LABORATOIRE AMÉNAGEMENT ÉCONOMIE TRANSPORTS | TRANSPORT URBAN PLANNING ECONOMICS LABORATORY

Regional passenger rail transport Efficiency: a test of measurement and explanation in the case of France

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Research context

- **Two Research questions:**
  - To **measure** the **productive efficiency** of the rail passenger transport (TER) in each French region
  - To identify **major determinants** of efficiency. We test four groups of explanations.
- **Three research opportunities!**
  - Huge evolution of rail regulation in France
  - Need of knowledge in a special bargaining period
  - Unique Database (financial & contractual)

Available researches

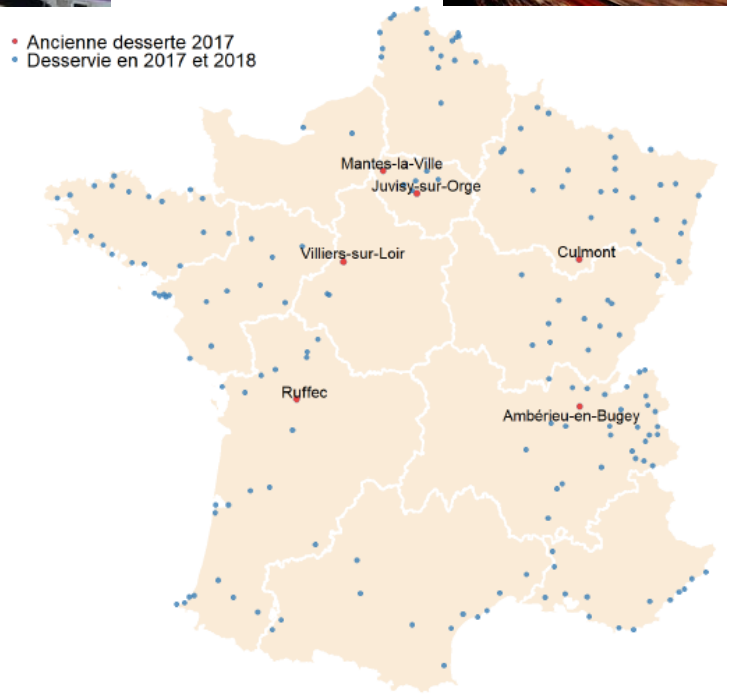
- Measurement of the productive efficiency of the railway industry by stochastic frontier:
  - Asmild, Holvad, Kronborg, 2009; Bouf and Peguy, 2001; Cantos and Maudos, 1999, 2001; Cantos et alii., 2012; Coelli and Perelman 1999; Cowie and Riddington 1996; Friebel, Ivaldi and Vibest, 2010; Gathon and Perelman 1992; Merkert, Smith and Nash, 2012; Oum and Yu 1994; Oum, Waters and Yu, 1999; Smith and Nash, 2014)
- Regional rail passenger transport:
  - Farsi, Filippini and Greene (2005): Swiss regional railway companies
  - Mizutani, Kozumi and Matsushima (2009): Japan
  - Link (2016): rail franchises in Germany.
- Regional rail passenger transport in France:
  - Lévêque, 2004, 2005. Very few data are available due to the monopoly context of our misgiving incumbent operator.

Background: regional rail main data

- TER: 272.7 million travellers / year (HSR: 109.6 million) [2018]
  - TER: 13.2 billion Pkm / year (HSR: 48.9 billion annual Pkm)
  - 2 268 cities served *versus* 173 for HSR (TGV)
  - Average speed: 83 km/h
- TER: 50% of SNCF circulation
  - 5,580 circulations per day / 11,200 circulations
  - 18% of “SNCF Mobilités”' turnover
- TER: 2° Regional budget after education and vocational training
  - €3.3 bn (operating subsidies €2.8 bn + €0.5 bn investment) [2010-2017]
  - Cost coverage rate by revenue: 29%

Source: ARAFER, 2019; National Transport Account, 2018.

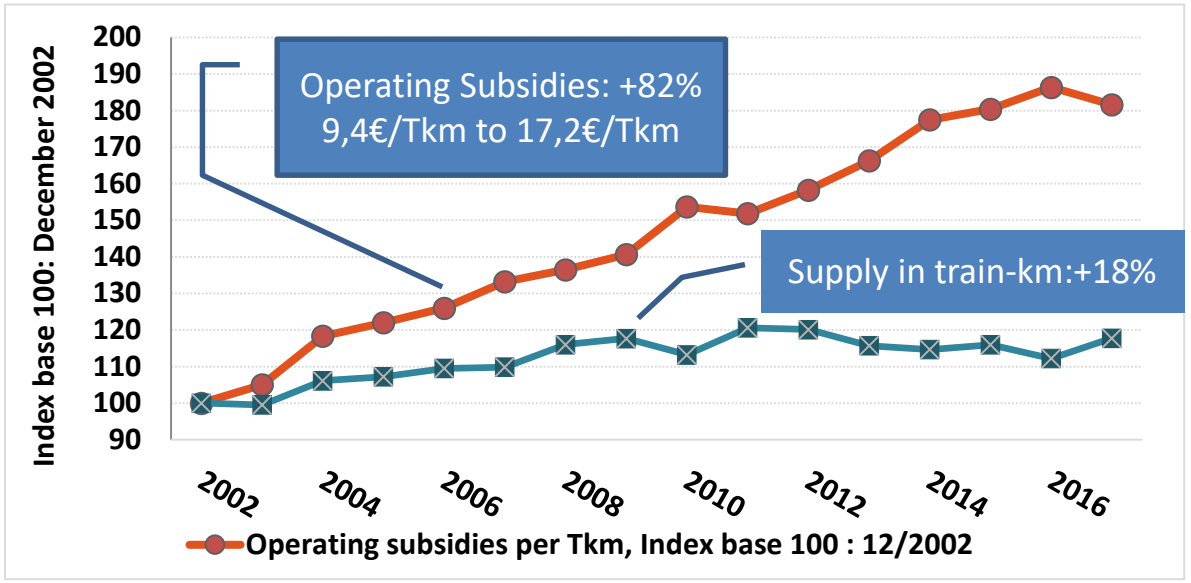
Background: the regional rail network main part of the French rail system



Source: ARAFER, 2019. The French passenger rail transport market.

