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REGIONAL ACCESSIBILITY AND SPATIAL IMPACTS OF TRANSPORT NETWORKS. AN APPLICATION IN CASTILLA-LA MANCHA (SPAIN)

Héctor Samuel Martínez Sánchez-Mateos
Departamento de Geografía y Ordenación del Territorio. Universidad de Castilla-La Mancha
HectorS.Martinez@uclm.es

I. ACCESSIBILITY ANALYSIS IN TRANSPORT RESEARCH

Accessibility can be defined as the «ease to access». Johnston states that is «the relative opportunity for interaction and contact» (quoted in Higueras, 2003: 415). In Geography it is usually considered as a spatial feature that makes sense comparing different parts of a given territory.

The accessibility as a spatial feature joins location and movement, apart from link directly with regional cohesion (Gutiérrez et al., 2006). In its application it is frequently misunderstood and vaguely defined by indexes broadly synthetics (Geurs y van Wee, 2004: 127).

Deepen on these considerations; these authors contribute a comparing analysis of several empirical applications base on spatial accessibility. Following this they understand that every accessibility indicator unfolds in four components: land-use, transport, temporal aspect and individual factors. The use and combination of these components will depend on the aims and objectives of the analysis, just as variables, indicators, specific formula and data requirements will depend on these components.

Following the analysis objectives certain components will weight more than others, and in a similar way, the variables, indicators and data sources will therefore depend from these components.

II. METHODOLOGY AND MODEL FOR ANALYSIS

The analysis focuses on the regional scope under the Spanish administrative division. This scale limits the individual component of the accessibility, being more present the land-use and transport components.

The land-use component has been added using the urban network and its functionality. Two approaches were used to do that: qualitative, detecting functions and polycentric aspects (Pillet et al 2007 and 2010) and quantitative, using specific mathematical expressions to assess acessibility.

The transport component was understood as supply and has been quatified by travel times for journeys in the study area. The road is analyzed under the private car view, with almost no limits in the access to the network. Whereas, for rail it is necessary to include an analysis of operations since access to rail offers obvious limits. Rail services (frequencies, travel times) are taken into account to calculate rail accessibility, defining the potential market areas, which are likely to be restricted by the access to the stations and the real accessibility of the different stations by rail operations.

At last, the temporal component was implemented as a dynamic perspective of the system and therefore, the transport network. The paper includes two analysis scenarios: the current scenario (*scenario 0*) and the *scenario PEIT* which is the aim scenario for the Spanish transport planning currently in force (Ministerio de Fomento, 2004).

This theoretical approach set the base for an applied model which adds all these considerations. The paper chooses a mixed approach for the accessibility analysis, following the van Wee et al. proposal (2001), combining two main elements:

— The **network accessibility**, as an infrastructure oriented calculation. This is an element related to the transport component an uses mathematical expressions based on travel times and origin-destination matrixes.

— The **ease to attract flows and movements**, which is driven to capture functionality and the different potential of places. This element is related to the land-use component and compensates the matrixes weighting their results with the demographical potential in a gravitational formula.

Both elements show the essential aspects which should be included in every accessibility analysis (Gutiérrez, 2001).

II.1. Road accessibility calculation

The road accessibility could be understood as fundamental in the study area for two main reasons: The infrastructure development is considerably superior to any other transport mode and, besides, this combines with the high motorization indexes and the private car ownership data.

To calculate the urban accessibility by road we used this formula:

$$A_i = \frac{\sum_{j=1, j \neq i}^{n} d_{ij}}{n-1}$$

Where A is the accessibility of point i and d is the minimum distance of travel time between i and all possible j in the given area.

To introduce the attracting potential of the i places this formula has been weighted including the population of i and j. For this we used a gravity expression that shows the accessibility potential (Gutiérrez, 2001; López et al., 2008; Condeço-Melhorado et al., 2011):

$$P_i = \sum_{i=1\ j\neq i}^{n} \frac{M_j}{C_{ij}}$$

P is the potential accessibility for i, which derives from the cocient between the mass sor destiny potential attractiveness of j destination (M_j) and the friction of distance (C_{ij}) which is the time travel previously calculated.

Both calculations can be normalized and combined using a GIS software.

II.2. Rail accessibility calculation

The rail accessibility is conditioned by two main factors: the existence of stations and the availability of services in the existing stations. Basically, these limit the potential accessibility of this mode.

