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THE IMPACTS OF URBAN PUBLIC TRANSPORTATION: EVIDENCE FROM THE PARIS REGION[†]

Abstract

Evaluating the impact of transport infrastructure meets a major challenge since rail lines are not randomly located. We use the natural experiment offered by the opening and progressive extension of the Regional Express Rail (RER) between 1970 and 2000 in the Paris metropolitan region, and in particular the deviation from original plans due to budgetary constraints and technical reasons, in order to identify the causal impact of urban rail transport on firm location, employment and population growth. We use a difference-in-differences approach on a specific subsample, selected to avoid endogeneity bias which occurs when evaluating transportation effects. We find that the increase in employment is 12.8\% higher in municipalities connected to the new network compared to the existing suburban rail network between 1975 and 1990. Places located within 20 km from Paris are the only affected. While we find no effect on overall population growth, our results suggest that the commissioning of the RER may have increased the competition for land high-skilled households are more likely to locate in the vicinity of a RER station.

JEL Classification: D04, H43 and R42
Keywords: impact evaluation, location choice, transport infrastructure and urban structure

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Introduction

Urban public transit is considered as a key policy to ease urban congestion and promote environmentally-friendly transportation. In Europe as in the United States, multiple projects demonstrate the belief of policy makers in the efficiency of public spending for transportation. Mention may be made of the "Crossrail"[1] project in London, the "Grand Paris Express"[2] in France or the plan for high speed rail in California[3]. Besides, spending for inland transport infrastructure is significant: 0.7 percent of the GDP in North America and 0.8 in Western Europe and even 0.9 in France (OECD, 2011). Empirical evaluations are needed to assess the return of costly infrastructure investments. Following this idea, this paper offers evidence of the way urban rail transit can shape urban development. To do so, we use the natural experiment offered by the improvement of the Paris commuter rail system from the 1970s to the 1990s. During this period, the Paris metropolitan region spread and the population rose from 9,248,931 in 1968 to 10,952,011 inhabitants in 1999 (INSEE, Census). This growth has been accompanied by the improvement of the commuter rail system and the commissioning of the so-called Regional Express Rail (RER thereafter). This policy mainly led to the improvement of the existing network but also consisted in the construction of new stations and lines. This fast and high-capacity enhanced network offers a interesting identification strategy to estimate the causal impact of public mass transit on firm, employment and population location across the metropolitan area. More concretely, we estimate the effect of a station opening or improvement at the municipality level.[4] We implement this difference-in-difference design on a specific subsample chosen to address the endogeneity bias (explained below). We find that the number of jobs grew by 12.8% in municipalities connected to the RER network on the 1975-1990 period, compared to the growth rate that would have prevailed in the absence of the improved infrastructure. We obtain similar results for firm location but find no significant impact on population growth.

The literature gives support to the idea that transportation plays a key role in the economics of cities. There are both empirical and theoretical evidence that transport infrastructures influence the location of people and economic activities within cities, but also between cities which is not covered in our work. The standard monocentric city model predicts that a decrease in transportation costs should increase the share of the population who lives in the suburbs (Alonso, 1960). According to this model, it will also cause a rise in the size of the city thanks to lower congestion costs. Empirical results support this theoretical prediction. Baum-Snow (2007) studies the effect of highways on the shape of US cities. He shows that roads explain one third of the population displacement from city centers to the outskirts. Similar results hold for Spain (García-López et al., 2013). Duranton and Turner (2012) highlight the positive impact of highways on city growth: a 10% increase in the stock of highway causing a 1.5% rise in local employment in the US. However, in line with theoretical models in economic geography, Faber (2014) confirms

[1] http://www.crossrail.co.uk/

[2] http://www.societedugrandparis.fr/english-version

[3] http://www.hsr.ca.gov/

[4] We will use the terms municipality and city interchangeably to design the administrative unit which is our unit of observation (more than 1300 of them in the Paris region).

that transportation could decrease economic activity in some cases. Indeed, he finds that highways caused a reduction in the GDP growth of peripheral counties in China.

Empirical studies on firm location choices also highlight a positive link with transport infrastructures. Coughlin and Segev (2000) show that highways foster foreign-owned manufacturing plant location in US counties. Holl (2004a,b) finds similar results for Portuguese and Spanish firms. Strauss-Kahn and Vives (2009) show that the proximity to an airport is a significant factor for headquarter relocation in the United States. More generally, transport infrastructure is positively associated with the productivity of cities. According to Fernald (1999), highway construction in the US increased the productivity of vehicle-intensive industries at a metropolitan scale. The contribution of our work is to provide results for firms, employment and population, in order to assess the differential impact of transportation depending on the type of economic agent.

While the effects of highways on cities have been widely studied, public transportation has been subject to less evaluation. Some papers highlight the fact that mass transit has a specific effect on cities, compared to other means of transportation. First, commuter rail systems help reduce air pollution in cities. Chen and Whalley (2012) show that the opening of the metro of Taipei reduced measured concentration in carbon monoxide by 5 to 15 percent. Second, rail influences the location of people and jobs in cities, in a different way of other means of transportation. According to Baum-Snow and Kahn (2000), commuter rail investments caused a slight increase in the local value of properties in 5 majors American cities. It also encourages switching from driving to public transportation. Besides, Burchfield et al. (2006) show that cities built around early public transportation are less sprawled than cities built for cars, because of higher commuting costs. Glaeser et al. (2008) emphasize a ubiquitous effect of public transportation on the poor. On the one hand, the mobility of the poor is higher in American cities with a high level of public transportation service because car-based mobility is too expensive. On the other hand, such cities are more segmented. In fact, low income people are stuck close to rail stations while rich people live in neighborhoods only accessible by car. Our results emphasize once again that European and American cities work differently (Brueckner et al., 1999). In the Parisian case, we find suggestive evidence of a gentrification effect of commuter train in the inner ring of Paris suburbs. Finally, considering the case of a major European city appears relevant as urban mass transit plays a bigger role in commuting than in Northern America. For example, only 5.3 percent of American workers use public transportation to commute[5] (McKenzie and Rapino, 2011), while 13.3 percent of French workers do (François, 2010) and even 22.6 percent of Japanese commuters[6] (Japan Census, 2010). Besides, car is prevalent in the US (90.0%), less prominent in France (72.3%) and even rarer in Japan (46.9%).

Because transportation infrastructures are not randomly located, evaluating its impact faces up to a severe endogeneity issue. The consequence is that a naive evaluation which would directly compare connected to unconnected areas could be biased. In addition, the intentions of policymakers are not clear; they may intend to connect either dynamic or deprived areas depending on the public policy goal at the time of decision.

[5]Without people working at home.

[6]Workers and students over 15 years; public transportation includes company's or school bus; two modes of transport can be given, in that case, users are shared between the two modes, on a half-half basis.

The consequence is that the sign of the endogeneity bias is unclear. That is the reason why we implement our difference-in-difference design on a specific subsample. The literature offers some examples of identification strategies to address this issue. Such strategies, based on natural experiments or clever instruments, yield the causal impact of new infrastructures. Duranton and Turner (2012) evaluate the impact of the highway network in the United States on the local evolution of employment. They use an instrumental variable strategy, based upon the 1947 plan of the interstate highway system, partially based on military purposes, and on the 1898 network of railroads, to address the endogeneity of the location of highways in 1980. Michaels (2008) also uses the 1947 plan as an exogenous source of variation of roads for evaluating the impact on interstate trade. Donaldson (2013) shows that railway extensions in India led to a decrease in interregional trade costs and increased both incomes and trade. To do so, he uses a natural experiment provided by 40,000 km of planned lines which were never built for arguably exogenous reasons. Banerjee et al. (2012) find a moderate positive effect of transportation access on income growth in China. They use the fact that railroad lines were built in China to connect European concessions on the coast and inland historical cities in the 19th century. They argue that crossed areas, which were located in between these two kinds of cities were "quasi-randomly" linked to the railway network and can be compared to similar unconnected areas.

Our identification strategy combines the approaches of Donaldson (2013), Duranton and Turner (2012), Michaels (2008) and Banerjee et al. (2012). Concretely, the RER network has been implemented with the aim of connecting new economic subcenters located between 15 and 30 km away from the historical center of the city. Some existing commuter rail lines happens to cross existing stations which are located between the historical core and these subcenters. Such stations are included in the RER enhancement program, but without intention to treat. These stations are consequently "quasi-randomly" treated and can be compared to similar untreated stations in order to estimate the causal impact of railway improvement. In addition, many plans have been presented in the 1960s to improve the Paris suburban train. They differ from each other, often because of technical reasons, pointing out some exogeneity in the selection of the rail line actually included in the RER network.

Finally, data availability and precision is a key issue to accurately estimate the impact of transportation on location. Gibbons et al. (2012) insist on the fact that such an evaluation is more complicated in developed countries as transportation networks are already dense. In these conditions, it is necessary to measure not only if a given area is linked to a network but also the quality of rail service. To do so, we develop a method to recover the journey time by train across the Paris metropolitan region, at various points in time. We show that a one-minute decrease in the journey time to Paris increases the city's employment by 2 percent.

This paper is organized as follows. The first section relates the history of urban planning in the Paris region. The second section explains our estimation strategy. The third section details the econometric model we use and the fourth section presents the data used in estimation. The fifth section sets out the results and finally, the sixth section concludes and discusses our findings.

