APPLICATIONS OF TRANSPORT ECONOMICS AND IMPERFECT COMPETITION

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ABSTRACT

The great majority of analyses made in transport economics use, explicitly or, more often, implicitly, the common assumption of perfect competition. This is the case, for instance, when infrastructure projects are evaluated using the mere sum of the surpluses of transport users and providers. Even when putting aside the question of externalities such as noise, safety or environmental quality, the real chain of economic interactions that takes place in transport provision or downstream of transport provision is not taken into account. Surely enough, describing and simulating this chain could be quite complex. Nevertheless, it is not uninteresting to try to estimate if it does make a big difference or not to make this approximation.
The paper makes such an attempt for two broad kinds of applications of transport economics:

Transport pricing: building on a generic formulation of imperfect competition pricing behaviour that encompasses a broad range of competition situations, and taking the railway case as a benchmark, simulation results give an idea of the order of magnitude of optimal tariff variation when perfect competition is assumed as compared to « real » competition situation. These results are completed and somewhat mitigated by observations on the final welfare impact of this discrepancy.

Project assessment: the consequences of imperfect competition situations are analysed, first, for transport provision, discussing the diverse levels of representation of economic interactions that are used in usual project assessment. Second, we use both theoretical and heuristic formulations of the interactions that take place within simple chains of economic actors downstream of transport provision. Besides pure « short sighted » profit maximisation and the base case of perfect competition, the more general imperfect competition modelling mentioned above is completed with simple « surplus sharing » behaviours.

As a whole, imperfect competition effects seem to be high within the transport sector and should be treated, both for project assessment and for infrastructure pricing. The case is less

clear as regards imperfect competition downstream of transport but still deserves attention. The numerous simulations and the economic analyses performed lead us to give hints for improving some of the current practices of economic assessment concerning infrastructure pricing and project assessment.

INTRODUCTION

The great majority of transport infrastructure decision-making recommendations use, explicitly or more often implicitly, the general assumption of perfect competition. This is the case of the marginal cost pricing principle or, in the case of project appraisal, when infrastructure projects are evaluated using the mere sum of the surpluses of transport users and providers. The chain of economic interactions that takes place downstream of transport provision is generally assumed to be in a the classical first best situation, run by perfect competition, with perfect taxes, no externalities and constant returns to scale. This assumption is necessary for the validity of the usual partial equilibrium analysis which underlies both usual pricing doctrines and cost-benefit analyses (see for instance Lesourne 1960 quoted by Quinet 1998 and Quinet and Vickerman 2004). As soon as these assumptions are not fulfilled, the formulae and criteria become much more complicated. This point is exemplified by an abundant literature, reviewed for instance by Vickerman (2007).

The sources of imperfection are manifold and each of them is a cause of departure from the usual practices. A first type of imperfection is related to equity concerns which undermine the usual assumption of optimal distribution obtained by transfers through non distorting taxes; for instance Meyeres and Proost (2001) and Meyeres and alii (2001) have taken into account the consequences of imperfect taxes on equity and environmental externalities. Other imperfections are linked to the so-called agglomeration externalities, which lead to a lot of recent developments both on the theoretical and on the practical sides (for instance Graham 2007). Increasing returns to scale in the whole economy are another source of imperfection which can lead to two different developments; first, along with spatial consideration, these increasing returns to scale are the core of the new economic geography and have consequences on locations and relocations, with consequences on welfare calculation (see for instance Behrens et al 2009 for a recent contribution in this field); second, even without spatial consideration, increasing return to scale induce market imperfections such as the emergence of monopolies or oligopolies leading to departures from the competitive assumption and the first best results it implies.

This text considers neither spatial consequences nor agglomeration externalities as a lot of attention has already been paid to these effects, both on the theoretical and on the applied sides.

It addresses the consequences of imperfect competition in the economy, and this choice is motivated by several reasons; first it has not been so extensively addressed; second it is possible to design simple models which allow taking a view of the magnitude of these effects; third, market imperfections of that kind are frequent, especially in the transport sector; fourth, competition may vary a lot among the modes and, if these differences are not taken into account, it may lead to large distortions between modes and errors in practical decisions.

This text concentrates on two issues, infrastructure pricing and project assessment. The second section explains the sources and kinds of market imperfection under consideration, and presents hypotheses about firm behaviours. The third section addresses the consequences of market imperfection on infrastructure pricing. The fourth section analyses the consequences of market imperfections on project assessment, again in the transport sector, while the fifth one deals with market imperfections outside the transport sector and their effects on project assessment.

MARKET IMPERFECTION AND FIRM BEHAVIOUR

Situations of market imperfection are frequent, especially in transport

Market imperfection can be assessed either from a theoretical point of view through the number of competitors or from an empirical point of view through the Lerner index.

From a theoretical point of view, transport markets are generally characterised by the small number of competitors. Let us consider the rail markets: for long distance passenger traffic, there is in general just one rail operator (RO), the competition is intermodal, the competitor being air transport, and it often happens that there is just one or a few air competitors on each origin-destination relation. For medium and short distance passenger traffic, there are in general just one or very few competing rail operators, and the main competition comes from road transport. Road transport is generally regarded as being operated under approximately pure competition conditions between road hauliers, having no strategic behaviour[1]: then, in the case where one RO is competing only with road transport, everything looks as if the RO were a monopoly. On-track competition is more frequent in freight transport, but here again, the competitors are just a few on each single relation.

From an empirical point of view, imperfect competition is characterised by the fact that the Lerner index (the relative difference between price and marginal cost) is different from zero. This fact is well acknowledged for all sectors. Among the most recent studies let us quote Christopoulou and Vermeulen (2008), whose international survey displays notable mark-up levels in the Euro area and the US over the period 1981-2004. Still, one may argue that the deregulation of many sectors may have lead to much lower mark-ups in a more recent period. Bouis (2008) does cover a more recent period on several OECD countries, and obtains average mark-ups in the (rounded) range 1,1 to 1,2, which corresponds to Lerner indexes of about 0,1 to 0,2; sectoral mark-ups may go up to 1,5 and above. The difference

[1] This statement may be challenged by observation of data, though. For instance, data on road haulage costs in France allow to estimate the evolution of proxies of Lerner indexes, which display values that were around 0,4 to 0,5 25 years ago and went sharply down but are still staying around non negligible values about 0,15 to 0,2 nowadays.

between prices and costs is also well documented in transport, for instance in the case of air or rail (Ivaldi and Vibes 2008 for instance).

How far is the market power exerted?

It is then highly plausible that market power does exist. The problem is, then, to estimate to which extent this power is exerted..