The first limitation introduces the necessity of using a side transport mode to access the rail services, particularly in a regional scale, where stations located in a city must be accessed by other cities with no station using other means. This transforms rail accessibility in a discrete variable, spatially discontinuous.

With all these considerations we thought that rail demand decreases gradually regarding two factors:

a. The distance to the closest station, reaching a break-point which rail has no effect on the transport system.

b. The connective choices that offer each station, expressed by frequencies and rail services that actually connects each station with others.

These imply that we should only regard the stations and a restricted area around them to take the accessibility into consideration. The main methodological problem will come from how we are taking these travelers areas or preferential demanding zones for rail: constant (fixed radius) or variable (implementing a distance decay function). We will choose the first option because lacks of relevant data to implement the distance decay with effectiveness.

III. RESULTS. THE TRANSPORT NETWORK AND THE ACCESSIBILITY IN CASTILLA-LA MANCHA

III.1. Accessibility results in *scenario 0*

1.1. Road

There are two different areas in the regional simple that can explain how the accessibility configuration is: central locations and peripheral situations. The morphological structure of the regional surface facilitates the inertial better connection of central areas; strengthen by the fact that they are topographically plain and historically more populated. On the other hand, the periphery is more hilly, less populated and historically worse connected. The accessibility results emphasize these aspects.

1.2. Rail

The general picture shows a clear fragmented aspect, result of the tree-shape configuration of the Spanish rail system. Inside the region it is almost impossible to connect between the different four branches that cross it.

Once we only look at the accessible areas by rail there are big differences between regional areas. This depends on the better national corridors which are the Madrid-south and Madrid-east ones. These two cross the region and their interoperability in the central area of the region configure a sort of «regional axis» that shows the better inner connection by rail and, therefore, good accessibility results.

On the contrary, the other corridors lack good results and the potential of regional connection is almost impossible in some cases because of the service configuration.

III.2. Combined modal accessibility

Implementing road and rail together in a GIS software 4 areas can be drawn from the analysis done:

— Zone 1. Intermodality areas: Areas which have effective access to rail services. These areas have the availability of intermodal regional connections in the system.

— Zone 2. Intermediate areas: They are not included in the preferential rail services areas, but their location in the regional system and the road configuration allow them to show good accessibility results.

— Zone 3. Semi-peripheral areas: It is an area far from the central locations, with bad accessibility results but with potential to be improved by connections.

— Zone 4. Peripheral areas: They show the worst situation following our method. They lack rail access and their potential to improve is limited because their remoteness conditions.

The interpretation of these results might be taken as relative, because limits and quantitative results rely on the assumptions made and variables used in the mathematical expressions. Rather than extract specific considerations, these results show the general patterns under how the transport system and their infrastructure configuration organize the region in accessibility terms.

A general conclusion extracted from these results shows that almost 90% of the regional population which lives in barely 50% of the municipalities are included in zones 1 and 2 (positive), while the 10% remaining lives in the other 50% of municipalities with negative accessibility situations. This highlights a rural configuration which relates bad access with rural structures in the periphery.

III.3. Scenario 2020: changes in the road accessibility

The foreseeable accessibility changes can be extracted only for the road since we do not have data to extract travel times and services for the rail system.

Changes in accessibility configuration are calculated comparing the forthcoming travel times by the hand of the new motorways proposed, so only two options can have room: no changes and accessibility improvement.

The results show that central area is not going to improve remarkably, despite some new motorways will be built. On the other hand, improvement is mainly located on the periphery, with important differences: the west and south part improve more that east and north-east. This obviously has local interpretations, but in general we can state that improvement is more related with two factors:

— The starting point is crucial, have a current good accessibility result mean that any further infrastructure change will not have a big impact.
— In the peripheral areas, closeness to other regional hubs matters.

IV. FINAL THOUGHTS AND CONCLUSION

The method shows interesting results and can be improved as well by adding more relevant information. In this train of thought, transport costs can include another element to assess the friction of distance rather than only travel times.

The use of GIS software highlights the relevance of these technologies and their usefulness to achieve research goals combining factors and methods.

In the application, the methodology allows us to extract relevant conclusions on the accessibility configuration, its foreseeable evolution and how it impacts a regional structure, while unravels how is the difficult interaction between modes in a specific region which lacks a strong cohesion.

In the modal interpretation, private car and roads are predominant in the system. Not only because the inertial trend, but also because the inefficiency of any other mode that can address the expected mobility. This dependence must be seen as a weakness of the system and should be implemented in the regional and national transport planning, which currently are not.