1 Urban planning of the Paris region

The history of the suburban rail is quite intricate. It reflects the changing place of Paris in the national planning policies and the complicated relation between the city of Paris and its suburbs. First, there is a strong and long-lasting opposition between the city of Paris and the outskirts of the city. The border, marked by a protection wall in the 19th-century, replaced by a urban highway in the 1960s and the 1970s (*Boulevard Périphérique*), is still present in the minds.[7] The city of Paris has been strongly renovated by Baron Haussmann[8] in the 19th century and is still very much organized according to the overall scheme defined and followed then. Conversely, the development and organization of the suburbs have been quite uncontrolled, which did not prevent the population from growing rapidly while it stabilized and eventually declined in the city center (see Table 1). The first proposals to guide and organize urban growth were presented in the 1930s[9] but were only partially put in place. The post-WWII decade is marked by the attempt to "contain" the Paris Region growth (Cottour, 2008), especially strong in an urban plan issued in 1960, called the PADOG[10]. This plan intended to limit urban development to the already built-up areas of the region. This central part should be reorganised and equipped, partly thanks to transportation infrastructures, while the rest of the region should remain unbuilt. At that time, the capital city was regarded as crowded, overdeveloped and its size and growth were seen as detrimental to the balanced development of the country. This sentiment was best summarized by the expression *Paris and the French desert* which refers to a French book by the geographer Jean-François Gravier, that was very influential in the (central) authorities in charge of regional development in France.

Table 1: Population decentralization in the Paris region

	Paris	Suburbs
1901	2,714,068	2,021,731
1946	2,725,374	3,872,556
1975	2,299,830	7,578,735
2006	2,181,371	9,351,027

Note: suburbs designate the *Île-de-France* region without Paris
Sources: Census (Insee)

The coming to power of President De Gaulle is a turning point in the planning policy for Paris. Given that preceding attempts to limit urban growth had proven quite inefficient, the Government decided to organize the scattered and under-equipped suburbs[11]. Urban policy for Paris changed from malthusianism to an open support to economic and demographic development. Following this idea, a new urban plan, the SDAURP[12] was presented in 1965 and included the redistribution of administrative boundaries, the

[7]Even today, the city of Paris is significantly denoted by the term *intra muros*.

[8]Prefect of the Seine Department between 1853 and 1870, which included Paris in until 1967.

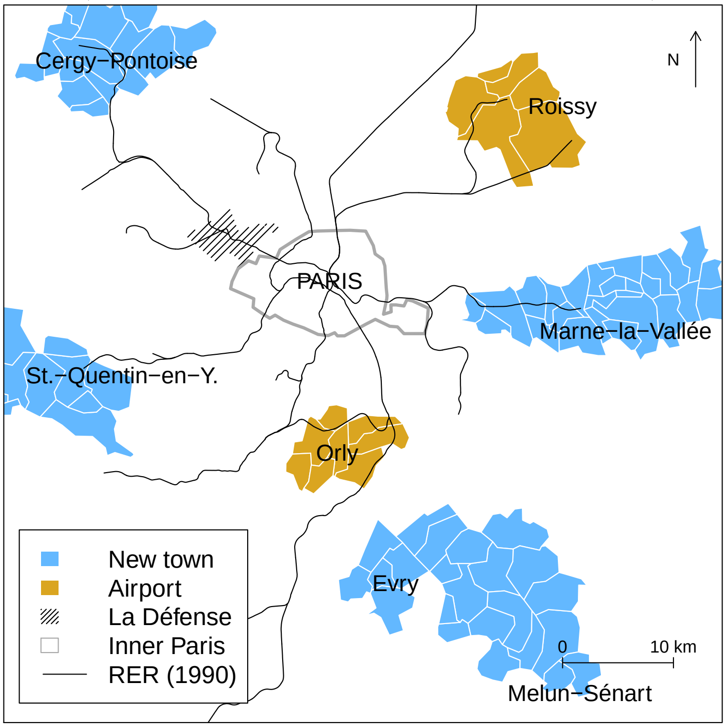
[9]The *Plan Prost* in 1932 for example.

[10]*Plan d'Aménagement et D'Organisation Générale de la Région Parisienne.*

[11]During a helicopter tour over the metropolitan area, President De Gaulle would even have ordered Paul Delouvrier, General delegate for the Paris region, to "Put this mess in order !"

[12]*Schéma directeur d'aménagement et d'urbanisme de la Région Parisienne.*

Figure 1: Economic subcenters of the Paris metropolitan region (new towns, airports and business district)



construction of new infrastructures, the decentralization of job and population in "new towns". New towns designate planned sub-cities located between 15 and 35 km away from the center of Paris in relatively underdeveloped areas. They were supposed to receive between 500,000 and 1,000,000 inhabitants and thus disperse the population over the Paris region, in order to reduce urban congestion. This SDAURP plan especially envisioned an ambitious commuter rail system, the so-called Regional Express Rail. The RER was supposed to upgrade the suburban train network by the construction of hundreds of kilometers of new lines crossing the historical core of Paris towards the new subcenters of the Paris metropolitan area: the new towns (*Marne-la-Vallée*, *Cergy-Pontoise*, *Saint-Quentin-en-Yvelines*, *Melun-Sénart* and *Évry*) the two airports (*Orly* and *Roissy*) and the business district of *La Défense* (see figure 1 and 2).

This ambitious project has been implemented in the two subsequent decades but in a more modest way that initially planned, due to a worsened economic situation and a political change in 1969. In the end, the RER project principally consisted in upgrading existing lines, connected together by tunnels under the historical city core of Paris. It also included the construction of new branch lines towards airports and "new towns" not connected by an existing line, the commissioning of new trains and higher frequencies (see figure 3). Concretely, only 71 of the 433 RER stations are fully new; 98 km of railways were built and 22 km were reopened out of a 600 km network. However, the five line network, progressively opened between 1969 and 2004, reaches the goals assigned by the 1965 plan to connect the new subcenters to the historical center of Paris.

Despite only few new track segments, the RER led to a significant improvement of the

Figure 2: RER projets in 1960 (PADOG plan) and 1965 (SDAURP plan)

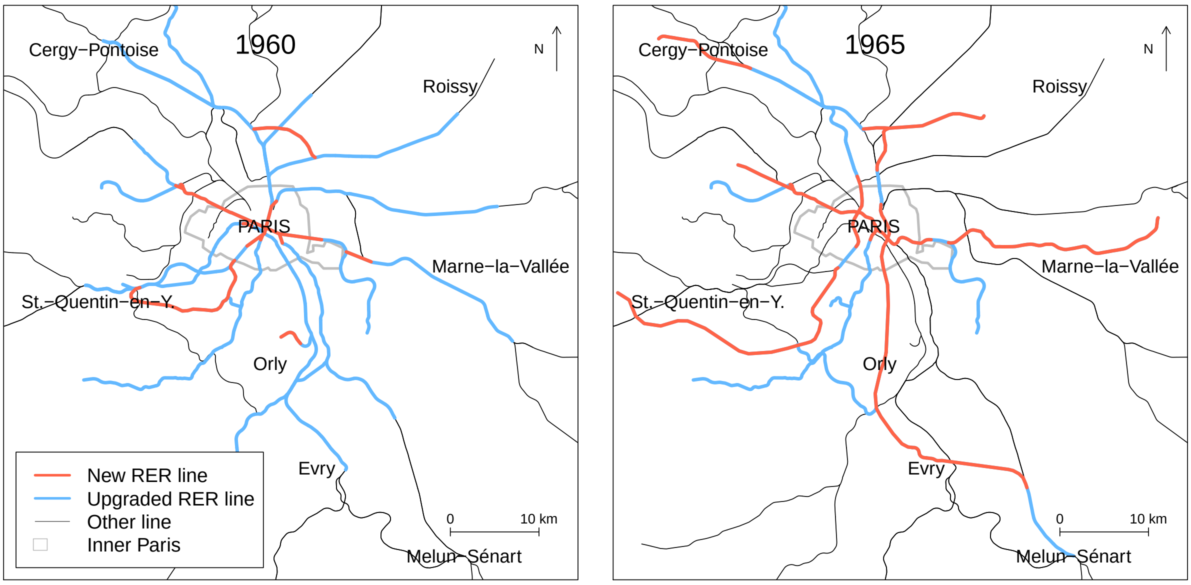
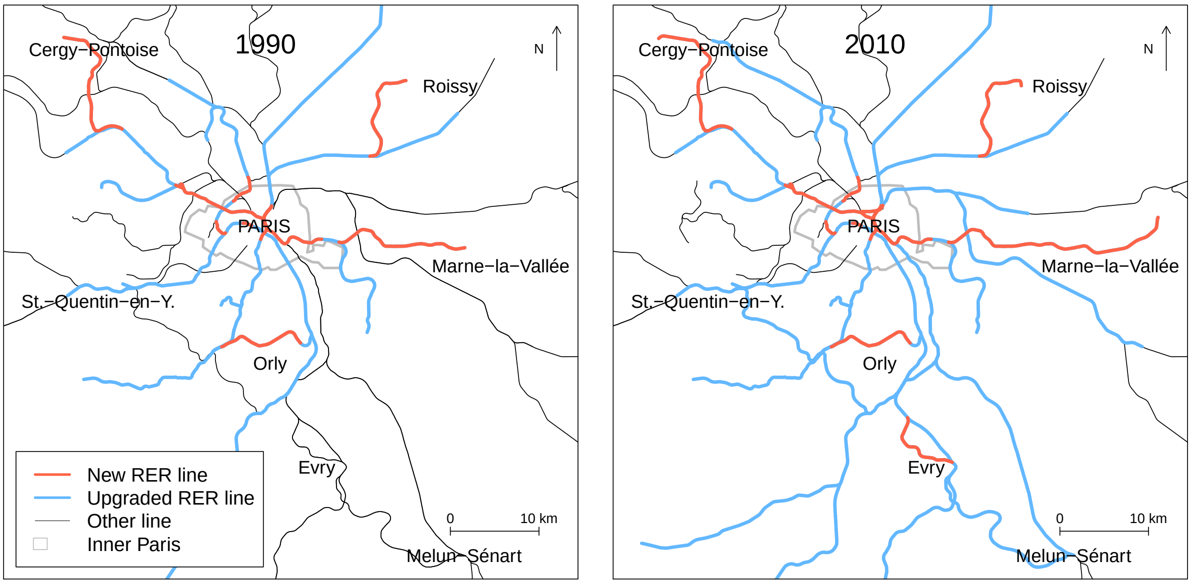


