Improving equity of public transportation planning. The case of Palma de Mallorca (Spain).

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Abstract

Public transport planning requires consideration of equity in access of the population to the transport service. This paper presents a methodology for the analysis of public transport in the city of Palma and its evaluation in terms of spatial and social equity. First, the analysis of supply based on the activity of the bus stops has been performed. Then an AHP multicriteria weighted model over a set of socioeconomic variables has been developed to obtain a public transport demand index. Finally the analysis of equity has been made using the Gini Index and a sensitivity analysis of bus lines. The results show the distribution of equity for all the 88 districts of city. This paper presents a simple and powerful methodology exportable to transportation planning studies in other geographic areas.

Keywords: transport equity, AHP multicriteria analysis, transport planning, gis-t

1   Background

The practice of public transport planning requires consideration of equity as an essential attribute to ensure balanced use and access of the population to the service [1] [2]. Two types of equity in transportation planning are distinguished: horizontal and vertical. The horizontal is related with spatial justice. It's oriented to maintain a balanced supply to the needs of all individuals. Vertical refers to the adjustment of supply transport to the unique needs of specific population groups (social justice).

Public transport planning requires the development of a set of tasks as: demand analysis, selection of routes and stops, setting timetabling, etc. The practice of planning requires having a deep understanding of the social situation in order to provide rational solutions adapted to the different needs of the population. In this research we have used the methodology of G. Currie [1] for public transport service analysis. The method has been adapted to our study area and a set of enhancements have been proposed: multi-criteria analysis of socioeconomic information, sensitivity analysis of bus routes. There are scarce effective methods of transport optimization based on the maintenance of social equity. In general, the demand analysis is performed giving more importance to the economic profit of the service rather than considering their social sustainability.

The main objective of this work is to propose a methodology to assess the horizontal and vertical equity of public transport and to test it at Palma municipality.

The study area is the city of Palma de Mallorca (Spain). The planning and management of public transport in Palma is performed by the Empresa Municipal de Transportes (EMT) who depends of the Palma City Council. The EMT has a total of 31 routes, involving a total of 959 bus stops distributed in an area of 19,535 hectares [4]. BUS Transport system in Palma cover the needs of a population of 421,708 people (2013) and 42,457 tourist places [3] distributed in 88 neighbourhoods. Currently its use is predominant by social groups with low income, elderly, women and students.

2   Methodology

In this research we have used the methodology proposed by G. Currie [1] for public transport service analysis. The method has been adapted to our study area and a set of enhancements have been proposed: multi-criteria analysis of socioeconomic information and a sensitivity analysis of bus routes.

2.1   Supply analysis

The analysis of the supply is based on the service level of the bus stops and includes the next steps:
-    Geolocation of 959 bus stops.
-    Bus stop service level (BSSL). Total buses per day are obtained for each bus stop for 12 hours period on working days.

- District Service Level (DSL). First a 300 m buffer is generated from each bus stop. Then an overlay of

$$DSLx = \sum_{n=1}^{mx} \left(\frac{Area_{Buffer\,n}}{Area_{District\,x}} * BSSL_n \right) \quad (1)$$

buffer map and districts has been made. Finally a DSL index is calculated for each district using the expression (1).
(x= district ; mx = total number of bus stops buffers included in the district x; n=bus stop)

2.2 Analysis of potential demand

We consider the total population of district as the first indicator of public transport demand.

In order to obtain a social indicator of public transport need (PTN index) for each district an AHP multicriteria analysis has been developed over a set of socioeconomic variables. It includes the next tasks:
- Creation of a socioeconomic database of Palma districts who include: demographic information, population income, economic activity, etc. All the information was provided by the Municipal Palma Observatory [5]. All the variables are normalized in a range of 0 – 1.
- A group of six experts provides weights to each of the variables according with their role in transport need. The average weight value is assigned to each variable. The final value of each district will be calculated using the expression (2).

$$PTN_x = \sum_{i=1}^{n} w_i x_i \quad (2)$$

(x= district ; i= variables ; wi = weight of variable (i); xi= value of variable (i))

2.3 Equity analysis

The supply and the demand of public transport have been analyzed jointly to identify imbalances in the transport service. The Gini index has been obtained to detect the level of inequality between public transport service and population or Public Transport Need Index.

Finally a sensitivity analysis of bus routes has been developed to detect their importance in providing equity to the bus service. For this purpose we have calculated the *Gini* index by performing modification times of each bus route.

All the cartographic information of the study can be found at the web map viewer PalmaBusTransport [6].

The software used to develop the study has been ArcGIS 10.1 and Microsoft Excel 10.

