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ACCESSIBILITY TO NODES OF INTEREST: A PRACTICAL APPLICATION OF THE VARIOUS FORMS OF THE IMPEDANCE CURVES OF TWO BORDER REGIONS[1]

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Abstract: The impedance is in the field of statistics – territorial, the greater or lesser difficulty of an area to be served/provided adequate infrastructure and related services, which are useful to improve the quality of residents. In the opposite direction, to a greater impedance is low attractiveness of the region to the establishment of new productive activities. The purpose of this research is to provide a comprehensive picture as possible of the existing methodologies for the development of the impedance, in relation to some border regions and providing practical applications based on the territories of Trentino Alto Adige and Friuli Venezia Giulia. The research highlights the main existing methods for determining accessibility (attractiveness) of land, according to their own infrastructures and related services. The analysis reveals the strengths and weaknesses, as well as the salient features of the equation used, producing a real benchmark between the different approaches, using from time to time as a function of impedance the logistic curve, the exponential and the linear form, in addition to providing the spatial behavior of the attractiveness in relation to regions bordering with foreign.

Key words: accessibility, regional development, impedence curves, statistical territorial, infrastructures

Introduction

The research is based on some experience already gained by the authors in the field of territorial accessibility, depending on the region of Tuscany, in addition to the present literature on the subject. There are many approaches that have been proposed, and in some cases made empirically, the extent of accessibility planning. These methodologies are all of Anglo-Saxon origin and are born in

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[1] The authors share the results of research and are jointly and severally liable for the content of the report. Specifically, Raffaella Chiocchini be attributed the section “GIS analysis to calculate impedance distances” and the matrix of the distances between municipalities and infrastructure; Gioacchino de Candia has conducted the research by developing the equations, introduction, analysis and conclusions.
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order to provide adequate mapping of the territories, according to the "attractiveness" of the same commercial.

The measures of accessibility can be summarized in three broad categories:

- measures based on cumulative opportunities;
- measures gravitational;
- measures based on choice “utilitarian”.

The measures of the first type are the most simple and based on counting the number of opportunities within a range of distances expressed in terms of time (or space). All potential destinations within a certain period of time are equally weighted, so the choice falls on the points that have a greater number of destinations, in relation to the cut chosen in terms of the distance interval.

Measures based on gravity are characterized by the denominator of the equation (index) that expresses the impediment in relation to accessibility between points in geographic space. The impedance is represented by a function expressed in terms of travel times or travel cost. The synthetic form is the following:

$$A_i = \sum_j a_j f(t_{ij}) \qquad (1)$$

where a_j is the activity/service/infrastructure in the area j, t_{ij} is the distance in terms of travel time (or cost of the trip) between zones i and j, $f(t_{ij})$ is the impedance function. The shape of this function is often exponential or logistic (Andy, Niemeier, 1997).

Measures based on the utilitarian choice are the result of choosing an individual based utility on the choice of a specific opportunity/service/infrastructure compared to the total possible choices. If it is assumed that an individual’s utility checks to each destination chosen from a set of possible choices (C) and the choice falls on the one that maximizes its utility, accessibility can be defined by means of a logit model multidimensional. The accessibility A_n for an individual n is then measured by the following equation:

$$A_n = \ln\left[\sum_{\forall \in C_n} \exp(V_{n(c)})\right] \qquad (2)$$

where $V_{n(c)}$ is the matrix of spatial and temporal components observed in relation to the choice c for the individual n and C_n is the set of choices for the individual *n*. The logit model serves to summarize the measures of desirability of a group of choices (Ben Akiva et al., 2006). The specific utility function includes variables representing the attributes for each choice and reflects the attractiveness and the impedance of a destination, which must be the best for the same destination, while reflecting the tastes and preferences of the individual.

The research focuses mainly on the shape and its application of the impedance function, identifying the methodology for the Italian case with an elaborate experiment in respect of the municipalities of Trentino Alto Adige and Friuli-Venezia Giulia, with an extrapolation to the capitals of the provinces of Trento and Bolzano, in addition to the main city of the region of Friuli Venezia Giulia (Trieste).

The application concerns the hospitals, schools of secondary grade, airports and railway stations, up to the final conclusions and the future possibilities of further development of the model and its applications on a municipal scale.

Materials and Methods

The methodology used in this paper is part of the category of models called "gravitational", which are characterized by the denominator of the equation (index) that expresses the impediment in relation to accessibility between points in geographic space. The calculations have been made considering the cost of travel, which depends on the distance or travel time between certain points located on the transportation network that represent the points of departure and arrival. The formula that represents a generalized way in this class of accessibility indicators is:

$$A_i = \sum_{j \in D} W_j^{\beta} f(c_{i,j}, \alpha) \qquad (3)$$

where A_i is the accessibility of a resident of the area *i* with respect to the node *j* in the region *D*, W_j^{β} is a measure of the activities or services (mass of opportunity) located in zone *j*, *β* is a calibration parameter (used to account for the effects agglomeration) and $f(c_{i,j})$ is a function of impedance generally decreasing with the cost (or with the distance or travel time).

