An ex-post cost benefit analysis of Italian High Speed train, five years after

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Abstract

The core of Italian HS rail plan is the Turin – Salerno line, in operation since 2009. The central segment Milan – Rome has been working well since the opening, with good demand figures quite in line with the later forecasts. The extremes of the line, namely the extensions to Turin and to Naples/Salerno has remained for long far less used. In 2012, unique case in Europe, a newcomer entered in the market and pushed a radical change in Trenitalia marketing, quality and pricing. This positive fact has fostered the market, with supply and demand dramatically increased, reduced fares and distributed benefits to the users, also in terms of new mobility practices.

The paper aims at revising a former Cost Benefit Analysis exercise, produced just two years after line opening, in the light of the changed conditions. In particular, applying a similar methodology and estimating on the basis of third-party sources the current Origin-Destination demand matrix, we will recalculate the economic feasibility indicators.

The cost-benefit analysis gives a marginally positive result in the most-likely case. To the contrary, extrapolating pre-competition trends without competition, gives a very negative result. In fact, we show that travel time benefits are a fraction of the cost. The largest benefits comes from the new demand, which in turn comes from increased frequency, from the introduction of mixed traditional/high-speed services and from the fall in prices due to the entrance of NTV.

Keywords: High-speed rail, cost benefit analysis, ex-post.

1. Introduction

The core of Italian HS rail plan is the Turin – Salerno line, in operation since 2009. The central segment Milan – Rome has been working well since the opening, with good demand figures quite in line with the later forecasts. The extremes of the line, namely the extensions to Turin and to Naples/Salerno have remained for long far less used. In 2012, unique case in Europe (Beria and Grimaldi, 2017), a newcomer entered in the market and pushed a radical change in Trenitalia marketing, quality and pricing. This positive fact has fostered the market, with supply and demand dramatically increased, reduced fares and distributed benefits to the users, also in terms of new mobility practices.

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The paper's first aim is to revise the results of a former Cost Benefit Analysis (Beria and Grimaldi, 2011), produced just two years after line opening, in the light of the changed conditions. At those times we estimated 2010 traffic figures as quite far from the thresholds needed to justify the 32 billion Euro investment in socio-economic terms. In particular, we found that on the Milan-Turin the traffic was as low as 9.5% of the needed level, and on the Milan-Bologna, the best performing line according to our indicators, at 73.6%. These results were calculated using the methodology suggested by de Rus and Nombela (2007) and de Rus and Nash (2007) and hypothesising a long-term traffic growth of 3% p.a., which looked quite generous at the time.

Few years after, we observe that demand did not evolve linearly, but had very steep increases between 2012 and 2015, unforeseeable looking at 2011 data. Already in 2013, 12.3 billion passenger-km travelled on high-speed services, 2.2 times the figures of 2010. A relevant component of this increase is due to, the entrance of a private newcomer - NTV – in the Italian high-speed market, providing services in competition with the ones of the former incumbent, Trenitalia, and engaging with it a harsh competition in terms of prices and supply quality.

A second aim of the work is to discuss the socio-economic effect of alternative scenarios, both for the actual and the do-nothing one. In particular, we will evaluate what would have happened if no new line was built, if competition had not developed or if it had developed anyway on the conventional network. Apart the realism of some of these alternatives (for example, it is unsustainable that a level of supply such as the current one is compatible with the historical 2-tracks line), this exercise will allow to separate the effect of the "high-speed" from the effect of new capacity and that of competition.

The following of the paper is structured as follows. Section 2 introduces the case and in particular discusses how competition developed. Section 3 explains the scenarios and how the evaluation was performed. Section 4 presents the results of the analysis and Section 5 provides some policy indications at the light of the results. For easiness of reading, all methodological aspects and assumptions done are collected in the Annex.

2. The Italian case of high-speed and the effect of competition

2.1 History of the project

The project for the Italian HSR (in Italia "Alta Velocità", from here on *AV*) dates back to 1990. Initially, it was to be a new system, independent from the rest of the network. The project foresaw a T-shaped network: from Turin to Venice (west to east) and from Milan to Naples (north to south). To date, the line is operational between Turin and Naples, while from Milan to Venice is under construction. However, the characteristics of the line has changed substantially, from being a passengers-only line to a mixed line, including also numerous interconnections. This design change had substantially increased the cost of the line, making the Italian HS (more properly called *High Speed/High Capacity*) the most expensive one in Europe, per km (Campos et al., 2009 and Nash, 2015).

This network should have been built through Project Financing by a new mixed society, called *TAV SpA*, with a 60% of private capital to be completely repaid and the rest owned by the Italian state. This however did not happen and already in 1998, a public fund had to buy back the entire stock of shares of TAV, due to the unavailability of private shareholders to provide entitled capitals (RFI, 2007). The story ended with the forced take-over of 13 billion Euros of TAV debts by the State balance (Beria and Ponti, 2009) and the return of the line under the control of RFI, the national network operator.

From the perspective of economic feasibility, the issue of cost-rise plays a key role, as we will underline also in Section 4. From an initial estimation of 10.7 billion€ in 1992 for the Turin – Salerno line, the bill was of 32.0 billion€ already in 2006 (RFI, 2007), doubling in real terms[1]. This gives a per km cost of 24 M€ (Rome-Naples) to 68 (Bologna-Florence, almost entirely in tunnel), with the worst case being the 54 M€/km of the Milan-Turin, totally in plain and excluding urban accesses. From the benefits side, to date, there was no freight train using the line and interconnections are used only in a few cases, resulting in no actual benefit from those extra-costs.

2.2 The effect of competition

As we outlined in a former contribution (Beria and Grimaldi, 2017), the entrance of NTV in the Italian high-speed rail market is a relevant exception in the field, since it is the only worldwide case of on-track competition. The only other cases take place on conventional intercity services, such as *MTR Express* in Sweden, *WESTbahn* in Austria or *RegioJet* and *LeoExpress* in the Czech Republic.

