THE INFLUENCE OF THE IMPEDANCE FUNCTION ON GRAVITY-BASED ACTIVE ACCESSIBILITY MEASURES: A COMPARATIVE ANALYSIS APPLIED TO PORTUGUESE MEDIUM-SIZED CITIES

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Active accessibility, i.e. walking and cycling accessibility, has been growing in importance as an urban planning objective to promote the creation of sustainable and healthy spaces. However, there is not a unique way of measuring active accessibility, but instead four different categories of measures can be found in the literature: topological, walkability-type, distance-based, and gravity-based or potential accessibility measures. Gravity-based accessibility measures incorporate a travel impedance function, calibrated with different parameters, in order to reflect the influence of distance or time needed to travel between origins and destinations. Several impedance functions have been used to reflect the cost of travelling, namely inverse power, negative exponential, linear, modified Gaussian, amongst others. Moreover, the parameters used in each of these functions are also varied, and so, in accordance with the impedance function and the parameters used, different, and often quite distinct, values of accessibility can be obtained for the same measure and the same location. To measure active accessibility the importance and influence of the chosen impedance function and associated parameters is therefore emphasized, not only due to the level of spatial data detail required to measure it, but also because active modes are extremely sensitive to travel distance as they negotiate it with muscle power.
This paper contributes to this discussion, by measuring and comparing several gravity-based active accessibility measures, stabilizing all other specifications of the measures (namely spatial disaggregation, origins and destinations, and attractiveness of opportunities), and varying only the impedance function and the associated parameters, in order to evaluate their influence on the final result. In particular, we have calculated, applying these variations, twenty-four different 'walking to school' accessibility measures, using as origins all buildings of the Portuguese medium-sized cities selected as case-studies, where public transport is rudimentary, and people travel mainly by car or by active modes. Schools were chosen as destinations as they constitute fixed space-time constraints and often represent important locations in these cities. Cycling was neglected due to the insignificance of this mode in the majority of these cities and lack of data regarding slope, and also because walking to school is being actively promoted as a health improvement policy.
We compared the different measures by applying spatial pattern analysis, correlation analysis, and factor analysis. Spatial analysis reveals that all measures produce similar spatial results when identifying high and low accessibility locations, but different values for the medium accessibility locations. Correlation analysis helps to interpret how similar and how distinct these measures can be, and to what extent, i.e., which parameters and which impedance functions actually affect the overall accessibility value. Finally, by applying factor analysis to these measures we can identify a small group of factors that explain a high total variance, and in turn allows us to identify clusters of measures in accordance with their loadings. Overall, our results show that these measures are extremely sensitive to the chosen function and associated parameters, alerting that their choice may reveal substantially different phenomena, and arguing and stressing therefore that they should be made clear in all active accessibility measurements. We conclude our paper by presenting the limitations of our work, namely the specificities of our case studies and the chosen destinations (schools), and suggesting further developments, as for instance to validate the measures with experts and local stakeholders, and to calculate the measures in different spatial and cultural settings.

Keywords: accessibility, active travel, travel impedance, distance decay function, walking to school