Diagnosing Transportation: Developing Key Performance Indicators To Assess Urban Transportation Systems

Yousaf Shah, Kevin Manaugh, Madhav Badami, and Ahmed El-Geneidy, School of Urban Planning, McGill University

McGill +RAM Transportation Research at McGill CIRRELT

INTRODUCTION

Rapid urbanization is putting pressure on transportation agencies to respond to an increasing demand for greater efficiency and effectiveness in transportation networks. In response, policy makers, faced with limited budgets and time constraints, are looking for tools and processes to identify priority problems in a timely and cost effective manner. Rapid assessments can be performed using a diagnostic study that identifies cities' individual problems within the global context. Using a series of performance indicators based on a review of research and practice from around the world, this paper assesses different cities' transportation networks. The performance indicators rank cities according to an overall score as well as different categories of transportation performance. Such an approach allows planners to identify priority problems in the transportation network so as to design targeted solutions. The final results benchmark the performance of transportation systems according to peer cities with relatively similar sizes. Such a process assists in benchmarking performance while accounting for context, so that appropriate best practices can be shared between cities around the world.

Three questions are addressed to develop the diagnosis:

SELECTION

What kind of performance indicators must be measured to identify priority problems in urban transportation?

Three principles are used to identify the performance indicators:

1. Validity – the indicator must have a direct linkage to a relevant policy intervention
2. Availability – the indicator must be quantifiable with easily accessible data
3. Reliability – the data must have been gathered by a public or governmental authority

TABLE 1: LIST OF GOALS, PERFORMANCE INDICATORS AND AVAILABILITY OF DATA

Goals	Count	Indicators	Cities	Agencies	Research	Total	Data
Demand/Context		Total population	3	6	2	11	100%
Affordability and Accessibility							
Improve access to daily destinations	8	Transit coverage by population (% of people who live within one or two km of rapid transit)	1	2		3	10%
		Average length of commute (minutes)	5		1	6	100%
Provide affordable mobility	6	Share of household income spend on transport (%)	2		3	5	78%
Coordinate transportation and land use plans	4	Length of roads per 1,000 people (Km)	1	1		2	97%
Mobility							
Reduce congestions, delays and travel time	10	Average speed of trip (km/hr)	4	1	2	7	86%
Encourage the use of and improve transit and active transport networks	9	Transport trips by mode (% by mode)	7	6	5	18	100%
Provide for efficient freight travel	4	Annual volume of container traffic (tonnes)	3			3	10%
Economic Development							
Facilitate economic growth through effective management of the transport network	7	Cost of vehicle congestion (in USD)	2			2	6%
Quality of Life							
Protect and promote public health	9	Number of noise/vibration exceedances per year	1		2	3	5%
Respond to public expectations	3	Public transport customer satisfaction (%)	3		1	4	11%
Address the mobility needs of the elderly, youth, and persons with special needs	8	Share of transport facilities with step-free access (%)	2		1	3	6%
Operational Efficiency							
Provide an integrated public transport system	4						
Provide a transportation system that is maintained, reliable, and efficient	7	Public transport capacity (Passenger- km)	2		2	4	95%
Ensure fiscal sustainability	7	Cost recovery from fares (Fare-box Recovery Ratio - %)	1	2	1	4	95%
Environmental and Resource Conservation							
Improve air quality	12	Greenhouse gas emissions from passenger travel (Kg/capita)	2	3	1	6	71%
Advance environmental sustainability	7	Annual energy consumption of transport (Mj)	1	4		5	78%
Reduce dependence on non-renewable resources	2	Bio and fossil fuel used per VKT or per capita (L)	1		1	2	2%
Safety							
Reduce accidents	9	Road fatalities	3	6	2	11	97%
Ensure personal security	5	Crime rates on publitransport (%)	1			1	2%
Infrastructure Condition and Performance							
Maintain infrastructure in good condition	3	Percent of roads meeting a state of good repair (%)	2			2	8%

DATA SOURCES

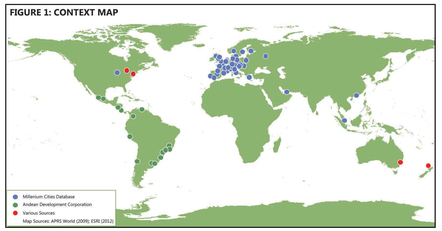
What kind of readily available data is appropriate for measurement?