Regulatory background: an atypical institutional design

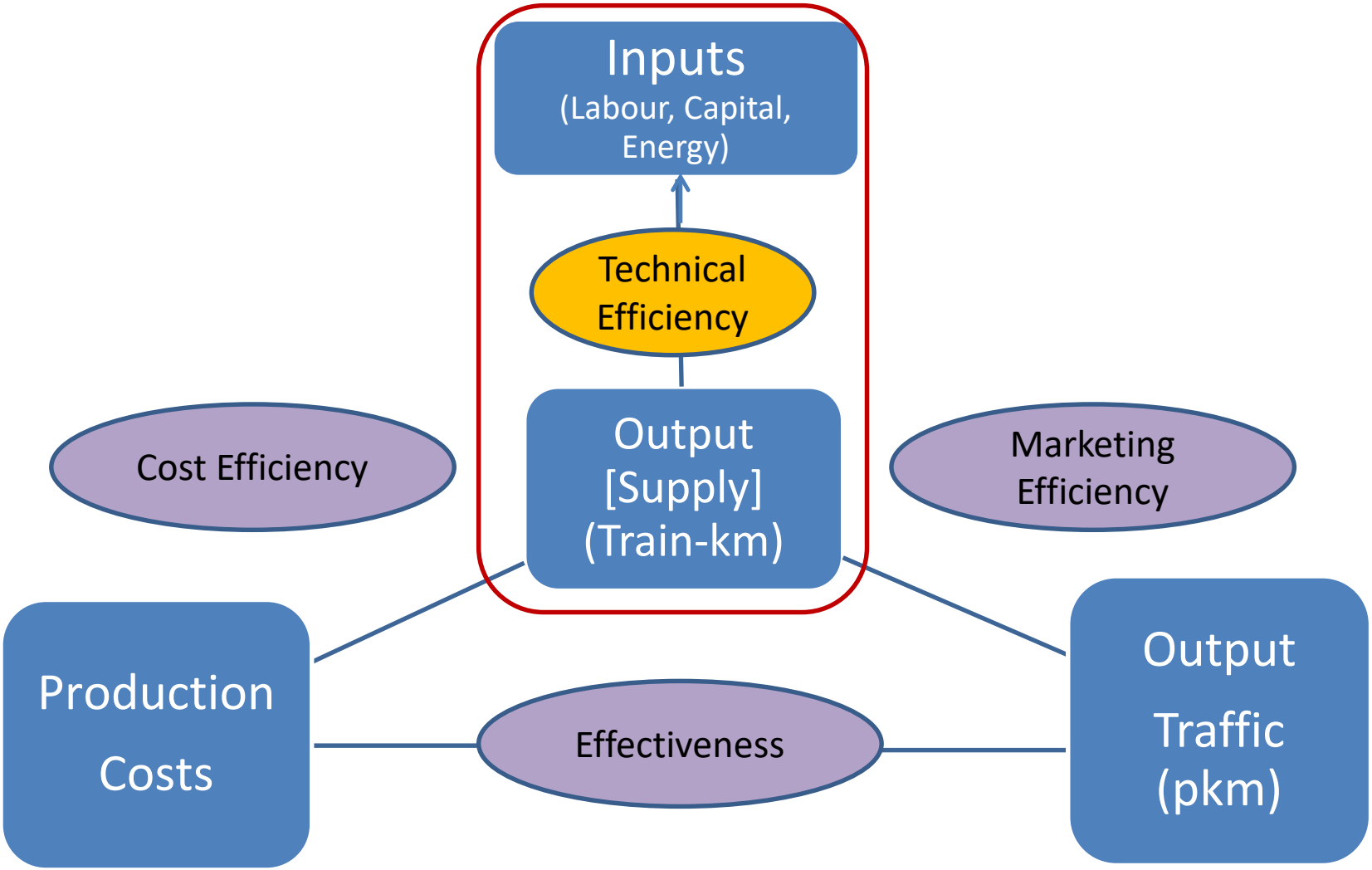
- **Unlike** most **European countries**, the French regional passenger transport market is **not yet open to competition** [PSO, European regulation, EC 2007/1370]
- **Regional Rail policy** [SRU law, 12/2000]**:** a large local freedom, as result **specific contract** for each of the twenty French regions
- **Cost-Plus contract**: PTAs finance the *ex-post* deficit! **Atypical** with regard to European rail contracts [ERRAC]. Largely protective of a historical monopoly adverse to risk.
- A continual and dramatic **production cost drift…**



Method. Research hypothesis (1/5)

- H. 1. Each region can be considered as **a particular firm** for which it is possible to study its productive performance.
- H. 2. Rail operator productive performance depends on the **all system around** (Link, 2016).
  - H. 2.1. **Societal environment**: socio-demographic characteristics, general economics indicators… No influence from operators or PTA's.
  - H. 2.2. **Rail production system**: network (age, complexity, density of use), rolling stock (age, heterogeneity), station…
  - H. 2.3. **Contract design and contract management.** Policy variables. Very specific in France, with monopoly (no rail franchise): Desmaris (2004).
  - H. 2.4. **Quality** in rail production

Method. A measure of rail productive Efficiency (2/5)



Method. Model specification (3/5)

- We measure and explain productive inefficiency that arises from an excess use of inputs, also called **technical efficiency (TE).**
  - The **output** is fixed by the regional rail transport authority.

  → The rail operator inefficiency is interpreted as an **excess use of inputs to produce a given output,** not as a production shortfall given a certain level of inputs.

- We use a **production stochastic frontier model** (Cobb-Douglas-type):

$$\ln(TrKm) = \beta_0 + \beta_1 \ln RS + \beta_2 \ln Lab + \beta_3 \ln En + \varepsilon$$

  - Output: Train-km ($TrKm$)
  - Inputs: Rolling stock (RS), Labour (Lab) and Energy (En)
  - Error term: ε

Method. Model specification (4/5)

- The **specificity of the frontier** method is the two-part error term:

$$\varepsilon = -u + v$$

  - $u \geq 0$ accounts for technical inefficiency
  - v is statistical noise

- The **technical efficiency** is defined as the **ratio** between the observed output and the frontier output (reached when $u = 0$):

$$TE = e^{-u}$$

We assume that $v \rightsquigarrow N\ (0, \sigma_v^2)$ and $u \rightsquigarrow N^+(\mu, \sigma_u^2)$.

- To test if some variables explain the inefficiency level, we set :

$$\mu = \delta Z$$

  - δ is a vector of **parameters** to be estimated
  - Z is a vector of **variables** explaining inefficiency.

