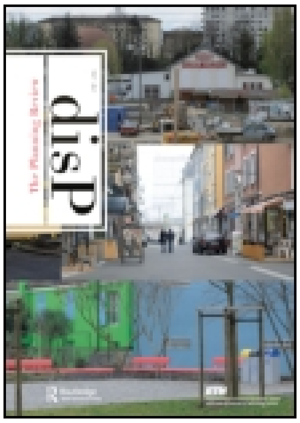

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High-Speed Rail Demand: Before-and-After Evidence from the Italian Market

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Abstract: Recent openings of new high-speed rail (HSR) lines in Italy, together with the April 2012 entrance of a new private operator in the Italian HSR market in competition with the national incumbent, have created the conditions for an investigation of long-distance travel demand. In this paper, we present some empirical evidences on the evolution of national passenger demand before and after HSR major openings, a unique case study based on source data, a retrospective survey and extensive counts on board trains, gathered between 2008 and 2011. Results show a significant increase of traffic volume by rail due to the introduction of HSR and we estimate short-term direct HSR demand elasticities with respect to travel time in the range of –1.5 and –2.1, and in the range –0.7 to –1.1 in terms of HSR modal shares. The different elasticity values confirm the presence of a strong "induced demand" effect.

1 Introduction

Many high-speed rail (HSR) projects of the early 1980s and 1990s have now been completed, while others have been developing all over the world – despite the current economic crisis. In Europe, in order to achieve the strategic objectives of social inclusion, cohesion and accessibility, the European Commission launched a program in 1998 to define standards for the development of an integrated and interoperable HSR network. Indeed, European HSR has expanded considerably in recent decades: following the LGV (*Ligne à Grande Vitesse*) between Paris and Lyon (420 km), HSR services are nowadays available in Spain (AVE), Germany (ICE), Benelux (Thalys) and Italy (TAV) for a total of about 6500 kilometers. New projects are under discussion or are in progress in Sweden, UK, Portugal, Russia and Turkey. In the Far East, five new HSR lines have joined the pioneer Tokaido-Shinkansen HSR line, launched in 1964 between Tokyo and Osaka for the Tokyo Olympic Games, for a total of 2300 km serving 353 million annual passengers. As of 2011, China has the most extensive routes in service, including more than 3500 km of rail lines operating at 300 km/h, and the network is expected to expand rapidly in the next few years.

Many economic studies in the literature (de Rus et al. 2009) have analyzed the motivation behind the introduction of HSR and have come up with the conclusion that, due to high construction costs (Campos, de Rus 2009), only high traffic volumes and/or severe rail congestion problems justify the investment to build a new HSR line. Despite the large external and wider economic benefits, the question of the economic viability of HSR projects still remains open. A review of the economic studies on HSR projects (Nash 2009) has shown the break-even volume of passengers to justify HSR lines is largely variable (from 3 to 17 million passengers per year) depending mainly on the construction costs, which vary enormously according to circumstances. Therefore, reliable HSR demand forecasts for several scenarios are essential, using a comprehensive system of validated mathematical models (Cascetta, Coppola 2012; Roman et al. 2010 among others) as well as comparisons with similar international experiences.

In this paper, we focus on direct measured effects of the earliest introduction of HSR in Italy in 2010. The results presented here represent a contribution to the literature in that most of the studies on future HSR services are based on modeling forecasts. Additional issues of interest in the Italian case study presented in this paper stem from the HSR operational model and the particularity of the HSR network configuration.

In fact, different typologies of HSR operational models can be distinguished (Campos, de Rus 2009), depending on the use (exclusive or mixed) of the HSR infrastructure. The Japanese case is an example of an exclusive HSR infrastructure with a single operator: the high-speed railway is completely separate from the rest of the railway network and the high-speed trains run only on such infrastructure. On the other side, we find the French operation model, in which the HSR trains can use both HSR and non-HSR (duly potentiated) infrastructures. From the operations perspective, there are cases with a single operator in charge of infrastructure and operations, as in Japan, where each of the six Shinkansen lines (infra-

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structure and service) is managed by a different operator, or as in Spain and France, where there is a single national operator in charge of infrastructure and service. Other cases include situations in which there is a distinct owner of the infrastructure and a different service operator, as in Germany and Italy, and in Benelux for the Thalys, whose trains run on the HSR infrastructure of different national railways (Netherlands, Belgium, France). When the new private HSR operator NTV (*Nuovo Trasporto Viaggiatori*) started operations in Italy on April 2012, it was the first case of competition among HSR operators using the same infrastructure and the same market and hence is the focus of this case study.