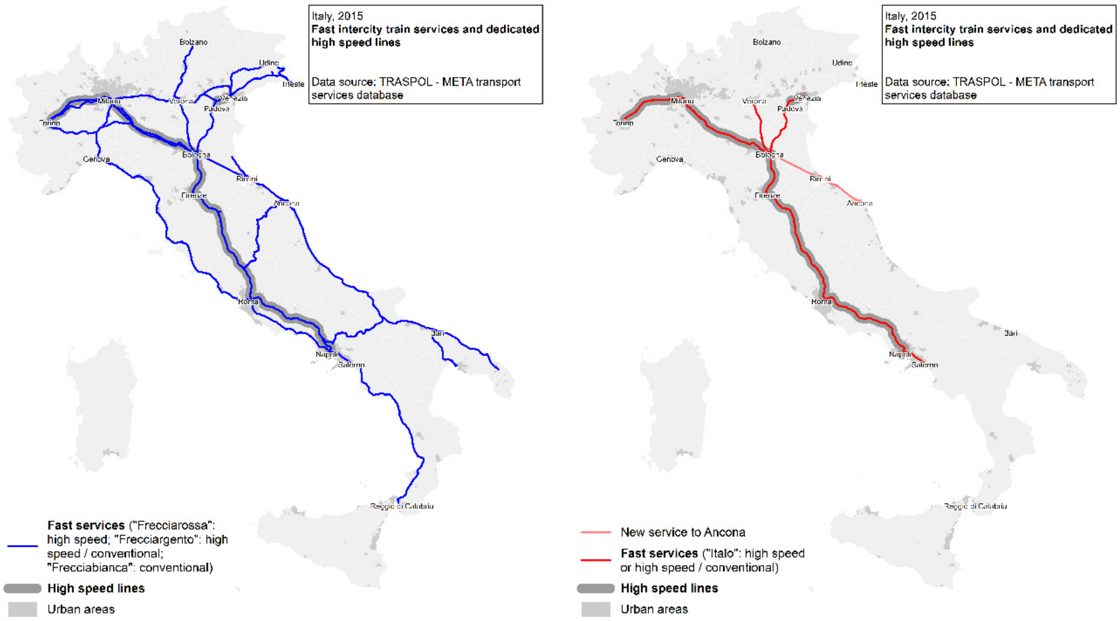


Figure 1. The network of Italian fast trains, including full high speed ones (Frecciarossa, Frecciabianca, Frecciargento, Italo). Source: Beria and Grimaldi, 2017.

The competition started in 2012, a few years after the full opening of the HS line (2009), probably when the former market situation was still consolidating. Despite the financial weakness of the competitor, up to now the effects and the changes to market have been large. They basically lay in three fields: quality, which improved, quantity, which also increased in terms of seats and frequencies, and prices, which surely decreased, even with different patterns.

[1] 10.7 billion $Euro_{1994}$ is equal to 15.5 billion $Euro_{2006}$.

Concerning the last point, prices, Cascetta and Coppola (2014) suggest a reduction in average fares of high-speed services (on routes benefiting from competition) by 31% between 2011 and 2012; in a following study, they confirm a reduction by 34% in two years.

Bergantino et al. (2015) study both supply and prices. They outline how the incumbent did not reduce the supply after the entrance of the competitor, so that the overall capacity of the Rome-Milan pair increased by 56% in 2012. Also fares are studied, finding that both the incumbent and the newcomer adopted strategic pricing behaviours (i.e. fares of both companies are influenced by fares of the others). They do not find evidence of predatory pricing by the incumbent, whose fares remain on average 29.92%-34.67% higher than the ones of the newcomer. They also find evidence of a significant effect on fares of competing air services, which reduced up to 13.26 € on the Rome-Milan route.

Beria et al. (forthcoming) study another line, the Milan - Ancona, looking at before and after NTV entrance prices. They find that one year after competition, looking at a 3-months comparable period, incumbent prices have decreased of 10-20% (according to booking advance) and newcomer's are further slightly lower.

3. The evaluation of a new infrastructure with triggered competition

3.1 Definition of scenarios

Available figures show that the opening of the Turin-Salerno HS infrastructure in late 2009, rose demand volumes of about 50% in the first year of operation (Beria and Grimaldi, 2011). However, the impact of opening the market to competition three years later was much more impressive. Operated services increased from 70,802 km/day in 2010 to 120,897 km/day in 2013 (+70.7%). Demand volumes rose from 5.6 billion passenger-km in 2010 to 12.3 billion in 2013 (+119.5%; Dell'Alba and Velardi, 2015), but the following years were similarly impressive, even if no precise data is publicly available.

Given these facts, we use the Italian case to discuss how the contemporary opening of a new infrastructure and of competition in the market on it, influence generated welfare. Actually, this comparison depends on the observed demand figures, but also on the counterfactual situation: what would have happened if no infrastructure or no competition have existed? How much of welfare generated is due to one fact or to the other or to the existence of both?

To do that, we carry out an ex-post cost-benefit analysis of 6 alternative compositions of intervention and reference scenarios, summarised in Table 1. The alternatives imply different compositions in terms of infrastructure investment (HS lines are built or not) and of the degree of competition (full, "half" or no competition). The degree of competition is intended in terms of increase in overall supply and users (in this sense, the "half" competition alternatives entail a half increase in supply and users) and reduction in fares. In the absence of any transferable evidence, the reduction in average fares (from 0.12 to 0.09 €/passenger-km, see Annex) is set to be the same in the full and "half" competition alternatives, and zero in the no-competition alternatives.

Alternatives 1.a, 1.b and 1.c compare the present situation (infrastructure+competition) with a reference case in which the HS line was not built. The subcases consider the degree of competition in the reference scenario. Alternative 2 is an unreal case in which the new HS line is built, but no competition takes place. This is the cost benefit analysis of the infrastructure. Alternatives 3.a and 3.b are also unreal cases in which HS lines are not built, but competition takes place on conventional network both in the reference and intervention scenarios.