Method. Descriptive statistics Dataset (5/5)

Variable	Label	mean	sd	min	max	Nb obs.
Output						
Train-km (Million km)(1)	$TrKm$	8,66	5,09	3,40	27,98	100
Inputs						
Rolling stock (Motorised Unit)(1)	RS	111,03	64,83	37,00	387,00	100
Labour (Million €)(1)	Lab	100,72	61,91	36,91	315,00	100
Energy (Million €)(1)	En	9,00	5,60	2,80	37,51	100
Efficiency determinants						
Density (Inhab/km²)(2)	$Dens$	108,41	66,96	43,53	327,11	100
Crime rate (per 100 inhab.)(3)	$CrRa$	2,40	1,04	0,94	5,54	100
Network length (Thousand km)(4)	$Netlen$	1,09	0,35	0,57	2,00	100
Rolling stock average age (years)(4)	$RSAge$	14,15	3,77	6,70	22,51	100
Number of rail stations(4)	$NbSta$	130,93	54,41	49,00	344,00	100
Contract degree of accuracy(5)	$ConAcc$	85,05	34,03	28,00	178,00	100
Operator compensation (%)(5)	$OpComp$	1,27	1,34	0,00	3,70	100
Lateness rate (per 100 trains)(6)	$LatRa$	8,31	3,05	3,42	17,29	73
Cancelation rate (per 100 trains)(6)	$CanRa$	1,95	1,18	0,80	7,33	73

(1) Source: Enquête annuelle sur les Transports collectifs régionaux - DGITM, CGDD, CEREMA – Régions de France - GART – UTP - FNTV, years 2012, 2013, 2014, 2015 and 2016.

(2) Source: INSEE. https://www.insee.fr

(3) Source: Interstats. https://www.interieur.gouv.fr/Interstats/

(4) Source: Ville, Rail & Transport N°564, 574, 587, 598 et 611.

(5) Source: C. Desmaris. Own database.

(6) Source: Autorité de la qualité de service dans les transports (AQST)

Results. TE explanation: a large explanatory set (1/4)

Model	(1) OLS	(2) SFA	(3) SFA	(4) SFA
Frontier				
Intercept	-1,797***	-2,007***	-1,588***	-1,748***
ln(Rolling stock)	0,052	0,267***	0,153***	0,207**
ln(Labour)	0,736***	0,657***	0,672***	0,620***
ln(Energy)	0,146**	0,032	0,040	0,109*
Efficiency				
Density		-0,002***	-0,001***	
Crime rate		0,120***	0,120***	
Network Length			0,113**	
Rolling stock average age			-0,001	
Number of stations			-0,002***	
Contract degree of accuracy			0,002***	
Operator compensation			-0,021***	
Lateness rate				0,000
Cancelation rate				0,045
Residuals				
$\sigma^2 = \sigma_u^2 + \sigma_v^2$		0,022***	0,005***	0,030**
$\gamma = \sigma_u^2/(\sigma_u^2 + \sigma_v^2)$		1,000***	0,799***	0,968***
R2	0.940			
Residuals skewness	-0.479			
Log likelihood		89.707	137.607	55.097
LR Test Pr(>Chisq)		0.000***	0.000***	0.014**
Nb observations	100	100	100	73
Nb individuals		20	20	19
Nb period		5	5	4

Societal Environment

- Density: Efficiency +
- Crime rate: Efficiency –

Rail system

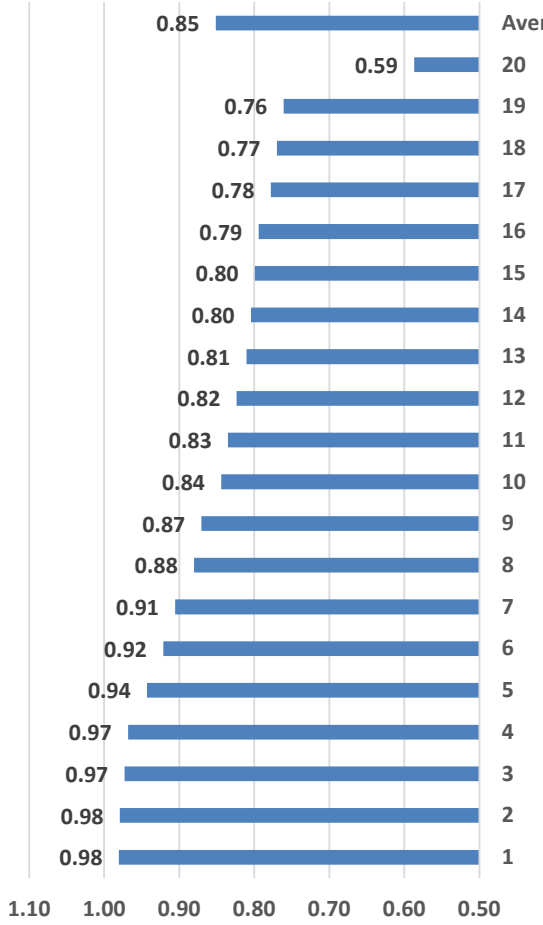
- Network length: Efficiency –
- Age RS: Efficiency + (?)
- Number of stations: Efficiency +

Contract & governance

- Contract Accuracy: Eff. –
  - E^- (t-1)$\rightarrow A^+ \rightarrow E^-$
- Operator extra remuneration: Eff. +
  - $R^+ \rightarrow E^+$: Positive incitation to effort!