Figure 3: RER network in 1990 and 2010



commuter rail network and made commuting much easier (see figure 6 in the appendix for an example). According to our simulations, the mean travel time to Paris[13] was 49.9 minutes in 1969. Between 1969 and 2009 it decreased by 5.8 minutes for the municipalities connected to the RER while it decreased only by 1.3 minutes in the municipalities left apart from the new network. Thus, the RER offered about a 10 percent drop in commuting time for connected municipalities. This improvement may seem limited but the average effect hides a wide variety of situations. First, the journey time may only change for some neighborhoods. Second, some lines did not much improve the travel time because they almost exclusively used existing rail tracks.

2 Identification strategy

The issue of this study is to find an appropriate identification strategy that can address the endogeneity issue. A significant problem of transportation system evaluation is that new infrastructures are obviously not randomly located. To address the issue, we propose a method that uses only a subsample of municipalities within which the treatment can be considered as exogenous.

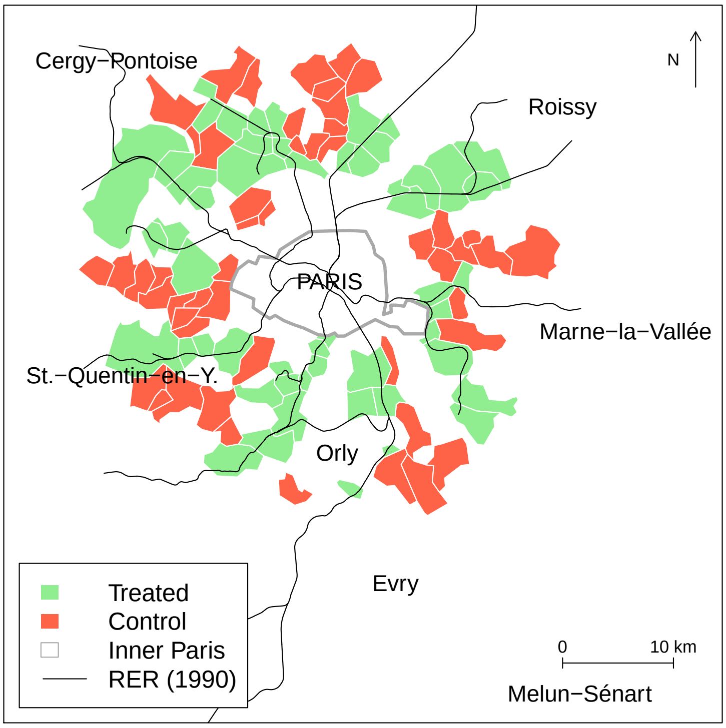
As new lines and new stations were actually rare, our empirical strategy focuses on existing stations. We build a control group containing some suburban train stations that were not connected to the RER in 1990 and we compare it to some stations that already existed in 1960 and that have been upgraded to RER stations later. This section describes precisely which stations we select to obtain an exogenous treatment, using four arguments: first, intermediate stations that are located in between Paris city center and new economic subcenters were upgraded "by accident"; second, after a long period of under investment the RER suddenly improved Paris suburban rail system in the 1970s, 1980s and 1990s; third, the initial plans and the actual RER network differ, which suggests there is no clear intention to treat in our regression sample; finally, RER lines were often selected for technical reasons.

2.1 Comparison of intermediate cities

The first point of the identification strategy focuses on intermediate cities. As stated above, the RER network has been implemented with the aim of connecting airports and new towns to the historical center of Paris. Consequently, RER lines happen to cross municipalities located in-between. We argue these municipalities have been connected to the RER network without intention to treat which is similar to the identification strategy of Banerjee et al. (2012). In addition, the RER project mainly consisted in the enhancement of the existing commuter train network. This means that the intermediate stations have mostly been built in the 19th century, thus leaving no possibility of RER route manipulation. Besides, urban planning policies were highly centralized until the 1982 decentralization law, which limited the influence of local authorities on the RER project definition.

[13] Travel time to Paris is the mean of the 20 minimum travel times to the 20 boroughs of Paris. In addition, we only consider the municipalities between 5 and 35 km from Paris which are the most likely to benefit from the RER, excluding the underground catchment area.

Figure 4: Control and treatment groups



In our regressions, we only consider municipalities with at least one commuter rail station in 1960. We first exclude termini areas from both control and treatment groups as they might have been explicitly targeted by the RER policy. By termini areas, we mean the historic city of Paris and municipalities which are part of a new town, host an airport or the business district of "*La Défense*" (see figure 4). Treatment is clearly not exogenous in these cases. In addition, it is impossible to find a proper counterfactual for these municipalities. In fact, there is no new town, airport, historic city center or business district which have not been connected to the RER in the Paris metropolitan region. Municipalities connected to the underground network are also removed because it is not possible to use our identification strategy for them, that is to say a strategy based on intermediate municipalities. After that first step, our subsample contains municipalities with at least one suburban train station in 1960 which belong neither to the historical city center nor to a new economic subcenter. Among these stations, some were upgraded and connected to the RER network because they were located on the path between the historical city center and new economic centers or because of technical reasons, which is confirmed by numerous project changes. We logically use this first type of stations as a treatment group. On the opposite, other municipalities, which were still served by commuter train but not by the RER, are used as a control group. Finally, we only include the inner ring of Paris suburbs (municipalities located within 20 km from Paris) in our sample because outer ring municipalities were often rural in the 1960s. Table 9 in the appendix shows that there is no significant difference in the employment growth of control and treatment groups before the RER implementation, providing support for the exogeneity of the treatment.

Furthermore, we argue that the location of the new economic centers in the Paris metropolitan region is exogenous. Indeed, the initial 1965 project mentioned the construction of eight new towns while only five have been actually built. Moreover, experts of that process (Alduy, 1983) insist on the fact that they were located in mostly rural areas and not in already developed places. The Orly airport has been established on a WWI military base. The Roissy airport has been located in a large agricultural land plot. Consequently, it is very unlikely that the location of these subcenters (airports and new towns) have been determined to facilitate the connection of intermediate cities to the RER.

2.2 Underinvestment in suburban rail until the 1970s

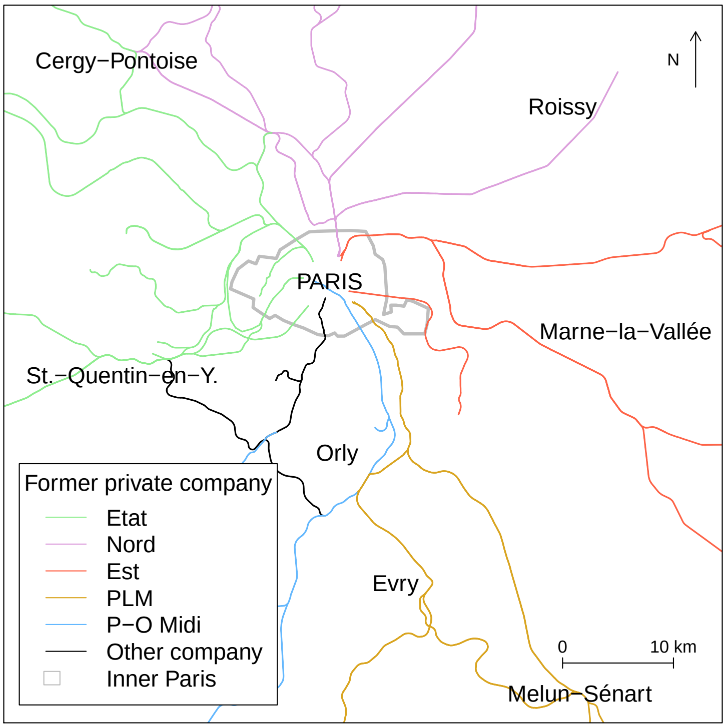
After a long period of underinvestment in suburban rail, the introduction of the RER offers a rapid and unprecedented improvement of the Paris mass transit system. The French railways have been mostly built during the 19th century by private companies. Each company was in charge of connecting a specific part of France to Paris. This institutional context results in a highly centralized network: the majority of lines are directed towards Paris and circular tracks are scarcer than radial ones, especially in the Paris region. In addition, networks of different companies were hardly connected and each of them ended in a different terminal station in Paris (see figure 5), even after merging the private companies in a unique public company in 1938. Consequently, it was not possible to go across Paris by train. A very dense and efficient subway system was built between 1900 and WWII, but it only served the city center. Contrary to certain initial projects[14], the subway was not connected to the existing railway lines serving the suburbs, because the Paris city council pushed for this solution against these connections in order to limit urban sprawl (Gerondeau, 2003). Consequently, commuting from one suburb to an other required a train change and a metro connection (see figure 6 in the appendix for an example).

