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Rail Corridors between Minimal Use of Train and Unsystematic Tightening of Population: A Methodological Essay

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***Abstract*—**In the current situation, the automobile has become the main means of locomotion. It allows traveling long distances, encouraging urban sprawl. To counteract this trend, the train is often proposed as an alternative to the car. Simultaneously, the favoring of urban development around public transport nodes such as railway stations is one of the main issues of the coordination between urban planning and transportation and the keystone of the sustainable urban development implementation. In this context, this paper focuses on the study of the spatial structuring dynamics around the railway. Specifically, it is a question of studying the demographic dynamics in rail corridors of Nantes, Angers and Le Mans (Western France) basing on the radiation of railway stations. Consequently, the methodology is concentrated on the knowledge of demographic weight and gains of these corridors, the index of urban intensity and the mobility behaviors (workers' travels, scholars' travels, modal practices of travels). The perimeter considered to define the rail corridors includes the communes of urban area which have a railway station and communes with an access time to the railway station is less than fifteen minutes by car (time specified by the Regional Transport Scheme of Travelers). The main tools used are the statistical data from the census of population, the basis of detailed tables and databases on mobility flows. The study reveals that the population is not tightened along rail corridors and train use is minimal despite the presence of a nearby railway station. These results lead to propose guidelines to make the train, a real vector of mobility across the rail corridors.

***Keywords*—**Coordination between urban planning and transportation, Rail corridors, Railway stations, Travels.

I. Introduction

METROPOLITAN urban areas are increasingly confronted with the phenomenon of peri-urbanization. This phenomenon tends to respond to the demographic growth of the city in its morphological expansion beyond its core [1]. The demographic evolution of peri-urban communes has resulted in high consumption of land. In addition to this spatial voracity, peri-urban space generates significant traffic mobility. The question of the spatial structuring of peri-urbanization is increasingly acute in view of the imperatives of sustainable development. In this respect, the current reflections focus on two essential points. The first is to formulate alternative solutions by opting for rail transport as a response to the automobile problem. Indeed, the development of train use and the improvement of railway station accessibility are often put forward by urban planners in travel policies.

The second point focuses on the coordination between urban planning and transportation. This coherence allows curbing the urban sprawl phenomenon, which penalizes the organization of a public transport network [2]. It is also in a favorable context for the potential role of transport networks as guidelines of urban development. In this context, the railway has played a major role in structuring linearly urbanization during the process of industrialization; the study of rail corridors would be interesting in the sense that it may be the best method to preserve this linearity which is the structuring force of the railway [3].

Through the literature, several researches were conducted primarily on the location of population along the railway lines. The conclusions of these works are different because the objectives and the methodology are different. For example, Pumain [4] took into consideration the database of standard gauge railways and retained all units in 44 French departments which have reached at least 2,500 inhabitants between 1831 and 1911. She concluded by a negative development for the 61 units not served of this sample. Larroque and Jigaudon [5] took all modes of insertion to the network, including the opening of the narrow gauge lines and have set the bar to 5,000 inhabitants between 1851 and 1954 for the whole of France. They concluded that the overall observation of the service led them to record a lack of differentiation vis-à-vis the demographic evolution.

In another context, the definition of the perimeter of rail corridors is an exercise that varies depending on the purpose of the study. For example, Séguret [6] defined rail corridors of 3 km wide from the existing line in order to consider modes other than motorized. Desjardins et al. [7] have defined rail corridors taking into account all communes whose administrative center is located within 3 km of the tracks. This method aims to know the degree of adhesion by inheritance or, conversely, the spatial indifference of urbanization in relation to the rail network.

Given the above, our main idea is therefore to take again the work on the rail-demographic relationship and to opt for a demographic observation since the 1960s until today. We supplement the study by the knowledge of travel practices of population located along rail corridors. Therefore, we ask the following questions: what is the tightening degree of population along rail corridors? What are the travel practices

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of this population? And, which place occupies the train in the peri-urban service?

Concerning the perimeter of corridors, we preferably opt for the drive access time to a railway station as a selection criterion instead of the distance. Two points argue this choice: first, the distance does not structure space in metropolitan areas, but accessibility [8]. Then, for stations located outside major urban centers, the car and walking are the two modes of transport used to complement the train [9]. It is therefore important to take advantage of the role that the car can play in improving the use of stations. In the following section, we will strive to detail the methodology specifying the sites selected for the study, defining the perimeter of the rail corridors and specifying the various indicators and tools used.

II. Methodology

A. Presentation of Study Sites

The sites selected for the study are the three metropolitan urban areas (10,000 jobs at least in the urban center) of the Pays de la Loire region (western France): Nantes, Angers and Le Mans. These three cases of study are interesting for the growth of peri-urban spaces across urban areas [10] and the presence of important railways serving these spaces, as shown in Fig. 1. The urban transports perimeter of Le Mans has recently experienced an expansion and the station of Champagné is now included within this perimeter.

