

Meta-Observatory of Mobility At Country And City Scale

Manon Eskenazi, Gaele Lesteven, Fabien Leurent

▶ **To cite this version:**

Manon Eskenazi, Gaele Lesteven, Fabien Leurent. Meta-Observatory of Mobility At Country And City Scale. 96th Annual Meeting Transportation Research Board , Jan 2017, Washington, United States. hal-01658282

HAL Id: hal-01658282
https://hal.science/hal-01658282

Submitted on 12 Mar 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

META-OBSERVATORY OF MOBILITY AT COUNTRY AND CITY SCALE

Manon Eskenazi
LVMT, Ecole des Ponts ParisTech – IFSTTAR – Université Paris-Est Marne-la-Vallée,
6-8 Avenue Blaise Pascal, 77455 Marne-la-Vallée cedex 2, France
Email: manon.eskenazi@enpc.fr

Gaele Lesteven, Corresponding Author
LVMT, Ecole des Ponts ParisTech – IFSTTAR – Université Paris-Est Marne-la-Vallée,
6-8 Avenue Blaise Pascal, 77455 Marne-la-Vallée cedex 2, France
Tel: +33 (0)181668867; Fax: +33 (0)164152140 Email: gaele.lesteven@enpc.fr

Fabien Leurent
LVMT, Ecole des Ponts ParisTech – IFSTTAR – Université Paris-Est Marne-la-Vallée,
6-8 Avenue Blaise Pascal, 77455 Marne-la-Vallée cedex 2, France
Email: fabien.leurent@enpc.fr

Word count: 5,869 words text + 6 tables/figures x 250 words (each) = 7,369 words

Submission Date July 29, 2016
Updated version November 15, 2016

ABSTRACT

This meta-observatory of mobility assesses mobility around the world, at the dual scales of both countries and major cities. Using data collected from observatories and other sources, specific analytical methods have been developed that lie at the intersection between the geographical analysis of mobility and territorial statistics. These methods are used to characterize the mobility profile of a given territory: the profile is a combination of the demographic, socio-economic and political characteristics, as well as technical components such as vehicles and infrastructures. The city profiles and country profiles are then compared.

Keywords: Mobility, indicator, observatory, comparison, country, major city

INTRODUCTION

Mobility is a phenomenon that forms a system (1), a system that allows us to identify the relations between people and the places they frequent (2). It connects the travel demand generated in a territory with the transportation supply located in it. The relation of supply to demand determines practices as well as traffic conditions and service quality. Mobility systems are strongly embedded in territories, both because mobility allows people to travel to the different locations where they carry out the activities that constitute social and economic life, and because transit infrastructures have a local spatial presence and their use produces impacts that are both local (accessibility, noise, particulate emissions, accident risk) and global (CO2 emissions).

This analysis applies to several territorial scales: the conurbations that constitute population centers, regional city systems or, wider yet, entire countries. There exist numerous mobility observatories based in the private, public and university sectors, which work on mobility in the world's big cities (MIT Mobility Observatory, Eltis, UITP, Civitas etc.). Similarly, big supranational or state bodies (World Bank, International Road Forum, CIA, etc.) run observatories that explore mobility at national scales. To our knowledge, however, there are no observatories that seek to combine the national and urban scales in characterizing mobility. The goal of the research presented here is to conduct a global assessment of mobility, at a given moment, by means of a meta-observatory that links the urban and national scales. This comes down to asking the following question: can mobility be treated as a specific phenomenon that can be observed across the planet, as is the case with meteorological phenomena?

In order to move towards this ambitious goal, our research has sought to discern the territorial characteristics of mobility that would constitute the essential outcome of this kind of capacity for observation and understanding, and to explore a diversity of cases at a dual spatial scale, first countries and then a sample of global ranking cities. If daily mobility mainly occurs at the urban scale, regulations operate not only at the local scale but also at the national scale. It is the reason why we decided to adopt a holistic point of view, looking at both local and national levels. To do this, we developed analytical methods that draw on the geographical analysis of mobility and on territorial statistics. At the national scale, we compiled statistical databases to characterize the mobility systems of the world's 194 countries. We then broke them down into clusters, classifying the countries within different mobility profiles. With regard to the cities, we compiled data from different sources and of different kinds on 35 cities with populations in the multi-millions. After characterizing each city's mobility system against a set of indicators, we again classified them into different mobility profiles.

Such profiles synthesize the key elements of a given city or country as concerns its mobility. Both the profiling method and its results constitute a tool for planners and researchers in order to assess the particular situation of a given territory or to benchmark different situations and solutions. This work is part of a research program funded by Renault car maker that we conduct about motorization and car regulations. It sets up a descriptive framework of car use and regulation across the world.

The body of the article is divided into four parts, followed by a conclusion. We begin with a quick run-through of the general principles that constitute an observatory and previous writings relating to the observation of mobility. Then we tackle the national scale, presenting the method

of analysis and its application as of 2013, identifying seven country profiles. Next, we tackle the conurbation scale, again in terms of principles, methods and results. Finally, we compare the results obtained at the two territorial scales.

CHARACTERIZING MOBILITY: METHODOLOGICAL PRINCIPLES

From existing observatories to the meta-observatory

The identification and critical review of the data supplied by observatories prompted us to establish a "meta-observatory". The mission of this "meta-observatory" is to identify mobility profiles from a selection of relevant indicators relating to different territorial scales.

