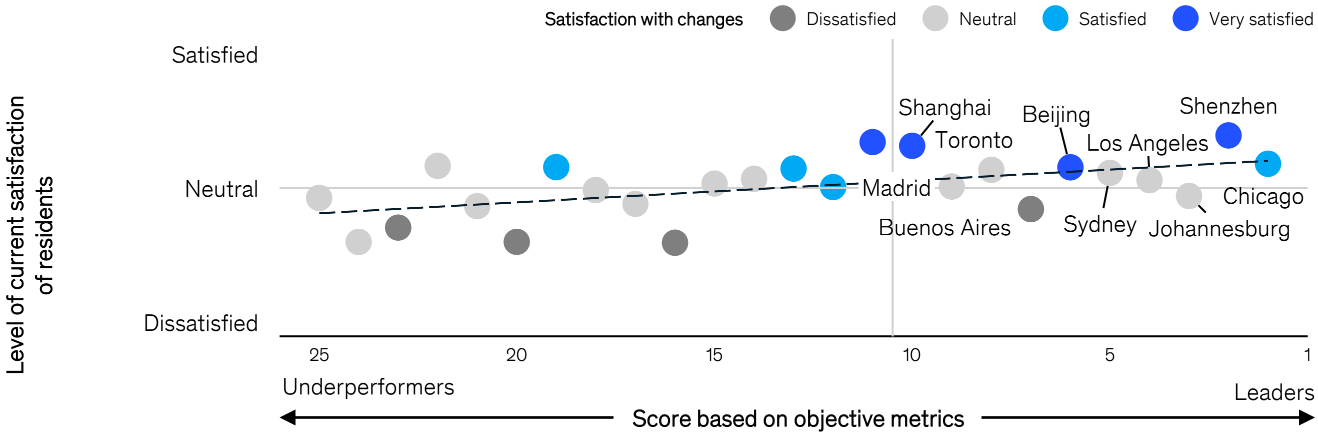
Public-transport efficiency

Personal-transport efficiency

To reduce traffic congestion, New York authorities charge drivers a special fee for entering certain city districts

Exhibit 39

Perception and reality: Personal-transport efficiency



Travel comfort

The travel comfort index measures convenience of using public transport. It includes the following metrics: bus fleet age, age of underground rolling stock, and share of buses and underground stations accessible to persons with reduced mobility.

Leaders in travel comfort among the examined cities are Beijing, Istanbul, and Toronto (Exhibit 40). Beijing and Toronto have the newest underground rolling stock, and Istanbul has one of the newest bus fleets.

The Chinese capital deserves special mention, as it is actively modernizing both buses and underground train cars. The city has a plan to convert its bus fleet to clean energy sources, and about 3,000 environmentally friendly buses have already been deployed within the framework of that plan.

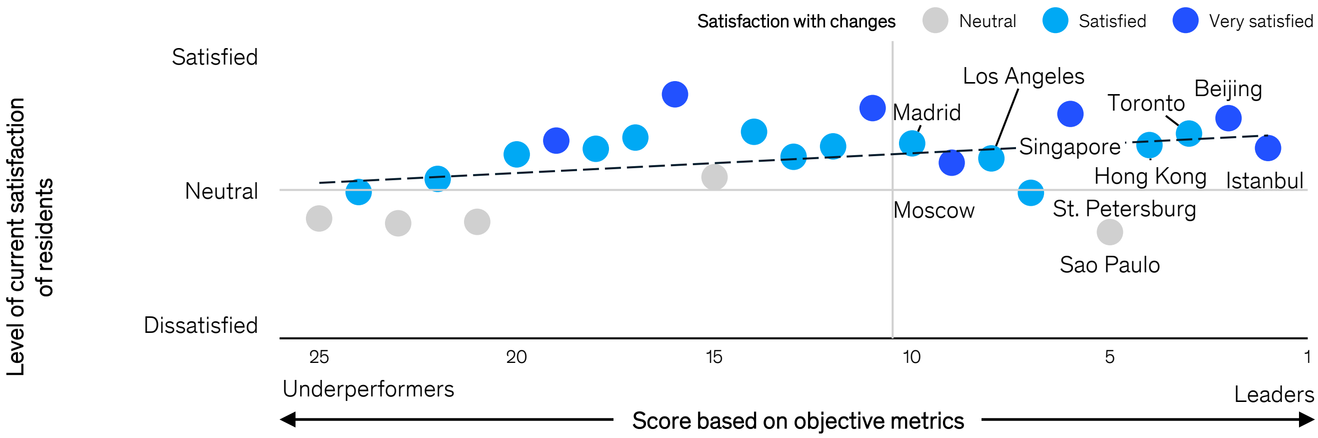
Concurrently, new train models are being put in operation. For example, in 2019, BDK06 trains were launched on the Batong line. On some trains, LCD displays with route progress information have been installed for the first time.

Residents of most leading cities are satisfied with travel comfort improvements. Positive perceptions are supported by objective metrics. This does not apply to Latin American cities, primarily Buenos Aires, and São Paulo, where city residents have rather low levels of satisfaction with both the current situation and recent changes.

The average age of the Istanbul bus fleet is five years

Exhibit 40

Perception and reality: Travel comfort



Ticketing system

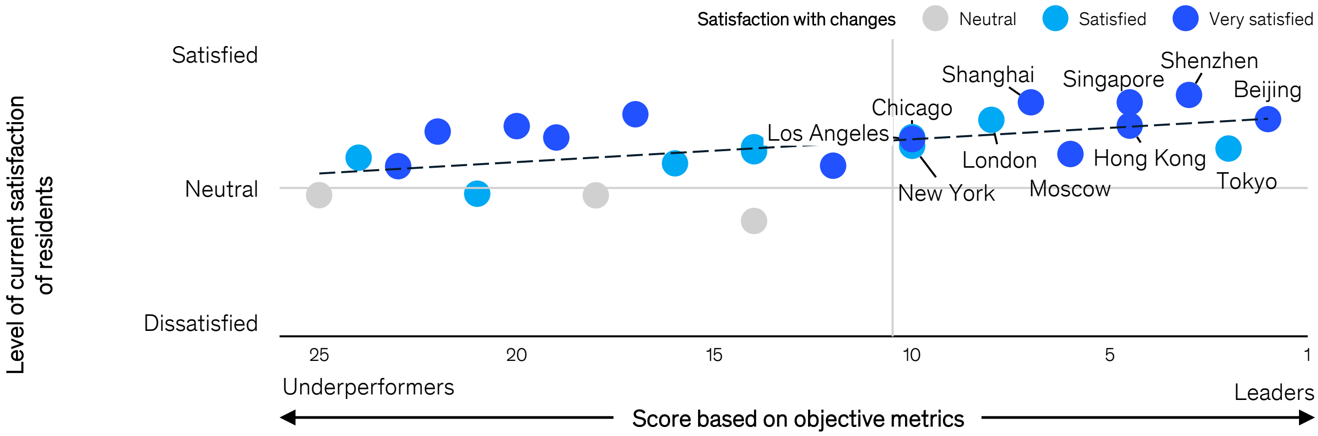
In our assessments of ticketing systems, we relied on travel card use data and availability of alternative payment options. Index measurement was based on the following metrics: possibility to use smart travel cards on multiple modes of public transport, possibility to top up travel cards remotely, possibility to pay using biometric data, possibility to use travel cards to pay for nontransport services, etc.

The top three index values were registered in Beijing, Tokyo, and Shenzhen (Exhibit 41). In all those cities, it is possible to use travel cards to pay for nontransport services and to use mobile devices to pay fares. However, what truly makes the cities stand out is that they have implemented technologies enabling fare payments using biometric data. For example, a face-scan fare payment system has gone online in Shenzhen. Passengers can have their faces scanned while they are passing the turnstile, and later the fare is automatically debited from their personal accounts. a similar system is being tested at four underground stations in Tokyo.

All in all, the level of satisfaction with changes and the current situation is strongly correlated with the objective metrics. Residents of all leading cities are satisfied both with the current state of their ticketing systems and with the recent changes in that area. The five cities with the greatest satisfaction with changes are Asian cities, where public perceptions are consistent with outstanding objective metrics.

Passengers report that it takes less time to enter the station using the new system than before, when they had to place a card or smartphone over the reader

Exhibit 41
Perception and reality: Ticketing system



Electronic services

Convenience

Travel comfort

Ticketing system

Electronic service

Intermodality

In the course of our analysis of electronic services implemented in various cities, we assessed transport applications, real-time availability of transport-related information, and availability of high-speed internet on vehicles and at stops. In particular, we reviewed the following metrics: average rating of official transport applications, penetration rates of the most popular applications, and Wi-Fi availability on trains, at underground stations, on buses, and at bus stops.

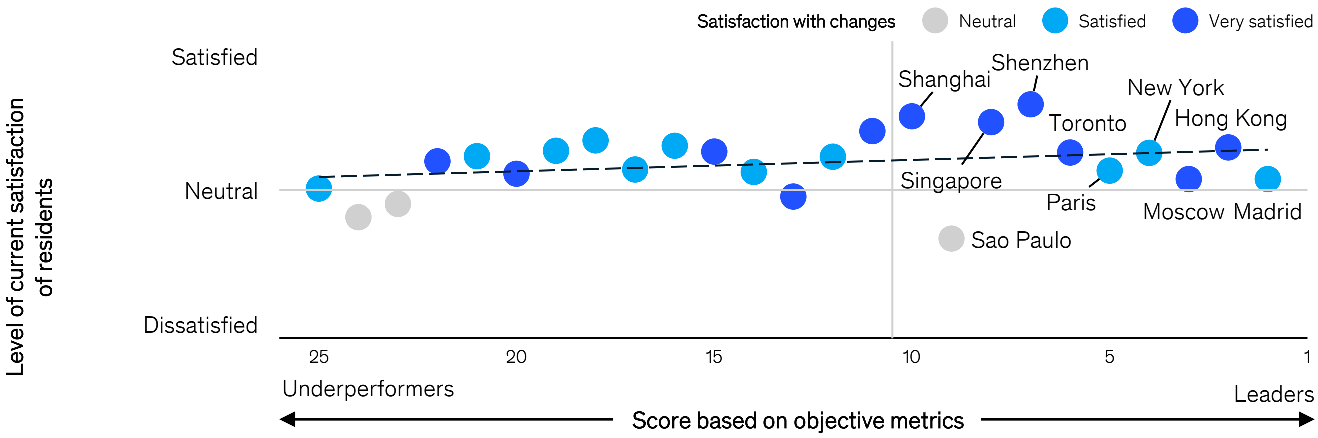
The electronic-services leaders among examined cities are Madrid, Hong Kong, and Moscow (Exhibit 42). Madrid and Moscow have rather sophisticated official transport applications, as confirmed by high user ratings and high download numbers. In addition, high-speed internet is available at bus stops and on buses in all leading cities.

Residents of most cities are generally satisfied with changes in electronic services, which is consistent with objective metrics. The exceptions are three Latin American cities: Buenos Aires, Mexico City, and São Paulo. Despite the low level of satisfaction with the current situation and changes in electronic services, São Paulo is part of the top ten for this group of metrics. As with certain other subgroups of metrics, Asian cities post the highest levels of satisfaction with the current situation.

In the Moscow Metro, Wi-Fi works even between stations

Exhibit 42

Perception and reality: Electronic services



Intermodality

To assess intermodality, we used metrics measuring convenience of switching from one mode of transport to another. The index comprises the following metrics: average distance from an underground station to the three nearest surface transport stops, average time required to switch from one mode of public transport to another, and availability of unified public-transport navigation for passengers.

The intermodality leaders among the examined cities are Toronto, Chicago, and Milan (Exhibit 43). In all those cities, it takes less than one minute to switch from one mode of public transport to another, while the average value across all examined cities reaches two minutes. Toronto also boasts the shortest distance from an underground station to the three nearest surface transport stops: less than 90 meters, versus the average of 135 meters.

In all but one city, residents are satisfied with intermodality changes. Similarly, in most cities (except two), the current situation is perceived in a positive way. Those perception data are consistent with objective metrics. In two Latin American cities (Buenos Aires and São Paulo), the level of satisfaction with the current situation and recent changes is rather low, even though the capital of Argentina is one of the top ten cities in this subgroup of metrics.

Convenience

Travel comfort

Ticketing system

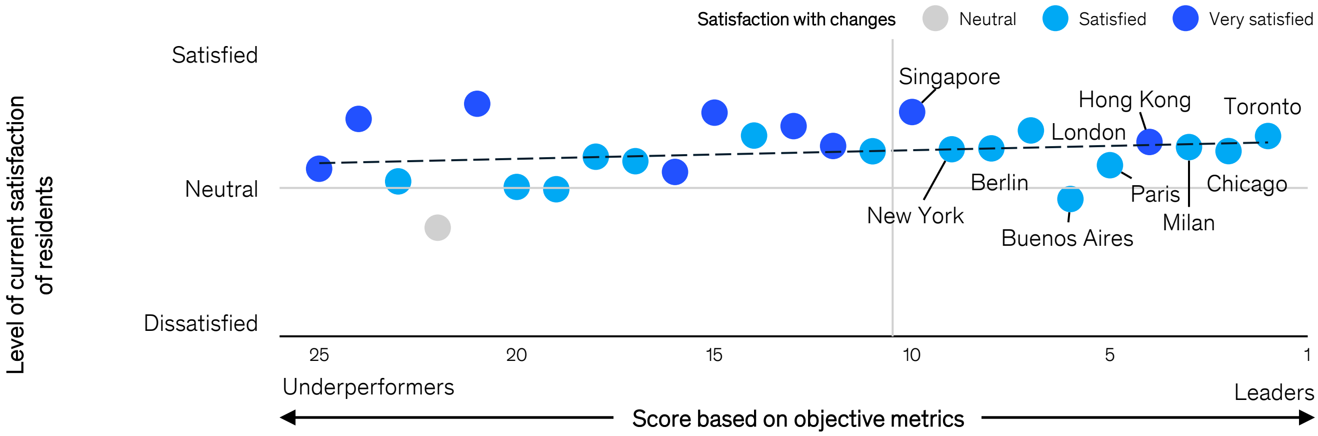
Electronic service

Intermodality

Chicago has one of the highest intermodality levels among the examined cities

Exhibit 43

Perception and reality: Intermodality



Physical safety

To assess physical safety, we analyzed the following metrics: number of traffic accident fatalities on public roads per million population, public-transport disinfection measures, number of underground accident fatalities, and safety rules compliance index.

The leaders in this subgroup are Singapore, Tokyo, and Sydney (Exhibit 44). For example, Singapore and Hong Kong have excellent scores for safety rules compliance, while Tokyo has the lowest number of traffic accident fatalities per million people: 9.5, versus the average of 34.

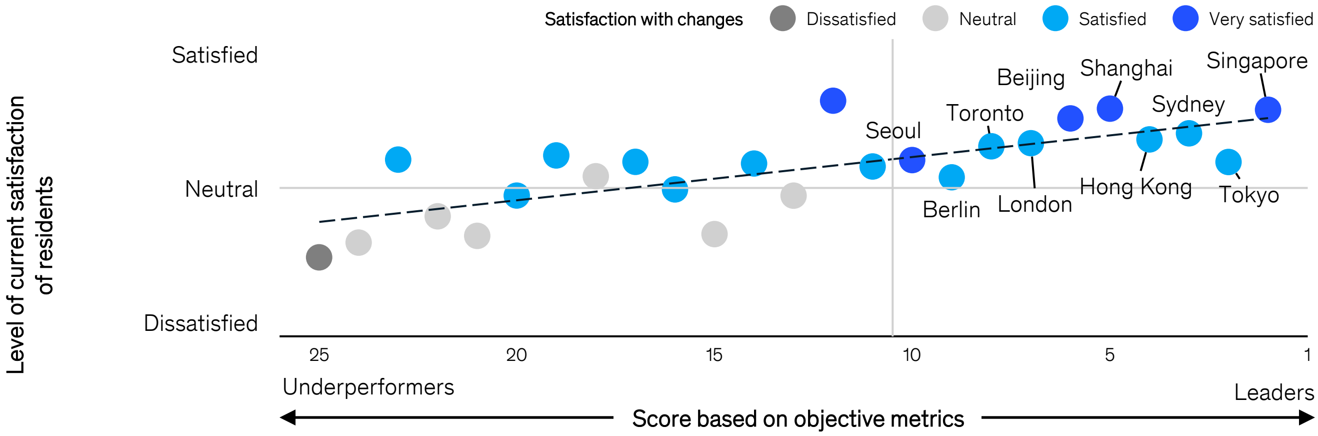
Objective metrics for the physical-safety index have a strong positive correlation with city residents' level of satisfaction with the current situation in that area. Satisfaction increases as relevant metrics improve. Thus, in cities with superior objective metrics, the level of satisfaction with physical safety is generally higher.

Curiously, dissatisfaction with changes is particularly noticeable in cities with the worst physical-safety index values. Residents of those cities are also dissatisfied with the current situation.

A speed limit of 30 kilometers per hours is in effect on more than 80 percent of Madrid's streets

Exhibit 44

Perception and reality: Physical safety



Environmental safety

The environmental-safety index enables informed judgments about the extent of safety of transport moving along city roads. The index comprises the following metrics: average age of motor vehicles on the roads, availability of diesel and petrol fuel quality standards, index of commercial transport regulation maturity, share of electric-vehicle sales, availability of subsidies or incentive programs to promote transition to environmentally friendly fuels and EVs, etc .

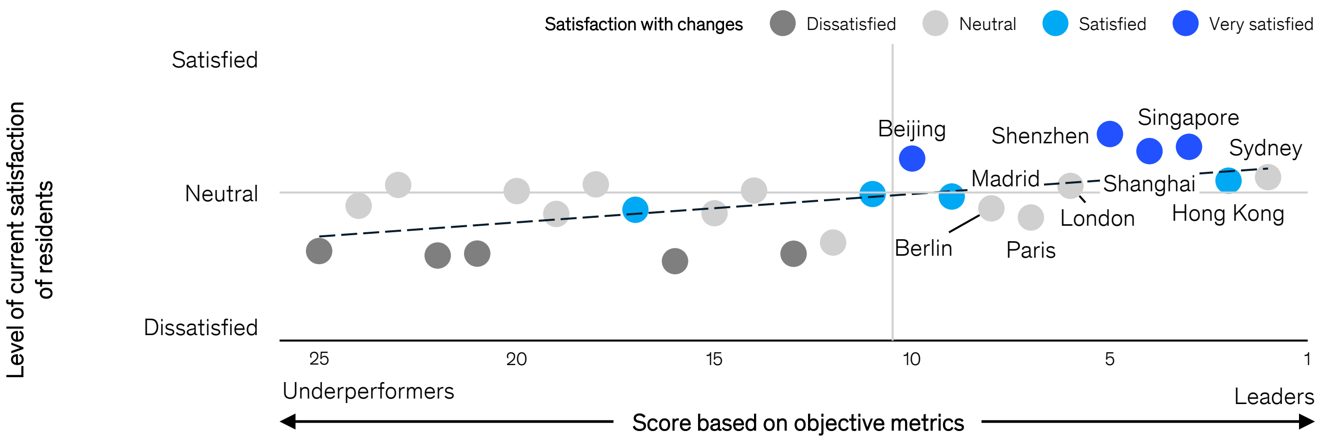
Environmental-safety leaders among the examined cities are Hong Kong, Sydney, and Singapore (Exhibit 45). Hong Kong and Singapore boast the lowest age of cars on the roads: five years in Hong Kong and 5.4 years in Singapore. In addition, Hong Kong has one of the highest shares of EV sales in total car sales (14 percent). Sydney is characterized by a low concentration of NO_2 in atmospheric air (4.97×10^{15} molecules per square centimeter) and a low number of commercial vehicles registered in the city (328 per $1 billion of GRP based on purchasing power parity).

City residents are generally dissatisfied with the current situation and recent changes. Asian cities are an exception to that general rule. There is a positive correlation between objective metrics and city residents' level of satisfaction: in cities with inferior objective metrics, residents are usually dissatisfied with both the current situation and recent changes.

Madrid has acquired 520 new compressed-natural-gas (CNG) buses

Exhibit 45

Perception and reality: Environmental safety



Impact of the COVID-19 pandemic

COVID-19's impact on urban transport systems

The COVID-19 pandemic has drastically changed habitual living conditions, ways of thinking, and human behavior, especially in the urban environment. The implications of the pandemic are not limited to introduction of lengthy lockdowns, advancement of remote working formats, and a ubiquitous decline in social activity. The pandemic has affected, quite literally, all domains of economic and public life, including the operation of urban transport systems.

At this time, we are observing several key trends:

— lower mobility with an increasing share of private cars in the modal split of most transport systems

— lower popularity of public transport, as it is more frequently perceived as associated with risks of COVID-19 infection

— declining revenue of transport systems due to lower mobility and, therefore, inevitably poorer service in urban public transport

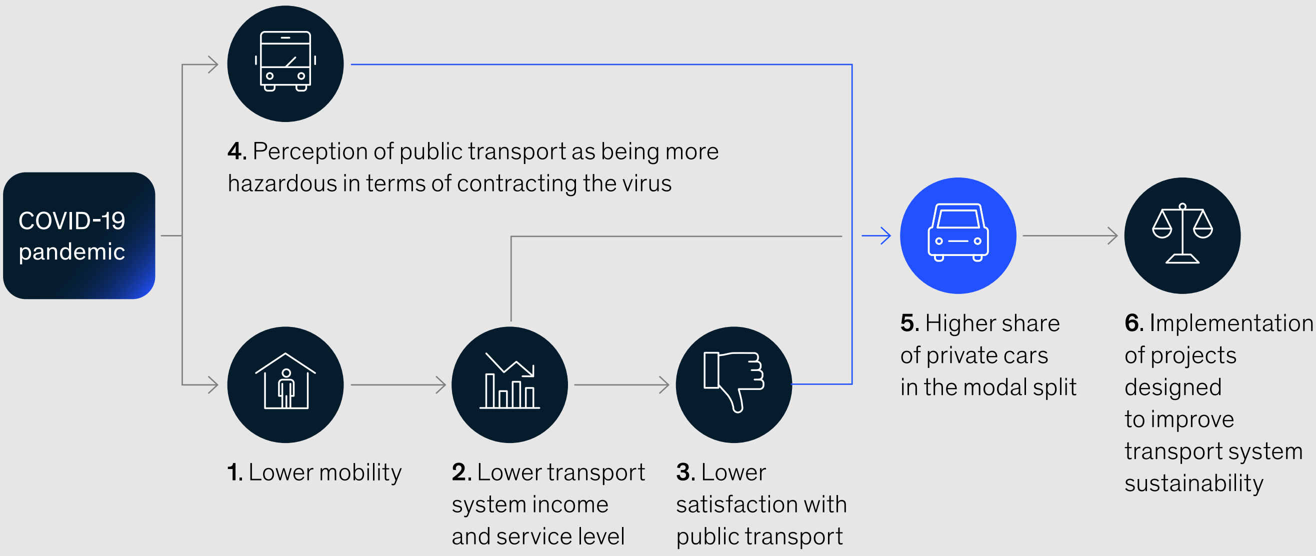
In the long run, these trends may lead to further growth in the number of private cars on the roads, which will place an additional burden on transport systems and cause an even more substantial decrease in the ticket revenue of public transport. We anticipate that city governments will respond with projects designed to improve the sustainability of their transport systems.