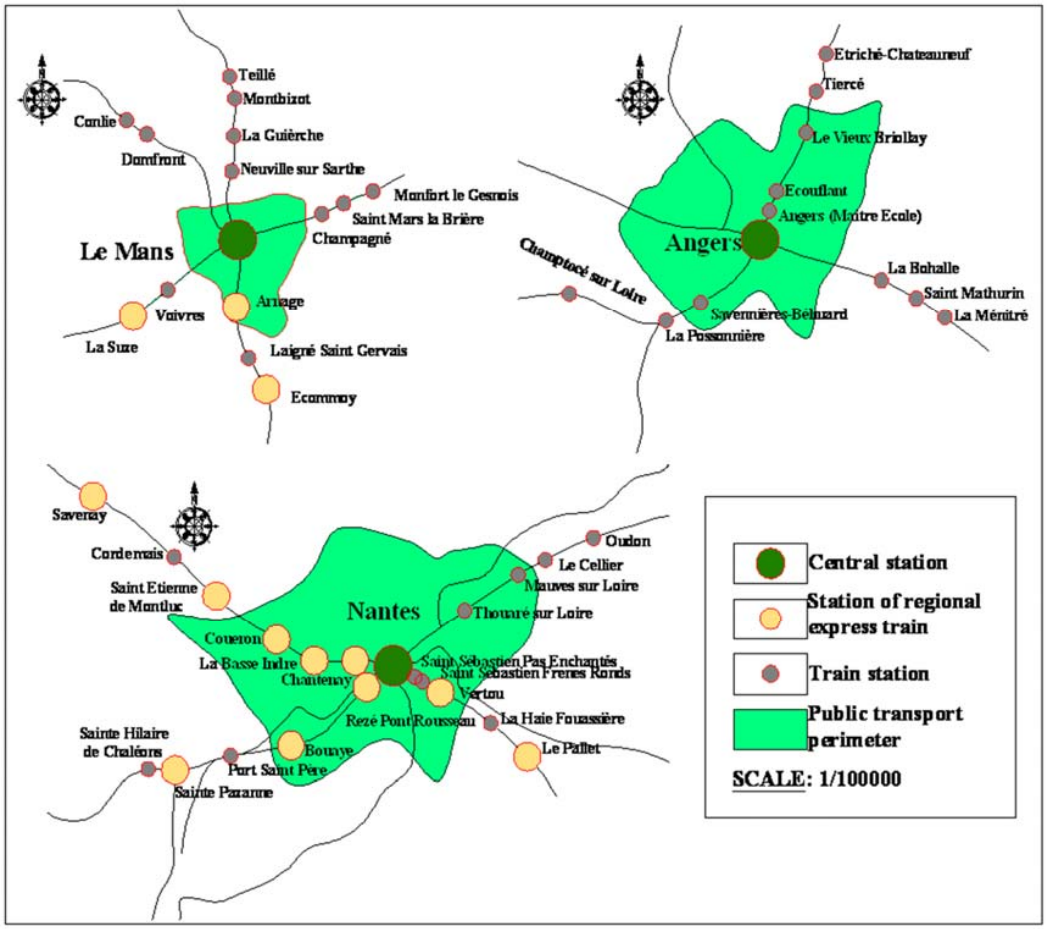

Fig. 1 The three railways (Accessibility plan of the regional transport network of Pays de la Loire region, June 2008)

B. Setting of Rail Corridors Perimeter

The perimeter considered to define the corridors includes the communes of the metropolitan area (cutting of 2010) with a station outside the city center. We add to this perimeter the catchment areas of peri-urban stations, as shown in Fig. 2. It includes the communes of the metropolitan area with an access time to a railway station strictly less than 15 minutes. This access time, which is registered in the Regional Transport Scheme of Travelers, defines statistically the pseudo-catchment areas of railway stations. Experienced catchment areas include more qualitative aspects of mobility practices.

Following this logic, we get rail corridors which are in the form of cones widening gradually as one move away from the city center [11]. Therefore, the perimeter includes a total of 47 communes for Nantes, 49 for Angers and 77 for the Le Mans, as shown in Fig. 3. Note that we have not considered the

Northern Corridor of Nantes served by the tram-train Nantes-Chateaubriant because the line was re-opened fairly recently (in 2014).

