Transportation Accessibility

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Transportation planners use the term *accessibility* to describe the ease with which an individual can reach a set of destinations from a particular location. Accessibility is an important determinant of a site's value.[1]

[1] Medda, Francesca. "Land value capture finance for transport accessibility: a review." Journal of Transport Geography 25 (2012): 154-161.

Measuring Accessibility

There are three basic types of accessibilty metrics:

- Isochrone-based metrics,
- Distance-decay metrics, and
- Utility-based metrics.

Isochrone-based metrics

An *isochrone* is an area that can be reached within a specified length of time. An isochrone-based accessibility metric is the number of opportunities within an isochrone. Examples of isochrones-based accessibility metrics are:

- The number of jobs within a 30-minute drive of a residential development.
- The number of workers within a 45-minute transit commute from an office building.
- The number of households within a ten-minute walk of a transit station.

Distance-decay metrics

One weakness of isochrone-based accessibility metrics is that they require the analyst to specify a threshold value within which an opportunity "counts," and beyond which it does not. For example, if we are calculating the number of jobs within 30 minutes of a site, a job that is 29 minutes away will contribute to the site's measured accessibility, but a job that is 31 minutes away will not. In reality, there is minimal practical difference between 29 minutes and 31 minutes, but they happen to fall on either side of the selected threshold. Distance-decay measures can address this weakness. Instead of counting all destinations within an isochrone equally and disregarding destinations outside the isochrone, each destination is weighted according to its distance from the site. Weights are based on a distance-decay curve like the one in Figure 1.

Based on the distance-decay curve in Figure 1, a destination immediately adjacent to the site would be fully included in the accessibility score. A destination that is 25 minutes away would contribute 70 percent of what it would if it were immediately adjacent to the site, and a destination that is 35 minutes

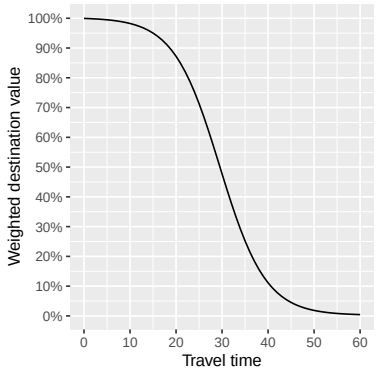

Figure 1: Example of a distance-decay curve

away would count as 25 percent. Beyond 60 minutes, the contribution to the accessibility score would be so small that you would no longer include it in the analysis at all.

Just as the analyst needs to select a threshold value for an isochrone-based accessibility metric, they would need to select a distance decay function to define the shape of the curve. In fact, they could select a function to define a curve like the one in Figure 2, and this would be equivalent to an isochrone-based accessibility metric.

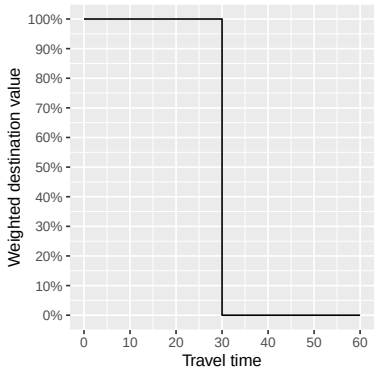

Figure 2: Distance-decay curve that would reproduce an isochrone-based measure

Utility-based accessibility metrics

Utility-based accessibility metrics weight destinations based on their relative utilities (usefulness or desirability) to an individual traveler. If the only thing a traveler cares about is how long it takes to travel to a destination, then a utility-based metric could be exactly the same a distance-decay metric. However, utility-based metrics can also account for other characteristics of a destination that might make it more or less desirable.

Which is best?

Utility-based metrics incorporate more information than distance-decay metrics do, and distance-decay based metrics incorporate more information than isochrone-based metrics do. A major advantage of isochrone-based metrics is that they are easy to understand and to communicate to a general audience. Some researchers have argued than since the various alternative accessibility measures are highly correlated, the advantages of isochrones-based measures (primarily ease of communication) outweigh the technical advantages of other measures.[2]

[2] Kapatsila, Bogdan, Manuel Santana Palacios, Emily Grisé, and Ahmed El-Geneidy. "Resolving the accessibility dilemma: Comparing cumulative and gravity-based measures of accessibility in eight Canadian cities." Journal of Transport Geography 107 (2023): 103530.

Improving Accessibility

For simplicity, this discussion focuses on isochrone-based accessibility measures, but the general principles would apply to distance-decay and utility-based measures as well.

If we think of accessibility as the number of destinations within an isochrone, then there are two ways to increase a site's accessibility:

1. Increase the density of destinations within an isochrone.
2. Increase the size of the isochrone so that it encompasses more destinations.

Filling the isochrone

If the size of an isochrone is fixed, but land uses can change, the only way to improve accessibility is to increase the density of destinations within the

isochrone.

Enlarging the isochrone

The size of an isochrone is not fixed as long as it is possible to change the transportation system. Transportation networks determine the sizes of isochrones. The characteristics of the transportation system that are most important in determining the size of an isochrone depend on the mode of travel.

