INSTITUT D'ECONOMIE INDUSTRIELLE

IDEI Report # 12

Rail Transport

June 2007

The European Market for Freight Services : Towards A Simulation Model of Competition

INSTITUT D'ECONOMIE INDUSTRIELLE

IDEI Report #8 on Passenger Rail Transport

June 2007

The European Market for Freight Services: Towards A Simulation Model of Competition

The European Market for Freight Services: Towards A Simulation Model of Competition

prepared by

Marc Ivaldi

Acknowledgements

The authors acknowledge with gratitude the advice and research support of Deutsche Bahn AG, but note that the views expressed remain those of the authors alone and in no way represent the views of Deutsche Bahn AG or its representatives.

1. INTRODUCTION

This report presents a methodology to build a simulation model for analyzing the competition on the market for freight services in Europe. It is a first step in an ambitious project to develop a tool which is aimed at analyzing different aspects of competition such as entry of various types of competitors or different forms of competition such as inter- and intra-modal competition, and at evaluating the effects of different industry structures depending on the role of regulators and the technical organization of transport firms. This tool should be useful for the delineation of relevant markets, the measure of market power, the definition of the optimal price of access to the rail infrastructure and the evaluation of the impact of external effects.

What is original here is to account for the strategies of actors of the transport system and their interactions. In other words, we consider here what economists call equilibrium solutions, i.e., the market outcomes when all actions and strategies of actors have exerted their effects. To fully assess the effect of a change like the entry of a new firm on the market for instance, we propose to proceed by comparing the *ex ante* situation which, by definition, is an equilibrium, and the *ex post* situation when the industry or the market has reached an equilibrium, after all actors on the market have changed their strategies to adapt to the entry of a new competitor and all interactions implied by these new strategies have been exercised. To perform such an analysis we use models of game theory.

We illustrate how this methodology can be used to address a critical problem for the rail freight industry, namely the “problematics” of the single wagon. Railways claim that part of the rail freight business would collapse if nothing is done to maintain the capacity for railways to collect shipments in single wagons at different points of the network as close as possible from clients. Indeed it is only at this condition that profitable trains can be assembled at some point of the rail network. The challenge comes from trucks which are more flexible for collecting shipments at the customers’ whereabouts. Clearly the competition issue is crucial here and this problem is an excellent candidate to illustrate the proposed methodology.

We implement the methodology on real data for the European freight industry and we simulate the impact of a road charge, i.e, we evaluate how the conditions of competition are modified by taxing the road freight service whose proceeds could be used to develop other transport modes, in particular the rail freight service. ***The policy conclusion is that a road***

charge could be beneficial for the society as a whole provided that external effects are taken into account. The social benefit would be even more striking provided that the rail industry improves its productive efficiency. Thus implementing a road charge and improving rail efficiency are two complementary policies.

Note that, in Appendix 1, we display the mechanics - more precisely the economics - at work behind this methodology using a fairly simple setup in order to attract the attention of the interested reader on the main machinery.

We conclude by drawing the steps of the agenda of future research and development.

2. THE SINGLE WAGON ISSUE

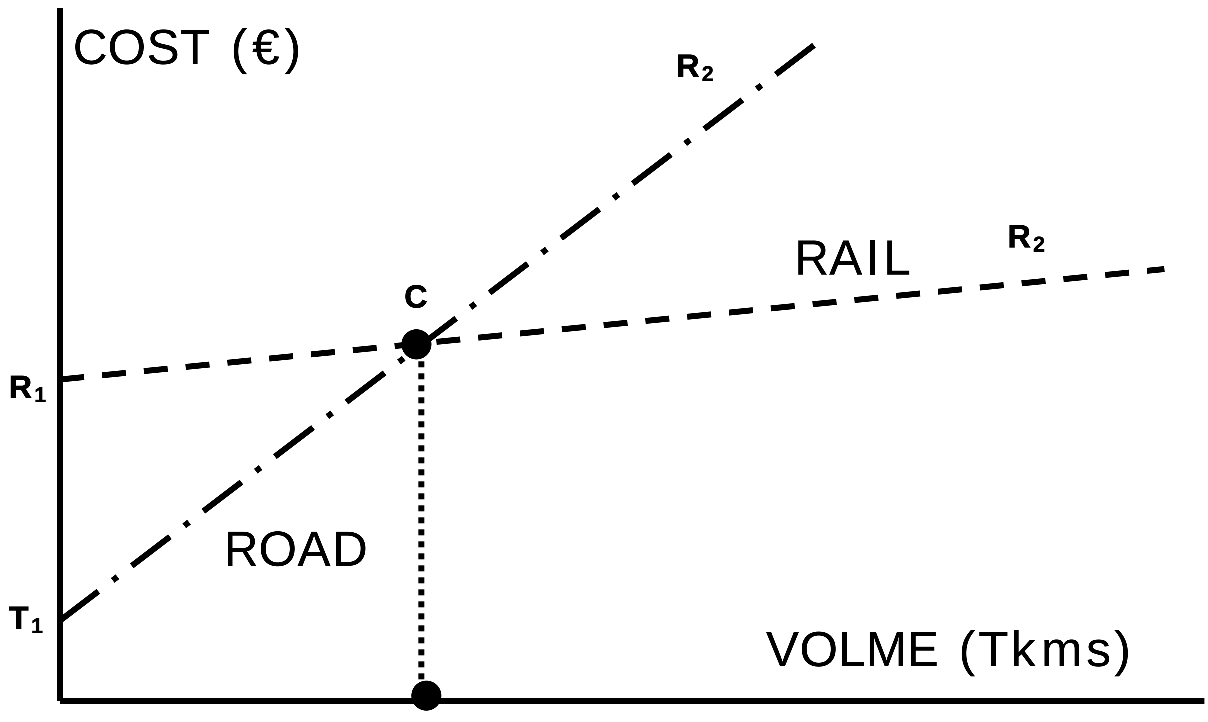
In 2005, the question of the single wagon has been addressed in a report by McKinsey for the Community of European Railway and Infrastructure Companies (CER). As a contribution to this debate, I have developed my own analysis of this question. The following discussion is the support of the presentation provided in Appendix 2.

