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Intermodal competition: studying the pricing behavior of the French Rail Monopoly

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1. Introduction

In France, the railway national passengers' transport is still characterized by a monopoly. This monopoly is set by the orientation law on domestic transportation (Loi d'Orientation des Transports Interieurs) of 1982 which gave Société Nationale des Chemins de Fer (SNCF) the exclusive right to operate the domestic railway network.[1] Competition is however possible on freight transportation and international passengers' transportation since 2004 and 2009.[2]

Since the national railway company is still the only company providing domestic railway transportation, one could expect that SNCF's pricing behavior will be the one of a monopoly. However, two reasons prevent SNCF to act as such. First, if there is no intramodal competition, there is for certain service a strong intermodal competition of air and road transportation. Second, train tickets' prices are not totally freely set by SNCF. The French state regulates these prices for public service reasons.[3]

This article analyses SNCF's pricing behavior on most of the origin/destination pairs (O&D) it operates from/to Paris with high-speed (HS) trains (TGV), taking into account the limited leeway that the company enjoys to set its prices because of price ticket's regulation. It studies how the monopoly adapts its pricing strategy taking into account the intermodal competition, staying however into the institutional framework set by the French regulation. Does regulation have an impact on the monopoly behavior?

To do so, it used two unique data sets entirely collected for the present study. One encompasses most of the train tickets maximum prices for O&D operated from/to Paris by SNCF from 2007-2012. This data set enables to study econometrically the main determinant of SNCF's pricing behavior. The second data set includes prices for selected planes and trains on specific O&D characterized by air intermodal competition. It enables to compare tickets' prices of trains and planes on selected routes.

This article also gives some insight on the type of competition that would better suit passengers' rail transportation. The European Commission is currently considering to fully liberalize passengers' rail

[1] Article 18 of this law, today codified as article L.2141-1 of the Transportation Code.
[2] International transportation also includes "cabotage", i.e. the right for a company providing an international service to allow some passengers to do national trips if the train stops in intermediary stations located in the same country than the departure/arrival point Nevertheless, there is currently only one alternative transport operating company offering international service (between Paris and Venice) and it does not offer cabotage for its passengers.
[3] For more details on this issue, see Perennes (2012).

transportation in Europe.[4] This liberalization means splitting network and operations in order to introduce intramodal competition. On the contrary, other countries in the world (in particular Japan and the US) have chosen to keep a vertically integrated railway industry and rely only on intermodal competition or "yardstick competition" to promote efficiency.

It is organized as follows. First, it briefly describes the market for national passengers' transportation in France and the intermodal competition that exists in this industry. It also reminds how transport economic literature has studied intermodal competition (section 2). It then explains in which extent train tickets' prices are regulated (section 3). Based on this description, it empirically analyses the main determinants of SNCF's pricing behavior taking into account the regulatory constraints SNCF faces (section 4). To strengthen the conclusion of section 4, section 5 provides an additional analysis, comparing prices series of train and airplane tickets on selected routes. Section 6 summarizes the main findings and concludes.

2. Intermodal competition: example of the French market for passengers' transportation and summary of the literature

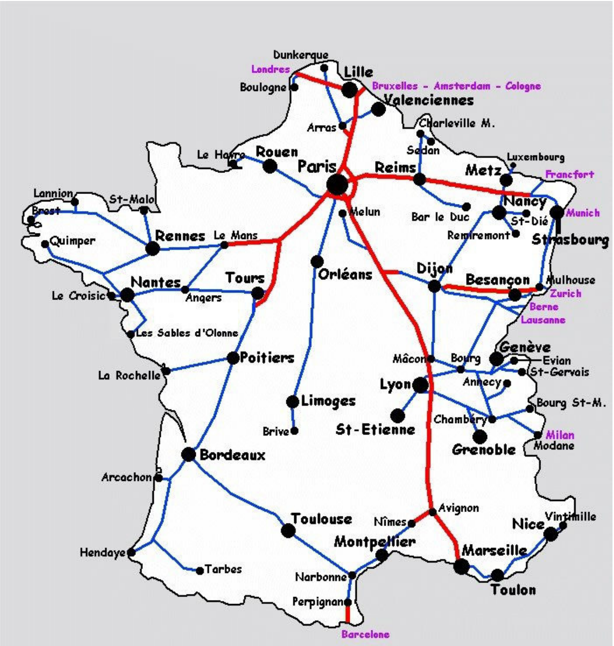
2.1. French market for passengers' transportation

In mainland France, passengers can use -besides their personal cars- trains or planes to go from one city to another.[5]

The main characteristics of the French passenger's transportation market are the following. First, the motorway network is well developed. It covers the whole country and is in good shape. Nevertheless, motorway tolls are quite expensive. Second, the air transport supply is also well developed, with numerous routes offered by the incumbent operator Air France. However, Air France reduced its offer over the past twenty years for some of its O&D that face a strong competition from TGV (Guyard (2004)).[6] In the late 2000s, following the European air transport liberalization, numerous low cost carriers have also started to offer air service between some French city pairs. The air transport supply in France will be described more precisely in sections 4 and 5. Third, France has an extended rail network. If one excludes regional transportation, almost 90% of the passengers' rail transportation is operated by HS trains (90%) even if the HS lines represent less than 10% of the rail network (Auphan (2012)). HS trains can use both HS lines and normal lines. This ability allows them to offer service to numerous cities, even if HS lines only constitute a small portion of the entire route. A "non HS" offer still exists for some regions, such as Auvergne and Normandy. The passengers' rail transport supply will be more described more precisely in section 3. Maps 1, 2 and 3 illustrate the passengers' transport supply in France.

[4] On January 10th the European Commission has presented a draft proposal of the fourth railway package. One of the main proposals of this package is to introduce competition for passenger's transportation in 2019.
[5] For legal reasons, there are no long distance coaches in France. Indeed, the French law gives SNCF the final approval for all national coach passengers' services. The idea is to protect SNCF's rail monopoly, avoiding coaches' intermodal competition. See Mariton (2006).
[6] For exemple Paris-Lyon, Paris-Marseille, Paris-Strasbourg, Paris-Nantes, etc.