Moreover, while most HSR projects were conceived to connect pairs of cities in a distance range of 500–700 km (e.g. Tokyo–Osaka, Paris–Lyon, Madrid–Barcelona, among others), creating a competing modal alternative to air transport, in Italy, due to the geographic structure of the country, the HSR connects a sequence of medium and large metropolitan areas at distances in the range of 100–250 km. As a result, the Italian HSR not only competes with air transport, as has been observed in many case studies (Givoni 2006; Roman et al. 2007), it also competes with the auto. Such structural differences in the Italian national transportation market, together with the ongoing economic crisis, which has no antecedents in the globalization era, create the conditions for a unique case study to investigate the behavior of long-distance passengers and to test travel demand forecasting methodologies.

The paper is organized as follows. In section 2, the Italian HSR project is presented starting with the characteristics of the current network and its recent developments. In section 3, the empirical evidence of the evolution of inter-province travel demand in the study area (in-scope demand) are discussed in terms of overall travel demand growth, modal shares and travelers' characteristics, before and after the new HSR line operations. The latter is based on an extensive survey campaign consisting of on-board counts and a retrospective survey gathered between 2008 and 2011. In section 4, some direct elasticity values of HSR demand with respect to travel time, both in absolute terms and in modal shares, are estimated based on the observed passenger volumes and passenger-km values of the years 2009 and 2010. Finally, conclusions and current research areas are reported in section 5.

2 The Italian HSR Project

In Italy, the first HSR service was launched in 1992 between Florence and Rome with the so-called *direttissima*, which allowed trains to run at 230 km/h covering the 254 km between Rome and Florence in about two hours. The project for the *direttissima*, however, dated back to 1970. In fact, the new generation HSR (i.e. with trains running at 300 km/h maximum speed) started

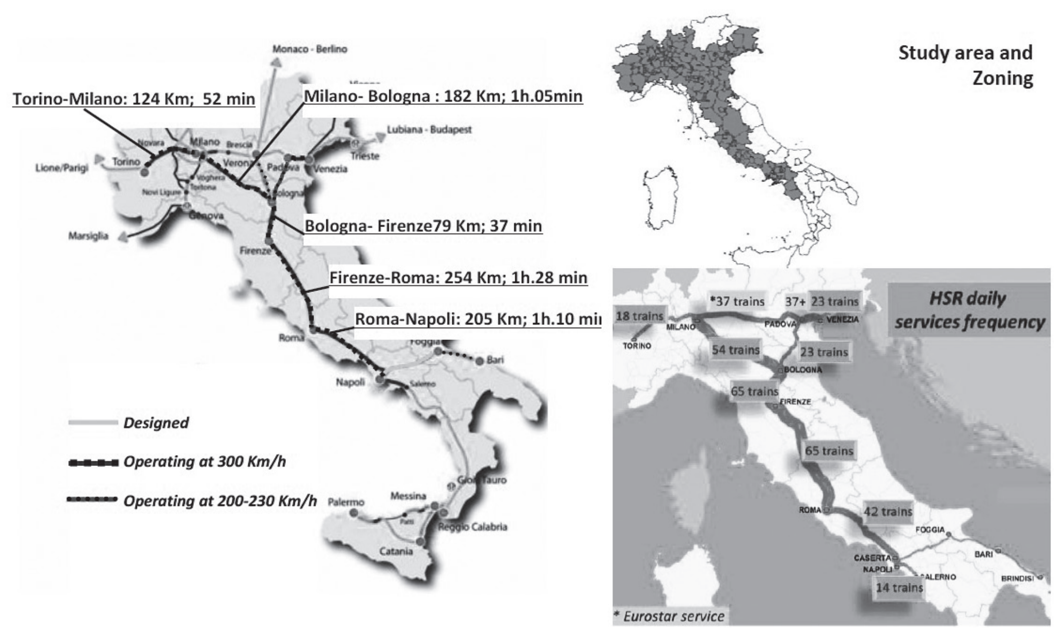


Fig. 1: The Italian high-speed rail network.