In fact, the sources of information on mobility are numerous and diverse. Some offer observatory systems, in other words information exchange platforms with clearly defined aims and observation protocols, on the basis of which indicators are constructed and the results regularly disseminated. Observatories can be classified into several families, depending on the scale of analysis: international observatories that analyze groups of countries or cities, national and regional observatories and, more rarely, city scale observatories. The scale of analysis determines the type of indicator required and the way the results are presented (annual report, survey, key figures, etc.) (3).

Mobility indicators, a tool for assessing and promoting sustainable mobility

Since the 2000s, systems of indicators have proliferated, accompanying the diffusion of the notion of sustainable development (4) and more recently of livability (5, 6). These indicators are both tools for assessing public policy and comparators (7). The OECD defines indicators as parameters that provide information on a phenomenon, and whose main purposes are to inform, to quantify and to communicate (8). This means that they must be consistent and relevant, present information simply, and be reproducible in other contexts (9).

For our purposes, they may be either descriptive indicators or performance indicators (10). The former provide information on the state of the mobility system and are useful for assessing whether a mobility system is sustainable at a given moment or for comparing a group of parameters or territories. These kinds of indicators can form the basis for policy orientations. For their part, performance indicators can be used to compare a system between two given dates or to show whether the current state meets a given target. They are useful, for example, in the evaluation of transportation plans.

Next, the choice of indicators depends on the scale, the context and the availability of data (10). For example, indicators for individual behaviors have a markedly local dimension (11): while relevant at city scale, they are difficult to access at national scale for all countries, because they require a costly and powerful statistical apparatus.

The main systems of indicators we identified characterize and compare mobility at urban scales (7, 12, 13, 14, 15). Country scale indicators that compare mobility systems are less common (16, 17), and rarely include interactions with the local scale. We therefore propose to establish a system of country scale indicators that will help to understand the framework within which local mobility develops, before developing a system of city scale indicators. Primarily descriptive, these indicators allow comparisons to be made country by country, city by city, followed by analyses that combine countries and cities.

REVEALING THE DIVERSITY OF MOBILITY AT COUNTRY SCALE

"Country" methodology

Choice of indicators

As we have just stressed, building a relevant system of indicators depends on the availability and reliability of data, in particular in emerging nations where statistical systems are not always as robust as in developed countries.

We chose six indicators that give information on travel demand, available transportation supply and the use made of it. These indicators form a system. They allow us to apprehend mobility practices that are both co-produced by a set of economic, organizational and cultural factors (18) and are relatively simple to access. In fact, the data that form their inputs are relatively basic and, usually, easily available (Table 1). We added two other indicators to estimate the country's potential for innovation in mobility: technology can be a vehicle of innovation (leapfrogging), can replace traditional tools (19) and can modify the mobility system. To facilitate international comparisons, the indicators are as far as possible notated per inhabitant.

1. **Urbanization rate** is a widely used framework indicator. It refers to the percentage of the population living in urban areas as defined by national statistical offices. Above all, it provides information on travel demand. City life creates special mobility conditions. Transportation supply is more dense, the infrastructure more developed.
2. **Gross national income (GNI) per capita** is also a framework indicator. It is used to estimate the population's standard of living. We have used and refined the classification proposed by the World Bank to distinguish between low-income countries (GNIpc < 750 dollars), lower middle-income countries (GNIpc between 2000 and 4000 dollars), upper middle-income countries (GNIpc between 4000 and 13,000 dollars), high-income countries (GNIpc > 13,000 dollars) and very high-income countries (GNIpc > 20,000 dollars). This indicator also gives information on travel demand, since higher income correlates with longer travel distances (20).
3. **Road network density** is an indicator of supply. It refers to the ratio between the total length of the road network and the country's total surface area. It provides information on the density of the available supply and is a prerequisite for the use of individual motorized modes.
4. **Motorization rate** gives the number of passenger cars per 1000 people. This usage indicator provides information on the use of the car as a transportation mode. There is a strong correlation between wealth and car use (21).
5. **Available rail infrastructure** is an indicator of supply, giving the total length of the rail network. It combines with the data on road network density, and distinguishes countries with large rail systems from those without.
6. **Annual per capita distance traveled by train** characterizes the use of rail transit per traveler, as an alternative to road travel. The indicator is expressed in numbers of rail passenger kilometers per year and per capita. Even if it remains difficult to compare large countries like Canada, China or Russia with small European countries, this indicator gives a hint of rail use in a given country.
7. **Access to electricity** is an indicator of potential for innovation, referring to the percentage of the population with access to electricity. Access to electricity reflects *i)* a country's capacity to equip itself with infrastructures to provide basic services for its

population, and *ii)* the country's potential to acquire alternatives to fossil fuels for its energy needs, and eventually to develop electromobility.

8. **Rate of mobile phone use** is the final indicator used. This is also an indicator of innovation potential, referring to the percentage of the population signed up to a mobile phone service (pay-as-you-go or contract). Mobile phones are increasingly used for organizing day-to-day travel, whether smartphone apps to manage travel plans or innovative car sharing services in real time, or as a substitute for certain trips in very poor households.

