THE IMPACT OF ACCESS PRICES ON TRAIN TRAFFIC: AN ECONOMETRIC STUDY FOR FRANCE

ABSTRACT

To guaranty fair and nondiscriminatory access to rail networks for new entrants, European Commission raised the importance of regulation by promoting short run marginal cost. But, in order to recover the full cost of infrastructure, Infrastructure Managers may use mark ups over the marginal cost, using Ramsey pricing for example. However, a Ramsey pricing implementation for rail infrastructure is strongly limited by the lack of information on the demand elasticity of train paths. The aim of this article is to try to fill this gap (at least in France) by conducting an empirical research on the price sensitivity of the traffic using a French dataset covering a period from 2003 to 2016. Preliminary results show that track access charges influence negatively the train path demand for high speed and freight trains; however, track access charges seem to not influence the train path demand for regional trains. Nevertheless, if track access charges are related to the track category (UIC category) or to the kind of line (high speed or conventional) results may differ. Regarding regional and freight trains, the track category seems to determine the statistical significance of track access charge elasticity while the kind of line seems to explain the impacts on the demand of rail paths for high speed railway trains. For high speed trains, results suggest that the access price elasticity of train paths is relatively close to the value considered by DB Netz.

I. INTRODUCTION

The Directive 91/440/EC introduced the right of access to the infrastructure for limited categories to international freight operators. In 2007, this right was extended to all freight, domestic and international services in the EU. Then, in 2009 the access to the railway infrastructure was extended to international passenger services. During this period, several EU countries have introduced competition in the form of competitive tendering for the provision of passenger services under public services and/or in the form of open access competition for the provision of commercial passengers services. Since the directive 2001/14/EC, the current European regulation is promoting short-run marginal cost charging but allows infrastructure managers (IM) to levy mark-ups to recover the full cost of infrastructure but only *"when the market can bear it".* Indeed, track access charges (TACs) are one of the main tools for IM to cover their costs but these costs may also be covered by direct subsidies from governments. Nonetheless, the calculation of TACs must be in accordance with European directives (art. 31 of directive 2012/34/EU).

Mark ups principles are generally based under Ramsey-Boiteux approach, under a cost causation approach or under the competitiveness of markets (segments) approach. However, even if the approaches adopted may be very different between European countries they have the same purpose: apply a level of TACs with or without mark-ups but by fulfilling the requirements of European directives 2012/34/EU and 2015/909/EU. Some countries decided then to follow the Ramsey-Boiteux principle while other ones choose another technique to determine their TACs. The debate remains open as a continuation of the discussion in economics between the marginalist school and the institutionalist school.

The aim of this article is to try to fill this gap, at least in France, by conducting an empirical investigation under the price sensitivity of the traffic through an econometric analysis using a French dataset covering the period 2003-2016. The second part of this research attempts to identify the context in which this research could be positioned by focusing on a first time on the controversy between Marginal and Institutional schools; a particular attention is then given to the Ramsey pricing principle. The third and the fourth parts of this research present the data and the models used in this study to define the track access charges elasticity of the demand of French train paths. Results and conclusions are presented and discussed in the fifth part.

II. CONTEXTUALIZATION OF THE SUBJECT

European access charging schemes are frequently subject to discussions between States, IMs and RBs. On one hand, two schools of thought go head-to-head: the theoretical pricing controversy between marginalist and institutionalist schools (Duffy 2004).

On one hand, neoclassical literature based on the welfare theory suggests that a marginal cost pricing model may allow the attainment of the social optimum (Marshall 1890, Hotelling 1938). Given the magnitude of the full costs[1], a pricing higher than the wear and tear cost (average cost pricing for example) should be avoided. Marginalist school suggests that in order to offset an almost sure decrease of the demand, a public intervention by subsidies is required. The amount of subsidies employed to recover full cost will be compensated by an increase of users.

On the other hand, the "Institutional school" argued that this is precisely the adoption of these subsidies that does not ensure the social optimum (Coase 1946, Roth 2006, Winston 2010). The intervention of the state looking to fix this market failure, leads to a second-best scenario. Initial costs may then be covered either by infrastructure users or by public funds. The first option assumes that users will have to pay significant charges that can limit the number of users and which may result in a reduction or a limitation of the demand. The second option assumes that users cannot cover full costs, which is not a social welfare optimum.

European railway market practices indicate that most if not all the European countries use the principle of marginal cost pricing, combined with subsidies, mark ups or other resources. In this regard, the two most followed charging principles in Europe are Ramsey-Boiteux oriented[2] (Ramsey, 1929, Boiteux, 1956) or follow a competitiveness of market segments approach[3] (Dierker 1991).