What is especially important for our concerns, pricing and project assessment, is the firms' pricing reaction to a variation in costs. The literature on this topic has been developing, among other fields, for international trade and notably, closer to our transport field, for the automotive industry. What comes out of the empirical analyses is that, as Gron and Swenson (2000) tell: "empirical research on cost pass-through documents that firms in imperfectly competitive markets often pass-through less than 100% of the cost shocks they experience". This is backed also by observations in the transport industry (Rolin and Sauvant 2005). Classical results of such studies display a cost pass-through between 0,5 and 1, that takes several months or even 1 or 2 years to accomplish. We will come back to this point in sections 4 and 5. This result is often thoroughly explained by the classical formulae. When the market power is fully exerted, the Lerner index should obey the following well-known formula:

$$L \equiv \frac{p-c}{p} = -\frac{1}{\varepsilon} \qquad \textbf{(E1)}$$

Where ε is the elasticity of the firm (equal to the elasticity of the market in case of monopoly). It often happens that these classical formulae do not fit the facts. It is the case for instance when, in situation of monopoly, the Lerner index is lower than the inverse of the market elasticity. There are some evidence that this situation can happen, especially in the case of transport. DIFFERENT (2008) and Meunier and Quinet (2010) make the case for such situations in France, as well as Clark et al (2009) building on the Norwegian transport context. Similarly, there are situations, found for instance in the results of traffic models, where observed elasticities are lower than 1 in absolute value.

These considerations led us then to look for a more general behaviour than what we could call "classical profit maximisation behaviour" or "blunt profit maximisation behaviour" so as to introduce a theoretical formulation that would be more consistent with such observations, and that could be backed by economic interpretations explaining firms' attitudes, possibly by introducing a broader range of concerns than systematic short-term individual segment-level profit maximisation (Quinet and Meunier in DIFFERENT (2008))

We use a general formulation which covers not only the two extreme competition situations of perfect competition and usual profit maximisation with price competition, but also mixed attitudes where the operator is assumed to aim partly to maximise its profit and partly to maximise "market welfare" ie welfare without taking account of externalities, by maximising a combination of both according to a proportion *s*:

$$F = s * P + (1-s) * (SU(p) + P) \qquad \textbf{(E2)}$$

where *P* is the operator's profit and *SU(p)* its users' surplus. This objective function encompasses both the perfect competition and –rough- welfare behaviour if s=0 or profit maximisation behaviour if s=1.
It is easy to derive from this assumption that the price posted by the firm is such as:

$$L \equiv \frac{p-c}{p} = -\frac{s}{\varepsilon} \qquad \textbf{(E3)}$$

Where *c* is the firm's marginal cost, *p* its price, ε its demand price-elasticity and *s* a parameter between 0 and 1. It is possible, knowing the costs and prices and elasticities, to calibrate the s value. If s is lower than unity, there is an indication that the firm's behaviour is not the profit maximisation, but the more general behaviour corresponding to the maximisation of F. Such a behaviour may be backed by a variety of reasons:

- when the firm is an historical operator, the persistency of a welfare maximisation goal, remaining from the old status of public firm, through internal processes or management mentalities
- the effects of a regulation of prices
- political pressures on price levels, implemented into internal self-regulation
- strategic attitudes of the firm: considerations of social acceptability, "lean dog" strategic attitudes, threat of new entry on the market, reputation for other markets (or for further development of the same market), fear of competition authorities, …
- a bad knowledge of the market (for instance, overestimation of actual elasticities), a bounded rationality behaviour
- uncertainty on the firm's estimation of demand elasticity, combined with firm's risk aversion
- the fact that at least on the short run, marginal costs are very low, much lower than what stems from the accounting records.

We will adopt this general formulation and see that in the following calibrations, it often happens that the s parameter is lower than unity.

INFRASTRUCTURE PRICING UNDER TRANSPORT MARKET IMPERFECTIONS

In situations of imperfect competition, Optimal Infrastructure Charges (IC) can be assessed either through algebraic formulae derived from theoretical considerations based on economic analysis or through simulations reckoning based on real situations. In the framework of imperfect competition which is the mark of competition in transport, the first approach gets rapidly limited due to the complexity of mathematical derivations. Very often they cannot be algebraically tractable as soon as situations not too simple have to be taken into consideration. As a consequence, only a few very general and generally well known results can be derived through such a method.

The second approach, the numerical calculations based on real situations, allows to use the power of computer calculation and to test more varied and complicated situations[2].

Theoretically, nothing prevents such a method to be applied on a large scale, for instance at the country level. The overall model would use as entries the cost and demand functions for each routes of each operators, the ICs to be tested on each route, as well as the structure of the competition (if any) between the operators; the outputs would be the prices and the traffics on each mode and various other items such as the profits of the firms, consumers' surplus and welfare. In practice, the implementation of this model is hampered by the lack of data: we have no good knowledge of the cost functions of the operators at the level of each route; we do not know precisely what the type of competition between the operators is. This draw-back induces to use more simple and crude methods, restricting the ambitions of the modelling framework. The method which is implemented can be entitled "sensible simulation", and presents the following features:

- It involves a simple network; in the following we use a single relation origin-destination, one or two modes serving this relation.
- The agents are the final consumers, the transport operators (one rail operator, zero or one operator of the other mode) and the rail infrastructure manager (RIM). The rail operator pays an IC to the infrastructure manager.
- The nature of competition between the operators is typified according to the considerations developed in the previous section. One is a monopoly, which aims at reproducing the case of medium range link, long of about 200 to 400 km; the other is a duopoly, aiming at reproducing the case of long distance relation, of about 500 to 1000 km where rail is in competition with air transport. In the first case the rail service is in competition with road, and, as we assume here that road operators are run under perfect competition, they have no strategic behaviour and the rail operator (RO) behaves as a monopoly. In the second case the rail service is in competition with an air operator or a few air operators and the competition between air and rail takes the shape of a Bertrand competition between two firms supplying substitute services: the Rail Operator (RO) and the Airline Company (AC).
- A continuum of possible behaviours for the operators is encompassed, according to the considerations developed in the previous section, between two extreme cases: the marginal cost pricing corresponding to the behaviour of an operator aiming at maximising the welfare and the profit maximising behaviour.
- The demand function is either a linear one or a logit one
- The cost functions of the operators are linear
- The parameters of the cost and demand functions are not calibrated on a specific real situation, but set up in order to reproduce typical situations such as: long distance trips competition between air and rail or short distance competition between road and rail,. The values of the parameters are set in accordance with the common knowledge of the specialists of the field; elasticities are drawn from the results of current traffic models, costs are drawn from various analyses of the cost structure of operators.
- Other parameters are introduced such as the cost of public funds or external costs

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2 The following text draws on Quinet 2005 and Meunier and Quinet 2010

The outputs are the Optimal Infrastructure Charge (OIC), the corresponding traffics and prices, the profits of the firms (the RIM, the RO and in case of duopoly the AC), the users' surpluses and the welfare.

The fact that the network and the modelling principles are simple and do not involve much data allows to make a lot of simulations regarding the shape of the demand function, the values of the parameters, the behaviour of the operators, and therefore to by-pass the scarcity of reliable data through exploration of the sensitivity of the results to the parameters.

Six cases are used, and the relevant data set is presented in table 1. Situations A to C are "monopoly-like" situations of competition between high speed train and motorways for diverse travel distances, so as to represent more or less tough competition conditions and market shares for rail; in these cases subscripts 1 relate to rail and subscripts 2 relate to road. Situations D to F are situations where high speed train is competing with air transport, again for diverse travel distances so as to represent a range of competition situations and a variety of relative competitive advantages for rail; in these cases, subscripts 1 relate to rail and subscripts 2 relate to air.

