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Research paper

Towards indicators outlining prospects to reduce car use with an application to European cities

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ABSTRACT

The paper brings together the diverse aspects which affect the sustainable urban mobility transition. They are labelled as Spatial, Socio-economic, Supply, Satisfaction and Strive dimension and summed up as 5S. We come up with a systematic procedure for creating indicators under each dimension. The proposed indicators reconcile the need for wide-scope coverage with operability and as such they provide a platform for international comparisons. Apart from that, we have covered some relevant aspects which are in the course of the development yet. These are walking facilities and institutional capacity. To illustrate the operationalization of our conceptual framework, we have provided the data for ten European cities and conducted a pilot study using multivariate graphical technique, Co-plot. This kind of data visualization enables preliminary analysis of performance without weighting decisions.

1. Introduction

The growth of urban population produces urban mobility challenges worldwide. Cities are faced with the challenge to support growing transport demand and to cope with the pressure imposed by private car usage. Reducing proportion of car travel implies creating favourable environment to shift to more sustainable transport options. Public transport, walking, cycling or different forms of shared transport, are seen as rudiment for future urban transport development. In light of this, even car manufacturers themselves are starting to develop a new business segment offering mobility on demand and/or car sharing schemes. In this way the industry is entering a new era of selling mobility rather than cars (Firnkorn and Müller, 2012). This business model assumes a transition from owning to accessing cars and as such it stimulates a sharing platform. In a broad sense, the extension of amount of time a car is in use, is one of the strategies in the spirit of circular economy.

At the European level, the overall picture shows that although cities are connected with some of the world's most advanced transport systems, urban mobility is still inefficient. Apart from accidents, air and noise pollution, urban transport produces a significant share (23%) of all CO_2 emissions, while congestion which is mostly located in and around urban areas affects economy and accounts for 1 % of the EU's GDP (European Commissions' Urban Mobility Package, 2013). Respecting the principal competence of national and local authorities and more than that, the uniqueness and specificities of European cities, the Union sets up general policy objectives rather than binding targets. In this respect, EU acts as a financial and operational support for sharing experiences, best practice, developing and delivering sustainable mobility solutions and fostering cooperation among cities. The importance of urban mobility for the EU as a whole is documented in a number of program documents dating back to the 1990s. The latest impetus is Urban Mobility Package, a strategic guide to sustainable urban mobility planning and support for local authorities to deal with urban mobility challenges. In its White Paper (European Commission, 2011a), European Commission (EC) entrenches a strong commitment to sustainable urban mobility. Strategic challenge for cities in coming decades is ascertained by “the necessary transition from a primarily car based personal mobility in cities to a mobility based on walking and cycling, high quality public transport and less-used and cleaner passenger vehicles” (European Commission, 2011b, p.89).

The ability of the city to “catch the future” and outgrow car dependence is the matter of a variaty of factors. However, most of them will not automatically or instantly bring a change in mobility patterns. We can rather talk about the chances and preconditions to be less heavily dependent on private cars. That is why we use the term “prospects” to refer to influential factors.

One important question is how to evaluate city profile in respect to its potential to adopt sustainable transport strategies. A way to reveal strengths or weaknesses of a specific city, is to perform a comparison with others. In favour of this is the EC initiative for the development of Urban Mobility Scoreboard, that should facilitate to benchmark and

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compare cities across the EU. This enables to outline the best performers and successful urban policies. International cross-city comparisons are based on urban mobility indicators, which are often used to construct indexes or some kind of scorecards. However, these tasks are very much restricted by the availability of variables and/or data. Consequently, the ability to capture arrays of factors is also restricted.

This article grew out from the thorough review of existing sustainable urban transport indicator frameworks. Although there is a large body of knowledge on the topic, the reader is often left having learned little about the practical use of indicators. The principal aim of this article is to fill the gap between conceptual framework of the phenomena and its operationalization. We propose an indicator set which brings together the diverse aspects that might reduce car use in urban areas. These aspects are structured to constitute main pillars − dimensions: Spatial, Socio-economic, Supply, Satisfaction and Strive. The structure is named "5S", after the initial letter of each dimension. The dimensions are decomposed into themes, indicators and variables.

The rest of the paper proceeds as follows. First we expose the scope and the aim of our study. The indicators are explained and referred to the literature in Section 3. The corresponding variables and insight to data sources are given as well. This section ends with an overview of the research procedure. The utilization of indicators for cross-city comparisons is demonstrated in Section 4. We have provided the data for ten European cities and conducted a pilot study using multivariate graphical technique, *Co-plot*. The paper ends with a summary of findings.

2. The scope of the study

In order to accommodate our study among the previous work in the field, we first distinguish two research directions.