Map 1: Rail network



Source: portail ferroviaire de Guillaume Bertrand

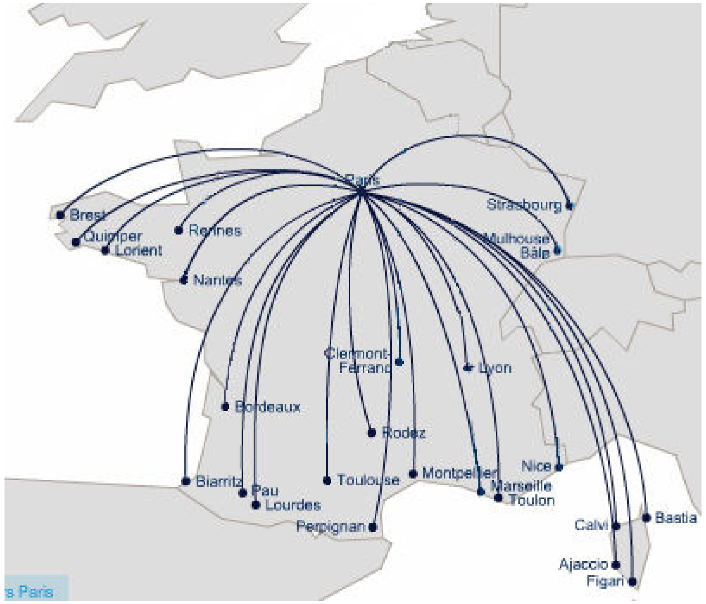
In red, the HS lines

In blue, the regular network

Map 2: Motorway network

Source : Arcachon guide

Map 3: Air France national network (from/to Paris)



Source: Air France

To give an idea of the distances involved, there are 932km between Paris and Nice (9h30 by car and a €72.50 motorway toll, 1h20 by air, 5h37 by train). Between Paris and Brest, there are 592km (6h21 by car and a €28.10 motorway toll, 1h10 by air and 4h29 by train).*

*: Distances, travel time by car and toll fees are given by the website “viamichelin.fr”. Air travel time and train travel time are given by Air France’s and SNCF’s websites.

2.2. Literature review

Intermodal competition between rail transportation and air transportation has been extensively studied by transport economic literature (see for example the literature review of Capon et al. (2003) or the recent article of Behrens (2011)). However, articles studying this issue choose to focus on intermodal competition from the passengers' point of view using stated or revealed preferences data and logit models. For specific routes, models try to evaluate passengers' preferences based on linear or non-linear utility functions and to understand how these preferences lead to the observed market shares of each travel alternative. Other articles (Ivaldi (2008)) study this same question based on game theory models.

The approach of the present article is slightly different. It focuses on the overall pricing behavior of the incumbent company for its whole HS offer. The question is not how the passengers choose their transport mode but how a company facing intermodal competition sets its prices on all the routes it offers taking into account intermodal competition and the institutional framework (price regulation). It does not use preferences data but prices data. A similar approach was undertaken by Antes *et al.* (2004) for Germany and the rail incumbent (Deutsch Bahn). Based on a qualitative study of Deutsch Bahn price data and consumers' survey, their article concludes that intermodal competition has a strong influence on the overall pricing strategy of the monopolistic rail operator. The present article determines if similar results can be found in France.

Economic articles have also studied the impact of intramodal competition and market structure on pricing strategies in the airline industry (see for example Stavins (2001)). Only one recent article (Bergantino (2012)) takes into account the possible intermodal competition on airline prices. More precisely it compares fares for planes going to/coming from islands –no road/rail intermodal competition possible- with fares of planes that are not leaving mainland. It concludes that when intermodal competition reduces, airlines increase their fares. The present article investigates if this conclusion is also valid for a monopolistic rail companies facing airlines competition.

3. The market for rail passengers- transportation in France

3.1. Description of the national rail passengers' offer in France

This article focuses on HS national train transportation. It studies neither international rail transportation, nor regional (including commuters) rail transportation. As underlined in the previous section, there are two types of trains in France: HS trains (TGV) and "normal speed" trains (Intercités or IC). TGV can use both HS and normal tracks, when Intercité can only use normal tracks.

The first TGV was launched in 1981 between Paris and Lyon (south-east part of France). In 1989, an extension of the HS network was opened for the west of France. In 1993, a HS service was opened for the north of France. In 2001, the HS line serving south east was extended to Marseille. In 2007, East of France also got its HS line. Finally in 2011, a HS line was opened between Dijon and Belfort, in the

East part of France. This new line does not serve Paris (Auphan (2012)). The current HS network is represented on Map 1.

All in all, the HS network (LGV) constitutes less than 10% of the total rail network. However, 90% of the passengers' traffic –excluding regional transportation- is made by TGV since TGV can use both HS lines and regular lines. Only a few regions (Normandy, Auvergne, Limousin) do not have a TGV offer. In parallel, for almost all of the cities served by TGV, there is no "regular" Intercités offer.

3.2. Regulation of the train tickets'-prices

National passengers' rail transportation in France is still characterized by a monopoly. This monopoly dates back to 1937 and SNCF's setting-up. When SNCF's legal form was modified in 1982[7] a new law defined the role, missions and obligations of the newly set company. This law on domestic transportation (Loi d'Orientation des Transports Interieurs, hereafter "LOTI") also gave SNCF the exclusive right to operate the domestic railway network. At that time, all consumer goods' prices (including train tickets) were regulated by the French State. In 1986, a national ruling[8] liberalized consumers' goods' prices: from that moment the State has stopped to regulate those prices. Consumer goods' prices are now freely set. Nevertheless, train tickets prices are one of the exceptions to this rule and continue to be regulated directly by the State.[9]

Train ticket regulation is defined by SNCF's specifications ("cahier des charges") that were set at the same time than the LOTI in 1982. These specifications are complemented by decrees (arrêtés and décrets). The last version of these complementary decrees dates back to 2011.[10] Regulation only affects second class tickets (i.e. it does not affect first class tickets[11]). The regulation of train tickets' prices differs for Intercités and TGV:

1. For Intercités trains, a basic fare (BF_IC_i) for an O&D *i* is calculated by a simple formula:

$$\mathbf{BF\_IC_i = A*km_i + B}$$

   Where km_i is the number of kilometers for the O&D *i*, A and B are numeric constants[12] set each year by SNCF and approved by the French Secretary of Transportation. Then, a reduction coefficient may be applied to this basic fare. For example, kids under 12 get 50% off, some commercial cards give 25 to 60% off, etc.

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[7] SNCF became a 100% state owned company.

[8] Ordonnance n° 86-1243, December 1th 1986.

[9] One may underline that almost all the retail prices of goods produced by network infrastructures (energy, telecommunication) are still regulated in France, because the State considers that the competitive functioning of previously vertically integrated and monopolistic industries is not good enough to set competitive prices. However, the founding principles of rail tickets' price regulation in France are not this competitive concern, but public service. For a detailed discussion on this topic see Perennes (2012).

[10] Décret 2011-914 and arrêté of December 16th 2011.

[11] Since the 1980s, SNCF is free to set is price for its first class tickets, mainly intended for business travelers. Nevertheless, SNCF chose as a commercial policy to set the first class tickets' prices equal to 1.5 times the second class tickets' prices. This is however not a legal rule, just commercial policy.

[12] A and B are not exactly numeric constants: different couples (A,B) are defined for different ranges of kilometers (less than 16km, between 16km and 32km, etc.) See appendix A.