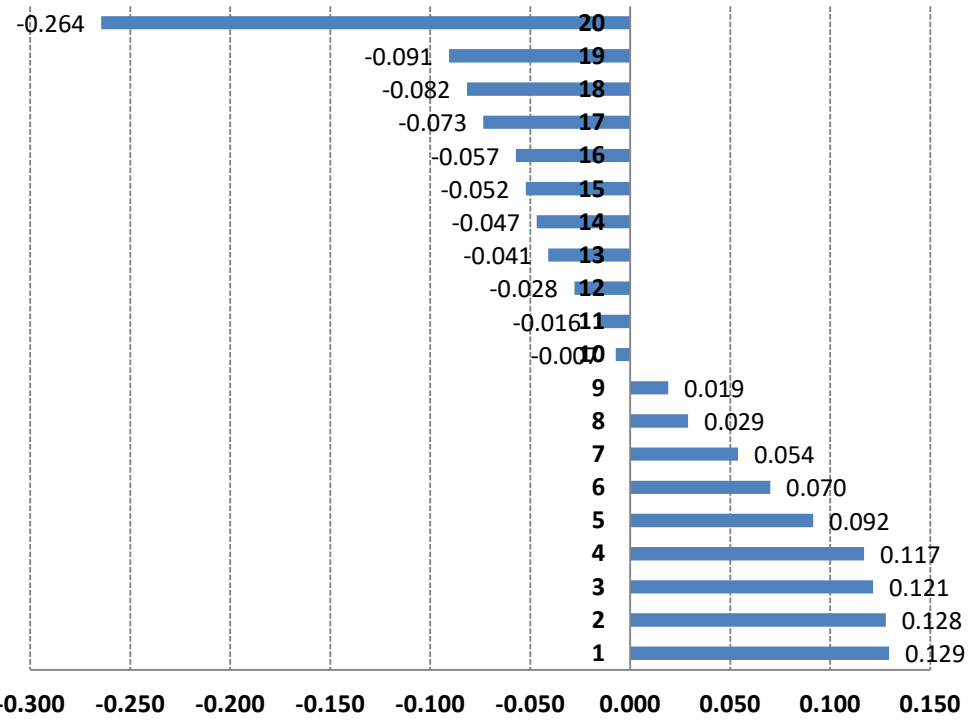
Results: Technical Efficiency heterogeneity (2/4)

Average efficiency per Region



Own results from Enquête annuelle sur les transports collectifs régionaux - DGITM, CGDD, Cerema – REGIONS DE FRANCE - GART – UTP – FNTV.

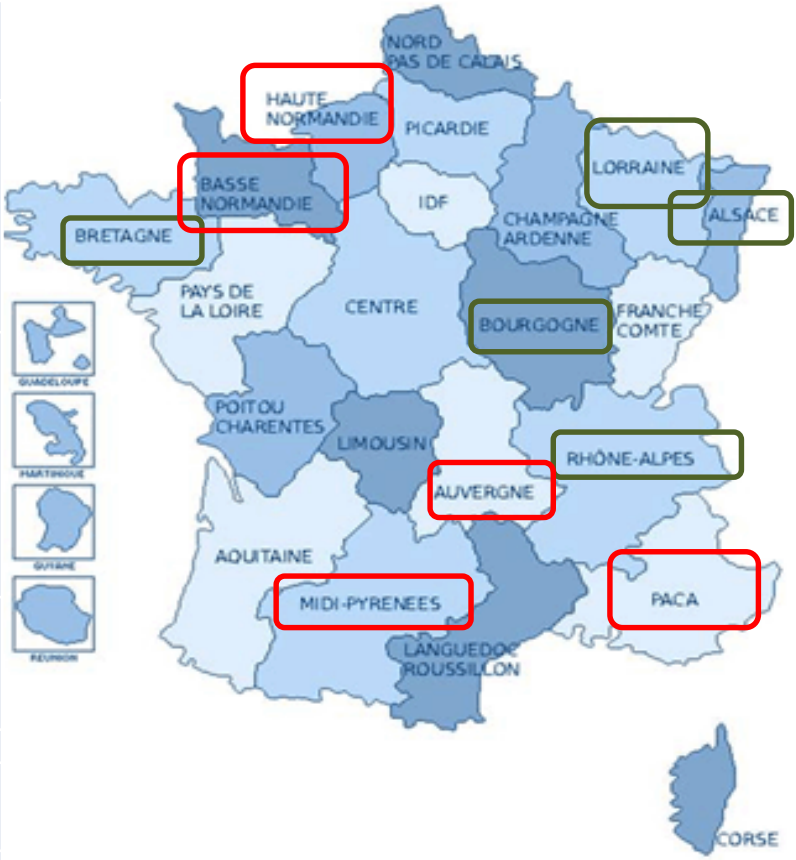
Average deviation from overall average efficiency (percentage points)



- **Average efficiency is rather high** at 0.85 → **regions could gain 15% efficiency**, by adopting the best practices of the incumbent.
- A **broad range of situations** [0,59-0,98] → Many regions could improve their technical efficiency, without changing operator.

Results: Technical efficiency groups (3/4)