Table 1 Main Data Set

	Link	A	B	C	D	E	F
Market structure		Monopoly	Monopoly	Monopoly	Duopoly	Duopoly	Duopoly
Constant Unit Parameters							
Rail Infrastructure Cost	b	2,06	2,06	2,13	3,44	5,52	5,21
Environmental Costs	e1	1	2,25	1,75	3,5	4,5	4
	e2	4,4	9,9	7,7	15,4	19,8	17,6
Operator's costs	c1	16	13	16	19	24	16
	c2				55	80	65
Variables describing the current situation							
Operator's prices	p1	43	43	52	48	59	50
	p2				62	102	85
Elasticities	E11	-0,9	-1	-0,9	-1,5	-1,2	-1,5
	E22				-1,7	-1,5	-1,5
	E12				0,8	2,3	2,5
	E21				1,5	1,5	1,5
Traffics	Q1	0,31	0,26	0,33	0,31	0,24	0,17
	Q2				0,39	0,45	0,51
Infrastructure charges	RIC	12,60	12,60	5,80	16,15	20,56	10,28

From the numerous simulations, we quote and illustrate the more salient features [3]
First, as long as there is market power in the downstream market, and in absence of Cost of Public Funds, the OIC are low, and lower than the marginal infrastructure costs. It is necessary to decrease the prices of the operator's inputs, and the single input on which the IM can act is the IC. This point is exemplified for instance in the case of a profit maximiser monopoly, as shown by table 2:

Table 2 Comparison of OIC and marginal infrastructure cost in the case of a profit maximiser monopoly

Link	Costs of Public Funds		Optimal Infrastructure Charge	Marginal Infrastructure Cost
	IM	RO	0IC	b
C	1	1	-34,2	2,1
C	1,3	1	-5,7	2,1
C	1,5	1	4,3	2,1
A	1	1	-18,9	2,1
A	1,3	1	5,9	2,1
A	1,3	1,3	-1,5	2,1

The direction of Optimal Infrastructure Charge (OIC) variations is normal from a theoretical point of view. The surprising point is the high distance between marginal cost and OIC. It is not a matter of small correction, but of magnitude. It even happens that in some cases, the charge should become a subsidy. This table shows also that the gap highly depends on the value of the Cost of Public Funds (CPF). OIC increases with the CPF of the IM. It appears that in the cases under review, OIC is equal to the marginal infrastructure cost for values of CPF around 1.3 to 1.5 for the IM and 1.0 for the operator. When both CPF of the IM and of the operator are equal, optimal IC increases with these CPF and becomes equal to the marginal cost of infrastructure when they are infinite.

Second, taking into account the external costs increases the IC if the mode is less environmental friendly than its competitor, and decreases it in the reverse situation which is usually the case for rail vis-à-vis air or road transport. Table 3 shows examples of these effects which go in the expected direction. But it appears that the intensity of the effect is rather low. In the range of values considered, external costs tend to have observable but lower impacts on prices and optimal charges, as compared to the impact of CPF. And unlike the current doctrine which would lead to add the net external cost to the IC, optimal pricing does transmit only a fraction of external costs in the IC.

Table 3 Effects of external costs on OIC in the case of profit maximiser operators

Link	Market Structure	External Costs e1	e2	Rail Price p1	OIC
	Monopoly	0	0	32,9	0,4
B		2,25	9,9	30,9	-2,0
E	Duopoly	0	0	64,4	20,4
E		4,5	19,8	59,1	14,0

[3] More details on the simulation process, calculations and data can be found in Meunier and Quinet 2010 and in DIFFERENT 2008

Another striking fact is the change in welfare induced by changes in the IC. It stems from table 4 below that, as long as the IC are not "too" different from the OIC, the changes in welfare are small and that the effect of a sub-optimal IC bears mainly on the components of welfare: revenues of the IM and the operator's revenues and consumer surplus.

Table 4 Consequences of a sub-optimal IC (CPF of the IM=1.3; CPF of the RO=1.0; profit maximiser operators)

Link	Market Status	Comment	IC	Welfare	Revenues of	
					IM	RO
A	Monopoly	In this simulation the IC is the marginal cost of infrastructure	2,06	45,1	5,6	5,9
A		In this simulation the IC is the OIC	9,0	46,3	2,9	7,6
D	Duopoly	In this simulation the IC is the marginal cost of infrastructure	3,4	46,5	0,1	8,9
D		In this simulation the IC is the optimal one	2,0	46,7	-0,9	9,7

Another important point is to properly assess the behaviours of the firms, expressed by the values of the parameters s. In other words, does the quality of representation of imperfect competition matter much on OIC, and therefore on the distortion introduced by Perfect Competition Assumption (PCA) relatively to OIC? As shown in the table 5, the behaviour of the rail's competitor (the value of *s2*) does not impact too much the optimal solution, while large changes from the initial value *s1* lead to important differences between the calculated IC and the optimal one.

Table 5 Impact of the values of the behaviour parameters *s1* and *s2* on the OIC

Link	Market Status	*s* Parameters		OIC
		s1	*s2*	
C	Monopoly	0,52	1,00	4,3
C		1,00	1,00	-12,6
C		0,00	1,00	23,0
F	Duopoly	0,84	0,17	7,3
F		0,84	1,00	10,3
F		1,00	1,00	11,6
F		0,00	1,00	34,3

Lastly, does the quality of knowledge on demand impact much on OIC levels, and therefore on the gap between OIC and the results of PCA pricing? A last series of simulations, not reproduced here, show the importance of a good knowledge of demand functions on OICs: the higher the elasticities, the higher the IC. This point is understandable: when elasticities are high, the monopoly power of the operators is lower and the IC can be increased.

From these simulations, we may conclude that ignoring imperfect competition may lead to high biases in the estimation of "optimal" IC, and that the quality of knowledge on imperfect competition conditions and on demand does matter for the level of the distortion.

PROJECT ASSESSMENT AND TRANSPORT MARKET IMPERFECTIONS

In many sub-sectors liberalisation has led to imperfect competition with a small number of firms, even taking into account the substitute markets, as we have seen in the second section. Even if the competition wished for instance by the European Commission takes place, it is probable that the number of actors will be very small on each segment of market. In such a situation, prices are not equal to the (marginal) costs, but depend on strategic interactions of the actors, and depend on the structure of the market: how many competitors and what type of oligopoly. The analyst who performs a project assessment study has to decide on the assumptions on future prices, in both situations "with" and "without" the investment.

This important decision is often paid not much attention; usually a rough assumption is made. In many cases a subjective estimate is used, paving the way to strategic actions by the promoters of the scheme. Generally speaking, ex post prices are considered as exogenous parameter, while in fact, in imperfect competition situations, they are endogenous. The purpose of this section is to explore this issue; more precisely to assess the magnitude of the possible error coming from usual current assumptions on prices and to use economic analysis to get sensible prices, treating prices as endogenous variables[4].