Exhibit 46 lays out the interaction of these trends in terms of six key insights.

This section discusses the key short-term and long-term trends engendered by COVID-19, presents a comparative description of measures taken by city authorities to combat COVID-19 (showing how city residents perceive those measures), and identifies the key activities carried out in cities to assure long-term sustainable development of their transport systems.

Exhibit 46

Impact of COVID-19: Key insights



1. Restrictive measures and an increased share of remote employment resulted in much lower mobility (hereinafter, mobility shall mean the number of trips). Thus, at the peak of restrictions, the average mobility of residents in the examined cities was just 32 percent of the level recorded before the pandemic outbreak. At the time of this writing, mobility has not recovered fully; in the examined cities, it averages merely 69 percent of the level observed before the pandemic. Considering an ever-greater spread of remote working formats, one may also presume that mobility might not recover even after the pandemic is over.

2. Since people now use public transport less frequently, giving preference to their private cars, ticket revenue of transport systems covered by the study has dropped by 37 percent on average, which made some administrations reduce public-transport service levels.

3. As follows from data on the eight cities we examined, the lower the level of service, the lower city residents' satisfaction with public transport and its popularity. This drives up the share of private cars in the modal split. In the cities where the level of service is the same or growing, however, we observe a less notable decline in the share of public transport in the modal split.

4. City residents believe the risk of viral infection in public transport is much higher than in a private car. Thanks to safety measures and competent communication with the people, some city authorities have been able to soften perception of public transport as a "hazard" and have sustained its popularity during the pandemic.

5. As private cars are perceived to be safer and people are less satisfied with public transport, the share of private cars in the modal split in the examined cities has grown from 40 to 48 percent on average. In a poll of city residents, most of them indicated that they will remain active users of their private cars after the pandemic. With a further decrease in the share of remote employment, this trend may lead to serious adverse effects, including lower efficiency of transport systems and higher early-death rates.

6. Sustainable development of urban environment will be facilitated by projects designed to reduce the use of private cars and popularize the modes of travel associated with physical activity (walking, cycling, etc.).

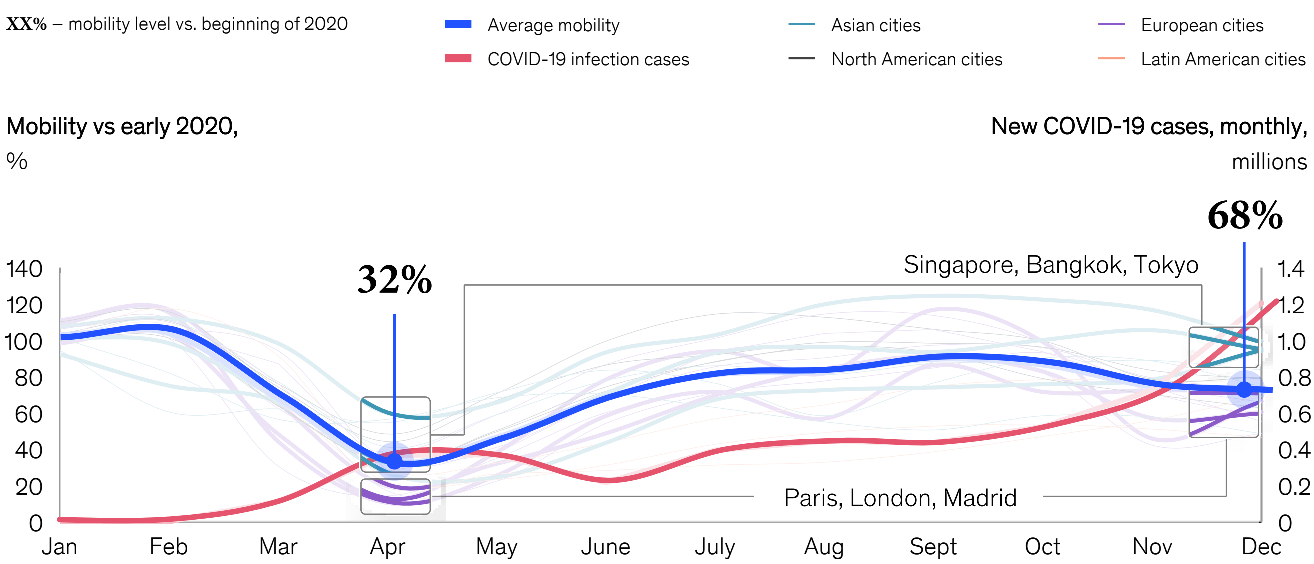
COVID-19's impact on city residents' mobility structure

The COVID-19 pandemic has led to a systemic shift in residents' mobility structure. At the peak of restrictions, mobility in the examined cities averaged 32 percent of the level observed in early 2020.

Because of the increased number of employees working remotely and the imposition of repeated and/or long social-distancing restrictions, overall mobility still remains low. In the examined cities, the metric averages 68 percent of the level recorded before the pandemic (Exhibit 47). The figures vary depending on city specifics. For example, in Paris, London, and Madrid, mobility declined to 10 to 20 percent at the onset of the pandemic; by the end of 2020, it rebounded to 45 to 65 percent of the pre-pandemic level. In Singapore, Bangkok, and Tokyo, mobility has already returned to 90 to 100 percent of the pre-pandemic level.

Exhibit 47

Mobility change in the examined cities during the pandemic



Some residents plan to come back to the way of life they were used to before the pandemic. On average, 10 percent of respondents said that once the COVID-19 pandemic is over, they will stop working remotely and return to their offices.

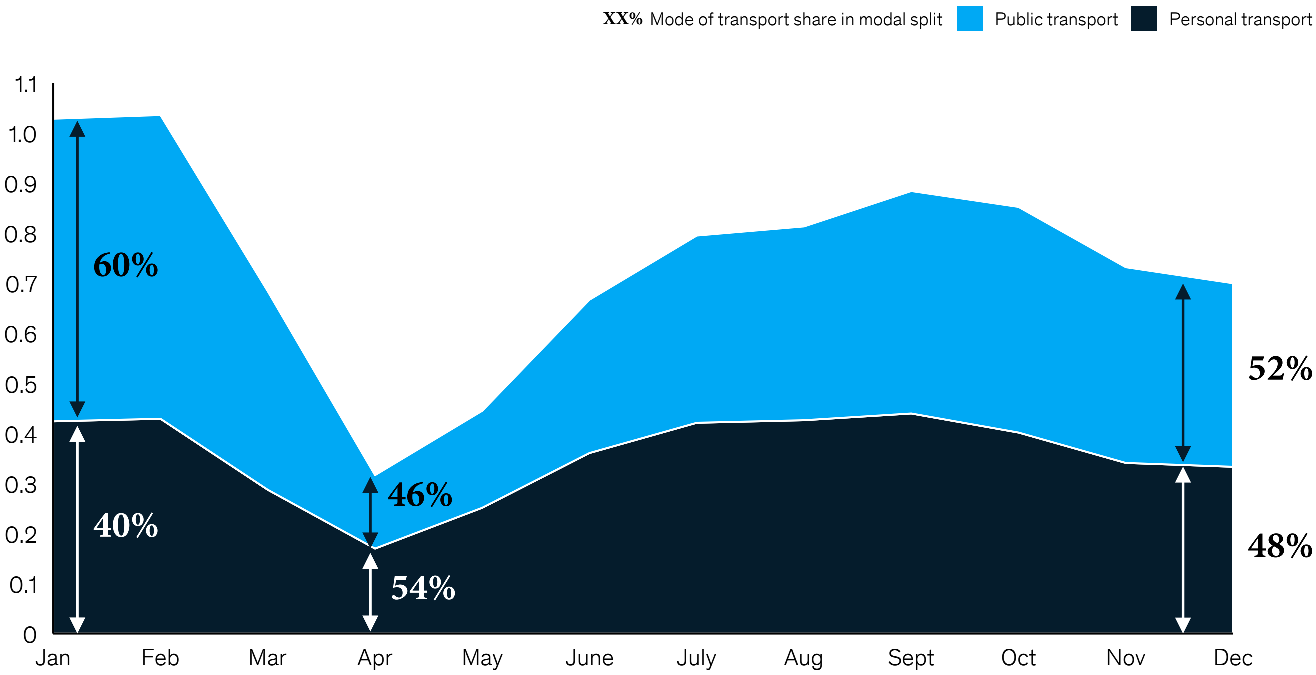
People from different regions assess that prospect differently. In Asian and Latin American cities, the post-pandemic share of employees working remotely is not likely to sustain any significant changes: only 6 percent of Asian city residents and 5 percent of Latin American city residents said they intend to return to their offices. In North America and Europe, however, we expect a more substantial decrease in remote employment after the pandemic. According to our survey, 14 percent of North American city residents and 12 percent of European city residents will switch from remote work to office work in 2021–22.

Along with overall mobility, the pandemic forced people to change their attitude to existing modes of transport. At the peak of restrictions, mobility declined rapidly on average, but the rates of decline differed depending on the mode of transport. Public transport suffered a much heavier loss than personal transport. People began using their private cars much more frequently. That, in turn, led to a significant shift in the modal split: the share of public transport dropped from 60 percent before the pandemic to 46 percent at the end of 2020 (Exhibit 48).

As the first wave of the pandemic was coming to an end and the most stringent restrictions were being removed, the trend persisted: city residents still gave preference to private cars. As a result, personal-transport mobility recovered faster and by September reached or exceeded the figures recorded in early 2020. By the end of 2020, the share of public transport in the modal split still had not returned to the 2019 level, while the share of private cars in all examined cities grew by eight percentage points on average relative to the figures observed in 2019.

Exhibit 48

Averaged modality change in the examined cities relative to early 2020



From the standpoint of long-term development of transport systems, this trend is associated with a multitude of adverse effects, including traffic congestion, city air pollution, and rising early death rates. The most important question, however, is whether the increasing share of personal transport is systemic or temporary—that is, due to the pandemic only.

Judging by the responses to our survey of examined-city residents, we expect that the trend will persist in the longer term. Respondents said that after the pandemic, they plan to make 47 percent of their trips by private cars, versus 48 percent at this time (Exhibit 49). Although some city residents will keep using public transport, most transport systems will see the shift toward personal transport persisting through 2021–22.

Since many residents will begin traveling to work again and use personal transport for that purpose more frequently, city transport systems will come under growing pressure.

To assess the situation, we must understand the reasons for which the use of public transport has decreased. Was there a change in the preferences of active users of public transport, or did they just travel less in 2020?

Our analysis of data on one of the examined cities shows that the observed change had several causes. Active personal-transport users currently use public transport even less frequently than before the pandemic, while their overall mobility has changed insignificantly. Their number of personal-transport trips has increased by nine percentage points, while overall mobility has decreased by 5 percent (Exhibit 50). Among residents who are more active in using public-transport services, overall mobility has decreased by 35 percent, and they now choose public transport as the preferred way of travel less frequently: its share in the modal split has decreased by 15 percentage points. Therefore, one may conclude that the observed trend is the outcome of a complex totality of behavioral changes.

Exhibit 49

Modal split change in the examined cities due to the pandemic

Mode used or intended to use, % of trips

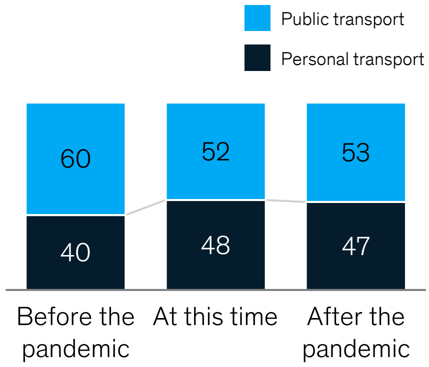
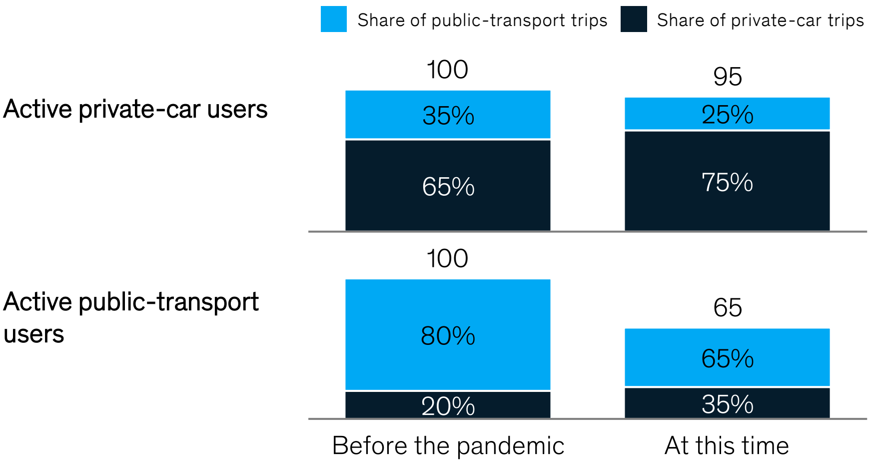


Exhibit 50

Trips by mode of transport: city-level example



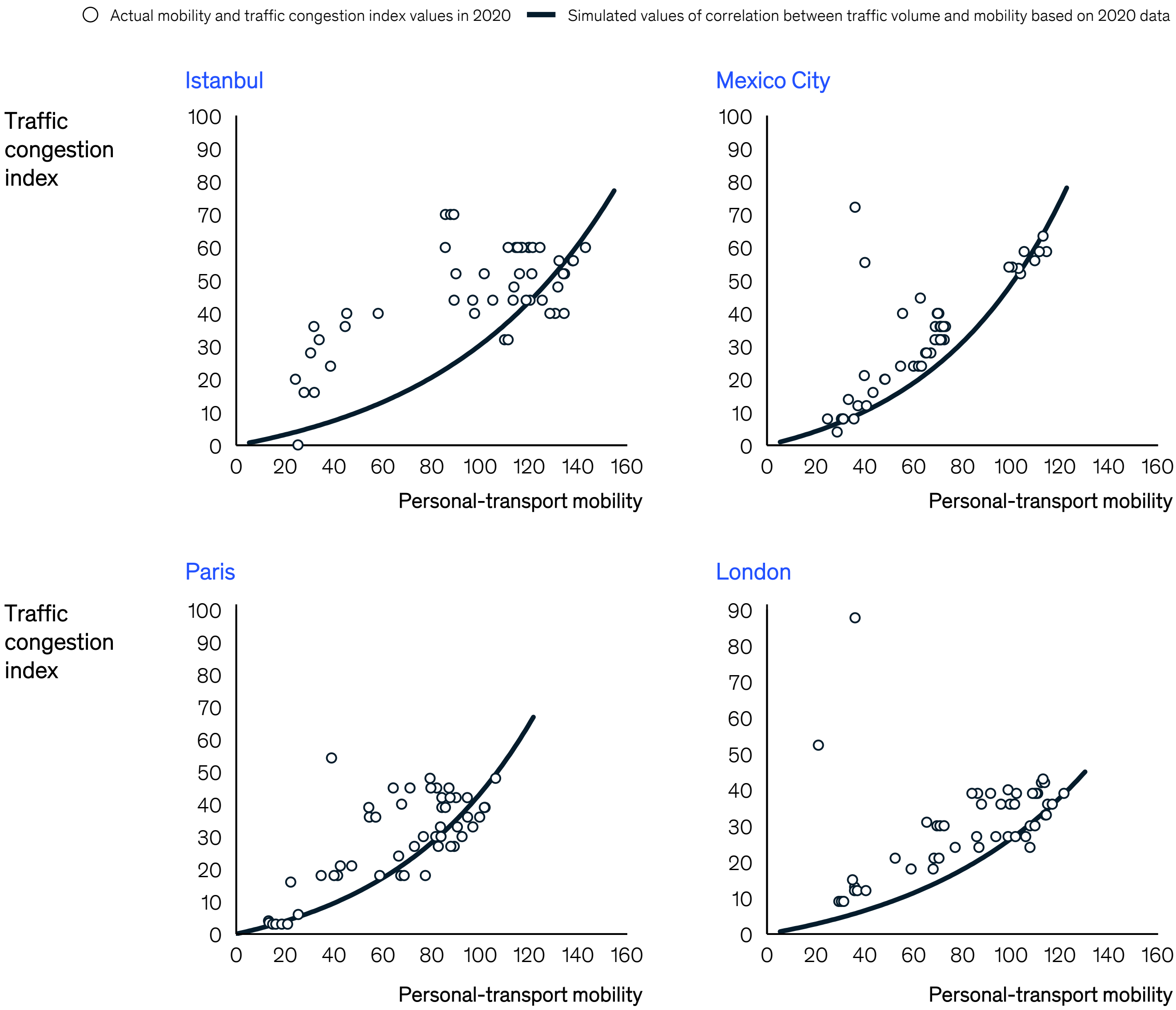
The declining share of remote employment combined with people's reluctance to use public transport may cause street and road traffic in some cities to exceed the values recorded before the pandemic.

Throughout the year, we have observed significant fluctuations in the number of cars driven in all examined cities. Street and road traffic levels also have been changing. For example, at the peak of restrictions in the examined cities, the number of motor vehicles on the roads decreased to unprecedented lows. Later on, personal-transport mobility gradually recovered, but with the second wave of the pandemic in the 2020, new restrictions were put in place. The existing conditions enabled us to assess the correlation between traffic volume and personal transport mobility.

For the examined cities, this correlation is described in the form of exponential functions, which differ due to city specifics, such as street and road building density, maturity of smart transport systems, and other characteristics (Exhibit 51).

Exhibit 51

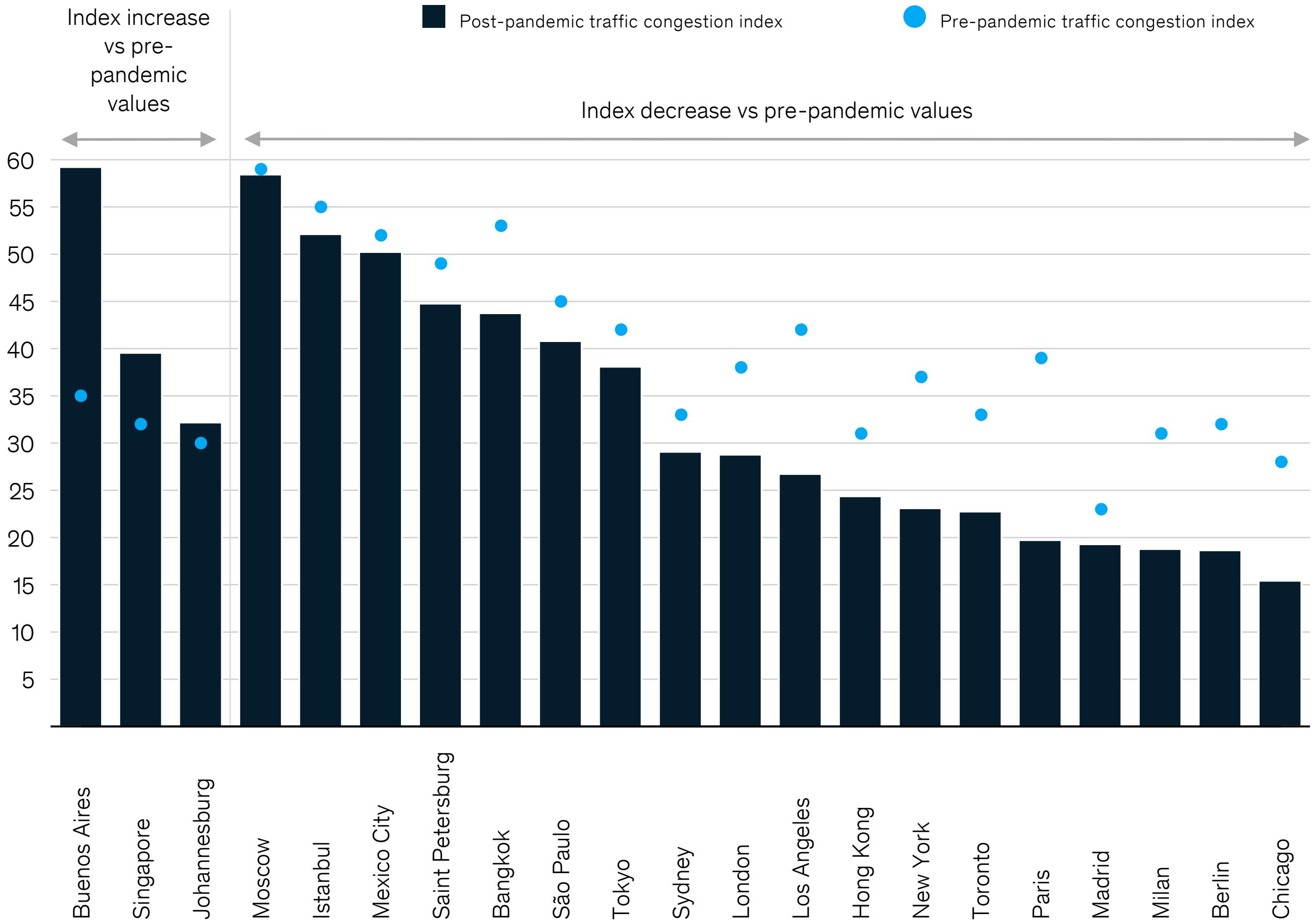
Observed changes in mobility and traffic congestion index and their description using exponential functions



Having analyzed correlation between the traffic congestion index and mobility and forecasts ventured by city residents with respect to their own mobility when the share of remote employment decreases, we assessed post-pandemic road and street traffic in the examined cities. In some cities, residents expect the traffic to be higher than before the pandemic (Exhibit 52). But in most cities, city residents were quite cautious in their assessment of the potential decrease in the share of remote employment, so one may expect lower traffic on the roads in those cities. The modal-split shift toward personal transport, however, may lead to a sharp increase of the traffic congestion index as the pre-pandemic overall mobility level is reached.