C. Indicators and Tools Used

The establishment of a set of indicators and tools deemed necessary to carry out this study. Firstly, it is important to know the demographic gains over a long period of four decades and the index of urban intensity to determine the dynamics of rail corridors. It would be interesting to isolate in the evolution of urban population the natural balance and the contribution of migration [5]. Demographic gains of the main communes served by a railway station will be therefore put in relation to the two balances: natural and migratory. The index of urban intensity allows us to detect human presence around the railways. It is calculated by adding the number of inhabitants, the number of jobs and the number of students, which are reported to the total area in hectares. This calculation method has been defined by the typology of stations presented in the Territorial Cohesion Scheme of Tours (French city) [9].

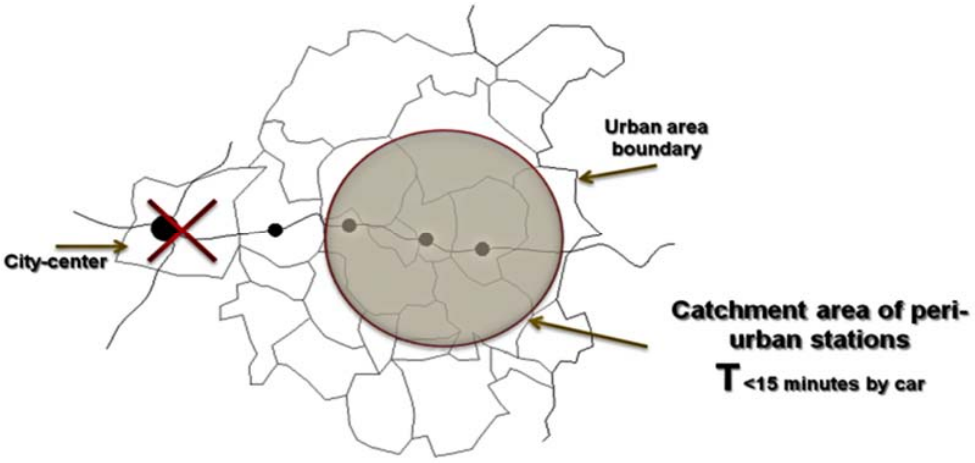

Fig. 2 Principle of cutting of a rail corridor

Secondly, it is a question of knowing workers' travels and students' travels in order to determine the potential market of the train and to understand the interdependence or independence relations between the rail corridors and between the corridors and the city-center. The study of travels permits additionally to understand the functioning of the whole territory taken into account for the study. For the determination of the potential market of train, we were inspired by the work of the Agency of Urban Planning and Interurban Development of Rennes agglomeration focused on the rail corridors of the Rennes urban area. This potential market concerns two categories of people. Persons who reside in the rail corridors and leave their communes to work or study in another commune situated in the same corridor and served by a railway station (intra-corridor flows) and persons whose destination is the city-center (radial flows).

The points of departure and destination of a trip often determine the means of transport used to accomplish it [12]. For this reason, persons excluded from the calculation are those who work or study in their commune of residence and those whose communes of destination do not have a railway station. In addition, the main tools used are statistical data from the census of population, the bases of detailed tables and the bases on mobility flows. Using these tools, the following section analyzes the extent to which rail corridors tend to guide demographic growth within urban areas and to what extent accessibility to railway stations can be considered as a determinant of modal choices in terms of travels of students and workers.

III. Comparison of Demographic Evolutions in the Corridors and the Rest of the Urban Areas

Since 1968, rail corridors in the three urban areas have seen a steady increase in population growth, as shown in Fig. 4, but the rate of growth varies from one period to another (stable, increasing or regressive). All the gains in the corridors of Le Mans, Angers and Nantes amounted to 39,558, 40,818 and 86,514 inhabitants, respectively. Overall, these gains represent across the five intercensal periods 56%, 31% and 28% of urban areas population growth.

TABLE I
DISTRIBUTION OF POPULATION IN URBAN AREAS

Urban area 2010	Le Mans	Angers	Nantes
Rail corridors	108,090 (32%)	89,166 (23%)	240,343 (28%)
The rest of urban area	230,891 (68%)	305,544 (77%)	621,768 (72%)
Urban area	338,981 (100%)	394,710 (100%)	862,111 (100%)

Currently, one-third of Le Mans population, slightly less than a quarter of Angers population and more than a quarter of Nantes population resides near the train, as shown in Table I. These small shares are the result of a demographic growth that took place mainly outside the rail corridors. The tightening of the population did not take place along the railway because, on

the one hand, the railway does not adequately serve the residential areas built since the 1960s and, on the other hand, stations implanted in the countryside are the work of engineers and not grafts of activities or dwellings [13]. In addition, we often build far from the railway for reasons related to availability and land prices [14].