2. For TGVs,[13] the system is more complex. For each O&D *i*, SNCF sets a basic fare (BF_TGV_i) that is approved by the French Secretary of Transportation. These basic fares cannot -to obey the regulation - depart too far from the “kilometric reference” i.e. the basic fare that would have been calculated if the numeric constants (A,B) defined above were applied. More precisely, the decree gives a 40% leeway to SNCF. Formally:

$$\mathbf{(1\text{-}40\%)(\ A^*km_i + B) \leq BF\_TGV_i \leq (1\text{+}40\%)(\ A^*km_i + B)}$$

Then reduction coefficients may be applied to this basic fare. SNCF also sells a certain number of cheap tickets several weeks before departure. These tickets called “Prems” have a constant price on all the French territory (they do not vary depending on the number of km).

4. Empirical analysis of the main determinants of SNCF’s pricing behavior

4.1. How to study SNCF’s pricing behavior

To study more accurately SNCF pricing behavior and SNCF’s reply to intermodal competitive pressure, one should ideally dispose of the set of SNCF’s and of its competitors’ actual prices, along with the date of sale.[14] These data are of course not available because of business confidentially. Nevertheless, this does not mean that some conclusions cannot be drawn from the available data.

First, one can use the list of regulated basic fares set up each year by SNCF with the approval of the French Secretary of Transportation. As explained in the previous section, SNCF’s train tickets’ prices are still strongly regulated. For Intercités trains, the national company does not have any freedom to differentiate its price depending on the specific situation of a particular O&D. However, the situation is different for TGVs. The incumbent company submits yearly for approval to the French Secretary of Transportation a list a train tickets’ basic fares. Each of them can depart for the normal base fare (under the 40% leeway rule) depending on the “conditions of speed and comfort” and on the “competitive situation”. [15] Since SNCF has the lead on the setting of TGVs’ different basic fares (the Secretary of Transportation only approves them) and since it is allowed by its specification to adapt them to the competitive pressure, one can study how SNCF uses the leeway it gets from the State to adapt these basic fares, in particular how it takes into account the competitive pressure from other transport modes. From an empirical point of view, it means that the relevant variable that should be studied is the ratio between the kilometric basic fare (i.e. the basic fare that would have been set applying the kilometric reference) and the actual basic fare. This ratio should lie between 0.6 and 1.4 for each O&D. The empirical analysis presented in this section studies the main potential determinants of this ratio (competitive pressure, track access charges, etc.). To the best of my knowledge, these basic fares data and the ratio deriving from them were never used in an empirical article trying to study SNCF pricing behavior.

[13] This regulation is also applied to some Intercités (called “Corail Teoz” or “Intercités avec réservations obligatoires”). However, this article does not study this exception.

[14] Not only the basic fare, but also the number of passengers benefiting of a reduction coefficient and the number of “Prems” tickets sold.

[15] See SNCF’s specifications, article 14.

Second, this analysis can be complemented by a dynamic comparative study of the tickets' prices for selected planes and trains on several O&D. One can compare at several moment in time how the tickets' prices evolve for different transport modes. This dynamic analysis will be held in section 5 of this article.

4.2. Data set and descriptive statistics

This article focuses on TGV tickets' price. It does not study Intercités prices. It also only studies the price of tickets between Paris and other cities (and not between two cities other than Paris)[16]. The data were collected from miscellaneous sources, allowing the empirical analyses to rely on a unique dataset.

Endogenous variable

SNCF yearly publishes on its website a document ("Recueil des prix") that goes over the entire list of basic fares for each O&D. It also included the kilometric references (A, B). This document is available online for the years 2007 to 2012.[17] To calculate the ratio between actual basic fare and kilometric basic fare (hereafter "the ratio") the number of kilometers of each O&D is necessary. However, this number of kilometers does not correspond to the actual number kilometers of tracks between the two stations of an O&D. To calculate its prices SNCF uses another measure called "tariff kilometers" that sometimes equates to the actual number of kilometers of tracks but sometimes corresponds to the number of kilometers of tracks of the previous line (i.e. before the building of the HS line).[18] In addition, some stations that are close by (for example Marseille and Aix-en-Provence that are distant of 30km) may have the same number of tariff kilometers with Paris. There is no ready-made data set of tariff kilometers. However, this information appears on each tickets sold by SNCF. Therefore, an important work of collection has been held to find train tickets (or electronic images[19]) and to isolate the tariff kilometers for each O&D. 158 tariff kilometers have been collected[20]. The ratio is then calculated as follows:

$$R = \frac{BF\_TGV_i}{A \times km_i + B}$$

[16] This choice was because the determinants of tickets' prices for train that do not depart from/ends in Paris differ between city pairs (in particular these determinants are different for two cities located in the same part of the French territory and for two cities located in different regions of the country)

[17] The year 2012 is available on SNCF-s website http://www.voyages-sncf.com/ext/editorial/pdf/cgv/dispositions-generales-sncf.pdf. Older versions of the "Recueil des prix" are available on the website http://quatramaran.ens.fr/.

[18] In particular, the number of tariff kilometers between Paris and Lyon, which is the most important line in terms of numbers of passengers, is 512 (the actual number of tracks kilometers is approximately 430). That corresponds to the number of kilometers of the former line, which went from Paris to Lyon trough Dijon.

[19] Electronic images of train tickets are available on websites that allow passengers to resell their train tickets: auction websites such as Ebay.fr, classified websites such as Auboncoin.fr or websites specialized in train tickets reselling such as trocdestrains.com.

[20] SNCF's Recueil des prix gives 172 maximum prices for O&D. Among these O&D, there is no service for 6 O&D (i.e. TGV are no longer going directly from Paris to this city in 2012, but the corresponding basic fare is still mentioned in the "Recueil des prix"). So, only 8 tariff kilometers (less than 5%) are missing.

Where BF_TGV_i is the basic fare as available in the Recueil des prix, (A,B) are the constants that can be found in the same document and km_i the number of tariff kilometers for the O&D.

Looking at the data, one finds that in compliance with regulations, the value of the ratio R is never below 0.6 or above 1.4. More precisely, this ratio is on average equal to 1.13 but never go beyond 0.9 with a maximum value of 1.39 (see appendix). In other words, SNCF mostly uses the leeway it gets from the regulation to increase its prices compared to the linear tariff rather than to decrease them.

Explanatory variables

If there is always an alternative to rail transportation by car (since all cities in France are linked to the road network) that is not always true for air transportation. Map 3 shows that there is no air service, for example, between Paris and Lille or Paris and Dijon. In these two examples, the closest airport is one of the Parisian airports, so one cannot fly from these cities to Paris. The competitive pressure can be tackled from two angles: price competition and travel time competition (Crozet (2005)).

Travel time

Travel time by train was collected on SNCF's website. Driving time was estimated based on data collected on the website "Viamichelin"[21]. To avoid multicollinearity, the model does not use the travel total duration (by car/by train) but the relative speed of car transportation compared to rail. Looking at the data, one finds that driving to/from Paris is always longer than taking a train. Train travel can be more than three times faster than car travel as shown.

