Assessing the fairness of transport systems in US metropolitan areas

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While transport research has studied the disparities created by modern transport systems for decades, systematic inquiry into the fairness of these disparities is of relatively recent date. One important reason why fairness has received limited attention lies in the related need to engage in normative reasoning, a form of academic inquiry that transport researchers have typically preferred to avoid (Páez, Scott and Morency 2012).

In this paper, we take an explicitly normative stance in evaluating the fairness of transport systems in US metropolitan areas. We draw on Martens' recent work (Martens 2017), in which he developed an elaborate argument in defense of an intuitively appealing standard of justice: a transport system is fair if, and only if, it provides a sufficient level of accessibility to all under virtually all circumstances. The proposed fairness standard is thus a standard of sufficiency, a principle defended in a more general sense by a number of philosophers (e.g., Frankfurt 1987) and also proposed for the domain of transport by studies into transport and social exclusion (e.g. Farrington and Farrington 2005).

This sufficiency principle can be described mathematically as follows:

$$AFI_r = \frac{1}{N}\sum_{i=1}^{q} n_i \cdot \left(\frac{z - y_i}{z}\right)^2$$

where AFI_r represents the Accessibility Fairness Index for region *r*; *N* represents the total population in region *r*; *q* the number of groups in region *r* experiencing accessibility levels below the sufficiency threshold *z*; n_i the size of the *i*-th group in number of persons; and y_i the accessibility level experienced by the *i*-th group below the sufficiency threshold *z*.

The AFI_r score of a metropolitan area depends on three components: the height of the sufficiency threshold; the share of the population groups falling below the threshold; and the exact level of accessibility experienced by those population groups. The AFI_r score denotes the severity of the accessibility deficiency in a region, i.e. the extent of the deviation from a fair transport system.

The AFI has two important properties. First, the AFI score represents the fairness of a transport system in a single number, which enables direct comparison of the fairness of transport systems across metropolitan areas. Second, the AFI makes it possible to determine the contribution of each population group within a region to the overall level of accessibility deficiency. Because the AFI measure is totally decomposable and subgroup consistent (Foster and Sen 2008 [1997]), the contribution of each population group can be expressed as a percentage, with the contributions of all subgroups adding up to exactly 100%. The pattern of these percentage scores, across space and population groups, enable a detailed description and assessment of the fairness of transport systems.

We will use this index to analyze the fairness of transport systems in US metropolitan areas. For this purpose, we have obtained data on car-based and public transport-based accessibility for 30 metropolitan areas from the Accessibility Observatory at the University of Minnesota. We will use this database for two analyses:

- A systematic description of the (spatial) patterns of fairness of transport systems across the selected metropolitan areas. The focal variable is the *contribution of population groups to overall accessibility deficiency* (defined in a percentage; see above). We compare the patterns across the regions using common (spatial) statistics in an effort to identify groups of regions with distinctly different patterns.
- A preliminary explanatory analysis of the fairness of the transport systems of the selected metropolitan regions, for a number of accessibility measures and sufficiency thresholds. Here, we will analyze (1) whether different accessibility measures and sufficiency thresholds lead to largely comparable or fundamentally different 'rankings' of metropolitan regions vis-à-vis each other; (2) whether low or high rankings of metropolitan areas are primarily the result of land use patterns or of the transport network (drawing on work by Levine, Grengs, Shen et al. 2012); and (3) whether the ranking of metropolitan areas is correlated to basic descriptors of urban regions, such as population size, employment size, surface area, and average income level.

We are currently preparing the data for a selection of metropolitan regions and expect to present the first results at the hEART Conference at the Technion in September 2017.

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