	Distance (km)	Travel times before HSR	Travel times after HSR	Decrease of travel times
Turin–Milan	125	1h 33m	54m	–42%
Milan–Rome	515	4h 30m	*3h 3h 30m	–33% –22%
Milan–Napoli	720	6h 30m	*4h 20m 4h 50m	–33% –26%
Milan–Bologna	182	1h 40m	65m	–35%
Bologna–Florence	79	59m	37m	–37%
Rome–Napoli	205	1h 45m	1h 10m	–33%

* Direct service between Milan and Rome

Tab. 1: Distances and Travel Times by Rail before and after HSR Service on Selected OD Pairs.

	# **Runs/day**	**Train-km/day**	**Seat-km/day**	**Avg. Distance/train**	**Avg. Train Capacity**
Trenitalia (2013)	135	86 706	48.1 mil.	744	555
NTV (from April-2013)	50	35 374	15.9 mil.	691	451

Tab. 2: Comparison between current service offered by NTV and Trenitalia.

in December 2005 between Rome and Napoli (205 km) and Milan and Bologna (182 km). The project took a second step in December 2009 when the Milan–Turin (125 km) and the Bologna–Florence (79 km) lines were completed, as well as the urban penetration into the cities of Rome and Napoli. Starting in 2010 the backbone of the Italian HSR network was fully operative (see Fig 1).

Today the service includes several city pairs at distances between 100–250 km, e.g. Rome–Napoli (205 km in 1 hour and 10 minutes), Milan–Turin (125 km in 54 minutes) and Rome–Milan (515 kilometers in 3.5 h) that offers direct service (i.e. no stops in Bologna and Florence) in three hours (Tab. 1). The HSR service frequency on the HSR network ranges from 1 train/h to 4–5 trains/h in the peak period on the sections between Rome, Florence and Bologna (Fig. 1).

The Italian HSR project is still under development. The travel times station-to-station, which have already been reduced, depending on the OD (origin-destination) pair, by about 20–40% (Tab. 1), are expected to be further reduced with the completion of the new underground bypass stations in Bologna and Florence that will allow speeding up the service in dense urban areas. Moreover, Trenitalia has announced the launch of a new generation HS train running at 360 km/h as of 2015, which would reduce the travel time from Rome to Milan to two and a half hours. Several extensions of the current network are in progress, such as Milan–Venice and Turin–Lyon or are being discussed (e.g. Napoli–Bari and Milan–Genoa).

When the new HSR operator Nuovo Trasporto Viaggiatori (NTV) became operative in April 2012 on the national HSR network, competing with the incumbent Trenitalia, it gave rise to the first case of competing HSRs operating on the same line (i.e. multiple operators on a single infrastructure). NTV's fleet included the Alstom AGV trains with a capacity of 460 seats per train against the Trenitalia rolling stock, i.e. the ETR 500 and the ETR 600, respectively, with 600 and 430 seats per train. In terms of runs and train-km, NTV was expected to cover about 28% of the Italian HSR market after the ramp-up period in year 2012: 35 300 train-km/day vs. 86 700 train-km/day by Trenitalia (Tab. 2).

3 *Empirical Evidence*

Since 2008, a vast campaign of surveys has been carried out to monitor the evolution of the national demand for passenger transport, compared to the modification of HSR services, in terms of total trips, modal split between auto and train services, individual trip frequency, travelers' daily routines and life-styles. The available data were gathered by means of:

a) On-board counts
b) Retrospective survey gathered on the Rome–Napoli segment in 2008

c) Mixed Revealed Preferences and Stated Preferences (RP/SP) survey carried out in May 2009 and October 2010

The on-board counts were gathered on HS trains in the study area (see Fig. 1). Passengers on board between each stop were counted on weekdays, Saturdays and Sundays in May and October, for three subsequent years (i.e. 2009, 2010, and 2011). On weekdays, the sample size was between 30% and 40% of the universe of HS trains, depending on the OD pair, and between 15% and 30% on Saturdays and Sundays.

