Influence areas of railway stations : how can we explain their geographic forms?

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Abstract

The enhancement of the railway transport system is at the heart of land use planning policies in France. It questions the implementation of a rail services strategy based on characteristics of influence areas of railway stations. This implies to have a good knowledge of these areas through field surveys. However, since the French rail network is very dense, implementing surveys on each station is quite impossible. This paper aims to highlight the existence of factors which may impact on the forms and functioning of influence areas. It analyzes the diversity of forms which may be explained by spatial anchoring, the railway network shape and railway services consistency.

1. Introduction

There is a growing interest in understanding influence areas of railway stations from land use planning stakeholders. This geographic area has become a key territorial challenge to enhance rail services use. It is the reference territory for evaluating the potential train ridership, the analysis scope of accessibility to the station and also the study field for implementing transit oriented development policies (Guerra et al. 2011; Cervero 2007; Ermacora et al. 2013). So that, having a good knowledge of these areas is important. Field surveys are good tools to assess them but, in a context of budgetary constraints, considering the dense French rail network (3,000 stations), conducting surveys on each station is quite impossible because there are so many other rail planning priorities.

Our research aims to analyze the existence of factors which may impact on the forms and functioning of catchment areas of railway stations. Our hypothesis is that there is a variety of them, which may be explained by the type of stations, land-use environment, railway network shape and consistency of railway services. Our paper begins with a brief review of literature. Then, we will criticize the French tradition to compare a railway influence area with a 3km circle. The next analysis will focus on the potential links between geometric forms of influence area and stations features. Finally, we will deal with the subject of modeling the threshold distance of influence areas.

2. Literature review

The territorial influence of a railway station is measured with different geographic areas. In various writings, we can find the concept of catchment area, attractiveness area, or influence area. These terms all refer to the same object: a geographical area around a station. However, they do not mean exactly the same thing. Thus, in market studies, rail network owners and operators use the term of catchment area to define the area in which individuals are likely to take the train. Their logic is based on evaluating a potential ridership. Besides, territorial actors (Regions, intercommunalities, urban planning agencies) have the same approach in their territorial diagnosis plans. However, they prefer talking about attractiveness area to define the area in which a resident may find an advantage of taking the train (ATU 2009, Ermacora 2013).

The definition of these perimeters is mainly based on considering an acceptable amount of time of railway station access for individuals. It therefore refers to the concept of accessibility. This may be also stated as an accessibility area. Their geographical representation takes the form of isochronous curves evaluated from the road network (Bahnville 2009) or a circle considering a bird’s-eye access.

Areas based on potential train ridership rely on the concept of an area which can be connected to the station. Our definition of influence area will not be based on this principle. On the contrary, it will reflect the idea of an effective connected area. Using this expression means that we consider the daily mobility practices to get to the station. In other words, this leads us to take individuals choices into account. Indeed, they do not necessarily reach the nearest station: they may choose the railway station located on their route direction or with more train services. This definition reflects the concept of “lived territory”.

The differentiation between connectable and connected area leads to different methods of delimitation. The connectable influence area is defined on the basis of a maximum access time to the station which can also be expressed in meters. Two methods are mainly used: the Euclidean method is based on the drawing of a circle centered on the station, illustrating a bird's-eye accessibility. The second one concerns the drawing of isochrons reflecting a real-time access according to the road network. It must be stated that a majority of work use the Euclidean method that appears to be the "golden rule" (Harrison, 2012) and are mainly based on a walking access to the station. Thus, there is an international convergence to define a walkable access area with a radius of 800m to 1km around the station (Guerra et al. 2011, Blainey et al. 2011). However, Harrison (2012) highlights a lack of literature on the relevance of this value.

But the territorial influence of a railway station goes beyond this proximity perimeter. It should be also defined by its driving accessibility. International practices do not converge to the same value. French engineering firms tend to define an influence area of a rail station by a circle with a 3 km radius. Cervero (1995) evaluates the driving distances around 5 km to get to American suburban rail stations. This value is also observed on suburban French railway stations (Audiar 2013). Ermacora et al. (2013) suggest a distance of 7 km for suburban stations of Montreal. Some scientific work (Bahnville 2009) are based on a driving accessibility in the range from 15 to 20 minutes around the station.

3. Methodology

Considering that most of urban rail stations are yet covered by specific field surveys, we chose to focus on regional rail stations located outside major urban centers. As a consequence, our study scope mainly includes French periurban and rural stations.

Our analysis is based on the implementation of an indicators database from field surveys data gathered on two regional regions of Northern France (sample of 99 stations). For each station, indicators characterize the services supply (train and parking), the major destination, travel time by train and car, the description of influence areas, and the rail network shape.