The data used in this study come from several sources: the World Bank (WB), the International Road Federation (IRF) and, where applicable, the CIA World Factbook. These bodies collect data from official sources in 194 countries. We chose the most recent year for which data are available, i.e. 2013. In the event that data is not available, we try to estimate it as accurately as possible, first by going back to previous years (until 2011), then by employing related indicators. For example, we use the motorization rate, which covers all motorized modes, if there is no data on the rate of passenger car use.

TABLE 1 Choice of indicators and data availability

Indicator	Unit	Definition	Type	Source	Date	Country with data	
Urbanization rate	%	Percentage of population living in cities	Framework	WB	2013	194	100%
GNI per capita	Constant 2010 dollar	Gross national income (GNI) divided by number of inhabitants	Framework	WB	2013	130	67%
Road network density	km/ 100 km²	Ratio between total length of road network and country's total surface area.	Supply	IRF	2013	186	96%
Available rail infrastructure	km	Total length of rail network	Supply	WB CIA	2013 2014	189	97%
Total annual distance by rail per capita	Passenger. km per capita	Number of passengers per year multiplied by travelled distance divided by total population	Usage	IRF	2013	126	65%
Motorization rate	No of cars / 1000	Number of passenger cars (excluding 2W) per 1000 people	Usage	IRF	2013	155	80%
Access to electricity	%	Percentage of population with access to electricity	Innovation potential	WB	2012	194	100%
Mobile phone usage rate	%	Percentage of population signed up to a mobile phone service	Innovation potential	WB	2013	194	100%

Breakdown into clusters

The indicators are used to identify mobility profiles. To do this, we broke the data down into clusters, so that they can be structured into homogeneous classes. This accentuates the contrast between one class and another, by minimizing intra-class inertia and maximizing inter-class inertia. For each indicator, we defined eight classes ordered incrementally by the value of the indicator and made the median in each class coincide with the average score. We removed the small island states from the analysis, as well as the European principalities (Liechtenstein, Monaco and Andorra), a total of 34 countries, with the result that our study base contained 160 countries. A radar chart was drawn for each of the 160 countries. The radar chart consists of eight axes, each representing one indicator. The shape formed by each country on the radar chart, based on its position on each of the axes (Figure 1), is used to define mobility profiles.

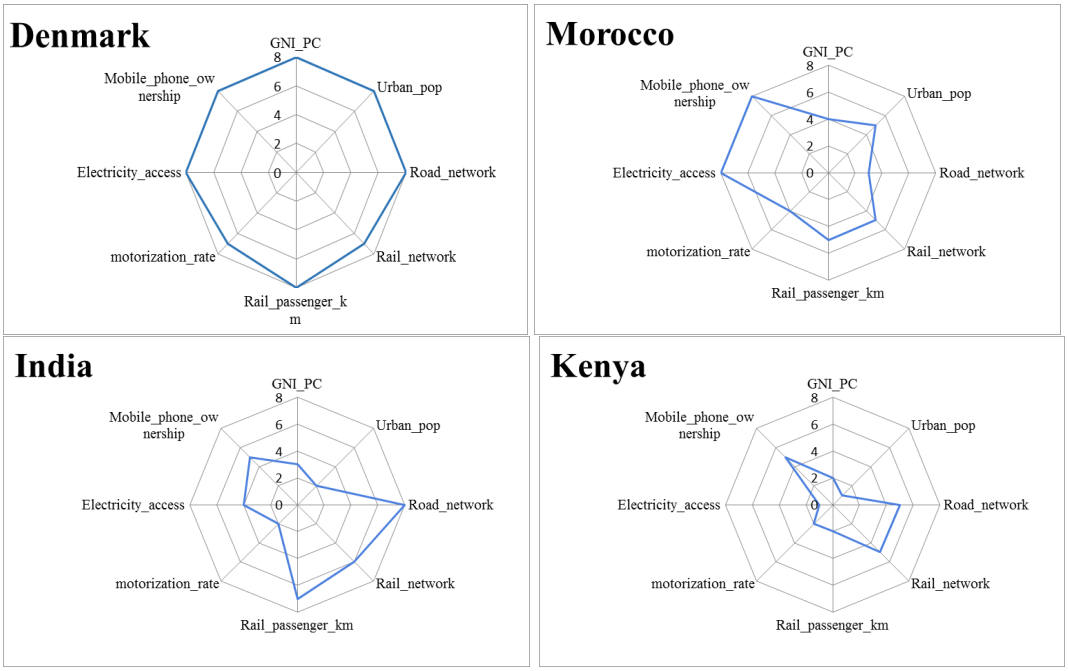


FIGURE 1 Radar charts – some country examples

Results: seven major profiles

From this classification by indicator, we established a typology of the countries according to their mobility profile. Seven major profiles emerged, illustrated on a map (Figure 2).

