Isochrone Maps to Facilities. Shopping Centres in the Metrosur Influence Area (IMaFa)

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Background

MetroSur is the name of a new metro line developed in recent years in Madrid. MetroSur's area of influence is located in the southern outskirts of Madrid's metropolitan region. This area is characterized by the presence of densely populated cities such as Alcorcón, Getafe, Leganés, Móstoles and Fuenlabrada, and has one of the highest concentrations of shopping centres in the region of Madrid. These centres make up new centralities in these peripheral areas –attracting traffic flows– and are linked to new urban developments. They are situated in spaces with good accessibility by private transport but, in some cases, with poor accessibility by public transport.

The study area has seen a constant rise in congestion levels, and there is therefore an increasing need for the provision of good quality public transport. The mobility changes induced by the shopping centres in the area (with increasing number of customers, coming from longer distances), and the difficulty of access for a significant portion of the population (those without private cars), creates a need for public transit provision.

One of our main motivations for developing this accessibility instrument was to assess the level of service of public transport when accessing shopping centres in the MetroSur influence area. However isochrone maps can be applied to other type of facilities (health care, education, etc.)

The main research question to be addressed is whether shopping centres in the study area can be accessed easily by public transit.

Conceptual framework and theoretical underpinnings

Our instrument of isochrone maps defines accessibility as the opportunities for ease of access and takes as a case study the access to shopping centres by public transit.

The accessibility instrument is measured as the process associated with getting to and from the shopping centres by public transit.

The theoretical underpinning of this accessibility instrument is that the more accessible the selected shopping centres, the greater the likelihood that they will be accessed by public transit (Murray *et al.*, 1998).

This measure is therefore relevant from several points of view:

1. To owners / operators of public transport services and urban planners, who can assess the level of service for the MetroSur influence area, regarding the access to the main shopping centres;
2. From an environmental perspective (emissions of pollutants) (Keijer and Rietveld, 2000). Accessibility by public transport is a critical issue from the point of view of both sustainable mobility (Black, 1996) and sustainable accessibility (Weber, 2006).

Because it is a simple measure, isochrone maps are easy to communicate and easy to interpret by decision makers and transport planners alike, as well as by the rest of the stakeholders.

Operational aspects

The accessibility instrument presented here measures the travel times by public transport to shopping centres.

Isochrone maps are drawn using the network coverage analyses included in a GIS. Given the spatial nature of network coverage analyses, GIS have become useful tools which provide capabilities for data collection, data management and handling, spatial analysis, network analysis, and cartographical presentation of results (Zhu and Liu, 2004).

Coverage or service areas can be delineated by GIS through the creation of buffer areas (bands) around shopping centres, based on Euclidean (straight-line) distance or travel times along a network. The choice of the distance calculation method significantly affects the final results. For a given distance threshold (for example, 0.25 km), service areas are larger using Euclidean distances than network distances, since the first method overestimates the size and the population of the service areas (Gutiérrez and García-Palomares, 2008).

In our case, we decided to use buffer areas considering distance along a public transport network, through the quickest network paths. The population covered in each buffer area was then estimated following previous studies (Gutiérrez *et al.*, 2000; Murray, 2001; Murray *et al.*, 1998).

The input required is a digital public transport network, providing information on travel times, type of mode (train, metro, bus) and transfer times between transport modes, which is combined with a street network to calculate pedestrian access times from the stations/stops to the shopping centres also through the quickest network paths.

The location of the shopping centres and the metro and train stations and bus stops are also required as input data.

The population data available at census track level (0.25 square kilometres on average) are used to calculate the population covered within each buffer area.

We use the EMME3 traffic assignment model which gives us travel time matrices by public transport. A commercial GIS –and specifically its network analysis capabilities– is then used to calculate distances between public transport stops/stations and shopping centres through the street network, simulating the real routes followed by the population on their way to those shopping spaces. The EMME3 model was chosen because this is currently being used by the Public Transport Authority of Region of Madrid. However other software can be used if they include traffic assignment models and network analysis tools.

We also use GIS to calculate the isochrone maps; with this method, the resulting coverage area is not a circle (as it would be using Euclidean distances), but an irregular polygon containing all the sections of streets and public routes located within a network distance threshold.

Results can be obtained within three days when all the data and technical expertise is available for the analysis. This is an estimated time accounting for one day for processing the traffic model using EMM3, one day for bringing the results to the GIS and calculating of the isochrone maps and one more day to elaborate maps and other outputs such as graphics and tables.

This accessibility instrument can be understood by everyone, as access to shopping centres is expressed as travel time, which is a familiar indicator. However some technical knowledge of network analysis using GIS is required.

Relevance for planning practice

Isochrone maps make it possible to assess accessibility to shopping centres by public transport. It can be understood as a measure of accumulated opportunities when considering the amount of population or employment within a certain distance or time threshold from one or several shopping centres. Taking into account the total population within time thresholds, the measure of accumulated opportunities provides an estimation of the potential demand for shopping centres.