Moreover, we defined the scope of influence areas on the basis of mobility practices observed in the field. To do so, because of a lack of data relied on all train users, we worked on a database of French train users who have a work transit pass. This data represents not less than 80% of train use during peak hours. This percentage is also a reference chosen in Canada (Ermacora et al. 2013). Our influence area corresponds to the dominant area defined as a geographical area bringing together the places of residence which have the highest level of train subscribers. We retained the threshold of 10% of train users living in the town and modulated this value according to the station attendance.

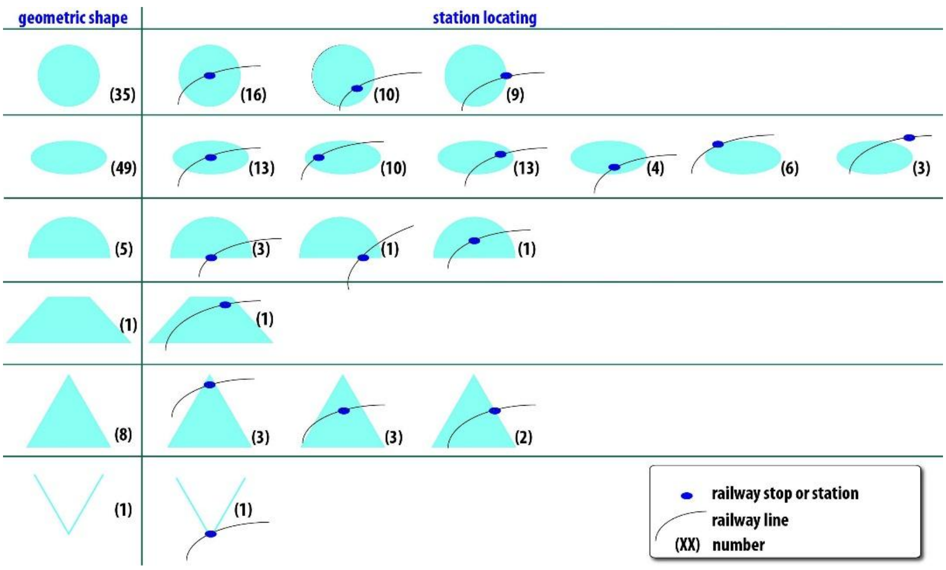
Then, data are analyzed using econometric statistical methods to highlight potential correlations between influence areas forms and indicators.

4. Results

4.1. Relevance of a circle with a 3 km radius : reality or myth?

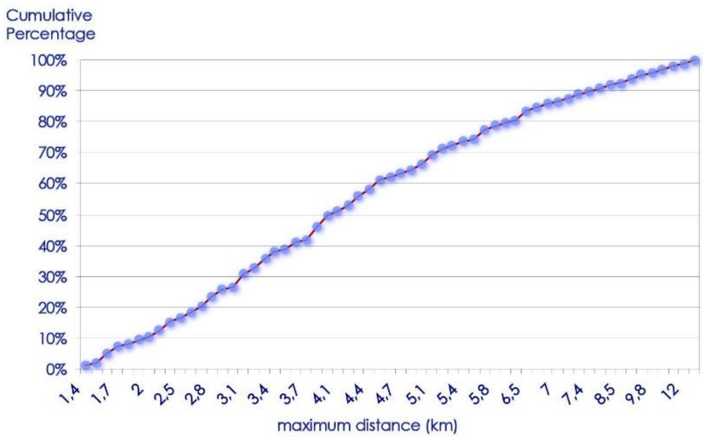
Because of a lack of surveys, French practices delimiting the boundaries of influence areas of railway stations often rely on the use of a concentric circle with a 3 km radius centered on the station. Does this "standard" really make sense? First of all, using the geometric shape of a circle implies that we consider the influence is uniform around the station. The relevance of this simplified method is being called into question when there are urban cuts due to physical barriers such as level crossings, rivers, or even the lack of continuity of the road network (Ermacora et al. 2013). Moreover, the cases of our sample show that there is a variety of geometric shapes (fig. 1). The circle characterizes the influence area of nearly 35% of stations. But a derived form, the ellipse, appears to be the most common form. The different forms observed may be explained by both the morphology of the built area and the proximity of other railway stations so that they can cause distortion of the circle.

fig. 1. Different geometric shapes of influence areas



Then, the relevance of a 3km radius may be questioned. Several French studies (Hasiak 2012, Grébert et al. 1999) underline some changes in distances of suburban stations influence. Based on our sample, we compared theory of a 3km radius with reality. The distribution of influence area distances (fig. 2) shows that this value of 3km only represents less than 30% of cases. The median distance is around 4 km. Despite an important range of values (11.8), 80% of railway stations have an influence within 6 km.