The first line searches for drivers of mode choice by empirical examination of possible impacts either alone or in combination. Typically, surveys are used to investigate a range of objective and subjective factors. The most common studies fall into three broad categories: 1) the influence of individual characteristics and preferences, like age, gender, income, household composition, attitudes, habits, perception, lifestyle, etc. 2) the influence of level of service in terms of travel attributes, as for example, travel time, cost, comfort, safety etc. 3) the influence of land use/built environment, like population and job density, mixed land use, road network characteristics and facilities (parking, walking and biking facilities), destination accessibility, etc. Another characteristic of this line of research is the limited coverage-the assumptions are usually tested for a particular city of interest where the survey has been conducted.

The second line of research in some way rises out of the knowledge accumulated from the first line of research. Based on evidence on factors influencing travel decisions, a body of research attempting to provide more comprehensive and measurable picture of the city grew up. In general, this is in a way a holistic approach, since it attempts to evaluate the city profile as a whole in respect to sustainable mobility patterns. This kind of evaluation is frequently accompanied by an observation of a set of cities. The outcomes are the rankings or clustering of cities or simply the evidence of performance. Given the broad geographical and/or temporal coverage large scale data are required. As pointed out by Haghshenas and Vaziri (2012), transportation data can be often found at the country and not at the urban level. On the other hand, some databases covering world cities information have insufficient data about urban transportation. This is probably the reason why there are a limited number of studies that succeed to capture the multidimensionality of the problem.

As we attempt to address and integrate a number of diverse indicators, our paper is nested within the latter approach. Several studies from this stream are outlined in brief bellow.

Moeinaddini et al. (2015) use statistical data from International Association of Public Transport (UITP) database and perform a correlation analysis to identify urban structure variables that affect private motorized daily trips. Based on correlation results, 18 indicators are extracted. They relate to various themes − public transport performance, road network characteristics, urban population density, motorization rate, modal split data (the authors listed the indicators without denoting categorization). In order to rank cities according to these indicators, an urban mobility index is proposed. Based on literature review, Santos et al. (2013) identify factors that might influence the observed modal split in medium-sized EU cities. Along with socio-economic factors that most variables relate to, weather conditions are also included. The choice of variables has been contingent upon the coverage of Urban Audit, which was the main data source for this study. The results confirmed expected correlation of the chosen variables with the modal share. To understand travel behaviour and cluster German cities according to mode orientation, Klinger and Kenworthy (2013) introduce the concept of mobility culture. A set of 23 indicators has been proposed to cover a range of relevant urban dimensions including urban form, socio-economic characteristics, transport infrastructure, transport demand and mobility related perceptions. The data have been provided from several national sources. The underlying factors of urban transport patterns drawn from European Environment Agency (EEA) report on urban transport (Agentschap, 2013) include urban form, socio-economic factors, quality and provision of transport infrastructure and transport costs. In line with three pillars of sustainable development (environment −economy-society), Gillis et al. (2015), propose sustainable mobility indicators for urban environment, structured around three dimensions: global environment, economic success and quality of life. Beside these, the fourth dimension, mobility system performance, was added. The set contains 22 indicators. The proposed methodology for their aggregation into global score, would enable future wide-spread evaluation of cities. Fundamental dimensions of sustainability (economic, social and environmental) also served as a framework for formulating indicators to measure sustainability of passenger transport systems in selected European cities (Alonso et al., 2015).

When it comes to analytical tools for cross-city comparisons the common are composite indicators, multi-criteria analysis or various statistical techniques. Validation of these analytical procedures is another field of research beyond the scope of this study.

Based on work done so far (Table 1), we were able to highlight main drivers that are found to be significant for car usage. We have named them as Spatial, Socio-economic, Supply and Satisfaction. Apart from them, we have included one more aspect concerning political will i.e. institutional capacity, referred as Strive dimension. Our intention was to provide good coverage of the influencing factors but also to inspire policy makers. For that reason we opt to include mainly those aspects and related indicators which are the reflection of urban policy. In line with this, we did not consider some other relevant impacts on car usage which have been reported in the literature, like various psychological factors or weather conditions.

3. 5S − dimensions and indicators

To make the "5S" conceptual framework operable, we have first decomposed the dimensions into the related themes. The elaboration of themes requires the appropriate indicators, which can be seen as a set of criteria reflective to each theme. Finally, we convert the indicators into variables. At this point we delineate the variables that are feasible to be utilized for the international (intra EU) comparison.

3.1. Outline of the research procedure

The research procedure has two steps (Figs. 1 and 2). In the first step, the dimensions and related themes are specified based on body of knowledge (scholar articles, policy documents, project reports). The potential indicators reflective of the theme are then examined. In the