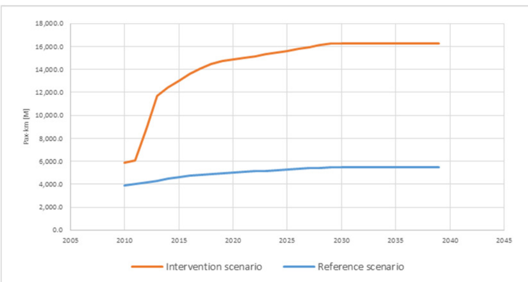
To reduce the complexity, we fixed the trend from 2013 onwards, assuming a declining increase of traffic in the intervention alternative: +6% 2014, 1% since 2020 and +0% since 2030. All other cases are left to scenarios: the increase of demand after competition and the traffic trend in the reference case.

Alternative	*Intervention*	*Reference*
1.a	HS lines built Full competition	HS lines not built No competition
1.b	HS lines built Full competition	HS lines not built “Half” competition
1.c	HS lines built Full competition	HS lines not built Full competition
2	HS lines built No competition	HS lines not built No competition
3.a	HS lines not built Full competition	HS lines not built No competition
3.b	HS lines not built “Half” competition	HS lines not built No competition

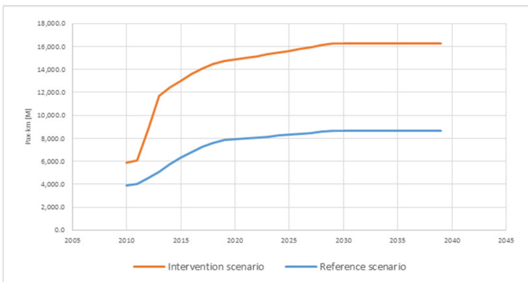
Table 1. Description of different alternatives in terms of infrastructure investment and competition level in the intervention and reference scenarios (our elaboration)

Figure 2 represents the amount of users of HSR services in the reference and intervention for the six scenarios; volumes of passengers and services for some years are provided in Table 8 (Annex). For example, case 2 shows the trends of the demand that we would have had if no competition had taken place: an increase of demand in 2010 when the line is opened and an increasing trend in the following years similar to the one of the base case. Scenario 1.a is the one with most difference between intervention and reference and thus the one with most benefits: the opening of the line generated sufficient capacity and momentum to unlock also the competition, which, in turn, boosted the demand. We believe that the most realistic reference scenario is something between 1.a and 1.b: some competition could have taken place on the traditional line (similarly to what has happened in Austria or Czech Republic), but its impact would have been capped by the existing capacity constraints.

1.a



1.b



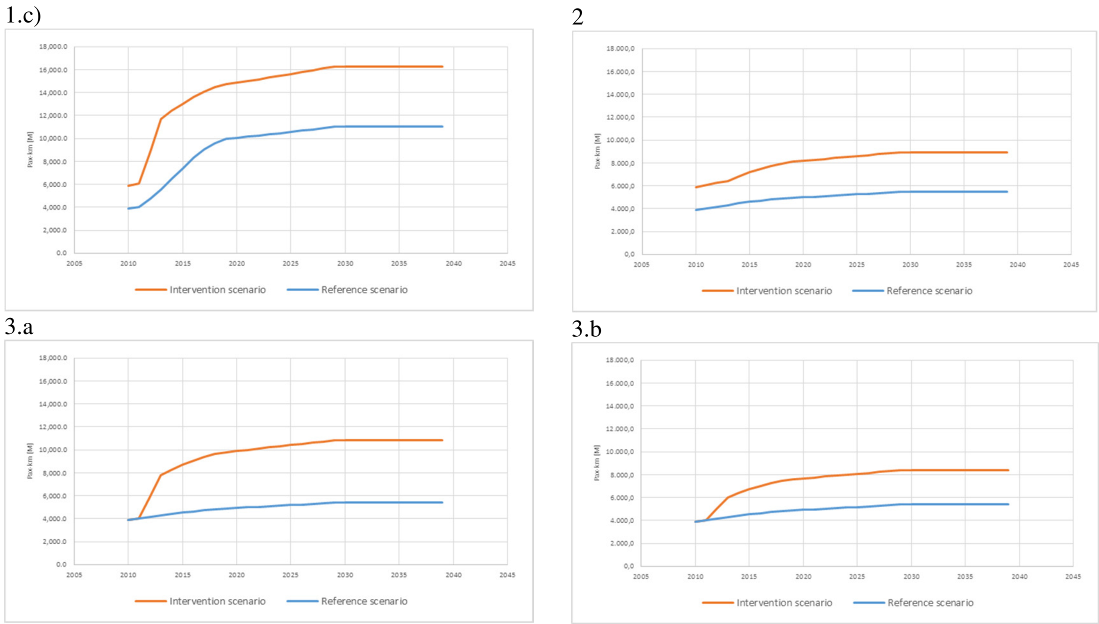


*Figure 2. Million-passenger*km in the intervention and reference scenarios for the different analysed infrastructure and competition alternatives (our elaboration).*

3.2 Assessment methodology

The evaluation is carried out according to standard methodology, as explained in the Annex. To calculate benefits for users we used the conventional 'Rule of Half', as represented in Figure 3. Users' benefits are based on perceived costs and include saved travel and waiting times and – particularly important in our case – a reduction in fares. The component of reduction in fares for existing users instead represents a transfer within the society (a benefit for the users, an equivalent cost for the producers): in this sense, the net benefit of reduced fares is just the triangle related to new users (new or shifted from alternative modes).

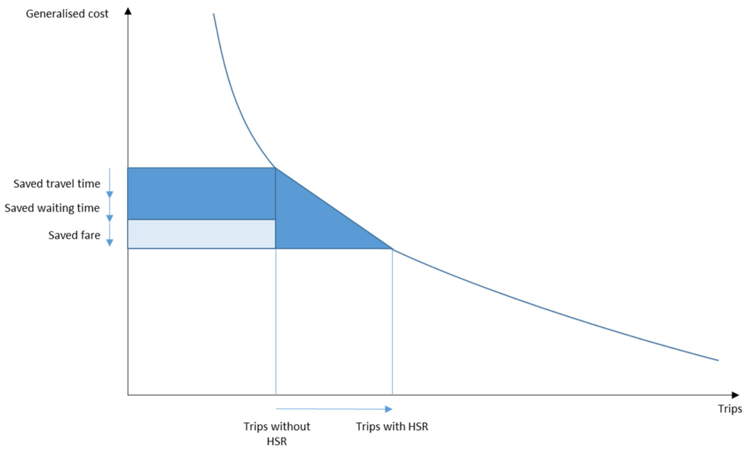


Figure 3. Variation in users' surplus due to saved travel and waiting time and saved fare, using the 'Rule of Half' (our elaboration). The light rectangle is a transfer among users and producers, and thus not contributing to NPV, while the rest is a net societal benefit.

