An Early Evaluation of Italian High Speed Projects

Una prima valutazione
dell'Alta Velocità in Italia

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Introduction: the Italian High Speed project

History of projects

The Italian High Speed Railway (in Italian "Alta Velocità") was conceived in 1990 as a new system, substantially independent from the rest of the network, to provide fast links among the cities of Turin, Milan, Bologna, Florence, Rome and Naples (RFI 2007), along the "backbone" line of the country. Soon, the former model inspired to the well known French system, turned into something different, namely a new high performance doubling of the existing network, but completely integrated with it trough numerous interconnections and despite the different voltage. In 1996, according to this new vision, the name of the planned system was changed into AV/AC (acronym of High Speed/ High Capacity, in Italian "Alta Velocità/Alta Capacità"). It conceived the new lines as high capacity fast doublings, capable to host heavy freight trains thanks to low slopes, together with high speed passengers trains. This radical change was officially inspired by environmentalist stakeholders, aiming at making the rail mode attractive also to freight, thanks to higher speed and performance, and thus helping modal shift.

Works of the first phase lasted more than a decade and were recently completed in the main parts. To date, the Italian high speed network is made of the sections listed in Table 1 and represented in Figure 1. The full Turin – Salerno axis, excluding only Florence and Bologna urban sections, has been completed on December 2009.

Table 1 clearly points out one of the main differences in the current network, homogeneous only in appearance. The Florence – Rome line is much older and was essentially a fast doubling of a conventional line, still using the normal Italian voltage of 3kV DC. The rest of the line Turin – Naples is the core of the project conceived in the Nineties and

L'Italia ha affrontato, negli ultimi 15 anni, un eccezionale sforzo finanziario per costruire circa 1 000 km di linee ferroviarie ad alta velocità. Ulteriori estensioni sono attualmente in costruzione o sono state pianificate, in particolare sulle principali relazioni internazionali. Questa rete è comunemente considerata fondamentale nella visione europea di un sistema di trasporto continentale.
Questo articolo analizza il passato ed il futuro di questa rete, laddove possibile da un punto di vista quantitativo. La prima parte dell'articolo ripercorre la storia del progetto Alta Velocità, soffermandosi in particolare sulle questioni relative alla regolazione degli investimenti ed alle vicende finanziarie nelle prime fasi ed alle questioni attuali relative alla regolazione dei servizi ferroviari.
Nella seconda parte l'analisi dell'offerta, dei guadagni di tempo permessi, della domanda e dei costi permette di sviluppare una valutazione ex post – semplificata ma indipendente - dei progetti realizzati, sottolineandone i successi e le potenzialità ancora inespresse, ma anche le significative criticità.
L'ultima parte dell'articolo analizza i piani di espansione futura, confrontando i costi, la domanda esistente e quella attesa. Tale analisi permette di derivare alcune indicazioni di politica dei trasporti e strategie di riduzione dei costi, al fine di controllare la spesa pubblica in un periodo di crisi, senza abbandonare l'idea di una rete ferroviaria moderna ed efficace.

Italy has undergone, in the last 15 years, an exceptional public financial effort to build approximately 1,000 km of high speed rail lines. Further extensions are under construction or planned, especially in the most important international relations. This network is widely considered as fundamental to comply the European vision of a continental-wide transport system.
The paper analyses the past and the future of such network, where possible from a quantitative point of view. The first part of the article reviews the history of the *Alta Velocità* scheme, particularly focusing on the issues related to the economic regulation of the investments and the financial troubles at first and then on the present issues related to the regulation of rail services.
The analysis of the supply, the time gains, the demand and the costs allows to build a simple but independent evaluation of the past projects from an ex-post perspective, pointing out the successes, but also important critical issues.
The second part of the paper analyses the future expansion plans looking at the costs, the existing and expected demand and derives some policy indications and cost reduction strategies capable both to control public expenditure in a period of crisis and not to abandon the idea of a modern and effective rail network.

JEL classification: D61, L92, R42.
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Section	Opening year(s)	Maximum speed [km/h]	Voltage type	Distance [km]	Max. Slope [%]
Turin – Salerno axis					
Turin – Milan	2006 – 2009	300	25 kV AC	125	14.8
Milan – Bologna	2008	300	25 kV AC	182	15.0
Bologna – Florence	2009	300	25 kV AC	79	15.0
Florence – Rome	1977 - 1992	250	3 kV DC	254	12.0
Rome – Naples	2005 – 2009	300	25 kV AC	205	21.0
Naples – Salerno	2009	250	3 kV DC	29	18.4
Milan – Venice axis					
Milan – Treviglio	2007	200	3 kV DC	27	12.0
Padua – Venice	2006	220	3 kV DC	25	12.0
Other lines					
Verona – Bologna	2009	200	3 kV DC	114	12.0

Italian high speed network operating sections (June 2011) (Table 1).

adopts the French standards of 25kV AC. It requires specific high speed rolling stock. The two end sections of the Milan – Venice line, not yet existing as a whole, adopt the same 3 kV DC standard and must be seen again as a fast doubling due to capacity reasons, not used by high speed trains only. Finally, the Verona – Bologna line must be mentioned. It was doubled and upgraded in the same period and opened in 2009 as an high performance traditional line and is currently used by the High Speed services to Rome by multi-power fast trains.

Currently, high speed programmes count numerous new lines to be built (see Figure 1). The main one will connect Milan to Venice, linking numerous mid-sized cities at short distance. Other lines will connect Milan to Genoa, Naples to Bari and Naples to southern regions. However, the largest and most expensive projects underway aim at connecting Italy to neighbour countries trough the Alps: the Frejus line (Turin – Lyon), the Brenner line (Verona – Munich), the Trieste – Divaca line. Not all the mentioned projects are already fully defined and financed.