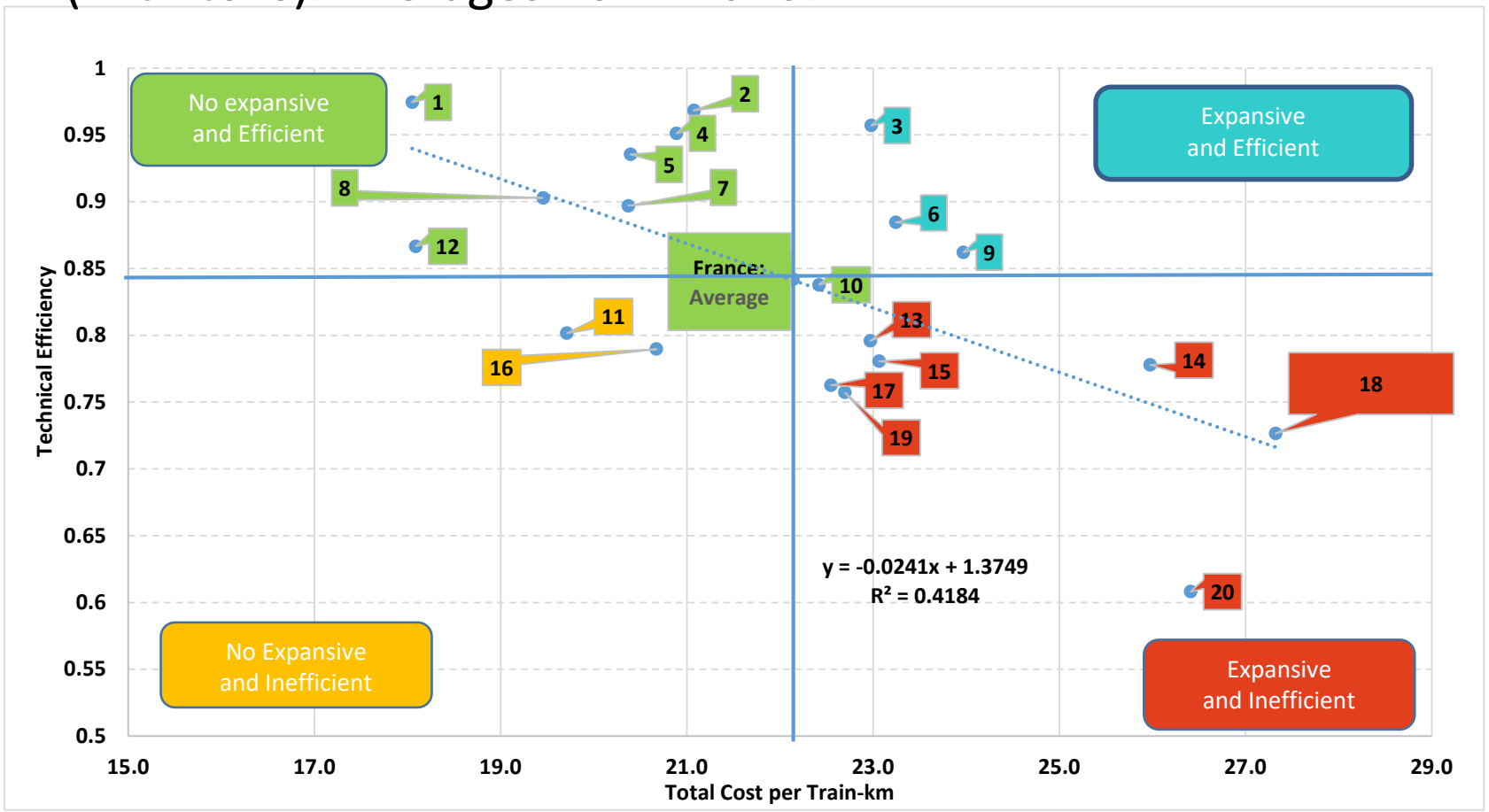
Technical Efficiency: Ranking order	2012	2013	2014	2015	2016	Average efficiency	Rank meaning
1	0,98	0,98	0,98	0,99	0,97	0,981	
2	0,96	0,98	0,98	0,99	0,98	0,979	
3	0,97	0,97	0,97	0,99	0,97	0,973	
4	0,97	0,97	0,95	0,98	0,98	0,968	**Efficient [Mean − 1 ∗ Sdt deviation]**
5	0,95	0,97	0,95	0,88	0,95	0,943	
6	0,96	0,92	0,93	0,92	0,88	0,921	
7	0,97	0,89	0,86	0,86	0,94	0,905	
8	0,85	0,87	0,90	0,88	0,89	0,880	
9	0,90	0,88	0,87	0,87	0,83	0,870	
10	0,86	0,88	0,84	0,84	0,80	0,844	
11	0,80	0,84	0,86	0,86	0,82	0,835	**Average of efficiency [Mean − 2 ∗ Sdt deviation]**
12	0,82	0,83	0,83	0,84	0,80	0,823	
13	0,82	0,82	0,81	0,79	0,81	0,810	
14	0,82	0,82	0,80	0,81	0,77	0,805	
15	0,81	0,81	0,78	0,83	0,77	0,799	
16	0,84	0,85	0,78	0,77	0,73	0,794	**Sub-Efficient [Mean − 3 ∗ Sdt deviation]**
17	0,75	0,78	0,78	0,81	0,76	0,778	
18	0,80	0,76	0,73	0,75	0,80	0,770	
19	0,79	0,75	0,76	0,80	0,71	0,761	
20	0,58	0,57	0,60	0,59	0,58	0,587	**Low efficiency**
Average efficiency per year	**0,86**	**0,86**	**0,85**	**0,85**	**0,84**	**0,851**	
Standard deviation	0,10	0,10	0,10	0,09	0,11	0,10	
Efficient:	*0,90*	*Average of Efficiency:*	*0,80*	*Sub-Efficient:*	*0,70*	*Low efficiency:*	*0,60*



Own results from Enquête annuelle sur les transports collectifs régionaux - DGITM, CGDD, Cerema – REGIONS DE FRANCE - GART – UTP – FNTV

Results: a different view of railway productive performance (4/4)

- Correlation Technical Efficiency and Total cost per train-Km (with tolls). Averages 2012-2016.



Main conclusions

- **A better understanding of the French context with incumbent in monopoly**
  - Average TE *gap with SNCF of 15%* and a *large scale of TE* performance between French regions operators → Possibility of **improvement with the same operator IF** TE success factors generalized on the all territory?
  - *Complementary* cost production performances view → **Overcome the ratio approach**
  - *Efficiency factors* → To **inform incumbent or new potentially operators** in this negotiation period time…
- **A richest technical efficiency regional rail Model: "Model 3".**
  - A broad set of factors impact **railway companies performances**. **Three groups** can be identified:
    - (1) **Societal**
    - (2) **Technical rail system**
    - (3) **Contractual and governance**
  - Ability to choose **relevant variables** to specific **monopoly rail contracts**.

Further improvements

- **Obtain full transparency on the data**
- **Model improvements**
  - Introduce more explanatory variables about **rail system**:
    - Network (age and morphology); Social firm climate (strike); Intensity of network use (Tkm/Km of ligne); Intensity of charge: Vok/Tkm
  - Develop deep analysis of **contract design or contract management** impact (Desmaris, 2004):
    - contract size, contract duration, subsidies, rail market share, Continuity of Service (offer deductible, penalty for non-performance)…
    - Grasp the dynamics of contracts
- **French regional rail context improvements**
  - Explain the technical efficiency of **each region**
  - Adapt the study to the **new administrative geography** (13 regions since 2016)
  - Use **complementary methods** (cost frontiers) to better understanding of French situation