3 Results

The distribution of population in Palma shows spatial pattern of people concentration at peripheral areas. The old town has gradually lost population for the benefit of the first extension areas (*Eixample*) and the tourist area (Arenal district). There is a significant increase of population at the first belt of the city (especially toward the northeast) (Figure 1).

Regarding the social demand for transport, the result shows a significant increase at the main suburbs of Palma: Pere Garau, Bons Aires, etc. These residential areas concentrate a great number of immigrants and local population with scarce resources.

The supply of bus service has a radial distribution. The areas with the highest level of service are the main roads surrounding the old town of Palma. In these areas the bus stops have more than 200 buses per 12 h.

Equity analysis shows a distribution model with significant imbalances in different neighborhoods. Neighborhoods with low levels of horizontal equity correspond to areas with a high bus service and small population (Port Zone, El Mercado, Plaça dels Patins) or with areas of high population and smaller bus service (Pere Garau, Son Gotleu).

The Gini index for public transport service and population is 0,4 and 0,34 for public transport demand (PTD). The index increase with inequality, therefore we can say that the bus service is adapted the social needs of the city (Figure 2).

The sensitivity analysis of bus lines show that routes L15 , L3 , L7 , L8 , L33 , L5 have the greater sensitivity to maintain the level of service to the population and are responsible for maintaining the horizontal equity service (Figure 3). That means that a little change in the timetables of these routes will have a great impact on the equity of public transport system.

4 Conclusion

The proposed methodology is an improvement in the integration of various techniques of geographical and socioeconomic analysis to study the equity of public transport.

The city of Palma has a good level of bus service but moderate equity imbalances have been detected. In some populous districts of the periphery could be adequate to check the current level of bus service and adapt it to their actual level of need.

5 Acknowledgments

Figure 1: Population, Public Transport Need Index and Equity Maps by districts.
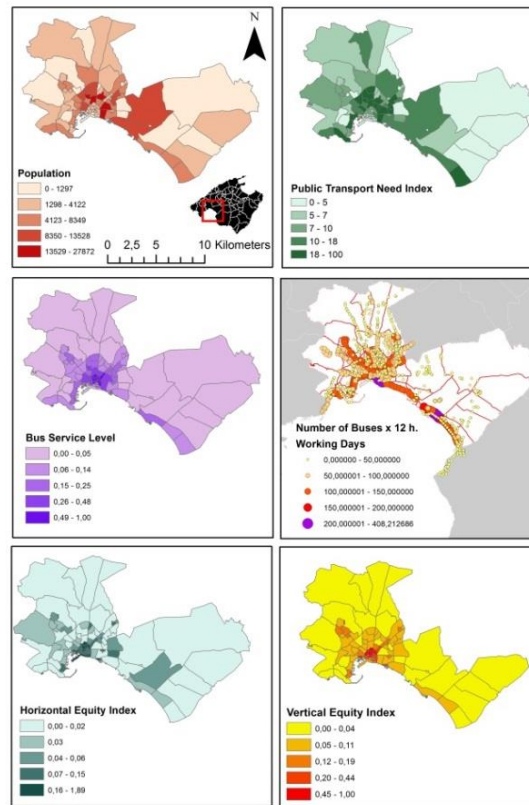
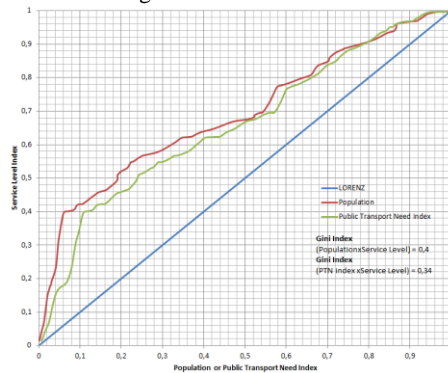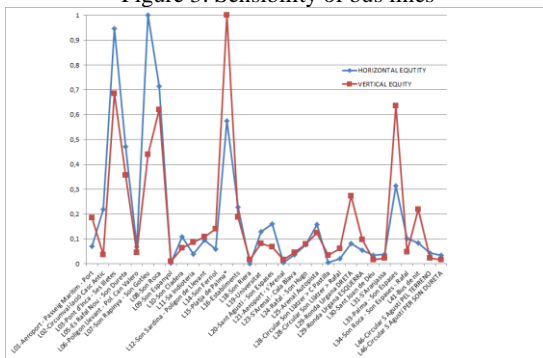

Figure 2: Lorenz Curve

Figure 3: Sensibility of bus lines

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