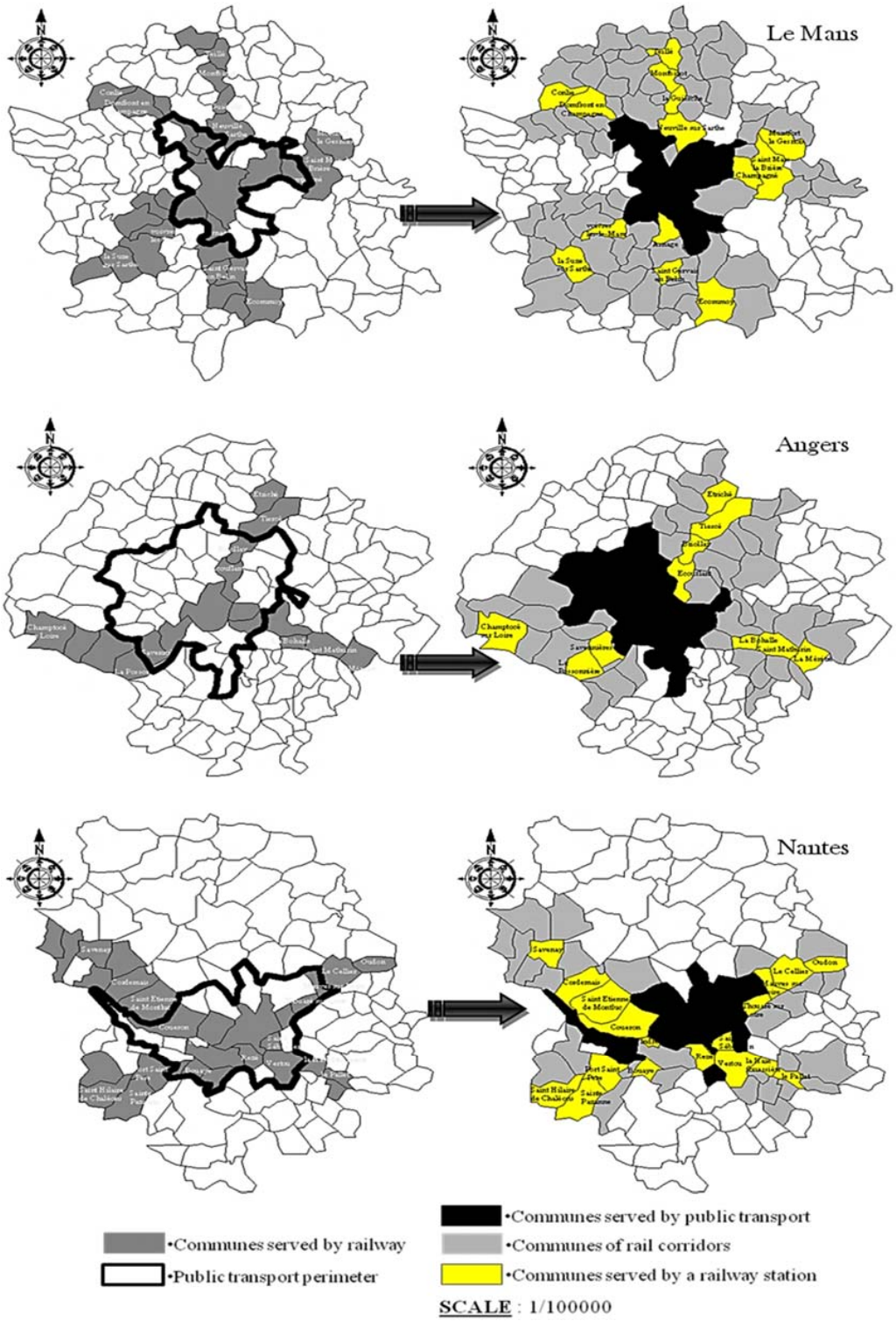

Fig. 3 Communal composition of metropolitan urban areas

Focusing more closely on the evolution of the population in each rail corridor, we note that each corridor has a different rate of growth and the volume of demographic gains varies according to the intercensal period. Consequently, we have five types of dynamics: more or less recent, irregular, moderate, rather strong and heterogeneous, strong. These dynamics were identified from the calculation of demographic gains over the five intercensal periods (1968-1975, 1975-1982, 1982-1990, 1990-1999, and 1999-2009). In addition, Table II shows that the Northwest and Northern corridors of Le Mans only lost population between 1968 and 1975; the Southwest corridors of Le Mans and Nantes are experiencing a demographic decline during the most recent period.