The function of impedance, which focuses on the analysis, it assumes different expressions depending on the authors. In elaborations, from time to time and to test the ability of the impedance function of representing the attractiveness of a city, it is chosen as a function the logistic curve (4), the exponential curve (5) and the linear form (6). Therefore, the different expressions of the impedance function take the following forms:

$$f(c_{i,j}) = \left(\frac{1}{1 + \exp - k(c_{i,j} - c_0)} \right) \tag{4}$$

with $c_0 = \frac{1}{2}(c_{min} + c_{max})$,

where $c_{\min}$ is the minimum cost and $c_{\max}$ the maximum cost observed and

$$k = 2\ln\left(\frac{1}{\gamma} - 1\right) \Big/ (c_{\max} - c_{\min}) \qquad \gamma > 0$$

$$f(c_{i,j}) = \exp(\gamma c_{i,j}) \tag{5}$$

with $\gamma > 0$

$$f(c_{i,j}) = \gamma c_{i,j} \tag{6}$$

with $\gamma > 0$

To get the most appreciable, γ must have a value greater than zero, but very small. In the calculations the value γ has always been set equal to 0.05.

The methodology, referred to in the preceding paragraph, has been applied at municipal level for all municipalities in the Trentino Alto Adige and Friuli Venezia Giulia, which has focused experimentation. For the municipality of Trento and Bolzano was made in part processing, as the capital of the autonomous provinces [3]; similarly we proceeded to the town of Trieste.

As stated in the introductory paragraph, infrastructure considered for experimentation on a municipal basis were as follows:

- hospitals (public and private);
- upper secondary school;
- railway stations (platinum, gold and silver);
- airports.

[3] Constitution of the Italian Republic, Titolo V, parte II, artt. 114 ss..

One last point should be made in relation to the construction method of the list of municipalities and summarize their functions impedance: the medologie used are the "arithmetic mean" and the statistics called MPI (Mazziotta Pareto Index). This indicator represents a novelty in the field of statistics and is proposed in the following form:

$$MPI = \mu(1 - CV^2) \quad (7)$$

where μ is the simple arithmetic mean and CV is the coefficient of variation. Where CV is greater than 1, the statistic is negative, defining the low (very low attractiveness) of the municipality.

Finally, the distances between the towns and their infrastructure have been calculated using the software ArcGis, on the road graph Tom Tom 2012.

GIS analysis to calculate impedance distances

The travel times was calculated through the GIS software ArcGIS Network Analyst module. We have used, for calculating drivetime origin to destination cost matrix, the road graph Multinet of Tom Tom where the data on road conditions are updated at the end of 2012. As points data, to find the driving distance, were used as source data the centroids of the municipalities of Trento an Bolzano and Friuli Venezia Giulia regions (Istat 2012) and centroid of the sub-municipal areas (Istat 2010) only for the cities of Trento, Bolzano and Trieste, while as destination points have been used all the considered infrastructures (hospitals, railway stations, secondary schools and airports). We have used to calculate drivetime distance the infrastructure that are derived from georeferencing public administrative archives; these infrastructures are integrated with the Point of Interest (POI) that are included in the graph road datasets. The facilities that we have used, are:

- Railway stations (platinum, gold e silver) year 2012 RFI (Railway Italian Infrastructures) source;
- Airport year 2010 ENAC (Italian Civil Aviation Authority) source;
- Public and private hospital with first aid year 2007 Health and Care Ministry source;
- Secondary school year 2011 Ministry of Education source.

The administrative boundaries of the Trento, Bolzano and of Friuli Venezia Giulia regions and the centroid of administrative and sub-municipal data are used too in the ArcGis project.

All the output OD cost matrix, that is the result of GIS processes, consists of all drivetime in minutes of travel cost and kilometric distances from origins to destinations. The calculations were performed with ideal conditions parameters and in the absence of traffic and using a traveling speed, that is set on the road graph. The traveltime speed used, is referred to the highway code speed and to road signs contained in the updated road graph. The tool used is ArcGIS "OD cost matrix algorithm" contained in the Network Analyst package; this tool allows us to calculate all the driving distance, starting from closest to farthest.

Analysis of Results

Trentino Alto Adige

The Trentino region is divided administratively in two provinces: Trento and Bolzano. The municipalities are in total 333 to 1,043,294 inhabitants, according to the latest Italian Census of Population and Housing. In preparing the model, as explained in the previous paragraphs, we proceeded to isolate the municipalities of Trento and Bolzano, thus obtaining an array of impedance functions for the remaining 331 municipalities.