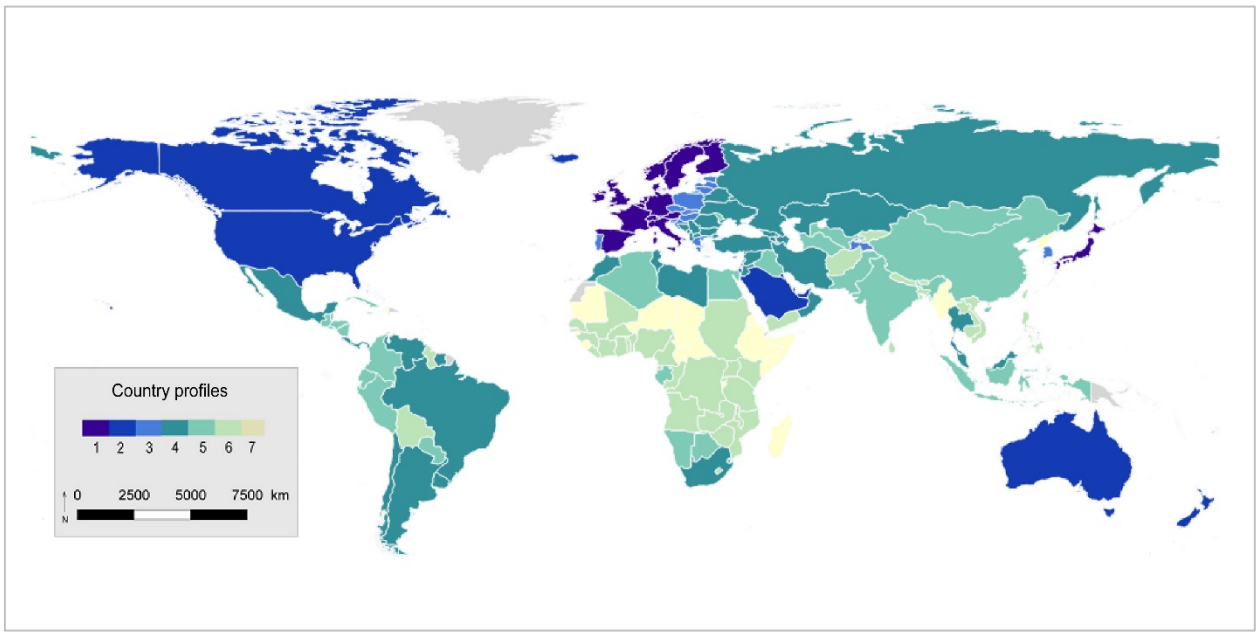


FIGURE 2 Typology of countries

The first three profiles (profile 1, 2 and 3) primarily contain the Northern countries. The differences lie in the level of wealth and the use of rail, since the motorization rate in these three profiles is very high. The road and power infrastructures are also highly developed.

Profile 1: "Very rich countries, high share of road and rail"

This first profile is characterized by very high-income countries (GNI per capita over 30,000 dollars per year) with very high motorization rates (more than 400 cars per 1000 people), which possess developed road and rail transportation infrastructures, and where rail usage for passenger transportation is also developed. The Western European countries and Japan belong to this first group.

Profile 2: "Very rich countries, predominance of the car"

These are also very high-income countries (GNI per capita over 20,000 dollars per year), with high levels of motorization (more than 300 cars per 1000 people) and a developed road network, but a relatively limited passenger rail infrastructure. They include countries with large surface areas such as the USA, Canada and Australia, developed islands (Iceland, Cyprus, Malta), as well as oil producing countries on the Arabian Peninsula such as Saudi Arabia and Qatar.

Profile 3: "Rich countries, developed transit infrastructures"

In this group, we find high-income countries (GNI per capita between 13,000 and 23,000 dollars per year), with a high motorization rate (more than 300 cars per 1000 people) and developed rail infrastructures. The countries of Eastern Europe (Poland, Hungary), the Balkans (Croatia, Slovenia), together with the Baltic states and Portugal, fit this profile.

Profile 4: "Middling rich, urbanized countries, with middling motorization"
These are mainly upper middle-income countries. They are urbanized countries with medium motorization rates, between 70 and 300 passenger cars per 1000 people. The transportation infrastructures are middlingly developed. However, we can see a distinction in the use of the rail network for passenger traffic between countries with low use (Turkey, countries of the former Yugoslavia), and others that use it more – Thailand, Morocco, Romania or Kazakhstan.

Profile 5: "Middle-income countries, with middling urbanization and low motorization"
These are middle-income countries with a medium level of urbanization. We can see that several indicators have moved out of sync. These countries have good access to electricity and mobile phones. This intermediate group reveals contrasting realities:
- middling rich countries, with annual per capita GNI of between 3000 and 10,000 dollars, a low rate of motorization ranging from 50 to 100 cars per 1000 people, and finally an urbanization rate of more than 55%. These countries are characterized by transportation infrastructures (roads and rail) with very middling levels of development. They are often countries with large surface areas, some of which live off oil and mining revenues (Algeria, Gabon, Peru). The heavyweight in the class is China.
- slightly less rich countries (per capita GNI between 1000 and 5000 dollars), with less motorization (between 20 and 70 cars per 1000 people), in which more than half the population lives in cities. It includes the countries of Central America and Indonesia.
- countries whose profile is quite close to the one described above, but with less urbanization (one third to half of the population in cities) and greater use of rail transportation. This class includes Egypt, India and Pakistan.

Profile 6: "Middle-income countries, with low urbanization, developing infrastructures"
This sixth profile encompasses lower middle-income countries (per capita GNI above 750 dollars per year), where at least one of the mobility indicators is beginning to emerge. This is the most populous profile (42 of the 160 countries studied). These countries have lower urbanization – the urban population exceeds 50% in only seven – and their access to electricity remains low. Three categories can be identified:
- first countries where the motorization rate is more than 10 cars per 1000 people, such as Kenya, Kirghizstan or Vietnam.
- countries with a developed rail infrastructure, often associated with a colonial legacy, such as Bangladesh or Tanzania.
- countries where mobile phone ownership is taking off. This final indicator applies to many African countries, in particular English-speaking countries, as well as the Philippines.