In the period between the first projects and now, the functional model changed again. While all new lines, except the Brenner, were originally presented as High Speed

lines, the lack of significant passenger traffic turned them to high capacity lines, supposed to host both heavy freight trains and fast passengers trains. This is particularly true for the expensive Alpine crossings. Finally, during 2011, the

High speed infrastructure in Italy (June 2009, source RFI website www.rfi.it.) (Figure 1).
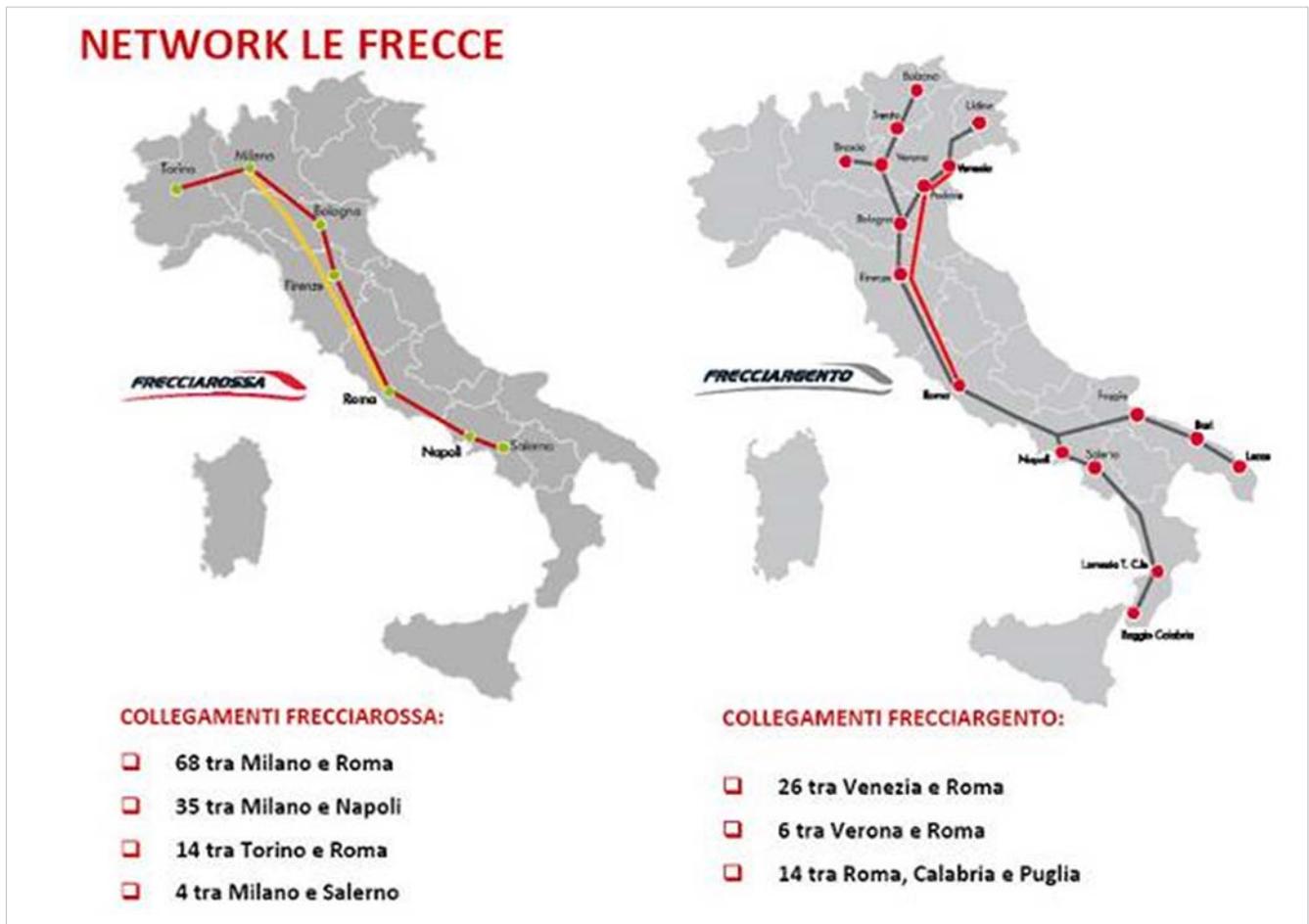
High speed (Frecciarossa, on the left) and medium-high speed (Frecciargento, on the right) services in Italy (source: FS 2010) (Figure 2).

scarcity of public funds suggested a new wave of design characteristics, defined by policy makers as "frugale infrastructures"[1]. In this case the lacking lines, with scarce traffic compared to the capacity of a full new line, should be built progressively and preferring selective doublings or technological upgrades (ResPublica 2010).

Shifting from infrastructures to passenger services, since 2009 a new commercial product has been introduced by the monopolist Trenitalia, named "le Frecce" ("the Arrows"). In the following years the network has been widened and fine-tuned. Currently, *Frecciarossa* is the brand for full high speed products using the Turin – Naples line; *Frecciargento* the one for other high speed services linking Rome with the other important cities and only partially using the HS network (Bolzano, Verona, Venice, Udine, Bari, Reggio Calabria); *Frecciabianca* the one for the other top-grade services not using the high speed lines, because not existing yet (mainly Turin – Milan – Venice, Genova – Rome and Milan – Bari) or because of different commercial choices.

Not yet operative, a private newcomer – NTV – is expected to offer services in open access regime since 2012 on the main line Turin – Milan – Rome – Naples.

The governance and the regulatory context of Italian railways

Italian railways apply the European directives concerning unbundling of network and services. Both the service branch *Trenitalia* and the infrastructure branch *RFI* are owned by the same public holding, Ferrovie dello Stato[2].

Looking at the network, it remains an unregulated legal monopoly, as the whole national network, including the new High Speed lines, has been directly franchised (that is, without competitive tendering) as a legal monopoly to RFI – Rete Ferroviaria Italiana, the network manager of the State-owned holding FS[3], for 60 years since 2001. Such natural monopoly is not subject to any regulatory mechanism concerning efficiency: the subsidies and the investments are ruled by a Programme Contract; tolls are decided by the Ministry of Transport, but using only the relevant information and the costs of RFI itself.

Looking at passengers services, Trenitalia remains by far the dominant operator. In 2003 Italy implemented the European Directives on rail competition (2001/12/CE, 2001/13/CE and 2001/14/CE) into the *Decreto Legislativo n. 188*

of 8 July 2003. It states that long distance passenger services ought to be opened to competition *in* the market. As a result, two newcomers (Arenaways and NTV) rose to compete with Trenitalia. The first started operating on the Milan Turin, but already closed due to normative barriers imposed. The latter is expected to start on high speed services. A regulatory body for services only has been created recently (2009) inside the Ministry of Transport, with the name of *Ufficio per la regolazione dei servizi ferroviari* (URSF).

The relative openness of the 2003 decree (in particular, the easiness to obtain the licence and the slots. Beria *et al.* 2010) is perceived as a threat by the incumbent that actually succeeded in partially blocking the competition by means of rising more restrictive entrance barriers or by the increase in the costs of the network. In particular, the 2012 Financial Law[4] requires high speed users, including the newcomers, to pay an extra train access charge to cross finance social services.