The retrospective (before-and-after) survey was carried out in March 2008 on the multimodal connection Rome–Napoli and vice versa. The reference universe was made up of all the users who travelled with HS trains, but also with alternative rail services and modes: Eurostar trains, Intercity trains and trips by car on the highways (air demand is negligible on such OD pairs). Such universes were assumed to be different for weekdays compared to Saturday and Sunday, therefore, three different demand sampling schemes were considered.

Four different questionnaires were submitted to car users, IC train users, ES train users and HS train users. They all have questions concerning the common socioeconomic characteristics of the users, such as the existence of possible time constraints for the trip undertaken. The questionnaire submitted to HS train users differs from the others, as it included some questions concerning whether any increase in trip frequency and/or possible changes in travel choices arose after the introduction of the new HSR service. Furthermore, the exact locations of the trip's origin and destination were asked in order to compute access/egress times and costs exactly.

Finally, two RP-SP surveys were carried out in May 2009 and October 2010. The sample of travelers was obtained through stratified random sampling, with 36 strata defined by: two travel purposes (business and non-business), three distance classes (<100 km; between 100 and 400 km, >400 km), three main modes (auto, air, rail), two city types as origin zone, i.e. city with or without a HSR station.

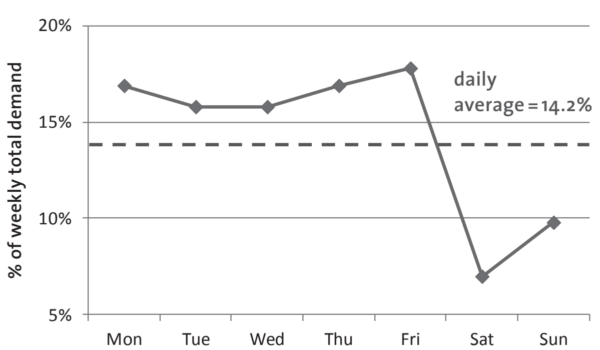
The RP part of the interview (i.e. the recruiting questionnaire) concerned some socio-economic aspects of the traveler and the information related to the last ex-province trips carried out in the previous three months (if any), such as: the trip's purpose, origin, destination, departure time, arrival time and the modes and the services used to arrive at destination, the departure and arrival time of the chosen service trip as well as the desired departure or arrival time at destination, as previously described. The sample from the panel was enriched by observations gathered at the HSR stations and the airports in the study area. The SP part of the survey, consisted of six scenarios conceived to test:

- Fare levels
- Level-of-Service (L.o.S.) attributes (travel time + access/egress)
- HSR operator (i.e. brand effect)
- Run departure time (only in the survey of October 2010)

In addition OD matrices were acquired on highways and between airports to evaluate the effects on the HSR competing modes.

3.1 *Travel Demand by Mode*

The counts were used to update the existing outdated OD matrices of Eurostar and Intercity trips and to estimate the total inter-province OD flows on HSR as well as the share of weekday trips, using the available distributions of the trips over weekdays and months (Fig. 2).



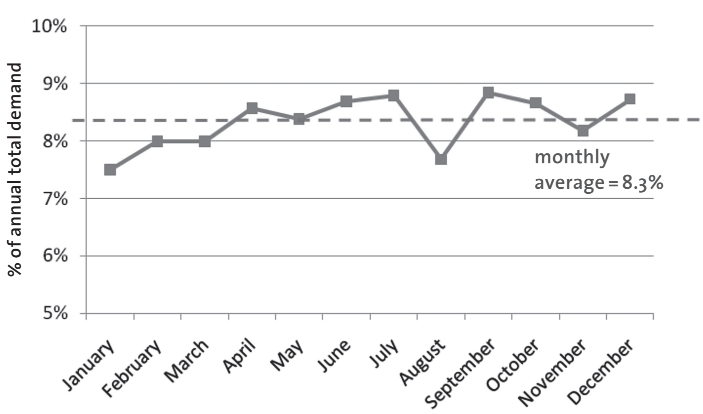


Fig. 2: Distribution of weekly HSR demand (left) and distribution of monthly HSR demand (right).