Profile 7: "Low-income countries, little infrastructure development"
The final profile refers to low income countries (per capita GNI below 750 dollars a year), where development of transportation and telecommunications infrastructures is low. In these countries, the values of all the indicators are low. The countries of sub-Saharan Africa are overrepresented in this category.

The seven profiles we have defined can be used to identify stages in the development of the mobility system. The first two profiles contain rich and highly urbanized countries. Whereas the countries in the first profile are relatively homogeneous in terms of geographical location – they

are the Western European countries and Japan – and transportation infrastructures, the second profile is more diverse. The main difference between the two lies in the use of the rail network: we find that countries with large surface areas (USA, Australia, etc.) show lower use of the passenger rail network, and that the developed island countries (Bahamas, Iceland, Cyprus) have no passenger rail infrastructure, which makes them more dependent on the car. The countries in the third profile show a similar developmental trend as those in the first, but are currently less rich and a little less urbanized.
From profile 5 onwards, half the population lives in cities and access to electricity and the mobile phone is becoming widespread. It is interesting to see that the level of rail use is quite similar between profiles 4 and 5, despite the fact that the profile 5 countries have smaller rail networks. This is explained by the intensive rail use in several countries in this profile (China, India, Mongolia).
In the profile 6 and 7 countries, urbanization rates remain low, and less than half the population has access to electricity. These two profiles essentially cover African and Southeast Asian countries. We nevertheless find increased use of mobile telephones in profile 6, as well as a much more developed rail infrastructures, which may be explained by the colonial legacy.

This country-based analysis reveals a strong link between urbanization rates and levels of wealth, which coincide with infrastructure development and mobility consumption. It would therefore seem useful to continue this work at city scale, since daily mobility is first of all a local phenomenon embedded in specific population centers.

REVEALING THE DIVERSITY OF MOBILITY AT CITY SCALE

"Cities" methodology

Choice of indicators
First of all, by contrast with the country level analysis, the city scale analysis cannot be exhaustive. For the moment, it focuses on a series of 35 major cities with multi-million populations (Figure 4), which we investigated through student research. Other cities are being studied, and will be added to the assessment.

Observing forms of mobility in a city entails identifying traditional modes (walking, passenger car, bus, bicycle, individual taxis, etc.) but also more diversified modes (vehicle sharing schemes, collective taxis, motorized and pedal tricycles, mototaxis etc.). In the emerging countries, informal transportation is not usually observed statistically, but is identified and characterized qualitatively. More generally, the modal distribution of mobility is counted in numbers of trips and, more rarely, in the distance covered by individuals in each mode.

For each major city, the information was collected from specific locally available sources. In many cases, household travel surveys are a major source. Generally speaking, in cities with several million inhabitants, municipal governments provide online access to statistical information on transport provision and qualitative information on mobility policy. In addition, to characterize traffic levels on the road network, real-time information apps like Google Maps or a local equivalent have become valuable resources, especially for cities where data is lacking or of bad quality.

Fine characterization of urban mobility

In order to compensate for the heterogeneity of some of the available data, while taking account of the local context, we developed a multi-criterion analysis grid. This grid employs five composite indicators, which provide a fine characterization of city scale mobility. Each of these five composite indicators is made up of several indicators (Table 2) and is scored on 9 points. The scores are transposed to 5 axes. Each axis corresponds to a composite indicator, and together they form a radar chart.

1. The *Infrastructure* axis combines indicators characterizing the density and quality of the road and rail networks. It takes into account the level of congestion and the extent to which roads are used for public transit and walking and cycling modes.
2. The *Vehicles* axis characterizes the use of the urban street network. A first indicator represents modal distribution. A second indicator focuses on the size of the motor vehicle fleet and its composition (proportion of private cars and motorcycles), before evaluating air quality (emission levels, presence of electric vehicles).
3. The third axis represents *Public Transit*. It assesses the performance of the public transit network, taxi services and shared vehicles (bicycles and cars), plus the existence of informal transportation.
4. The *Regulation* axis relates to the planning and management of the mobility system. It aggregates indicators that assess the level of institutional organization and traffic and parking regulation, as well as vehicle quotas.
5. The final axis characterizes *Demand*, taking account of the degree of urban density, population growth and economic growth, the average number and duration of trips, in the absence of data on average distances in many cities.

TABLE 2 Indicators forming the five axes of analysis

Infrastructure	Vehicles	Public transit services	Regulation	Demand
- Provision and quality of road network - Congestion level - Density of rail network - Presence of dedicated bus lanes and cycle lanes	- Modal distribution - Number of passenger cars and motorcycles on roads - Air quality	- Informal transit services - Performance of public transit - Performance of taxi services - Integrated ticketing - Performance of vehicle sharing services	- Institutional organization of transportation systems - Road safety - Traffic regulation - Environmental regulations - Parking - Vehicle quota system	- Urban density - Demographic dynamism - Economic dynamism - Number of trips - Average trip time

Each city is described by 5 synthetic scores, from 1 to 9. When displayed in the form of a radar chart, they show the city's mobility profile as a schematic. From one city to another, the polygon can take very different shapes (Figure 3): for example, Figure 3 reveals weak regulation and poorly developed public transit in Maputo, compared with Amsterdam where the axes are almost all at maximum.