TABLE II
DEMOGRAPHIC GAINS IN RAIL CORRIDORS

Evolution of population in rail corridors		Demographic gains between 1968 and 2009				
Dynamic	Rail corridors	1968-1975	1975-1982	1982-1990	1990-1999	1999-2009
Recent dynamic	Northwest corridor of Le Mans	-445	+69	+531	+537	+1412
Irregular dynamic	Northern corridor of Le Mans	-60	+2076	+780	+1306	+3957
	Southwest corridor of Le Mans	+2925	+4001	+2261	+1750	-1030
	Southeast corridor of Angers	+1256	+4136	+3170	+1442	+3984
	Southwest corridor of Angers	+458	+2630	+1881	+1187	+2946
	Southwest corridor of Nantes	+4961	+3838	+3541	+5281	-12499
Moderate dynamic	Northeast corridor of Le Mans	+1595	+2121	+1541	+1558	+1955
	Southern corridor of Le Mans	+3625	+1957	+1053	+1059	+3024
Fairly strong and heterogeneous dynamic	Northeast corridor of Angers	+4430	+3858	+3405	+3703	+2332
	Northeast corridor of Nantes	+2748	+5798	+3181	+4039	+4017
	Northwest corridor of Nantes	+2827	+6341	+5674	+3892	+7465
Strong dynamic	Southeast corridor of Nantes	+6172	+5979	+8764	+7098	+7397

Regarding the existence or not of a plausible relation between the dynamic of corridors, their demographic weight and their respective urban intensity indexes, as shown in Table III, a differentiation of the situations is observed. Compared to Le Mans, there is a high proportionality between the dynamic of the corridor and the number of jobs, and between the urban intensity index and the number of jobs. The situation is harmonious for the corridors since the least populated corridor is the least dynamic and the most populated corridor is the most dynamic. For example, the Southern Corridor combines a greater demographic growth and a rather strong demographic dynamic, has the highest number of jobs, and therefore, has the highest urban intensity index. Conversely to the previous case, the Northwest Corridor is the least populated, as well as the least dynamic and contains a small number of jobs. The Northeast corridor with moderate dynamic displays a higher urban intensity index than the Southwest and the Northern corridors, despite its demographic weight is lower than the two others. These two corridors are experiencing an irregular demographic dynamic and have practically the same value of the urban intensity index. However, the Southwest corridor is much denser in terms of population, jobs and students.

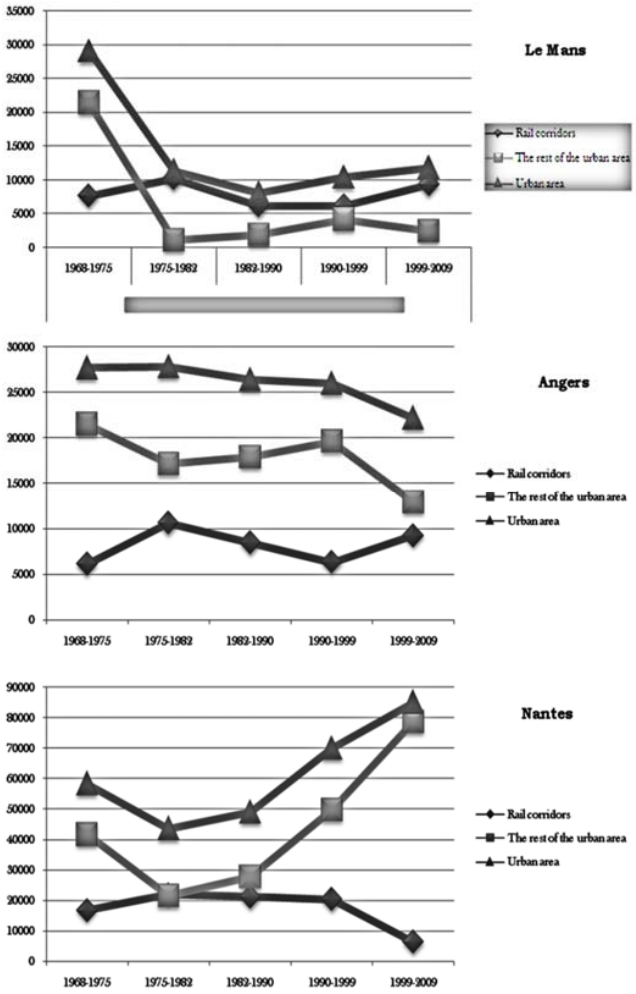

Fig. 4 Demographic gains in urban areas

Compared to Angers, the corridor dynamic is proportional to its demographic weight and the number of jobs (the Northeast corridor combines the strongest dynamic with a high number of jobs. In contrast, the Southwest corridor is the least dynamic and has fewer jobs). However, the most dynamic corridor does not necessarily have the highest urban intensity index. Comparing the Southeast corridor with the Northeast corridor (the most dynamic), it was found that the urban intensity index of the first is higher than the second (2.08 vs. 1.85). The situation is thus contrasted for the Angers corridors.