The cost-benefit analysis is carried out separately for six line sections, where most of the traffic attributable to the HS line occurs. Four are the new HS line segments. The other two are the Florence-Rome, where a high-speed line was built in the previous decades (and whose cost is not included in the current evaluation, as well as travel time benefits) and the Venice-Bologna, a conventional line used by Venice-Rome services once the new line is left. These segments have been considered because, although travel times did not change, users benefited from an increase in services (and a consequent reduction in average waiting times) and from a reduction in fares, directly caused by the construction of HSR and of the market opening.

The CBA performed is considering, as usual, all direct and indirect effects: users benefits, investment, running costs, externalities, induced demand benefits. However, calculations show that the new demand is so high that the triangle of the surplus is much higher than the rectangle of existing users. This is the typical situation in which the linear hypothesis of the rule-of-half may fail, and in which wider effects may be not negligible. This may drive to underestimation of benefits.

4. Results

The aggregated results of the analysis for the six scenarios are reported in Table 2. Further tables provide details for a selection of them, line segment by line segment. In particular, Table 3 reports scenario 1.a (current situation vs. no investment and no competition) Table 4 scenario 2 (investment on the line, but no competition) and Table 5 scenario 3.b (no investment and some competition on the traditional tracks).

Tables include all costs and benefits sources. Consumers' surplus is made by travel and waiting time benefits and reduction in fares. New users also generate extra revenues for the operator, which is a net benefit with respect to previous non-trips or trips done by car. For this reason, perceived costs are also corrected for reduction in fuel taxes and tolls. In addition, also environmental externalities are considered for car and air shifters and obviously all additional operating costs of line and trains.

A first consideration is that, in all the considered scenarios, the new infrastructure and the competition "spread" their benefits well beyond the four sections where new lines where built; in fact, socio-economic profitability indicators improve significantly including the two sections Florence-Rome and Bologna-Venice, where no new lines were built but many high-speed services previously not existing do operate.

The scenarios with best indicators are 3.a and 3.b (Table 2). This is quite obvious: they entail no investment but include the large benefits of competition. The result is that competition generated a net benefit for Italian society of 5 to 7 billion€. These come from a reduction of fares from existing users, but especially from the additional revenues (which represent a benefit) of new users, not travelling by train at previous fare levels. The only problem with these scenarios is that they are totally hypothetical: the lines considered were near to saturation, except Florence – Rome and Rome – Naples and consequently the supply we have now would have been impossible. In this sense, a more realistic (but impossible here) scenario would have included some investment cost for capacity expansion, but not at HS standards.

Scenario 2 is the "typical" assessment of a new infrastructure. Its result, for the present case, is clearly negative. Travel time savings and benefits for the new users account to some 10 billion€, plus some external benefits from car trips avoided, but they are very far from the investment needed for the new line (32 billion€ reduced by conversion coefficients). This means that, without the competition which took place after 2012, this investment would have been *extremely negative* from the socio-economic viewpoint, in line with previous estimations (Beria and Grimaldi, 2011).

Alternative	*1.a*	*1.b*	*1.c*	*2*	*3.a*	*3.b*	
Intervention ǀ HS lines	Yes	Yes	Yes	Yes	No	No	
Intervention ǀ competition	Full	Full	Full	No	Full	"Half"	
Reference ǀ HS lines	No	No	No	No	No	No	
Reference ǀ competition	No	"Half"	Full	No	No	No	
Investment	-25.451	-25.451	-25.451	-25.451	0	0	M€$_{2010}$
Residual value	4.579	4.579	4.579	4.579	0	0	M€$_{2010}$
Travel time benefits	6.346	7.092	7.637	4.258	0	0	M€$_{2010}$
Waiting time benefits	1.640	1.281	1.017	751	638	68	M€$_{2010}$
Reduction in fares (due to competition)	2.612	0	0	0	1.301	712	M€$_{2010}$
New operating costs of lines and services	-12.479	-12.479	-12.479	-10.535	-9.667	-7.634	M€$_{2010}$
Saved operating costs of lines and services	7.872	9.689	10.842	7.872	7.872	7.872	M€$_{2010}$
Revenues generated by new rail users	16.244	11.892	8.809	7.235	7.872	4.306	M€$_{2010}$
Saved external costs (car)	2.773	2.048	1.517	934	1.353	740	M€$_{2010}$
Saved external costs (air)	1.095	809	599	369	534	292	M€$_{2010}$
Lost fuel taxes and motorway tolls (car)	-4.502	-3.325	-2.463	-1.517	-2.197	-1.202	M€$_{2010}$
Generated rail services external costs	-960	-960	-960	-810	-671	-530	M€$_{2010}$
Saved rail services external costs	492	606	678	492	492	492	M€$_{2010}$
NPV (Benefits - Costs)	260	-4.219	-5.676	-11.824	7.527	5.116	M€$_{2010}$
NBIR (Net Benefits / Investment)	1,01	0,83	0,78	0,54	N.A.	N.A.	
BCR (Benefits / Costs)	1,01	0,90	0,86	0,69	1,60	1,55	

Table 2. Comparison among the results of cost-benefit analysis in different alternatives, for the whole network of HS services (our elaboration)

