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The social dimension of barrier effects of transport infrastructure

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Abstract. Motorways and railways increase regional accessibility but can at the same time reduce local accessibility by creating barriers in pedestrian and bicycle networks. This can influence several SDGs, such as SDG 5 (gender equality), 10 (reduced inequalities), and 11 (sustainable cities and communities). This paper presents some first principles of how quantitative indicators of direct barrier effects can be adapted in order to address specific social groups. To demonstrate this, the indicator 'Choice', from a set of four indicators previously developed, was adapted to assess accessibility by children to parks, and waterside and leisure facilities. The indicator was applied to a case in Gothenburg, Sweden, where a GIS-based analysis measured changes in barrier effects brought about by hypothetically placing an existing motorway and railway in tunnels. The results demonstrate how such local accessibility indicators can be adapted to make them relevant for impact assessments of infrastructure projects, and thus enable the measurement of compliance with social sustainability targets in transportation infrastructure planning.

1. Introduction

Transport infrastructure such as motorways and railways are built to create effective connections on a metropolitan and regional scale but can at the same time create barriers in local pedestrian and bicycle networks (severance) and reduce local accessibility. These barriers affect three SDGs in particular. Conditions for gender equality (SDG 5) are reduced as women in many countries, including Sweden [1], have less access to a private car, which allows an individual to have access to the car road network and overcome the barriers. The impact of this condition is aggravated by the fact that women bare a larger part of the responsibility for household and childcare then men. These responsibilities typically require accesses to local services. Infrastructural barriers divide cities into spatially segregated neighbourhoods and districts and can lead to social segregation that impacts possibilities to reduce inequalities (SDG 10). The spatial fragmentation caused by infrastructure has been shown to correlate with ethnic segregation on the level of residential areas [2] and can negatively affect the conditions for different societal groups to meet in public space [3,4]. Further, barriers can reduce access to jobs for poorer communities in a process referred to as spatial mismatch [5]. Barriers hinder the creation of sustainable cities and communities (SDG 11) as they limit the possibilities to build networks for bicycle and pedestrian traffic, and in turn limit possibilities to achieve a reduction of CO2 emissions through a modal shift [6].

Despite conflicting with these development goals, barrier effects of infrastructure receive little attention when impact assessments of transport investments are undertaken, and are commonly described only in broad, qualitative terms [7], which creates the risk of being undervalued or even ignored.

The quantification of barrier effects is challenging due their complex and multifaceted nature. Korner [8] describes how barrier effects arise from the meeting of the transport system; the land use system; and the wishes, needs and capabilities of people. The effects of a barrier develop in a sequential process, originating in direct effects (for example, longer travel times, or a reduction in catchment area for businesses); to indirect effects, such as change of mode of transport, of destination, of trip frequency; and to wider effects (for example, reduction in social contacts within and between neighbourhoods, or deterioration in health).

In an earlier phase of the present research, four indicators were developed, covering the four direct effects identified in the literature [9].. The parameter values used in the indicators, such as the selection of destinations and the maximum distance that people are willing to walk or cycle to reach these destinations, were chosen based on general assumptions. The aim of this paper is to present some principles for how the parameters used in the indicators can be adapted to the wishes, needs and capabilities of people.

2. Theoretical background

In addressing this issue, the question arises: What categorisation of social groups is relevant for the assessment of the interaction between people and transport in general? As assessments of the social impacts of transport are mostly focused on the distribution of the costs and benefits of the car-based traffic system, the most relevant categorisation for these assessments is to divide a population in groups of those who have access to a car and those who do not [10]. People can have no or limited access to a car due to age (too young or too old), gender, disabilities, income, or because of ethical considerations or personal preferences.

Geurs et al. [11] describe a conceptual chain for social impacts, consisting of the sequence: source – effect – impact – receptor. The focus in the first part, source – effect, is on the source, and in the second part, impact – receptor, the focus is on the receptor. An effect becomes an impact when it exceeds a defined sensitivity level of the receptor. This distinction between effect and impact is valuable for determining which types of technique are relevant for the assessment.

Relatively little has been done to develop tools to estimate social impacts [13], and it has proven especially difficult to define conceptual models and indicators to quantify theoretical concepts derived from social sciences [11]. Rajé [10] points out the experience and communication gap between users and planners and policy makers, and argues for an exploration of the “lived experience of transport structure and transport organisation.” These observations indicate the importance of being aware of the limitations of categorising people in standard socio-demographic groups and ensuring that the categorisation and aggregation of the categories used are defined in relation to the impacts that are being assessed.

Another challenge for the assessment of social impacts is the complexity in the way people appropriate the spaces surrounding infrastructure. On the one hand there are clear cases like the removal of a freeway in Seoul, which unsurfaced an existing river and where a highly appreciated park was created and which has led to a clear increase of real estate prices in the surrounding area [14]. On the other hand, there are cases where, despite the problems of noise and pollution, local residents appropriate the spaces around and underneath exiting infrastructure. Lou and Ferretto [15] describe how the freedom and accessibility of these spaces allow them to function as stage for a diversity of social activities that are either not tolerated in other public spaces or that impossible due to the scarcity of space due to high density. An example of this is the Mei Foo housing district in Hong Kong, where residents have created a local market and places to meet and gather underneath the fly-over that crosses the district [15].

For the quantification of the direct effects of barriers, four indicators have been developed by the authors [9]. Those indicators cover the four direct barrier effects that were identified in the literature: Travel time to destinations ('Travel time'); number of destinations accessible within a given distance from an origin ('Choice'); number of households within a given distance from a facility ('Catchment'); and transport efficiency of public services, such as ambulances and public transport ('Service efficiency'). The indicators are based on a Geographic Information System (GIS) model, consisting of the street network and destinations points.