As in the case of infrastructure charges, taking the situation of rail as an example, we will use simulations on two situations one for monopoly and the other duopoly, taking for these two categories "average estimates" from the more numerous situations considered in the previous section.

The monopoly situation aims at reproducing the case of medium range links, about 400 km long; the duopoly situation aims at reproducing the case of long distance relation, of about 800 km. In the first case the rail service is in competition with road, and, assuming road operators are run under perfect competition, they have no strategic behaviour and the rail operator (RO) behaves as a monopoly. In the second case the rail service is in competition with a single air operator or a few ones, and the competition between air and rail takes the shape of a Bertrand competition between two firms supplying substitute services: the Rail Operator (RO) and the Airline Company (AC).

The numerical values of the parameters are chosen so as to represent sensible estimates of a standard situation (they are drawn from real data often subject to secrecy).

As in the case of the previous section, there are 4 agents:

- The Rail infrastructure manager
- The Rail operator
- The Users
- And in the case of long distance relation, the Air operator

For simplicity, we assume that there are neither environmental costs nor costs of public fund, and that cost functions are linear. The demand functions are logit. The calibration process gives the results shown in table 6:

[4] The following section develops considerations given in Quinet 2009

Table 6 Observed and calibrated parameters

	Observed parameters	Calibrated parameters
Monopoly		
RO's Price	70,00	48,00
Ro's Cost	20,00	18,50
IM's Price	16,50	16,50
IM's Cost	3,44	3,44
RO's Traffic	na	0,30
Demand elasticity	-1,50	-1,54
s1	na	0,41
Duopoly		
RO's Price	70,00	72,94
Ro's Cost	20,00	71,56
IM's Price	21,00	21,00
IM's Cost	16,00	16,00
AC's Price	72,94	70,00
AC's Cost	71,56	75,00
RO's Traffic	60,00	23,06
AC's Traffic	40,00	40,63
Demand elasticities		
e11 (RO versus AC price)	-1,50	-2,36
e22	1,00	0,83
e12	-2,00	-1,96
e21	1,00	0,48
s1	na	0,30
s2	na	0,97

This table deserves several comments: first, calibration provides a good fit with observed data except for traffic in the case of duopoly. Second, the calibrated values for parameter s of the RO have the same magnitude in both market structures, around 0,35. It implies that the RO has the same behaviour in both markets, which is sensible. In the duopoly case, the value of the parameter for the air company is close to one, showing that the air company fully exerts its market power in almost pure profit maximiser behaviour, here also in accordance with the expectations.

Two types of investments are simulated. One results in a decrease in the travel time, consequence for instance of a new high speed line. The second one is a decrease of operation costs of the RO; it may come either from the change from diesel to electric power, or from a new, double deck, train replacing a single deck train.

In both cases, the relative decrease (in operation costs or in travel time) is equal to 25%. From the French experience, in terms of travel time savings, this percentage is a bit low for long distance HST links (the travel time saving is often around 40%) and seems a reasonable average for medium distance HST. It is a sensible estimate for current operation cost decreases.

The conclusions of the simulations are exemplified in the case of travel time saving investment. Simulations about decrease of the operation cost of the RO, not shown here, provide similar conclusions. The main results are shown in the following two tables. The first one is based on the behaviour of profit maximiser operators (all s parameters have value 1), which will be named afterwards "blunt profit maximisation behaviour", the second one is built with the calibrated values of s, which will be named afterwards "strategic behaviour". In order to appreciate the size of the effect, let us note that the 25% travel time saving is wiped off, in monetary terms, by an increase of the price of the RO of 25%.

Table 7 Travel time savings. "Blunt" profit maximising behaviour. Effects of various assumptions on prices.

Travel time decrease by 25%; Firms' behaviour: profit maximization									
Duopoly	s1= 1,00		s2= 1,00						
	Changes vis-à-vis the ex-ante situation								
	RO Traffic	RO price	RO's Benefit	RIM Benefit	Consumer Surplus	Welfare	AC traffic	AC price	AC's Benefit
ex ante situation	23,06	72,94	-	-	-	-	40,63	71,56	-
ex post situation									
1 Gain kept by the RO	23,06	91,17		0,00	0,00	420,44	40,63	71,56	0,00
2 Gain left to the user	39,9	72,9	520,9	84,3	563,9	948,5	34,6	71,6	-220,6
3 gain shared half and half	30,7	82,1	514,7	38,1	243,5	696,7	37,9	71,6	-99,6
4 Same as 3, but with AC reaction	30,43	82,05	505,05	36,84	271,36	714,02	38,69	70,83	-99,24
5 Duopoly equilibrium	35,43	76,72	516,67	61,89	465,81	877,43	37,32	70,34	-166,93
Monopoly	s1= 1,00								
	Changes vis-à-vis the ex-ante situation								
	RO traffic	RO price	RO benefit	RIM benefit	Consumer surplus	Welfare			
ex ante situation	0,19	62,03	-	-	-	-			
ex post situation									
1 Gain kept by the RO	0,19	77,54	2,98	0,00	0,00	2,98			
2 Gain left to the user	0,32	62,03	3,62	1,68	3,95	9,25			
3 gain shared half and half	0,25	69,78	3,61	0,77	1,72	6,10			
4 Monopoly equilibrium	0,29	65,74	3,71	1,23	2,81	7,75			

Table 8 Travel time savings. Mixed Optimisation. Effects of various assumptions on prices.

Travel time decrease by 25%; Firms' behaviour: mixed optimization									
Duopoly	s1= 0,30		s2= 0,97						
	Changes vis-à-vis the ex-ante situation								
	RO Traffic	RO price	RO's Benefit	RIM Benefit	Consumers' surplus	Welfare	AC traffic	AC price	AC's Benefit
ex ante situation	40,7	53,1	-	-	-	-	36,4	69,1	-
ex post situation									
1 Gain kept by the RO	40,7	71,3	742,3	0,0	0,0	742,3	36,4	69,1	0,0
2 Gain left to the user	63,3	53,1	249,4	112,8	942,0	1 011,5	27,8	69,1	-292,7
3 gain shared half and half	51,52	62,19	588,85	53,98	419,38	922,14	32,32	69,13	-140,07
4 Same as 3, but with AC reaction	51,03	62,19	578,92	51,52	453,07	943,26	33,31	68,11	-140,25
5 Duopoly equilibrium	58,96	55,67	354,51	91,15	836,56	1034,30	30,79	67,32	-247,92
Monopoly	s1= 0,41								
	Changes vis-à-vis the ex-ante situation								
	RO traffic	RO price	RO benefit	RIM benefit	Consumer surplus	Welfare			
ex ante situation	0,31	48,00	-	-	-	-			
ex post situation									
1 Gain kept by the RO	0,31	63,51	4,81	0,00	0,00	4,81			
2 Gain left to the user	0,48	48	2,20	2,11	6,06	10,37			
3 gain shared half and half	0,39	55,75	4,08	1,01	2,71	7,80			
4 Monopoly equilibrium	0,44	51,11	3,11	1,66	4,64	9,40			