TABLE III
URBAN INTENSITY OF RAIL CORRIDORS

Corridors	Population 2009 (inh.)	Number of jobs	Number of students	Areas km²×10²	Urban intensity index
Southeast corridor of Nantes	77457	24641	19238	228,93×10²	5,3
Southwest corridor of Nantes	61206	33286	20827	302,33×10²	3,81
Northeast corridor of Nantes	37990	12013	10310	239,87×10²	2,51
Northwest corridor of Nantes	63690	20399	16204	439,64×10²	2,28
Southeast corridor of Angers	30799	8303	13808	253,85×10²	2,08
Southern corridor of Le Mans	28341	8151	6980	228,18×10²	1,91
Northeast corridor of Angers	35381	13786	16146	353,3×10²	1,85
Northeast corridor of Le Mans	22438	8136	5769	205,46×10²	1,77
Southwest corridor of Le Mans	24354	6802	7579	288,72×10²	1,34
Northern corridor of Le Mans	23229	4597	5963	253,73×10²	1,33
Southwest corridor of Angers	22986	5914	10606	320,45×10²	1,23
Northwest corridor of Le Mans	9728	1491	2446	183,97×10²	0,74

Compared to Nantes, the most populated corridor is the most dynamic (Southeast corridor), the least populated corridor is not necessarily the least dynamic (Northeast corridor) and the corridor with a higher urban intensity index is not necessarily dynamic (the Northwest corridor is certainly more populated than the Northeast corridor but it has a lower urban intensity index: 2.28 versus 2.51 for the Northeast corridor. Also, the Southwest corridor is denser in terms of jobs and students than the Northwest corridor, although it is less dynamic). We cannot therefore conclude that there is a proportional relationship between the demographic weight, the urban intensity index and the dynamic of corridor. The situation of rail corridors in Nantes is therefore contrasted.

IV. POPULATION GROWTH VARIABILITY OF COMMUNES SERVED BY RAILWAY

Looking more closely at the communes served by a railway station, it can be seen that the growth and demographic gains observed over a period of 40 years are variable from one commune to another. Several types of population growth are attributed to them: moderate, irregular, relatively recent, regular, declining, and fairly strong, as shown in Table IV. This differentiation clearly shows that the peri-urban communes served by the railway are not necessarily dynamic and do not systematically have higher population growth rates than the other communes in the urban area. The demographic dynamic of these communes cannot be related to the existence of a station on the territory. This is mostly related to a number of difficulties, such as the low density of peri-urban crowns, the low number of train stations, the neglect of urbanization around railway stations by public policies in France in recent decades, and the incompatibility of urban development with the railway corridors in a large majority of French urban areas [15].

TABLE IV
DEMOGRAPHIC GAINS OF SUBURBS AND PERI-URBAN COMMUNES

Demographic Gains (DG) since 1968 (inh.)	Demographic growth		Examples
Suburbs	DG < 2000	Growth relatively recent	Port-Saint-Père, Saint-Gervais-en-Belin
		Declining	Indre, Arnage
	2000< DG <6000	Growth relatively recent	Rezé
		Irregular growth	Bouaye et Thouaré-sur-Loire
	DG >6000	Irregular growth	Couëron, Vertou et Saint-Sébastien-sur-Loire
Peri-urban commune	DG <1000	Moderate growth	la Ménitré, Ecommoy, la Possonnière, Saint-Mars-la-Brière, Voivres-lès-le-Mans, Etriché, la Guierche, Conlie, Savennières
		Irregular growth	Saint-hilaire-de-Chaléons, la Bohalle, Saint-Mathurin-sur-Loire, Champtocé-sur-Loire, Montbizot, Domfront-en-Champagné
Declining			Teillé
1000<DG<2000	Fairly strong growth		Cordemais, Mauves sur Loire, Briollay, Oudon
	Regular growth		Montfort le Gesnois, Neuville sur Sarthe, le Pallet, le Cellier
	Irregular growth		la Suze sur Sarthe, Champagné
DG>2000	Irregular growth		Saint Etienne de Montluc, Savenay
Growth relatively recent			la Haie Fouassière, Sainte Pazanne
Fairly strong growth			Tiercé, Ecouflant

If we compare France with Germany, we find that the German railway mode is more relevant thanks to the importance of the population density, the timing of the railway, the density of services and the urban policy. Since the end of the Second World War, the French authorities have promoted road transport by developing relatively dense road and motorway networks [16]. At the same time, the railway appeared already on the defensive since the National Society of Railways inherited at the time of its creation a composite heritage, a difficult financial situation and a hypertrophied network [13].

On the other hand, the migratory balance is the explanatory factor for demographic gains in a particular intercensal period. In this respect, we cite as example the communes of Neuville-sur-Sarthe and Ecouflant. Neuville-sur-Sarthe has experienced progressive population growth since 1962. The largest demographic gain occurred between 1975 and 1982 and it is mainly due to the migratory balance (+ 6.9%). The largest volume gain in the commune of Ecouflant was between 1968 and 1975. Over this period, the average annual change in the population was + 20.2%, mainly due to positive net migration (+ 18.9%).