Exhibit 52

Projected post-pandemic traffic congestion index vs. 2019 index values recorded in the examined cities



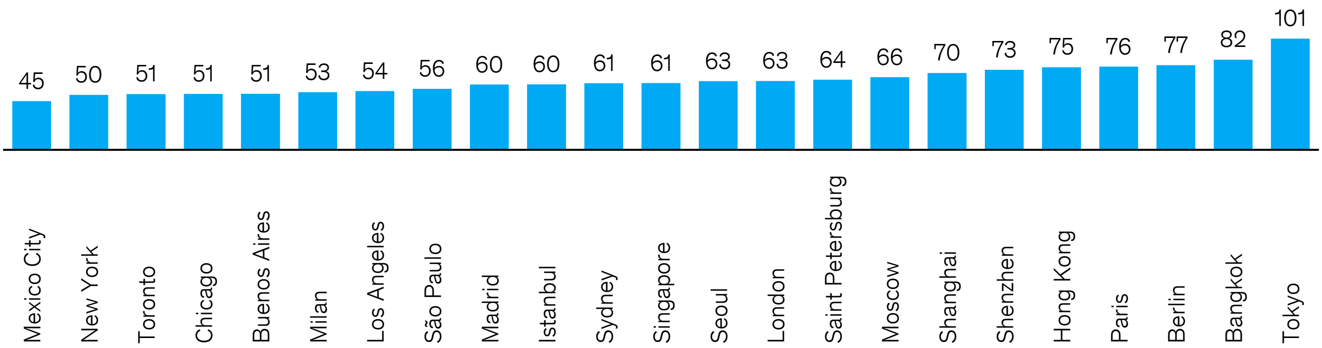
One of the critical tasks currently facing most examined transport systems is to restore the popularity of public transport both in the short term and in the long term. In some cities, authorities have already scored some successes in making their public transport more attractive, primarily by informing residents about the safety of public transport in an effective manner and maintaining a high level of service throughout 2020.

Impact of service-level changes on performance metrics

Decreased mobility has led to a reduction in the number of trips by public transport in the examined cities (Exhibit 53). This was also affected by the overall decline in public-transport popularity among city residents.

Exhibit 53

Public-transport passenger traffic in the examined transport systems in 2020 vs. pre-pandemic levels, %



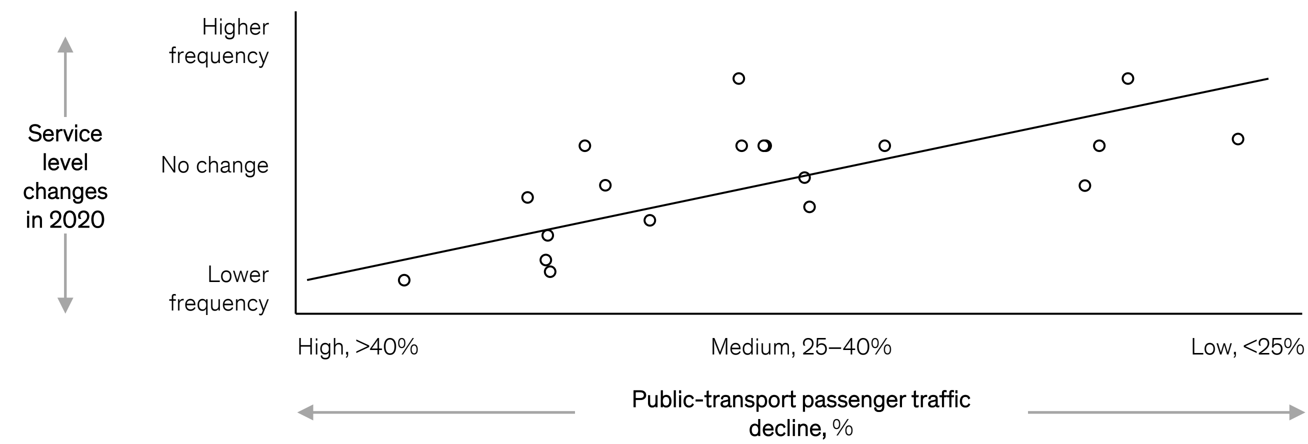
However, considering the important social role that transport systems play in people's lives, administrations of most transport systems did not pass the burden of declining revenue on to city residents: during the pandemic period. Fare increases in 22 cities were maintained at or below the inflation rate. This indicates that most of the examined transport systems suffered an actual decline in ticket revenues.

On the back of trends associated with declining revenues and shrinking passenger traffic, some of transport systems had to lower the level of service, at least judging by what city administration and transport operator spokespersons said to the press.

Some city authorities have done the opposite, however. They abstained from reducing service levels in 2020, raising them instead. This enabled them to maintain higher passenger traffic than in megacities where the level of service was reduced (Exhibit 54).

Exhibit 54

Correlation between public-transport passenger traffic decline and service-level changes in 2020



Impact of safety perceptions and COVID-19 response measures

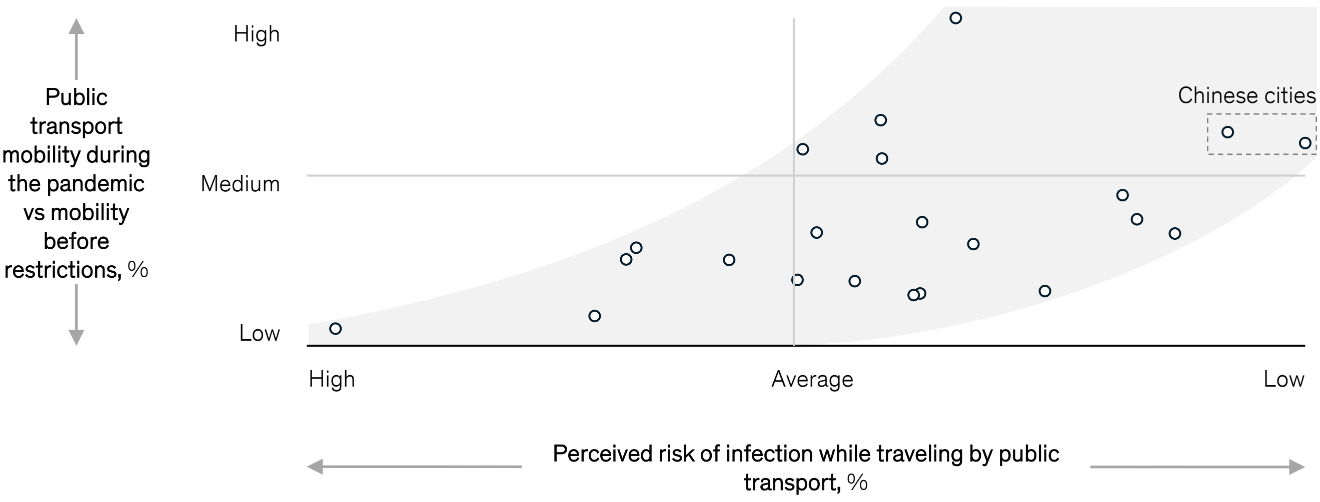
During the COVID-19 pandemic, city residents have traveled by public transport less frequently because they believe it exposes them to a higher risk of viral infection. To a great extent, this attitude results from low visibility of biological safety measures.

The results of our study show that in 2020, big-city residents were less willing to use public transport and preferred using personal transport. According to our respondents, the risk of viral infection while traveling by public transport is two times higher than while using a private car. People view private cars as the safest mode of transport; private-car transportation outperforms taxis, car sharing, and even the modes of travel associated with physical activity.

Residents' perception of the risk of infection affects their preferred modes of travel. Thus, in cities where risk of infection in public transport is perceived to be low, we observe higher public-transport mobility during the pandemic (Exhibit 55).

Exhibit 55

Correlation between perceived risk of infection while traveling by public transport and passenger traffic decrease in 2020



Cities in China have achieved a lower perceived risk of infection on public transport through a mandatory mask regime, social-distancing regime, regular disinfection, and other epidemiological safety measures

However, analysis of data collected in some of the examined cities precludes statements to the effect that the number of trips by public transport substantially affects the spread rate of the infection. In some megacities, including Paris, Singapore, and Hong Kong, effective processes were put in place to track affected-person contacts, and no serious outbreaks attributable to public-transport systems were reported. According to multiple experts, biological safety measures also play an important role in the reduction of COVID-19 incidence among public-transport passengers.

The most widespread measures include mandatory use of personal protective equipment, more frequent disinfection of vehicles and infrastructure facilities, and introduction of social-distancing rules in public transport. The examined cities have different sets of measures, though. For convenience of analysis, those measures are divided into six categories (Exhibit 56).

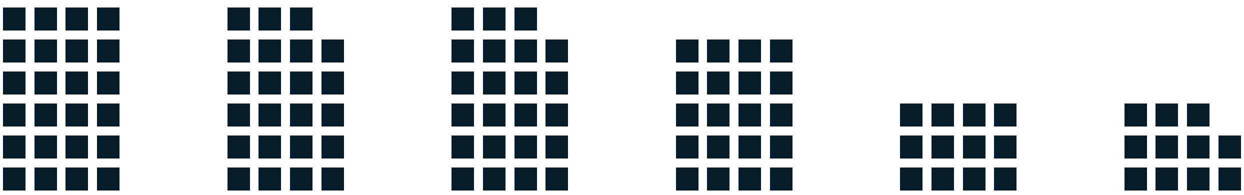
Exhibit 56

Activities carried out in cities to improve public-transport safety

Personal protective equipment (PPE)	Disinfection	Social distancing	Service level	Cycling infrastructure	Limited number of passengers
Mandatory use of PPE by passengers and employees	Frequent disinfection and implementation of effective innovations	Stickers, markers, and barriers to support social distancing	Same or higher public-transport frequency	Better cycling infrastructure	Limits on the number of passengers in public transport

Number of cities actively taking safety measures

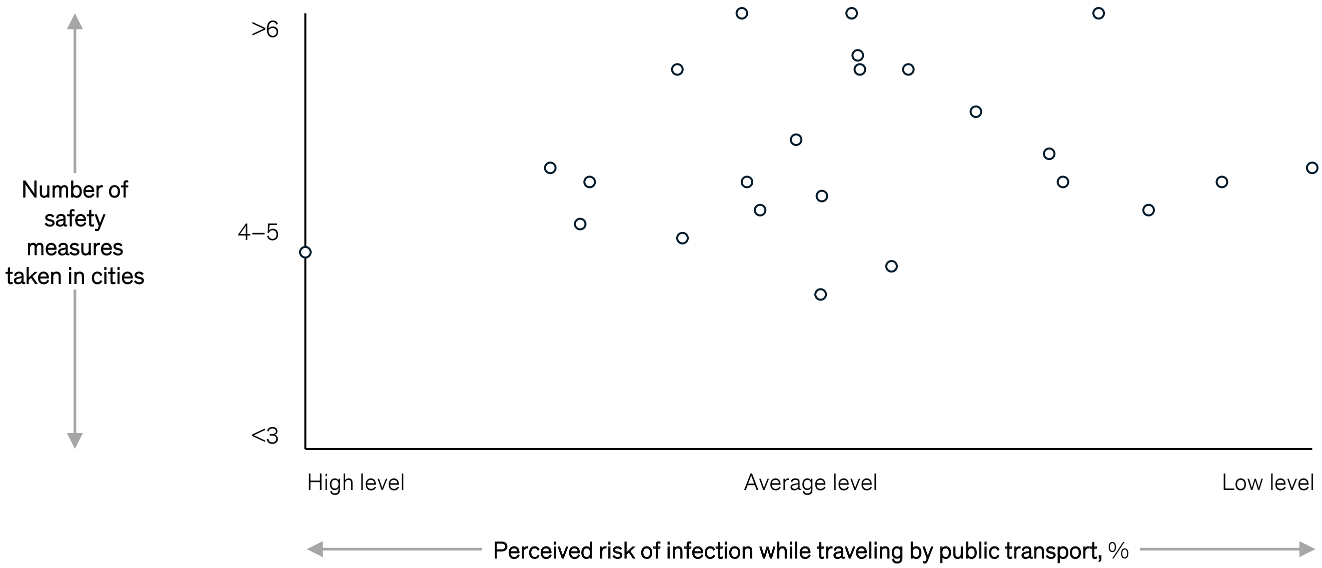
City actively taking measures in the respective category



Efficacy of such activities was noted in multiple studies published in 2020, but the fact that they are being carried out in a city does not have direct impact on how city residents perceive the risk of infection in public transport. Despite the existence of an indirect relationship between the two metrics, in some cities the measures have had a less significant impact on perception of biological risks associated with public-transport travel (Exhibit 57). This might be because city authorities have not effectively distributed information on such initiatives.

Exhibit 57

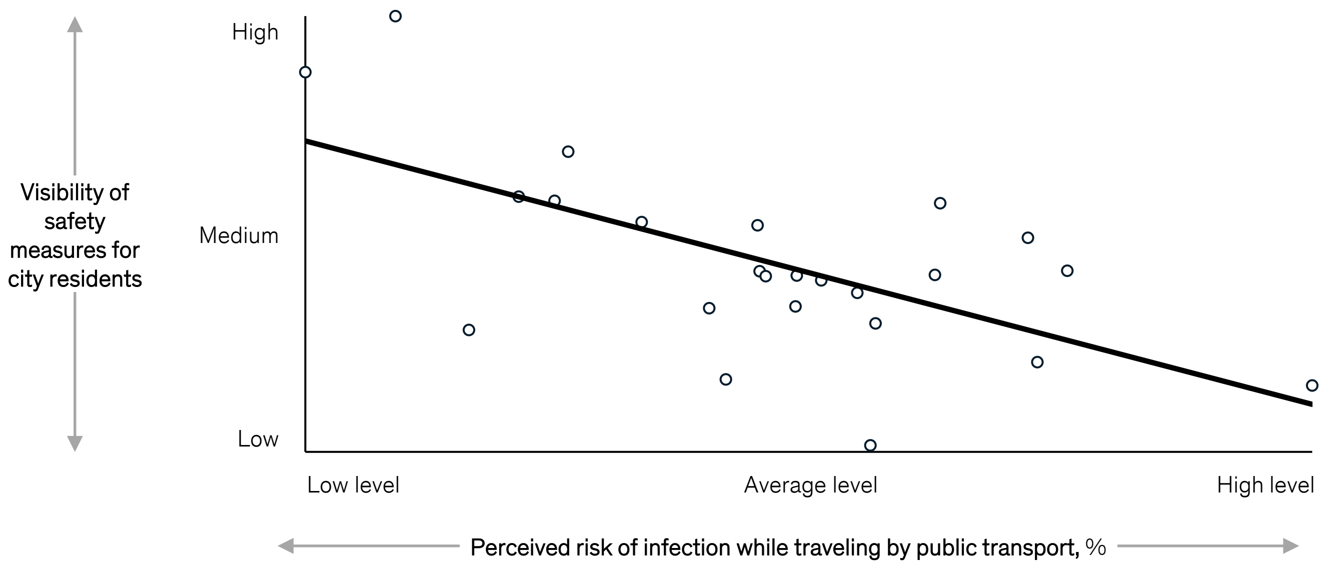
Correlation between the number of biological safety activities carried out in a city and perceived risk of infection in public transport



The data we acquired during our study testify to the fact that it is the visibility of biological safety measures that immediately influences how residents perceive the level of risks associated with traveling by public transport and, therefore, what modes of transport they prefer to use. In cities where authorities managed to arrange effective communication, and the residents were more aware of relevant activities, respondents assess the risk of infection in public transport to be lower (Exhibit 58).

Exhibit 58

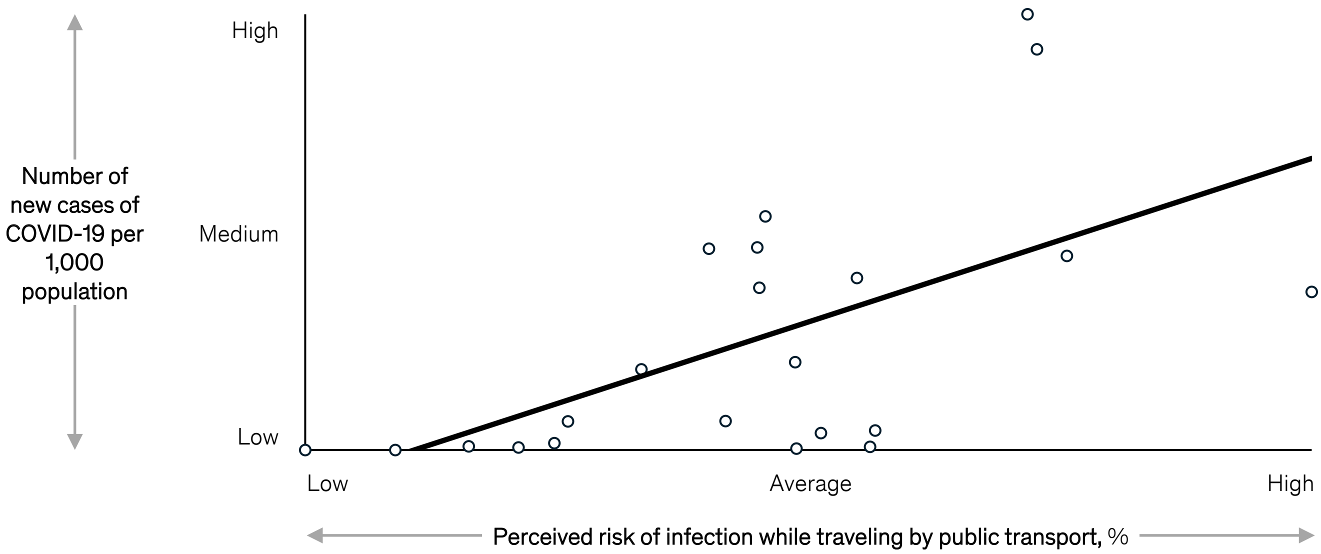
Correlation between perceived risk of infection while traveling by public transport and visibility of biological safety measures



However, the total number of COVID-19 infection cases also is an important factor for determining the risk of infection by population. The perceived risk of infection is lower in cities with fewer infection cases (Exhibit 59).

Exhibit 59

Correlation between perceived risk of infection while traveling by public transport and number of new infection cases



Impact of city projects supporting sustainable transport development

During the pandemic, megapolis authorities launched various projects to support the trend toward sustainable development of transport systems. The purpose of most such projects is to assure biological safety of people, but to a significant degree, those projects are also designed to support sustainable development of transport systems and boost popularity of modes of travel associated with physical activity.

The most extensive category of such projects—representing 29 percent of the total number of projects—envisages steps to assure biological safety of city residents (Exhibit 60). This comes as no surprise because the priority objective of all transport systems in 2020 was to minimize the risks of viral infection in public transport, so people would not be scared of taking a bus or an underground train.

Mitigating the risks associated with the use of public transport is the mission to be addressed by public-transport digitization projects, which account for 16 percent of the projects. Most projects in this category are expected to ensure transparency of public-transport traffic metrics, so users can make an informed decision about the time of departure subject to the expected number of contacts with other passengers.

Projects in the remaining categories are being implemented by city authorities to support transport system stability in the longer term and reduce the growth in the share of private cars in the modal split. These other projects include efforts to make public transport more efficient and private cars less popular and to develop infrastructure supporting modes of travel associated with physical activity. Taken together, they account for 55 percent of the projects, as city authorities understand the importance of residents returning to public transport.

Exhibit 60

Categories of projects implemented by cities during the COVID-19 pandemic

Categories	Examples of projects	Share of total number of projects
Biological-safety assurance	Improvement of quality standards for vehicle disinfection Limitation of the number of passengers in vehicles	29%
Development of modes of travel associated with physical activity	Construction of temporary bicycle lanes Increase of the number of bicycles offered by sharing services	28%
Reduction of popularity of private cars	Introduction of paid areas for cars within city limits Imposition of more stringent speed limits for motor vehicles in downtown areas	17%
Public-transport digitization	Development of application features designed to track passenger traffic in real time Implementation of an electronic check-in system for public-transport passengers	16%
Improvement of public-transport efficiency	Construction of new dedicated lanes	10%

Examples of projects implemented under the influence of the COVID-19 pandemic

New York: Public-transport digitization

New York's Metropolitan Transportation Authority tracks public-transport passenger traffic using the MYmta application.

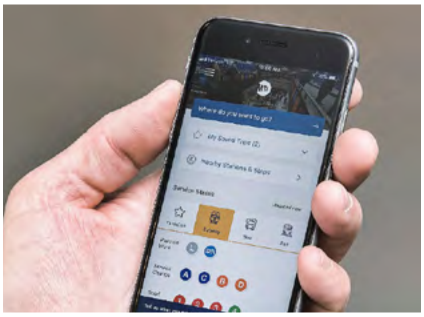
Project description

The MYmta application shows the number of public-transport passengers in real time—the first full-scale launch of such a feature in the United States.

Special sensors are used to track the number of passengers based on infrared radiation and 3-D object-recognition technologies. The sensors are placed above bus doors and connected to GPS trackers installed on each vehicle.

Project objectives

Using this feature, passengers can quickly assess how full the approaching vehicle is. This gives them an opportunity to do early route planning, so they are more likely to comply with social-distancing rules and mitigate the risk of infection.



The MYmta application is available in six languages

40%
Share of vehicles with onboard sensors

550,000
Passengers using the feature every week

Paris: Making personal transport less popular

Paris set speed limits low to improve traffic safety and encourage active modes of transport.

Project description

The city reduced car travel speed to 30 kilometers per hour throughout Paris (except for Boulevard Périphérique) and in all streets where pedestrians have a priority.

Project objectives

The project is designed to improve traffic safety in Parisian streets and to mitigate noise and environmental pollution. It is also expected to boost the popularity of modes of travel associated with physical activity, including walking and cycling.

Paris streets have a speed limit of 30 kilometers per hour

90%
Mitigation of traffic accident fatality risk

Moscow: Biological safety

Russia's capital set disinfection standards for its transport system.

Project description

The health standards cover disinfection of doors, stairs, escalator handrails, and ticket machines at all 269 underground stations. Washing frequency depends on passenger traffic; on average, it occurs every 1.5 to 2 hours.

In addition to washing, trains entering the yard are subjected to UV treatment. Air-conditioning systems in cars of the Oka and Moscow series are equipped with built-in UV lamps; portable UV lamps are used to process other models of cars.

Project objectives

The frequency and intensity of disinfection of vehicles and public-transport stations have been significantly increased to improve biological safety and reduce the risk of contracting COVID-19 in the Moscow transport system.

Hand sanitizers are installed in Moscow Metro stations

1.5–2 hr.

Time between cleanings at Moscow Metro stations

8,500

Number of buses, e-buses, and trams disinfected daily

London: Active-travel promotion

London's Streetspace program makes the city's streets more welcoming to walkers and cyclists.

Project description

Streetspace for London, a program designed to transform London streets, was launched in May 2020. Key workstreams include the expansion of cycling infrastructure, creation of new pedestrian areas, establishment of "school streets" (closure of streets adjacent to schools during drop-off and pick-up times), and introduction of new dedicated bus lanes. Also as part of the Streetspace project, the city implemented the "green man" concept, where some traffic lights are green by default, changing to red only as a motor vehicle approaches the crossing.

Project objectives

The project is designed to stimulate active foot travel and reduce personal-transport mobility.

The Streetspace program has transformed more than 40 London streets

89 km

Length of new bicycle lanes

22,000 km^2

Area of road network allocated to pedestrians

New York: Making public transport more efficient

New York developed a system of dedicated lanes on city streets.