In each of the tables, for each simulation, are shown various cases, for instance in the duopoly situation:

- the ex ante situation,
- several options for the assessment assumptions of the ex post situation
- Case 1: the RO keeps the whole gain. It increases its price by an amount equal to the monetary equivalence of the gain in travel time. This benchmark case may be
- seen as a "level 0" assumption which in usual CBA gives a welfare variation of $Q * \Delta c$ where Q is the initial traffic and Δc the unit cost gain
- Case 2: the gain is totally left to the consumer while the Airline Company (AC) does not react (does not change its price). The RO does not change its price, a rather frequent assumption. This benchmark case may be seen as a "level 1" assumption which in usual CBA gives a welfare variation of approximately $(Q+\Delta Q/2) * \Delta c+(P-c)* \Delta Q$ where Q is the initial traffic, Δc the unit cost gain and c the marginal cost, ΔQ the traffic increase, and P the price. With Perfect Competition Assumption, price is supposed to be equal to marginal cost and the welfare variation boils down to $(Q+\Delta Q/2) * \Delta c$.
- Case 3: it is an intermediate assumption, where the gain is shared in equal parts between the consumer and the RO. The RO increases its price by half the gain in travel time. Here again this is a "level 1" assumption that takes into account variation in profits due to increased traffic, but the assumption on the ratio $(\Delta p/\Delta c)$ is different from the former one. In this case, as in the two previous ones, the AC is supposed not to react and not to change its price.
- Case 4: same as Case 3, except that the AC is supposed to react to the change and to adapt its price in order to maximise its objective (profit maximisation or mixed behaviour).
- Case 5: the result of the Nash equilibrium in a framework of Bertrand competition where the agents behave to maximise their objective function.

For each of these rows, the columns show the changes in the welfare and its break-down in its components, and the prices and traffic levels. From these figures several conclusions and answers to the previous questions can be drawn. Let us first consider the case of blunt profit maximising behaviour where s1 and s2 equal 1 (table 9); then we will analyse the case of strategic behaviour. (table 10).

- First, the differences between the results of various simulations go in the right directions, the ones which are predicted by economic analysis. Especially, welfare is higher when the gain is given to the user and when the RO does not use its market power. Similarly, in the case of duopoly, the changes in prices of the RO and of the AC vary in the same direction. The important point is that simulations help to take a view of the possible magnitudes of the effects, and to enlighten those which are large
- The results of case 1 (gain kept by the RO) both for monopoly and duopoly show a much lower welfare than for cases 2 to 5. It means that assuming that the RO keeps the gain of the investment provides a large underestimation of the welfare. This assumption means that the RO increases its price so as to wipe out the travel savings for the user, the situation of which is kept unchanged vis-à-vis the ex ante situation.

This assumption is a crude one, probably rarely used. In that situation there is no change in traffic pattern (especially neither induced nor transferred traffic).

- The tables show another extreme hypothesis according to which the whole gain is passed to the user. They correspond to cases 2 both in duopoly and in monopoly. These assumptions would be correct in situations of perfect competition. Here, in the case of monopoly they lead to a large overestimation of 19% (welfare variation of 9,25 instead of 7,75); in the case of duopoly, the gap is smaller if it is assumed that the AC does not change its price, it amounts to 8% (948,5 instead of 877,4). But the gaps are more important for some components of the welfare; for instance the consumers surplus is overestimated by 41% (3,95 instead of 2,81) in the case of duopoly and by 21% (563,9 instead of 465,8) in the case of duopoly.
- It could be thought that, since case 1 is an underestimation of welfare and case 2 an overestimation, an intermediary assumption would be a good approximation. This situation is depicted in case 3 where the gain is shared half and half between the user and the RO; the RO raises its price by half the gain in travel time. The results of this assumption are described in case 3. They show that, contrarily to the expectation above, the gaps in welfare do not decrease much in comparison with case 2: they amount to 18% in the case of duopoly (7,8 instead of 9,4) and to 22% in the case of monopoly (6,1 instead of 7,75). And this intermediate assumption leads here to an <u>under</u>estimation of the welfare variation.
- Therefore welfare is very sensitive to the RO price assumption. It is clear that this price falls between the level which leaves the gain to the user and the level which leaves the gain to the RO. But the variations of welfare between those two limits are large and not easy to estimate; no simple rule of thumb appears. As we have seen, a small error in this choice can lead to a large error in the welfare, which can reach 20 or 30% and its sign and magnitude cannot be easily predicted. This result advocates for treating prices as endogenous variables in project assessment, as soon as there is imperfect competition.
- Up to now, the assumption has been made that, in the case of duopoly, the AC does not react to the changes in the market: it keeps its price constant. It is the "no strategic reaction" assumption. Let us see what happens when this general assumption is cleared; let us assume that by chance the assumption on AC changes is fully correct: it corresponds to the optimisation of profit of the AC given the RO price. The results are developed in case 4. It appears that the gap is narrowed but still large: 19 % (714,0 instead of 877,4).
- Besides the choice of the right price for the RO, a possible source of error is to "forget" the existence of the competing mode, in this case the air transport. It is interesting to see the weight of the AC in the total welfare. AC intervenes in the welfare through two terms: the benefit of the firm and the surplus of the air users. Let us assume that the analyst is able, by the use of some crystal ball, to perfectly forecast the RO's price and traffic but does not consider the other mode. He will reckon a welfare summing RO's benefit, RIM benefit and consumers' surplus of the rail users, and he will reckon the rail consumers surplus through the usual rule of trapezium: $CS=(p_a-p_b)*(q_a+q_b)/2)$, where p are prices, q are traffics, subscript *a* designates the values after the investment and *b* the values before the investment.

The analyst does not take into account the AC benefit nor the air consumers' surplus which can be estimated by the same formula.
Applying these rules to the case 5 (duopoly equilibrium) and using the prices and traffics of this case leads to the following table:

Table 9 Consequences of ignoring the other mode reaction

Prices and Traffics known by the analyst				Prices and Traffic not used by the analyst			Check on consumers surplus		
RO price	RO traffic			AC price	AC traffic		Calculated through the trapeze rule		Calculated by logsum
76,7	35,4			70,3	37,3				
Welfare calcualtion achieved by the analyst				Welfare calculation forgotten by the analyst					
RO 's benefit	RIM benefit	Rail consumers surplus	Total Calculated Welfare	AC benefit	Air consumers surplus	Total Omitted Welfare	Rail consumers surplus	Air consumers surplus	total consumers surplus
516,7	61,9	422,4	**1 000,9**	-166,9	47,6	**-119,3**	422,4	47,6	465,8

This table indicates that omitting the competitors and its customers amounts to overestimating the welfare by 14% (1000,9 instead of : 1000,9-119,3=877,4).
This overestimation adds to the error coming from a wrong choice of the price and traffic of the RO; as we have seen from the previous considerations, this error can be either an over or an underestimation, the magnitude of which can reach around 20%.
The previous tables show also that the forecasted traffic is highly sensitive to the assumption on prices. In case 2, where the saving is entirely passed to the user -a frequent assumption which amounts to forgetting the strategic reactions due to imperfect competition- the error is an overestimation of traffic by 13%, a non-negligible figure, which is in the order of magnitude of the average overestimation estimated by Flyvbjerg (Flyvbjerg and alii 2003).