These initial decisions deprived the Paris region from an efficient suburban train system until the 1970s. However, rail seems to have played a big role in population decentralization in the second part of the 19th century and first part of the 20th century. Table 6 in the appendix shows an important correlation between the 20th century suburban train network and the population growth in the inner ring of the Paris region. The deficient mass transit system raised many proposals in the 1920s and the 1930s aiming at connecting isolated lines by building railway tunnels through the city of Paris and the suburbs (Larroque et al., 2002). If the first extensions of the subway to the suburbs were actually built in the 1930s, almost nothing was done at this period for the suburban rail system.[15] After WWII, which logically stopped rail projects, a new suburban train system for Paris was regularly mentioned, without being actually started. The principle that investments should be redirected from the overdeveloped capital city towards the rest of the country probably hampered such plans. After a long period of inaction, several plans for new transport system have been proposed in the 1960s. These projects resulted in the RER construction from the the 1970s to the 1990s. This rapid enhancement of the

[14]For example, the Haag project in 1887.

[15]Except for the electrification of the Sceaux line in the south part of the Paris region.

Figure 5: Paris suburban train network in 1960



Note: the map shows the passenger rail network in 1960. It also indicates the former private company which owned each line before the nationalization of the network in 1938. News towns and airports are reported on the map but did not exist at that time.

Paris suburban rail system offers a good opportunity to evaluate the impact of transport infrastructure at a metropolitan scale.

2.3 Differences between plans and realisations: political and budgetary reasons

The first substantial plan for suburban mass transit is included in the PADOG plan issued in 1960 (see figure 2). It summarises the previous projects and proposes the digging of several tunnels through Paris in order to connect isolated suburban railway lines. The plan is rapidly followed by the civil work start for the East-West line in 1961. However, the PADOG clearly intended to contain the urban development of the Paris region within already built-up areas in order to stop the population growth. However, this central part should be reorganised and equipped, partly thanks to rail and road infrastructures, to respond to the saturation of the Paris region. This malthusian plan was logically not in line with the ambitions of President De Gaulle for the Paris region. The SDAURP plan of 1965 consequently envisioned a much more ambitious commuter rail system, the so-called Regional Express Rail (see figure 2). The RER was supposed to upgrade the suburban train network by the construction of hundreds of kilometers of new lines crossing the historical core of Paris towards the major subcenters of the Paris metropolitan area (the new towns, the two airports and the business district of *La Défense*). The implementation of the RER has been more modest than projected in the 1965 plan and closer to the 1960 one. Zembri (2006) shows that the election of President Pompidou after the resignation of President De Gaulle in 1969 played a major role in the way the RER was implemented. The cost of the projected new lines was the first reason to review the initial project. The new administration considered it was possible to achieve similar goals by partially using the existing network. Consequently, the SDAURP has been deeply modified and the construction of new lines has been far rarer than envisioned in 1965.

We noticed substantial difference between the 1960 PADOG plan, the 1965 SDAURP plan and the built network (see figures 2 and 3). Consequently, there is hardly any line which would not be included in at least a RER project or in the current RER network. In other words, almost all municipalities of our subsample could have been treated. The differences between the PADOG plan and the built network are due to the construction of the five "new towns". The differences between the 1965 SDAURP plan and the built network are due to the 1969 political change. Such changes in the RER program suggest that long-term economic anticipations did not play a central role in the choice of RER routes except for new subcenters. It would be surprising that development perspectives change so rapidly when considering the construction of a transport infrastructure designed to last more than one century. On the contrary, they are more consistent with non-economic factors: political change and shifts in urban policies.

2.4 Differences between plans and realisations: technical reasons

Looking at figure 3, we notice that some RER lines were not built towards the new economic subcenters we mentioned before. Related to that point, Collardey (1999) details many technical reasons which explain the selection of RER lines amongst suburban rail lines. First, some lines were totally out of date and needed a major improvement[16]. Second, three stations in Paris required an underground extension, and were logically connected to the RER in order to relieve traffic congestion.[17] Third, Gerondeau (2003) interestingly describes the difficult relationships between the two public companies in charge of Paris suburban train network, RATP and SNCF. RATP, the subway company, envisioned the RER project as a regional subway which would be independent of the SNCF suburban network. The first two lines and the SDAURP plan of 1965 have been planned according to this idea and consequently required the SNCF to sell local lines, without any main-line traffic, or to build brand new lines. Indeed, the only lines which are mentioned in both the 1960 and 1965 plans, and which have been actually connected to the 1990 RER network, are three local lines.[18] The 1969 political change led to a shift in the project. RER had then to be an interconnected network, meaning that trains should

[16]For example, the Vincennes line which serves the south east part of region, was still served by steam-engine trains in 1969. A previous improvement plan had been postponed by WWII, which explains why this line was prioritized in the RER project.

[17]In Austerlitz station, suburban train interfered with main-line traffic when crossing the station, St-Lazare station was the first station in terms of suburban traffic, free surface railway tracks were needed in Lyon station for high speed rail.

[18]The Vincennes line, the Sceaux line and the Saint-Germain-en-Laye line

be able to run on both RATP and SNCF tracks and connect stations belonging to both networks. This institutional context is important for us, because it enables certain railway lines to be upgraded, which was not possible during the first phase of the program. All in all, technical reasons are logically independent of economic growth and thus strengthen our exogeneity hypothesis.

3 Econometric method

In this section, in accordance with our identification strategy presented in the previous section, we present the estimator used to measure the effect of the RER on firm location, employment and population.

We aim to estimate the causal effect of a RER station opening in a municipality on employment, population and firm location. In this section, we describe a very simple difference-in-difference method to compute this causal estimate by comparing treatment and control groups. Our baseline estimates cover the 1975 to 1990 period. Considering the fact that the RER network progressively spread over the Paris metropolitan region, the treatment group enlarges over time while the control group becomes smaller (see figure 4). Consequently, there are too few municipalities in the control group in the inner ring after 1990 and it is impossible to use our identification strategy after that date. As major network improvements were put into service in the 1970s and the 1980s, this time restriction should not prevent the estimation of a treatment effect.

$$\Delta \ln Y_{i,75\to 90} = \delta \mathrm{RER}_{i,75\to 90} + \beta X_{i,1975} + \epsilon_i \tag{1}$$

The dependent variable is the growth rate in population, employment or count of firms (Y) in municipality i between 1975 and 1990, $\Delta \ln Y_{i,75\to 90} = \ln Y_{i,1990} - \ln Y_{i,1975}$. We regress this variable on the treatment which equals one only if the municipality is connected to the RER network between 1975 and 1990[19]. We also add initial socio-demographic and geographic controls X_i: initial density of the considered variable, distance to Paris, geographic dummies (North, South, East or West of Paris), and measures of alternative transportation infrastructure (highways, and commuter train for some specifications). Finally, we exclude forests and water areas to calculate the area of the municipalities, considering this type of area is very unlikely to be urbanized. We also exclude the rare municipalities with changing boundaries.

Table 2 shows some discrepancies between control and treatment groups. Note that these discrepancies are larger at more than 20 km from Paris, while they are quite limited in the inner ring. Such differences are due to small rural municipalities of the outer ring, which are unlikely to be treated. Consequently, we only consider municipalities located within 20 km, avoiding this possible selection bias in the urbanized inner ring. Control and treatment groups always refer to such municipalities in the rest of the paper. Finally, treatment summary statistics are difficult to interpret. Between 1968 and 1975, the job growth rate is higher for untreated municipalities compared to treated ones. It is due to the fact that control group municipalities are smaller and grew more rapidly because of a catch-up phenomenon. However, in the subsequent period, job growth rate is similar in both groups which can be due to the effect of the treatment.

[19] Alternative time spells and variables are tested as robustness tests, see part 5.3.

Table 2: Comparison of control and treatment groups: mean values and standard deviations

	< 20 km from Paris		*> 20 km from Paris*	
	Untreated	Treated	Untreated	Treated
Pop. density in 1975 (people per sq. km)	4686 (3500)	6370 (2703)	1237 (1377)	2119 (1244)
Empl. density in 1975 (worker per sq. km)	1382 (1468)	1881 (1405)	280 (405)	640 (677)
Firm density in 1975 (firm per sq. km)	151 (155)	180 (104)	27 (27)	53 (42)
Travel time to Paris in 1975 (minutes)	46 (7)	42 (5)	58 (9)	54 (7)
Distance to Paris (km)	14.6 (3.6)	13.3 (3.3)	28 (4.3)	25.3 (4.2)
Surface (sq. km)	4.7 (2.5)	6 (4.2)	5.5 (3.1)	6.6 (3)
Job growth rate 1968-75 (in pct)	0.15 (0.42)	0.111 (0.265)	0.29 (0.672)	0.457 (0.446)
Job growth rate 1975-90 (in pct)	0.259 (0.589)	0.184 (0.368)	0.446 (0.639)	0.298 (0.406)
Number of municipality	50	51	57	23

Sources: Census 1975, Sirene 1975 (Insee).

Note: treatment status in 1990. Standard deviations in parenthesis.