Flying time is composed of four parts: time necessary to go by car from the city center to the closest airport[22], flight duration, time necessary to go from the airport[23] by car to Paris center and 30 additional minutes due to check-in and security checks.[24] Flight duration was collected on the airlines' websites. Almost half of the cities that have a direct TGV connection with Paris do not have an airport at less than 90 minutes' drive (sometimes the closest airport is located in Paris). Therefore, a dummy variable was created that equals 1 if there is a "credible" plane alternative to train, i.e. if the total flying time is equal to or inferior to the duration of the travel by train. Looking at the data, one finds that 363 observations[25] offer a "credible" air transport alternative (it is quicker to fly than to take a train).[26]

Price competition

[21] http://www.viamichelin.fr/ (website that helps individual drivers to plan their trips)

[22] The car driving time was collected on "Viamichelin".

[23] This airport may be Paris-Orly, Paris CDG or Paris-Beauvais. Paris-Vatry was not included in the sample.

[24] On Air France's website, the airline company points out that last minute check-ins in Paris for a flight to another French city is 20 minutes before departure in Orly and 40 minutes in Charles-De-Gaulle (http://www.airfrance.fr/FR/fr/common/guidevoyageur/aeroport/enregistrement_hle.htm). Therefore, I choose to use 30 minutes as a proxy for additional time required by airports check-in and security checks.

[25] Observations have two dimensions: O&D and year. For example Paris-Lyon-2007 is an observation.

[26] There are three categories of airlines: regular airlines, low cost carriers and business airlines (in France, Airlinair and Chalair). This last category offers service with smaller aircrafts (ATR 42 or 72, 48 to 70 seats or even Beechcraft 1900 19 seats). Here, all three categories are considered.

To apprehend the price competition between cars and trains, the data set uses the driving cost per kilometer Driving costs were estimated through "Viamichelin". They encompass toll fees[27] and gas expense. Prices' evolution was also taken into account.[28] Looking at the difference between the price of a regular train ticket (the BF_TGV defined above) and the total driving cost, one finds that on average it is cheaper for a driver that is alone in his or her car to take the HS train. It is particularly true for remote destinations with expensive toll fees. Driving may however be cheaper when the quickest way is a road without toll booths.[29]

Since air transportation tariffs are based on yield management principles, it is not possible to estimate an "average" price for air transportation.[30] Therefore, the only proxy for price competition that can be used is the existence of low cost carriers service (in France, these low cost carriers are Easy Jet and Ryanair). There are not many low cost carrier alternatives. Only 6 observations offer a low cost carrier alternative at less than 20 mn. 78 observations are located at less than 60 mn.

Control variables

Other element can impact train tickets' prices level per kilometers: the importance of the destination station (number of passengers), SNCF's costs and the "line" on which the destination city is located.

The price can also differ depending on the importance of the destination station. If the final station is an important station (such as Lyon, Marseilles, etc.) SNCF may choose to charge less per kilometer in order to encourage passengers to use these stations. Annual numbers of passengers per station were only available for two years of the data set. Therefore, the model uses the total number of passengers for the last available year (2010) for each O&D, regardless of the observations' year.

Differences in costs can also explain the relative variation of the ratio. There is no reason to think that the cost of the rolling stocks differs from one city pairs to another. What can however

[27] In this article, I do not suppose that the consumers try to avoid toll fees. That is possible in France using the secondary road network, since only motorways have toll booths. This choice is based on two grounds: first only a few drivers have such a cost optimizing behavior, second, since I study the regular price ticket (and not the discounted one sold a few months in advance) the consumer who bought this ticket is less likely to be a costs optimizer.

[28] Prices evolution was calculated separately for gas and tool fees. Gas prices were calculated based on the average price of on liter of super unleaded petrol during the first week of January each year (http://france-inflation.com/graph_super.php). For the toll fees, they are reevaluated each year by the government. The government allows each company in charge of a highway to raise its price based on inflation, but also based on the maintenance works required for the highways of which the company is in charge. Therefore, each company is allowed to apply a different fees' rise. In the dataset, I specify for each O&D the company(ies) that runs the highway(s) between both cities and apply the relevant rise coefficient(s).

[29] As it was explained in footnote 27, the hypothesis here is that the driver chooses the fastest way and does not try to avoid toll booths.

[30] "Yield management is the process of understanding, anticipating and influencing consumer behavior in order to maximize yield or profits from a fixed, perishable resource (such as airline seats or hotel room reservations)." (Wikipedia) To do so, yield management used market segmentation: its aim is to differentiate consumers according to their willingness to pay. In the transportation business, a good way to differentiate costumers (in particular between business and leisure) is to see when they book their trip (a few days or a few months in advance) and, in the case they are buying a round trip ticket, to see if they stay in their destination city on Saturday night.

dramatically differ is the cost of tracks (tracks building and tracks maintenance) and therefore the cost of tracks usage. Currently in France there is a vertical unbundling between operations and infrastructure[31]. So, it is easy to single out the costs of tracks usage for SNCF. They correspond to the track access charges paid by SNCF to the company that owns the network, namely Réseau Ferré de France (RFF). These track access charges are available through an interface developed by RFF for the train operating companies. Here again, the model does not use the total amount of access charge, but the price paid by kilometer. There is a wide variation in the track access charges (between €3.30 per km and €21.45 per km). These charges have constantly increased during the time period. The most expensive track access charges can be found in 2012 for city pairs that are totally covered with HS tracks (in opposition with normal tracks).

The basic fares (and the ratio) are probably not only set on a city by city basis but also take into account the "line" on which the destination city is located. In other words, when two cities are located on the same line, their basic fares are not independent. In particular, if a city is located just a few kilometers before another city, it basic fares cannot be superior to the basic fare of the city located farther (passengers would in this case buy a ticket for the second city and get off at the first one). This phenomenon was identified by Antes *et al.* (2004).[32] Because of this, the ratio can differ from one city to another but it cannot differ too much so the basic fares need to remain coherent (the farther you go, the more you pay). Based on the departure station (Paris Montparnasse, Gare du Nord, Gare de Lyon, Gare Montparnasse, Gare de l'Est) and on the French geography it is possible to allocate all city pairs in 9 groups.[33]

4.3. Empirical analysis

The ratio (R) is supposed to be correlated with: the existence of an airline service for the city pairs ("plane alternative"); the existence of a low cost carrier service ("low cost alternative"); the relative driving time; the driving cost per kilometer; the annual number of passengers in the destination station, the average access charge per kilometer and the "line index".

Model selection

As explained in the description of the data set, data are available for 6 years, between 2007 and 2012. Therefore, it is possible to use panel-data models.

[31] Before 1997, SNCF owned the rail network. In the 1990s the European Commission asked the European States to separate infrastructure and operation in order to liberalize the railway industry. France followed the European commission requirements and decided to unbundle network and operation.

[32] They therefore call rail transportation an "open system" since "passengers who travel on a train from A to B are free to enter and exit at any stop between initial origin and final destination. Hence reducing the prices on the. O&D from A to B, may have severe yield effects on all O&Ds that lie in between the contested line, and on those that include the contested segment."