fig. 2. distribution of influence area size



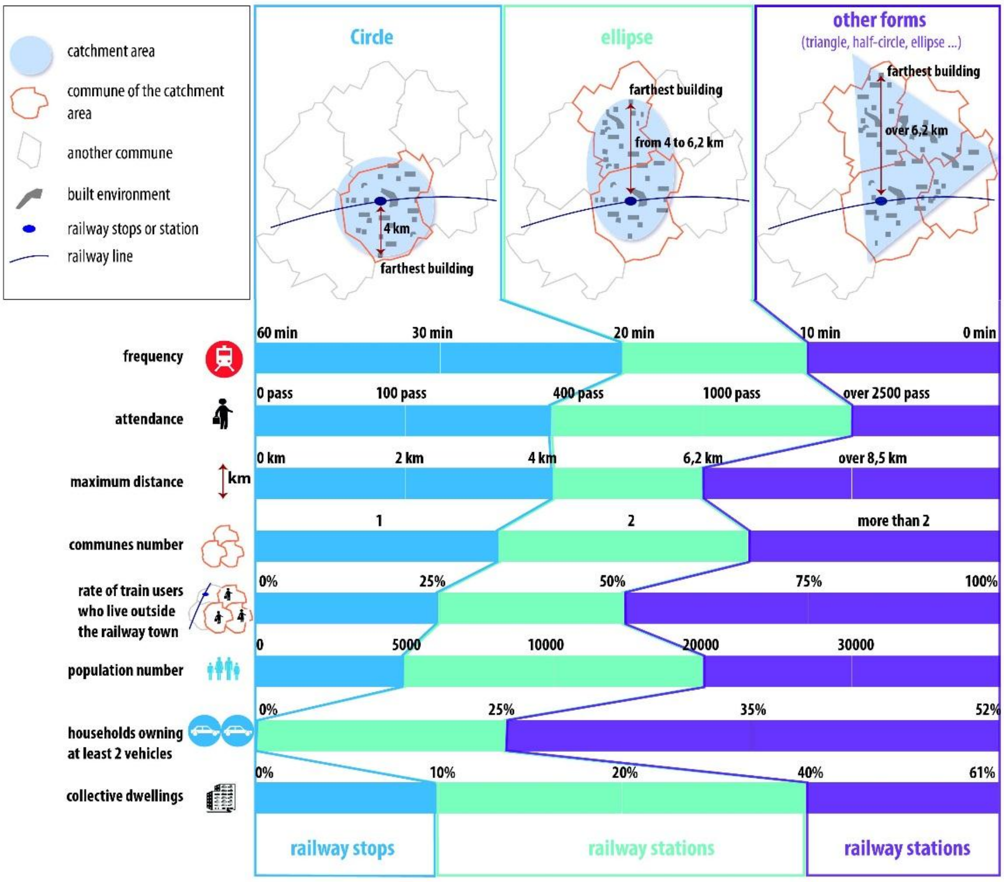
To conclude, it appears irrelevant to define an influence area with a circle of 3 km radius, centered on a railway station. Our results emphasize the diversity of cases. They discredit the use of both an arbitrary value and the geometric shape of circle. How then may we estimate the shape and threshold distance defining an influence area of a railway station? The following will provide some answers.

4.2. Are there some links between features and geometric shapes of influence areas?

Our work aims to prove that influence areas of railway stations may be highly variable in their form and size according to their features and spatial anchoring.

Based on our indicators, we first characterized the functioning of influence areas with a typology led on the basis of a multiple correspondence analysis combined with an ascending hierarchical clustering. Then, we examined the relationship that may exist between clusters and geometric shapes by measuring the distance from cluster to supplementary variables.

fig. 3. Profiles of influence areas of periurban railway stations



The results highlight three different profiles of influence areas of railway stations (fig. 3). The first group refers to influence areas whose scope is limited to 4 km, corresponds to the town where the station is located, and covers residential areas with low population. It essentially brings railway stops together, for which attendance is less than 400 passengers per day and train frequency at morning peak hours higher than 20 minutes. In contrast, another cluster corresponds to the broadest influence areas covering several towns (over 6 km, at least three towns) and more populations owning at least two vehicles. This group characterizes suburban stations with heavy traffic (over 2500 pass/d), a very good service quality (frequency is less than 10 minutes). Finally, the intermediate cluster consists of influence areas with an average size (between 4 and 6 km) covering two towns but for which at least 50% of train users live in the station town. These areas cover from 10,000 to 20,000 inhabitants. There are mainly railway stations served by trains every 10-20 minutes in the morning peak hour.

Each cluster corresponds to a dominant geometric shape of influence area. The lowest areas are mainly commensurate with a circle, the average size of areas with an ellipse. Finally, the widest influence is represented by several geometric shapes (ellipse and other shapes).