We investigate further on those differences in the appendix Table 7, where we regress dummy variable indicating the presence of a RER station on the characteristics of the city. It appears that a large portion of the differences between treatment and control can be attributed to physical geography: area, altitude and distance to Paris are the main determinants. RER lines were designed to connect the center of Paris to remote economic subcenters. Accordingly, the larger is the municipality and the closer to Paris is a city, the greater is the chance to be on the straight line between Paris and a subcenter and thus the larger is the probability to be treated. Since large and central cities are more populated, discrepancies between control and treatment group are not inconsistent with the exogeneity of treatment. In the most naive specifications, coefficients associated to the population density in 1975 are significant predictors of the number of RER stations in a municipality. However, those variables lose impact and statistical significance in the inner ring[20] when introducing the area of the municipality, the distance to Paris and the maximum altitude, providing support to our strategy. In addition, we do not select municipalities within 5 km from Paris to ensure that both groups contain all types of municipalities and to exhibit a sample for which the common support condition holds (see figure 2).

Finally, an important caveat should be added regarding interpretation of the results. There may actually be two effects of RER station openings: attractiveness and dis-

[20]The coefficient associated with the lowest population density, under 1 000 inhabitants per squared kilometer, is still significant; only 6 municipalities on 101 are in this situation. It indicates that the less populated municipalities, in the rural fringes of the metropolitan area, have been neglected in the implementation choice of the RER.

placement. If employment rises due to increased attractiveness, untreated municipalities should not be affected. In that case, the RER network increases employment or the total count of firms in the whole region. On the contrary, if employment increases in a treated municipality because of a displacement effect, it necessarily implies a decrease for other municipalities, and even potentially municipalities belonging to the control group. Obviously, the reality is most likely in between. To discriminate between the two effects in the case of firm location, Schmidheiny and Brülhart (2011) suggest the use of a nested logit model in order to separate the respective share of relocation and attractiveness. The estimation of such a model requires considering outside options for individual firms (for example, the rest of France and other European countries). We leave this more ambitious exercise to future research and note that focusing on effects inside the Paris area makes it challenging to isolate the two effects rigorously.

4 Data

We use data at the municipality level from different sources to provide information on firm counts, employment and population. We also build a new dataset to precisely describe the evolution of the urban transportation system between the 1970s and the 2000s. Municipality is the most accurate geographical scale available since more precise data are computed only from the 1990s. However, French municipalities are particularly small in comparison with other European countries. The Paris metropolitan region contains 1300 municipalities which is an adequate geographical scale for this type of estimation. Finally, there are 101 municipalities in the regression sample (see figure 2).

Concerning firms, we use the French administrative business register "Sirene" between 1974 and 2004. It provides exhaustive information on the industry, the location at a municipality level, the opening and closing years. We aggregate firm counts at the municipality level, year by year. We also use information on foreign investment over the period under study. Until the 1990s, foreigner investors had to register every investment in France at the French Treasury. A dataset of foreign direct investment (FDI) has been computed using this administrative requirement. So, we have data on shareholding including the nationality of the stakeholder and the proportion of capital held by foreigners. As this compulsory registration has been phased out in the 1990s, reliable data on FDI are available only until 1994. Finally, we use census data to assess population level, employment and the social composition of municipalities at each census year (e.g. 1968, 1975, 1982, 1990 and 1999).

Our first treatment variable is the most simple one: the presence of a RER station in the municipality. However, this basic variable may not fully account for the better train service due to the RER: higher frequency, new trains, new lines. To test the robustness of our approach, we also use alternative variables: the number of RER stations in the municipality, the share of the municipality within 1 km from a station and the travel time decrease. These variables are more precise and can thus give a better information on the improvement of transport service quality. However, all this variables are aggregated at the municipality scale, while they only affect economic agents located in the vicinity of a station. Consequently, the results are more difficult to interpret because we do not know exactly who benefit from such improvements. Indeed, in a given municipality, there are both treated (in the catchment area of a RER station) and untreated (in other parts of the municipality) economic agents. In other words, a higher number of RER stations or a greater reduction of travel time do not necessarily imply a transport service improvement of same magnitude, at the municipality scale. Besides natural measure of the improved quality of the network would be the increased frequency of trains, which played a big role in the improvement of the Paris commuter train system. Unfortunately, it seems impossible to find such data over a long period of time.

To measure the evolution of the journey time, we use the reduction of travel time. To build this variable, we make the significant assumption that RER did not increase the speed of trains. This assumption is likely to hold as a big part of the electrification of the commuter train network was completed several years before. Consequently, the measured variation of the journey will be due to the connection of isolated lines. Concretely, we consider the commuter train and metro networks as one graph. The train and metro stations are the nodes of this graph. In the same way, the lines which link the stations are considered as the edges of this graph. We apply a simple shortest path algorithm to calculate the journey time between two stations of the transportation system. To compute this journey duration for a given year, we remove edges corresponding to lines opened after this date. We thus obtain a matrix of travel duration between every station of the transportation system, year by year, from 1969 to 2009. We aggregate the matrix in a single variable which is the mean of the travel time to the 20 districts of the city of Paris. This variable, hereafter, the mean travel time to Paris, is a good summary of the transportation system as the network is highly centralized towards Paris. We consider the travel time to all districts of Paris. Indeed, the RER consisted, inside Paris, in the digging of four tunnels to connect isolated lines. The travel time to the closest districts may thus not have decreased while a new tunnel may allow a better connection, and thus a lower travel time, to more districts neighborhoods.

To take into account the rapid development of road transportation in the Paris metropolitan region, we also control for the access to the highway network. Indeed, highway construction is not generally and uniformly distributed among Paris metropolitan region. Car-based accessibility is improved in some municipalities while it is stable in other. We do not want highway construction to bias RER effect estimation. More precisely, for a given municipality, we create a dummy which equals one if the nearest highway is less than 1 km away.

5 Results

5.1 The RER effect on employment

Table 3 provides our benchmark results on employment growth. The first column presents the most naive way to estimate the parameter of interest: all municipalities are included except for the most central part of the Paris region, very urbanized and connected to the dense subway system. We also control for some basic characteristics of the municipalities. A dominant feature of the city-level growth in the Paris area seems to be the catching up, since the effect of initial job density declines steadily with the level of density. A second salient and probably related result is the strong influence of highways on employment growth. This suggests that this growth of initially low density cities was helped by the strong rise in car equipment and motorway density in this period. However, this phenomenon is unlikely to bias the estimation of RER effect: RER station location and highway location appear unrelated (see table 7 in the appendix). The effects of RER and suburban train are not statistically significant in this naive specification, while the order of magnitude of the RER variable is of very comparable magnitude as in the following columns. This suggests to restrain the control group to those cities which already had a train station at the beginning of the period. When comparing RER stations only to other suburban train stations in column (2), we obtain a positive and significant impact of 9.1%. Besides, this column shows that the economic subcenters of the Paris metropolitan region (e.g. new towns, business districts and airports) grew extremely rapidly between 1975 and 1990. Excluding these subcenters in column (3) slightly decreases the coefficient associated to the treatment at around 6.3% which becomes insignificant. It may indicate that employment growth is higher in municipalities which were explicitly targeted by the RER program, suggesting that ignoring the endogeneity issue leads to overestimate the treatment impact. The result of our preferred identification strategy is reported in column (4): the growth of employment between 1975 and 1990 is 12.8% higher in municipalities connected to the RER, compared with the growth rate that would have prevailed in the absence of new infrastructures. Note that we find no significant effect further away from Paris, where there were only 23 municipalities with a RER station in 1990.

5.2 Different tastes for accessibility

We now turn to the effect of RER on firm counts and across sectors for employment. Table 4 indicates that the positive effect of the Regional Express Rail is also valid for firm location choices. We note that the estimated impact on the number of firms is very similar to the one obtained for employment. Looking at the effects on foreign-owned firms, striking differences arise. First, initial density does not seem to exhibit the same catch up effect as in column (1). Second, the RER treatment effect is much larger in magnitude, but less significant, for this set of firms and reaches 32%, suggesting that mass transit affects foreign firms more intensely than local ones. It is also to be noted that highways also have a much stronger impact. Therefore, transport infrastructure, and access to the city center seem dominant determinants for foreign investors. The last three columns show the effect of the RER on the industry specialization of the city, broken down between construction, manufacturing and services. The point estimate is similar across industries. Under such conditions, we can not conclude that RER caused a shift in industry composition in treated municipalities.

Table 5 reports results for the overall population growth. While we find in general no significant effect on the population growth, we find suggestive evidence of a gentrification effect. We do not observe either income or housing prices at the city level in the 1970s and the 1980s. Given this data limitation, the skill level of the population can be considered as an acceptable first approximation. We break down the population into three categories: low-skilled (junior high school and lower), middle-skilled (senior high school and vocational education) and high-skilled (college diploma and higher). We find a slight but significant impact of the RER only on the high-skill population. It could suggest that accessible areas became more attractive for households that are likely to pay more for their housing: only wealthy households could afford to stay or move in these areas