For each infrastructure has processed the elaboration of the impedance function, in the forms logistics, exponential and linear; thus obtained a series of lists, where each time sorting is based on the arithmetic average (of the functions of impedance) and MPI on statistics.

The overall results shown in pie charts have two salient features:

- the arithmetic average of leaves essentially unchanged the distances between the towns and infrastructure;
- MPI tends to restrict the range of variation of the distances.

Another aspect to consider is the characteristic of the MPI[4] statistic, which produces negative values, when the coefficient of variation is greater than 1, so the negative output may cause difficulty in reading the results, an untrained eye.

[4] The authors of MPI recommend for this chart the standardization of variables. In the present research was not undertaken standardization, because this operation causes a loss of information for absolute data, and because in this case and after some testing this results difficult to read, both because the process of standardization is used when the selected variables are expressed in different units of measure. In this research, the unit of measurement is always unique: travel times in minutes.

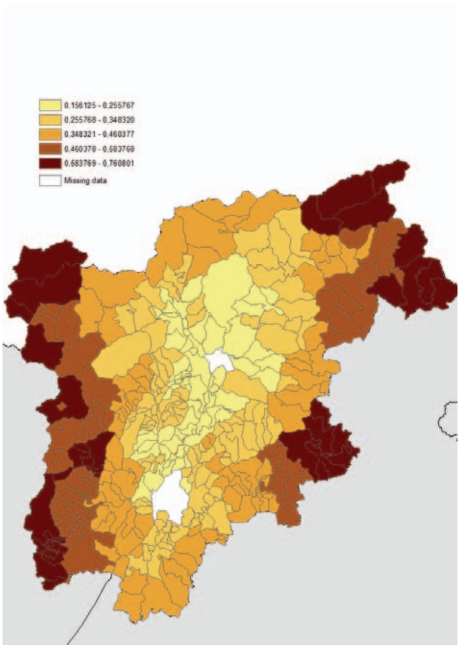

Figure 1. Synthesis of the impedance function in the logistics form, through arithmetic average *Source: own calculation*

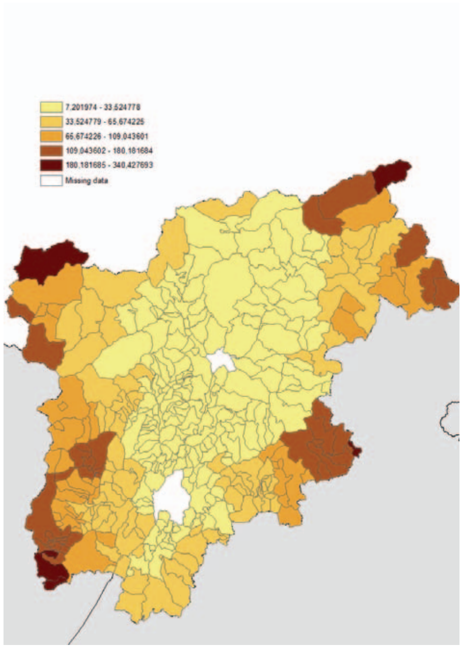

Figure 2. Synthesis of the impedance function in the exponential form, through arithmetic average *Source: own calculation*

Among the functions of impedance, the logistics curve and the linear form seem to provide the best results. In fact, the exponential curve tends to overestimate over the longer distances between municipalities and related infrastructure, producing a ranking that both in the case of synthesis through the arithmetic mean and through MPI, is profoundly dissimilar to the rankings produced by the logistic function and linear[5].

In relation to the synthesis methodology, is preferable to the arithmetic mean, which leaves substantially unchanged the distances between the common, while also respecting the range of variation of the logistic curve. Further confirmation of the goodness of synthesis by the arithmetic mean, as well as the exclusion of the exponential curve as a function of impedance, comes from the application of

[5] It is well to specify that the logistic function can be seen as a special case of the exponential function: while the exponential function is monotonous, the logistics function has an inflection point that, in its general form, has coordinates (0.5, 0.5). Up to this point the two curves tend to resemble each other (almost coincident). Above this point the exponential curve tends towards infinity, while the logistic curve asymptotically grows up to +1. In this section the two curves (and their values) tend gradually to differentiate.

the correlation coefficient of Gini is the summary of the rankings, both for the distribution of the common alphabetical order.