The regulation of investments

In the initial intentions of the Nineties, the new HS line 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. However in 1998 the State had already to buy back the whole shares of TAV, due to the unavailability of private shareholders to provide entitled capitals (RFI 2007). The process of re-nationalisation of TAV SpA lasted from 2000 to 2007 and ended with the coverage of 13 billion Euros of debt by the State balance (Beria and Ponti 2009). Today TAV SpA is no more operative as a project financing subject.

In the meantime, the costs of the Turin – Salerno axis rose from expected 10.7 billion € in 1992 to actual 32.0 billion € in 2006, meaning a doubling of costs in real terms (RFI 2007)[5]. Moreover the lines cost reached, on average, 32 M€/km, compared to 10 M€/km in France and 9 M€/km in Spain. This extraordinarily high costs have been analysed in a public consultation to the Parliament by RFI in 2007 (and reported by the Corte dei Conti 2009, pag. 19). They pointed out the following causes of extra-costs:

– Direct award to General Contractors (4.0-6.0 M€/km);
– Project specificities due to orography and seismic of Italian land (6.7-7.0 M€/km);
– Environmental and landscape compatibility (5.0-6.0 M€/km);
– Land use issues and urbanisation (1.5-2.0 M€/km);
– Technology innovation and newer safety rules (1.5-2.0 M€/km).

While the latter issues cannot be commented without entering into the details of the design choices, the first one – the direct awarding to General Contractor – reveals a severe governance process that could have been avoided and that makes the Italian case different to any other example in Europe.

According to the CEO of Ferrovie dello Stato, in fact, the choice to award the construction of an entire line without a competitive tendering process to select the best contractor, caused an extra-cost of 14 to 20%, quantified in 4 to 6 millions Euro per km of line. Moreover, a problem of overdesign seems to exist and also the cost of compensations rose significantly to gain the acceptance of local authorities to new lines.

Eventually, the totality of costs associated to the High Speed project up to now have been totally paid by the state budget as capital expenditure. Moreover, such effort has been done on the basis of extremely weak evaluations and without public and detailed estimations of expected demand. In the following we will try an independent assessment of the results.

Ex-post analysis of the existing Turin – Salerno line

In this section we carry out an early ex-post evaluation of the existing high speed network in Italy, one year and a half after the full start of the new services on December 2009, progressively activated since 2006. We evaluate the sections of the line through a standard and simplified cost-benefit benchmark, as suggested by de Rus and Nombela (2007) and de Rus and Nash (2007), presented in the following.

As studies on traffic elasticity suggest (for example, Litman 2010), demand usually needs at least five years in order to fully respond to reductions in travel time. So, a comprehensive and robust enough ex-post evaluation should be done only after such a time. However, the number of frequencies supplied on the lines looks now quite stable after the first years of operations and we think that it is already possible to draw some early considerations and to learn some lessons, in order to improve the planning of new lines.

A review of the (few) data available

Only a few data are nowadays available on High Speed demand in Italy. This fact is understandable from the viewpoint of the railway undertaking Trenitalia, this being a commercially sensitive information and considering that new operators are willing to enter the market in the near future. However, it seems that more transparency from the public side on the basic data and outcomes of one of the largest public works undertaken in the last decade, would benefit the public debate especially about planning new lines. To make a comparison, full data on air routes

Section	Demand relations	Reference value	Simulated value	Error	Source of reference value
Milan – Rome	direct relation only	3.00	3.00	0.0%	FS (2009)
Milan – Turin	direct relation only	1.00	1.01	-1.1%	unofficial
	all ODs	1.50	1.34	10.7%	
Rome – Naples	all ODs	2.00	2.18	-9.1%	Est. from 1.4 in 2007, Cascetta et al. (2011)
Total passengers on HSR	sold tickets	20.0	19.9	0.4%	FS (2010)

Comparison among simulated and reference values for demand on available Italian HSR sections (Table 2).

passengers and frequencies are publicly available (in ENAC 2010), despite the higher level of competition present in air sector.

The data available specifically on HS lines is of two types: the timetable and some press releases with extremely aggregate data on ridership and average load factors. Ferrovie dello Stato declared that about 20 million tickets were sold in 2010 for high speed services (FS 2010), that is all *Frecciarossa* and *Frecciargento* trains (those in Figure 2). No information about average travel distance is available. In addition, some national newspapers reported that about 3 million passengers travelled[6] the direct Milan – Rome relation in 2010 (ItaliaOggi 2010), that is not counting passengers starting or ending trips in the intermediate stops of Bologna and Florence. A recent paper (Cascetta *et al.* 2011) gives very disaggregated data about the Rome – Naples link, reporting 1.4 million passengers. Such data refers however to 2007: high speed services started on line in 2006, but the new infrastructure was not completed with final urban penetrations up to 2009, so time savings were still limited (1h27 vs. 1h10 today) and present ridership should be increased. Finally, other non official estimates report a traffic of 1.5 million passengers travelling on the Turin – Milan link, out of which 1.0 million travelling to Milan and 0.5 million continuing to other destinations southward. Further data on traffic is available on Trenitalia balance sheets, but they never refer to HS lines/services only and include the whole long distance branch.

On the basis of this very limited information we try to distribute total declared demand on the network, using a very simple gravitational model, with the typical form in Equation (1). It must be noticed that the model has no statistical significance, but more consistent simulations are impossible due to the lack of sufficient observations to calibrate the model. For this reason, the model will not be used for predictions, but only to distribute the declared total 2010 passengers. To cope with such limitedness, we will accompany the following CBA results with sensitivity analysis.

The model considers an Origin-Destination matrix of $n \times n$ zone; T_{ij} is the number of expected trips from origin zone

i to destination zone j, P_i and P_j are the populations of i and j; C_{ij} is a travel cost friction factor, while α and β are calibration parameters.

$$T_{ij} = \alpha \frac{P_i P_j}{C_{ij}^{\beta}} \qquad (1)$$

We adapt this standard definition for our purpose by:
– using total passenger traffic in stations[7] Pax_x as a proxy of "rail" populations. The number of inhabitants would be too rough, also because needs to define the catchment area of each station. The total passenger traffic in stations might represent both the dimension of the urban area (i.e. the catchment area), the dimension of rail market and the "propensity" of inhabitants to use rail;
– developing a cost friction factor with a Cobb-Douglas function proportional to high speed service travel time (in minutes) and inversely proportional to service frequency (in HS connections/day, with $\gamma<0$, excluding trains not using the lines and thus not included in the observation of total traffic).