	2009	2010	delta % (2010–09)	2011	delta % (2011–10)	delta % (2011–09)
Total demand	6767	9067	34.0%	9413	3.8%	39.1%
Weekday demand	5028	6433	27.9%	6931	7.7%	37.8%

Tab. 3: HSR Demand Growth (in millions of passenger-km/year) in the Study Area.

	2009	2010	delta % (2010–09)	2011	delta % (2011–10)	delta % (2011–09)
Traffic within HSR catchment area	3356	3367	0.3%	3427	1.8%	2.1%
Total domestic air demand	16742	18240	8.9%	19645	7.7%	17.3%

Tab. 4: Domestic Air Demand (in millions of passenger-km/year).

	2009	2010	delta % (2010–09)	2011	delta % (2011–10)	delta % (2011–09)
HSR in-scope demand	867	847	–2.3%	841	–0.7%	–3.0%
Total national highways demand	64555	64498	–0.1%	63605	–1.4%	–1.5%

Tab. 5: Changes in Demand (in millions of vehicles-km/year) on the Highways.

It can be observed (Tab. 3) that the HSR demand level in 2011 is about 9.4 billion passenger-km. Our estimates show an outstanding increase of HSR demand (+34.0%) in the short-term in 2010 due to the completion of the HSR network between Salerno, Milan and Turin (see section 2) and an additional tail of +3.8% in 2011. The increase during weekdays is slightly lower, though significant: +27.9% in 2010 and +7.7% in 2011.

Using the source data available on domestic air transport (ENAC 2009, 2010), an analysis of domestic air travel demand was carried out. It can be observed (Tab. 4) that the changes are significantly different if we compare passenger-km relative to trips between the zones served by the new HSR service (our study area) and the total domestic air demand. Between 2010 and 2009, while total passenger-km increased by +8.9%, passenger-km relative to the trips within the study area remain almost invariant (+0.3%). Such a spread difference is still significantly different between 2011 and 2010: +7.7% considering total air passenger-km against +1.8% for passenger-km, if we consider only the trips between airports within the study area.

Using the source data available on highway traffic (AISCAT 2009, 2010), an analysis of the changes in long-distance trips by auto was carried out. A substantial difference was observed (Tab. 5) between the vehicle-km, in the catchment area, related to the OD pairs where auto is competitive with the HSR (e.g. OD at distances greater than 100 km), and those related to the entire national highways network: –3.0% vs. –1.5% between 2009 and 2011.

The above analysis shows that the demand for auto and air modes between the OD pairs not served by the new HSR services (reference sample) have varied at a significantly different rate with respect to the demand between OD pairs within the HSR catchment area. In other words, the introduction of the new HSR services had a direct impact on the modal split of long-distance travel demand. Moreover, it can be observed that the outstanding increase of HSR trips is mainly concentrated in the first year of operations (2010), but it is still significant in 2011 due to the time-lag effect, which must be taken into consideration when doing economic analysis.

Focusing on the trips between the main cities connected by the new HSR lines (Napoli, Rome, Florence, Bologna, Milan and Turin)[1], it can be observed (Tab. 6), both in terms of passengers and passenger-km per year, that there was a substantial reduction in the share of trips in autos (passengers went from 45% to 37%, passenger-km from 31% to 25%) and an increase in the HSR modal share (passengers increased from 37% to 49%; passenger-km from 42% to 54%); air transport basically maintained its market shares; Intercity rail showed a decrease from 9% to 6%.

	No. of passengers/year (in millions)				Passenger-km /year (in millions)			
	2009		2010		2009		2010	
Auto	8.0	45%	8.0	37%	1 800.7	31%	1 799.1	25%
Air	1.4	8%	1.7	8%	980.0	17%	1 072.0	15%
Intercity	1.6	9%	1.4	6%	523.8	9%	442.5	6%
HSR	6.6	37%	10.9	49%	2 434.3	42%	3 901.0	54%
Total	17.6	100%	22.0	100%	5 738.9	100%	7 214.6	100%

Tab. 6: Modal Split between the Main Cities Served by HSR during 2009 and 2010.