Another current practice is to pass a part of the benefits to the Infrastructure Manager which is in charge of infrastructure investments and, in many countries, is asked to cover its costs by its own. It is often implicitly considered that sharing the profit between the RO and the IM has no consequence on the welfare and will not induce strategic consequences on the behaviour of the firms. The following simulations show that on the contrary, trying to share the pie has tremendous consequences when the infrastructure charge increase is proportional to the unit gain.

Table 10 Effects of a change in infrastructure charge

travel time decrease 25%; firms' behaviours : profit maximisation

Duopoly	s1=1		s2=1								
	Changes vis-à-vis the ex-ante situation										
	RO's Benefit	AC's Benefit	RIM Benefit	Consumer Surplus	Welfare	IM price	IM marg cost	RO price	AC price	RO Traffic	AC traffic
ex ante situation						21,0	16,0	72,9	71,6	23,1	40,6
ex post situation											
Duopolyy equilibrium, half the gain is given to the IM	231,1	-79,3	293,4	215,6	**660,8**	25,6	16,0	83,7	71,0	28,9	39,1
Duopoly Equilibrium	516,7	-166,9	61,9	465,8	**877,4**	21,0	16,0	76,7	70,3	35,4	37,3

Monopoly	s1=1								
	Changes vis-à-vis the ex-ante situation								
	RO benefit	RIM benefit	Consumer surplus	Welfare		IM price	IM marg cost	RO price	RO traffic
ex ante situation						16,2	3,5	62,0	0,2
ex post situation									
Monopoly equilibrium, the gain is given half to the IM	1,7	2,4	1,3	**5,4**		23,9	3,5	71,5	0,2
Monopoly equilibrium	3,7	1,2	2,8	**7,8**		16,2	3,5	65,7	0,3

In these simulations the IM increases its price by half the saving per user (in the table above, it increases its price by half the travel time saving), while the marginal infrastructure cost is unchanged. These values are in accordance with the usual practice which tends to increase the rate of profit for new lines in order to fund a part of the investment. When the IM raises its price, it looses a part of the traffic. The calculation of its revenue should take into account the impact of its pricing attitude on the RO's price and on the traffic.

The effect is important also on the welfare, which gets lower by 25% in the case of duopoly (660,8 instead of 877,4) and by 30% in the case of monopoly (5,4 instead of 7,8). This point prompts us to make a link with the previous section about optimal pricing, and to check how high the cost of public funds should be to justify such an increase. It is easy to check that it would happen for a CPF such that:

- in the case of duopoly: CPF= 1,93
- in the case of monopoly: CPF= 3.

In the present numerical simulations these values largely exceed the current values of CPF, which, as seen in the previous section, lie around 1,2 to 1,5.

This result advocates for a special attention to the infrastructure charges and to how they are linked to the gains provided by the investment.

All these results are confirmed by the simulations on operation cost savings. The differences are milder since the cost saving ratio used, 25% of the present cost, amounts to a smaller absolute value of price: 7% instead of 25%.

If now we get a look at the results in the hypothesis of strategic behaviour, where the *s* parameters are endogenous, we find milder results in each case, the gaps between the various hypotheses are smaller. It is not surprising to see that the hypothesis of a gain passed to the user and consequently no change in the price provides a welfare very close to the hypothesis of market equilibrium in this context of strategic behaviour: in fact, the blunt profit behaviour followed by the firms is intermediate between profit maximising and (an imperfect version of) welfare maximising. This result points out the importance of precisely knowing the behaviour of the firms in order to make the proper assumptions about prices.

PROJECT ASSESSMENT AND DOWNSTREAM MARKET IMPERFECTIONS

Usual CBA for transport infrastructure projects take into account surpluses of (all or part) transport users, transport providers and infrastructure managers, but do not take into account what takes place downstream of transport. For instance, the freight transported is destined to a factory, which will benefit from the project by means of economies of time or cost for this transport. But this benefit may be passed-through, fully or partly, to the firms that are the factory's clients, which may in turn passed it through downstream.

Thus, usual CBA makes the implicit assumption that the initial transport benefit is simply dispatched through the chain of interactions downstream of transport, in a null-sum game; or, at least, that this assumption is an approximation that has very minor consequences. This assumption is correct in perfect markets (Dodgson, 1973; Jara-Diaz, 1986); but is it the case in practice? Among other authors, Venables and Gasiorek (1999) analysed this question and concluded that the extent of any underestimation or overestimation will depend on the degree of variation between price and marginal cost and the elasticity of demand for the activity. The order of magnitude of underestimation they obtained for some industries was found to be between 10% and 40%, but overestimation might happen in other cases.

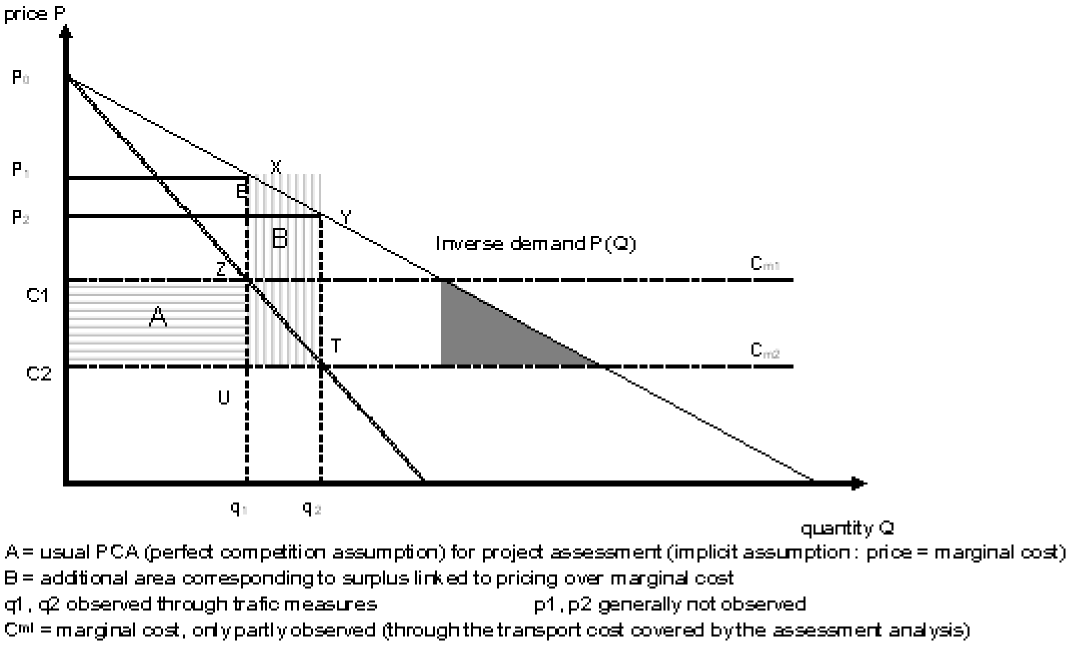

Figure 1 – Imperfect pricing effects vs Perfect Competition Assumption

The basic departure from PCA may be illustrated by the figure shown in figure 1 above.