As a consequence, the form used is the one in Equation (2).

$$T_{ij} = \alpha \frac{Pax_i Pax_j}{travel\_time_{ij}^{\beta} \cdot freq_{ij}^{\gamma}} \qquad (2)$$

We build an 8×8 matrix made of the following zones: Turin, Milan, Bologna, Florence, Rome, Naples, Verona and Venice/ Padua. Such matrix ignores trips using the services continuing northbound and southbound the main axes Turin – Naples and Venice – Naples[8]. We estimate that ignoring those services should make us lose some 1.2 million passenger in 2010[9], that we initially remove from the total during the calibration phase. Data on frequencies and time is taken from Trenitalia 2010 timetable[10].

This distribution model estimates the values in Table 2 and gives the results of Figure 3.

The map shows that the core of demand is between Bologna and Rome, where the large demand from Milan and the smaller from Verona and Venice sum up. Moreover, from

Bologna to Florence nearly all links are classified as HS and just a handful of regional connections still exist. To the contrary, Turin – Milan and Rome – Naples have a very limited demand because of competition from car, but also from regional trains. In conclusion, only the line Milan – Rome has a significant demand, while the rest is scarcely used, even when a new line exist (Turin and Naples).

A stylised Cost Benefit Analysis to assess the socio-economic effects

The demand itself is not a sufficient indicator of economic success/insuccess of an investment, being at least also the cost relevant. To assess such results also from an economic perspective we then move to a CBA perspective.

To do that, in a context of missing data, we refer to De Rus and Nombela (2007) and de Rus and Nash (2007), that proposed a simplified cost benefit methodology to make broad comparative evaluations of high speed railways. They develop a comprehensive formula to estimate first year passenger traffic to justify the investment on the basis of travel time savings and cost differences with respect to the former situation. This obviously ignores a lot of aspects related to HSR schemes, for example environmental and decongestion benefits due to mode shift. However most of the evaluations made on HSR made it clear that travel time savings are by far the most important benefit of such projects, and that it is not possible to justify HSR investments only on the basis of environmental reasons. We will comment and roughly quantify the dimension of such ignored effects later in the paper.

The authors built the Formula (3) that estimates the Q_0 first year diverted demand from conventional rail to high speed rail in order to have NPV=0. All the needed parameters are listed and briefly described in Table 3.

$$Q_0 > \frac{1}{v\Delta t(1+\alpha)}\left[\frac{r-\theta}{1-e^{-(r-\theta)T}}I + C_q + C_t\frac{r-\theta}{r}\frac{1-e^{-rT}}{1-e^{-(r-\theta)T}} - C_C(1+\alpha)\right] \quad (3)$$

In fact, as we are looking at current traffic on the network, we will estimate total traffic after the construction of the

Parameter used by the model (de Rus & Nombela 2007; de Rus & Nash 2007) (Table 3).

Parameter	Description
v	average value of travel time (VOT)
Δt	average time savings
α	proportion of generated passengers with the project with respect of Q_0
r	social discount rate
θ	annual growth of benefits and costs, which depends on Q
T	life of the project
I	economic investment costs
C_q	annual maintenance and operating cost variable with Q
C_t	annual fixed maintenance and operating cost
C_c	annual variable cost of the conventional mode

new rail link, that is high speed traffic on first year in Equation (4).

$$Q_{HS} = Q_0(1+\alpha) \quad (4)$$

We set the parameters described in Table 2 as: v = 20 €/hour-pax, α = 50%[11], r = 3.5%, θ = 3.00% and T = 40 years. We set economic investment value to be 80% of its financial cost to consider transfers and macroeconomic effects, and we consider a residual value – in the last year of analysis – of 50% of the economic investment (as suggested by the same authors of the model).

Available data confirm the fixed maintenance and operating costs (C_t) suggested by Campos and de Rus (2009) to be of the order of 30,000 € per kilometre of single track of high speed rail in Europe[12]. Finally, economic train operating costs of high speed trains are calculated by the Italian transport network manager (RFI 2005) to be 9 €/train-km for high speed trains and 10 €/train-km for conventional long distance trains. We thus estimate C_q and C_c multiplying those value for the number of new high speed trains and the one of conventional trains removed.

On the basis of this model we then estimate the needed demand to justify the investment on the basis of benefits in terms of time reduction and operating costs, in Table 4. Comparing the needed demand with the simulated current traffic and with Trenitalia load factor targets (see Figure 4) we can have a first picture of the socio-economic results of the investment, considering that other benefits (environmental, congestion and wider benefits) exist but are not changing the overall result (see afterwards).

The results of our simulation in Table 4 suggest that the achieved time and operating cost savings alone do not justify the investment in any of the considered sections, except the Milan-Bologna one in the most optimistic case. The section, together with the Bologna – Florence section, could achieve positive or marginal economic results considering the other than direct benefits, as we will discuss in a while. The balance seems instead negative for the Rome – Naples section and very negative for the Turin – Milan section. We will comment such results in the concluding section.

To complete the picture, as said, values in Table 4 have been estimated on the basis of time and operating costs savings only. It must be recognised that other significant benefits exist, even if usually minor (Nash 2009) and not capable of changing a result other than marginal:

– *mode shift* can provide a reduction in external costs[13], both in the shift from car and from airplane. Cascetta et al. (2011) evidenced that 7.8% of the HS users were diverted from car on the Rome-Naples section in 2007. To assess the value of those external costs saving it would be crucial to

Representation of estimated traffic on high speed services *"Frecciarossa"* and *"Frecciargento"* in Italy 2010. Small points represent stops of *"Frecciargento"* services outside the High Speed network, that have not been modelled as single destinations. Source: our elaboration on Wikimedia Commons map (Figure 3).

understand which part of those diverted users used to travel during peak hours, when the non internalised part of external costs is significant due to congestion (Nash 2009). Assuming the Rome – Naples as a benchmarking, the amount of demand shifted from car for all pairs (especially the longer) is however irrelevant compared to the overall highway traffic: no more than 2,000 cars/day on the most crowded section. Data on air traffic shows a decrease of 1.3 million passengers a year (i.e., 647 million passenger-km. Our elaborations on ENAC 2007 and 2010) on city pairs linked to HSR, with respect to the national trend (that showed a +5.31% increase 2007-2010). Considering 1.1 €cent/pax-km (Nash 2009) of non internalised external cost by plane, it means a benefit of 7 M€ per year, i.e. 214 M€ of total actualised[14] benefit. If we compare this indicative value with the total economic cost of the HSR of 17,700 M€, plus the external costs of high speed train operations and of the construction of the new lines, we understand that the benefit due to air pollution reduction is not significant.