1.a: Intervention: HS lines and full competition Reference: no HS lines, no competition	*Turin-Milan*	*Milan-Bologna*	*Bologna-Florence*	*Rome-Naples*	*Sections with HS infrastr.*	*Venice-Bologna*	*Florence-Rome*	*Whole HS network*	
Investment	-7,550	-6,705	-5,698	-5,498	-25,451	0	0	-25,451	M€2010
Residual value	1,359	1,206	1,025	989	4,579	0	0	4,579	M€2010
Travel time benefits	712	2,777	1,542	1,315	6,346	0	0	6,346	M€2010
Waiting time benefits	626	257	187	243	1,312	147	181	1,640	M€2010
Reduction in fares (due to competition)	122	613	332	418	1,486	125	1,001	2,612	M€2010
New operating costs of lines and services	-648	-2,640	-1,652	-2,083	-7,023	-771	-4,685	-12,479	M€2010
Saved operating costs of lines and services	158	1,646	1,165	1,129	4,097	492	3,282	7,872	M€2010
Revenues generated by new rail users	755	3,814	2,083	2,580	9,233	771	6,239	16,244	M€2010
Saved external costs (car)	129	651	355	441	1,576	132	1,065	2,773	M€2010
Saved external costs (air)	51	257	140	174	622	52	420	1,095	M€2010
Lost fuel taxes and motorway tolls (car)	-210	-1,057	-576	-717	-2,559	-214	-1,728	-4,502	M€2010
Generated rail services external costs	-50	-203	-127	-160	-540	-59	-360	-960	M€2010
Saved rail services external costs	10	103	73	71	256	31	205	492	M€2010
NPV (Benefits - Costs)	-4,537	719	-1,150	-1,097	-6,065	706	5,619	260	M€2010
NBIR (Net Benefits / Investment)	0.40	1.11	0.80	0.80	0.76	N.D.	N.D.	1.01	
BCR (Benefits / Costs)	0.46	1.07	0.86	0.87	0.83	1.68	1.83	1.01	

Table 3. Results of the cost-benefit analysis. Alternative 1.a (our elaboration)

2: Intervention: HS lines, no competition *Reference: no HS lines, no competition*	*Turin-Milan*	*Milan-Bologna*	*Bologna-Florence*	*Rome-Naples*	*Sections with HS infrastr.*	*Venice-Bologna*	*Florence-Rome*	*Whole HS network*	
Investment	-7.550	-6.705	-5.698	-5.498	-25.451	0	0	-25.451	$M€_{2010}$
Residual value	1.359	1.206	1.025	989	4.579	0	0	4.579	$M€_{2010}$
Travel time benefits	382	1.934	1.198	744	4.258	0	0	4.258	$M€_{2010}$
Waiting time benefits	233	147	154	73	608	38	105	751	$M€_{2010}$
Reduction in fares (due to competition)	0	0	0	0	0	0	0	0	$M€_{2010}$
New operating costs of lines and services	-381	-2.307	-1.694	-1.393	-5.776	-544	-4.215	-10.535	$M€_{2010}$
Saved operating costs of lines and services	158	1.646	1.165	1.129	4.097	492	3.282	7.872	$M€_{2010}$
Revenues generated by new rail users	92	1.779	1.244	807	3.922	269	3.044	7.235	$M€_{2010}$
Saved external costs (car)	12	230	161	104	507	35	393	934	$M€_{2010}$
Saved external costs (air)	5	91	63	41	200	14	155	369	$M€_{2010}$
Lost fuel taxes and motorway tolls (car)	-19	-373	-261	-169	-822	-56	-638	-1.517	$M€_{2010}$
Generated rail services external costs	-29	-177	-130	-107	-444	-42	-324	-810	$M€_{2010}$
Saved rail services external costs	10	103	73	71	256	31	205	492	$M€_{2010}$
NPV (Benefits - Costs)	-5.731	-2.427	-2.700	-3.209	-14.067	237	2.006	-11.824	$M€_{2010}$
NBIR (Net Benefits / Investment)	0,24	0,64	0,53	0,42	0,45	N.A.	N.A.	0,54	
BCR (Benefits / Costs)	0,28	0,75	0,65	0,55	0,57	1,37	1,39	0,69	

Table 4. Results of the cost-benefit analysis. Alternative 2 (our elaboration)

3.b: Intervention: no HS lines, "half" competition Reference: no HS lines, no competition	*Turin-Milan*	*Milan-Bologna*	*Bologna-Florence*	*Rome-Naples*	*Sections with HS infrastr.*	*Venice-Bologna*	*Florence-Rome*	*Whole HS network*	
Investment	0	0	0	0	0	0	0	0	M€$_{2010}$
Residual value	0	0	0	0	0	0	0	0	M€$_{2010}$
Travel time benefits	0	0	0	0	0	0	0	0	M€$_{2010}$
Waiting time benefits	159	-8	-28	12	136	-27	-40	68	M€$_{2010}$
Reduction in fares (due to competition)	43	164	83	121	411	36	265	712	M€$_{2010}$
New operating costs of lines and services	-326	-1.623	-1.091	-1.185	-4.225	-443	-2.966	-7.634	M€$_{2010}$
Saved operating costs of lines and services	158	1.646	1.165	1.129	4.097	492	3.282	7.872	M€$_{2010}$
Revenues generated by new rail users	258	994	500	734	2.486	215	1.605	4.306	M€$_{2010}$
Saved external costs (car)	44	171	86	126	427	37	276	740	M€$_{2010}$
Saved external costs (air)	18	67	34	50	169	15	109	292	M€$_{2010}$
Lost fuel taxes and motorway tolls (car)	-72	-277	-140	-205	-694	-60	-448	-1.202	M€$_{2010}$
Generated rail services external costs	-23	-113	-76	-82	-293	-31	-206	-530	M€$_{2010}$
Saved rail services external costs	10	103	73	71	256	31	205	492	M€$_{2010}$
NPV (Benefits - Costs)	268	1.125	607	770	2.770	265	2.082	5.116	M€$_{2010}$
NBIR (Net Benefits / Investment)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	
BCR (Benefits / Costs)	1,64	1,56	1,45	1,52	1,53	1,47	1,57	1,55	

Table 5. Results of the cost-benefit analysis. Alternative 3.b (our elaboration)

Finally, group 1 scenarios are the most interesting because considering both the benefits of competition *and* of the high-speed. In our case, just scenario 1.a (reference without any competition, the most likely to have happened) reaches the breakeven of the indicators and thus results marginally positive. Benefits come from reduced travel time (about 6 billion€), but this component is not the main one. Additional benefits are due to the Mohring effect for increased train frequency (1.6 billion€). Reduction in fares for existing users give further 2.6 billion€. However, these effects together would have been largely insufficient to justify the investment. The largest benefit comes from the revenues of new users. As already commented, this is a net societal benefit because accounts for the higher willingness to pay for a train ride in substitution for other options (car, plane or no trip).