The McKinsey report raises two main questions. First, it investigates the sustainability of the rail freight industry by evaluation the scope for intermodal competition. In other words, the issue is to assess whether the rail technology and service can compete with the other transport technologies, in particular with the road technology. Second, it analyzes the impact of a road charge on the profitability of the different freight service operators. This question is directly to the debate in the European Union about the so-called Eurovignette, which is a road charge that trucks should pay when they move shipment between origins and destinations. We address these questions as follows.

The rail freight service faces a technological challenge that can be represented in a very simplified way as in Figure 1. To start a road freight service with trucks, the fixed cost is much lower than for a rail service. It is why point R_1 is higher than point T_1 on Figure 1. We assume that the variable cost increases with the volume hauled. Assume also that a truck and a wagon carry the same volume of merchandises. Clearly, as the volume to be hauled increases, the variable can be higher for the road service than for the rail service. Indeed, as soon as a train of X wagons has been assembled, it requires only one driver, while, to carry the same volume on road, it requires X drivers. This is why the slope of the road technology is steeper than the one of the rail technology in Figure 1.

If the fixed cost of the rail technology is not too high, there is a chance for the two cost functions to cross at some point C. First, note that if the rail technology entails very high cost, the road technology could be optimal all the way and it would be unprofitable for the society to maintain the rail technology. Second, in case the point C exists and corresponds to some realistic volume, then it would optimal for the society to use the road technology up to the point C and then to carry all the commodities on rail. If the cost of unloading trucks and loading wagons is not negligible, then, in a decentralized economy, there is a room that the optimal solution for the society would have no chance to be implemented.

Figure 1: The rail and road cost functions



This is why the idea of a road charge has been proposed. Indeed a road charge can have two effects. Either it could increase the fixed cost of the road services, which could move the point C to the left at the lower volume. Or it could steeper the slope of the road cost function, which has also the effect of moving point C to the rights. In both cases, the scope for rail services becomes larger. Note that the road charge must be connected with effects on intermodal competition which motivates the following model. In the sequel, we do not distinguish between single wagon and bulk freight.

3. A MACROECONOMIC MODEL OF THE EUROPEAN FREIGHT INDUSTRY

In some European countries, the rail freight industry is in bad shape. Accordingly to the McKinsey's report, the average revenue across Europe is 0.0456 euros per ton-kilometer while the long-run marginal cost is 0.05 euros per ton-kilometer. The industry as a whole is not profitable and cannot survive in these conditions.

This situation is due to at least two main reasons. First, there is a noticeable and well documented lack of efficiency although efforts have been provided to improve the situation (See Friebel, Ivaldi and Vibes, 2003). Second, the discrepancy between the average revenue and the marginal cost is also due to the particular cost structure presented in the previous section and to the imbalances that this cost structure could create in the competition process.

To analyze this situation, we consider a fairly simple competition model. There are 3 firms corresponding to the different transport modes, i.e., rail, road and other modes, indexed herein as 1, 2 and 0 without loss of generality. Here a firm is finally an industry. Each firm competes in prices to obtain a share of shipments. For each shipment, a representative customer chooses among the three modes by comparing quality to price, according to logit-type preferences. This model is a simplified version of the model used by Ivaldi and Vibes (2007) to analyze the competition on long distance passenger markets.