[33] These groups are the following: from Paris to city located in the French Alpes , in Burgundy and Franche Comté, in Brittany, in Esat of France (Alsace and Lorraine), in the Languedoc, in the North of France, in the South-East (PACA) in and around the region Poitou-Charente and in the South-West of France.

$$y_{it} = \alpha_i + \sum_k \beta_k X_{kit} + \sum_p \gamma_p Z_{pi} + \varepsilon_{it}$$

i indicates the different city pairs and t indicates the years. Variables X change over time when Z are time invariant. α_i are the random individual specific effects.

Because of the very nature of the data studied, some explanatory variables are time-invariant (car relative duration, number of passengers, line index) or "quasi time invariant" (existence of a "credible" regular airline alternative). In addition, the within variations of R and of many other variables changing over time (LCC alternative, driving cost per kilometer and access charge per kilometer) are rather small compared to the between variations.[34] Therefore, the coefficient of regressors will be imprecisely estimated in a fixed effect model. A natural solution is to use a random-effects model (RE).

One may view the random part of the individual-specific effect as the political influence of the mayor of the city linked with Paris. If he or she has a strong political influence, the average basic fare (and the ratio) is lower. With this interpretation of the individual specific effect, it is possible to assume that it is uncorrelated with the regressors.

In addition to this RE model, one can also use a simple pooled ordinary least square regression (OLS) to estimate the influence of the various regressors with a using all city pairs for all years.

Results

For both models, regressors are jointly significant, with a p-value of 0.000. More than one third of the variation is explained with R^2 around 0.37-0.48. Coefficients have the same symbol in both models. The constant is close to 1 that means it is inferior to the average value of R in the data set (1.13 as explained above).

[34] See **Table 7** in Appendix. One will also find in the Appendix a Breusch-Pagan test and a Haussmann test that strengthen the choice of a random effect model.

Table 1: Results of empirical models

	OLS (1)	PANEL RE (2)
Plane alternative	-0.0876***	-0.0326***
	(0.0055)	(0.0071)
Relative car duration	0.0637***	0.0713***
	(0.0068)	(0.0145)
Low cost alternative	-0.0541*	-0.0124*
	(0.0093)	(0.0043)
Cost per km by car	0.9025***	0.5509***
	(0.1259)	(0.0666)
Price per km access charge	-0.0158***	-0.0061***
	(0.0010)	(0.0005)
Line	-0.00142	-0.0042*
	(0.0001)	(0.0021)
Passengers	-4.46e-10	-1.44e-09
	(7.17e-10)	(1.75e-09)
_cons	1.0470***	1.0015***
	(0.0228)	(0.0283)
N	852	852
n		142
r2	0.4778	
r2 within		0.1515
r2 between		0.3859
r2 overall		0.3776

Note: Standard errors in parentheses

**p<0.05, ** p<0.01, *** p<0.001*

Regarding the estimated coefficients, the existence of an air alternative to train and/or of a low cost carrier service decrease the value of the ratio. That means that if there is intermodal competition, SNCF decreases its tickets' prices. That is coherent with intuition.

Relative car duration is harder to interpret. As explained above, this variable is always positive and always superior to 1. In both models, if the driving time is almost equivalent to the train time travel (i.e. the relative duration is close to 1) it increases the ratio but less than if the train is most "time competitive" (for example if the relative car duration is close to 3). This is also coherent with intuition. The effect of the driving cost per kilometer is similar to the one of relative car duration. This variable is always positive. The most expensive the driving cost per kilometer, the higher the ratio. This means that when driving is expensive, SNCF can increase its prices. This is also coherent with intuition.

The line index and the annual numbers of passengers are not significant.

Regarding access charges, the coefficient -even it is rather small- seems to be counter intuitive. The negative sign means that the ratio is smaller for a city pair with expensive access charge than for a city pair with lower access charge. In other words SNCF is not passing to the passengers the difference in its “production costs”. On the contrary, the more SNCF pays RFF for tracks access, the cheaper the tickets. This may be represented on a scatter plot (see Figure 5 in appendix). This leads to the following conclusion: there is an endogenous relation between the basic fares (and then the ratio) chosen by SNCF and the access charges level set by RFF. In other words, there is a hidden relationship that links RFF’s and SNCF’s choices to set high prices for access charges and basic fares respectively. In the previous part, an implicit hypothesis was made when track access charges were chosen as a control variable: RFF does not take into account the intermodal competitive pressure to set it access charges. It only takes into account the costs related to the infrastructure. This hypothesis may be inaccurate. Indeed, the rule used by RFF to set its access charges is based on Ramsey-Boiteux pricing for natural monopoly. A natural monopoly experiences profit losses if it is forced to fix its output price at the marginal cost. To reach a non-negative profit (a zero profit) and to maximize social welfare a markup is added to marginal cost. This markup is inversely proportional to the elasticities of demand (the more elastic demand for the product, the smaller the price markup). In the present case, the demand elasticity depends on the intermodal competition. Therefore, RFF is likely to take into account competitive pressure when it sets it access charges. Hence, the ratio and the access charges are probably endogenous.

4.4. Conclusion of empirical analysis

Based on the descriptive statistics and on the empirical analysis it is possible to conclude that SNCF takes into account intermodal competition when it sets its basic fares. However, the analyses conducted in this part are only relevant for basic fares, which do not fully correspond to the price really paid by passengers. As explained in part 4.1, passengers -especially when they book their tickets in advance- do not pay basic fares but discounted fares (“Prems”). The pricing behavior of SNCF is indeed partially based on the same principles than the ones used by airlines companies (yield management) with some restrictions due to state regulation (Mariton (2008)). Therefore, it may be worthwhile to look at “hour by hour” prices to see if SNCF’s and airlines companies’ prices evolve similarly. If some common patterns can be found in both pricing behavior, this will be an additional proof that SNCF faces strong intermodal competition on some O&D.

5. Comparative analysis of price time series for selected O&D

5.1. Data set

As explained *supra*, there are only a few cities in France with an airport that offers a direct service to Paris. Including Geneva, since this Swiss city is located near the French border and its airport can be used by passengers going in the Alpes, 19 cities/airports have a direct flight to Paris competing with a

TGV service.[35] Only 4 airports (Biarritz, Geneva, Nice, and Toulouse) offer low cost service to airports "Paris Orly" or "Paris Charles de Gaulle".[36]

For these 19 cities, price data for service from Paris were collected between July ,25th 2012 and October, 22th 2012[37] for two departure times : a Thursday morning (October 25th 2012) and a Friday evening (October 26th 2012). October 26th 2012 was also the last day of class before the "All saints" holidays for French schools. Therefore, a lot of passengers were expected by SNCF on this precise Friday evening. Every 8 hours, the various tickets' prices for SNCF, Air France and a low cost carrier (Easy Jet) were collected on their websites.