Table 3: Effect of RER on employment at the municipality level

	(1)	(2)	(3)	(4)	(5)
Dependant variable:			$\Delta \ln$ employment$_{1975-90}$		
Sample restriction:					
Train station in 1975		✓	✓	✓	✓
No economic subcenters			✓	✓	✓
Distance to Paris	5-35 km	5-35 km	5-35 km	5-20 km	20-35 km
Intercept	0.216^{*} (0.115)	0.404^{***} (0.104)	0.42^{***} (0.1)	0.378^{***} (0.103)	0.345^{*} (0.191)
RER$_{1990}$	0.199^{**} (0.087)	0.091^{**} (0.046)	0.063 (0.042)	0.128^{***} (0.044)	-0.021 (0.09)
Train station $_{1990}$	0.086^{*} (0.049)				
Highway$_{1990}$	0.166^{***} (0.056)	0.056 (0.051)	0.087^{*} (0.052)	0.082 (0.052)	0.023 (0.099)
$5km \leq d_{Paris} < 10km$	0.029 (0.08)	0.096 (0.064)	0.057 (0.07)	0.055 (0.075)	
$10km \leq d_{Paris} < 15km$	ref.	ref.	ref.	ref.	
$15km \leq d_{Paris} < 20km$	0.083 (0.057)	0.021 (0.058)	0.007 (0.055)	0.02 (0.053)	
$20km \leq d_{Paris} < 25km$	0.16^{*} (0.097)	-0.081 (0.081)	-0.143^{*} (0.077)		0.017 (0.111)
$25km \leq d_{Paris} < 30km$	-0.04 (0.095)	-0.109 (0.102)	-0.126 (0.092)		ref.
$30km \leq d_{Paris} \leq 35km$	-0.196^{*} (0.104)	-0.214 (0.139)	-0.108 (0.134)		-0.068 (0.15)
Job density$_{1975}$ < 200	0.131 (0.086)	0.008 (0.102)	-0.039 (0.105)	-0.288 (0.267)	0.046 (0.124)
Job density$_{1975}$ $[200, 500]$	ref.	ref.	ref.	ref.	ref.
Job density$_{1975}$ $[500, 1000]$	-0.317^{***} (0.067)	-0.326^{***} (0.072)	-0.325^{***} (0.071)	-0.389^{***} (0.099)	-0.317^{**} (0.135)
Job density$_{1975}$ $[1000, 2500]$	-0.472^{***} (0.082)	-0.481^{***} (0.08)	-0.479^{***} (0.079)	-0.514^{***} (0.114)	-0.443^{***} (0.108)
Job density$_{1975}$ > 2500	-0.562^{***} (0.123)	-0.654^{***} (0.094)	-0.651^{***} (0.092)	-0.632^{***} (0.119)	-0.662^{***} (0.121)
Maximum altitude	-0.0008 (0.0006)	-0.0003 (0.0006)	-0.0002 (0.0005)	0.0006 (0.0005)	-0.001 (0.001)
South	0.184^{***} (0.069)	0.068 (0.07)	0.075 (0.066)	-0.042 (0.059)	0.218 (0.147)
West	0.191^{**} (0.079)	0.073 (0.078)	0.024 (0.073)	-0.026 (0.076)	0.089 (0.149)
North	ref.	ref.	ref.	ref.	ref.
East	0.306^{***} (0.077)	0.146 (0.09)	0.081 (0.083)	0.009 (0.066)	0.22 (0.175)
New town		0.523^{***} (0.147)			
Airport		0.067 (0.069)			
La Defense		0.471^{***} (0.123)			
Number of observations	483	209	181	101	80
R^2	0.176	0.35	0.27	0.447	0.18

Note: Standard errors in parenthesis. Significance levels: *** 1%, ** 5%, * 10%.

Table 4: Effect of RER on firms and employment by industry

Dependant variable:	Δ ln firm$_{75-90}$		Δ ln employment$_{75-90}$		
Sample:	All firms	Foreign firms	Manufac-turing	Construc-tion	Services
Intercept	-0.023	0.115	2^{***}	2.612^{***}	1.013^{***}
	(0.073)	(0.318)	(0.346)	(0.725)	(0.375)
RER$_{1990}$	0.102^{***}	0.315^{*}	0.138^{*}	0.14^{*}	0.124^{***}
	(0.035)	(0.161)	(0.072)	(0.084)	(0.046)
Highway$_{1990}$	0.073^{*}	0.287^{*}	0.241^{**}	0.083	0.055
	(0.04)	(0.161)	(0.107)	(0.082)	(0.051)
$5km \leq d_{Paris} < 10km$	0.01	-0.196	0.321^{**}	0.271^{**}	0.136^{*}
	(0.042)	(0.214)	(0.144)	(0.125)	(0.075)
$10km \leq d_{Paris} < 15km$	ref.	ref.	ref.	ref.	ref.
$15km \leq d_{Paris} < 20km$	0.037	0.038	-0.066	-0.071	0.06
	(0.053)	(0.193)	(0.128)	(0.115)	(0.053)
Maximum altitude	-0.0002	0.001	0.0008	-0.0008	0.0004
	(0.0005)	(0.002)	(0.0009)	(0.001)	(0.0006)
South	-0.02	0.175	-0.22^{*}	-0.138	-0.061
	(0.045)	(0.171)	(0.129)	(0.111)	(0.065)
West	0.108^{*}	0.147	-0.05	-0.095	-0.06
	(0.057)	(0.217)	(0.157)	(0.136)	(0.075)
North	ref.	ref.	ref.	ref.	ref.
East	-0.011	0.185	-0.073	0.034	0.042
	(0.047)	(0.241)	(0.114)	(0.118)	(0.072)
Firm density$_{1975}$ < 50	0.532^{***}	1.035			
	(0.133)	(0.659)			
Firm density$_{1975}$ $[50, 100]$	0.439^{***}	0.155			
	(0.098)	(0.402)			
Firm density$_{1975}$ $[100, 200]$	0.221^{***}	0.334			
	(0.078)	(0.313)			
Firm density$_{1975}$ $[200, 500]$	0.104	0.082			
	(0.07)	(0.248)			
Firm density$_{1975}$ >500	ref.	ref.			
Job density$_{1975}$ < 200			-0.081	-0.96^{*}	-0.412
			(0.259)	(0.54)	(0.263)
Job density$_{1975}$ $[200, 500]$			ref.	ref.	ref.
Job density$_{1975}$ $[500, 1000]$			-0.421^{*}	-0.121	-0.196^{*}
			(0.231)	(0.161)	(0.114)
Job density$_{1975}$ $[1000, 2500]$			-0.182	0.066	-0.277^{*}
			(0.285)	(0.217)	(0.149)
Job density$_{1975}$ > 2500			-0.12	0.275	-0.25
			(0.289)	(0.291)	(0.184)
log manufacturing$_{1975}$			-0.395^{***}		
			(0.065)		
log building$_{1975}$				-0.558^{***}	
				(0.16)	
log services$_{1975}$					-0.101
					(0.071)
Number of observations	101	88	101	101	101
R^2	0.532	0.266	0.538	0.431	0.361

Note: Standard errors in parenthesis. Significance levels: *** 1%, ** 5%, * 10%. All regressions are run on cities that had a train station in 1975, excluding economic subcenters and located between 5 and 20 kms away from Paris.

or wealthy households have a higher taste for public transport-based accessibility. Given that the inner ring was already widely urbanized in the 1960s (see Table 2), especially in the vicinity of suburbain train stations (see Table 6), a global population growth would have required to densify treated municipalities. Contrary to this idea, previous studies on French housing market highlight a low supply elasticity on the housing market (Grislain-Letrémy and Trevien, 2014), suggesting that the RER is unlikely to increase the total stock of housing in previously developed places.[21] Consequently, our results suggest that the increased accessibility resulted in a population displacement effect: a shift toward more wealthy residents around new stations.

5.3 Robustness checks

The central assumption of difference-in-differences is that the control group and the treatment group would have grown by the same amount in absence of the treatment. To test for the common trend assumption, we provide a placebo test. Concretely, we test our model on the 1968-1975 period to be sure there is no ex-ante trend gap between groups. The placebo test gives support to our identification strategy as we do not find any significant difference between the control and treatment group for both strategies before 1975 (see table 9 in the appendix). It also shows that the RER did not induce significant anticipation effects on firms. We would need data on an annual basis to ensure that there is no treatment effect in the immediate years before a station opening. However, we note once more that our identification strategy is more reliable in the inner ring than in the outer ring. Concretely, the effect of RER is close to be significant at more than 20 km from Paris on the 1968-1975 period, while the point estimate is very close to zero on the subsequent period. This could be due to the fact that small and rural municipalities have a higher volatility in the growth rate of employment.

Table 10 presents the results of the model tested on alternative interest variables. The first two columns decompose the treatment effect between the 1975-1982 and 1982-1990 periods. We find a stronger impact in the second period, that can be due to a certain delay in job location, for example related to the time required for office building construction. However, the sum of the two coefficients is close to the effect we highlight fot the whole period. The third column indicates that the significant treatment impact still holds when considering the change in job density level instead of the log growth of jobs.

Table 8 (in appendix) presents the estimation of treatment effect using alternative treatment variables: the share of the municipality located within 1 km from a station, the number of stations in the municipality and the travel time decrease between 1975 and 1990. All variables yield significant results. Indeed, if the whole of a municipality is located within 1 km from a RER station, the employment growth is 23.4% larger. Besides, employment increases by 10.5% with an additional station and by 2% when journey time to Paris decreases by one minute. This implies that employment grows respectively by

[21] This question would need to be linked with regulation of land use and building height, but here again lack of data makes rigorous investigation difficult.

13.6%, 13.6% and 9% in treated municipality using each alternative treatment variables.[22] These results are in line with our 12.8% baseline estimate and thus confirms the robustness of mass transit impact on employment.

6 Conclusion

The Regional Express Rail has been an important improvement of the Paris suburban train service. From 1969 to 2003, it progressively enhanced the mass transit system by connecting isolated lines, serving new economic sub-centers and introducing more frequent trains. This natural experiment allows us to estimate the impact of urban transit on population, firm and employment growth.