Dividing the effect on the four new segments of the line, the best performing one is the Milan – Bologna. Its cost was relatively low and the traffic is the highest after the Bologna – Florence, which in turn cost much more because in tunnel. The worst performing is the Milan – Turin. In this case the cost was outstandingly high, the traffic is quite low (it is the terminal part of the line) and a lot of reasonably fast regional trains still exist between the two cities at a much lower price. The Venice – Bologna and Florence – Rome segments have no investment and no travel time benefits, but account for the increase of traffic due to the speeding of the rest of the lines.

In conclusion, only the combined effect of new line and head-on competition has generated a sufficient amount of benefits to barely justify the investment. The problem of this project lays, as it is nowadays clear, in the cost side. The investment cost has exploded for various reasons (RFI, 2007), especially because of design choices and tendering procedure. If it had costs in line with comparable European cases, its socio-economic indicators would have been significantly better. The next section will further comment on that.

5. Policy indications

We have shown through the CBA that the direct effect of high-speed, namely a higher speed for existing users, is just a marginal benefit for the investment. In itself, it proved not capable to boost the demand to a level capable to generate the needed benefits.

The first policy indication is that *competition*, and its consequences in terms of fares, quality and frequency, had generated a substantial part of the benefits and, unexpectedly, had improved the performance of a project that, just five years ago, was far from viability (Beria and Grimaldi, 2011). It is meaningless to quantify them, because all effects are interrelated, but in our case the NBIR without competition is half than the one with competition. This means that making a CBA without estimating the effect of competition may substantially underestimate benefits. And, more interestingly, that high density corridors may generate huge benefits if there is competition.

A second issue is specific of the Italian case, but might be relevant also elsewhere. In this case, the direct benefit of *speed* is marginal. The turning point was capacity, as the line was saturated and no more regular slots were available. So, a fast doubling (maybe 250km/h instead of 300 km/h) could have given a substantial part of the observed benefits, at a much lower cost. Travel time benefits would have been smaller, but frequency and competition-related ones would have been similar. This would be even more true for a shorter but denser corridor, such as the Milan – Venice, where a new HS infrastructure is now being planned (and partially built). In this case, cities are less than 100km far from each other, but capacity constraints are the same and thus also the benefits in terms of frequency and fares. It is probably unnecessary to mention that a capacity expansion obtained with technological improvements would have been even more similar to our fictitious case 3.a (capacity expansion, full competition at no investment cost).

This second issue is related with that of *investment costs*. A more "frugal" investment, avoiding overdesign, focused on passenger trains, reducing locally the speed and the works of art, would have cost much less. Even more unjustified is the extra-cost due to the lack of tendering for civil works. RFI (2007) speaks about a 14-20% extra-cost for this reason. Assuming a realistic -25% investment cost (equal to 24 M€/km), the NBIR would have been 1.29 and the NPV positive for 5.5 billion€.

6. Conclusions

The debate on megaprojects takes often the shape of ideology. Assessment techniques, and cost-benefit analysis in particular, aim at clarifying the effects and their relative weights, helping decision-makers to take informed decisions and public opinion to have a grounded idea on how public money is spent.

In the case of Italy, the high-speed programme is one of the largest infrastructure investment after WWII, but it was not subject to an economic assessment prior to decision. In the paper we performed an ex-post analysis, in the light of important changes occurred in the market a few years after opening. In fact, in the first three years, we observed an increase in demand, due to the time savings allowed from the new line, but these benefits were far from counterbalancing the investment cost. In 2012 and later, a private newcomer, NTV, entered in the market with a comparable supply and serving similar routes than Trenitalia. The effect was disruptive: for both competitors quality increased, prices felt, frequencies and seats increased and ultimately patronage had a dramatic rise, above the most optimistic expectations.

The cost-benefit analysis clarified that the time benefits were a fraction of the cost, also because of a problem of overdesign that raised per-km investment cost to a level higher than any other comparable European case. Much more benefits are instead associated to the new demand, to increased frequency and to the introduction of mixed traditional/high-speed services outside of the high-speed infrastructure.

In conclusion, it would be important to consider that, under some conditions such as high population served, head-on competition can contribute much more than marginally in the socio-economic viability of transport megaprojects. In the present case it was able to make marginally positive an investment conceived for totally different purposes and doomed by the original sin of overdesign. Clearly it is not the panacea to make feasible all politicians' pet-projects, but can make the difference in some cases. From the methodological point of view, we showed how to use CBA to evaluate "unconventional" benefits, such as Mohring effect, network effect and competition-generated demand, which are aspects usually less considered in literature.

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Annex: methodology and data

General methodology

The cost-benefit analysis was developed according to the general methodology suggested in DG Regio (2014).

For the cost side, we included the usual elements: investment cost, O&M costs (parametrically estimated), residual value. The benefits' side includes consumers' surplus (rail users travel time savings), producers Surplus (delta revenues of the rail operators), externalities. All benefits and costs have been discounted to 2010.

The key point of the analysis lays in the variation in consumers' surplus. According to the guidelines, it was estimated using the 'Rule of Half' approach for all the traffic components (existing, diverted from other modes and induced ex-novo). The way this has been carried is described in detail below.

For all scenarios and line sections we calculated the usual indicators:

NPV, net present value: the sum of the discounted economic net flows of a project. If positive, indicates that the actualised benefits exceed the actualised costs during the entire lifetime of the project:

$$NPV = \frac{\sum_{n=0}^{N} Bn - Cn}{(1+i)^n}$$

NBIR, net benefits over investment ratio: a synthetic indicator showing the net benefit (benefits minus operation costs) for every Euro spent in the investment phase. A ratio above one means that the project is worthwhile.