When considering PCA, the analyst is supposed to observe the right quantities q1 and q2, but supposes that prices equal marginal costs, meaning that the welfare variation coming from a variation in marginal cost corresponds to the area C1-Z-T-C2, since the analyst estimates that the actual price variation equals the marginal cost variation i.e. the variation in transport cost. In this case, the additional welfare coming from the firm's profit on the additional quantity (area "B": X-Y-T-Z) is not taken into account. But if the firm chose to keep its price P1 unchanged, the PCA analyst would overestimate the welfare by the area Z-T-U. Note here that if the mark-up (p-c) is big enough[5] compared with the variation in cost, then it needs a very low cost pass-through to obtain overestimation with PCA.

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[5] Roughly, the cost pass-through should be lower than half the cost variation divided by the mark-up (P-c). Order of magnitude: with L around 0,2; transport cost ratio in final price = 5% and transport cost decrease of 20%, we obtain that this sufficient threshold is 1/40, which is very likely to be obtained.

Now let's look more precisely at what happens when we consider that the firm's pricing follows *(E3)*.
When cost pass-through is not too low, it is easy to show that variation in welfare is underestimated by a percentage given by:

$$\frac{B}{A} \approx \frac{(P_1 - C_1)(q_2 - q_1)}{(C_2 - C_1)q_1} = -\varepsilon L \frac{P_1 - P_2}{C_1 - C_2} = s\frac{P_1 - P_2}{C_1 - C_2} \qquad \textbf{(E4)}$$

where ε is the elasticity, *L* the Lerner index and the third term is the cost pass-through.
Let us see two special cases that correspond to assumptions that are commonly encountered:

1. If we assume that the demand elasticity stays quasi-constant (this would be strictly the case with a demand function such that $q = \gamma p^{-\alpha}$), then using *(E3)* the underestimation percentage has a simple expression in the form of an harmonic average:

$$\frac{B}{A} \approx \frac{1}{\frac{1}{s} + \frac{1}{\varepsilon}} \qquad \textbf{(E5)}$$

2. Another interesting case is the linear demand: in this case, since $\frac{p-c}{p} = -\frac{s}{\varepsilon} = -\frac{s}{\frac{dq}{dp}}\frac{q}{p}$

$p = \frac{c}{1+s} + p_0$ where $\frac{dq}{dp}, q_0, p_0$ are constants.
The underestimation ratio becomes then:

$$\frac{B}{A} \approx \frac{s}{1+s} \quad \textbf{(E6)}$$

We may check that, in the usual assumption of "local profit maximisation" ie *s=1* we obtain ½ and that in PCA we obtain 0.

We have up to now seen some aspects of a "one step" account of downstream interactions. Let us have a look at the broader problem which is that the interactions downstream of transport are chained interactions. Let us then imagine chained reactions where each one of *n* firms sells its output at price p_j (with marginal cost c_j) to its follower, until the last one addresses final demand $Q(p_n)$, and one of the firms encounters a variation in its costs. We will for the moment simplify by considering fixed input/output ratios and that we have a series of monopolies (no outside option): the cost change for any firm is the (possibly null) price change of its predecessor. So as to keep calculations tractable, we will choose the unit quantity of each product so as to correspond to its exact contribution for one unit quantity of final demand, which means that all intermediary quantities are $Q(p_n)$

At this point, we may argue that, since it is likely that in the great majority of cases the transport cost's variation is quite small relatively to the costs incurred at the end of the chain, the behaviour *(E3),* even though it may give an approximate equilibrium outcome, is too costly or difficult to use for such tiny signals. Following this idea, we will now consider heuristic behaviours where firms transmit a fixed proportion of the cost variation into their prices:

$\Delta p_j = \beta_j \, \Delta c_j$.

Then, if *i* is the firm that encounters initially the transport cost variation:

$\Delta p_j = \beta_j \, \Delta c_j \quad for \;\; j < i$ and $\Delta p_j = (\prod_{k=i}^{j} \beta_k) \, \Delta c_i$

Then:

$$\Delta\Pi_j = (p_j - c_j)\,\Delta Q \quad for \;\; j < i$$
$$\Delta\Pi_j = (p_j - c_j)\Delta Q + (\Delta p_j - \Delta p_{j-1})(Q + \Delta Q)$$

We observe that, as soon as only one of the firms situated downstream the transport cost variation uses $\beta_j = 0$ (price-taker or price rigidity) then the outcome is neutral for final demand, $\Delta Q = 0$ and the welfare variation becomes $\Delta W = (-\Delta c_i)Q$ ie the PCA estimate (if the PCA analysts correctly assesses that no induced traffic will appear for this segment – which depends on the degree of disaggregation of traffic studies and economic analysis-; if he takes induced traffic into account, he will overestimate the gain).

Another basic observation is that if chains have enough firms and β_j are sufficiently lower than 1, $\Delta p_n = (\prod_{k=i}^{n} \beta_k) \, \Delta c_i$ will be negligible and we come back to the previous case.

And in the case of exact integral transmission throughout all the downstream chain ($(\forall j = i..n)(\beta_j = 1)$) then we go back to the usual formula *(E1)* with a cost pass-through of 1, giving an underestimation ratio of $(-\varepsilon)L$. From the orders of magnitude seen in the second section, we obtain 10% underestimation with elasticity of -0,5 or 20% underestimation with elasticity (-1). Still, this supposes perfect pass-through along all the chain, which may seem rather optimistic.

As a whole, we have seen that:

- the risk that cost pass-through ratios would be so tiny that PCA overestimate welfare variations seems to be quite low
- taking into account the chains downstream transport is likely to make the estimate of overestimation taken from the monopoly case ($(-\varepsilon)L$) probably too high
- characteristics of final demand matter (low elasticities will mean less underestimation by PCA).

It would be necessary to distinguish between the diverse demand segments that are studied in traffic studies and economic analysis: for instance, own-transport vs transport for external clients, transport of raw materials vs final distribution of finished products. The analysis could be refined for some of these segments so as to better estimate demand reaction, chain length and pricing strategies. Without such deeper analysis, it seems that, although the monopoly case seems to be quite convincing, it would be more conservative not to take a correction for downstream imperfect competition, or to take just a few per cent.[6]

[6] This cautious approach could be backed by some theoretical papers such as Wang and Zhao (2007) who go as far as exhibiting formulations where welfare decreases when relative cost decrease is low (which is the case for high value products using road transport for instance: if transport cost share is about 5% , even with a strong 20% reduction in transport costs due to the project, final cost would decrease only by 1%). At a more global scale than a project's, general equilibrium models would not necessarily go in the opposite direction: for

CONCLUSION

We have tried here to look through the implications of imperfect competition, a frequent situation in the transport sector, on optimal infrastructure pricing and on project assessment –both inside the transport sector and downstream-, and to compare these implications to the simplifications of the usual perfect competition assumption (PCA), both through simulations and through theoretical formulations.