Contact the Autors

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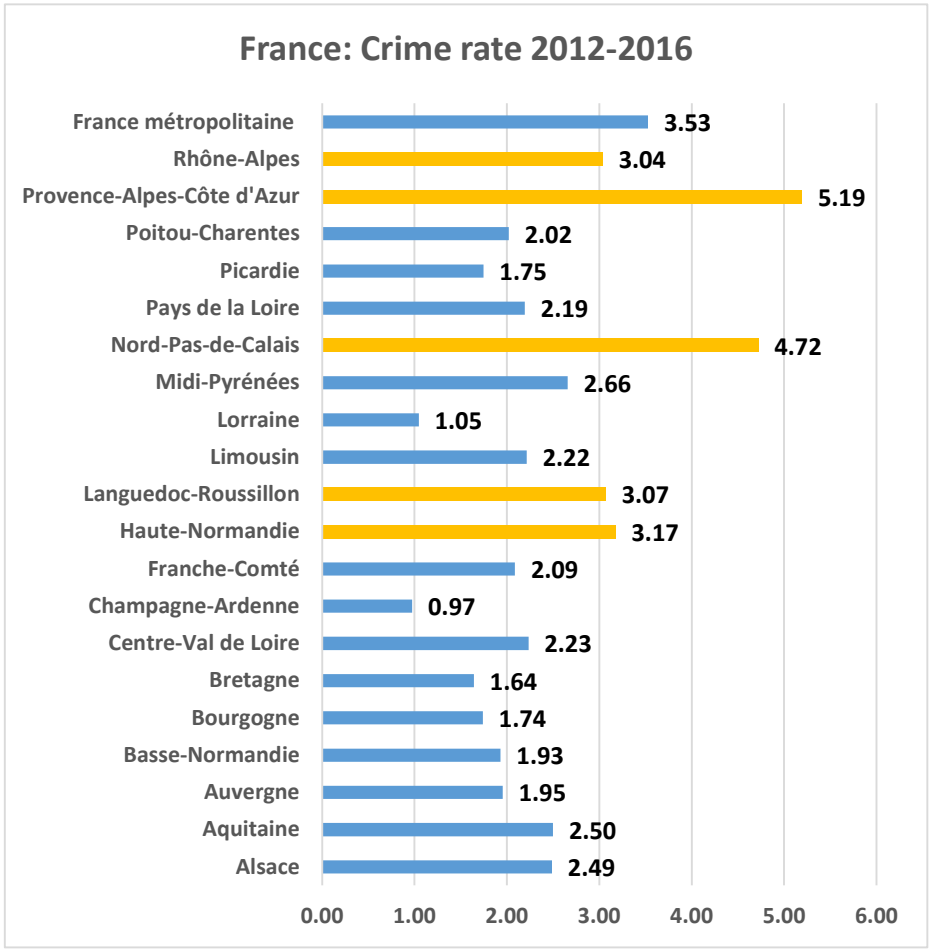
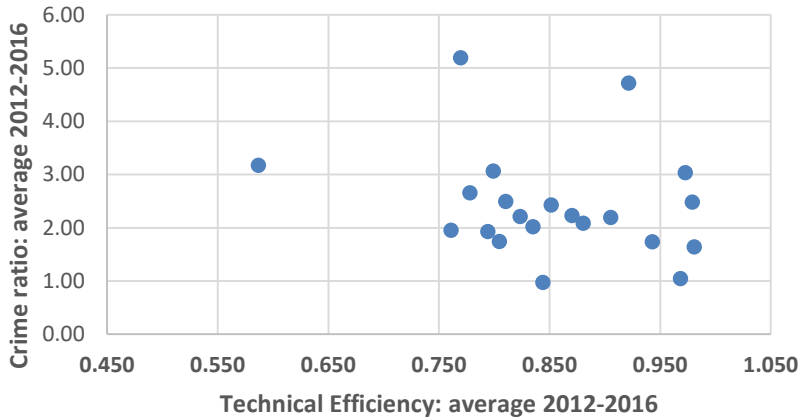
Results. A huge societal environment impact on rail TE (2/6)

- **Crime rate**



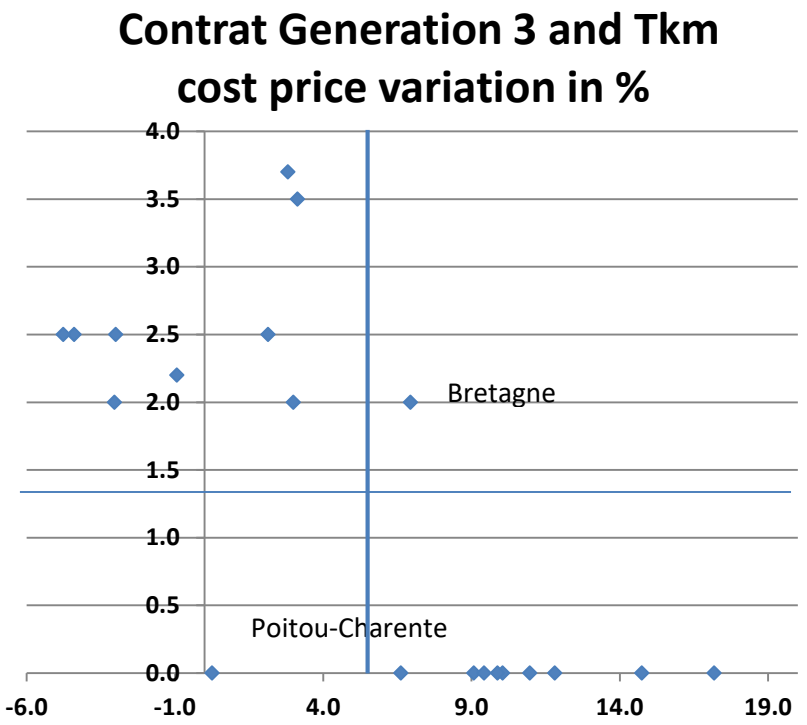
- **Rail TE impact**



- **Validation J. Leveque (2004, 2005) hypothesis.**
  - More safety costs: filtering staff on docks; security guard on board .
  - Disruptions scheduling costs: more regulatory, more operating (material, staff on board)…
  - Railway production is a delicate and sensitive technical system.