– the shift of high speed trains to the new line releases *new capacity* for freight and regional trains on the existing lines. If those were close to saturation, this could be a benefit. According to the last Italian transport plan (MTN 2001), in the late

Comparison among simulated demand and estimated demand needed to justify the investment, per section (Table 4).

Section		Turin – Milan	Milan – Bologna	Bologna – Florence	Rome – Naples
Investment cost	M€	7 788	6 916	5 877	5 671
Travel time 1999		1h 35'	1h 42'	50'	1h 45'
Travel time 2011		1h 03'	1h 05'	36'	1h 10'
Δt – time saving	h	0.53	0.62	0.23	0.58
Economic investment*	M€	5 270	4 680	3 977	3 838
New HS trains introduced	trains/day	18	68	100	40
Conventional trains cut	trains/day	10	66	110	44
C_q	M€/year	7.9	43.4	27.0	26.4
C_t	M€/year	8.9	12.9	5.5	13.3
C_c	M€/year	4.9	46.8	33.0	32.2
Demand to justify the investment	Mpax/year	**14.2**	**8.9**	**19.4**	**7.9**
2010 demand (our estimation ±10%)	Mpax	1.2 - 1.5	5.9 - 7.2	9.8 – 12	2.6 - 3.2
2010 demand (Trenitalia, 2007 target)	Mpax	2.1	8.8	11.5	4.6
* Including a residual value of 50% in the last year					
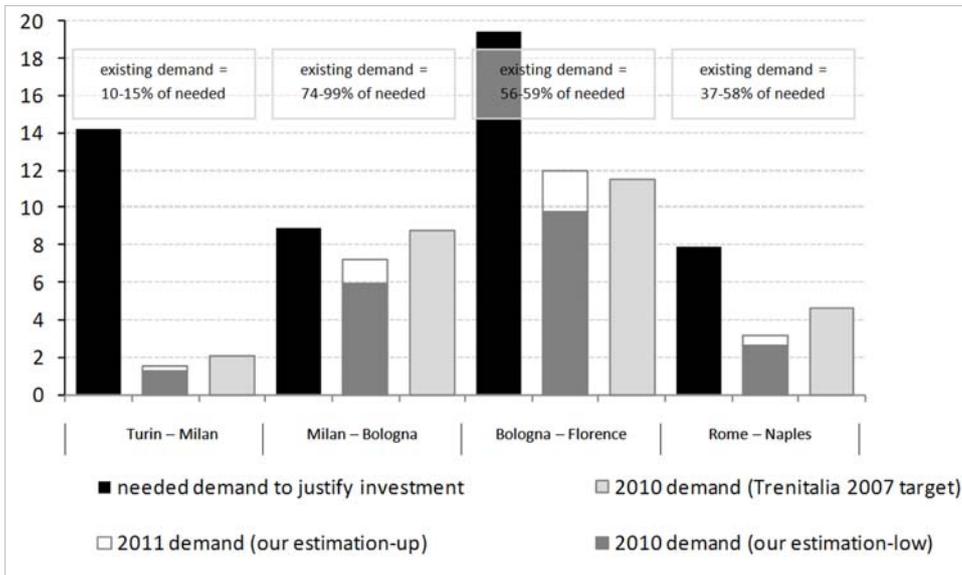
Grafical comparison among simulated demand, 2010 demand according to Trenitalia targets (Trenitalia 2007) and estimated demand needed to justify the investment, per section (Figure 4).

Finally, the used value of expected traffic growth θ of 3% per year may appear as rather optimistic. However, one must consider that in the first years of operation traffic is expected to grow at faster rates, as the comparison of the supply in 2010 and 2011 in Table 5 suggests. This may be due to some facts:

– people needs *time to change their behaviour* (Litman 2010) as a response to a reduction in travel times, in particular when it comes to change residence or workplace;

– a new open-access train operating company (*NTV*) is expected to enter the market in 2012, with a significant

Nineties the Milan – Bologna line was close to saturation between Piacenza and Bologna; also the Florence – Bologna line and the western part of the Turin – Milan (between Turin and Santhià) experienced high traffic levels. Urban nodes represented the most acute capacity problems: however new HS lines did not solve those problems and even worsen them by generating new traffic.

– *wider economic benefits* due to generated demand are usually not considered in traditional cost benefit analyses. Nash (2009) outlines that «leisure trips may benefit the destination by bringing in tourist spending, commuter and business trips reflect expansion or relocation of jobs or homes or additional economic activity». However there is still debate on whether these changes really are additional economic activity or whether it is simply relocated. Those benefits are usually significant for projects connecting depressed areas to economic centres and when the reduction in generalised travel costs is large. Typically, infrastructures generate significant wider economic effects in developing economies. European detailed calculations are rare. The estimated value of those benefits for the first section (London – West Midlands) of the planned British High Speed 2, a project costing 17,800 M€, is 4,000 M€[15] (DfT 2011). Rules of thumb suggest values of 10 to 20% of direct benefits in the best cases (Nash 2009, but also the World Bank).

increasing in the supply of services. In particular it will be interesting to observe if competition with the public incumbent *Trenitalia* will generate a reduction in average fares and more complex yield management with more low price offers. The combination of new supply and reduced fares should anyway attract new demand to HS services.

Comments on the ex-post analysis

A first comment can be spent on the demand.
The lines in operation, from Turin to Naples – Salerno, are the core of Italian long distance traffic, connecting the most important urban areas with the exception of West-East line from Turin to Venice. For this reason, one can expect that this line will be the most used even if the network will increase. Moreover, the distances involved are those suggested as the most suitable for HS trains.
However, only the central section of the line, from Milan to Rome, has a significant amount of demand. The two marginal

Comparison of high speed services supplied by Trenitalia (*"Frecciarossa"* and *"Frecciargento"*) in 2010 and 2011 (Table 5).

Section	2010 supply	2011 supply
Turin – Milan	16	22
Milan – Bologna	68	76
Bologna – Florence – Rome	100	118
Rome – Naples	40	46
Naples – Salerno	16	14
Venezia – Bologna	26	30
Verona – Bologna	6	12

Line	Line type	Estimated costs [M€]	Lenght [km]
Treviglio – Brescia – Verona – (Padua)	AV/AC	2 050 + 2 800 (+ 5 130)	196 (+75)
Brennero base tunnel (+ southern access)	AC	4 140* (+4 019)	55
Third Giovi pass	AV/AC	6 200	53
Frejus base tunnel (+ eastern access)	AV/AC	6 521* (+2 300)	50
Naples – Bari	AC	4 730	125
Venice – Trieste	AV(?)/AC	6 129	155

* Italian part only.