The debate of the charging principle from a theoretical but also from an empirical point of view remains one of the main subjects treated in the railway sector. The adoption of a charging model using mark-ups depends firstly on the charging principle chosen by IMs (or RBs) but secondly on the availability of the data. In this regard price elasticity of demand (for passengers and for RUs) are very important variables that must be known. Nonetheless, the calculation of this variable is very limited because of the availability of data.

This research aims to enrich the estimation of train path elasticity by employing an empirical study in order to compute the direct price sensitivity of train path demand in France by using an extended and very rich data panel for a period of 13 years. This particularity represents the main novelty of this research.

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[1] Around 85% of the total costs for the French railway infrastructure.
[2] Austria, Germany, Slovenia and the Netherlands (from 2020)
[3] France, Spain, Italy and in the near future Latvia

III. THE DATA

This research uses an internal dataset of French infrastructure manager SNCF Réseau, which compiles the traffic and the prices of almost all the sections of the French railway network between 2003 and 2016 for HSR and regional train services and for the period 2003-2009 for freight[4]. Indeed, there are almost 1.300 pricing sections (1.294) called SEL[5] that count more or less 35.000 kms of the French railway network. The result is a sample of 1.8116 observations (each line represents a pricing path section) with the traffic by year.

Access prices (TACs) for each section are well defined as well as their length and the traffic they supported per year during the period 2003-2016 (Table1).

Table 1 – Descriptive statistics, track sections, 2003-2016 (18 116 observations)

Variable	Obs	Mean	Std.Dev.	Min	Max
Year	18116	2 010	4	2 003	2 016
Length of SELs (kms)	18116	28	21	1	112
Traffic data					
Freight train.kms	5776	195 061	325 640	0	3 476 757
Regional train.kms	12252	200 271	217 967	0,4	1 607 863
HSR train.kms	6750	272 986	873 594	0,9	11 500 000
Access price data					
Freight path.km price	7558	1,26	1,71	0,000	14,87
Regional path.km price	12250	2,59	2,14	0,081	20,56
HSR path.km price	6861	5,01	3,50	0,002	28,57
Infrastructure data					
HSR - UIC 2-6	846	60	1	60	61
HSR - UIC 7-9	8	1	1	-	1
CRL - UIC 2-6	9 768	698	3,45	693	704
CRL - UIC 7-9	7 494	535	3,45	529	540
Socio-economic data					
Petrol	18116	55,95	18,59	25,49	86,86
HSR length	18116	1 858,64	216,70	1 540,00	2 166,00
National GDP	18116	1 935 230	179 671	1 637 438	2 194 243
National Employment	18116	24 300 000	282 722	23 700 000	24 800 000
National Ind. Employment	18116	3 566 158	233 986	3 280 109	4 004 674
Regional GDP	18116	191 900	153 746	58 794	680 717
Regional Population	18116	5 794 653	2 651 744	2 484 288	12 100 000

Some other variables are also taken into consideration in this study. As almost all the European IMs, SNCF Réseau TACs are differentiated with respect to each type of service: freight, regional passenger and High-Speed passenger services. It is important to clarify that high-speed trains may run on high-speed railway (HSR) paths and on conventional railway lines (CRL).

[4] It was not possible to this research to collect data for a longer period for the freight service, because of a change in the method of accounting for access charges.

[5] From the french « Section élémentaire de ligne »

In addition, each SEL has also a pricing category which depends on the traffic they support: UIC 2-6 are the SELs that generally support higher volumes of traffic and that are in “better” conditions in terms of maintenance while UIC 7-9 are those that support less traffic and are generally in worse conditions in terms of maintenance.

Concerning the comparison between the HSR and CRL SELs in the network, it can be seen that among 18.116 SELs studied in 14 years, 854 are HSR SELs and 17.262 are CRL SELs.

Among this total:

- 9.7% of SELs are HSR SELs. The length of these HSR paths are significantly higher than the length of CRL SELs
- There are no HSR lines from pricing category UIC 7-9.
- 85,6 of the SELs used by HSR trains are CRL lines and are from the UIC 2-6 pricing category
- 4,7% of the rail paths used by HSR trains are CRL from the pricing category UIC 7-9.

However:

- 66% of these trains (trains.km) run on HSR lines from the pricing category UIC 2-6.
- 33% run on CRL from pricing category UIC 2-6.
- 0,7% run on CRL from pricing category UIC 7-9.

All of these specific characteristics were taken into consideration in the models because it may mislead the use of fixed or random effects as well as results of the models.