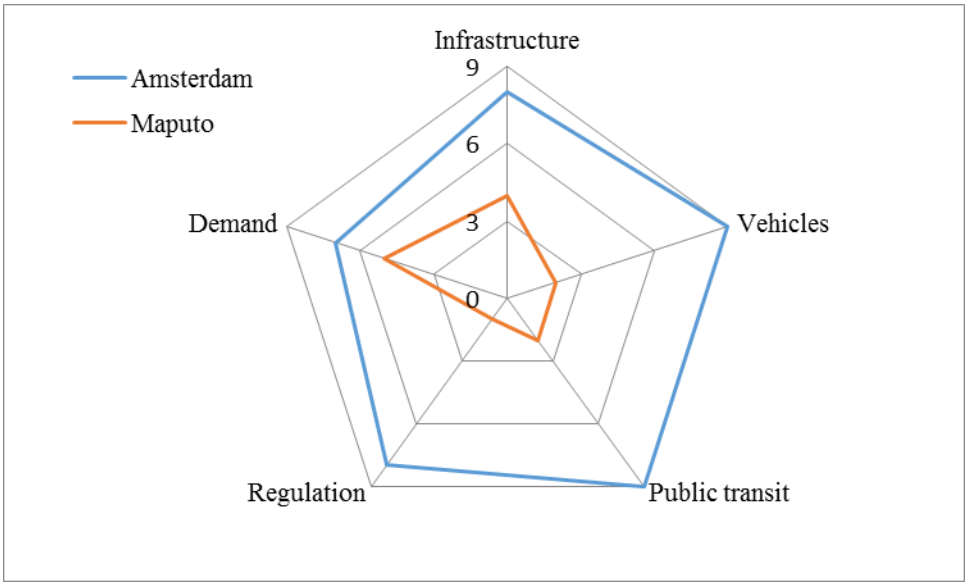


FIGURE 3 Radar chart – two city samples

Results: six city profiles

A fine analysis of the radar charts allows us to classify cities in terms of the pace of economic and demographic development (slow or rapid dynamics), trends in modal share that favor or oppose sustainable development of the city, as well as the degree of regulation. This characterization produces six city profiles, valid as of 2015. The profiles focus on different mobility systems and don't include land-use orientations. Slow or fast dynamics refer to local evaluation about economic and demographic growth that interferes with transportation demand.

"Slow demand dynamics, sustainable development oriented"

This profile covers developed cities where the dynamic is slow, which reveal a modal share that is responsive to sustainable development priorities. These cities have long-standing mass transit systems, which meet travel needs. There are public and private initiatives to improve the efficiency of existing modes, as well as emerging shared modes. Berlin, London, Montreal or Vancouver possess this mobility profile.

"Slow demand dynamics, car oriented"

This profile describes cities where the dynamic is slow and mobility appears stable, with no apparent change in modal share. The private car remains dominant, and shared mobility services are a niche phenomenon. Changes in modal share tends to take place more through regulation than through changes in behavior (e.g. tolls on car sharing lanes in the USA). Big American cities like Chicago, Los Angeles, Philadelphia or San Francisco, or in Europe Rome, fit this profile.

"Rapid demand dynamics, sustainable development oriented"

These are cities with medium levels of development, but rapid growth dynamics. They have a fairly adequate road infrastructure. They are cities where formal and informal systems coexist and which are devising innovative transit solutions to tackle urban problems (e.g. the BRT in Bogotá). These cities, like Bogotá, Curitiba and Santiago in Latin America, or Wuhan in China,

are looking to introduce modal share initiatives in favor of sustainable development, which limit the growth of individual car use.

"Rapid demand dynamics, personal transportation oriented"
Cities in this profile show middling levels of development. Their populations are still growing. Their road infrastructures are often undersized and poorly maintained. Public transit is lacking, which leads to significant car use and the associated traffic congestion. Institutional regulation is weak: there is no control of car numbers, but there is public transit planning with projects for structural transit lines. These cities include Istanbul, Ekaterinburg, Buenos Aires, Mexico and Delhi.

"Rapid demand dynamics, low regulation"
This profile encompasses cities where development is rapid and insufficiently controlled. Travel demand is very high because of demographic growth and continuing urban sprawl. Capacity on the road and/or rail infrastructures is insufficient. The roads are congested, despite relatively low car numbers. There is little institutional regulation, which prompts the emergence of informal modes and permits car sharing. Mumbai, Lagos and Dhaka are examples.

"Rapid demand dynamics, strong regulation"
One city stands out. This is Beijing, where the transit system is developing rapidly, within a framework of strong political control.

A city's profile is valid at a given time, and is likely to change. In particular, the implementation of strong mobility policies can influence modal share. For example, we expect Delhi's 2020 profile to differ significantly from its profile in 2015, in light of the plan for very large scale development of the city's rail transit system.