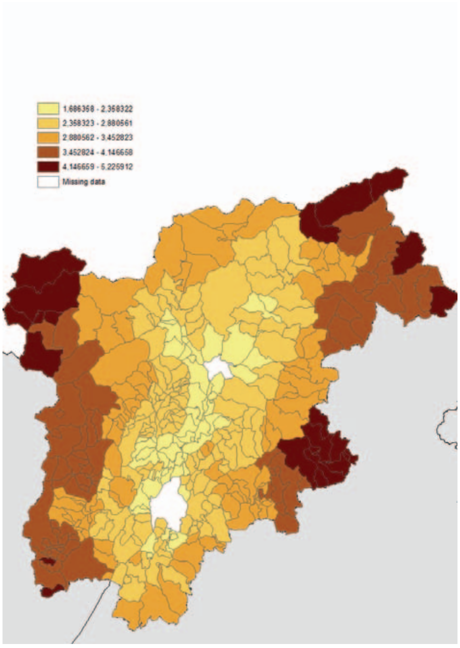

Figure 3. Synthesis of the impedance function in the linear form, through arithmetic average *Source: own calculation*

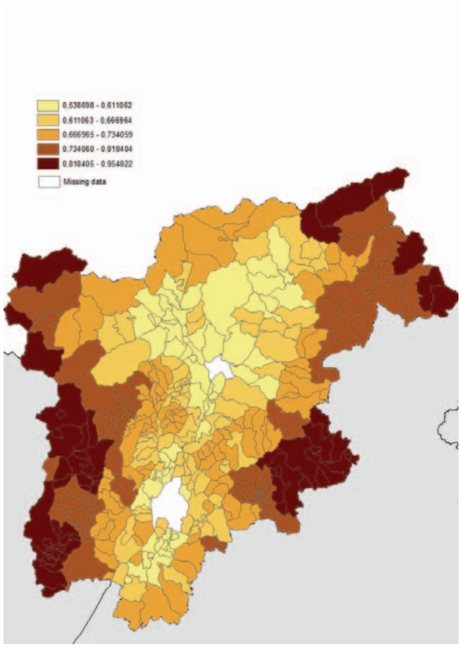

Figure 4. Synthesis of impedance function in the logistics forms, using MPI *Source: own calculation*

Table 1. Gini index of correlation between the rankings (mean)

	Mean Log	Mean Exp	Mean Lin
Mean Log	-		
Meean Exp	0.908	-	
Mean Lin	0.995	0.920	-

Source: own calculation

Table 2. Gini index of correlation between the rankings (MPI)

	MPI Log	MPI Exp	MPI Lin
MPI Log	-		
MPI Exp	0.876	-	
MPI Lin	0.986	0.852	-

Source: own calculation

For Trentino - Alto Adige Tables 1 and 2 clearly show how it achieves the maximum correlation between the functions of logistics and linear impedance, synthesized by the arithmetic mean. The use of synthesis via MPI, presenting negative values, demonstrates high discordance.

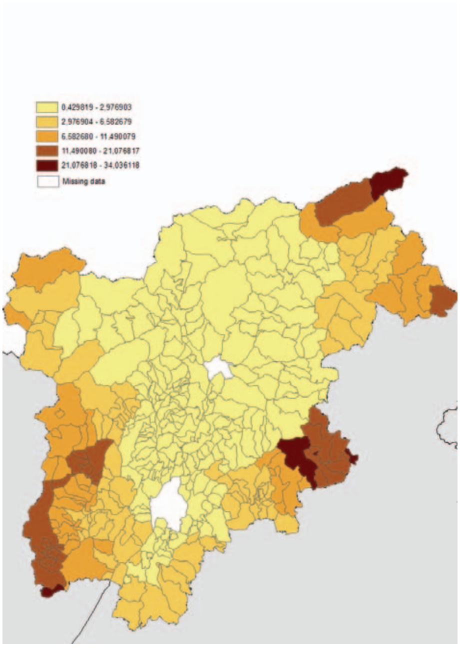

Figure 5. Synthesis of impedance function in exponential form, using MPI *Source: own calculation*

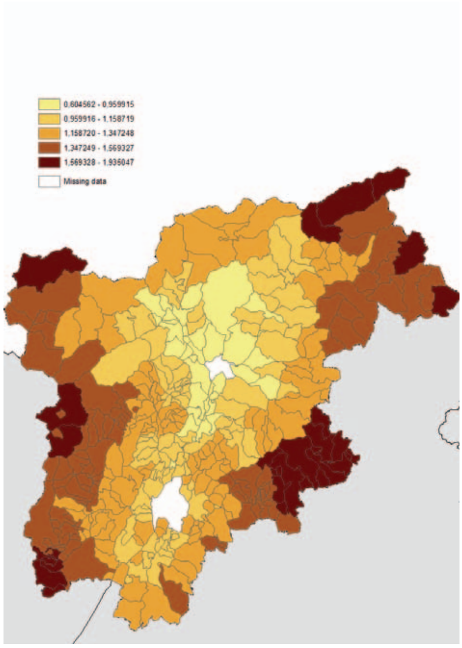

Figure 6. Synthesis of impedance function in the linear form, using MPI *Source: own calculation*

The same processing was performed by comparing the distributions by alphabetical order of the municipalities, the results of which are shown in Tables 3 and 4, which confirms the analysis in comparing the rankings increasing the synthesis of impedance functions.