4.3. How can we explain the extent of influence areas?

We assume that the extent of influence areas of railway stations depends on factors related to services supply (number of trains, parking) and its distance to the urban center. We tried to implement a single model estimating the size of a rail influence area (threshold distance) with explanatory variables based on services supply, territorial fabric features and shape of the rail network. The challenge was to be able to provide a tool for assessing influence areas to local authorities. However, the multiple regression methods (linear or not) based on these variables did not lead to a satisfactory model. Indeed, the residual dispersion rate was very high whatever the scenarios considered (around 70%) and the coefficients for the variables may statistically be zero. So, we chose to work with a two-step approach: establishment of a typology characterizing our stations sample and then feasibility analysis of modeling the threshold distance of influence area for each cluster.

The ascending hierarchical clustering based on Ward's method leads to identify four clusters defined according to the following indicators:

Table 1: statistical indicators – Clustering of stations sample

Cluster	size (number)	frequency at MPH (min)	number of parking spaces	minimum distance between stations (km)	distance to urban centre (km)
Cluster 1	6	20,505	515	5,107	60,715
Cluster 2	57	30	68	4,172	31,817
Cluster 3	26	30,758	100	7,119	66,351
Cluster 4	7	61,516	0	2,671	52,746

Since the size of clusters 1 and 4 are small, we did not try to define a model for these groups. However, we can provide some major trends. Indeed, for stations which are well-served (3 trains per hour), have lots of parking facilities, are located 60 km from the urban center, the threshold distance of the influence area is above the median value of 4 km. It may reach 8 to 15 km. The average reference value is close to 10.9 km. Likewise, concerning railway stops with a low frequency (60 minutes) and no car park, the extent of the influence area is limited in a range from 1.5 to 4 km. The average distance is about 3 km.

The multiple linear regression led on class 2 identifies a modeling function which explains 44% of dispersions according to frequency, parking facilities, distance between stations and distance to urban centre.

Table 2: statistical indicators of linear regression

Parameters	value	Standard Deviation	T-test (Student)	Pr > t	95 % confidence Interval Lower / upper bounds	
Constant	3,522	0,971	3,627	0,001	1,566	5,478
Frequency (MPH)	-0,07	0,025	-2,842	0,007	-0,12	-0,02
Number of parking spaces	0,007	0,003	2,374	0,022	0,001	0,013
Minimum distance between stations	0,531	0,187	2,845	0,007	0,155	0,907
Distance to urban centre	0,009	0,011	0,834	0,409	-0,012	0,03

NB : R-square = 0,440 ; adjusted R-square = 0,390

Train frequency tends to decrease by 70 m the extent of influence area when it rises by 1 minute, the other variables remaining the same. In contrast, parking facilities have a positive effect on the extent. Thus, 50 parking spaces around the station lead to an increase of the maximum distance of the influence area by 350 m. Also, if the distance between stations rises by one kilometer, the influence of the station will be extended to 530 m higher. Finally, the distance to the urban center is less significant: an increase in the distance of 10 km would lead to increase the extent of 90 m. This model allows us to understand influence areas of stations located close to the urban center (around 30km), served by 2 trains per hour during peak hours and with fewer than 100 parking spaces.

The cluster 3 is similar to the previous group if we consider the level of rail services but differs from parking supply, geographic remoteness of nearest stations and from its distance from the urban center. The attempt to modeling the threshold distance of influence areas was a failure since we did not succeed in providing a statistically representative model based on a weakened sample (17 stations after having excluded atypical values).

5. Conclusion

Diversity of influence areas forms invites us to consider that there is no precise rule to define them. We tried to model the threshold access distance in order to give to decision making actors some helps. But our work proves that this purpose is not so easy since each influence area is a specific case. Nevertheless, some findings may be useful for local authorities as a decision aid. First of all, this paper has proved that the 3km radius circle is not always relevant for defining the extent of rail influence areas. This value may correspond to small railway stops with low frequency located in small towns. But local authorities may expect broader railway influence areas when both train supply and parking facilities increase: from 6 to 15 kilometers (cases of high frequency and parking supply). Moreover, this paper highlights that it is rather simplistic to characterize an influence area by the only distance criteria. Indeed, it underlines that some other factors may influence the extent of these areas. First, train services supply positively affects the extent, which appears to be consistent since it is a criterion of modal choice. Then, train station parking facilities significantly play a role on the size of influence areas. Finally, the rail network, specifically the proximity of nearest stations, has a limiting effect on the extent. These first results are consistent with the findings of Vijayakumar et al. (2011) who worked on the basis of access travels.

To conclude, these first results question the potential existence of other explanatory factors. But what are the other criteria? Without being able to fully answer this issue, our paper invites to follow this research on the topic of understanding territories under influence of railway stations.

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