IV. MODEL

As noticed above, this research aims to establish the impact of the access price on the effective rail traffic by estimating a panel data model using a fixed and/or random[6] effects for every section of the network given by:

$$D_{it} = \alpha_i + \beta \cdot P_{it} + \gamma \cdot Z_t + \varepsilon_{it} \qquad (2)$$

Where,

D_{it} represents the demand (traffic) of train-km in the section *i* during year *t*. P_{it} is the average access price of each path section (SEL). Z_t is a set of external factors that may influence rail demand such as the macroeconomic variables like the GDP, the price of the petrol, the regional GDP (for regional services), the population of each region (for regional service) or the national employment for HSR service. α_i the characteristics of each SEL that are invariant and that may or not influence the predictor variables; in other words, it represents a mutually exclusive intercept which captures the distinctive, time-invariant features of each SEL. ε_{it} is the error term.

With the objective to choose the adequacy of a fixed effect model or a random effect model, this research decides to use the Hausman test (Hausman, 1978). Nonetheless, each SEL may have time-invariant characteristics that may be fixed for one or more periods.

[6] Depending on the kind of service and on the intrinsically variability of independent variables

In addition, these characteristics playing the role of control variables may marginally vary (when they vary). This should highlight the attention for some results concerning the Hausman test. Indeed, if data used in the model do not change across the periods or if the model uses dummy variables that considers very few parts of the sample, it may be more appropriate to use random effect than fixed effects (Caves et al 1985, Odolinski, K., Nilsson J-E 2017). However, this will depend on the set of control variables used for each model.

Hence, the main model for HSR path demands is defined by:

$$\log(D_{HSR_{it}}) = \beta_0 + \beta_1 \cdot \log\left(P_{HSR_{it}}\right) + \beta_2 \cdot \log(HSR_t) + \beta_3 \cdot \log(GDP_t) + \beta_4 \quad log \cdot (Employment_t) + \beta_5 \cdot \log(Petrol_t) + \beta_6 \cdot \mathrm{HSR}_1 + \beta_7 \cdot UIC_{2-6} + \varepsilon_{it} \qquad (3)$$

The main model for regional trains path demand is then defined by:

$$\log\left(D_{TER_{it}}\right) = \beta_0 + \beta_1 \cdot \log\left(P_{TER_{it}}\right) + \beta_2 \cdot \log\left(Regional_{GDP_t}\right) + \beta_3 \cdot \log\left(Regional_{Population_t}\right) + \beta_4 \cdot \log(Petrol_t) + \varepsilon_{it} \qquad (4)$$

Finally, the main model for freight rail path demand is:

$$\log\left(D_{Freight_{it}}\right) = \beta_0 + \beta_1 \cdot \log\left(P_{Freight_{it}}\right) + \beta_2 \cdot \log(GDP_t) + \beta_3 \cdot \log(Industrial\_employmentl_{GDP_t}) + \beta_4 \cdot \log(Petrol_t) + \varepsilon_{it} \qquad (5)$$

After the estimation of these three main models, this research decided to cross the average access price of each path section (SEL) with HSR and UIC variables to evaluate the pertinence of its use. Once this exercise done and in order to confirm the robustness of the model, the demand (tr.km) of rail paths is then estimated with respect to the variable resulting from the cross between the price of each path section, the HSR and the UIC.

V. RESULTS

This article proposes an empirical investigation under the price sensitivity of the traffic using a French dataset covering a period from 2003 to 2016 for passenger services (regional service and High-Speed Rail service) and covering the period from 2003 to 2009 for freight service. Results are presented in table 2[7].

This empirical analysis shows that when track access charges are taken as an isolated control variable its elasticity on the demand of railway paths is negative and statistically significant for high speed trains and freight trains services but without statistical significance for regional trains services.

Concerning the HSR rail paths demand, the magnitude of the elasticity of TACs may be larger when the nature of the railway paths is taken into consideration. Indeed, TACs elasticity of rail paths demand that can support trains running at high speed is higher in absolute terms than the elasticity of TACs of rail paths demand that support just conventional trains: between -0.404 and -0.448 for HSR paths and between -0.13 and -0.17 for conventional paths. However, due to the results observed on the random effects models, the elasticity for HSR paths should be considered with caution. Moreover, given that HSR paths do not represent 10% of the paths used by HSR trains, the elasticity of TACs of rail paths

[7] Results for each model and their Hausman test can be found in annexes 1,2 and 3

supporting conventional trains absorbs almost all the impact of the TACs on rail paths that support high speed trains. Nevertheless, the impact is negative and is close to the elasticity found by German infrastructure manager DB Netz (-0.09).