BCR, benefit cost ratio: the ratio between all discounted benefits and all discounted costs. Similarly to NBIR a ratio above one is the threshold for beneficial projects. In principle, the two indicators are similar when the investment cost is the largest part of all costs of the project. In some of our scenarios there is no investment cost (those modifying only the competitive environment) and thus the BCR is the only possible benefit cost ratio.

In the following paragraphs we clarify how each of the main components of the analysis have been calculated, including all used sources and specifying when the unavailability of data required the use of educated guesses.

Traffic data

No official data exist on patronage of high-speed rail services in Italy. We estimated traffic data per section in Table 6 from our former evaluation (Beria and Grimaldi, 2011) for 2010 and from Dell'Alba and Velardi (2015) for 2013.

Section	2010	2013
Sections where investment occurred		
Turin-Milan	1.3	3.8
Milan-Bologna	6.6	12.8
Bologna-Florence	10.9	18.0
Rome-Naples	2.9	7.5
Sections benefited from increase in services		
Florence-Rome	9.3	17.5
Venice-Bologna	1.3	3.1

Table 6. Million-passenger traffic on sections where investment occurred and on sections directly benefited from increase in services (our estimates).

Data on operated services on different sections are taken from official timetables (2010 and 2015).

Section	2010	2015
Sections where investment occurred		
Turin-Milan	18	46
Milan-Bologna	68	125
Bologna-Florence	100	184
Rome-Naples	40	98
Sections benefited from increase in services		
Florence-Rome	98	182
Venice-Bologna	26	48

Table 7. Daily services (both directions) on sections where investment occurred and on sections directly benefited from increase in services (source: official timetables). Non-stop services included.

Basing on 2010 and 2013 demand figures and on 2015 supply, we define our traffic scenarios applying different trends for the future, obtaining Table 8 passenger and service volumes. Intervention scenarios combine the gap due to speed increase (occurred in 2009), a base growth of 3% and the growth observed between 2011 and 2013, due to competition. For all years the volumes for different sections maintain the same proportions as in 2013. Patronage for 2014 and 2015 has been estimated from 2013 as proportional to declared load factors and supply increase. For the following years, a decreasing traffic increase have been imposed, in order to reach a 1% growth in 2020 and onwards.

Alternative 1.a

*Passenger*km/year [M]*	*2010*	*2015*	*2020*	*2025*	*2030*
Intervention scenario	5,888.9	13,038.8	14,867.6	15,626.0	16,260.5
Reference scenario	3,925.9	4,626.4	5,024.7	5,281.0	5,495.5

*Train*km/day*	*2010*	*2015*	*2020*	*2025*	*2030*
Intervention scenario	65,132.0	127,605.0	136,426.0	143,820.0	149,440.0
Reference scenario	67,926.0	72,815.5	74,136.0	76,236.0	77,700.0

Alternative 1.b

*Passenger*km/year [M]*	*2010*	*2015*	*2020*	*2025*	*2030*
Intervention scenario	5,888.9	13,038.8	14,867.6	15,626.0	16,260.5
Reference scenario	3,925.9	6,309.7	7,913.8	8,317.5	8,655.2

*Train*km/day*	*2010*	*2015*	*2020*	*2025*	*2030*
Intervention scenario	65,132.0	127,605.0	136,426.0	143,820.0	149,440.0
Reference scenario	67,926.0	88,555.6	95,242.0	97,080.0	98,988.0

Alternative 1.c

*Passenger*km/year [M]*	*2010*	*2015*	*2020*	*2025*	*2030*
Intervention scenario	5,888.9	13,038.8	14,867.6	15,626.0	16,260.5
Reference scenario	3,925.9	7,428.0	10,065.9	10,579.3	11,008.9

*Train*km/day*	*2010*	*2015*	*2020*	*2025*	*2030*
Intervention scenario	65,132.0	127,605.0	136,426.0	143,820.0	149,440.0
Reference scenario	67,926.0	98,402.8	108,206.0	110,818.0	112,474.0

Alternative 2

*Passenger*km/year [M]*	*2010*	*2015*	*2020*	*2025*	*2030*
Intervention scenario	5,888.9	6,591.7	7,516.3	7,899.7	8,220.4
Reference scenario	3,925.9	4,604.7	5,001.2	5,256.3	5,469.7

*Train*km/day*	*2010*	*2015*	*2020*	*2025*	*2030*
Intervention scenario	89,504.3	95,373.2	101,904.0	107,094.0	111,418.0
Reference scenario	67,926.0	72,815.5	74,136.0	76,236.0	77,700.0

Alternative 3.a

*Passenger*km/year [M]*	*2010*	*2015*	*2020*	*2025*	*2030*
Intervention scenario	3,925.9	8,692.5	9,911.7	10,417.3	10,840.3
Reference scenario	3,925.9	4,547.0	4,938.5	5,190.4	5,401.2

*Train*km/day*	*2010*	*2015*	*2020*	*2025*	*2030*
Intervention scenario	71,043.3	85,070.0	90,748.0	95,220.0	99,376.0
Reference scenario	67,926.0	72,815.5	74,136.0	76,236.0	77,700.0

Alternative 3.b

*Passenger*km/year [M]*	*2010*	*2015*	*2020*	*2025*	*2030*
Intervention scenario	3,925.9	6,898.6	7,866.2	8,267.4	8,603.1
Reference scenario	3,925.9	4,536.4	4,927.0	5,178.3	5,388.5

*Train*km/day*	*2010*	*2015*	*2020*	*2025*	*2030*
Intervention scenario	71,043.3	66,522.6	70,456.0	74,168.0	76,780.0
Reference scenario	67,926.0	72,815.5	74,136.0	76,236.0	77,700.0

Table 8. Passenger and service volumes in different scenario (our estimates)

Investment costs and residual value

Investment costs were provided by the Italian rail infrastructure manager (RFI, 2007), and summarised in Table 9 (financial values). In the CBA they were evenly distributed among 2002 and 2009 and converted to €$_{2010}$ present value. Financial values were corrected to economic ones using a shadow price of 0.85 (our elaboration on NUVV, 2001). Scenarios 3.a and 3.b do not entail investment costs, fictitiously assuming available capacity on lines (see comments in the main text).