COMPARING CITY PROFILES AND COUNTRY PROFILES

The advantage of the meta-observatory is that it can relate the characteristics of mobility systems in cities to the global mobility characteristics of countries. To do this, we mapped the results, combining city profiles and country profiles (Figure 4). It is noteworthy that cities in the same country usually share the same profile. In other words, the national framework predetermines the local framework. On the other hand, cities that belong to countries with similar profiles do not necessarily have the same profile. For example, Canadian cities have a mobility profile that is more geared to sustainable development than American cities, which remain strongly marked by the legacy of the automobile city model. It is the cities in the intermediate categories (profiles 3 and 4) that show the greatest diversity of profile. When wealth levels and urbanization and motorization rates are rising, different city models form. This is particularly true for cities in Asia and, to a lesser degree, in South America. In this way, city models emerge whose characteristics are molded by both the local context and the national framework. On the other hand, the meta-observatory cannot assess the function performed by the city in its national context. Nonetheless, its role as an economic driver or economic capital would be easy to identify.

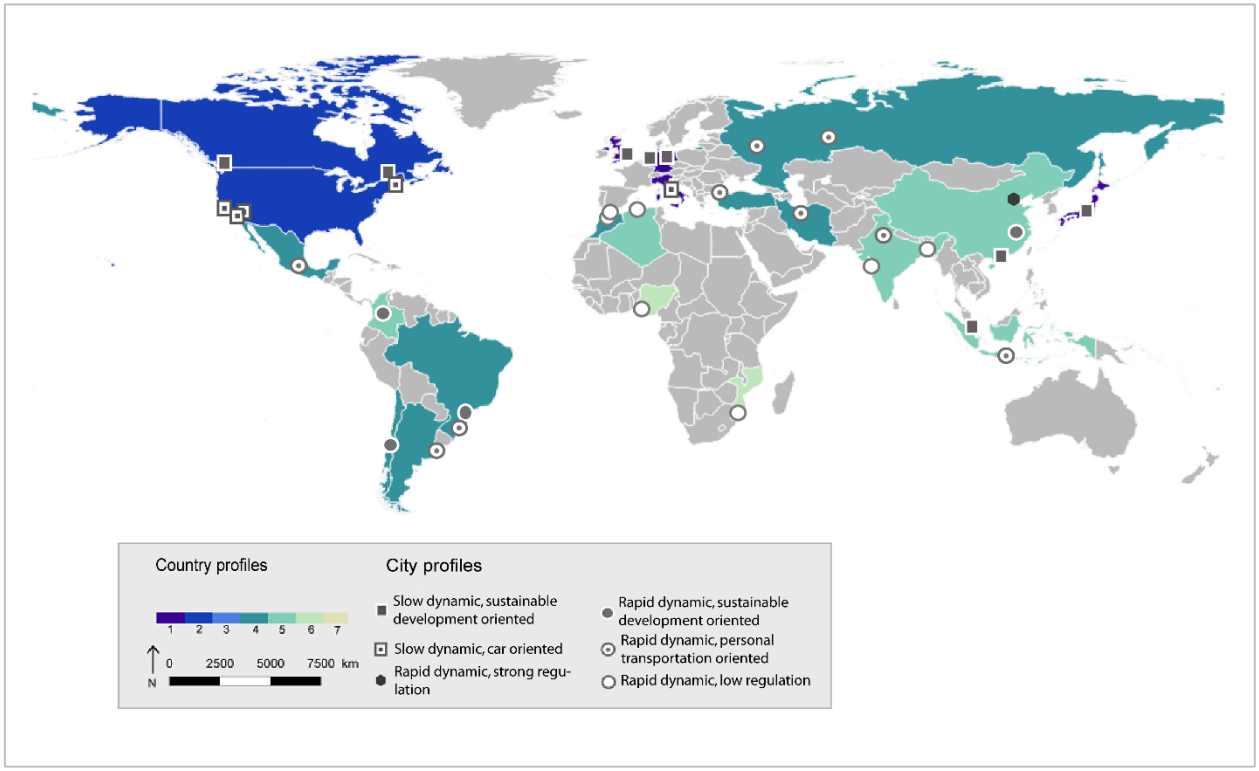


FIGURE 4 Relating country profiles and city profiles

CONCLUSION

We have established an original methodology for analyzing international mobility at two territorial scales, respectively the country and the conurbation. We have called this methodology a "meta-observatory", because it pulls together information generated elsewhere to produce a synthesis that is sensitive to demographic and socio-economic factors, as well as to transportation supply (infrastructure and vehicles) and local regulations. We applied this methodology to most of the world's countries and to a diverse sample of cities with populations in the millions. In this way, we were able to establish standard profiles to characterize existing mobility systems, respectively at national and metropolitan scale. These profiles are primarily socio-technical and demographic, economic and political. Our results relate to 2013 for the countries and up to 2015 for the cities. The intention is to update them periodically.

The method of analysis could be further improved. The sample of cities studied is still too small to draw firm conclusions on the profile typologies. The shortage and mediocre quality of some data, both national and local, make particular profiles hard to characterize precisely. Open data and data collection through other channels (GPS tracking to characterize mobility, etc.) offer prospects for improving the availability and quality of data. These options will also provide alternatives to heterogeneous national statistical systems, on which the big observatories like the World Bank's rely. They will allow us to select other indicators such as kilometers traveled per capita to measure road performance and compare it to rail performance. At both local and national levels, corruption can impact the way the mobility system is functioning (and the way it is described). We contemplate adopting a policy-transparency index at the national level to make the country profiles more relevant.