The migratory balance is also the explanatory factor for the demographic decline of certain communes during a given

period. People leave their communes for new horizons; it is about the small peri-urban communes such as Saint-Hilaire-de-Chaléons, Teillé and La Bohalle and the suburban communes such as Arnage, Rezé, Indre and Saint-Sébastien-sur-Loire.

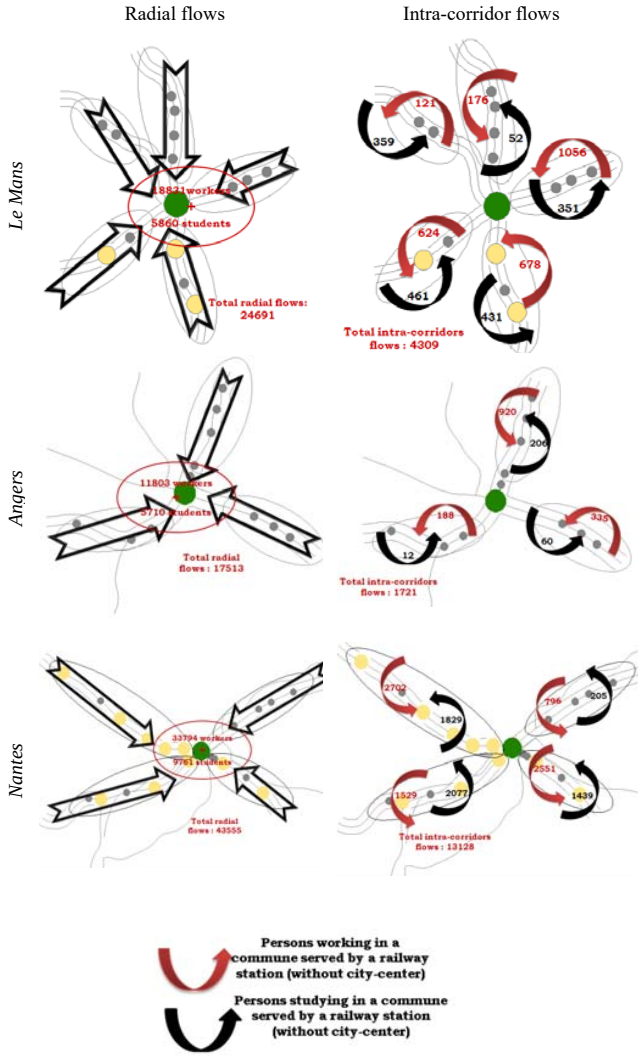

Fig. 5 Radial and intra-corridor flows

V. Evaluation of the Potential Role of Train in Terms of Travels

The potential market of workers and students travels for the train concerns 29,000 people (with 85% for radial flows and 15% for intra-corridor flows) for Le Mans, 19,234 people (with 91% for radial flows and 9% for intra-corridor flows) for Angers and 56,683 people (with 77% for radial flows and 23% for intra-corridor flows) for Nantes, as shown in Fig. 5. Comparing these figures with travels done at the scale of urban areas, we conclude that the potential train market remains modest with a share of 26%, 13% and 17%.

On the other hand, workers and students can make "inter-corridor" trips, they move to work or study in communes with a station located in other rail corridors. Their number may prove useful to the knowledge of the potential market of the train; however, it is not really true since the car can be more competitive than the train in terms of travel time. The latter by train (including the time lost at the central station) can far exceed that which is carried out by car. It is nevertheless important to know the communes, which polarize the travels of workers and students.

Concerning the commuting, communes in the suburbs polarize travels. This is the case of Rezé (Southwest corridor of Nantes), which receives more than 1,500 workers from the other corridors, Arnage (Southern corridor of Le Mans), Vertou (Southeast corridor of Nantes) and Saint-Sebastien-Sur-Loire (southeast corridor of Nantes) which receives between 600 and 1,000 workers. The other communes with a railway station receive a number of workers less than 600. The workers are also intercepted by communes whose employment exceeds the number of workers (Ecouflant and le Cellier) and peri-urban communes in the center of the basins of life (Champagné, La Suze, Ecommoy, Conlie, Tiercé, Saint-Etienne-de-Montluc, Savenay and Sainte Pazanne).

Concerning students' trips, the communes of Rezé and Saint-Sébastien-sur-Loire respectively receive 612 and 514 students. This can be explained by the presence of colleges and high schools on the territory of these communes. Other communes intercept flows like Arnage (172 students), Vertou (71 students), Saint-Etienne-de-Montluc (36 students), Neuville-sur-Sarthe 12 students), Bouaye and Saint-Pazanne (8 students for each), La Ménitré, Indre and Saint-Hilaire-de-Chaléons (4 students for each).