5.2. Results

Given the nature of the data at disposal, the analysis conducted in this part is more qualitative than quantitative. The simplest way to analyze price evolutions is to compare the prices of different groups of tickets (train/regular airline/low cost) for an O&D and for one time period (Thursday morning/ Friday evening) on a graphical representation. Three "rules" emerged from these graphical/qualitative comparisons of price series:

<u>(1) SNCF's and Easy Jet's prices seem correlated</u>

For some O&D (like Paris-Toulouse on Figure 1), there seems to be a strong correlation between low cost carrier's and SNCF's prices. This is not always the case (for example such a relation cannot be found in the data set for Paris-Biarritz on October 26th 2012).

<u>(2) Air France's prices are usually much higher than Easy Jet's/SNCF's prices.</u> <u>However a strong increase in Air France's prices is usually followed by a small increase in SNCF's prices</u>

Air France's prices often seem to be high and uncorrelated with Easy Jet's and SNCF's prices (see for example Figure 1). This may be explained by the fact data were collected only for a one way ticket (no return flight) when one of the yield management principle for regular airlines is to strongly differentiate prices between one way and round trip tickets, in order to separate leisure passengers from business passengers. For several O&D, Air France prices are not always constant. For these O&D Air France's prices do not evolve with as many "prices steps" as Easy Jet's or SNCF's prices. There is generally one important change in prices that occurs when cheap not refundable tickets are not available anymore. This can be seen for example for the O&D Paris-Lourdes on Thursday morning. This important price rise happens almost at the same time than a smallest rise in SNCF's prices (see Figure 3) .A similar pattern can be found in Figure .

[35] "Business airlines" as defined in footnote **Erreur ! Signet non défini.** are not included. If they were, four additional airports (Agen, Annecy, La Rochelle and Lannion) have a direct connection with Paris.

[36] Including "Paris Beauvais" airport used by Ryanair, two additional cities (Marseille and Beziers) have direct flights to Paris.

[37] The initial plan was to collect data for 3 months, i.e. till the day of departure of the train. Unfortunately a strike took place on October 26th 2012. Therefore some trains were cancelled and it was not possible to collect data a few days before the 26th.

(3) A few days before the train/plane departure SNCF's prices hit the maximum price set by regulation, therefore taking the train is a much cheaper option than flying (either with a low cost carrier or a regular airline). Looking at Figure , one observes a strong differentiation between Easy Jet's and SNCF's prices in the last few days before departure. This is explained by the fact SNCF's prices hit the price cap defined by the regulation. It is not allowed to raise its price above this level, even if it would be able to sell train tickets above this price. Looking at the 36[38] observations of the data set, one sees that the ticket prices hit the price cap in all cases but one. Easy jet and Air France do not face this regulatory constraint. For the 8 observations for which Easy Jet offers a competing service, Easy Jet's prices are always above SNCF's prices a few days before departures. The limited leeway enjoyed by SNCF to set its prices restricts the use it can make of yield management principles.

A more quantitative approach, based on a more extended data set, would be valuable to consolidate these findings. It would also be interesting to understand the causes of the correlations between SNCF's/Easy Jet's prices on the one side and Air France's/SNCF's prices on the other. Are these correlations based on an intentional pricing behavior or are they due to the fact all these companies used the same kind of pricing models (based on yield management)? The reply to this question may be important to ascertain if transports companies act as an oligopoly or if the market properly works.

6. Conclusion

Based on the analysis conducted in this article, one can conclude that (i) SNCF adapts its price depending on the potential intermodal competition it faces (ii) prices regulation effectively restricts SNCF's ability to set its prices: a few days before departure train is usually the cheapest alternative.

These findings may give food for thought in the context of the rail industry liberalization. Even if a complete intramodal competition is hard to put into practice in the short run because of the organization problems it triggers, intermodal competition may be a good way to damper the monopolistic behavior of the railroad incumbent. For O&Ds with no viable airline alternative (in particular when both cities are "too close" to each other), a solution to increase intermodal competition may be to allow private long distance coaches (Abraham, 2011). Another solution may be to introduce intra modal competition in priority on the routes without air travel alternative.

French legislators should also reconsider the goal of the price regulation set by laws and decrees. Has this regulation a public service objective, allowing each French citizen to travel for a reasonable price in the whole country, knowing that Easy Jet is sometimes cheaper than SNCF? Or is the goal of this regulation to limit SNCF monopolistic behavior, when this article has proved than SNCF used the limited leeway it gets from the legislator to adapt its basic fares to competition?

[38] The data set encompasses 19 O&D for 2 departure periods. However, the ticket prices for Geneva (in Switzerland) are not regulated.