A classic endogeneity issue arises from the fact that transport infrastructures are not randomly located. We address this problem by comparing suburban trains stations, which existed before RER introduction. Among them, some were upgraded into RER stations and other were not, for reasons we document to be to a large extent exogeneous to their future growth. First, one of the main goals of the RER program was to connect the city center to the new economic subcenters (airports, the business district of *La Défense* and new towns). We restrict to municipalities located in between such places, arguing there is no intention to treat such municipalities crossed by the RER. Second, we use the sudden a improvement in the Paris suburban rail service from the 1970s to the 1990s after a century of inaction.

Third, the discrepancies between the 1960s' projects and the 1990s' network confirms there were no clear intention to connect some areas rather than others except for economic subcenters. Fourth, we explain that technical reasons, which are independent of local economic perspectives, partially determined the choice of the first RER lines. Treatment effect is consequently estimated by the direct comparison of control and treatment groups thanks to a difference-in-differences method.

We find that the opening of the RER increases employment by 12.8% in the 1975-1990 period at the municipality scale. In addition, a one-minute decrease in the travel time to Paris increases employment by 2% over the same period. We find similar results for firm location; they are even more substantial for foreign firms. On the contrary, we find no effect on population except for high-skill people, suggesting a different willingness to pay for accessibility depending on the type of economic agent. We exhibit a placebo test for both strategies, showing there were no significant differences between control and treatment groups before the RER introduction.

[22]Note that there are averagely 1.31 RER stations per treated municipality, that 58% of treated municipality area is located within 1km from a RER station in average and that travel time is reduced by an additional 3 minutes in treated municipalities.

Table 5: Effect of RER on population by level of education

Dependant variable:	Δ ln population$_{75-90}$			
Sample:	All	$\leq$ Junior high school	Senior high school and voc.	$\geq$ College
Intercept	-0.016 (0.05)	-0.435 (0.473)	1.398^{***} (0.468)	1.629^{***} (0.299)
RER$_{1990}$	0.017 (0.027)	0.05 (0.042)	0.036 (0.039)	0.097^{**} (0.047)
Highway$_{1990}$	0.053^{*} (0.028)	0.009 (0.032)	0.013 (0.039)	0.026 (0.047)
$5km \leq d_{Paris} < 10km$	-0.067^{**} (0.033)	-0.007 (0.051)	0.066 (0.049)	0.11 (0.075)
$10km \leq d_{Paris} < 15km$	ref.	ref.	ref.	ref.
$15km \leq d_{Paris} < 20km$	0.099^{**} (0.039)	0.135^{**} (0.051)	0.063 (0.053)	0.021 (0.066)
Pop density$_{1975}$ $[1000, 2500]$	0.153^{**} (0.063)	0.169 (0.105)	0.043 (0.107)	
Pop density$_{1975}$ $[2500, 10000]$	ref.	ref.	ref.	
Pop density$_{1975}$ > 10000	0.006 (0.032)	-0.017 (0.051)	0.027 (0.069)	
Maximum altitude	0.0001 (0.0003)	0.0002 (0.0004)	-0.0001 (0.0005)	0.0003 (0.0007)
South	0.017 (0.041)	-0.164^{***} (0.055)	-0.172^{***} (0.056)	-0.136^{**} (0.066)
West	0.027 (0.042)	-0.296^{***} (0.055)	-0.283^{***} (0.07)	-0.112 (0.077)
North	ref.	ref.	ref.	ref.
East	0.035 (0.041)	-0.017 (0.056)	-0.005 (0.048)	-0.037 (0.058)
log low-skilled$_{1975}$		0.017 (0.061)		
log medium-skilled$_{1975}$			-0.161^{**} (0.068)	
log high-skilled$_{1975}$				-0.19^{***} (0.067)
Number of observations	101	101	101	101
R^2	0.383	0.512	0.465	0.423

Note: Standard errors in parenthesis. Significance levels: *** 1%, ** 5%, * 10%. All regressions are run on cities that had a train station in 1975, excluding economic subcenters and located between 5 and 20 kms away from Paris. The regressions on skill level are run on the labor force.

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A Appendix

A.1 Estimates

Table 6: Correlation between train and population since the 19th century

Dependant variable:	log population density				
Year:	1846	1896	1946	1975	1990
Intercept	7.142*** (0.554)	8.57*** (0.578)	10.402*** (0.468)	10.748*** (0.4)	10.594*** (0.393)
Train station $_{1975}$	0.203 (0.126)	0.515*** (0.142)	0.681*** (0.124)	0.52*** (0.109)	0.477*** (0.106)
$5km \leq d_{Paris} < 10km$	0.25 (0.272)	0.527* (0.285)	−0.035 (0.211)	−0.261 (0.187)	−0.209 (0.191)
$10km \leq d_{Paris} < 15km$	ref.	ref.	ref.	ref.	ref.
$15km \leq d_{Paris} < 20km$	0.672*** (0.222)	0.449* (0.25)	0.269 (0.226)	0.294 (0.206)	0.365* (0.198)
d_{Paris}	−0.185*** (0.044)	−0.216*** (0.045)	−0.244*** (0.039)	−0.21*** (0.038)	−0.195*** (0.038)
Maximum altitude	0.002 (0.001)	−0.001 (0.001)	−0.004*** (0.001)	−0.003** (0.001)	−0.002** (0.001)
South	−0.055 (0.166)	−0.138 (0.17)	0.163 (0.159)	0.351** (0.148)	0.232 (0.149)
West	0.424*** (0.151)	0.374** (0.165)	0.304* (0.16)	0.357** (0.156)	0.285* (0.156)
North	ref.	ref.	ref.	ref.	ref.
East	−0.205 (0.17)	0.12 (0.197)	0.468*** (0.154)	0.563*** (0.138)	0.572*** (0.14)
Number of observations	178	187	193	193	193
R^2	0.384	0.531	0.652	0.593	0.546

Note: Standard errors in parenthesis. Significance levels: *** 1%, ** 5%, * 10%. Sample: all cities located between 5 and 20 kms away from Paris. Note: the population density in 1846, at the very beginning of the rail development in the Paris Region, was 20.3% higher in municipalities connected to the 20th century rail network. It means that stations have not been randomly located. The population density in 1946 was 68.1% higher in municipalities connected to the suburban train network, suggesting that rail framed the urban development and increased population concentration in the Paris Region.

Table 7: Determinants of municipality selection for RER treatment - logistic regression

	(1)	(2)	(3)	(4)
Dependant variable:	Presence of a RER station			
Distance to Paris:	5-20 km	20-35 km	5-20 km	20-35 km
Intercept	0.316 (0.428)	6.757*** (2.338)	0.296 (0.624)	11.944 (9.091)
Pop density$_{1975}$ < 1000	-13.599^{***} (0.478)	-14.161^{***} (1.086)	-2.159^{***} (0.802)	0.082 (1.221)
Pop density$_{1975}$ $[1000, 2500]$	-1.717^{**} (0.709)	-1.175 (0.907)	-0.018 (0.66)	1.761* (0.92)
Pop density$_{1975}$ $[2500, 10000]$	ref.	ref.	ref.	ref.
Pop density$_{1975}$ > 10000	-0.193 (0.672)	0.499 (1.118)		
Pop growth$_{1946-75}$	0.034 (0.136)	0.071 (0.151)	-0.104^{*} (0.059)	-0.146^{*} (0.076)
Highway$_{1990}$		0.568 (0.609)		0.465 (0.785)
Surface		0.115** (0.057)		0.106 (0.116)
South		0.687 (0.86)		2.846** (1.205)
West		-0.126 (0.684)		1.64 (1.268)
North		ref.		ref.
East		-1.124 (0.835)		-1.67 (1.571)
Maximum altitude		-0.014^{**} (0.007)		-0.011 (0.009)
$5km \leq d_{Paris} < 10km$		-3.288^{***} (1.152)		
$10km \leq d_{Paris} < 15km$		ref.		
$15km \leq d_{Paris} < 20km$		1.415 (0.962)		
$20km \leq d_{Paris} < 25km$				-0.945 (1.583)
$25km \leq d_{Paris} < 30km$				ref.
$30km \leq d_{Paris} \leq 35km$				2.756 (2.532)
d_{Paris}		-0.445^{**} (0.184)		-0.534 (0.386)
Number of observations	101	101	79	79
AIC	134	131	90	85

Note: Standard errors in parenthesis. Significance levels: *** 1%, ** 5%, * 10%. All regressions are run on cities that had a train station in 1975, excluding economic subcenters.

Table 8: Effect of RER on employment - other treatment variables

	(1)	(2)	(3)
Dependant variable:	Δ log employment$_{1975-90}$		
Intercept	0.552^{***} (0.126)	0.428^{***} (0.103)	0.362^{***} (0.106)
Municipality share within 1km from a RER station	0.234^{**} (0.1)		
Mun. share within 1km from an other train station	-0.285^{**} (0.121)		
Number of RER stations		0.105^{***} (0.037)	
Number of train stations		-0.052 (0.042)	
$\Delta time_{Paris\ 1975-90}$			-0.02^{**} (0.009)
Highway$_{1990}$	0.115^{**} (0.054)	0.086 (0.056)	0.079 (0.053)
$5km \leq d_{Paris} < 10km$	0.036 (0.084)	0.071 (0.073)	0.039 (0.068)
$10km \leq d_{Paris} < 15km$	ref.	ref.	ref.
$15km \leq d_{Paris} < 20km$	0.012 (0.052)	0.029 (0.057)	0.044 (0.056)
Job density$_{1975}$ < 200	-0.395 (0.265)	-0.341 (0.273)	-0.313 (0.269)
Job density$_{1975}$ $[200, 500]$	ref.	ref.	ref.
Job density$_{1975}$ $[500, 1000]$	-0.409^{***} (0.088)	-0.372^{***} (0.095)	-0.364^{***} (0.103)
Job density$_{1975}$ $[1000, 2500]$	-0.522^{***} (0.102)	-0.481^{***} (0.109)	-0.471^{***} (0.119)
Job density$_{1975}$ > 2500	-0.597^{***} (0.122)	-0.605^{***} (0.111)	-0.589^{***} (0.118)
Maximum altitude	0.0007 (0.0006)	0.0007 (0.0005)	0.0006 (0.0005)
South	-0.083 (0.064)	-0.083 (0.062)	-0.039 (0.06)
West	-0.006 (0.073)	-0.052 (0.076)	-0.034 (0.076)
North	ref.	ref.	ref.
East	-0.03 (0.066)	-0.033 (0.063)	-0.034 (0.06)
Number of observations	101	101	101
R^2	0.501	0.463	0.436

Note: Standard errors in parenthesis. Significance levels: *** 1%, ** 5%, * 10%. All regressions are run on cities that had a train station in 1975, excluding economic subcenters and located between 5 and 20 kms away from Paris.