In this model, the margin of freight service *i*, that is to say, the difference between the price p_i and the marginal c_i is equal to the inverse of the own price elasticity ε_i, that is to say:

$$p_i - c_i = \frac{1}{\varepsilon_i}. \tag{1}$$

In other words, each firm sets its price so that its margin exactly matches the rent that it can extract from the consumer, which is given by the consumer's willingness-to-pay, itself measured as the inverse of the price elasticity.

Moreover, according to the logit specification, the market share of transport mode *i* is given by

$$s_i = \frac{\exp\left(\delta_i - \alpha p_i\right)}{\sum_{j=0}^{2} \exp\left(\delta_j - \alpha p_j\right)}, \tag{2}$$

where δ_i is the quality of transport *i* and α is a parameter to be estimated. Usually a normalization is imposed, namely $\delta_0 - \alpha p_0 = 0$. Given that the market share of rail is 16 percent and the one of road is 72 percent, given that we observe the prices of road and rail services, we can calibrate the parameter α.

With this demand system, the price elasticity is given by

$$\varepsilon_i = \alpha\left(1 - s_i\right), \tag{3}$$

and the consumer surplus is obtained by computing

$$CS = \frac{1}{\alpha} \ln\left[\sum_{j=0}^{2} \exp\left(\delta_i - \alpha p_i\right)\right]. \tag{4}$$

Suppose that we introduce a road charge t_i. Then, for road, the margin becomes:

$$p_2 - c_2 - t_2 = \frac{1}{\varepsilon_2}. \tag{5}$$

Mechanically the road price must increase and its market share must decrease, everything being equal. Note that, because of the non linearity of the model, these effects are not straightforward to determine. A solution can be obtained by using a numerical algorithm. When the road charge has been collected, it can be distributed partly or entirely to the rail industry. Suppose it is entirely transferred to the rail industry, then the transfer would be equal to:

$$t_2 = (t_1 s_1)/s_2 . \tag{6}$$

Suppose now that the rail industry is able to achieve efficiency gains in terms of cost reductions. Then the margin of the rail industry becomes:

$$p_1 - (c_1 - e_1 - t_1) = \frac{1}{\varepsilon_1} . \tag{7}$$

The combined impact of the transfer and the cost efficiency is not easily obtained. Indeed it affects the price of rail service, which affects in turn the market share of rail transport, which affects the market share of road transport, which affects the price of rail service, which affects the elasticity of rail service demand, which affects the price of rail service, and so on until a new equilibrium is reached. How this mechanics works is explained in Section 4.

4. SIMULATION OF THE IMPACT OF A ROAD CHARGE IN EUROPE

The data for the European freight industry are available on the site of the Directorate General Energy and Transport of the European Commission in its statistical pocket book 2006.[1]

In 2005, the total volume of freight service in the 25 countries of the European Union reaches 2376 billion ton-kilometers. The market share for road freight service is 72.6 percent (s_2, representing 1724 billion ton-kilometers), while the one of rail service is 16.4 percent (s_1, representing 392 billion ton-kilometers). Waterways and pipelines cover the rest of the market for 11 percent. The average price for road freight service is 5 cents per ton-kilometer (tkm) and 4.56 cents per ton-kilometer for rail. We assume that $c_1 = c_2 = 5$ at the initial conditions.

We need now estimates for the marginal costs. McKinsey's consultants estimate the long run marginal for rail freight service to be equal to 5 cents per ton-kilometer (c_1 in the equations). With this figure, it means that this industry is structurally bankrupt. Concerning the road service, we do not have a similar estimate. We assume that the road service generates

[1] See http://ec.europa.eu/dgs/energy_transport/figures/pocketbook/2006_en.htm.

a 10 percent margin, so that the long run marginal cost for road should be 4.5 cents per ton-kilometer (c_2 in the equations). Of course we could make different simulations for different values of the marginal cost of road freight service.

Using Equations (1) and (3), we first estimate the parameter α by solving:

$$\alpha = \frac{1}{\left(1-s_2\right)\left(p_2-c_2\right)}. \tag{8}$$

Now, given that the market share of rail freight service is not nil while the industry is not profitable, we assume that the rail industry receive a cost subsidy τ_1 that satisfies

$$p_1 - c_1\left(1-\tau_1\right) = \frac{1}{\alpha\left(1-s_1\right)}, \tag{9}$$

that is to say,

$$\tau_1 = 1 - \left(p_1 - \frac{1}{\alpha\left(1-s_1\right)}\right)\Big/ c_1 . \tag{10}$$

We have now fully characterized the initial situation which is summarized under Scenario 1 in Table 1 below. Given the values of market shares, prices and marginal costs, this implicit cost subsidy reaches a 12 percent level, which provides to the rail a 3.7 percent margin.