With respect to the elasticities of the demand for regional trains paths findings of the main model confirm the hypothesis that regional services are under PSO contracts and that the demand of regional trains paths is not affected by explain variables used in this study. This finding may not be completely surprising: regional authorities may not be influenced by the price signal, contrary to commercial market segments, since political reasons may also be considered by these authorities when they order trains paths. These other kinds of variables are not included in the model proposed in this research, therefore it cannot explain the variability of regional tr.km. Hence, in French railway network, when track access charges are not evaluated with respect to their pricing category (UIC) the main model used in this research do not achieve to explain significant impacts on regional rail path demand.

Furthermore, when TACs are associated with the pricing category of each rail path, results suggest that the elasticity of the demand of regional trains paths with low level of traffic (UIC 7-9) is directly impacted by TACs with a statistically significance (between -0.09 and -0.11). Elasticity of the demand for UIC 2-6 is still not statistically significant

Concerning the demand for freight railway paths, findings suggest that, given the high sensitivity of the freight, this market has negative relations with TACs when TACs are not related to the pricing category of paths. This “overall” negative impact of TACs on freight paths demand is principally induced by its impact on paths with low level of traffic (UIC 7-9: between -0.092 and -0.118).

Table 2: demand modeling: fixed and random effects models, main results

	HSR				Regional				Freight			
	fixed		random		fixed		random		fixed		random	
	min	max	min	max	min	max	min	max	min	max	min	max
LN_HSR_TAC	-0.129***		-0.098*									
LN_REG_TAC					0.004	0.020						
LN_FREIGHT_TAC									-0.051**			
TAC_HSR_LINES	-0.448**	-0.404**										
TAC_CRL_LINES	-0.133***	-0.170*										
TAC_UIC_2_6					0.007		-0.020				0.009	0.027
TAC_UIC_7_9					-0.085*		-0.108**				-0.118***	-0.092***
YEAR_D					0.060*	0.068**	0.098*	0.185***			-1.040***	-0.265***
LN_NAT_GDP	0.720***	0.893***	0.076	0.105	0.033	0.105			1.969**		1.865**	
LN_PETROL	-0.058				0.004	0.020			-0.373***		-0.345**	
LN_LGV_INFRA	1.077***	1.323***										

*p<0.05;**p<0.01;***p<0.001

This research does not focus on the discussion of optimal TACs allowing French IM to recover their fixed costs but aims to estimate the elasticity for each French rail service. Indeed, as expected, each service and each market have different elasticities. However, in the case of the recovery of IM costs, as the Ramsey-Boiteux rule suggests, it depends on the level of the elasticity and, in some cases, most importantly, on the level of the coefficient related to financing constraint which is generally interpreted as the social cost of public funds.

Ramsey-Boiteux is then a powerful tool that enables all stakeholders in the railway sector to determine a better TAC focusing on the calculation of elasticity of each service but without leaving outside the importance of the component associated to the cost of public funds which, in the sense of this research, suggests the “willingness” of States to subsidy or not rail services (freight and regional services).

ANNEXES

Annex 1: HSR path demand modeling: fixed and random effects models and Hausman Test results

Variable	model HSR 1		model HSR 2		model HSR 5		model HSR 4		model HSR 5	
	fixed	random	fixed	random	fixed	random	fixed	random	fixed	random
LN_HSR_TAC	-0.129***	-0.090**							-0.161***	-0.098*
LN_LGV_INFRA	1.077***	0.929***	1.153***	0.783**	1.323***	0.953***				
LN_GDP	0.878***	0.833***	0.893***	0.807**	0.720***	0.612***				
LN_EMPL	2.464	2.400	2.413	2.484						
LN_PETROL	-0.058	-0.068	-0.058	-0.067						
TAC_HSR_LINES			-0.404**	0.468***	-0.409**	0.464***	-0.448**	0.545***		
TAC_CRL_LINES			-0.133***	-0.086**	-0.137***	-0.091**	-0.170***	-0.084*		
YEAR_2004							-0.407***	-0.436***	-0.408***	-0.436***
YEAR_2005							-0.428***	-0.468***	-0.433***	-0.462***
YEAR_2006							0.011	-0.078	-0.001	-0.056
YEAR_2007							0.258**	0.157	0.245**	0.180*
YEAR_2008							0.154	0.020	0.136	0.055
YEAR_2009							0.317***	0.182	0.298**	0.219*
YEAR_2010							0.577***	0.359***	0.548***	0.414***
YEAR_2011							0.328**	0.113	0.296**	0.173
YEAR_2012							0.294**	0.090	0.261*	0.153
YEAR_2013							0.307**	0.084	0.271*	0.154
YEAR_2014							0.368***	0.133	0.330**	0.207
YEAR_2015							0.309**	0.071	0.270*	0.148
YEAR_2016							0.238*	0.009	0.200	0.085
_cons	-52.792	-50.868	-52.654	-50.946	-10.605***	-7.414**	9.639***	8.565***	9.590***	8.663***
N	6656	6656	6656	6656	6656	6656	6656	6656	6656	6656
r2	0.015		0.015		0.015		0.036		0.036	
r2_a	-0.094		-0.093		-0.093		-0.071		-0.072	
F	17.945		15.624		22.939		15.071		15.842	
Hausman Test	chi^2(5)	1837.10	chi^2(6)	92.36	chi^2(4)	95.06	chi^2(15)	107.74	chi^2(14)	-377.41
	Prob > chi^2	0.0000	Prob > chi^2	0.0000	Prob > chi^2	0.000	Prob > chi^2	0.0000	Prob > chi^2	-