Table 3. Gini index of correlation between the distributions (mean)

	Mean Log	Mean Exp	Mean Lin
Mean Log	-		
Mean Exp	0.883	-	
Mean Lin	0.975	0.856	-

Source: own calculation

Table 4. Gini index of correlation between the distributions (MPI)

	MPI Log	MPI Exp	MPI Lin
MPI Log	-		
MPI Exp	0.837	-	
MPI Lin	0.952	0.802	-

Source: own calculation

The Trentino – Alto Adige, despite the complex orography, proves to be readily accessible on the infrastructure analyzed The central part, rich valleys, is the one with the best connections, which open to the north, thanks to the presence of numerous alpine passes[6], that facilitate connections with Austria. To Switzerland

[6] The main ones are: the Brenner Pass, Pordoi, Stelvio, Sella and Tonale.

things change, since the presence of the Pass Müstair, little traffic, making it less easy accessibility to this area of South Tyrol.

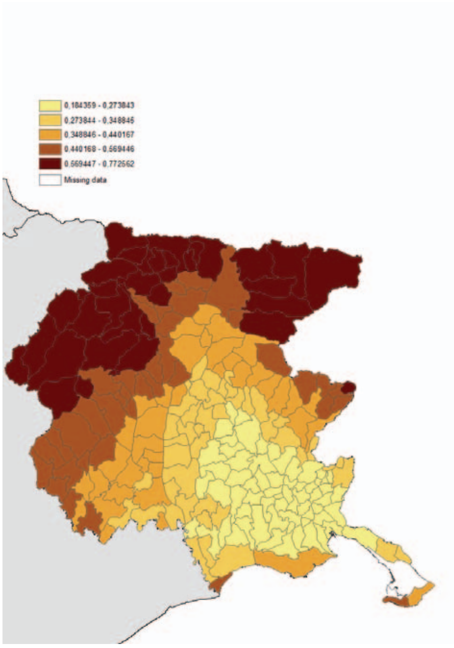

Figure 7. Synthesis of the impedance function in the logistics form, through arithmetic average *Source: own calculation*

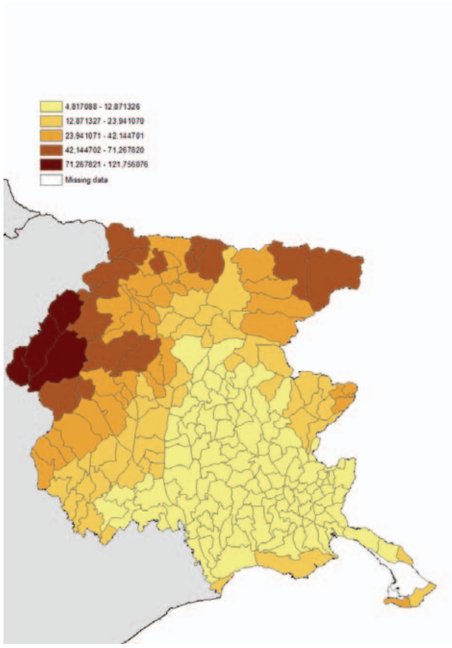

Figure 8. Synthesis of the impedance function in the exponential form, through arithmetic average *Source: own calculation*

A similar situation on the border with Friuli – Venezia Giulia has, especially in the area of North-western border, poor accessibility. These features are clearly visible using the impedance in the form of logistics and synthesizing the results using the arithmetic mean. The distribution of accessibility appears to be rather similar, using the linear form as a function of impedance, always summarized by the arithmetic mean.

Totally different mapping of accessibility, using impedance as a function of the exponential curve, in which case the entire region of Trentino – Alto Adige is greatly accessible at all latitudes. This is due to the characteristic of the exponential curve, which having no definable upper limit, tends not to consider the important orography of the territory.

To conclude this section, it is stressed the most accessible with reference to the Alpine passes located on the northern border, most trafficked and with greater range than the other passes.