We are now in the position to simulate the impact of a road charge. We assume for the moment that the proceeds raised with the road charge are used to finance the rail's cost subsidy which remains at the 12 percent level. We propose a road charge at 0.25 euros per ton-kilometer. This is Scenario 2 in Table 1. We observe that the market share of rail increases to 23.1 percent while the road's market share decreases to 58.8 percent. As expected, *there is a significant loss of consumer surplus by 20.6 percent.*

Note that this scenario also exhibits a decrease in the level of external effects. Based on the INFRAS/IWW's study in 2000, the external costs generated by road and by rail

Table 1: Simulation results

Scenario	1 Initial conditions		2 Road charge 0.25 c/tkm		3 Road charge 0.25 c/tkm CS constant		4 Road charge 0.25 c/tkm Rail cost Efficiency	
Firm	Road	Rail	Road	Rail	Road	Rail	Road	Rail
Market share (%)	72.6	16.4	58.8	23.1	52.4	36.0	48.1	43.0
Price (c/tkm)	5.00	4.56	5.09	4.58	5.04	4.45	5.02	4.39
Cost subsidy (%)		12.0		12.0		15.4		17
Margin (%)	10.0	3.7	6.7	4.0	5.9	1.3	5.4	5.6
ΔCS (%)			-20.6		0.0		+12.0	
ΔEF (%)			-21.3		-34.7		-43.3	

Note: ΔCS (ΔEF) means change in consumer surplus (external effects, respectively).

amount to 0.088 and 0.019 euros per ton-kilometer respectively.[2] As expected, *a drastic decrease of the road's market share alleviates the total cost of external costs for the society by 21.3 percent, which roughly compensates the loss of consumer surplus.*

In Scenario 3, we again simulate the introduction of a road charge of 0.25 euros per ton-kilometer but we impose that the consumer surplus remains at the level of initial conditions (Scenario 1). In addition to compute the new equilibrium prices and markets shares, we need now to determine the cost subsidy for rail. In this case the rail market share increases again and the road market share decreases. The cost subsidy is raised to a 15.4 percent level. Now the external effects are even more lessened. This is a very interesting situation since the two competitors, rail and road, loose profits for the benefit of the society. How this loss of profits would affect future investment cannot be addressed within this static model.

Finally, in Scenario 4, we assume that the rail firm is able to provide exogenous cost efficiencies so that the cost subsidy (including these cost efficiencies) reaches a 17 percent level. The road charge is still maintained at the same level. *What it is striking is that the consumer surplus now increases thanks to the improvement of the rail's productive efficiency which more than compensates the negative effect of the road charge on consumer surplus.*

In a separate simulation, we assume that the road charge must just cover the initial cost subsidy, i.e., 12 percent. The idea is to raise the lowest road charge so as to maintain the rail activity roughly at its initial conditions. It turns out that the road charge should be set at 22 cents per ton-kilometer. If, in addition, we impose that the consumer surplus remains

[2] http://www.unece.org/doc/poja/poja.uic.2.e.pdf.

unchanged, then the road charge must be set at 21 cents per ton-kilometer. In other words, our simulation with a 25-cent-per-tkm road charge is compatible with a redistribution system of the proceeds of the road charge to the rail service. However, another redistribution system could involve a lower subsidy to the rail service.

Our results of course depend on our hypothesis on the level of marginal costs of the road freight service. A lower level would allow for a larger scope for redistribution. However the direction of changes should not be modified.

5. CONCLUSION: A RESEARCH AGENDA

What we can conclude from the previous simulations is that a road charge could be beneficial for the society as a whole provided that external effects are taken into account. The social benefit would be even more important provided that the rail industry improves its productive efficiency. Thus implementing a road charge and improving rail efficiency are two complementary policies.

Nonetheless this conclusion is reached in a fairly simple model. It is indeed a macroeconomic model that looks at a very aggregate level in a static environment. It misses the fact that there are many operators in the industry, many different types of shipments and commodities, many different types of logistic chains. It misses that transport modes need to cooperate for geographic or technical reasons. It also misses the regulatory rules. On international freight business, several regulators could intervene. For instance, there are different infrastructure operators in the different countries concerned by a specific international rail services. It could be the case that there are different rules concerning the access to the infrastructure. The organization of the transport industry also matters. It is not rare that the largest players in the rail market are also important players in the road business. This should be taken into account.

All these aspects should be incorporated to build a more realistic microeconomic model of the European freight industry that is required to achieve two objectives: First, to design strategic marketing decisions in terms of prices, differentiation and product management; second, to contribute to the debate on the reforms of the rail industry in Europe by evaluating their impact.