Section	*Investment cost M€*	*Cost per km* M€/km*	*Line description*
Turin – Milan	7,788	54	Plain line in agricultural area, along the highway
Milan – Bologna	6,916	31	Plain line in agricultural area, along the highway
Bologna – Florence	5,877	68	Semi-continuous tunnel in complex rock
Rome – Naples	5,671	24	Plain / hilly line in agricultural area

Table 9. Construction costs per line section and travel times, Italy (our elaboration on RFI, 2007, and Beria & Grimaldi, 2012)

The residual value was conventionally set to be 50% of the economic investment costs (in 2039).

Operating costs

Operating costs of trains were calculated using economic unit operating cost values of 12 €/train-km for high-speed services and of 13.3 €/train-km for slower conventional services (our elaboration on RFI, 2005). These unit costs are applied to the supply volumes of Table 8. Infrastructure operating costs of the lines are included in operating costs of rail services and thus are not double-counted.

Variation in users' surplus: reduction in travel and waiting times and in fares

The calculation of users surplus is the core of the CBA and the most delicate operation. In absence of a full transport model, as mentioned above, we follow the guidelines and use the so-called "Rule of Half". In practice, we assume that existing passengers (those already using the train before, in this case the 2010 figures minus the 50% additional traffic of 2010) receive the full travel time reduction benefit. Instead, those using other modes before (car, plane or no travel) and whose initial cost is unknown, receive half of the entire benefit. This represent a linear demand function, where the former marginal user gets the full benefit as the existing users and the new marginal user gets zero benefit from the mode change.

Unit tavel time savings are derived from official timetables before and after the investment. Time savings are present only in alternatives that foresee HS lines to be built in the intervention scenario (1.a, 1.b, 1.c and 2). Venice – Bologna and Florence – Rome travel times lines do not change with respect to reference scenario and thus the benefit there is zero, also for new users.

Section	*Saved travel time [hours]*
Torino-Milano	0.58
Milano-Bologna	0.67
Bologna-Firenze	0.25
Firenze-Roma	0.00
Roma-Napoli	0.58
Venezia-Bologna	0.00

Table 10. Travel time savings per section (our elaboration on official timetables 1999-2015)

Travel time savings are not the only time benefit. The competition and the extra demand had increased significantly the number of trains, thus reducing the waiting time (or, more appropriately, the anticipate arrival at destination). This externality is known as Mohring Effect. Waiting time for the scenarios is defined as half the headway[2] between two following services in the same direction and the reduction of headway in the intervention scenarios is the unit benefit considered.

Travel time savings are valued using an average value of travel time of 20 €/passenger-hour, while waiting time savings valued using an average value of waiting time of 30 €/passenger-hour.

A further benefit for users is the possible reduction in fares. We observe that competition among NTV and Trenitalia actually entailed a reduction in average fares from 12 to 9 €cent/passenger-km (our elaboration on Cascetta and Coppola, 2014). As explained in section 3.2, although this reduction represents a transfer between the users' and producers' surpluses, it contributes defining the collective benefits for users shifting transport mode.

[2] Headway is defined dividing the number of daily services per direction by 14 operating hours. The maximum value of waiting time is set to 1 hour, to consider that in this cases regional trains become a better option (this has a limited effect only on the Milan-Turin). Moreover, since the analysis is made on a section basis, the amount of passengers on each section is multiplied by 0.491, which is the amount of passengers on the whole network of services over the sum of passengers on each section, to take into account of the fact that most passengers use different sections in a single trip.

Correction of transfers in the 'Rule of Half': fuel taxes, motorway tolls and rail service revenues

Benefits for new users (both diverted and generated) are calculated using the 'Rule of Half', applied to perceived (private) costs and not to social ones. For this reason, the CBA must be corrected rebalancing the transfers within society. For example, the reduction of fares is a benefit for users, but a cost for producers, and in fact it is not a net benefit except for the additional traffic. The same is true for fuel duties and motorway tolls.

Lost revenues in fuel taxes for the Government are calculated with a unit fuel tax of 4 €cent/passenger-km (our elaboration on Beria et al., 2012); lost motorway tolls for the concessionaries are calculated with a unit toll of 4.1 €cent/passenger-km (our elaboration on Italian motorways' website). Those unit values are multiplied by the component diverted from car (20.4%, according to Cascetta and Coppola, 2014) of the difference in passenger-km between the reference and intervention scenarios (Table 8).

Generated revenues for the producers of high-speed rail services are calculated with a unit average revenue multiplied by the difference in passenger-km between the reference and intervention scenario (Table 8).

In alternatives and scenarios entailing (full or "half) competition, unit revenues are set to linearly decrease from 12 to 9 €cent/passenger-km 2010 to 2013 and to be constant at 9 €cent/passenger-km from 2013 on (our elaboration on Cascetta and Coppola, 2014); when no competition is foreseen, unit revenue is set constant at 12 €cent/passenger-km.

Externalities

The last component of social surplus is represented by externalities: accidents, local and global pollution, noise, upstream and downstream effects (Maibach et al., 2008).

In this case, we observe a significant shift from car and from plane to the train thanks to competition and increased speed. This modal shift cuts the related car and plane externalities. We quantify them in 5 €cent/passenger-km (Campos and de Rus, 2009; Beria et al., 2012) for passenger shifted from private car (20.4% of new rail users, according to Cascetta and Coppola) and 3 €cent/passenger-km (Campos and de Rus, 2009; Maibach et al., 2008) for those shifted from air transport (31%, ibid).

However, the extra rail services (and the increased speed) cause an increase in external costs of rail (mainly noise). We parametrically give 1€/train-km for HS trains and 0.9 for the conventional ones.