Results. A huge contractual impact on rail TE

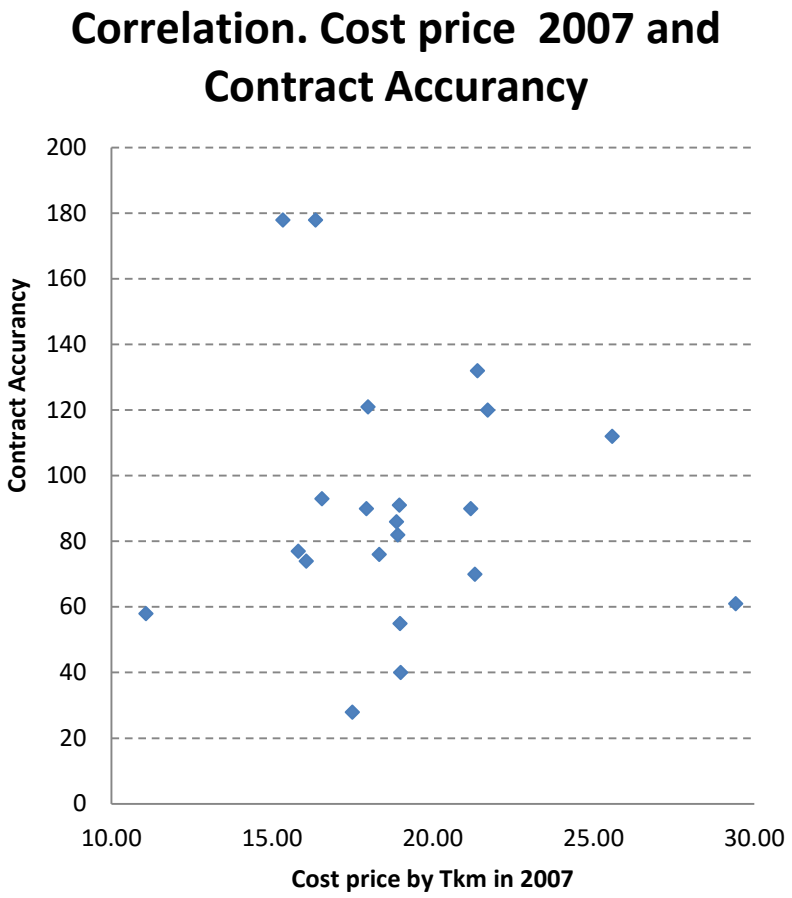
Train-km cost price (Euros)	Var Cost price 2016/2012 in %	Average Variation Cost price in %	Contrat. Operator Compensation
Aquitaine	14,7	10,0	0,0
Auvergne	10,0		0,0
Centre-Val de Loire	9,9		0,0
Champagne-Ardenne	9,1		0,0
Haute-Normandie	6,6		0,0
Languedoc-Roussillon	9,4		0,0
Limousin	11,0		0,0
Nord-Pas-de-Calais	11,8		0,0
Picardie	17,2		0,0
Poitou-Charentes	0,2		0,0
Bretagne	6,9	0,2	2,0
Lorraine	3,0		2,0
Pays de la Loire	-3,0		2,0
Basse-Normandie	-0,9		2,2
Bourgogne	-4,4		2,5
Franche-Comté	-3,0		2,5
Midi-Pyrénées	2,1		2,5
Rhône-Alpes	-4,8		2,5
Alsace	3,1		3,5
Provence-Alpes-Côte d'Azur	2,8		3,7
Region Average	**5,4**		**1,3**

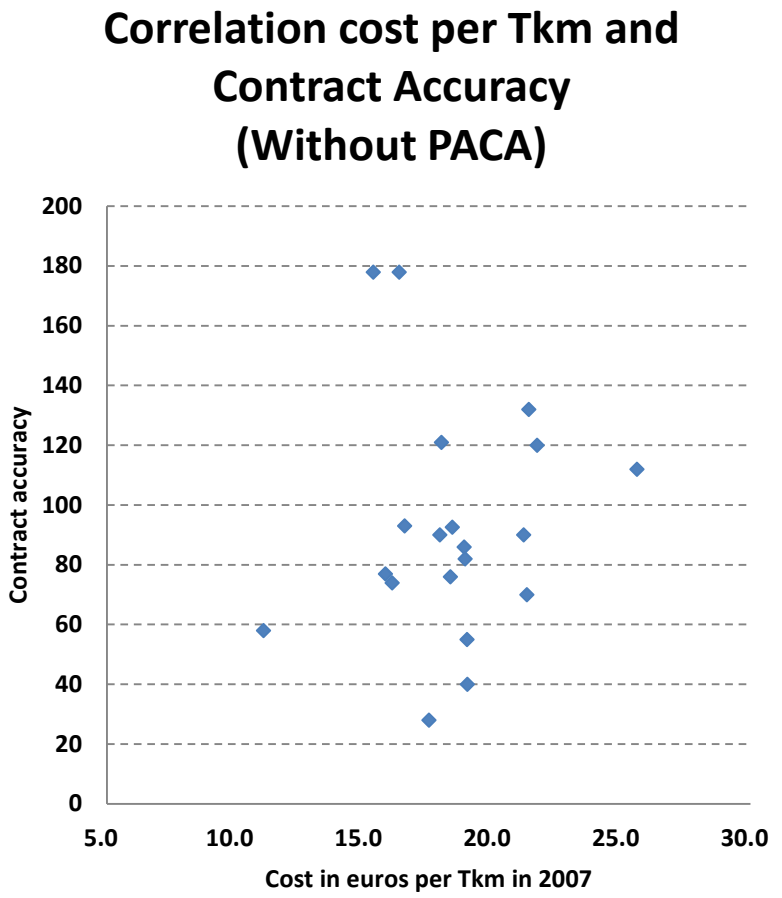


An « Extra remuneration » is granted to rail operator **as positive incitation to be efficient.**

- Generous Operator extra-remuneration → Cost increase < Average (Poitou-Charente excepted)
- No operator extra-remuneration → Cost increase > Average (Bretagne excepted)

Results. A huge contractual impact on rail TE





Actual Contract accuracy depends on **the previous cost performance**. PTA's search to protect from operator inefficiency.

- High production cost in 2007 → Very huge contract (PACA excepted)
- Low production cost in 2007 → Less accurate contract (Bourgogne, HN excepted)