REFERENCES

European Commission, Directorate-General for Energy and Transport in Cooperation with Eurostat, “European Union: Energy and Transport in Figures 2006”, http://ec.europa.eu/dgs/energy_transport/figures/pocketbook/2006_en.htm

Friebel, Guido, Marc Ivaldi and Catherine Vibes, "Railway (De) Regulation : A European Efficiency Comparison", IDEI Working Paper, n. 221, 2003.

INFRAS/ IWW, External Costs of transport : Accident, Environmental and Congestion Costs in Western Europe, March 2000, http://www.unece.org/doc/poja/poja.uic.2.e.pdf

Ivaldi, Marc and Catherine Vibes, "Price Competition in the Intercity Passenger Transport Market: A Simulation Model," IDEI Working Paper, n. 457, January 2007.

Mc Kinsey & Company, “The Future of Rail Freight in Europe,” presentation to the European Parliament, November 2005, http://www.cer.be/files/McKinseyFINAL-164934A.pdf

APPENDIX 1

A SIMPLE EQUILIBRIUM MODEL OF COMPETITION

How does it work?

Simple model

- Demand (consumer)
  - Rail = 1
  - Road = 2

$$q_1 = 1 + p_2 - \alpha p_1$$

$$q_2 = 1 + p_1 - \beta p_2$$

p = price

q = quantity

Demand

- Elasticity

$$\varepsilon_{11} = \frac{\partial q_1 / \partial p_1}{q_1 / p_1} = -\frac{p_1}{q_1}\alpha$$

$$\varepsilon_{12} = \frac{\partial q_1 / \partial p_2}{q_1 / p_2} = \frac{p_2}{q_1}$$

Demand

- Elasticity

$$\varepsilon_{11} = \left| -\frac{\partial q_1 / \partial p_1}{q_1 / p_1} \right| = \frac{p_1}{q_1}\alpha$$

- Willingness-to-pay

$$WTP_1 = \frac{\partial p_1 / \partial p_1}{p_1 / q_1} = \frac{1}{\varepsilon_{11}}$$

Supply

- Firm 1 $\underset{p_1}{\mathrm{Max}}\left(p_1 - c_1\right) q_1$
  - Optimality condition (Nash)

$$\frac{p_1 - c_1}{p_1} = \frac{1}{\alpha \dfrac{p_1}{q_1}} = \frac{1}{\varepsilon_{11}} = WTP_1$$

  - Rewriting

$$\alpha\left(p_1 - c_1\right) = q_1$$

Solve

$$\beta\left(p_2 - c_2\right) = q_2 = 1 + p_1 - \beta p_2$$

$$\beta\left(p_2 - c_2\right) = q_2 = 1 + \frac{1 + p_2 + \alpha c_1}{2\alpha} - \beta p_2$$

Solve

$$\alpha\left(p_1 - c_1\right) = q_1 = 1 + p_2 - \alpha p_1$$

$$2\alpha p_1 = q_1 = 1 + p_2 - \alpha p_1$$

- Reaction function

$$p_1 = \frac{1 + p_2 + \alpha c_1}{2\alpha}$$

Solve

$$\beta\left(p_2 - c_2\right) = q_2 = 1 + p_1 - \beta p_2$$

$$p_2 = \frac{1 + \alpha\left(c_1 + 2\beta c_2 + 2\right)}{4\alpha\beta - 1}$$

Equilibrium

$$\hat{p}_2 = \frac{1+\alpha\left(c_1 + 2\beta c_2 + 2\right)}{4\alpha\beta - 1}$$

$$\hat{p}_1 = \frac{1+\beta\left(c_2 + 2\alpha c_1 + 2\right)}{4\alpha\beta - 1}$$

$$\hat{q}_2 = 1 + \hat{p}_1 - \beta\hat{p}_2 \qquad \hat{q}_1 = 1 + \hat{p}_2 - \alpha\hat{p}_1$$

APPENDIX 2

DISCUSSION OF THE MCKINSEY REPORT ON

THE FUTURE OF RAIL FREIGHT IN EUROPE

McKinsey's survey

- Sharp knowledge of the industry
- Challenging analysis
- Reasonnable findings
  - To be checked with my own model

2

Questions raised in McKinsey's survey

- Is rail freight sustainable?
  - Is intermodal competition in freight markets welfare enhancing?
- What is the impact of Eurovignette?
  - What is the correct level of road charge?

3

McKinsey's replies

- Is rail freight sustainable?