The use of isochrone maps of shopping centres has several applications for urban and transportation planning. It allows assessment of the public transport network by identifying populated areas outside the coverage area. Greater attention should be given to areas which are not covered or poorly covered by the public transport system, than to implementing steps to extend the network or to increase the frequency of service provision.

This method can also be used to draw some conclusions about the location of new metro or train stations and bus stops, by comparing time thresholds after the location of new bus stops or stations on the network. It thus helps to determine the most suitable location to boost accessibility to shopping facilities.

It can also be used to propose facilities for soft modes, such as cycling.

This instrument was applied in 2005 in the Autonomous Region of Madrid, in collaboration between the regional Public Transport Authority and the Regional Health Department (Redondo, 2005).

The objective was to study the accessibility by public transport to specialized health centres in the region. The population was calculated (both in absolute and relative terms) within certain distance thresholds from the health facility. Three different scenarios were analysed for the years 2000, 2004 and 2008; each scenario considered changes in population and infrastructure in both transport and health centres. For each year, isochrone maps were calculated individually for each particular health facility (see for example Figure 1.

The instrument identified the less accessible health centres and the location of the population with poor accessibility to these types of facilities. The results influenced political decisions in two ways:

1. By reassigning the population with worst accessibility to other health centres, while maximizing their accessibility.
2. Identifying potential locations for new health centres in areas with long travel time to these facilities.

Strengths and limitations

The main strengths of the present accessibility instrument are its low data requirements, and the ease of calculation, transmission and interpretation of results.

The instrument requires relatively few data, which as we have seen, are basically related to the network, and to the locations of the defined economic centres.

Isochrone maps are easy to calculate through simple network analysis performed in a GIS.

Because the output is expressed as travel time thresholds, the results can be easily interpreted by policy makers and transport planners and simply transmitted to everyone.

However, due to the simplicity of the measure, the results of this instrument are not sufficiently realistic, as they use an all-or-nothing function (inside or outside the established distance) rather than a *distance decay* function.

This implies that everyone within the threshold area would have the same probability of access to a shopping centre, without considering the population which lies beyond the selected distance. Isochrone maps do not therefore accurately reflect the behaviour of traffic flows, which tend to decrease progressively as the distance increases.

Another drawback of this instrument is the choice of the distance threshold itself, which is somewhat arbitrary and may cause the results to vary significantly (Tillema, 2007).

Finally, since our case study focuses only on access by public transport the results refer only to this mode. Results computed considering access by private car would be certainly different.

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Figures

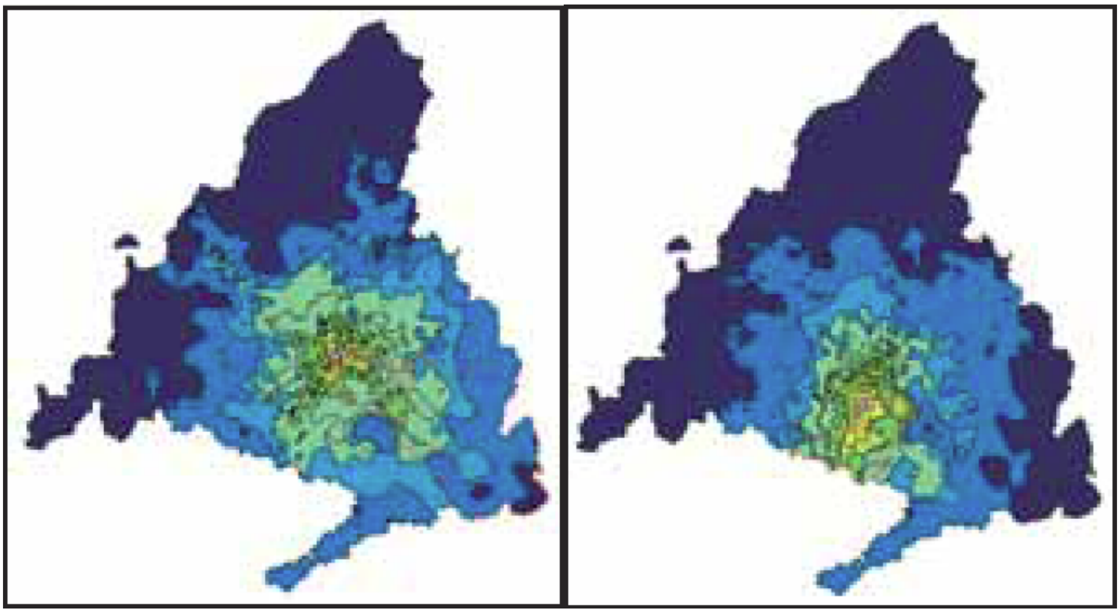

Figure 1 Isochrone maps Gregorio Marañon Hospital (left side) and Getafe Hospital (right side)