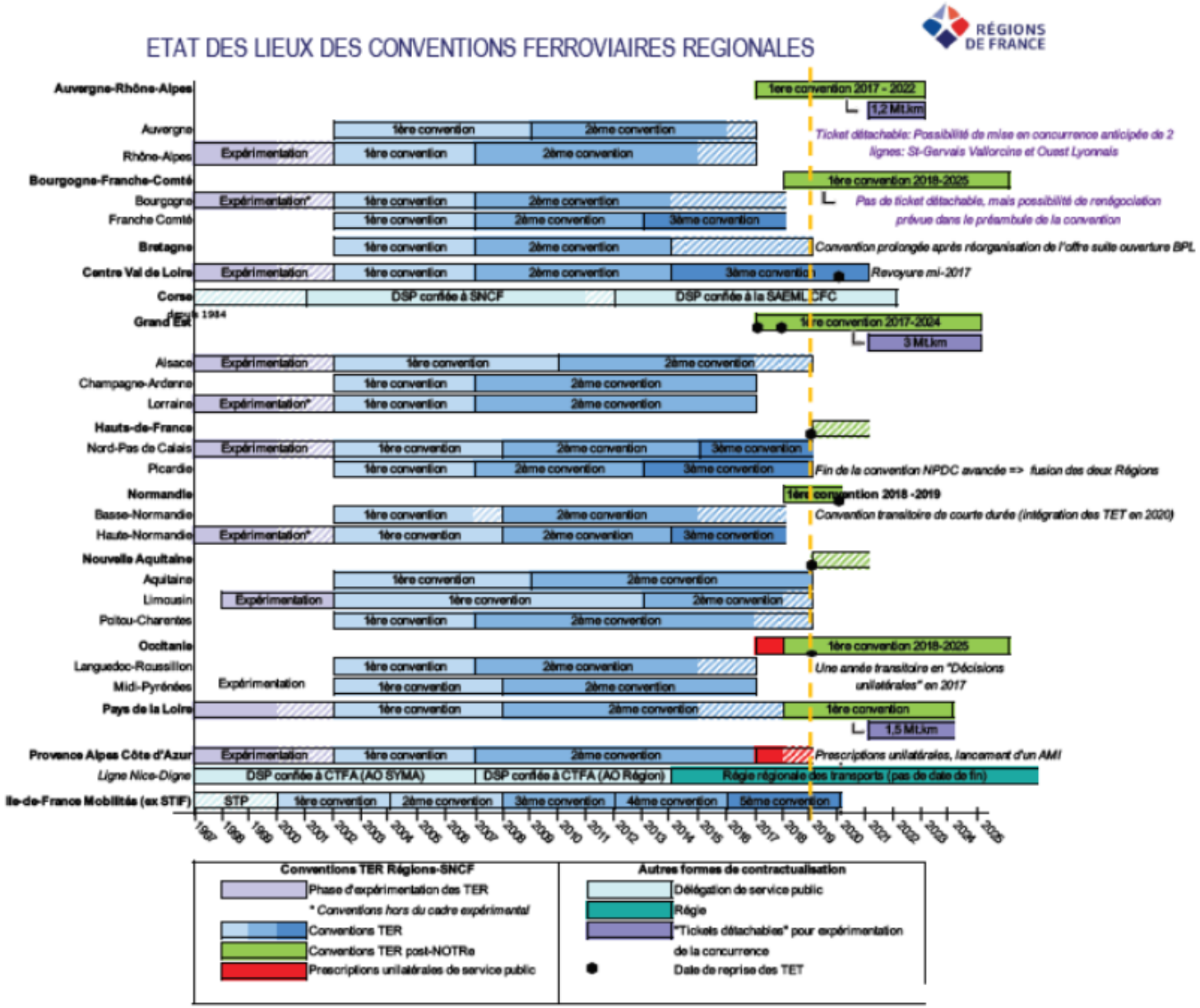
Governance modes SNCF/ Regions

Typology of urban public transport contracts

Contractual form		*Production risk borne by*	*Revenue risk borne by*	*Payment received by the operator*
Fixed-Price contracts	Net Cost contracts	Operator	Operator	$s = s^e$
	Gross cost contracts	Operator	Local Authority	$s = s^e + (r^e - r)$
Cost-Plus contracts	Management contracts	Local Authority	Local Authority	$s = s^e + (r^e - r) - (c^e - c)$

Where s^e is the amount of subsidies the local authority is expected to give to the operator[5] and s the amount he finally receives;
r^e is the expected commercial revenues and r the realised revenues;
c^e is the expected operating costs and c the effective operating costs.

William ROY, Anne IVRANDE-BILLON, 2007. Ownership, Contractual Practices and Technical Efficiency: The Case of Urban Public Transport in France, *Journal of Transport Economics* and Policy, 41, table 1. Adapted from QUINET and VICKERMAN, 2004.



ARAFER (2018). *Annexe, p. 25.*

Méthodologie : repérer les clauses contractuelles pertinentes (3/12)

Techniques	Incitatives	Contrôle	Adaptatives	Institutionnelles
Qualité produite	Incitation financière à la qualité	Transferts de l'information à l'AO	Conditions renégociation	Durée et précision contractuelle
Continuité du service	Pénalités financières transmission tardive (erronée) d'info à l'AO	Supervision directe par l'AO	Conditions rupture	Procédures de résolution des conflits Fréquence des rencontre
		Contrôle externe		Culture commune

Les contrats TER : complexité et diversité contractuelle (7/12)

	Alsace	Centre	Limousin	NPC	PDL	PACA	Rhône-Alpes
Objectif pluriannuel de recettes (OR)	Déterminé en f° : composante tendancielle, modif offre, divers (tarifs, conjoncture)	Annuellement par conjointement après proposition SNCF 7.2.3.	Montant absolu prédéterminé (+ 1%/ an ≈) Rencontre en 2006	Annuellement par les parties sur proposition SNCF	Conjointement par Région et SNCF lors du devis C.5.2.2.	Annuellement par négociation sur proposition SNCF	Revalorisé en f° ΔPIB en volume : >2,2% : OR +1,6% ; <0%:OR +0,5% ; linéaire. Si > 2 ans suite+3%, rg spéciale.
Partage risque commercial SNCF/ Région	+/- 2% : 50-50 +/- 2 à 4% : 75-25 +/- 4 à 6% : 100-0 < +/-6 % : Rencontre	Non prévue	Non prévue	+/- 2% : 50-50 +/-2 à +/-4% : 100-0 +/- 4% : Rencontre	+/- 4% : 50-50 + 4 à +6 % : 40-60 -4 à-6 % : 60-40 +/-6 % : Rencontre	Obj mini SNCF : 93% de l'OR –> 93%, 50-50 –+/- 7%, rencontre	> 3% : 50-50 +/- 3% : 100-0 -3 à - 5% : 0-100 < -5 % : Rencontre
Incitation à la baisse des charges	**OUI** $C1_N = C1_{N-1} * (P- 0,001)$ P : index en %	**OUI** Baisse de 1%/an des charges de structure CST	NON	**OUI** Comparaison Index et Δ PIB nominal A&B A<B : A ; A>B : moy AB	NON	**OUI** Frais de structure N : 2002* (0,96 *$RS6S_{n/2002}$) +0,04)	NON
Rémunération exploitant	**Comprise dans C1**	**Comprise dans C1** (implicite)	En sus : 2,146% de C1	**Comprise dans C1**	**En sus** : Rém service : 2% C1 ; Rém risque : 1,25% C1	**En sus** : % des charges C1 2002 : 3,2% ; 2003: 3,4% ; 2004: 3,6% ; 2005: 3,7%	**En sus** : % des charges C1 : 3% en 2002 ; 3,5% après