Project description

Fearing growth in the number of personal car trips, New York authorities decided to launch nine projects commissioning new dedicated-lane sections across the city.

The sections were selected based on the number of trips that may become more efficient following implementation of the new infrastructure.

Project objectives

The project is expected to contribute to two key objectives: boosting the performance of public-transport travel and reducing the impact of the COVID-19 pandemic on the growing share of personal transport in the city's modality structure. a positive impact on public transport performance was anticipated, based on comparisons with similar projects previously implemented in the city. Earlier pilots enabled more than 20 percent increases in public-transport speed and in some cases raised the number of trips by about 30 percent.

New York City's new bus lanes will be used by about 750,000 passengers per day

20 mi.

Length of newly created dedicated bus lanes

750,000

Trips per day affected by introduction of new dedicated lanes

Sample projects by category

Moscow Central Diameters (MCDs)

Public-transport infrastructure development

38%
Moscow survey respondents who mentioned the project

132 km
Total length of MCDs

60
Number of stations

20%
Increase in length of the underground network

22%
Increase in number of stations in the system integrated with the underground

130 million
MCD passenger traffic per year

5–12%
MCD passenger traffic per year

8%
Share of trips in the system integrated with the underground

$21 million
Time savings for city residents

Project description

The Moscow Central Diameters join fragmented railroad directions, creating fully functional lines that can be used to cross Moscow nonstop and reach the nearest neighboring cities. Railroad lines connecting Moscow and its immediate environs comprise a single transport system including the Moscow Underground. The first two diameters were opened in 2019.

Uniqueness of the project

Construction of the MCDs has become one of the world's largest city rail transport development projects. After their launch, the MCDs have greatly expanded the underground-integrated system, improving quality of life for millions of Muscovites.

The new diameters are used by new-generation Ivolga (Oriole) trains, each with 11 cars, that can carry more than 3,000 passengers. The trains feature numerous functions modern city residents may need, including free Wi-Fi, USB gadget chargers, and bicycle racks.

Project impact

Although the COVID-19 pandemic has driven down mobility, the project has already produced positive results. In particular, it has increased accessibility of the underground-integrated network, improved transport system performance, saved passengers considerable time, and reduced traffic at certain underground lines by redistributing passenger flows away from the most heavily used line sections.

The Ivolga (Oriole) new-generation train has 11 cars and carries more than 3,000 passengers

Hong Kong's Northern Connection: Tuen Mun–Chek Lap Kok Link (TM-CLKL)

Road infrastructure

Project description

The Tuen Mun–Chek Lap Kok undersea tunnel was opened in Hong Kong in 2020. Together with the Southern Connection, it will form a strategic route joining the Northwest New Territories with the Hong Kong–Zhuhai–Macau Bridge, Hong Kong Port, and Hong Kong International Airport/Northern Lantau.

Tuen Mun–Chek Lap Kok is the longest and deepest road tunnel in Hong Kong, with a diameter comparable to the height of a six-story building.

Uniqueness of the project

TM-CLKL is an innovative undersea tunnel construction project. Several records were set during its implementation. In particular, the builders employed the world's largest tunnel-boring machine (with a diameter of 17.6 meters) to bore, using the shield method, the deepest (50 meters) and longest (5 kilometers) tunnel in Hong Kong.

Special attention was paid to environmental protection. For example, more than 280 insectivorous plants on the brink of extinction were moved to alternative locations.

Also, the boring method was selected, at least in part, because of its lesser impact on the water environment.

Project impact

Construction of the tunnel greatly improved connectivity between the southern part of Tuen Mun County and the Hong Kong International Airport.

33%
Hong Kong survey respondents who mentioned the project

5.5 km
Total length of tunnel

22 km
Decrease in length of trip to the airport for Tuen Mun County residents

20 min.
Decrease in duration of trip to the airport for Tuen Mun County residents

The Tuen Mun–Chek Lap Kok undersea tunnel has a depth of 50 meters and length of 5 kilometers; no fare is charged

Display of bus load data in New York's MYmta application

Transport systems digitization

Project description

In New York City, MTA passengers use the MYmta application to plan their trips through the regional transit network. The planning process takes into account services offered by other transport organizations, such as the Staten Island Ferry, NYC Ferry Service, PATH, and NJ Transit.

The MYmta application was updated in July 2020 to reflect COVID-19 realities. In particular, it became possible to track the number of passengers on arriving trains and buses. This enables passengers to plan their trip routes so they comply with social-distancing rules.

Uniqueness of the project

Such a function had never before been launched in the United States on a full-scale basis. Special infrared sensors and 3-D object-recognition technologies are used to determine the number of passengers. The sensors are placed above bus doors and connected to GPS trackers installed on each vehicle.

Project impact

Using the application, passengers can quickly assess how full the approaching vehicle is. This gives them an opportunity to do early route planning so they are more likely to mitigate the risk of infection and comply with social-distancing rules.

10%
New York survey respondents who mentioned the project

40%
Share of vehicles with onboard sensors

550,000
Passengers using the feature every week

In New York, 550,000 people use the application every week

Milan's Strade Aperte

Cycling and pedestrian infrastructure

Project description

Milan has conducted an experiment involving rapid expansion of pedestrian and cycling space to protect city residents in the wake of relaxation of COVID-19 restrictions. The purpose of the Strade Aperte (Open Streets) project is to shape a new approach to mobility and public spaces, making the city more environmentally friendly and comfortable. The project, announced in 2020, envisages reprofiling of 35 kilometers of streets and expansion of the existing speed limit—30 kilometers per hour—to new areas across the city.

Uniqueness of the project

The project has drawn praise from the expert community as an example of a new perspective on street design. It is intended not only to ensure that cars can move from point a to point B in the shortest possible time, but also to increase the safety of all residents moving across the city.

The project's purpose is to give Milan residents protected and accessible streets, create new public spaces, and encourage walking and riding bikes or scooters as alternatives to public transport and personal cars.

Project impact

The key purpose of the project is to maintain a transport balance in the city—a balance that can be disrupted if residents make excessive use of personal cars. City authorities hope to prevent a resurgence of private car use as city residents return to their offices avoiding overcrowded public transport.

18%
Milan survey respondents who mentioned the project

35 km
Total length of reprofiled streets

60%
Target share of streets where a 30 km/h speed limit is in effect

Creation of bicycling infrastructure in Milan aims to increase the safety of all residents

Milan's low-emission zone: Area B

Environmental safety

Project description

In an attempt to reduce traffic congestion and air pollution, Milan authorities have imposed new city-entry restrictions that apply to vehicles with petrol and diesel engines. These include the low-emission zone (LEZ), which covers a significant part of the city. It is closed for most vehicles with high noxious emissions. No fee is paid by operators of vehicles that are permitted to enter the area.

Uniqueness of the project

When creating the largest LEZ in Italy, city authorities allocated special subsidies to support small and medium-size enterprises (SMEs) operating in the area. Those SMEs are to use the subsidies to finance acquisition of low-emission motor vehicles.

Project impact

The project's key objectives are to reduce traffic congestion in Milan and significantly decrease emissions and concentration of noxious substances in the city. City authorities project that air pollution will significantly decrease in the next several years. It is expected that by 2026, annual motor vehicle emissions will decrease by approximately 25 tons for inhalable particulate matter (PM10) and by 900 to 1,500 tons for nitrogen oxide (NO_x) particles.

23%
Milan survey respondents who mentioned the project

72%
City territory covered by Area B

98%
Milan residents living in Area B

50%
Expected reduction of PM10 emissions by 2022

50%
Expected reduction of NO_x emissions by 2026

40%
Expected reduction of CO_2 emissions by 2030

Restrictions on using motor vehicles equipped with petrol and diesel engines have been imposed on 72 percent of Milan's territory

Metro Micro ride-sharing service in Los Angeles

New types of mobility

Project description

Metro Micro, a ride-sharing service envisaging the use of vans and small motor vehicles, is operated by the Metropolitan Transportation Authority in certain areas of Los Angeles. The service is directly integrated in the existing city transport system and is designed to improve the quality of transport services in areas where operation of fixed-route buses is difficult.

Using the mobile application, passengers can plan end-to-end trips in real time, covering not only areas where Metro Micro is active, but also other bus and rail services. Users can also gain access to the service through an internet browser or the MTA call center. Payment for the services is possible with a transport card and Transit Access Pass (TAP) account or with any debit, credit, or prepaid card.

Uniqueness of the project

The microtransit network implemented in Los Angeles increases public-transport availability in areas with poor public-transport coverage or long public-transport waiting times. This type of transit is flexible and dynamic, easily adapts to demand changes, and is part of a three-year plan designed to upgrade the city bus network.

Project impact

More than 250,000 trips have been completed over the two years since the launch of the pilot project. All project targets, including average waiting time, passenger traffic, and average service rating (4.9 stars out of 5), have been fully achieved, and some targets have been exceeded.

In 2020, passenger traffic increased by 178 percent year over year, despite the COVID-19 pandemic.

22%
Los Angeles survey respondents who mentioned the project

250,000
Trips under the pilot project

178%
Growth of passenger traffic in 2020

5
City areas covered by the new service

10 min.
Average trip waiting time

Istanbulkart transport cards

Fare system

Project description

Istanbul municipal authorities introduced Istanbulkart transport cards in the spring of 2009. Since then, a lot has been done to integrate those cards with existing payment systems. Istanbulkart can be used to travel by city transport (buses, metrobuses, Marmaray trains, underground trains, sea shuttles, and trams) and take taxi rides. Users also can make advance payments accepted in various public places across the city.

Uniqueness of the project

Cardholders can use the transport card to pay for city beaches, gain access to public toilets, and buy water at Hamidiye vending machines installed at underground stations, on metrobuses and trams, at cable railway stations, and in various Istanbul districts.

Istanbulkart holders are entitled to certain bonuses: cash is credited to the card for each plastic or metal container dropped into a "smart" trash recycling bin. Cards can be topped up through a special mobile application by transfer from any credit or debit card issued by any bank.

Project impact

Owing to the partnership between Istanbulkart and TROY national payment system, transport cards are widely used in lieu of bank cards to make payments at markets, restaurants, and cafés, and 2.4 million payment terminals are scattered throughout Turkey. Istanbulkart can also be used to perform ATM cash deposit and withdrawal operations.

50%
Istanbul survey respondents who mentioned the project

18 million
Active travel-card users

2.4 million
Locations accepting travel-card payments

50,000
ATMs where travel cards can be used for cash deposits and withdrawals

The Istanbulkart transport card costs ten Turkish liras when purchased at an office or in a kiosk, and six Turkish liras when purchased through a vending machine. The associated mobile application can be used to top up the travel card

Seoul’s ’smart shelter’ bus stops

Travel comfort

Project description

“Smart shelters” are designed to protect people from summer heat and monsoon rains and to combat the spread of COVID-19. They are glass cubes equipped with an air conditioner and a UV sterilizer to ventilate and cool air. In addition, the shelters are fitted with surveillance cameras and digital screens to warn passengers that a bus is approaching.

They emerged in Seoul streets in August 2000. Each stop has hand sanitizers, free Wi-Fi, and plugs that can be used to charge mobile devices or notebooks. Heat visualization cameras are used to let in passengers only if their body temperature does not exceed 37.5 degrees Celsius.

Uniqueness of the project

New bus stops share real-time information with police and fire departments. To do that, they use smart video surveillance cameras, alarm signals, and smart noise sensors, thus enabling those services to minimize their response times.

Median barriers are replaced with green plants, giving new transport stops a city-garden appearance. Passengers are offered wireless mobile-phone charters, air cleaners, and free Wi-Fi.

Project impact

During the week after installation, smart stops were used by 300 to 400 people per day. The Seoul municipal authority expects that introduction of smart shelters will not only improve the quality of services provided by the city transport system, but also reduce social security costs related to mitigation of harm caused by small dust particles and expand application of smart technologies across the city.

10%
Seoul survey respondents who mentioned the project

37.5°C
Maximum permitted body temperature of stop users

$84,000
Cost of a bus-stop installation

Speed-limit areas for passenger cars in Madrid

Physical safety

Project description

A new decree on development of an environmentally friendly transport system went into effect in Madrid in October 2018. The city imposed a speed limit of 30 kilometers per hour, not only on the central ring road, but also on 80 percent of all streets—equaling 85 percent of total length of those streets, because some streets merge into others and the number of lanes at their various sections can change.

Uniqueness of the project

Madrid's decree introduces regulation for new modes of city transport (including shared transport) used in the city, stipulates the priority of public transport over personal transport, and imposes measures designed to increase the safety of vehicular traffic, particularly in areas adjacent to schools and hospitals, and pedestrian traffic, including for persons with limited mobility.

Project impact

The new restrictions are designed to increase safety across the city, improve the ecological situation, promote sustainable travel methods (electric vehicles, public transport, bicycles, etc.), and harmonize street space for pedestrians.

17%
Madrid survey respondents who mentioned the project

80%
Share of streets subject to 30 km/h speed limit

85%
Share of of total city road length subject to 30 km/h speed limit

5 km/h
Sidewalk speed limit for people using skateboards or roller skates

A speed limit of 30 kilometers per hour is in effect on 80 percent of Madrid's streets

Consultations with Buenos Aires residents before introduction of a new fare system

Engagement of city residents

Project description

In 2018, Buenos Aires was implementing a new system envisaging a gradual increase of public-transport fares. During that process, city authorities arranged consultations with local residents to collect their feedback. They received and processed e-mails and written applications from the residents of the Argentinian capital.

The consultations lasted for 20 days. During that time, the city authorities reviewed more than 850 applications that dealt with various matters related to operation of the new system. Most applicants asked to offer more discounts to various groups of city residents and expand the new system to cover additional modes of transport. Some applications contained specific proposals related to overall improvement of transport system performance.

Uniqueness of the project

During the project, city authorities urged residents to submit both reactions to the fares and proposals for improving the new fare system. As citizen applications were processed, some were selected for in-depth review and incorporation into the new system design. In this way, city residents had an opportunity to make personal contributions to the changes affecting their transport system.

Project impact

After the applications filed by city residents were collected, scrutinized, and categorized, city authorities published a report presenting key insights. The report also offered detailed descriptions of the most frequently asked questions and provided answers to about 50 of those questions. The city subsequently used some applications and proposals to further improve the transport and fare systems.

City residents had a generally positive response to the consultation process. In our survey of Buenos Aires residents, 47 percent of respondents noted that the process had become a key factor affecting their perception of the city transport system.

47%

Buenos Aires survey respondents who mentioned the project

850

Applications processed

50

Questions from residents answered in the final report

City residents asked for more discounts in Buenos Aires' new fare system

Moscow's Cargo Transit project

Freight logistics

Project description

Cargo Transit is a critical project designed to reduce the adverse impact that freight traffic has on Moscow's road network and environmental status. The project divided each administrative district of the Russian capital into two areas: a cargo transit area and a residential area.

Trucks and lorries may freely travel through the cargo transit area, while in the residential area, only vehicles with maximum permitted mass of 2.5 tons can be used to provide services to local enterprises or residents, and such permitted use should be supported by relevant documents. The project, which launched in 2014, proved to be quite efficient. In 2016–20, it was extended to include additional Moscow districts.

Uniqueness of the project

The project, the first of its kind in Russia, provides an efficient solution to deal with problems caused by extensive freight traffic on city streets. Residents of launch target areas have duly appreciated its contribution to safety and to the reduction of noise pollution.

Project impact

The project is designed to improve Moscow's environmental situation and boost road safety. It is supported by more than 90 percent of people living in the areas where the Cargo Transport system has been implemented.

12%

Moscow survey respondents who mentioned the project

22%

Reduction in the number of trucks and lorries in districts covered by the Cargo Transit project

10%

Reduction in noise pollution on the streets covered by the Cargo Transit project

61%

Reduction in the number of truck-pedestrian collisions in the streets covered by the Cargo Transit project

Trucks with maximum permitted mass of more than 12 tons can enter the city only between ten o'clock in the evening and six o'clock in the morning

London's Wood Lane arches

Transit-oriented development

Project description

A series of railway arches next to the Wood Lane tube station are to be converted into shops, galleries, and community spaces in a project backed by Hammersmith and Fulham Council. Of the 19 arches in the planned first phase, 13 will be used for retailing, while the other six will provide new pedestrian routes, bicycle parking, and storage facilities.

The arches area will be opened for pedestrians, with vehicular traffic to be banned; however, a parking lot is available in the nearby Westfield London mall. Location of the arches offers convenient access to London's bicycle route network. The project envisages 66 safe sections for cyclists, both personnel and visitors.

Uniqueness of the project

Completion of the project is intended to enable the transformation of unused transport infrastructure spaces. That will affect not only retail facilities, but also city residents who use the new pedestrian and biking routes.

Project impact

The White City renovation area covers five key facilities, which form an impressive group of top-quality residential, office, retail, and community spaces.

When project implementation started, the arches under the Circle line and the Hammersmith and City line (built in the 1860s) were not open for the public; they were filled with debris, loose stone, and waste. Upon completion of the project, the area will get additional retail space (2.3 million square feet), office space (2.2 million square feet), and 5,000 new houses.

6%
London survey respondents who mentioned the project

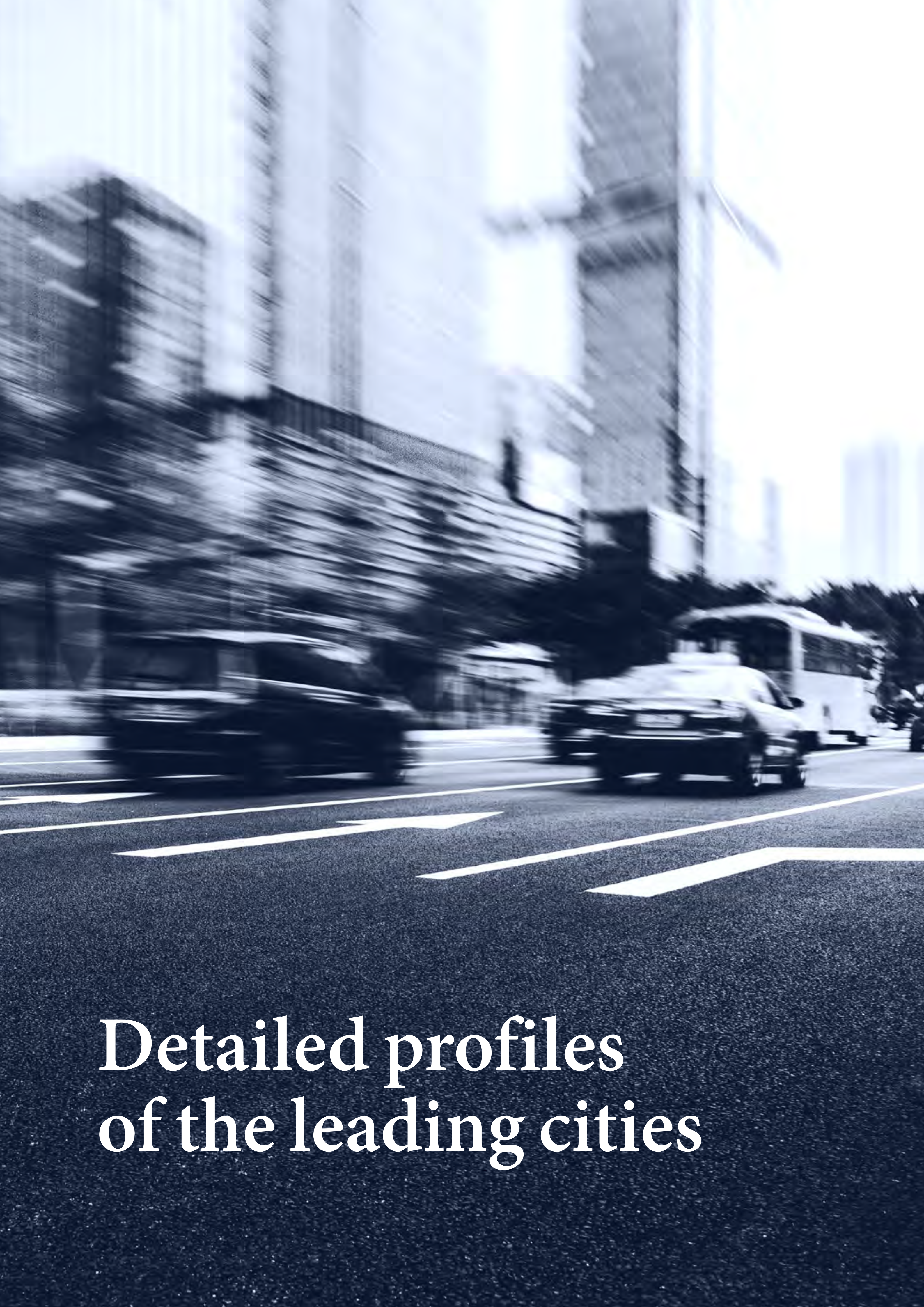
66
Sections reserved for bikers in the Wood Lane project

2.3 million sq. ft.
New retail space

2.2 million sq. ft.
New office space

5,000
Residential units to be built under the project

Shops, galleries, and public spaces have been created in an area adjacent to the Wood Lane tube station