VI. Modal Distribution of Commuting at Rail Corridors Scale

On all workers residing less than 15 minutes by car from a railway station and working outside their commune of residence, only 13% (Nantes) and 4% (Le Mans and Angers) travel on public transport. These percentages show that the use of public transport is low at the scale of rail corridors. Also, the presence of a railway station does not influence human behavior vis-à-vis the modes of displacement. Indeed, cars are still the most used means of transport to move to workplace (75% for Nantes and 85% for Le Mans and Angers). In addition, the modal shares of public transport and the two wheels are lower than that of the car, as shown in Fig. 6.

VII. Conclusion

The study of the demographic dynamics reveals initially that the tightening of the population does not occur systematically along the railway corridors. Secondly, the link between the corridor dynamics, the demographic weight and the urban intensity index is not probative for all corridors. In a third phase, the growth and demographic gains observed over 40 years are variable from one commune to another and the migratory balance is the explanatory factor for the couple "demographic gains-demographic decline" during a certain

period.

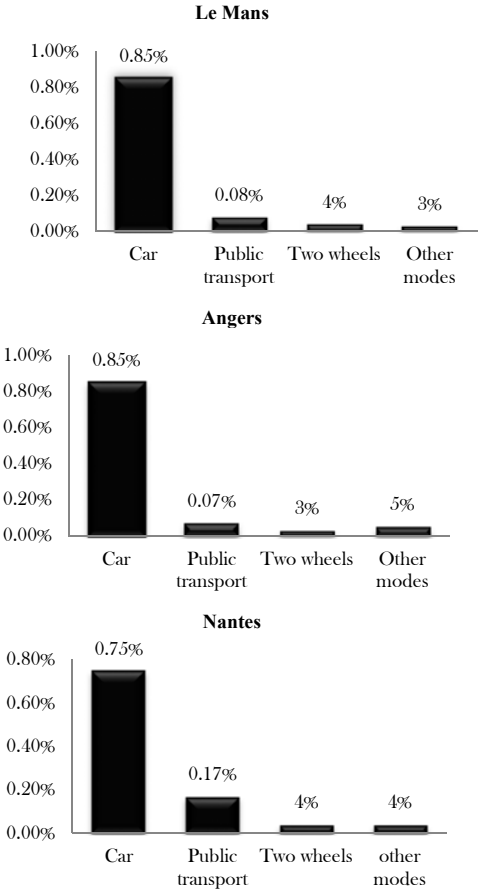

Fig. 6 Modal practices of commuting

The study of the displacements in the railway corridors permits on the one hand to understand the functioning of the territory by revealing three types of displacements according to the rail:

- *Radial travels* towards the city-center. In fact, the attractiveness of the center-cities vis-à-vis the corridors is largely linked to work and study (interdependence relation).
- *Intra-corridor travels* to communes served by a railway station.
- *Inter-corridor travels* towards communes with educational establishments and sectors with a high concentration of jobs.

It reveals on the other that the car is the main means of transport of the population residing along railways. Also, the use of the train is minimal despite the presence of a local railway station. This potential for train use is modest but it is not negligible. It is therefore important to highlight the different orientations that can be envisaged to transform the potential benefits of peri-urban rail service into real advantages. In other words, how will the peri-urban train be able tomorrow to constitute a true vector of mobility at the scale of railway corridors?

The answer to this question is obviously linked to a rigorous work on the accessibility perimeters and the catchment areas of railway stations. It is also linked to the railway policy currently conducted by the Pays de la Loire region on the three fields of investigation: implementation of the timetable in 2017, renewal of the railway fleet, development of pricing and multimodal information, regional network and rehabilitation of buildings closed to passengers, development of the multimodal exchanges and encouragement of the "train-bike" system.

On the basis of actions already carried out on the three sites, other tracks can be dug to complete the existing:

- Encourage car-sharing.
- Establish an advantageous hourly rate for commuters and students.
- Incorporate standards and rules for urban intensification around stations in urban planning documents.
- Dimension the car parks near the railway track and allocate them to the parking of compact vehicles (small cars, two motorized wheels) or heavy occupancy (car-pooling).
- Generalize the master plans of the cycle paths at the scale of commune communities served by the railway.
- Secure the access routes by car in the crossing of the hamlets and boroughs and improve the routes of access in soft modes to the station.
- Choose an urban form that is more economical in terms of space and establish services and businesses in each new neighborhood created near a railway station.
- Connect the stations with the urbanized zones located in catchment areas.
- Create new peripheral railway stations in the presence of an important urban fabric.
- Provide new stations in communes without a station, but served by the railway.
- Reflect on the revitalization of buildings (stations) that have not been rehabilitated.

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