Main planned AV/AC projects (MIT 2010). Some projects don't have high speed (AV) characteristics and are classified as high capacity (AC). Figures in parenthesis are considered as second phases of projects (Table 6).

sections, connecting the large cities of Turin and Naples with the mainline (but also Verona, even if not at 300 km/h) have much less travelers and trains far from the line capacity.

We try to suggest possible explanations for such disappointing outcomes: the Turin-Milan relation seems to be made of significant relations among intermediate origins and destinations (e.g. Vercelli-Milan, Novara-Turin, etc.), which cannot be served by high speed trains, but would have benefited from faster inter-city services[16].

Probably, if the line would have been designed and built with lower standards (similar to those of the Florence-Rome in Table 1) the balance would have been much better, with slightly lower benefits for the direct Milan-Turin relation, but significant benefits for other origins and destinations on the line.

The Rome-Naples relation probably suffers from the fact that the two big metropolitan areas experience very high travel times to the respective central stations, so that a fast connection between city centres marginally benefits the connections among the big peripheral areas.

Concerning the socio-economic assessment, even if demand results quite good (near to the major European HS lines) and benefits are high due to important time savings, the socio-economic result is not satisfying. In all the sections, except Milan – Bologna, the demand is no more than half of the needed one to justify the public cost. The main indication, especially for the central section, is then on the cost side: if the line would have had the expected cost and not the double or more, or if costs would have been in line with European average, the whole line from Milan to Rome would have been positive.

Comparison among current and expected passenger rail traffic (in trains/day) - as forecast by the official documents (our elaboration on sources). Forecasted values for the Brennero and Frejus base tunnels refer to the complete new line. For the Frejus, the secondary souce elaborates the complex official estimations (Table 7).

Line [trains/day]	Value type	Year	HS	LD	Source
Treviglio – Brescia – Verona – (Padua)	current	2011		45	*www.trenitalia.com*
	estimates	2020	100	4	*ResPublica (2010)*
Brennero base tunnel	current	2011		11	*www.obb-italia.com*
	estimates	2035	26	20	*BBT (2002)*
Third Giovi pass	current	2011		42	*www.trenitalia.com*
	estimates	2020	74		*TRAIL Liguria (2010)*
Frejus base tunnel	current	2011		4	*www.trenitalia.com*
	estimates	2035	24	4	*Debernardi et al. (2011)*
Naples – Bari	current	2009		12	*RFI (2009)*
	estimates	2024	22	32	*RFI (2009)*
Venice – Trieste	current	2009		12	*RFI (2010)*
	estimates	2029	6	20	*RFI (2010)*

Line [trains/year]	Value type	Year	Freight	Source
Treviglio – Brescia – Verona – (Padua)	current	2005	26,865	*Eurostat (2011)*
	estimates	2020	72,600	*ResPublica (2010)*
Brennero base tunnel	current	2005	25,355	*Eurostat (2011)*
	current	2007	33,722	*BAV (2009)*
	estimates	2030	86,207	*BBT (2004)*
Third Giovi pass	current	2005	27,260	*Eurostat (2011)*
	estimates	2020	90,750	*TRAIL Liguria (2010)*
Frejus base tunnel	current	2005	16,369	*Eurostat (2011)*
	current	2007	15,551	*BAV (2009)*
	estimates	2035	88,000	*Osservatorio Torino-Lione (2007)*
Naples – Bari	current	2009	3,300	*RFI (2009)*
	estimates	2024	6,600	*RFI (2009)*
Venice – Trieste	current	2009	23,100	*RFI (2010)*
	estimates	2025	82,500	*RFI (2010)*

Comparison among current and expected freight rail traffic (in trains/Year) - as forecasted by the official documents (our elaboration on sources) (Table 8).

Ex-ante considerations on planned extensions

A long list of projects related to the High Speed/High Capacity network expansion are at stake in Italy, already depicted in Figure 1. In the following we will refer to the major projects included in the last public document released by the Italian Ministry of Transport – the *Strategic Infrastructure Program* (MIT 2010) – which can be considered the most recent planning document, even if not giving any reference to actual and forecasted demand and lacks of cost-benefit considerations.

Expected demand, cost and performance

In absence of detailed data necessary to carry a full CBA, we will present in this section a first benchmark of the costs, of the present demand and of the official estimations on expected traffic for the main projects under consideration (Table 6). Among them, the Brennero base tunnel is part of the Verona – Munich high speed line, and the Frejus base tunnel is part of the Turin – Lyon high speed line. The Treviglio – Brescia – Verona – Padova is the central part of the Milan – Venice high speed line, whose extreme parts (Milan – Treviglio and Padua – Venice) have been already built with no high speed standard (see Table 1).
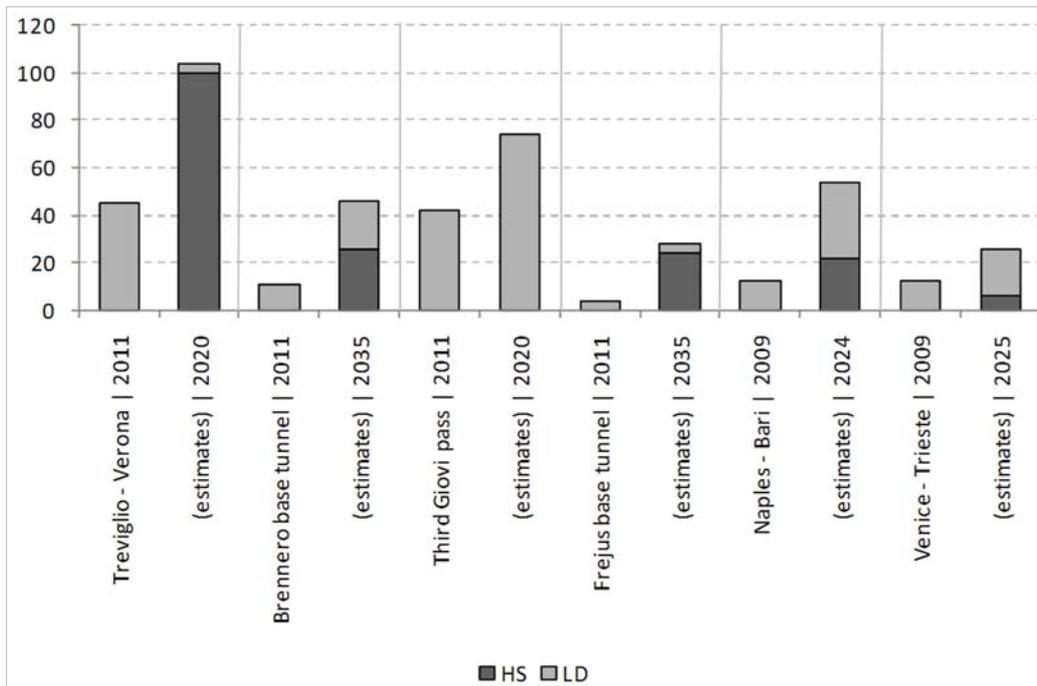Similarly to the existing lines, also the new links are supposed to be interested by both passenger and freight traffic[17]. Three of them, the Brennero, the Frejus and the Third Giovi pass, are mainly freight lines.