Detailed profiles of the leading cities

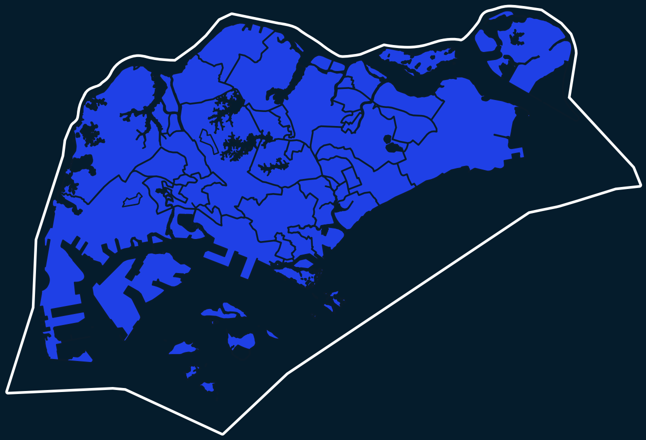
Singapore

General information

— Official city boundaries — Examined territory

697 km²

Examined territory area



5.7 million

City population

$96,000

GRP per capita, based on PPP

8,200/km²

Population density

110

Motor vehicles per 1,000 people

Public transport

91%

Share of residents satisfied with the current situation

89%

Share of residents satisfied with the recent changes

Personal transport

81%

Share of residents satisfied with the current situation

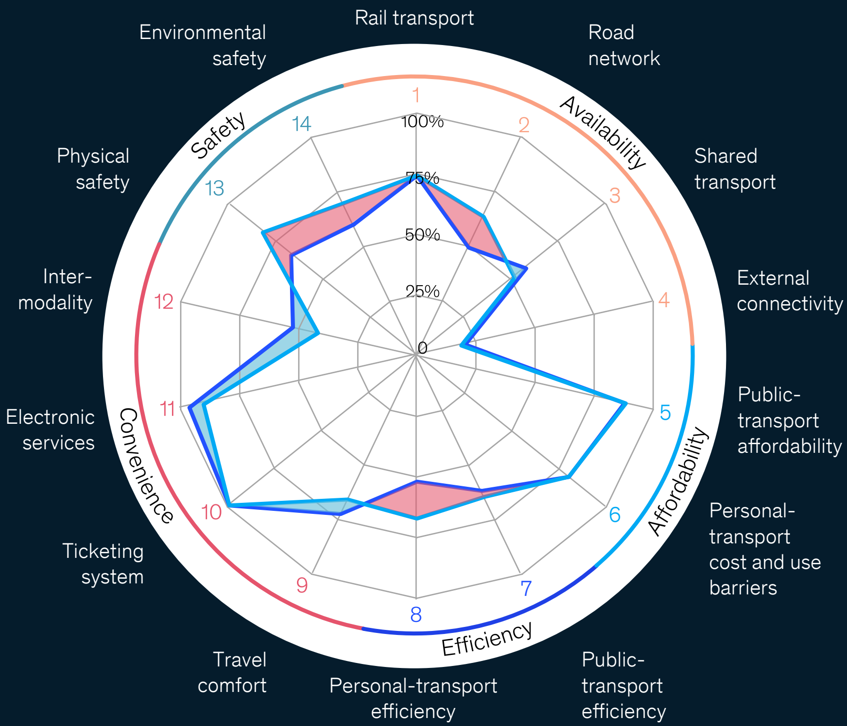
86%

Share of residents satisfied with the recent changes

Objective results for comparable metrics

Score out of 100%

— Objective metrics, 2021 — Objective metrics, 2018

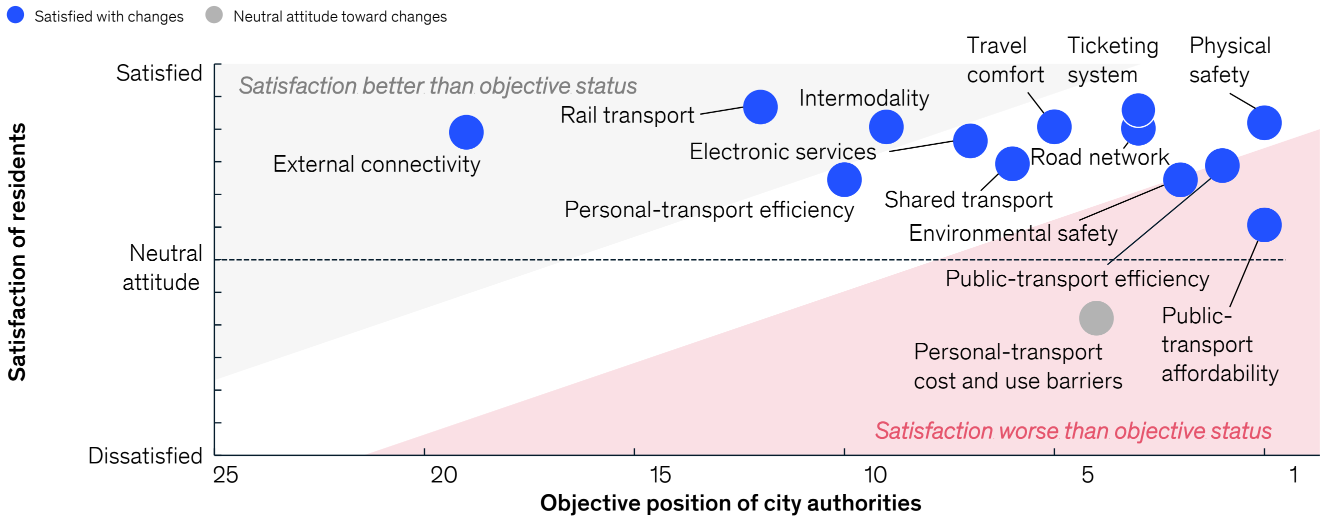


Changes vs 2018

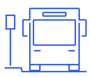
Singapore is leading the rankings on many dimensions, yet in several areas other cities have caught up and sometimes surpassed its scores

- **Convenience.** Scores have improved across the board. For example, intermodality improved with introduction of a unified citywide wayfinding system and increasing connectivity between metro stations and bus stops
- **Availability.** While availably of shared transport improved, the length of bicycle lanes grew slower than in other cities
- **Efficiency.** Congestion rate and time lost in traffic have increased for private transport
- **Safety.** Metrics have improved, yet several cities have seen larger improvement— for example, in share of EV sales

Gaps between objective status and subjective perception

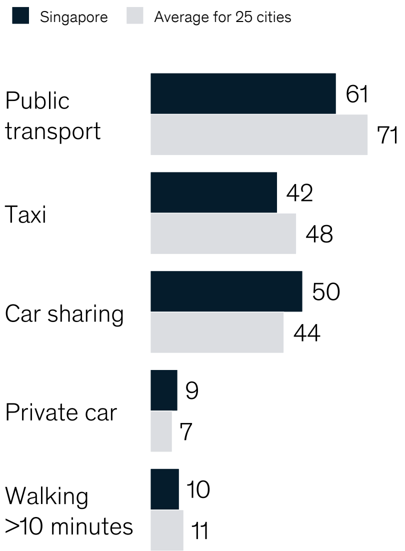


Key implemented projects

	Project	Highlights	Share of respondents who mentioned the project
	Bidadari Transfer Hub	First air-conditioned underground bus transfer station	70%
	Choa Chu Kang Transfer Hub	Hub opened in December 2018; project valued at 28.2 million Singapore dollars	25%
	CTE/TPE/SLE Junction	Project completed in May 2018; envisages connection of 4 elevated roads; project valued at 75 million Singapore dollars	24%

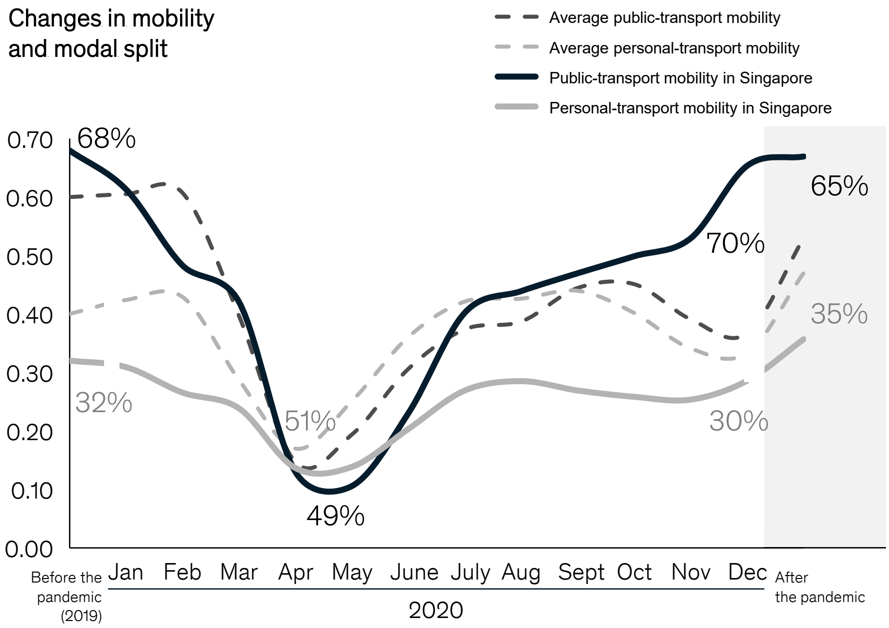
Impact of the COVID-19 pandemic on risk perception and mobility

Perceived COVID-19 contraction risk by modes of transport



56% Visibility of COVID-19 response in public transport

Changes in mobility and modal split



+3 pp Increase in Mobility Index after the pandemic vs 2019

+3 pp Increase in the share of personal transport in modal split after the pandemic vs 2019

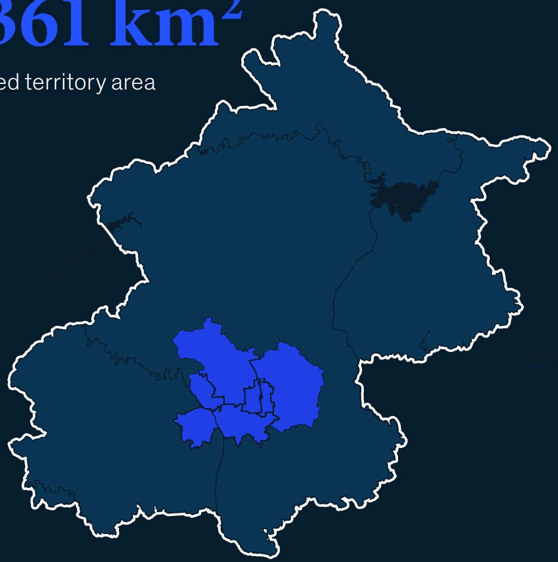
Beijing

General information

— Official city boundaries — Examined territory

1,361 km²

Examined territory area



18.7 million
City population

13,700/km²
Population density

$38,900
GRP per capita, based on PPP

305
Motor vehicles per 1,000 people

Public transport

93%
Share of residents satisfied with the current situation

98%
Share of residents satisfied with the recent changes

Personal transport

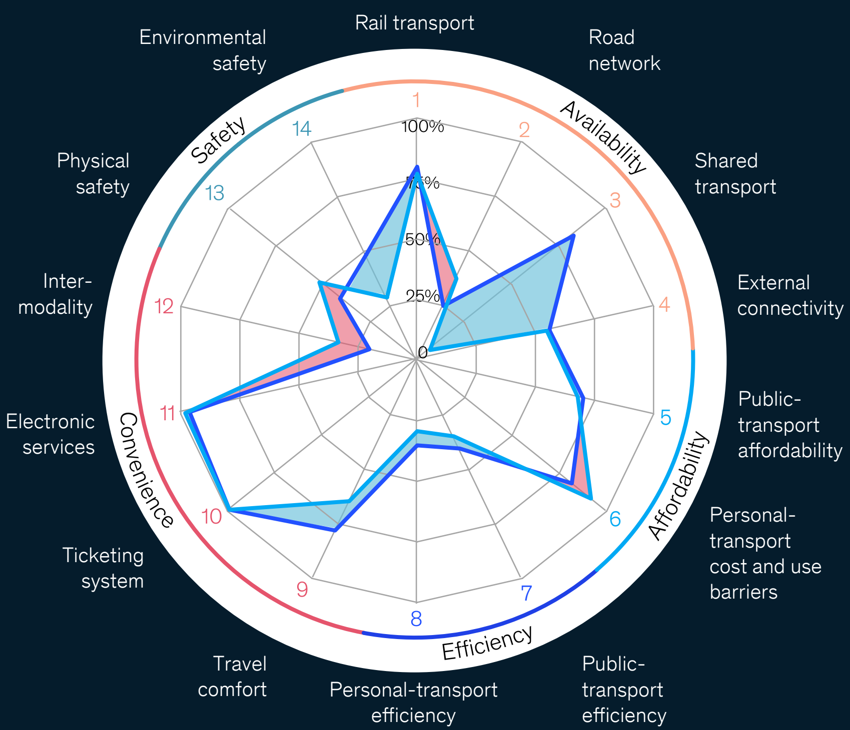
85%
Share of residents satisfied with the current situation

94%
Share of residents satisfied with the recent changes

Objective results for comparable metrics

Score out of 100%

— Objective metrics, 2021 — Objective metrics, 2018

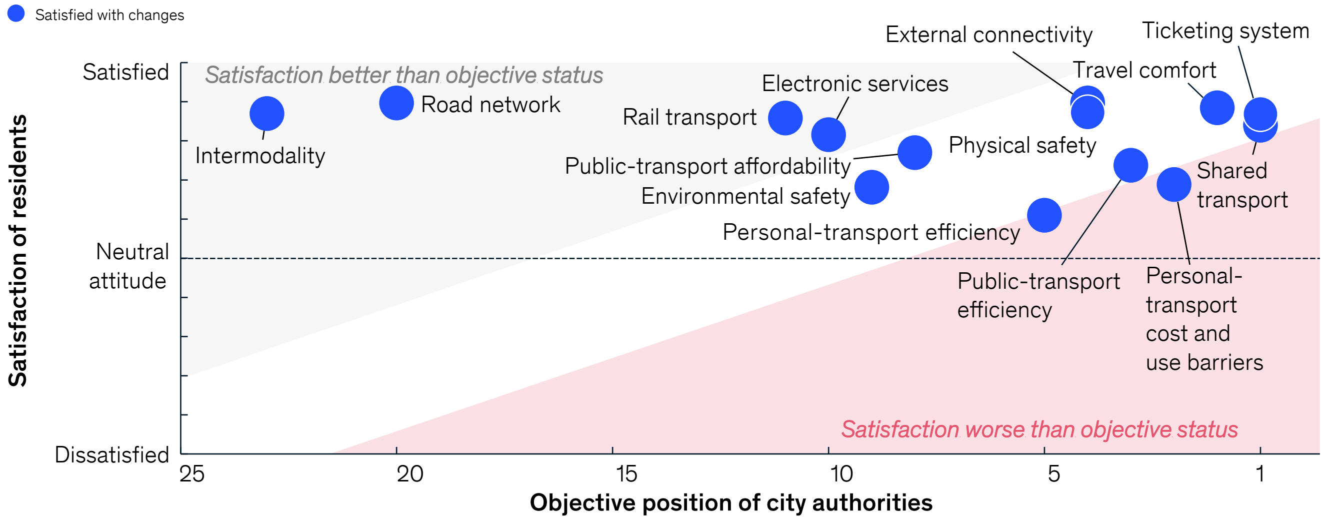


Changes vs 2018

Beijing has improved significantly in several areas, making it one of the leading cities on several aspects of transportation

- **Availability.** Availability of shared modes of transport, notably car-sharing vehicles, has increased manyfold
- **Affordability.** Reduction of score in private transport due to income growth higher than that of parking fees
- **Convenience.** Notable development in travel comfort with increased share of wheelchair-accessible buses, while average distance from metro to bus stations can be improved further
- **Safety.** While road safety hasn't seen large improvement, environmental safety increased with stricter standard being introduced and share of EV sales improving significantly

Gaps between objective status and subjective perception

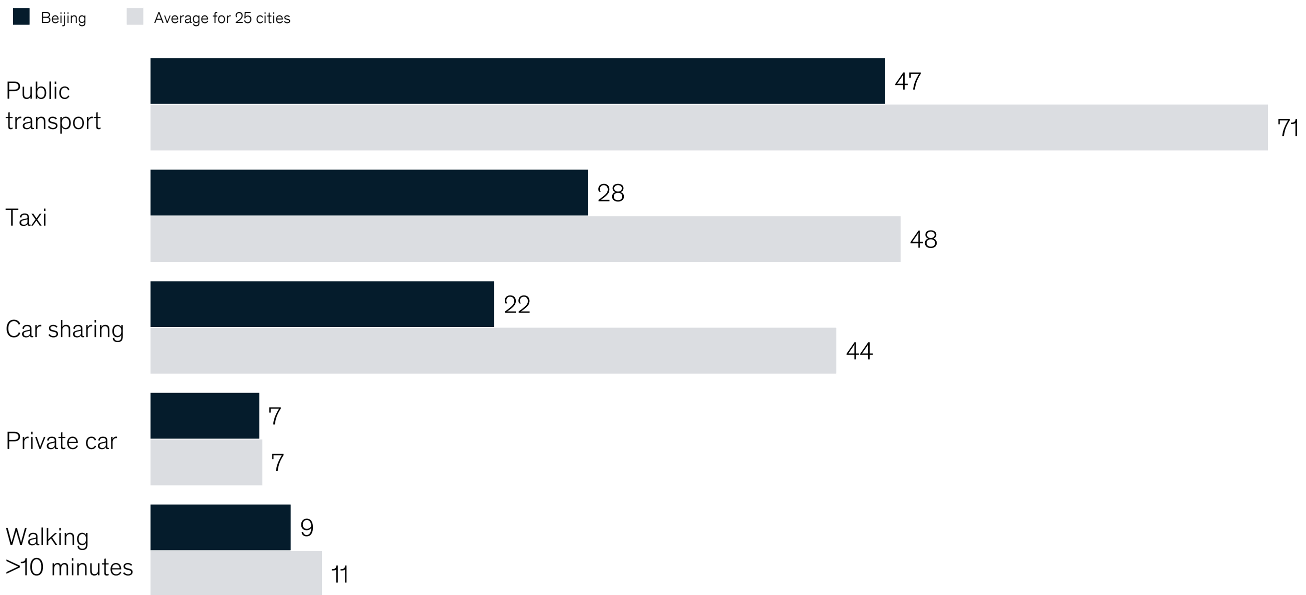


Key implemented projects

Project	Highlights	Share of respondents who mentioned the project
Fare payment using QR codes	Number of system users: 12 million people	38%
Smart parking system	Available information on 120,000 parking spaces	37%
Construction of bicycle lanes	Expansion of the bicycle lane southward to Shizhimen	31%

Impact of the COVID-19 pandemic on risk perception and mobility

Perceived COVID-19 contraction risk by modes of transport

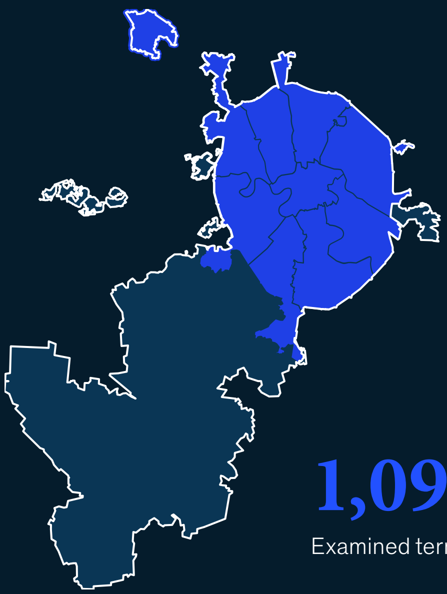


65% Visibility of COVID-19 response in public transport

Moscow

General information

— Official city boundaries — Examined territory



1,096 km²

Examined territory area

12.7 million
City population

11,600/km²
Population density

$85,500
GRP per capita, based on PPP

325
Motor vehicles per 1,000 people

Public transport

74%
Share of residents satisfied with the current situation

80%
Share of residents satisfied with the recent changes

Personal transport

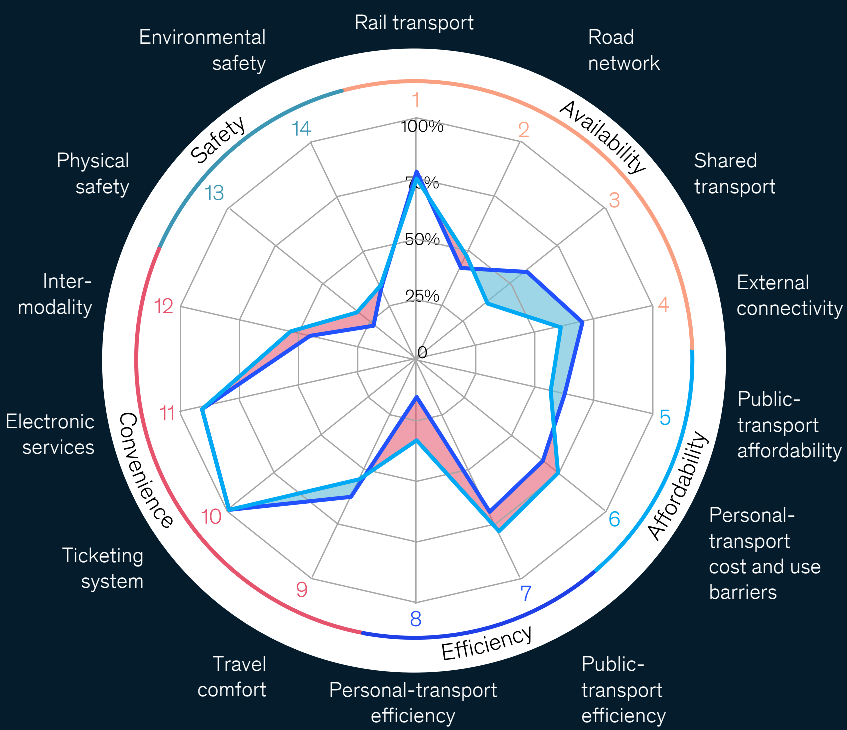
56%
Share of residents satisfied with the current situation

69%
Share of residents satisfied with the recent changes

Objective results for comparable metrics

Score out of 100%

— Objective metrics, 2021 — Objective metrics, 2018

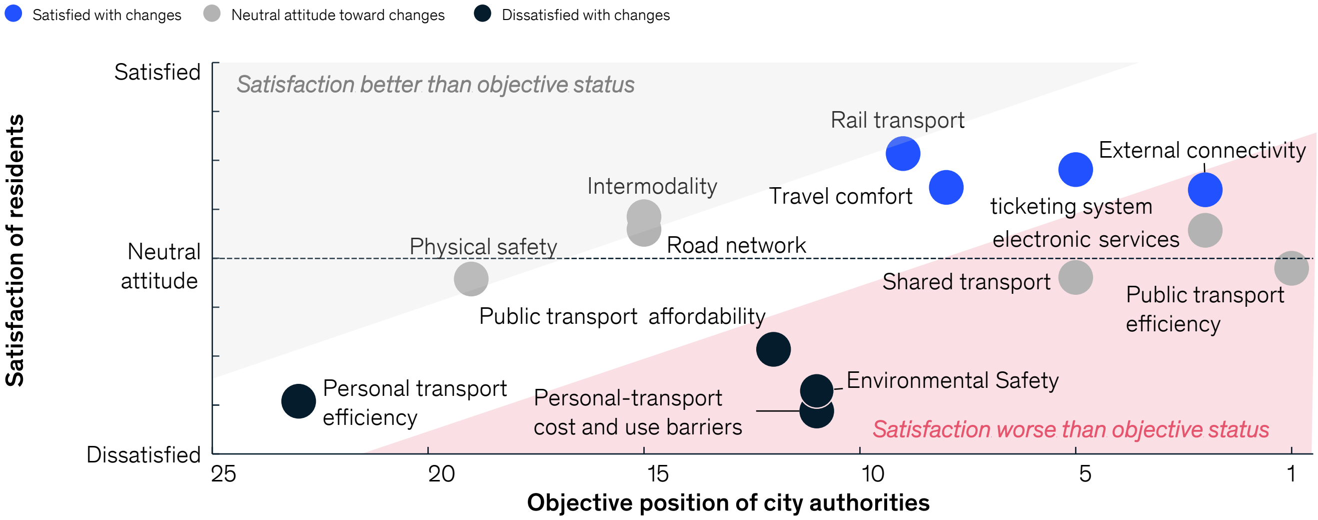


Changes vs 2018

Moscow has shown improvements across most dimensions and is ranked 1st in efficiency, with some scores decreasing as other cities catch up