Pedestrians and cyclists: Isochrones for pedestrians and cyclists are also called walksheds and bikesheds. Figures 3 and 4 show the area of a ten-minute walkshed from each of two secondary schools in Massachusetts, one served by a dense street network in the city of Cambridge, and the other served by a much sparser street network in the town of Douglas. Since walking and biking speeds don't vary much from one facility to another, the most important factor determining the size of a walkshed or bikeshed is the directness of pedestrian or bicycle routes. A network requiring pedestrians or cyclists to take more circuitous routes will yield smaller isochrones. The denser street network in Cambridge allows pedestrians to reach a wider area within ten minutes than the sparser, more circuitous street network in Douglas.

The most efficient way to enlarge a walkshed is to create pedestrian paths between locations in the network that are geographically close to one another, but connected by an otherwise circuitous route. Figure 5 how the the walkshed for Douglas High School could be expanded with the addition of a new pedestrian path (shown in blue). This short path shown in blue is about 160 meters long and increases the area of the walkshed by about forty percent.

Transit passengers: An isochrone for transit passengers is called a transitshed. This is the area that can be reached within a specified length of time by transit, including all stages of the transit journey:

- Walking to a transit stop,
- Waiting for a transit vehicle,
- Riding on a transit vehicle,
- Waiting to transfer from one transit vehicle to another, and
- Walking from a transit stop to the final destination.

Walking to and from transit stops (and between stops to transfer vehicles) can comprise a substantial portion of the total travel time for a transit journey, so dense, connected street networks that maximize walkshed areas will tend to also maximise transit shed areas.

Other factors that will determine the size of a transitshed are

- the presence of transit routes,
- the speeds of transit vehicles, and
- the frequency of transit service.

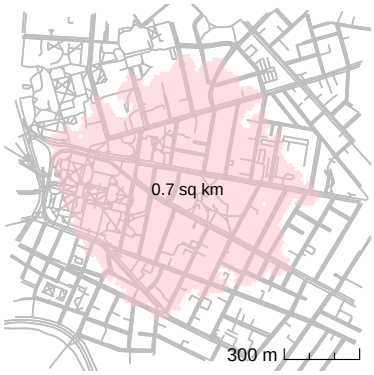

Figure 3: 10-minute walkshed from Cambridge Rindge and Latin School in Cambridge, Massachusetts

Figure 4: 10-minute walkshed from Douglas High School in Douglas, Massachusetts

Transit frequency can be particularly important because time spent waiting for a transit vehicle can be a substantial portion of transit travel time. This means transit isochrones can vary by by time of day (for example, if transit service is less frequent during the off-peak periods than during the peak period) and by day of the week (for instance, if there is less frequent transit service on weekends than on weekdays).

Figure 6 shows the 30-minute transitsheds for Cambridge Rindge and Latin School on at 8am on a typical Wednesday and at 2pm on a typical Sunday. Fewer routes run on Sundays, and those that do are less frequent, so the transitshed is about thirty percent smaller on Sunday afternoon than on Wednesday morning.

Drivers: A driveshed is an isochrone for drivers. The size of a driveshed will depend primarily on vehicle speeds. A well-connected, dense pedestrian network will generally lead to slower vehicle speeds. Facilities that allow for fast vehicle speeds will generally create circuitous and disconnected pedestrian routes.

Ideally, a driveshed would also account for the time a driver must spend looking for parking, but analyses often omit this time because it can be difficult to predict. Large parking lots can minimize time spent searching for parking.

High-speed vehicle routes and large parking lots that maximize size of a driveshed occupy substantial land area and may displace other land uses. In such cases, enlarging the isochrone may reduce the density of destinations, offsetting any improvements in accessibility. High density development within an isochrone can also shrink the size of an isochrone by increasing traffic congestion.

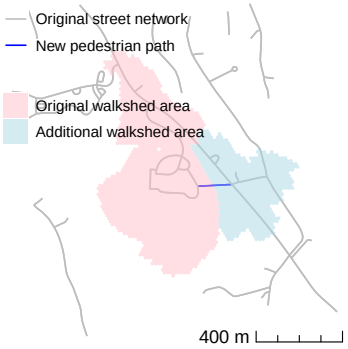

Figure 5: Expanded walkshed from Douglas High School

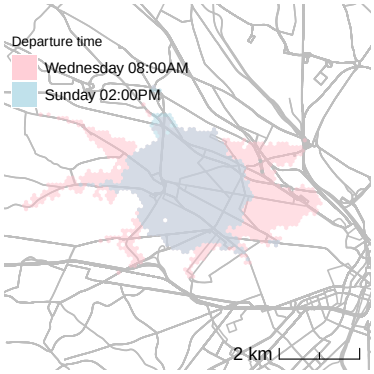

Figure 6: 30-minute transitsheds for weekday mornings and Sunday afternoons from Cambridge Rindge and Latin School in Cambridge, Massachusetts

Which is more effective?

If our goal is to maximize accessibility, is it better to do it by enlarging our isochrones or filling them? For all modes except the private car, the answer is both: one tends to reinforce the other. For car-based mobility, expanding the isochrone comes at the expense of filling it.

Researchers have found that proximity (or density) is a more important factor in overall accessiblity than travel speed is, even for cars.[3] This means that policies that limit development densities in order to maintain uncongested vehicle speeds are likely to reduce overall accessiblity.

Increasing development densities while enlarging isochrones for transit and non-motorized modes will generally be the most effective strategy for maximizing accessiblity.

[3] Thomas, Trevor, Andrew Mondschein, Taner Osman, and Brian D. Taylor. "Not so fast? Examining neighborhood-level effects of traffic congestion on job access." Transportation research part A: policy and practice 113 (2018): 529-541.