The majority of data is collected from two sources:

- The Mobility in Cities Database from the International Association of Public Transport (UITP) supplies statistics for 52 cities, of which 45 have sufficient information needed for this project.
- Data on 14 cities in Latin America is taken from the report "Observatorio De Movilidad Urbana Para América Latina" (Latin American Urban Mobility Observatory - translation by first author) by the Corporación Andina de Fomento (Andean Development Corporation - ADC).

The remaining four cities; Auckland, New York, Sydney, and Toronto, are assessed according to information available on the internet from public sector and research organizations. The final number of cities assessed for this project based on data availability is 63.

FIGURE 1: CONTEXT MAP



ANALYSIS

How can results be compared to better account for context?

In order to establish a contextual relationship, the cities are grouped according to population size. In this way, cities of vastly different population size will not be directly compared in terms of average travel time, for example.

In order to normalize the results so that indicators and scores can be measured and compared across cities a standardization technique must be applied.

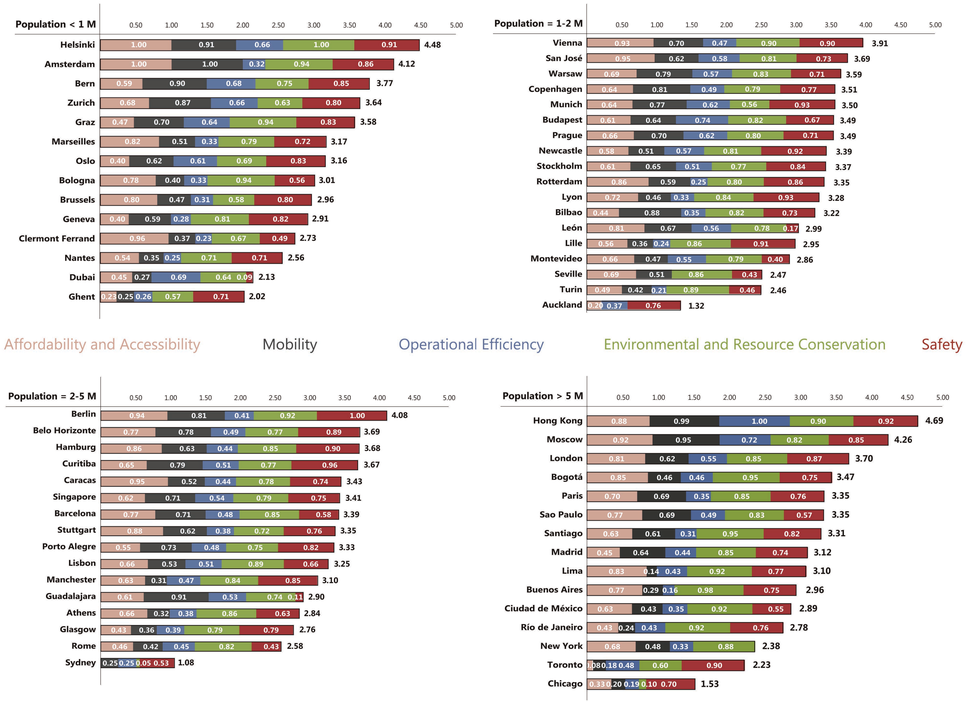
The most common approach is to utilize Z-Scores, the results of which are added using equal weights to derive a final score:

- Z-Scores for each city and individual indicator are first calculated using the "average", "stdev" (standard deviation), and "standardize" functions in Microsoft Excel.
- The resulting z-scores are added together by indicator category to produce cumulative z-scores and normalized to obtain a score between 0 for lowest and 1 for highest for each category of indicators.
- Normalized scores for each category are then added to obtain a cumulative score of transportation performance for each city.