The meta-observatory aspires to serve as a comparator of mobility on an international basis and to be used as a tool for planners and researchers in order to benchmark different situations and solutions. Thus, we would be glad to receive inputs into the meta-observatory from cities or countries.

Future steps will entail first continuing the fine characterization of urban mobility by studying additional cities, and by proceeding further with the analysis. For example, we plan to explore wether people residing in sustainable development-oriented cities travel shorter distances or spend less time traveling than people in areas with greater personal transportation use. Second, our aim is to put this analysis into perspective through a diachronic study of changes in mobility systems across the world. We currently examine the data over a decade (2003-2013) to measure changes in those systems, at both supply and demand sides. We are also plan to refine the comparison by looking at the infra-national level, especially for large countries, such as China or India.

ACKNOWLEDGEMENTS

This research was partly financed by the Renault group, within the framework of the Sustainable Mobility Institute in partnership with ParisTech. Our thanks to them.

REFERENCES

1. Urry, J. *Moblities*. Polity Press. Cambridge, 2007.
2. Cortes, G. Migrations, systèmes de mobilité, espaces de vie : à la recherche de modèles. *Espace géographique*, Vol. 27, No. 3, 1998, pp. 265-275.
3. Leurent, F., Boutueil, V., Alawi, B., Berrada, J., Sadeghian, S., Aguiléra, A., and O. Bonin., *Rapport de synthèse de la seconde phase du contrat REGINOV II (LVMT-IMD),* LVMT Champs-sur-Marne, 2015.
4. Gudmundsson, H. Making concepts matter: sustainable mobility and indicator systems in transport policy. *International Social Science Journal*, Vol. 55, No. 176, 2003, pp. 199-217.
5. Litman, T., Well measured: developing indicators for sustainable and livable transport planning. Report, Victoria Transprt Policy Institute, 2016 http://www.vtpi.org/wellmeas.pdf. Accessed July 18, 2016
6. Miller, H., Witlox, F., and C.Tribby. Developing context-sensitive livability indicators for transportation planning: a measurement framework. *Journal of Transport Geography*, Vol 26, 2013, pp. 51-64.
7. Costa, P. B., Morais Neto G. C., and A. I. Bertolde A. I. Urban Mobility Indexes: A brief review of the literature. Paper presented at the *WCTR 2016 Shanghai*.
8. OECD. *OECD Core Set of Indicators for Environmental Performance Reviews: A Synthesis Report by the Group on the State of the Environment*. Report No. 83, OECD, Paris, 1993.
9. Nicolas, J.-P., Pochet, P., and H. Poimboeuf. Towards sustainable mobility indicators: application to the Lyons conurbation. *Transport Policy*, Vol. 10, 2003, pp. 197-208.
10. Chakhtoura, C., and D. Pojani. Indicator-based evaluation of sustainable transport plans: A framework for Paris and other large cities. *Transport Policy*, Vol. 50, 2016, pp 15-28.
11. Gallez, C. *Indicateurs d'évaluation de scénarios d'évolution de la mobilité urbaine*. Rapport de convention DTT-INREST, Arcueil, 2000.
12. Shah, Y., Manaugh K., Badami, M., and A. El-Geneidy. Diagnosing transportation: Developing key performance indicators to assess urban transportation systems. In *Transportation Research Record: Journal of the Transportation Research Board, No. 2357*, Transportation Research Board of the National Academies, Washington, D. C., 2013, pp. 1-12.
13. Arthur D. Little. *The future of Urban Mobility 2.0. Imperatives to shape extended mobility ecosystems of tomorrow*. UITP, 2014. http://www.adlittle.com/reports.html?&view=644. Accessed April 27, 2016.
14. Zegras, C., and R. Gakenheimer. Driving Forces in Developing Cities' Transportation Systems: Insights from Selected Cases. In *MIT Press*, 2006.
15. Newman, P., and J. Kenworthy. *Cities and Automobile Dependence: An International Sourcebook*. Gower Publishing, Aldershot, 1989.
16. Senbil, M., Zhang, J., and A., Fujiwara. Motorization in Asia: 14 countries and three metropolitan Areas. *IATSS (International Association of Traffic and Safety Sciences) Research*, Vol. 31, No. 1, 2007, pp. 46-58.
17. Schäfer, A., and D. Victor. The future mobility of world population. *Transportation Research Part A*, Vol. 34, 2000, pp.171-205.
18. Massot, M.-H., and J.-P. Orfeuil. La mobilité au quotidien, entre choix individuel et production sociale. In *Cahiers internationaux de sociologie*, Vol. CXVIII, 2005, pp. 81-101.

19. Fong, M. Technology Leapfrogging for Developing Countries. In *Encyclopedia of Information Science and Technology (2nd ed.)*. Harshey, Pennsylvania, IGI Global, 2009, pp. 3707-3713.
20. Zahavi, Y. *Travel time budgets and mobility in urban areas*. U. S. Department of Transportation, Washington, D. C., 1974.
21. Kuhminhof, T., Rohr, C., Ecola, L., and J. Zmud. Automobility in Brazil, Russia, India and China Quo vadis? In *Transportation Research Record: Journal of the Transportation Research Board, No. 2451*, Transportation Research Board of the National Academies, Washington, D. C., 2014, pp. 10-19.