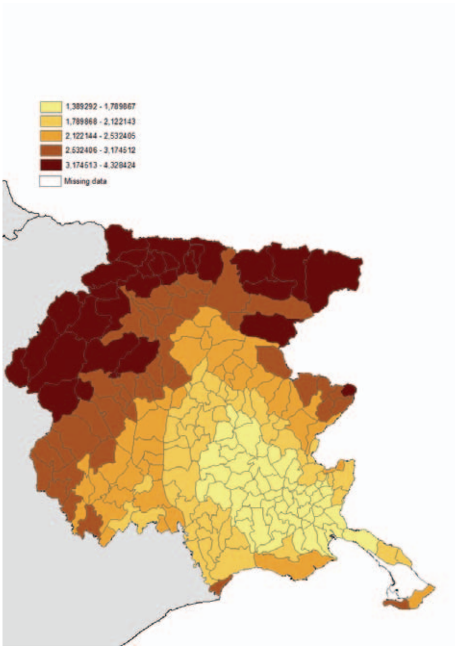

Figure 9. Synthesis of the impedance function in the linear form, through arithmetic average *Source: own calculation*

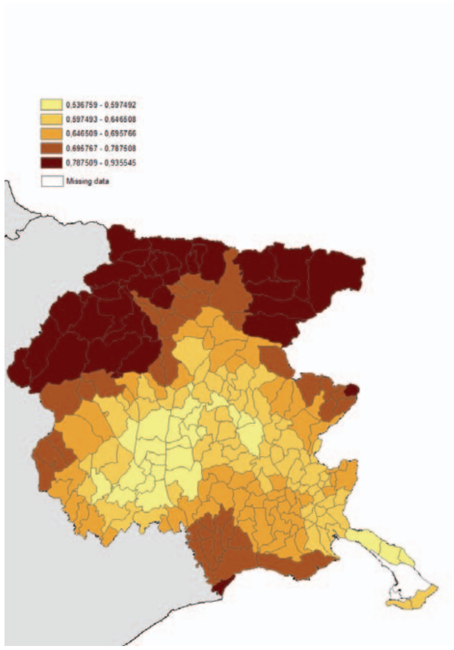

Figure 10. Synthesis of impedance function in the logistics forms, using MPI *Source: own calculation*

Friuli Venezia Giulia

The Friuli area is divided administratively into four provinces: Trieste, Udine, Gorizia and Pordenone. The municipalities are in total 218 to 1.221,86 million inhabitants, according to the latest Italian Census of Population and Housing.

In preparing the model, as explained in the previous paragraphs, we proceeded to isolate the municipality of Trieste, thus obtaining an array of impedance functions for the remaining 217 municipalities. The first infrastructure are analyzed hospitals with emergency rooms in the region, according to data from the Ministry of Health amounted to 11.

For each of them has been drafted its impedance, according to the form logistics, exponential, linear, and likewise we proceeded to upper secondary schools, airports and railway stations. It is thus obtained a series of lists, where each time the sorting is based on the arithmetic mean (of the functions of impedance) and on MPI statistics.

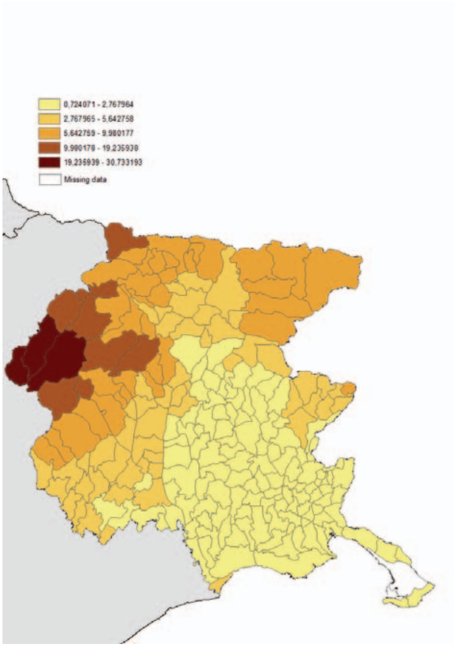

Figure 11. Synthesis of impedance function in exponential form, using MPI *Source: own calculation*

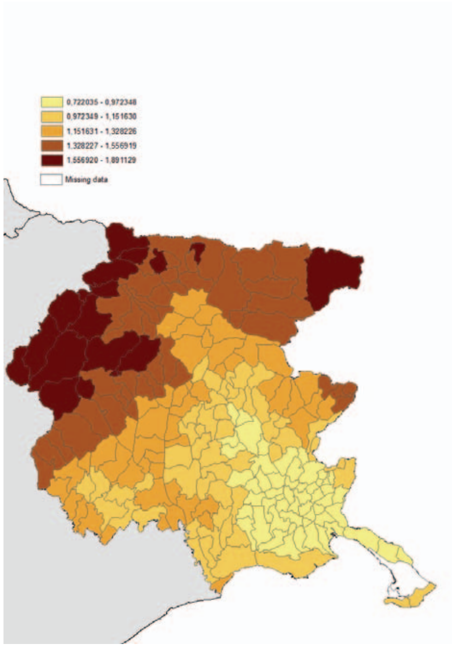

Figure 12. Synthesis of impedance function in the linear form, using MPI *Source: own calculation*

The benchmark between the various approaches to the Friuli Venezia Giulia is contained in Tables 5 and 6 with respect to the rankings and increasing in Tables 7 and 8 for the distributions.