- **Availability.** Development of metro, coupled with rapid growth in bicycle and car sharing since 2018
- **Efficiency.** Leading in average speed of public transport and the share of dedicated bus lanes, while average waiting time for bus exceeds several other cities. At the same time, private-transport congestion is among the highest in early 2021
- **Affordability.** Public transport became more affordable, while cost of parking is not following the average income increase and demand management measures for cars (eg, paid entry or restrictions on old, environmentally dangerous cars) are not implemented
- **Convenience.** Travel comfort is improving, due to new rolling stock and top-notch ticketing system and electronic services, while improvement in intermodality is slightly slower than in other cities
- **Safety.** Despite significant improvement, the score has decreased due to other cities' rapid improvements

Gaps between objective status and subjective perception

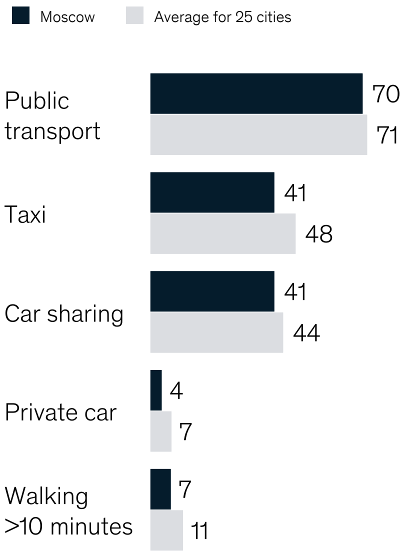


Key implemented projects

Project	Highlights	Share of respondents who mentioned the project
Turnstile-free fare-payment system	The use of the turnstile-free fare payment system on surface transport vehicles produces time savings of up to 25%	39%
MCD-1 and MCD-2 launch	Total length: 132 km; number of stations: 60	38%
Deployment of e-buses	No atmospheric emissions, noise pollution 30% less vs ordinary buses	31%

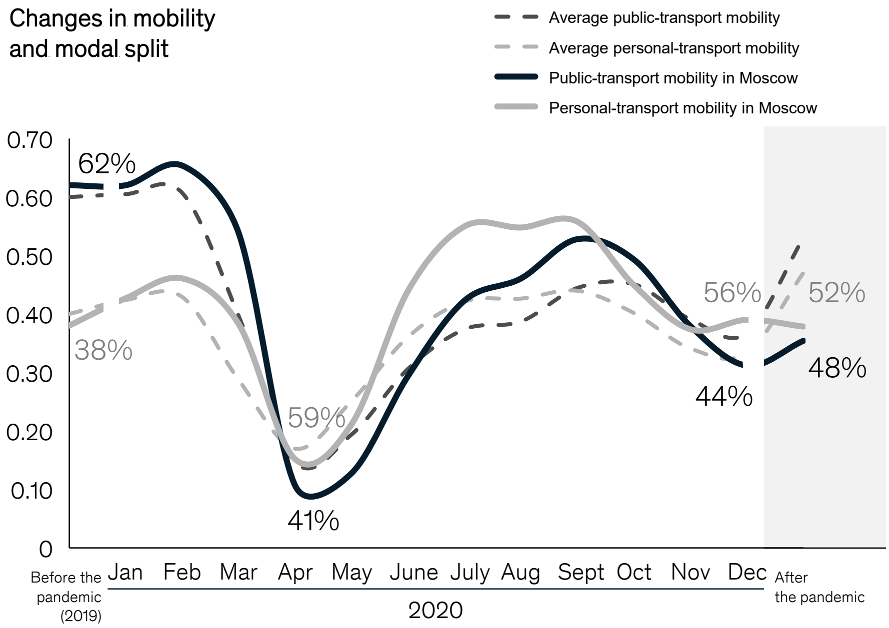
Impact of the COVID-19 pandemic on risk perception and mobility

Perceived COVID-19 contraction risk by modes of transport



47% Visibility of COVID-19 response in public transport

Changes in mobility and modal split



−27 pp Increase in Mobility Index after the pandemic vs 2019

+14 pp Increase in the share of personal transport in modal split after the pandemic vs 2019

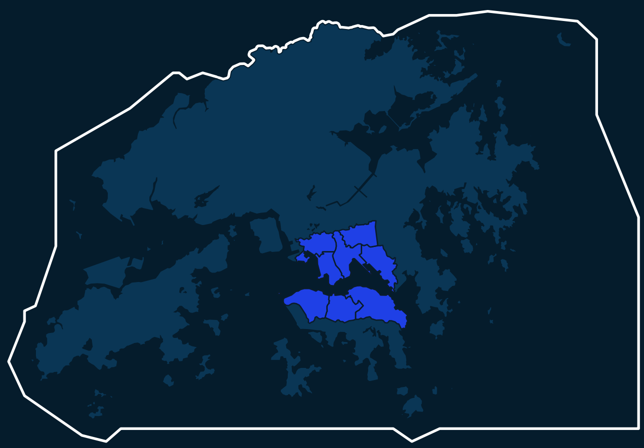
Hong Kong

General information

— Official city boundaries — Examined territory

90 km²

Examined territory area



7.5 million

City population

83,400/km²

Population density

$63,300

GRP per capita, based on PPP

100

Motor vehicles per 1,000 people

Public transport

86%

Share of residents satisfied with the current situation

88%

Share of residents satisfied with the recent changes

Personal transport

78%

Share of residents satisfied with the current situation

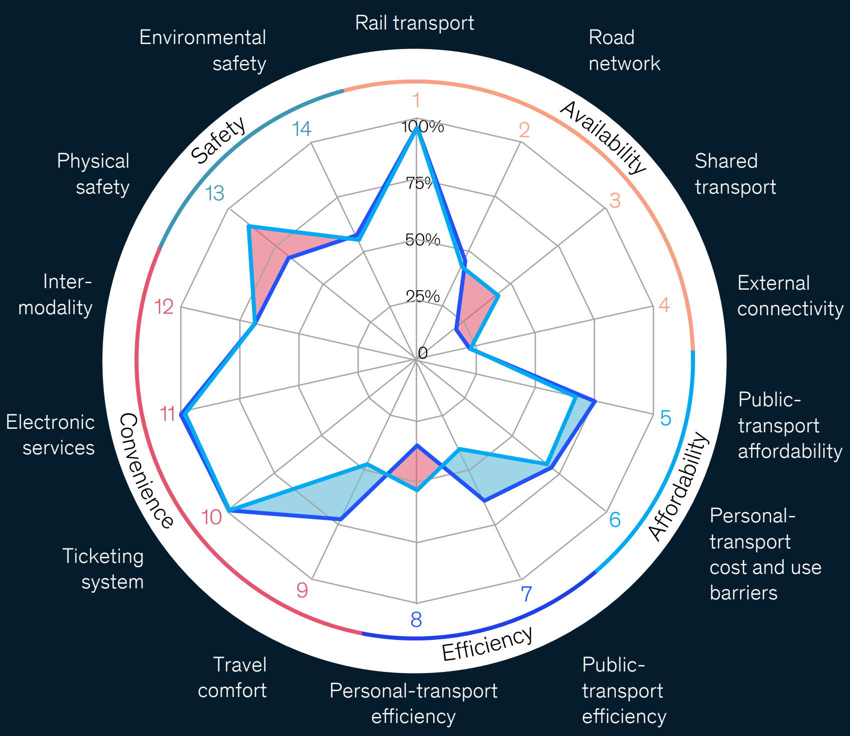
85%

Share of residents satisfied with the recent changes

Objective results for comparable metrics

Score out of 100%

— Objective metrics, 2021 — Objective metrics, 2018

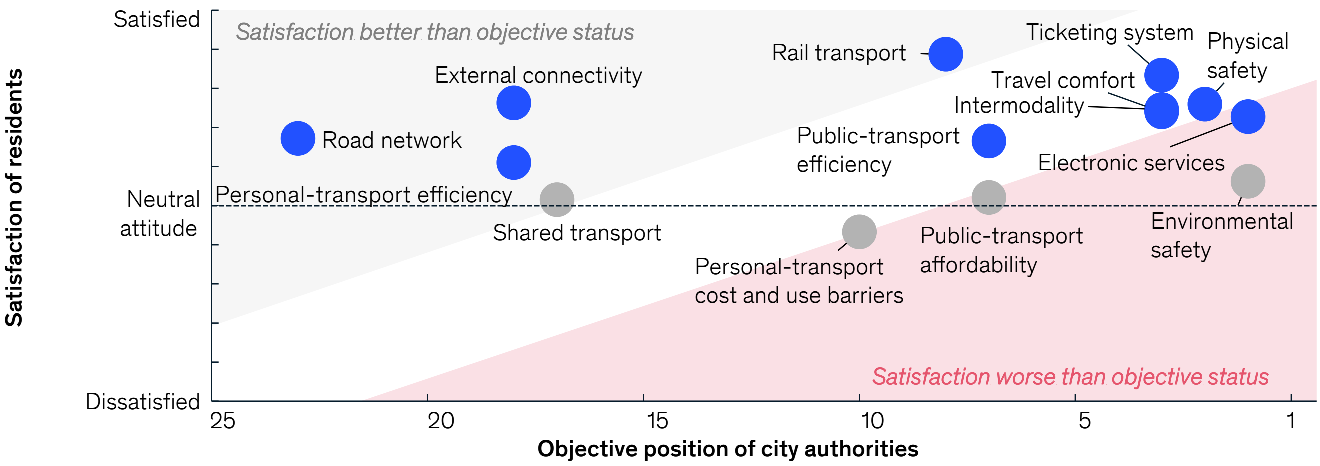


Changes vs 2018

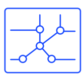
Hong Kong has largely maintained a strong performance from past ranking, with improvements in Efficiency, Convenience, and Affordability, yet the scores have decreased for some aspects, due to strong growth among other cities

- **Availability.** Bicycle and car-sharing availability in other cities is improving at a faster pace
- **Affordability.** Public transport has became more affordable as fares increase slower than income
- **Efficiency.** Public-transport speed improved significantly while congestion for private cars increased
- **Convenience.** Physical comfort has improved with an update of the bus fleet
- **Safety.** Despite improvements in safety metrics, the score has decreased as other cities rapidly catch up with leaders in road safety

Gaps between objective status and subjective perception

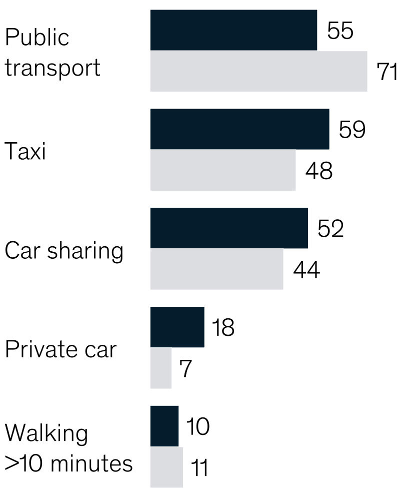


Key implemented projects

	Project	Highlights	Share of respondents who mentioned the project
	Tuen Mun–Chek Lap Kok Tunnel	Total length of 5.5 km; depth of 50 m	33%
	Liantang/Heung Yuen Wai Point	Boundary control point; rated load of 30,000 vehicles per day	29%
	Tuen Ma Line	Rated load of 70,000–80,000 passengers per day; expected to reduce passenger traffic served by the East Rail Line	26%

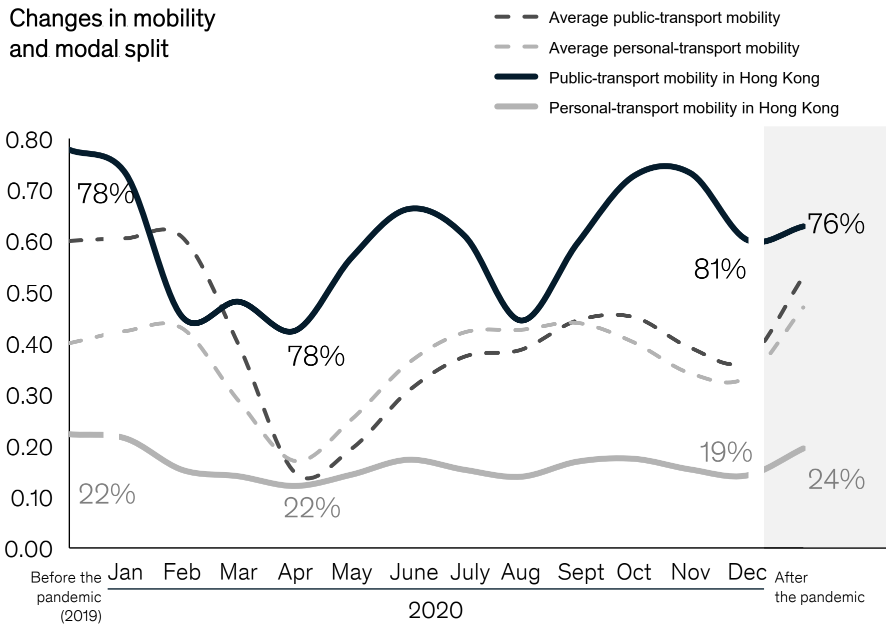
Impact of the COVID-19 pandemic on risk perception and mobility

Perceived COVID-19 contraction risk by modes of transport



35% Visibility of COVID-19 response in public transport

Changes in mobility and modal split



–18 pp Increase in Mobility Index after the pandemic vs 2019

+2 pp Increase in the share of personal transport in modal split after the pandemic vs 2019

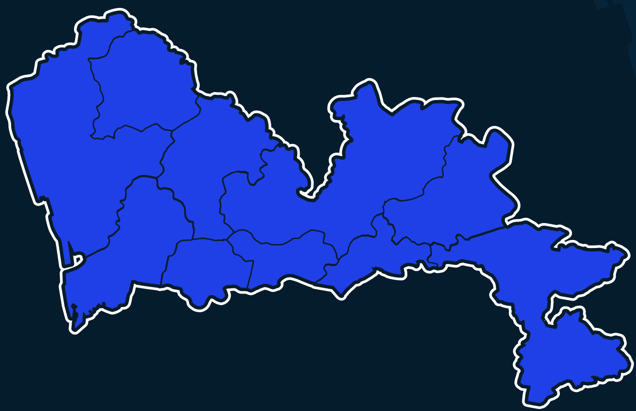
Shenzhen

General information

— Official city boundaries — Examined territory

1,919 km²

Examined territory area



13.4 million

City population

7,000/km²

Population density

$51,100

GRP per capita, based on PPP

260

Motor vehicles per 1,000 people

Public transport

94%

Share of residents satisfied with the current situation

98%

Share of residents satisfied with the recent changes

Personal transport

87%

Share of residents satisfied with the current situation

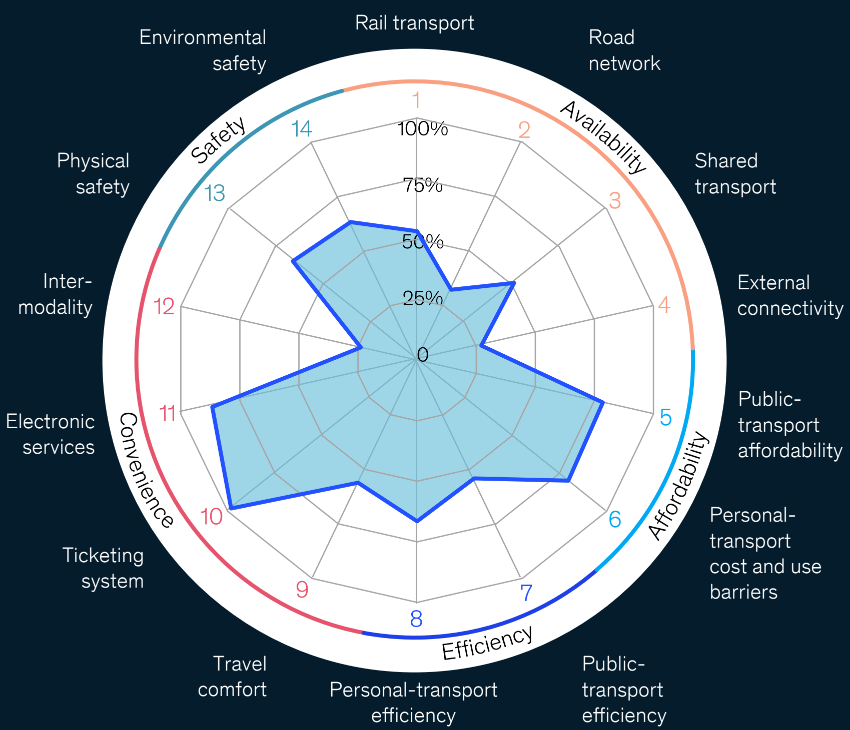
93%

Share of residents satisfied with the recent changes

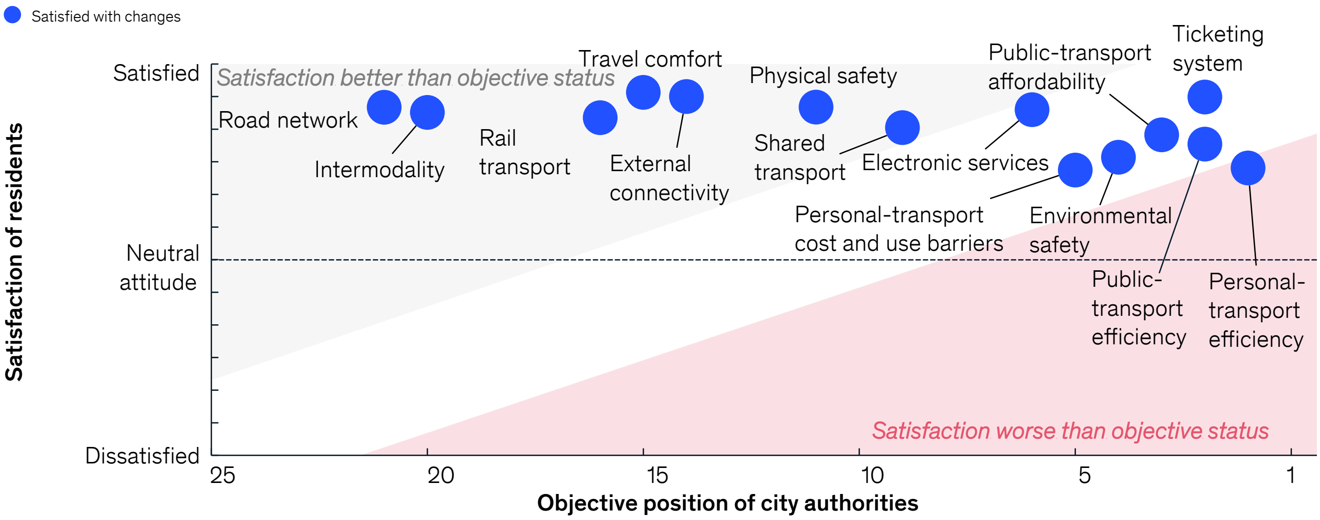
Objective results for comparable metrics

Score out of 100%

— Objective metrics, 2021 — Objective metrics, 2018



Gaps between objective status and subjective perception

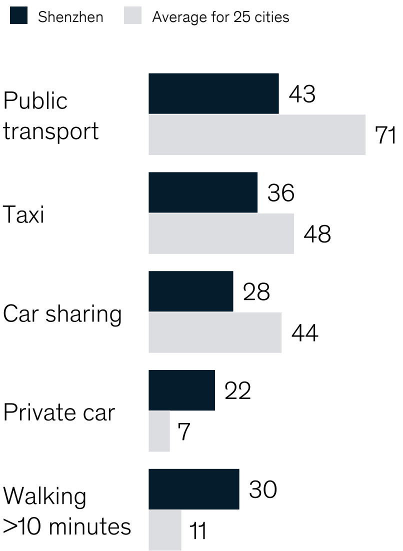


Key implemented projects

	Project	Highlights	Share of respondents who mentioned the project
	Electric buses	All buses replaced with e-buses (>16,000 buses)	**40%**
	Fare payment using QR codes	System launched in 2018; coverage of > 6,000 buses	**37%**
	Construction of bicycle lanes	>800 km of bicycle lanes created over the last 3 years	**34%**

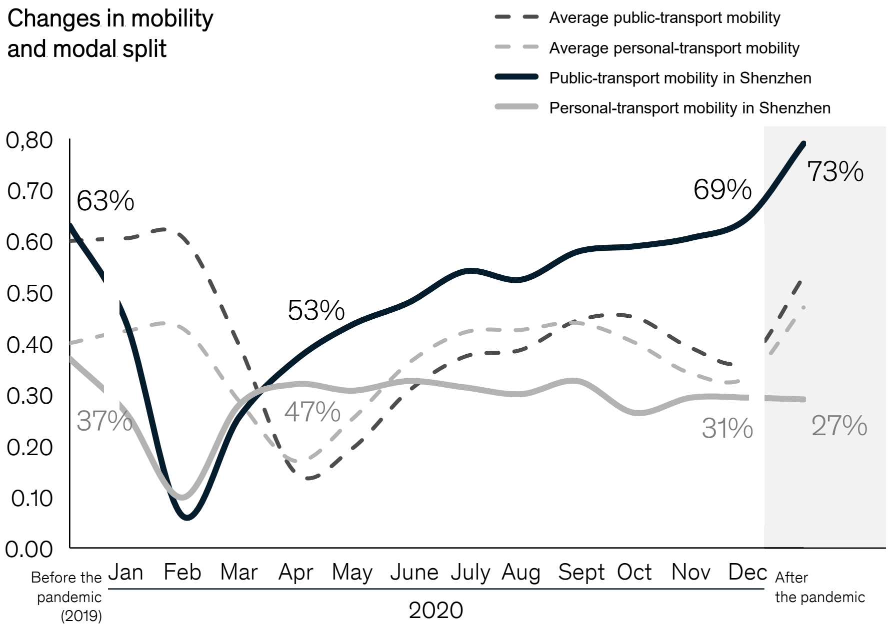
Impact of the COVID-19 pandemic on risk perception and mobility

Perceived COVID-19 contraction risk by modes of transport



78% Visibility of COVID-19 response in public transport

Changes in mobility and modal split



+8 pp Increase in Mobility Index after the pandemic vs 2019

−10 pp Increase in the share of personal transport in modal split after the pandemic vs 2019