YES, BUT

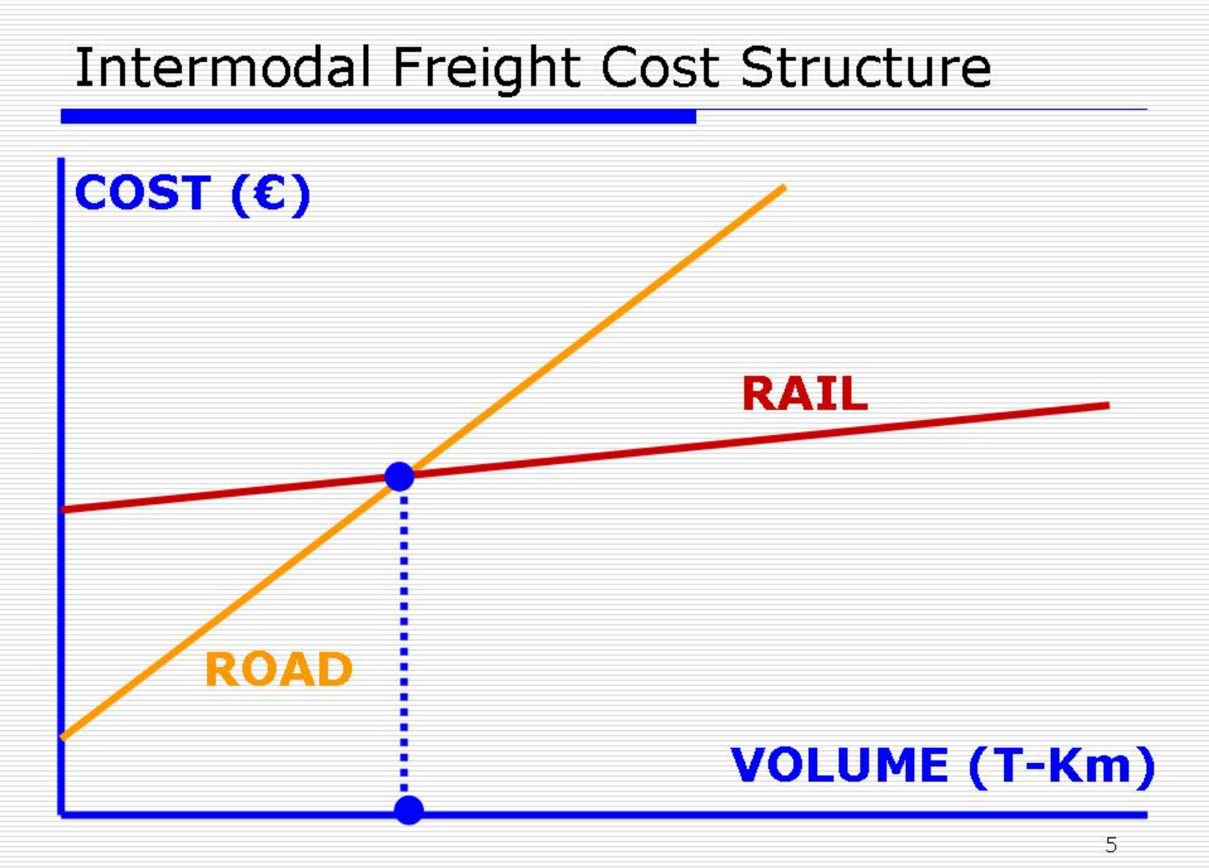
INTERMODAL FREIGHT COST STRUCTURE CREATES A MARKET FAILURE THAT NEEDS A REMEDY

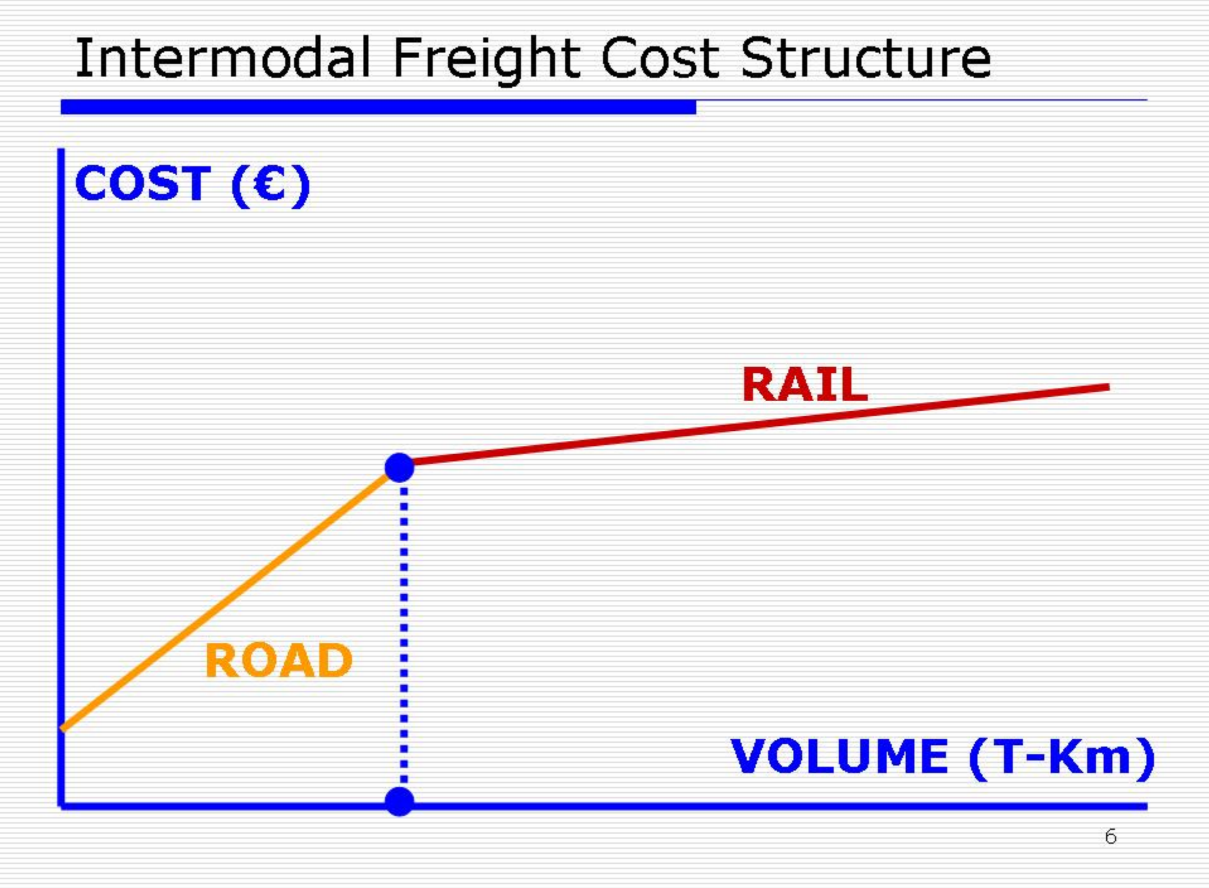
- What is the impact of Eurovignette?

SIGNIFICANT,

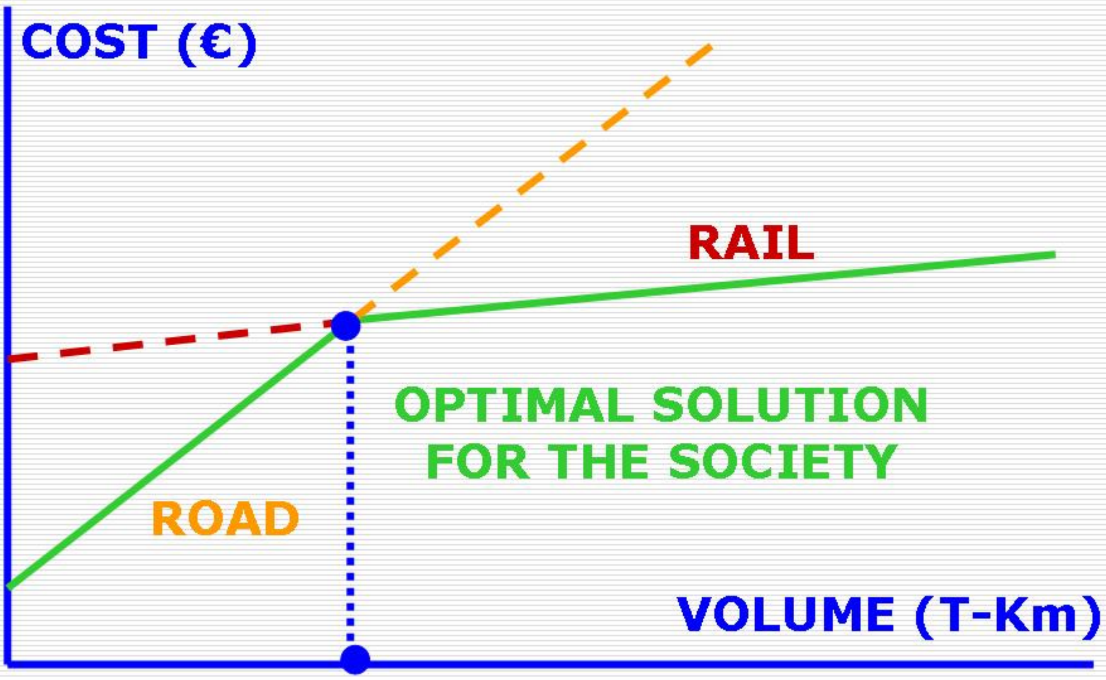
EUROVIGNETTE IS A POTENTIAL REMEDY

4


Intermodal Freight Cost Structure
COST (€)
RAIL
ROAD
VOLUME (T-Km)
5


Intermodal Freight Cost Structure
COST (€)
RAIL
ROAD
VOLUME (T-Km)
6

Intermodal Freight Cost Structure



7

Sustainable freight market

- How to implement the optimal solution?
- Economic textbook says:

A TAX SYSTEM IS NEEDED
TO SOLVE THE MARKET FAILURE

- Question?