Table 5. Gini index of correlation between the rankings (mean)

	Mean Log	Mean Exp	Mean Lin
Mean Log	-		
Mean Exp	0.883	-	
Mean Lin	0.997	0.908	-

Source: own calculation

Table 6. Gini index of correlation between the rankings (MPI)

	MPI Log	MPI Exp	MPI Lin
MPI Log	-		
MPI Exp	0.875	-	
MPI Lin	0.974	0.837	-

Source: own calculation

The synthesis performed by the arithmetic mean for this region shows a lack of accessibility in the border areas so the border with Trentino - Alto Adige, as with Slovenia. The situation is improving gradually you get closer to the sea, where the distribution infrastructure is more homogeneous. It should be noted, also the Friuli - Venezia - Giulia, a poor reliability of the logistic curve to represent the impedance of the territories.

Table 7. Gini index of correlation between the distributions (mean)

	Mean Log	Mean Exp	Mean Lin
Mean Log	-		
Mean Exp	0.877	-	
Mean Lin	0.996	0.903	-

Source: own calculation

Table 8. Gini index of correlation between the distributions (MPI)

	MPI Log	MPI Exp	MPI Lin
MPI Log	-		
MPI Exp	0.720	-	
MPI Lin	0.731	0.832	-

Source: own calculation

Summarising the results using MPI, the impedance analyzed by logistic function continues to provide the most convincing answers for both the Trentino – Alto Adige and Friuli Venezia Giulia. The authors note, thanks to previous experiences in other local contexts, such as Tuscany, the MPI as a summary of the functions of impedance fails to provide convincing answers, where the variability of the distances appear anywhere.

In the case of Friuli – Venezia – Giulia internal variability in its territory is smaller, so the differences respect to the “arithmetic mean” are minimal. For Trentino – Alto Adige, the differences are more glaring, given that this region has a more pronounced internal variability, preferring synthesis by the arithmetic mean.

In general, this region shows good accessibility in relation to the territories within the valleys and sloping down towards the sea.

Cases of Trento, Bolzano and Trieste

As stated in the previous paragraph, the municipalities of Trento, Bolzano and Trieste were analyzed separately. For these three municipalities have been produced elaborations only for the hospitals, in order to test the deployment of an infrastructure of great importance within the districts of the municipality.

In the town of Trento[7] is a single hospital complex, located in the district of St. Joseph - St. Clare. Therefore, the only analysis that can be conducted concerning

[7] The municipality of Trento is divided administratively into 12 districts: Gandolo, Meano, Bondone, Sardagna, Romagnano, Argentario, Povo, Mattarello, Villazzano, Oltrefersina, San Giuseppe – Santa Chiara, Centro storico – Piedicastello.

the average distance from each jurisdiction, in respect of the hospital citizens are within a distance of a journey time of less than 10 minutes districts of Oltrefersina, Old Town – Piedicastello, Villazzano, Romagnano, Argentario, Mattarello and Gardolo. All other districts are far beyond the 10 minutes, making it difficult to access the building. The district with the highest impedance is Povo (almost 17 minute ride).

Table 9. Rankings by aritmetic mean for districts of the municipality of Trieste

N.	Districts	Mean Exp
1	Barriera vecchia - San Giacomo	1.13532
2	Città nuova - Barriera nuova - San Vito	1.18345
3	San Giovanni - Chiadino - Rozzo	1.29617
4	Servola - Chiarbola - Valmaura - Borgo San Sergio	1.31650
5	Roiano - Gretta - Barcola - Cologna	1.45917
6	Altipiano Est	1.60556
7	Altipiano Ovest	1.95535
N.	**Districts**	**Mean Log**
1	Barriera vecchia - San Giacomo	0.06408
2	Città nuova - Barriera nuova - San Vito	0.09068
3	San Giovanni - Chiadino - Rozzo	0.20674
4	Servola - Chiarbola - Valmaura - Borgo San Sergio	0.24283
5	Roiano - Gretta - Barcola - Cologna	0.42321
6	Altipiano Est	0.64232
7	Altipiano Ovest	0.91377
N.	**Districts**	**Mean Lin**
1	Barriera vecchia - San Giacomo	0.12660
2	Città nuova - Barriera nuova - San Vito	0.16839
3	San Giovanni - Chiadino - Rozzo	0.25717
4	Servola - Chiarbola - Valmaura - Borgo San Sergio	0.27078
5	Roiano - Gretta - Barcola - Cologna	0.37662
6	Altipiano Est	0.47323
7	Altipiano Ovest	0.66926

Source: own calculation

The case is of Bolzano [8] is analogous to Trento. However, the districts that make up the municipality are on average less "impeding" than Trento. Even Bolzano there is only one hospital complex, where the average distance compared to the 5 constituencies that make up the municipality of less than 10 minutes to 4 of them. Only the district of Centre – Plani – Rencio has a journey time of higher education, the district became more "peripheral" than the hospital.