Prices are the cheapest one available on each websites

Figure 1: Evolution of the prices for one seat (train/plane) Paris-Toulouse

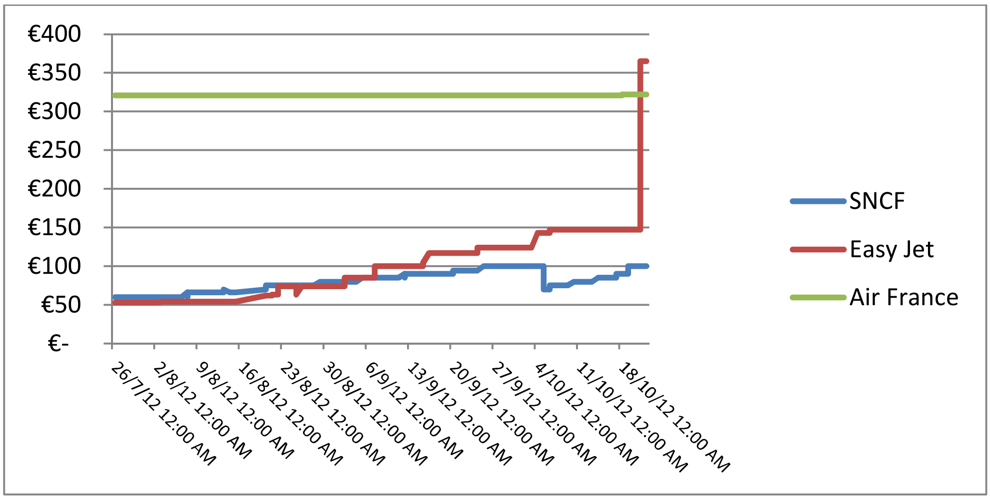


Figure 2: Evolution of the prices for one seat (train/plane) Paris-Lourdes

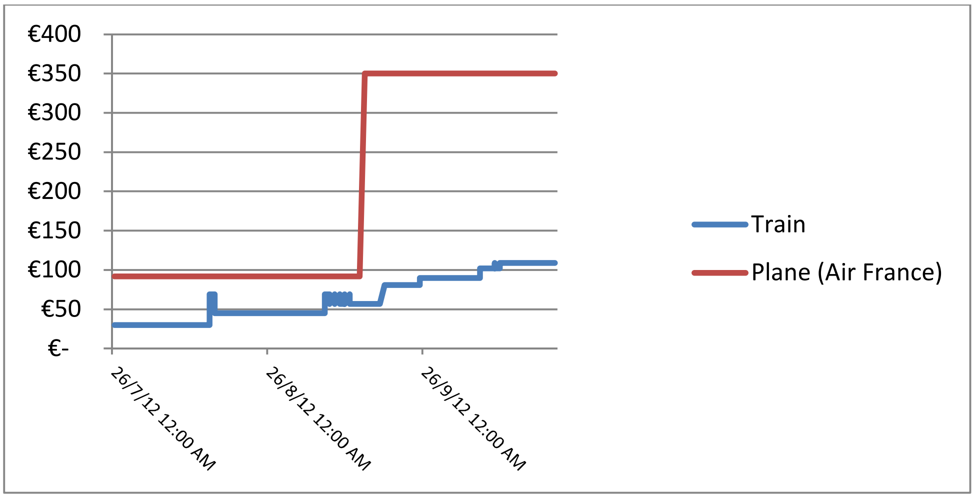
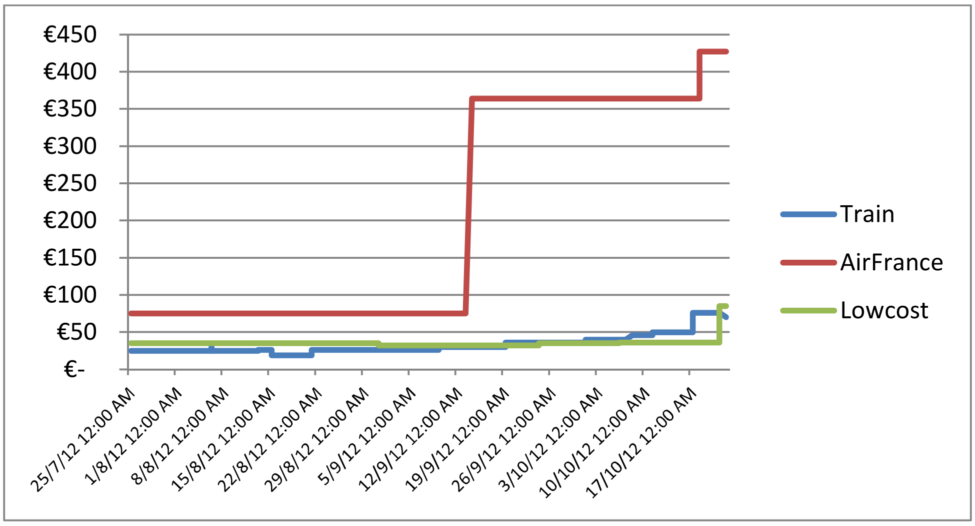


Figure 3: Evolution of the prices for one seat (train/plane) Paris-Biarritz



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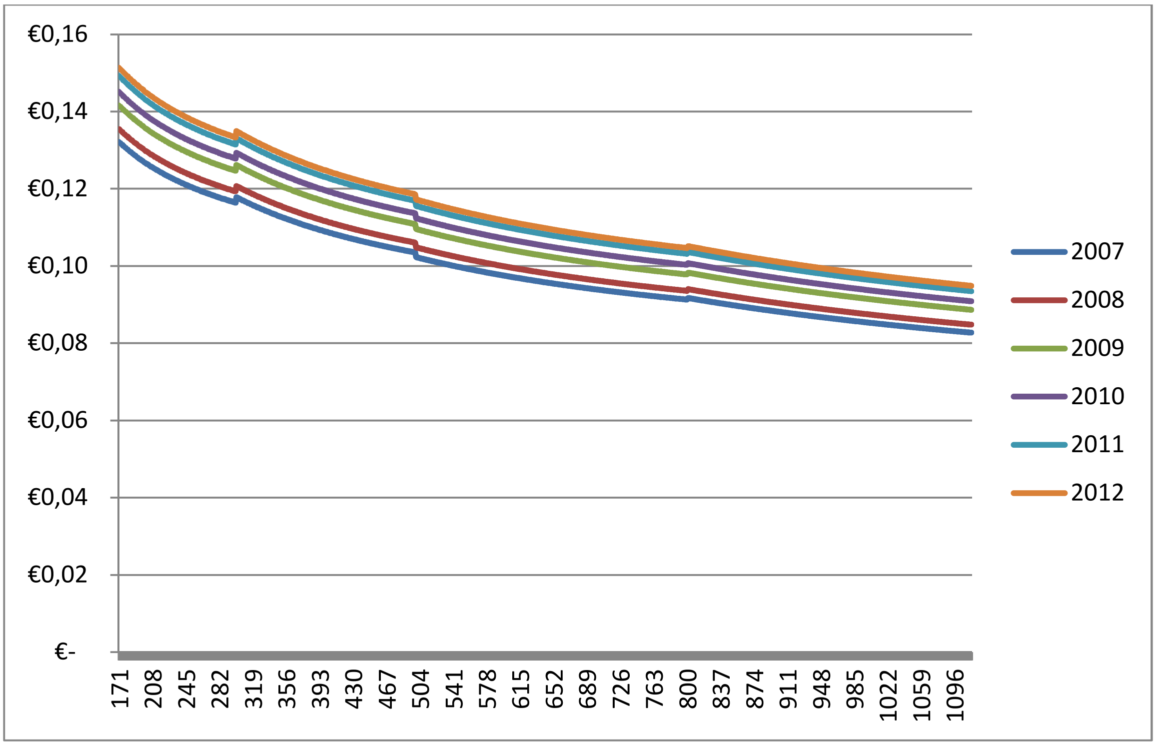
Appendix A: Value of (A,B)

As explained in 3.2, basic fares for Intercités trains are calculated by a simple formula: **$BF\_IC_i = A*km_i + B$**, with A and B couples of real numbers defined for different ranges of kilometers (less than 16km, between 16km and 32km, etc.). A and B's values are reevaluated each year. Based on their value available in the yearly "Recueil des prix", the linear price per kilometer, depending of the total length of the trip can be drawn.

Figure 4: Linear price per kilometers for Intercités trains



One can see on this graph that the price per kilometers decreases with number of kilometers. Therefore, one can expect that this commercial policy can also be found for HS trains.

Appendix B: Descriptive statistics

R value

Table 2 : Value of the ratio R

Variable	Obs	Mean	Std. deviation	Min	Max
R	924	1.13	0.09	0.90	1.39

Note: Obs in the number of observation

The smallest R is found for the O&D Paris-Miramas, a city located in the south of France near Marseilles and Aix-en-Provence at 750 km from Paris. The biggest R is found for Vendôme, a small city located between Orleans and Paris at only 176km from Paris.

