Public Transport versus Private Car: Estimation of Accessibility in a Metropolitan Area

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Most accessibility measures of population groups to urban facilities, such as jobs, health services, or parks are still based on aggregate data of both population and facilities distribution (Hensher, Ton, 2000; Lau, Chiu, 2003; Matisziw, Murray, 2006). Moreover, more detailed types of accessibility measures often only account for car-based travel (Geurs, Ritsema van Eck, 2001).

Recent advances in GIS databases, together with improved access to the data, enable direct and unambiguous estimation of accessibility for every set of urban facilities and population group(s), including accessibility by public transport (Sobek, Miller, 2006). The paper proposes an operational approach to accessibility, using estimates based on high-resolution GIS layers of the urban transportation network available in Israel – the layers of streets (with estimates of driving time), bus lines, bus stops, and, most important, bus departure/arrival times for every line and stop and real-world estimates of velocities, the latter reflecting time- and location-dependent congestion. The use of these detailed GIS data on the urban transport system is still in its initial stage, and the only application we are aware of is the multi-modal individual trip planning. The research thus makes a critical step from individual travel patterns to urban transportation and land-use planning. The approach is applied to examine two problems of accessibility in the Tel-Aviv Metropolitan Area (TAMA), a metropolitan region with a population of about 2 million.

We propose two complimentary measures of accessibility. The first set of measures is associated with the Service Area and denotes the area within which services can be accessed from a given origin O within a particular travel time (τ). A distinction is made between Bus Service Area (BSA) and Car Service Area (CSA), calculated for a given origin O and Travel Time (τ), and hence defined as $BSA_O(\tau)$ and $CSA_O(\tau)$. The second set of measures is associated with the Access Area and denotes the regions from which a destination D can be reached within τ with either bus or private car. The Bus/Car Access Area is calculated for a given destination D and Travel Time: $BAA_D(\tau)$ and $CAA_D(\tau)$.

The estimates of $BSA_O(\tau)$, $CSA_O(\tau)$ and $BAA_D(\tau)$, $CAA_D(\tau)$ provide the basis for estimating two basic measures of accessibility as depending on the travel time τ:

$$\text{Service Area ratio: } SA_O(\tau) = BSA_O(\tau)/CSA_O(\tau), \text{ and}$$

$$\text{Access Area ratio: } AA_D(\tau) = BAA_D(\tau)/CAA_D(\tau).$$

Several derived measures, as those based on the ratio of the average radiuses of the service areas can be also generated. The measures are generalized to account for multiple origins/destinations of a given type and for several public transportation networks available in the city (e.g. planned light-rail network). For instance, it is possible to assess the level of access to government institutions for a particular population within certain neighborhoods. Based on an average of $SA_O(\tau)$ and $AA_D(\tau)$ by

numbers/fractions of facilities located within the areas accessible within travel time τ, we construct accessibility maps for areas of origin/destination and population groups.

We present the ArcGIS application ***Urban.Access*** that makes possible the estimation of service and access areas, and the basic and derived measures of accessibility for local and areal sources and destinations. With the help of the ***Urban.Access*** we construct accessibility maps of service and access area ratios for TAMA for travel time τ varying from 20 to 60 minutes, for different hours of the day and days of the week. We compare these maps with the theoretical estimates that are based on the bus/car velocities only and demonstrate that knowledge of the time-table and velocities is critical for proper estimation of accessibility. In addition, we show that for the majority of origins and destinations, the use of public transport in TAMA demands at least one change of line. As a result, the waiting time at a station of change becomes an essential component of the trip time and accessibility with public transport almost does not grow with the increase of travel time.

Based on GIS databases for TAMA, the proposed approach is applied to two problems. The first investigates accessibility with the existing bus network in TAMA and demonstrates how the public transportation system evolves towards *lower* accessibility. That is, the reaction of the bus companies to the varying demand generates a vicious circle of (lower accessibility → worse service → lower accessibility → …) thus making *irreversible* the transition of the individuals' transport choice patterns from public transportation to private cars.

In the second example of the approach we estimate whether the planned metro lines and the accompanying alterations of the bus network will improve job accessibility for low-income population groups in the TAMA.

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