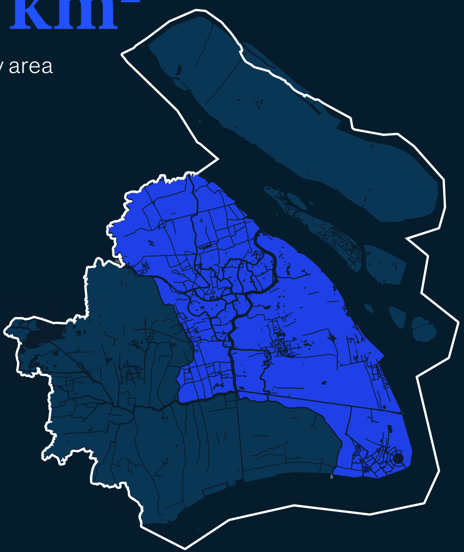
Shanghai

General information

— Official city boundaries — Examined territory

2,758 km²

Examined territory area



24.3 million
City population

8,800/km²
Population density

$36,600
GRP per capita, based on PPP

171
Motor vehicles per 1,000 people

Public transport

94%
Share of residents satisfied with the current situation

98%
Share of residents satisfied with the recent changes

Personal transport

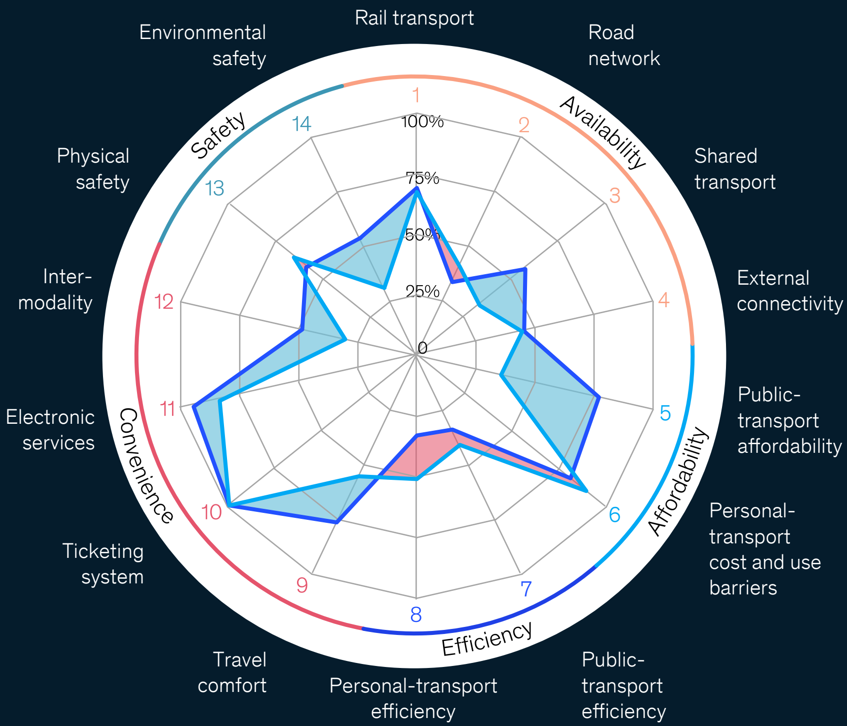
87%
Share of residents satisfied with the current situation

93%
Share of residents satisfied with the recent changes

Objective results for comparable metrics

Score out of 100%

— Objective metrics, 2021 — Objective metrics, 2018

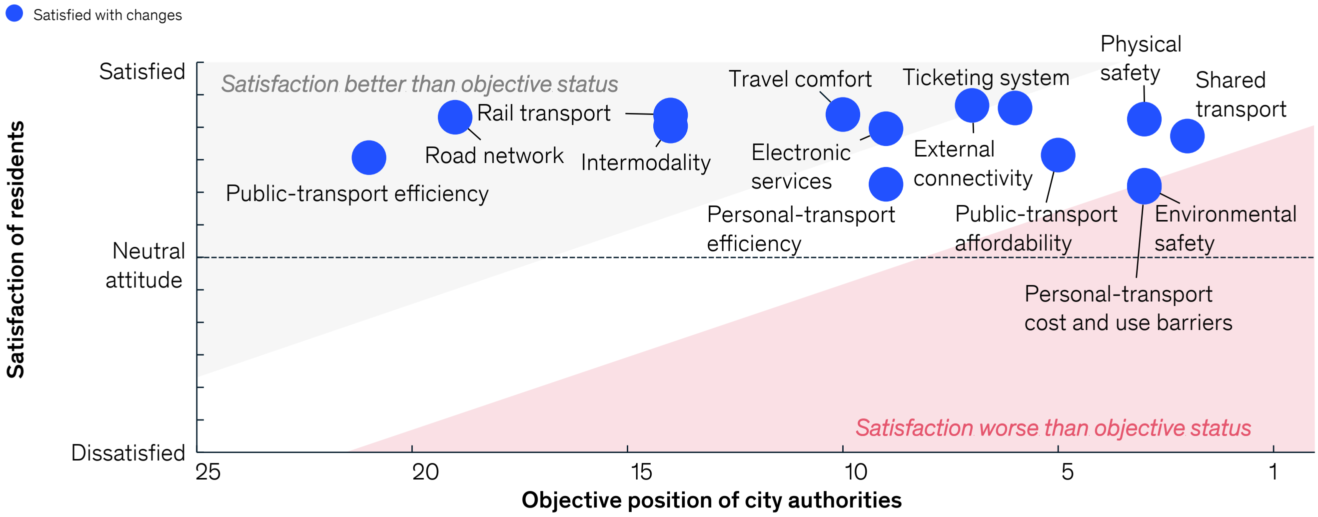


Changes vs 2018

Shanghai has made strong improvements across most dimensions, while congestion for private cars also increases

- **Availability.** Rapid increase in car-sharing availability
- **Affordability.** Public transport has become more affordable as fares increase slower than income
- **Efficiency.** Congestion rate for private transport increased, causing a decrease in the average speed during rush hour by car
- **Convenience.** Upgrade of public- transport fleet coupled with Intermodality improvement through unified city wayfinding system.
- **Safety.** a stricter environmental standard has been introduced for new cars; the share of EVs in car sales also increased

Gaps between objective status and subjective perception

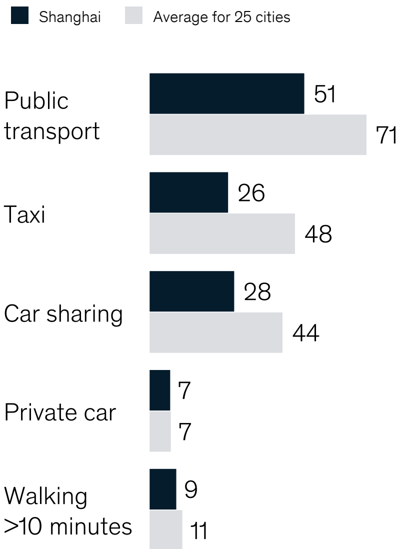


Key implemented projects

	Project	Highlights	Share of respondents who mentioned the project
	Fare payment using QR codes	Available on all Shanghai buses	67%
	Fully automated underground transit system	Driverless automated underground trains available on Lines 10, 14, 15, and 18	40%
	Underground Line 13	3 connecting passages to Lines 14, 15, and 18 built in 2020	37%

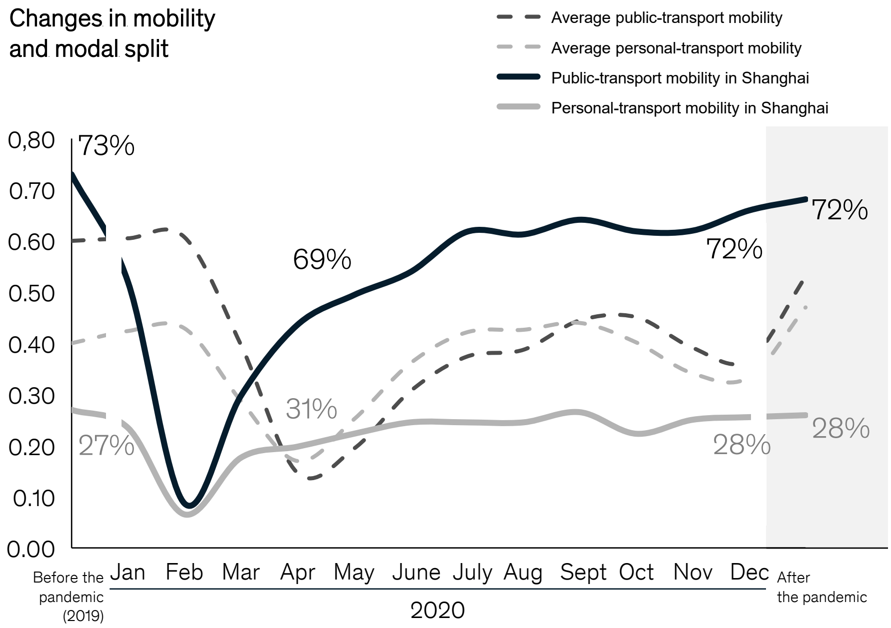
Impact of the COVID-19 pandemic on risk perception and mobility

Perceived COVID-19 contraction risk by modes of transport



72% Visibility of COVID-19 response in public transport

Changes in mobility and modal split



−6 pp Increase in Mobility Index after the pandemic vs 2019

+1 pp Increase in the share of personal transport in modal split after the pandemic vs 2019

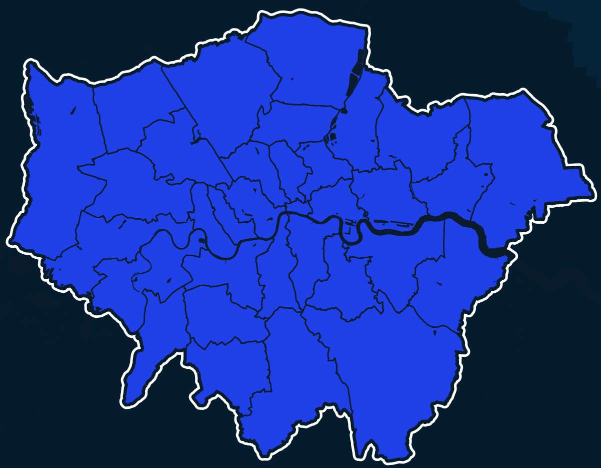
London

General information

— Official city boundaries — Examined territory

1,607 km²

Examined territory area



8.96 million

City population

5,600/km²

Population density

$62,750

GRP per capita, based on PPP

348

Motor vehicles per 1,000 people

Public transport

84%

Share of residents satisfied with the current situation

85%

Share of residents satisfied with the recent changes

Personal transport

76%

Share of residents satisfied with the current situation

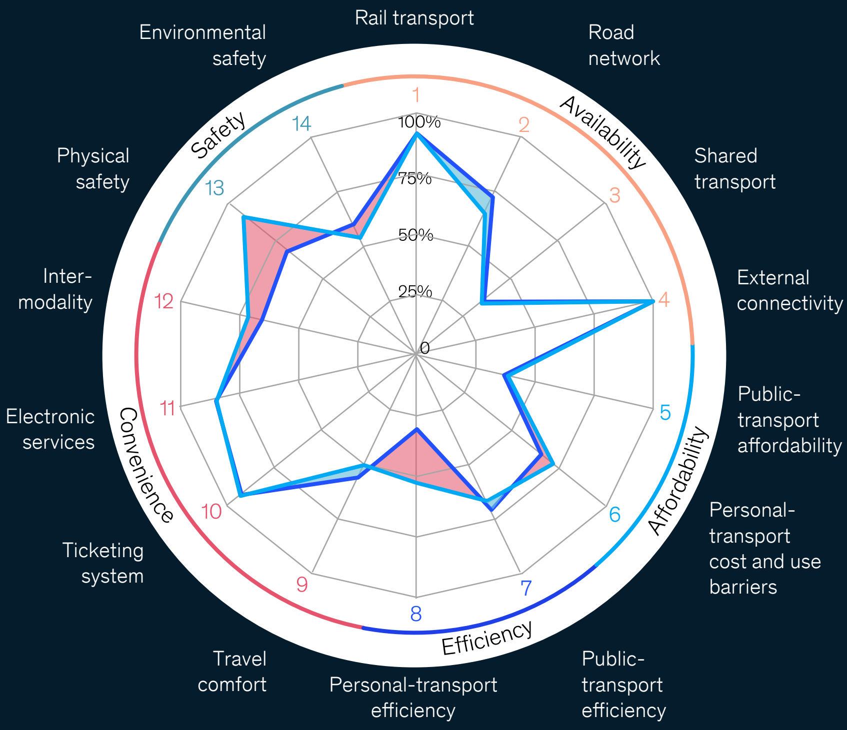
78%

Share of residents satisfied with the recent changes

Objective results for comparable metrics

Score out of 100%

— Objective metrics, 2021 — Objective metrics, 2018

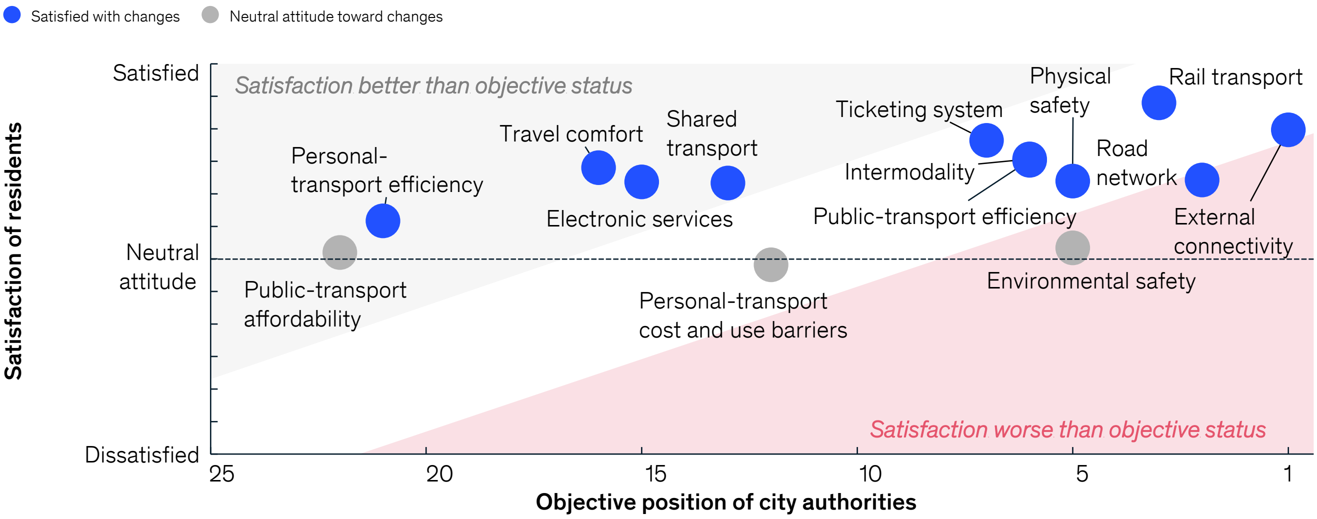


Changes vs 2018

London maintains its position among cities with the most developed transport systems yet faces increased congestion as do most of megapolises

- **Availability.** The share of bicycle lanes in the total length of the road network has increased
- **Efficiency.** The time spent on a rush-hour trip has increased because of higher congestion rates
- **Safety.** Despite improvements in safety metrics, the score has decreased because other cities are rapidly catching up with leaders in road safety of EVs in car sales also increased

Gaps between objective status and subjective perception

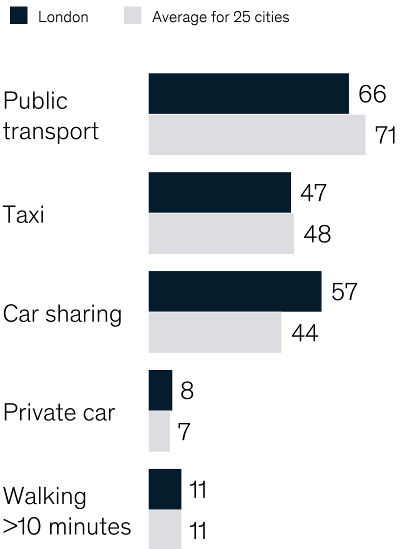


Key implemented projects

	Project	Highlights	Share of respondents who mentioned the project
	Streetspace for London	89 kilometers of new bicycle lanes	32%
	Publication of train schedules in “TFL Go” application	Enables en route tracking for subway, rail trains and tramways	23%
	Parking fee increase	Parking fees increased by 50% for diesel motor vehicles purchased before 2015, if they fail to meet current environmental standards	19%

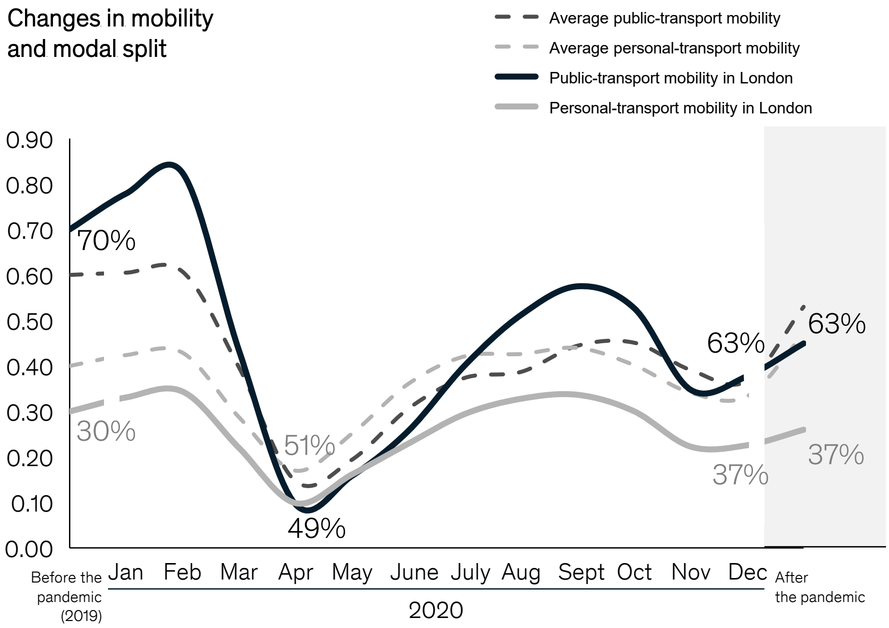
Impact of the COVID-19 pandemic on risk perception and mobility

Perceived COVID-19 contraction risk by modes of transport



37% Visibility of COVID-19 response in public transport

Changes in mobility and modal split



–29 pp Increase in Mobility Index after the pandemic vs 2019

+7 pp Increase in the share of personal transport in modal split after the pandemic vs 2019

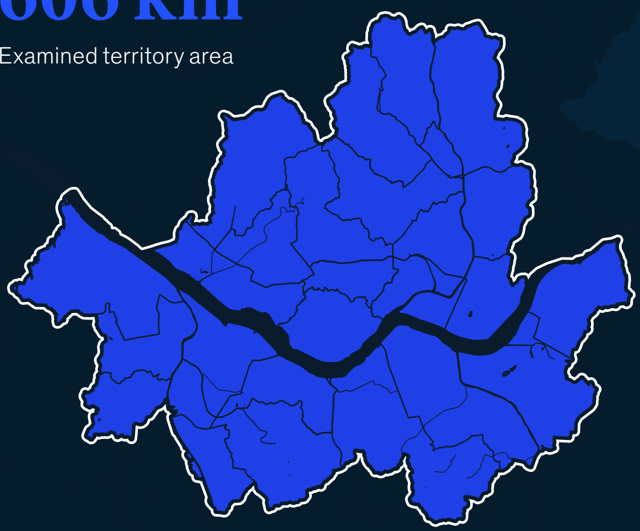
Seoul

General information

Official city boundaries — Examined territory

606 km²

Examined territory area



9.6 million
City population

15,900/km²
Population density

$51,000
GRP per capita, based on PPP

308
Motor vehicles per 1,000 people

Public transport

82%
Share of residents satisfied with the current situation

89%
Share of residents satisfied with the recent changes

Personal transport

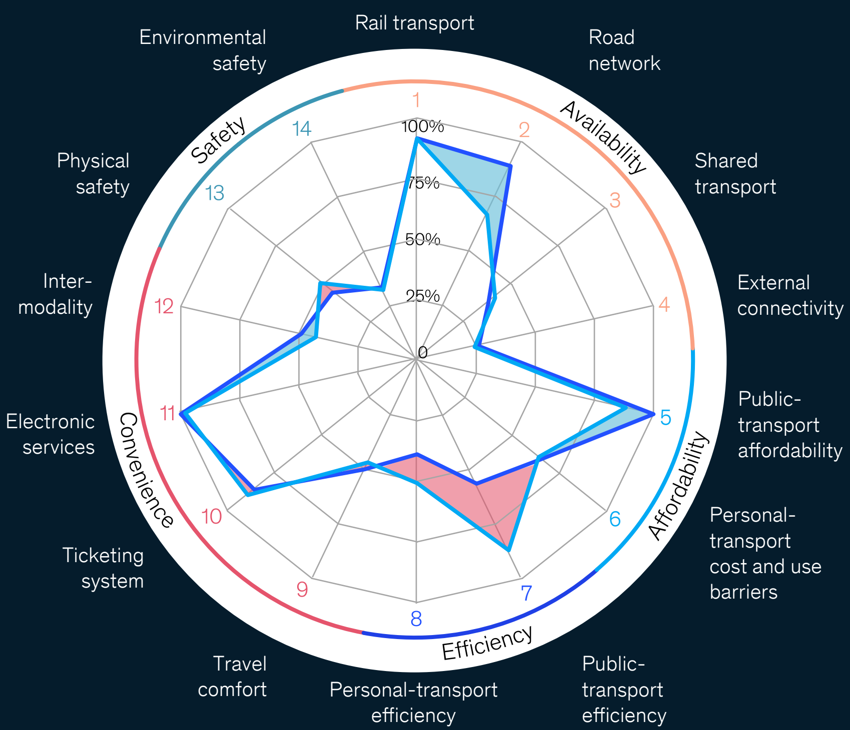
75%
Share of residents satisfied with the current situation

87%
Share of residents satisfied with the recent changes

Objective results for comparable metrics

Score out of 100%

Objective metrics, 2021 — Objective metrics, 2018

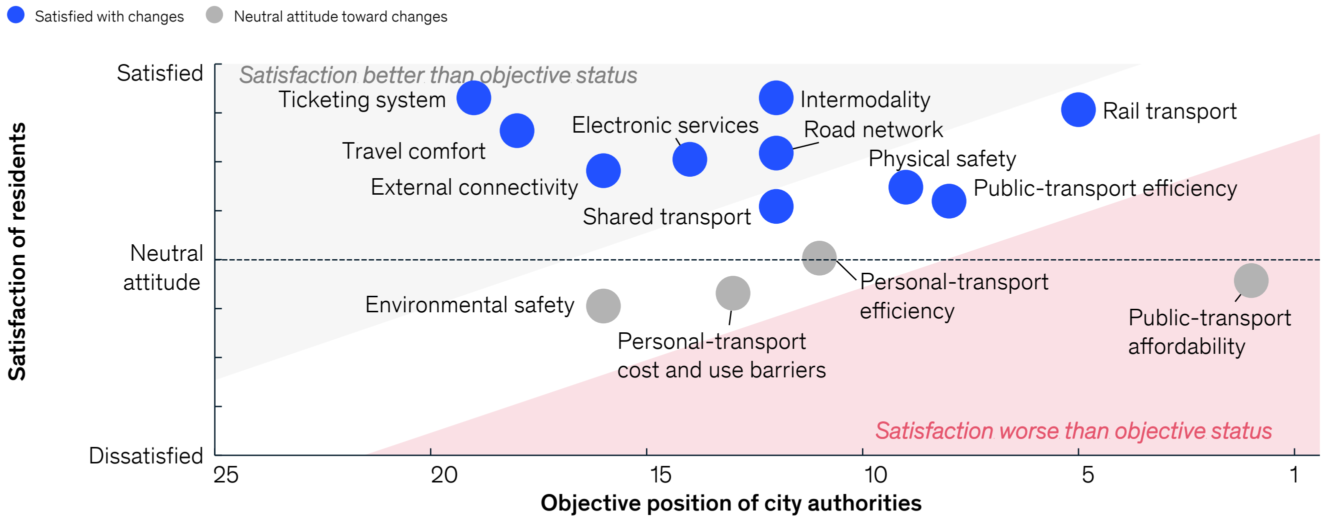


Changes vs 2018

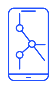
Seoul maintains its position among cities with most developed transport systems yet faces increased congestion, as do most of the megapolises