IS A ROAD CHARGE
A POTENTIAL SOLUTION?

8

Participation to the market

- Without subsidy and/or restructuring, the rail system fails
  - Long run marginal cost 5.00 c / tkm
  - Average price 4.56 c / tkm

THE RAIL SYSTEM CAN WORK
ONLY WITH AN IMPLICIT SUBSIDY AND
A COST RESTRUCTURING EFFORT

Implicit subsidy or cost restructuring effort must be at least equal to 11% (marginal cost)

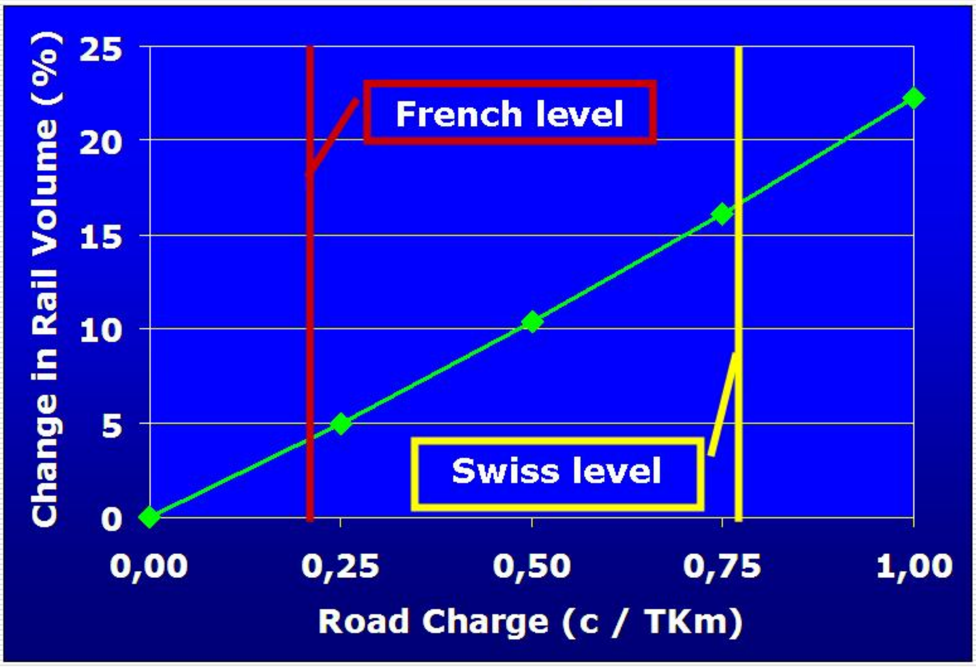
9

A simple model of the freight industry

- To check McKinsey's findings
- Competition analysis
  - As for analyzing competitive concerns
- Three hypothetical firms
  - "Rail"
  - "Road"
  - "Others"
    - Sea, Waterways, Pipelines, ….
    - ReLocalisation of shippers and customers
- Strategic behaviors of firms
  - Competition in price

10

Impact on modal split



11

Impact on consumer surplus (example)

	DIRECT EFFECT	INDIRECT EFFECT (reducing congestion & external effects)	NET EFFECT
Road Charge & Efficiency Gains on Rail	+4.5%	+9.0%	+13.5%
Road Charge & Efficiency Gains on Rail & Road	+1.5%	+6.0%	+7.5%

Incentives for restructuring

	Margin on rail freight services (%)		
Road charge c / tkm		With efficiency gains on road	With Efficiency gains on rail & road
0.00	4.0	3.7	6.4
0.50	4.5	4.1	6.8
1.00	5.1	4.6	7.1

13

Implications and questions

- Road charges have an effective impact on modal split
  - Substitution to alternative modes and choices?
  - Technological progress?
- Railway efficiency programs and road charges are complements in enhancing rail's competitive position
  - Link between road charges and efficiency gains?

14

Further open questions

- Road charges could affect consumer surplus positively by reducing congestion and external costs
  - Precise evaluation?
- More on the design of road charges
  - To check the cost structure of transport systems
- Transparency
  - To know more about marginal costs
  - To do European research on road usage

15