[8] The town of Bolzano is divided administratively into 5 civic centers: Oltrisarco – Aslago, Europa – Novacella, Don Bosco, Gries – San Quirino e Centro – Piani – Rencio.

Table 10. Rankings by MPI for districts of the municipality of Trieste

N.	Districts	MPI Exp
1	Servola - Chiarbola - Valmaura - Borgo San Sergio	0.99164
2	San Giovanni - Chiadino - Rozzo	0.99551
3	Altipiano Ovest	0.99738
4	Roiano - Gretta - Barcola - Cologna	0.99750
5	Barriera vecchia - San Giacomo	0.99937
6	Altipiano Est	0.99950
7	Città nuova - Barriera nuova - San Vito	0.99992
N.	**Districts**	**MPI Log**
1	Servola - Chiarbola - Valmaura - Borgo San Sergio	0.64995
2	San Giovanni - Chiadino - Rozzo	0.77603
3	Roiano - Gretta - Barcola - Cologna	0.92755
4	Barriera vecchia - San Giacomo	0.95172
5	Città nuova - Barriera nuova - San Vito	0.99385
6	Altipiano Est	0.99430
7	Altipiano Ovest	0.99843
N.	**Districts**	**MPI Lin**
1	Servola - Chiarbola - Valmaura - Borgo San Sergio	0.88536
2	San Giovanni - Chiadino - Rozzo	0.93196
3	Barriera vecchia - San Giacomo	0.96082
4	Roiano - Gretta - Barcola - Cologna	0.98235
5	Altipiano Ovest	0.99414
6	Città nuova - Barriera nuova - San Vito	0.99709
7	Altipiano Est	0.99778

Source: own calculation

Also The municipality of Trieste[9] was analyzed separately. We therefore proceeded to develop the impedance function in the three known forms, in order to summarize the results through arithmetic mean and MPI. To be consistent with the municipalities of Trento and Bolzano, Trieste elaborations were produced only for hospitals, which in this case appear to be two.

Table 9 and 10 contains the rankings for the synthesis using the arithmetic mean and MPI, compared to the impedance of logistics functions, exponential and linear. It should be underlined that between the divisions of Trieste there is a marked variability, for which the synthesis via MPI little lends itself to photograph the internal accessibility. The best results, also in this case, are obtained by synthesizing by arithmetic average. In this case, the constituency

[9] The districts of the municipality of Trieste are 7: Altipiano Ovest, Altipiano Est, Roiano – Gretta – Barcola – Cologna – Scorcola, Città nuova – Barriera nuova – San Vito – Città vecchia, Barriera vecchia – San Giacomo, San Giovanni – Chiadino – Rozzo, Servola – Chiarbola – Valmaura – Borgo San Sergio.

with the lowest accessibility is Altopiano Ovest, which has the maximum distance with respect to the two hospitals citizens. In all cases, by synthesizing arithmetic mean, the district with the lowest impedance is Barriera vecchia - San Giacomo

In general, we can say that the better you get access to those constituencies that predate the port area, and decreases as you approach the suburb north - west of the city.

Conclusions

The research has highlighted the main existing methods for determining accessibility (attractiveness) of land, according to their own infrastructures and related services. Focusing on gravity models, of which the “cost of trip” in terms of travel time, the report noted the strengths and weaknesses, as well as the salient features of the equation to the different forms of the impedance function.

In this sense, the research has yet produced a true benchmark between the different approaches, using from time to time as a function of impedance of the logistic curve, the exponential and the linear form. Also, another important comparison was produced by selecting the final values through arithmetic mean and MPI statistics. In addition, the importance of capillarity of the processing in the area, which have produced results up to the municipal level, as well as the towns of Trento, Bolzano and Trieste.

In general, it can be stated that the choice of logistic function to represent the impedance is found to be convincing, while the synthesis of elaborations produced via MPI are sometimes difficult to interpret, as well as heavily constrained to the variability of the observed phenomenon. Considering the experience that the authors have so far in the mapping of accessibility (attractiveness) of territories on a municipal scale via gravitational approach, it can be said that the arithmetic mean is always the most appropriate statistic to summarize the results of the impedance, while MPI statistics can only work in the presence of low variability between the municipalities and the related infrastructures selected. In addition, it is preferable to use the exponential curve for impedance analysis, for the reasons already widely dissertate in the research.

For the future, it remains to capillarizzare analysis in relation to other municipalities in other regions not only Italian, but also in Europe, extending, wherever possible, the ranks of the infrastructure. The ultimate goal is the mapping of the accessibility of Europe, in relation to the largest possible number of infrastructure.

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