RESULTS

With headline indicators selected and the necessary data gathered, a z-score analysis is conducted and initial results normalized according to each category:

FIGURES 2-5: CITY CATEGORY AND CUMULATIVE SCORES BY POPULATION GROUP



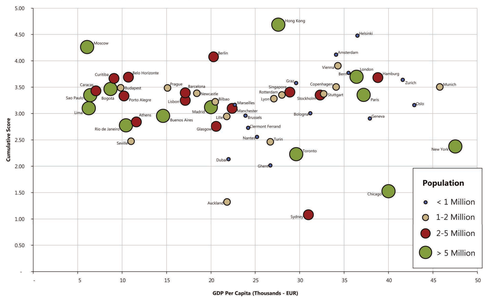
Another means of organizing the results is by Gross Domestic Product (GDP) per capita.

The resulting graph shows that transportation systems in high earning cities are not necessarily more efficient or effective, as a wide variety of incomes are distributed across the spectrum.

The lack of a strong relationship between high earnings and high cumulative scores may indicate that a city does not need to have high GDP rates in order to maintain an efficient and functional transportation network.

This result may bring into question the premise that an efficient transportation network affects a city's economic advantage. However, further study is required to establish an exact relationship.

FIGURE 6: CUMULATIVE SCORES BY GDP PER CAPITA



CONCLUSION

City administrators and policy makers who wish to use this dataset to benchmark their transportation networks can do so using the averages and standard deviations for each population group in this study. It should be noted that the averages provided are the mean of means, since much of the original data is already averaged. Likewise, the standard deviation numbers provided are the standard deviation from the mean of means. Table 2 provides the data.

TABLE 2: DATA FOR CALCULATING Z-SCORES

Indicator(s)	Unit(s)	Under 1 Million Mean	Under 1 Million St.Dev.	1-2 Million Mean	1-2 Million St.Dev.	2-5 Million Mean	2-5 Million St. Dev.	5 Million and more Mean	5 Million and more St. Dev.	Normalization Min	Normalization Max
Affordability and Accessibility										-4.66	2.49
Average duration of trip	minutes	25	3	25	6	28	12	36	13		
% of monthly income spent on transport	%	9%	2%	11%	5%	15%	8%	12%	5%		
Length of road per 1000 inhabitants	m	3,828	1,351	2,961	1,028	2,376	1,621	2,205	1,392		
Mobility										-6.45	4.55
Average speed of Trip	Km/h	31	8	29	7	30	6	27	6		
Daily trips on foot and by bicycle	%	31%	8%	31%	9%	27%	10%	24%	12%		
Daily trips by private motorised modes	%	54%	11%	47%	13%	50%	13%	48%	17%		
Daily trips by public transport	%	15%	6%	23%	14%	22%	9%	27%	13%		
Operational Efficiency										-3.13	3.89
Annual public transport passenger-Km per inhabitant	Km	1,272	762	1,730	1,219	1,337	992	1,768	1,418		
Recovery rate of public transport operating expenditure by farebox revenue	%	52%	23%	58%	28%	67%	31%	75%	32%		
Environmental and Resource Conservation										-6.19	1.93
Annual polluting emissions due to passenger transport per inhabitant	Kg	63	21	459	894	333	604	627	786		
Annual energy consumption for passenger transport per inhabitant	Mj	15,321	2,844	14,255	8,883	15,613	6,123	14,443	11,897		
Safety										-3.19	1.29
Passenger transport fatalities per million inhabitants		65	49	57	36	64	35	77	50		

This study has revealed that by using a combination of transportation policy and research, transportation agencies have sufficient information to begin developing a benchmarking process. However, the weakness lies in the availability of secondary data that can be used to develop a comprehensive database. With available and reliable data, a number of analytical tools are available, the simplest of which was demonstrated for this project. Armed with such tools, transportation planners around the world can conduct rapid assessments of transportation systems to identify where major weaknesses lie and where to look for best practices.

The process developed in this project can be utilized immediately to form an initial and rapid assessment of a city's transportation system. However, additional research and analysis is required to develop a fully implementable tool. In the meantime, transportation planners can use this framework to identify priority problems and to place the performance of their city's transportation network in the right context. Increased use of tools and processes such as the one presented in this paper can help harmonize available data around the world, thereby allowing anyone with access to the internet to partake in this exercise and help expand the dataset.

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