3. Method

Taking into consideration the need to account for the social impacts of barrier effects on local residents, and the difficulty in quantifying them, an approach was developed to adapt the more general direct indicators of static barriers [3], to give them a social dimension that can be used to measure social impacts. This method is here demonstrated in a case study in the north of Gothenburg, where a railway track and a motorway are increasingly turning into barriers as the surrounding area is being redeveloped. 'Children' was selected as an illustrative group, and the indicator 'Choice' [9] as an example, in order to make the social dimension explicit.

Choice measures for every segment in a street network how many points from a given category of destinations can be reached within a given distance. The parameters of this indicator, which can be modified in order to address a specific social group, are: the choice of networks associated with a given travel mode; the category of destinations relevant to that particular social group; and the distance or time threshold within which destinations can be reached.

The Swedish Transport Administration, Trafikverket, is currently planning the construction of a tunnel for part of the railway in the study area; in connection with this project an assessment of the impact on children was made [17]. In the assessment, schools, playgrounds and leisure facilities were identified as important destinations for the children living in the vicinity. For the purpose of testing Choice, the selected parameters are: the street network for pedestrian and bicycle traffic; parks, places near the waterside and leisure facilities as the destination category; a travel time of 0-10 minute, which can be considered a reasonable range for children to cycle to a park or leisure facility, either independently or accompanied by an adult.

Two versions of the street network were analysed, one with infrastructural barriers and one without. The difference between these two street networks versions is that there are eight connections (bridges and tunnels) across the barriers in the network with barriers, and 36 connections in the network without them. The extra connections were added to the network based on assumptions of logical continuations of the existing street network. The dataset concerning the destinations (parks, waterside, leisure facilities) was the same in both versions. Using the analysis results of the two networks, the percent increase of accessibility to parks, waterside and leisure facilities that removing the barriers would imply, was calculated.

4. Results

Figure 1 shows the results of the analysis of the increase in Choice of parks, waterside and leisure facilities. In large parts of the study area there is no or an insignificant increase, however in the northern part of the area (1) Choice increases up to 35 %. In Frihamnen (2), placing the road and railway in tunnels would result in insignificant changes, which is in stark contrast to the current planning debate where consensus appears to exist about the importance of removing the barriers in that area. The results show that barrier effects are distributed in an irregular way over the study area; this emphasises the complex nature of these effects, which makes them hard to predict, and important to analyse systematically and quantitatively.

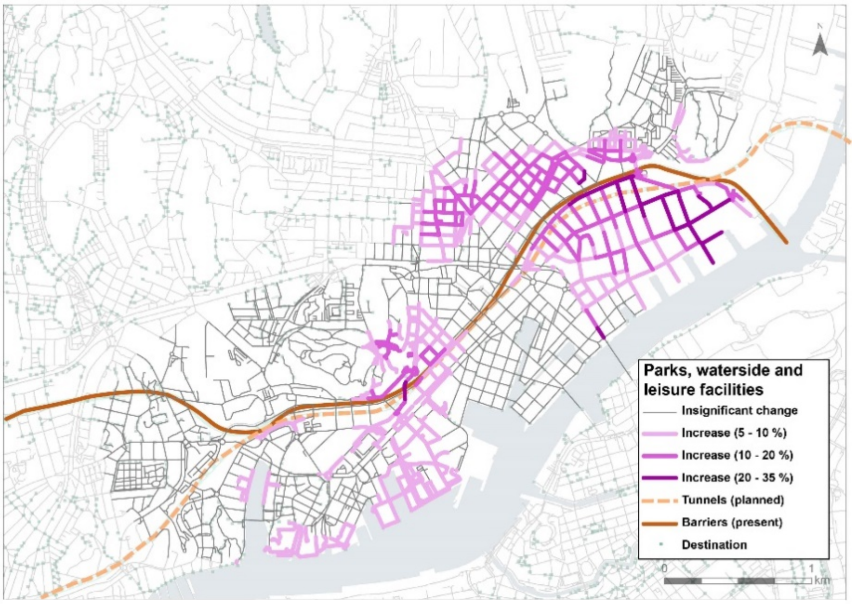

Figure 1. Increase in available choice of parks, and waterside and leisure facilities within a 10-minute travel time (bicycle) from every street segment, consequent to the removal of the barriers.

5. Discussion and conclusion

Returning to the research question – how we can make the quantitative indicators specific to different social groups – the above case illustrates that by selectively setting the three parameters (i.e. network, destinations and distance threshold) of an indicator, in this case Choice, can be adapted to address a specific social group. This makes the indicators more relevant for impact assessment of infrastructure projects and enables the measurement of compliance with social sustainability targets in transportation infrastructure planning. Also, the analysis of Choice can, for instance, be used to assess 'trips-not-made', an important social effect of transport that is not usually included in assessments, or undervalued [10]. An important aspect when setting the parameters of the indicators is choosing a relevant principle for social categorisation for each assessment, as there are no universal social categories that fit all situations and research questions. Further, it is important to use supporting evidence for choosing the parameter values (the values used here are just an example).

With the support offered by quantitative indicators, impact assessments could make it possible for different stakeholders to participate on equal terms in the planning process of infrastructure projects. Additionally, through clearer impact assessment, efforts to mitigate barrier effects can be prioritized.

Considering the groups most sensitive to barriers (children, women, older persons, people without access to a car), the networks for pedestrian and bicycle traffic are important, but also those of public transport.

One limitation of the current method is that it only considers street networks; further research is needed to incorporate public transport in the indicators. Another area that requires further exploration is the effect of the quality of connections on people's willingness to use them.

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