In Table 7 and Table 8 we report traffic values – current and forecasted – for considered projects. The same values are comparatively commented in the next paragraph (Figure 5 and Figure 6).

A comparative assessment of planned extensions

Comparing official estimations with current demand (Figure 5 for passengers and Figure 6 for freight), we can derive the following indications:
– All lines are expected to heavily increasing the present demand: often doubling for passengers and two to five times increasing for freight. These trends, if looked together and not singularly, appear very optimistic and in contrast with pre-crisis steady trends (see Trenitalia balance sheets).
– The Naples – Bari line appears comparatively weak from any point of view: few passengers, few freight and moderate time savings[18]. Since the existing line is obsolete, this means that if an investment is needed, this must not be a huge and costly HS line, but a cheaper but effective doubling and modernisation. Otherwise, the line should be ranked low due to its large cost.
– The Frejus tunnel and line is the project whose freight demand is expected to increase more (nearly five times the 2007 pre-crisis values). In our opinion this is hardly unjustifiable since the relation has continously lost traffic in the last decade[19]. According to forecasts, it is instead expected to overcome the Brenner line, which today experiences two times more traffic.

Graphical comparison among current and expected passenger rail traffic (in trains/day) - as forecasted by the official documents - on the planned new line (our elaboration on sources) (Figure 5).

capacity of 450 trains/ day and a potentiality of 700 (Gronda di Genova 2009), the double of existing demand.

Concluding remarks

Summary of results

In the paper we faced two issues: to evaluate ex-post the demand and the results of the new Italian HS lines between Turin – Milan – Rome – Naples and Verona – Bologna, and to 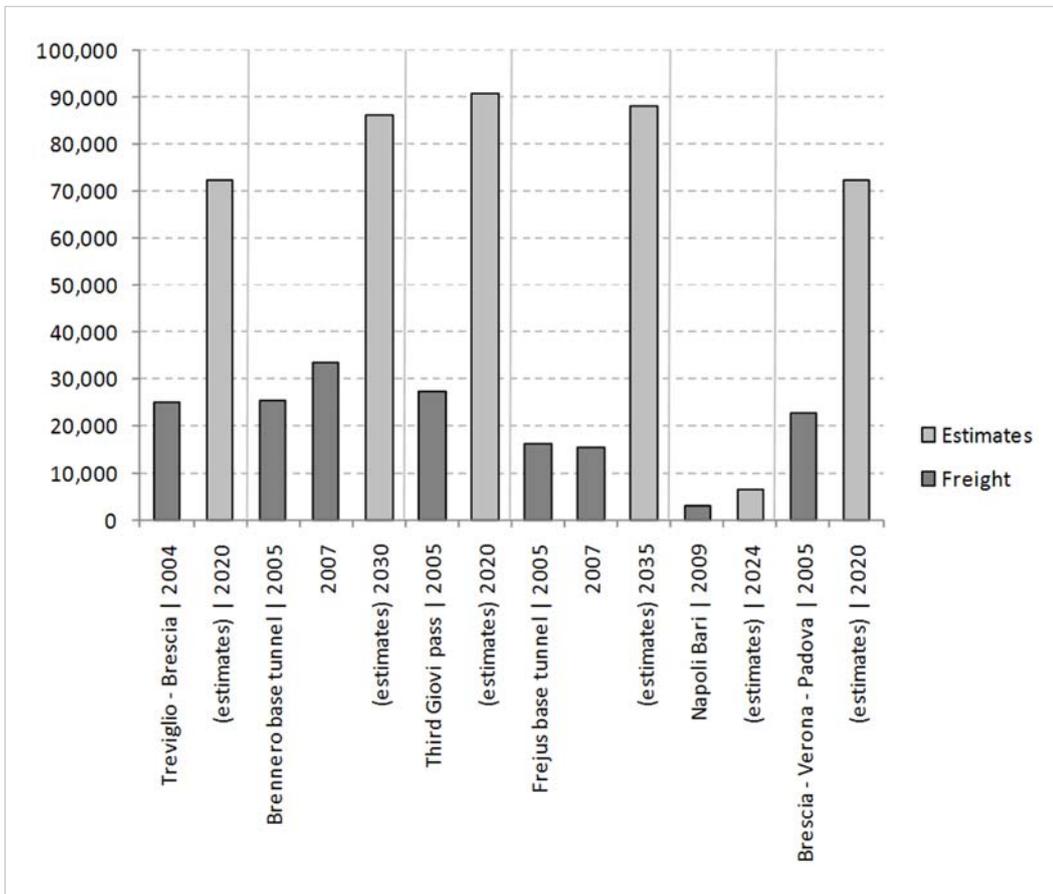provide a comparison of future extensions. For the first question, we built a simple distribution model to reconstruct the OD matrix starting from the very limited demand data available. We estimated the flows on the sections of the line and in general on the HS trains classified with the commercial name of *"Frecciarossa"* and *"Frecciargento"*. The most used sections are the central ones between Milan to Rome, with flows ranging from 6 to 12 Mpax/year in 2010. The other HS sections to Turin and Naples have much less demand, below any expectation and far below the capacity of the line, used exclusively for HS trains.

These results on demand, partially positive, partially negative, translate into a variable judgement from the socio-economic viewpoint: it is marginally positive for the Milan – Bologna line and potentially marginally positive for the expensive Bologna – Florence tunnel.