We use an expression of firm objectives which allows for more general goals than short term / one shot profit maximisation. These objectives may be interpreted as a mix of profit and welfare maximisation. We develop several reasons for such a more general objective. We show that sensible estimates of current situations are in favour of such a mixed behaviour.

The simulations show results the directions of which are in full accordance with predictions of economic analysis. They allow to have an idea of the magnitude of the departures from currently aknowledged doctrines. It appears that in many situations these magnitudes are large, and call for a change in these current doctrines and practices

As regards infrastructure pricing, simulations of optimal tariffs have been made for various situations such as monopoly and duopoly with another operator running a substitute service on another mode. The operators' behaviours are either profit maximisation, welfare maximisation or intermediate behaviour.

From this simulation exercise, several conclusions can be drawn:

- In cases of imperfect competition –a frequent situation in the transport field- and on the ground of pure welfare calculations, optimal infrastructure charge (IC) under imperfect competition are quite different from the standard theory of marginal cost pricing.
- The optimal tariff is highly dependent on the specificities of the situation: the level of the cost of public funds, the nature of competition (Cournot, Bertrand, …), the specification of the demand functions. And generally speaking our knowledge in these fields is often poor.
- Suboptimal IC induce losses of welfare, fortunately these loss of welfare are limited as long as the difference with the optimal IC is not "too far"; but even for small departures from the optimal IC, changes in the distribution of welfare are dramatic
- This point advocates for more research on the field of imperfection competition, especially on the applied grounds: data on costs, prices and elasticities, nature of competition.

instance, Behrens et al (2009) exhibit a model where short-run benefits of transport costs are counterbalanced by long-term effects on a sub-optimal redistribution of industrial activity across regions. This does not concern however localised cost variations like the ones infrastructure projects generate.

- Demand function differences –namely elasticities- have consequences never negligible and sometimes tremendous. The effect may depend on the nature of competition in the market.
- Market structure has an important impact on the optimal IC; so the ICs of two services similar in everything except the market in which they are run should differ. Generally speaking, IC levels for monopoly should be lower than for a duopoly.

As regards project assessment, the simulations show the following results:

- Prices in the ex post situation are, according to the economic analysis, endogenous while the current practice takes them exogenous and fixes them either according to arbitrary rules (the gain is passed to the user or kept by the RO) or according to subjective expert guess
- The difference between those common habits and the rational endogenous estimate induce important changes in the welfare of the projects, of the same magnitude as the other "wider effects" such as agglomeration effects.
- The differences are important on total welfare, and even more on the consumers' welfare (profits are not much impacted) and on variables such as traffics.
- The most current practices induce over-estimations of traffic, and are certainly an important cause of over –estimation which appear in the comparisons between ex ante forecasts and ex post reality.
- A recommendation would be either to derive price from endogenous model; but dealing with this model may be difficult on computational and data gathering grounds. In that case, a rule of thumb would be to choose a price around the value which shares the gain half and half between the users and the RO. More simulations should be made in order to ascertain and fine tune this ratio.
- A better knowledge of market structures and behaviours of the operators is necessary in order to rationally assess the correct prices.
- A special attention should be paid to how the benefits of an investment can be passed to the infrastructure manager. An increase of infrastructure charges per unit of traffic may have dramatic consequences of welfare reduction

Finally, as concerns the effects of imperfect competition downstream of transport on project assessment:

- although the theoretical monopoly case seems quite convincing, the distortions introduced by PCA downstream of transport in more real (chained) situations do not seem to be as strong as those observed within the transport sector;
- some simple formulae have been given for « one-step » downstream estimates, for common assumptions (linear demand or constant elasticity demand)
- although the risk of overestimation by PCA (downstream of transport) seems to be very low, if no detailed analysis of demand segments is available for the project, it would perhaps be better not to add anything to usual welfare gain estimation or, if some positive elements are available (high demand elasticity for transport of products experiencing high Lerner indexes), a few percent increase would probably be enough.

ANNEX 1 EXPLORATION OF PERFECT COMPETITION ASSUMPTION' S OVERESTIMATION POSSIBILITIES

We present here a more general estimation of the PCA distortion (ratio B/A) specified for two cases in section 5. Using the usual linear approximations used for CBA:

* welfare variation under PCA is: $\Delta W_{PCA} = (-\Delta c)\,(Q + \frac{\Delta Q_{PCA}}{2})$

if we suppose that $\Delta Q_{PCA} = \frac{\varepsilon Q}{p}\Delta c$ [7] since PCA supposes $\Delta p = \Delta c$

$$\Delta W_{PCA} = (-\Delta c)\, Q\, (1 + \frac{\varepsilon\,\Delta c}{2p})$$

* welfare variation with actual price reaction is:

$$\Delta W_c = (-\Delta c)\,(Q + \frac{\Delta Q}{2}) + \Delta Q\,(p - c - \frac{\Delta p - \Delta c}{2})$$

with $\Delta Q = \frac{\varepsilon Q}{p}\lambda \Delta c$ where $\lambda \equiv \frac{\Delta p}{\Delta c}$

$$\Delta W_c = (-\Delta c)\, Q (1 - \lambda\,\frac{\varepsilon}{p}(p - c - \frac{\Delta p}{2}))$$

Thus:

$$\frac{\Delta W_c - \Delta W_{PCA}}{\Delta W_{PCA}} = \frac{1 - \lambda\,\frac{\varepsilon}{p}(p - c - \frac{\Delta p}{2}) - (1 + \varepsilon\,\frac{\Delta c}{2p})}{1 + \varepsilon\,\frac{\Delta c}{2p}}$$

$$\frac{\Delta W_c - \Delta W_{PCA}}{\Delta W_{PCA}} = \frac{(-\varepsilon)}{2p}\,\frac{2\lambda\,(p - c) - \Delta c\,(\lambda^2 - 1)}{1 + \varepsilon\,\frac{\Delta c}{2p}}$$

We obtain the condition for PCA underestimation (since $\varepsilon < 0$) :

$$2\lambda\,(p - c) > \Delta c\,(\lambda^2 - 1).$$

For transport projects, usually: $\Delta c < 0$ and the condition becomes:

$$2\lambda\,\frac{(p - c)}{\Delta c} < \lambda^2 - 1$$

As soon as $\lambda > \frac{(-\Delta c)}{2(p - c)}$, the left hand term is lesser than (-1) and the right hand term is greater than (-1). Thus this is a sufficient condition for underestimation by PCA. Order of magnitude: with L around 0,2; transport cost ratio in final price = 5% and transport cost decrease of 20% ie $\frac{(-\Delta c)}{p} \approx 0{,}01$, we obtain that this sufficient threshold is 1/40 ($\lambda > \frac{1}{40}$), which is very likely to be obtained (a cost pass-through of 2,5% is sufficient for underestimation by PCA).

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[7] Other assumptions for PCA's errors may be taken, such as error on elasticity, or perfect traffic estimate; they give similar results ie low or very low cost pass-through threshold for obtaining an overestimation through PCA

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