*p<0.05;**p<0.01;***p<0.001

Own elaboration

Annex 2: Regional train path modeling: fixed and random effects models and Hausman test results

Variable	model Regional 1		model Regional 2		model Regional 3		model Regional 4	
	fixed	random	fixed	random	fixed	random	fixed	random
LN_REG_TAC	0.020	0.059***	-0.004	0.006				
LN_REG_GDP	0.076	0.108	0.105	-0.083	0.033	-0.113		
LN_REG_POP	0.679	-1.604***	0.043	-1.472***	0.290	-1.429***		
LN_PETROL	0.020	0.060*	0.004	0.027	0.007	0.029		
YEAR_D			0.060*	0.113***	0.068**	0.123***		
TAC_UIC_2_6					0.007	0.015	-0.008	-0.020
TAC_UIC_7_9					-0.085*	-0.065	-0.110**	-0.108**
YEAR_2004							0.022	0.019
YEAR_2005							0.043	0.043
YEAR_2006							0.011	0.010
YEAR_2007							0.025	0.017
YEAR_2008							0.048	0.046
YEAR_2009							0.055	0.056
YEAR_2010							0.029	0.032
YEAR_2011							0.098*	0.101*
YEAR_2012							0.134***	0.138***
YEAR_2013							0.145***	0.148***
YEAR_2014							0.183***	0.185***
YEAR_2015							0.175***	0.179***
YEAR_2016							0.139***	0.141***
_cons	-0.244	34.066***	9.306	34.429***	6.329	34.103***	11.208***	10.717***
N	12238	12238	12238	12238	12238	12238	12238	12238
r2	0.002		0.003		0.003		0.006	
r2_a	-0.090		-0.090		-0.089		-0.087	
F	6.161		6.201		6.487		4.636	
Hausman Test	chi^{2}(4)	116.10	chi^{2}(5)	83.42	chi^{2}(6)	67.18	chi^{2}(15)	-127.28
	Prob > chi^{2}	0.0000	Prob > chi^{2}	0.0000	Prob > chi^{2}	0.0000	Prob > chi^{2}	-

*p<0.05;**p<0.01;***p<0.001

Own elaboration

Annex 3: Freight train path modeling: fixed and random effects models and Hausman test results

Variable	model Freight 1		model Freight 2		model Freight 3	
	fixed	random	fixed	random	fixed	random
LN_FREIGHT_TAC	-0.051**	-0.037*				
LN_PETROL	-0.373***	-0.357**	-0.358***	-0.345**		
LN_NAT_GDP	1.969**	1.849**	1.865**	1.766*		
LN_IND_EMP	7.288***	7.610***	7.246***	7.588***		
TAC_UIC_2_6			0.007	0.009	0.022	0.027
TAC_UIC_7_9			-0.156***	-0.118***	-0.137***	-0.092***
YEAR_2004					-0.229***	-0.265***
YEAR_2005					-0.482***	-0.521***
YEAR_2006					-0.516***	-0.553***
YEAR_2007					-0.586***	-0.642***
YEAR_2008					-0.646***	-0.696***
YEAR_2009					-0.963***	-1.040***
_cons	-126.505***	-130.090***	-124.418***	-128.603***	11.339***	10.986***
N	4948	4948	4948	4948	4948	4948
r2	0.170		0.177		0.180	
r2_a	-0.035		-0.027		-0.023	
F	203.243		170.542		109.055	

Hausman Test	chi²(4)	81.990	chi²(5)	-2657.37	chi²(8)	-337.25
	Prob > chi²	0.0000	Prob > chi²	-	Prob > chi²	-

*p<0.05;**p<0.01;***p<0.001

Own elaboration