Instead, neither the environmental benefits of shift from air (approx 250M€ overall in 40 years), the possible wider economic benefits (no more than 10 to 20% more, in the most optimistic case), the reduction of congestions (very small and concentrated around urban areas only) and the expansion of capacity (that was already sufficient), can change the result of non-core sections, namely the Turin – Milan, the Rome – Naples. In all cases, the socio-economic benefits – although benefits are sometimes very high – have been dramatically reduced especially by the investment cost, that have been overwhelmingly high compared to similar European lines and substantially underestimated.

Future extensions, with the relevant exception of Milan – Venice doubling, appears to be more and more marginal

– Very high demand is expected on the Milan – Venice and this is realistic. However, the lessons learnt from the Milan – Turin line should not be forgotten: the presence of many medium sizes cities and Venice not being a big and dense metropolis[20] suggest that average trip distances should be low (100-200 km) and demand should not be concentrated but spread among many OD couples. Thus, the pure speed is probably not needed like from Milan to Rome and the investment should focus on increasing capacity, reliability and frequency of intercity trains, following the German or Swiss examples.

– The Brenner is the only project in which a saturation of the concurrent mode – the motorway – seems possible, while the others expect a future saturation of existing rail.

– The Brenner and the Frejus lines have opposite capacity problems: the first one has a capacity problem on long distance freight trains and the latter on regional trains near Turin. The two projects should take into account this, preferring a doubling of the line around Turin before the doubling of the pass line; the opposite is true for the Brenner.

– A huge freight traffic in expected on the Third Giovi pass, but one must take into consideration the capacity and the performances of the Genoa port. Moreover, the present line is actually a 5 tracks connection, characterised by strong slopes (up to 35‰) but with a

of High Speed / High Capacity, peculiar of the Italian network, did not work and determined higher costs. Those lines that are expected to host mainly freight traffic (the three mountain passes) should be designed for freight traffic only. The Milan – Venice line should be conceived as a high capacity line, with good standards, but without ignoring the fact that 250 or 300 km/h of design speed will change average travel times of just few minutes. Minor lines with no capacity problems (Naples – Bari) must be upgraded, but at the lowest possible cost, finding the best trade off between time savings and public

Graphical comparison among current and expected freight rail traffic (in trains/year) - as forecasted by the official documents - on the planned new lines (our elaboration on sources) (Figure 6).

compared to the Milan – Rome line. All forecasts appear to be extremely optimistic, foreseeing doublings of demand on all lines. Being their expected costs similar or higher than existing lines, the socio-economic result cannot be better.

Policy indications

The analysis allows us to suggest some policy indications:
– Some priorities between new lines are needed: the whole cost cannot be paid at once and the best projects must be chosen, being their forecasts already very different. The demand already gives an indication on which lines must be preferred, but an extensive and comparative CBA is needed.
– Radical cost reduction strategies must be applied. Costs are too high compared to European standards. A relevant part of such extra-cost is due to non competitive awarding for construction. A problem of overdesign seems also to exist.
– In particular, the model of High Speed lines must be overcome, since passenger demand on those lines is less and less and potential time savings are not changing behaviours substantially. Similarly, also the mixed-model

expenditure.
– An interesting strategy is that of dividing the project into functional sections and analysing them with a phasing approach: a line can be built progressively, and the characteristics of extensions can be changed according to how demand responded. In this way one can obtain the same benefits at lower and diluted cost and, more important, reducing the risk of overinvestment (see Debernardi *et al.* 2011).
– Much attention must be spent on nodes, i.e. the place of the network where true capacity problems exist and where capacity and speed improvements give the better payoff.

Notes

1 Sole 24 Ore, "Opere più frugali per coinvolgere i privati".

2 *Ferrovie dello Stato* turned his name to *Ferrovie dello Stato Italiane* in mid 2011.

3 Concession Act: Decreto Ministeriale n. 138T del 31 ottobre 2000, Ministero dei Trasporti e della Navigazione.

4 D.L. "Disposizioni urgenti per la stabilizzazione finanziaria", 12 luglio 2011, art. 21.4.

5 10.7 billion $Euro_{1994}$ is equal to 15.5 billion $Euro_{2006}$ (RFI 2007).

6 Actually the number refers to total year projections made on the basis of tickets sold up to October 2010.

7 Data are taken from station managers websites, www.grandistazioni.it and www.centostazioni.it. We sum all passengers using stations where high speed services start in each city. Turin Porta Susa station is managed directly by RFI and no data is available: we hypothesize a value of 15 million passengers.

8 Some trains continue northbound of Verona (1 train couple to Brescia, and 2 couples up to Bolzano), northbound of Venice (1 train couple up to Udine) and southbound of Naples (1 train couple to Reggio Calabria and 4 couples to Bari/Lecce).

9 With the hypothesis that average load factor on those peripheral sections is 200 passengers/train for trains to Reggio Calabria and Bari, and 150 passengers/train for trains to Brescia, Bolzano and Udine. Average High Speed load factor in 2007 was 215 (FS, 2007), but in this case the trains always continue to Rome serving also some intermediate cities.

10 See Table 5 for part of the used values.

11 This average value is confirmed by FS (2009) for the Milan - Rome relation, where a +50-60% of new demand is reported, and by Cascetta et al. (2011), where 30.8% of the 2007 high speed traffic between Rome and Naples is generated or diverted from other non rail modes (i.e. +44.5% of existing demand).

12 RFI estimates for the planned Naples – Bari line unit costs of 56,000 M€ per kilometer of double track line.

13 Reduction in greenhouse gases due to HSR introduction is quite controversial in general, even more in countries with high oil dependence for electric energy production like Italy or Britain (Nash, 2009).

14 Hypotesizing a traffic growth of 2%, a social discount rate of 3.5% and an horizon of 40 years.

15 However in Britain projects have to pass the cost-benefit test *without* considering wider benefits.

16 This is reflected also in the current supply on the relation, that is still made of 38 regional, 20 conventional long distance and only 20 high speed services (Source: Trenitalia website www.trenitalia.com, visited on September 2011. Simulated day: 12/10/2011).

17 Despite initial declarations, no freight traffic is using the existing high speed network.

18 Comparing current timetables with forecasts (RFI 2009) time savings are less than 1h in total.

19 Overall freight traffic (both on the road and on the rail) among France and Italy decreased from 51 Mtons in 2000 to 48.1 Mtons in 2007, before dropping to 38.2 Mtons in 2009. Considering only relations more strictly related to the project (namely Frejus/Moncenisio, Monte Bianco and Monginevro), values are 36.6 in 2000, 28.1 in 2007 and 20.7 in 2009 (BAV 2009).

20 Venice has 271k inhabitants and Padua 214k inhabitants.

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Image sources

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