Table 9: Effect of RER on employment - placebo tests

	(1)	(2)	(3)	(4)
Dependant variable:	Δ log employment$_{1968-75}$			
Distance to Paris:	5-20 km	5-20 km	20-35 km	20-35 km
Intercept	-0.072 (0.123)	-0.053 (0.125)	0.139 (0.182)	0.153 (0.181)
RER$_{1990}$	0.059 (0.043)		0.079 (0.115)	
$\Delta time_{Paris\ 1975-90}$		-0.002 (0.007)		-0.002 (0.023)
Highway$_{1990}$	0.051 (0.047)	0.058 (0.048)	-0.067 (0.083)	-0.062 (0.083)
$5km \leq d_{Paris} < 10km$	0.088* (0.053)	0.077 (0.052)		
$10km \leq d_{Paris} < 15km$	ref.	ref.		
$15km \leq d_{Paris} < 20km$	0.029 (0.057)	0.033 (0.056)		
$20km \leq d_{Paris} < 25km$			0.328*** (0.106)	0.341*** (0.102)
$25km \leq d_{Paris} < 30km$			ref.	ref.
$30km \leq d_{Paris} \leq 35km$			0.067 (0.132)	0.069 (0.133)
Job density$_{1968}$ < 200	0.245 (0.162)	0.236 (0.162)	0.118 (0.104)	0.105 (0.102)
Job density$_{1968}$ $[200, 500]$	ref.	ref.	ref.	ref.
Job density$_{1968}$ $[500, 1000]$	0.068 (0.085)	0.084 (0.089)	-0.125 (0.136)	-0.132 (0.136)
Job density$_{1968}$ $[1000, 2500]$	-0.118 (0.102)	-0.09 (0.108)	-0.131 (0.119)	-0.124 (0.142)
Job density$_{1968}$ > 2500	-0.2^{*} (0.101)	-0.182^{*} (0.104)		
Maximum altitude	0.0003 (0.0006)	0.0002 (0.0006)	-0.001 (0.001)	-0.001 (0.001)
South	0.13** (0.063)	0.137** (0.064)	0.207 (0.148)	0.235* (0.135)
West	0.107 (0.082)	0.103 (0.083)	-0.006 (0.127)	-0.006 (0.126)
North	ref.	ref.	ref.	ref.
East	0.114* (0.064)	0.1 (0.065)	0.114 (0.17)	0.105 (0.17)
Number of observations	101	101	80	80
R^2	0.235	0.226	0.257	0.251

Note: Standard errors in parenthesis. Significance levels: *** 1%, ** 5%, * 10%. All regressions are run on cities that had a train station in 1975, excluding economic subcenters.

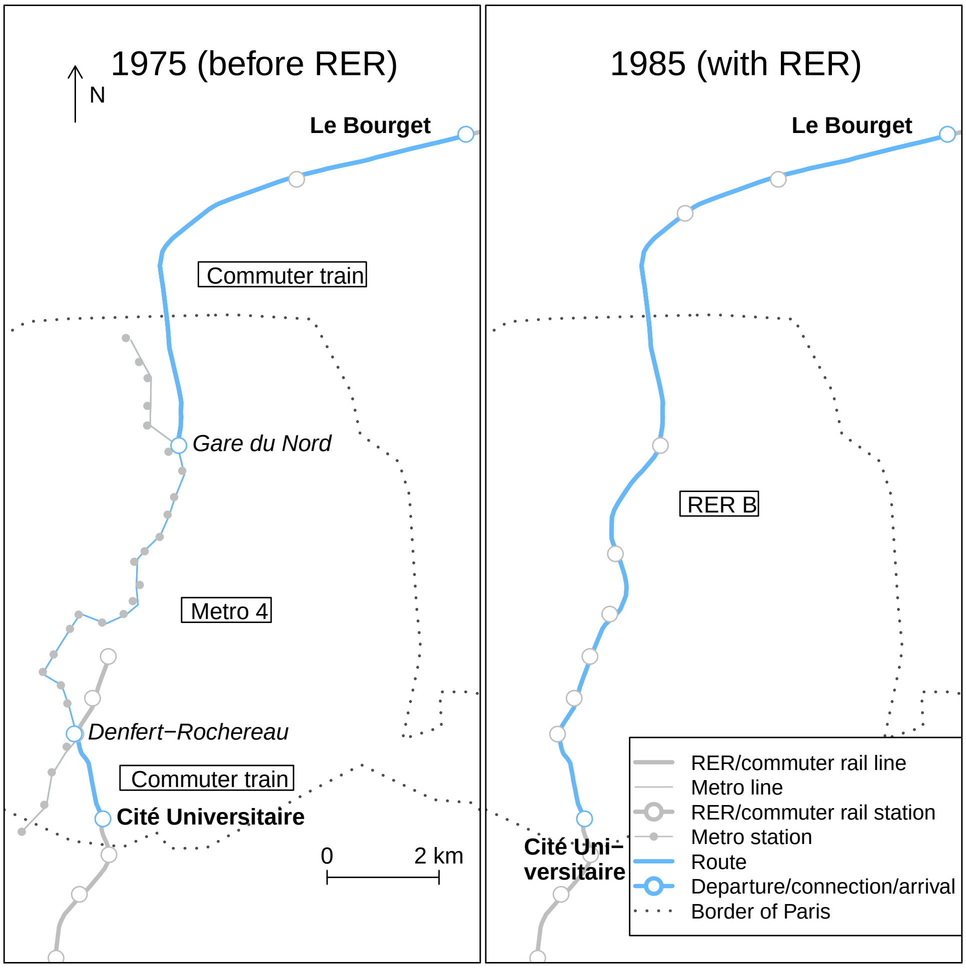
Table 10: Effect of RER on employment at the municipality level - alternative interest variables

	(1)	(2)	(3)
Dependant variable:	Δ ln job$_{1975-82}$	Δ ln job$_{1982-90}$	Δ job density$_{1982-90}$
Intercept	-0.154 (0.374)	0.098 (0.062)	-42.833 (143.438)
RER$_{1982}$	0.034 (0.036)		
RER$_{1990}$		0.072** (0.031)	201.124** (90.43)
Highway$_{1990}$	0.069 (0.045)	0.019 (0.029)	-22.359 (77.845)
$5km \leq d_{Paris} < 10km$	0.058 (0.059)	0.013 (0.05)	213.963 (237.623)
$10km \leq d_{Paris} < 15km$	ref.	ref.	ref.
$15km \leq d_{Paris} < 20km$	-0.013 (0.083)	0.004 (0.028)	-7.386 (62.47)
Maximum altitude	-0.0003 (0.0004)	0.0008*** (0.0003)	1.814** (0.821)
South	-0.047 (0.05)	-0.009 (0.039)	120.759 (116.739)
West	-0.031 (0.058)	-0.008 (0.039)	-16.826 (83.107)
North	ref.	ref.	ref.
East	-0.048 (0.039)	0.029 (0.043)	106.223 (142.997)
Job density$_{1975}$ < 200		0.074 (0.088)	-178.763 (113.249)
Job density$_{1975}$ $[200, 500]$	0.369 (0.313)	ref.	ref.
Job density$_{1975}$ $[500, 1000]$	0.123 (0.309)	-0.127^{**} (0.061)	-137.902^{*} (75.959)
Job density$_{1975}$ $[1000, 2500]$	0.079 (0.314)	-0.197^{***} (0.066)	-182.949^{*} (103.914)
Job density$_{1975}$ > 2500	-0.023 (0.313)	-0.22^{***} (0.076)	-673.754^{***} (245.442)
Number of observations	101	101	101
R^2	0.324	0.352	0.245

Note: Standard errors in parenthesis. Significance levels: *** 1%, ** 5%, * 10%. All regressions are run on cities that had a train station in 1975, excluding economic subcenters and located between 5 and 20 kms away from Paris.

A.2 Map

Figure 6: Example of the route between *Le Bourget* and *Cité Universitaire* with the RER



Note: before the commissioning of the RER, the journey between Cité Universitaire *and* Le Bourget *required two changes. First, you needed to take a commuter train station to the connection station* Denfert-Rochereau*. Then, you had to ride the metro line 4 to* Gare du Nord*. Finally, another commuter rail line led you to final destination,* Le Bourget*. Thanks to the RER, it is possible to cross Paris from* Cité Universitaire *to* Le Bourget *without any connection, instead of two connections before, which lowers the journey time from 45 to 26 minutes.*