Explanatory variables

Table 3 : Value of the explanatory variables related to travel time competition

Variable	Obs	Mean	Std. deviation	Min	Max
Train Duration	924	185	84	39	392
Car Duration	924	323	115	101	576
Relative car duration	924	1.87	0.42	1.27	3.32

Note: Car duration is calculated from city center to city center

Table 4: Number of observations located at 20, 40 and 60 minutes' drive from an airport offering low cost service to Paris

	20 minutes	40 minutes	60 minutes
Number of observations	6	43	78

The 6 observations located at less than 20 minutes' drive from an airport offering low cost service to Paris correspond to 3 O&D (Brest, Landerneau and Agde), and to 2 airline services (Paris-Brest operated by Easy Jet and Paris-Béziers operated by Ryanair). Both were launched in 2011.

Table 5: Price competition between cars and HS trains

Variable	Obs	Mean	Std deviation	Min	Max
Regular train ticket price	924	€64.84	16.98	28.00	100.00
Total driving costs	924	€83.37	35.89	20.40	186.99
Difference	924	-18.53	21.25	-86.99	30.29
Cost by km (car)	924	0.16	0.02	0.08	0.23

Note: The difference is equal to the price of the regular train ticket minus the driving costs

Control variables

For linear price per kilometer, see appendix A.

Table 6: Yearly track access charge

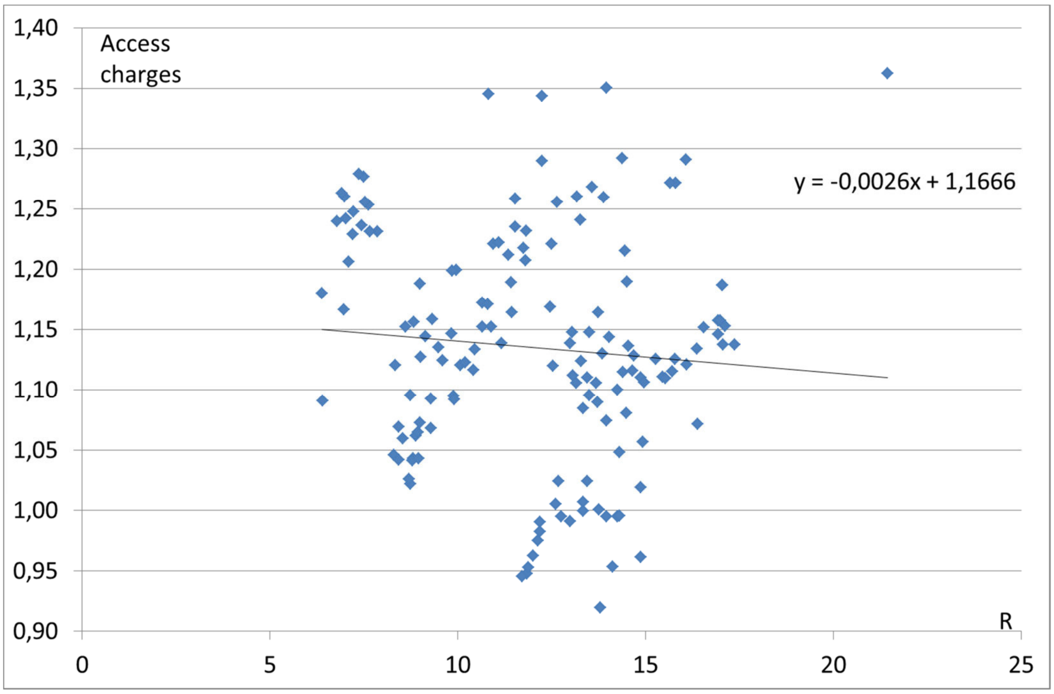
Track access charges (per km)	Mean	Standard deviation	Min	Max
2007	7.69	2.66	3.30	12.94
2008	8.40	2.65	3.91	14.33
2009	8.95	2.89	3.98	15.39
2010	9.67	1.77	6.40	13.53
2011	10.79	2.44	6.54	15.23
2012	12.05	3.03	6.38	21.45
Total	9.59	2.98	3.30	21.45

Note: This table gives the track access charges cost per km for each O&D.

The most expensive track access charges can be found in 2012 for city pairs that are totally covered with HS tracks (in opposition with normal tracks) (Vendôme, Lyon Saint Exupery, Macon Loche TGV, etc.).

Appendix C Track access charges

Figure 5: Link between ratio and the access charge per kilometer (for the year 2012)



Appendix D: Model selection – random effect

Table 7 : Variance decomposition

Variable		Mean	Std. Dev	Min	Max	Observations		
R	overall	1.127736	.091431	.9017995	1.387365	N	=	924
	between		.0904079	.9237334	1.365315	n	=	154
	within		.0151761	.9843537	1.213498	T	=	6
Plane alternative	overall	.3928571	.48865	0	1	N	=	924
	between		.4864461	0	1	n	=	154
	within		.0585734	-.4404762	1.22619	T	=	6
Relative car duration	overall	1.871794	.4228079	1.274648	3.320513	N	=	924
	between		.4239578	1.274648	3.320513	n	=	154
	within		0	1.871794	1.871794	T	=	6
LCC alternative (60min)	overall	.0844156	.2781606	0	1	N	=	924
	between		.2529756	0	1	n	=	154
	within		.1171468	-.2489177	.9177489	T	=	6
Price/km (car)	overall	.1625441	.0211399	.0788836	.2263559	N	=	924
	between		.0173733	.0947798	.2033813	n	=	154
	within		.012112	.1429201	.1855187	T	=	6
price/km (track access charge)	overall	9.592184	2.982943	3.3	21.45	N	=	870
	between		2.560307	5.085	15.40667	n	=	145
	within		1.542884	7.048851	15.63552	T	=	6
Nb of passengers	overall	1992184	3297582	36334	2.40e+07	N	=	906
	between		3306729	36334	2.40e+07	n	=	151
	within	0	1992184	1992184	1992184	T	=	6

```
Breusch and Pagan Lagrangian multiplier test for random effects

        R[num_od,t] = Xb + u[num_od] + e[num_od,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                       R |   .0082894       .0910459
                       e |   .0002099       .0144866
                       u |   .0040955       .0639964

        Test:   Var(u) = 0
                             chi2(1) =  1735.76
                         Prob > chi2 =     0.0000
```

The Breusch-Pagan test indicates that the random effects are highly significant. Therefore, the random effect model seems appropriate.

```
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |      eq1           .           Difference          S.E.
-------------+----------------------------------------------------------------
plane_al~BLR |   -.0071872     -.037313        .0301257        .0043134
lowcost_60~n |    -.008942    -.0132914        .0043494               .
price_km_car |    .4905123     .5343439       -.0438316               .
price_km_a~e |   -.0057175    -.0059876        .0002701               .
------------------------------------------------------------------------------
                          b = consistent under Ho and Ha; obtained from xtreg
           B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        6.94
                Prob>chi2 =      0.1391
                (V_b-V_B is not positive definite)
```

The Hausman test does not allow concluding that a fixed effect model would have been more appropriate than a random effect model. Therefore, based on the result of the Breusch-Pagan test and on the importance of between variation, the random effect model seems the most appropriate with the present data set.