- **Availability.** The road infrastructure quality index has improved
- **Affordability.** Public transport has become more affordable as fares increase slower than income
- **Efficiency.** Slower improvement in public-transport waiting times and length of dedicated bus lanes than in other cities, while congestion for private transport has increased
- **Convenience.** The upgrade of the public-transport fleet is being made faster in other cities. Intermodality improved through a unified city wayfinding system.
- **Safety.** a stricter environmental standard has been introduced for new cars, and share of EVs in car sales also increased

Gaps between objective status and subjective perception

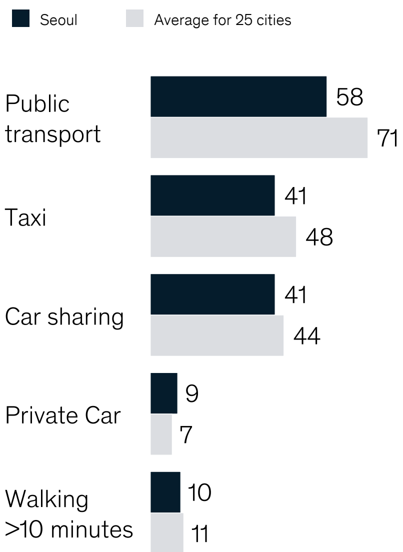


Key implemented projects

	Project	Highlights	Share of respondents who mentioned the project
	Public-transport application	Displays information about public-transport passenger traffic	30%
	Electric bicycles to lease	2 new e-bicycle lease stations opened in 2019	29%
	Gyeongui–Jungang Line extension	Part of the plan to extend the line to Dorasan Station	26%

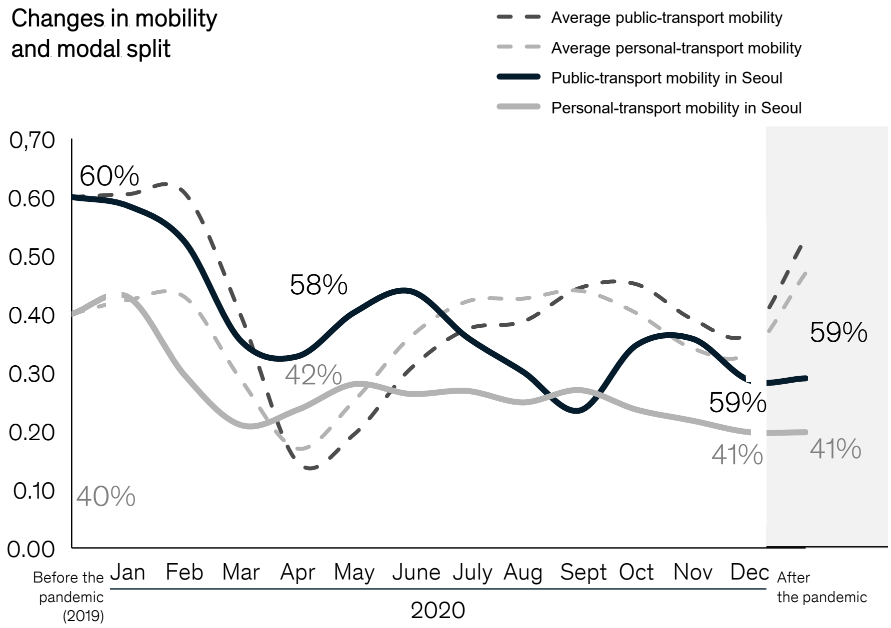
Impact of the COVID-19 pandemic on risk perception and mobility

Perceived COVID-19 contraction risk by modes of transport



50% Visibility of COVID-19 response in public transport

Changes in mobility and modal split



–51 pp Increase in Mobility Index after the pandemic vs 2019

+1 pp Increase in the share of personal transport in modal split after the pandemic vs 2019

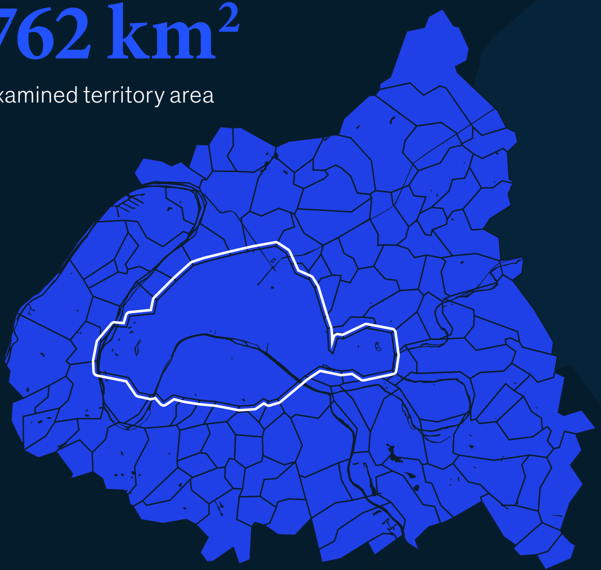
Paris

General information

— Official city boundaries — Examined territory

762 km²

Examined territory area



7.06 million

City population

9,300/km²

Population density

$55,300

GRP per capita, based on PPP

344

Motor vehicles per 1,000 people

Public transport

70%

Share of residents satisfied with the current situation

81%

Share of residents satisfied with the recent changes

Personal transport

68%

Share of residents satisfied with the current situation

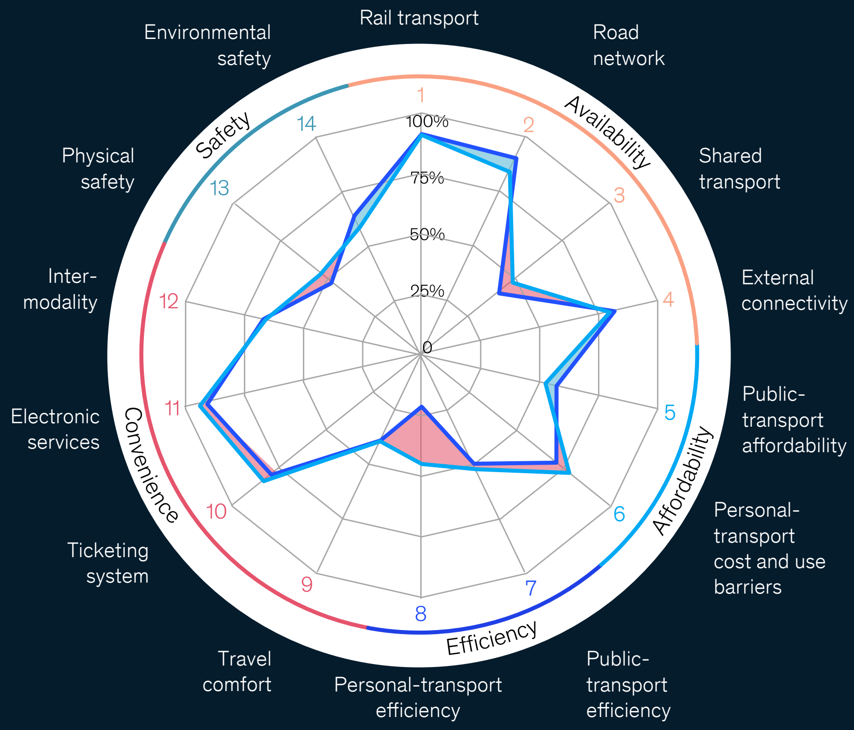
75%

Share of residents satisfied with the recent changes

Objective results for comparable metrics

Score out of 100%

— Objective metrics, 2021 — Objective metrics, 2018

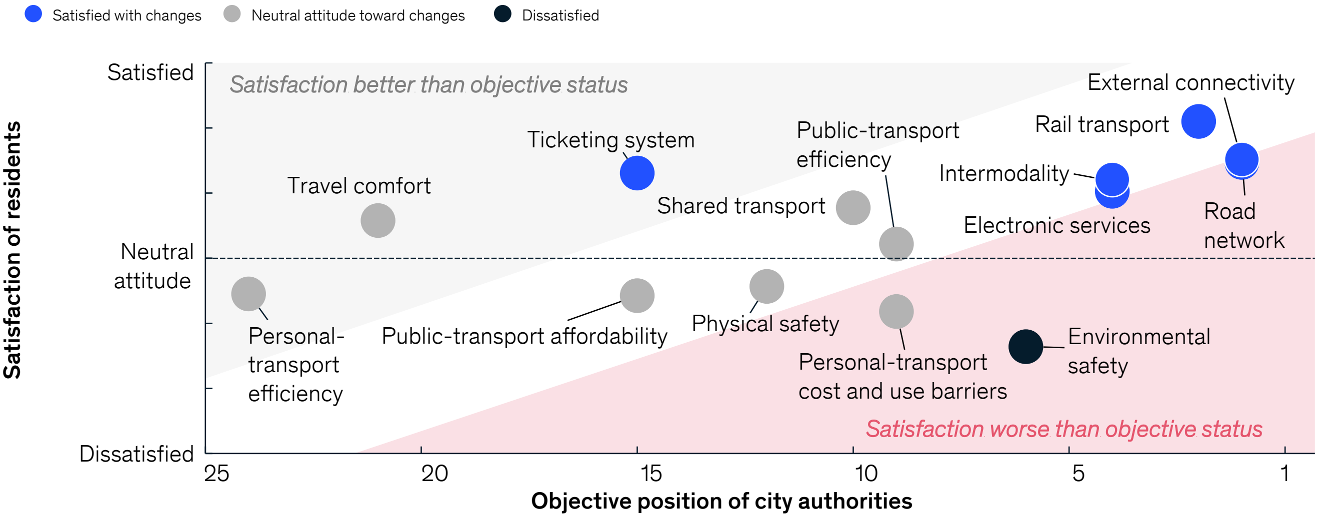


Changes vs 2018

Paris maintains its position among cities with the most developed transport systems yet faces increased congestion as most of megapolises. At the same time, other cities are catching up on some parameters, decreasing Paris's scores

- **Availability.** Improvement in pedestrian infrastructure connectivity; reduction of car-sharing fleets
- **Efficiency.** Congestion for private transport has increased, lowering average speed during rush hour

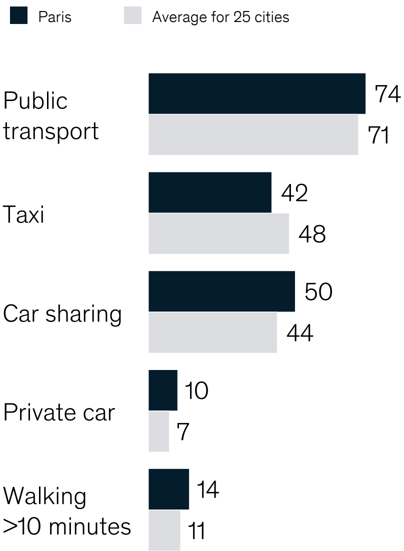
Gaps between objective status and subjective perception



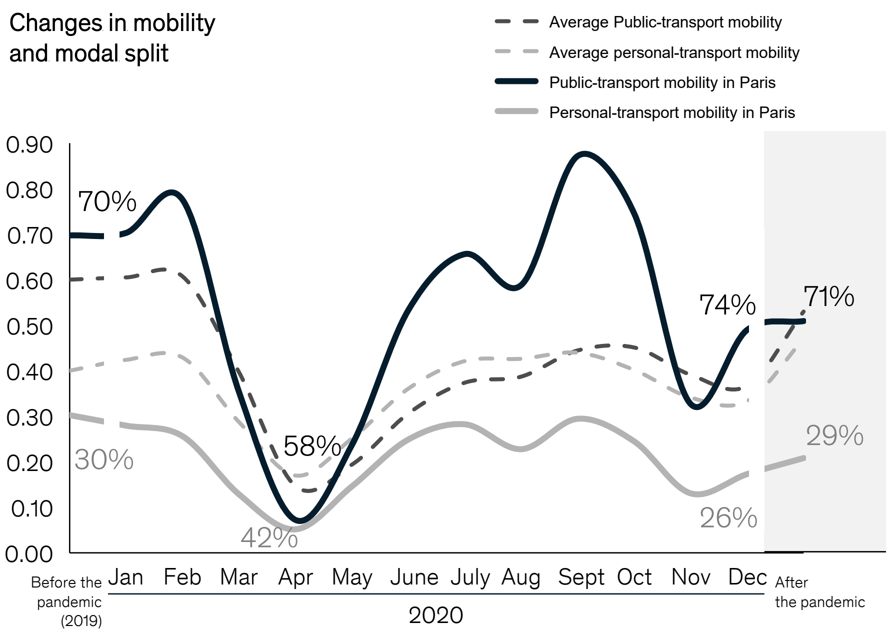
Key implemented projects

Project	Highlights	Share of respondents who mentioned the project
Navigo card top-up from smartphone	Travel card used by about 5.8 million people	24%
New autonomous trains	4 additional underground lines around Paris (200 kilometers, 68 stations)	20%
Extension of bicycle lanes and pedestrian areas	Certain streets partially converted into bicycle lanes and pedestrian areas	19%

Impact of the COVID-19 pandemic on risk perception and mobility



21% Visibility of COVID-19 response in public transport



−28 pp Increase in Mobility Index after the pandemic vs 2019

−1 pp Increase in the share of personal transport in modal split after the pandemic vs 2019

Tokyo

General information

633 km²

Examined territory area

9.6 million

City population

15,100/km²

Population density

$47,900

GRP per capita, based on PPP

286

Motor vehicles per 1,000 people

Public transport

79%

Share of residents satisfied with the current situation

95%

Share of residents satisfied with the recent changes

Personal transport

74%

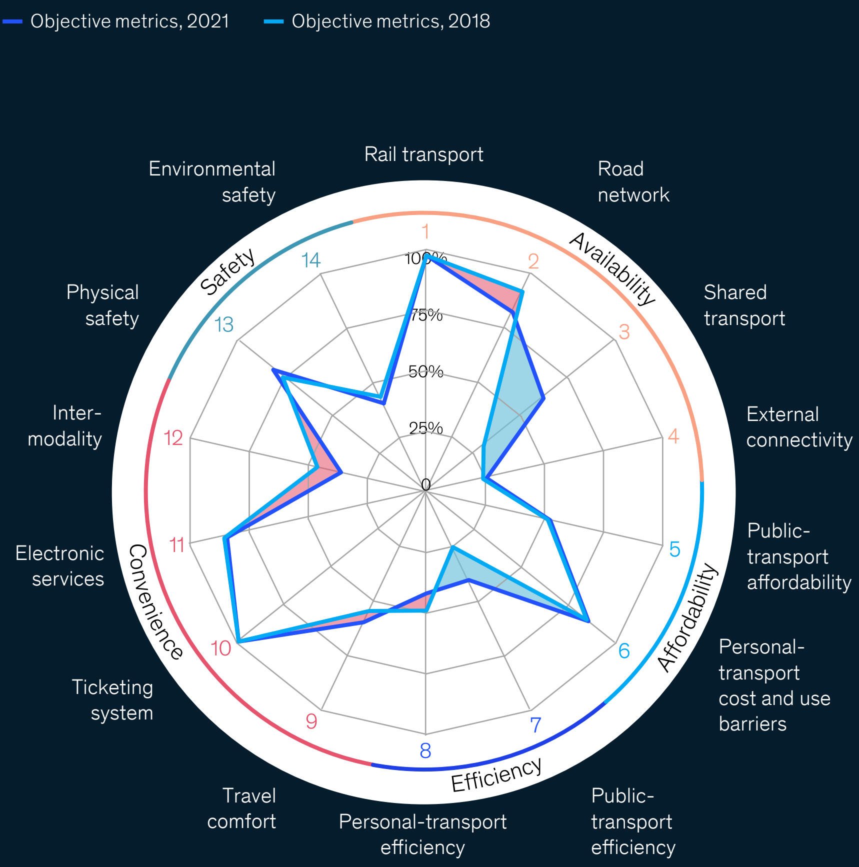
Share of residents satisfied with the current situation

95%

Share of residents satisfied with the recent changes

Objective results for comparable metrics

Score out of 100%

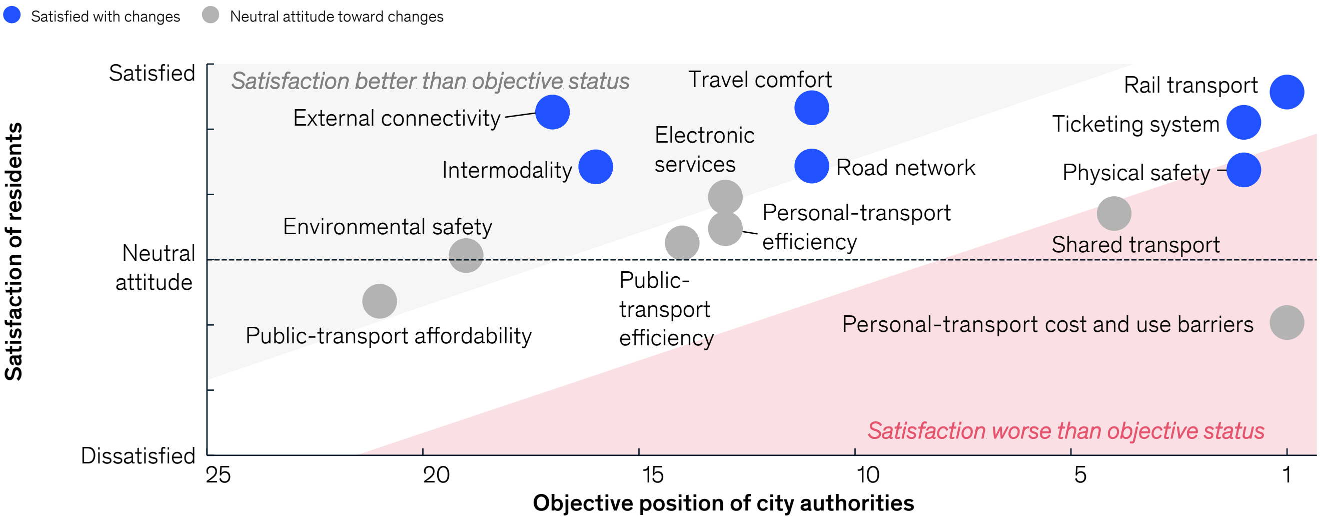


Changes vs 2018

Tokyo has significantly improved its scores since 2018, while some scores are deteriorating as other cities are catching up on such aspects as road availability or intermodality

- **Availability.** Improvements in availability of bicycle and car sharing, while other cities are catching up on road availability and quality
- **Efficiency.** Increase of average speed for public transport and reduction of bus waiting time

Gaps between objective status and subjective perception

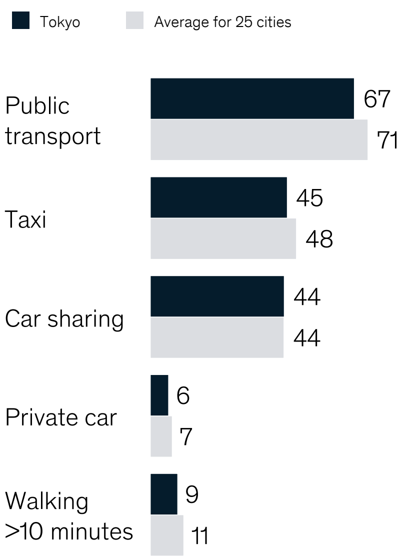


Key implemented projects

Project	Highlights	Share of respondents who mentioned the project
Takanawa Gateway Underground Station	By 2024, the station will be visited by >120,000 people per day	34%
Fare payment with points	The program is designed to stimulate underground trips outside of rush hour	30%
New bike lanes	New bike lanes will be opened in 24 Tokyo districts	21%

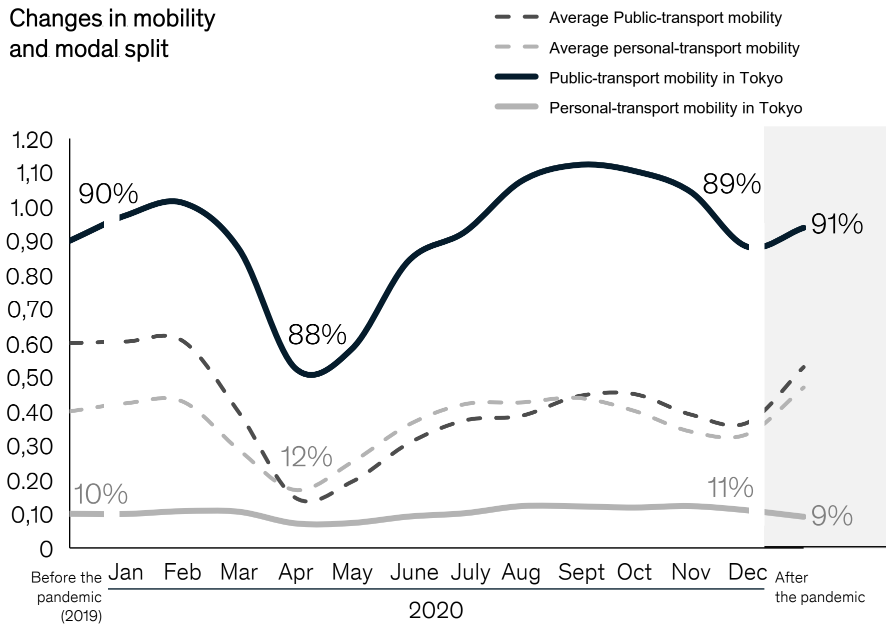
Impact of the COVID-19 pandemic on risk perception and mobility

Perceived COVID-19 contraction risk by modes of transport



24% Visibility of COVID-19 response in public transport

Changes in mobility and modal split



+3 pp Increase in Mobility Index after the pandemic vs 2019

-1 pp Increase in the share of personal transport in modal split after the pandemic vs 2019