Contrary to other studies that describe "high-speed trains as a substitute to aircrafts" (quoted in Givoni 2006), the reduction of modal shares reported here, i.e. higher by car than by air, can be explained by the network configuration of the Italian HSR network, which, due to the topography of the country, mainly connects populations and activities at distances between 100–250 km where air demand is negligible and induced demand effects are higher (see section 3.2).

3.2 Induced Demand

The demand generated by HSR can be split, in principle, into three components (Tab. 7):
• Diverted demand, which derives from the travelers' mode choice diversion toward HSR either from other modes (e.g. auto, air) or other rail services (e.g. Intercity)
• Economy-based demand growth, which is linked to the trends of national and international economic systems, under the assumption that the wealthier people are, the more they travel
• Induced demand that depends
– "directly" on generalized travel costs changes in travel choices such as trip frequency, destination or activity pattern in the mid- to short term, e.g. trips become more frequent because traveling with HSR is faster, cheaper and/or more comfortable
– "indirectly" on modifications of the travelers' mobility or lifestyle choices in the long term, e.g. travelers start commuting or make more frequent trips due to a relocation of the residence or the workplace. This can also be partly due to changes in land use, e.g. new residents, jobs and activities or interconnected thanks to HSR.

To investigate the phenomenon of induced demand by new HSR services in more depth, a retrospective survey was conducted in 2008 on the Rome–Napoli HSR segment (Cascetta et al. 2011). First, Eurostar reduced travel time from 1 hour and 45 minutes (with one-way 1st and 2nd class fares of 22 and 31 euro) before the opening of HSR, to 1 hour and 25 minutes (with one-way 1st and 2nd class fares of 33 and 43 euro) after the opening of the entire line (except urban penetration in Rome and Napoli) in December 2005. Second, in 2010 it was further reduced to 1 hour and 10 minutes (–18%) (with one-way 1st and 2nd class fares of 45 and 57 euro) after the completion of the urban penetrations in Rome and Napoli. Against these changes in the level of service, the modal share of HSR demand constantly increased from 2005 to 2010 despite the decline in total demand (all modes) observed in the years 2008 and 2009, due to the financial "sub-prime" crisis in 2009 (Tab. 8).

The retrospective survey, carried out in 2008 among travelers using different rail services (i.e. HSR, Eurostar and Intercity) and drivers on the highway between Napoli and Rome, after one

DIVERTED DEMAND	From other modes	*e.g. shift from air/auto to HSR*	*Endogenous factors*
	From other rail services	*e.g. shift from Intercity to HSR*	
INDUCED DEMAND	Direct	*e.g. changes of trip frequency, destination or related activity pattern*	
	Indirect	*e.g. increase of mobility due to change in life-styles and land use*	*Exogenous factors*
(ECONOMY-BASED) DEMAND GROWTH		*e.g. increase of overall mobility due to economic growth*	

Tab. 7: Taxonomy of the Impact on HSR Demand.

year of operations of HS trains, allowed an estimation of the components of the generated demand. Considering the average working day, it has been estimated that 53.7% of HSR travelers who did not change trip frequency and mode/service (i.e. travelers who travelled Eurostar, now moved to HSR), the remaining 46.3% consisting of: travelers (12.5%) who had not made any trips before; travelers (15.4%) who increased their trip frequency; travelers (6.9%) who diverted from other modes; and travelers (11.5%) who diverted from other services, mainly from Intercity trains (Tab. 9).

Furthermore, it has been observed that most of the trips generated on HSR were due to business trips (percentages ranging from 38.7% on Sundays to 57.4% on weekdays), while education-related trips (percentages ranging from 3.4% on Sundays to 6.2% on weekdays) and "other purpose" trips (percentages ranging from 52.5% on Sundays to 30.2% on weekdays) showed lower but still very significant rates. Moreover, a percentage of HSR induced demand was related to commuting (percentage ranging around 6%) corresponding to people that changed residence in the first year of operations (mainly from Rome to Napoli) and started to commute every day (Tab. 10).

4 *Elasticity Values*

The changes observed in long-distance domestic travel demand in Italy allows us to extract some aggregate (arc) elasticity (Cascetta 2009). The type of elasticity we are interested in is the direct "short-term" (i.e., computed after one year of HSR operations) elasticity of HSR demand with respect to HSR travel time. This was computed either in terms of total HSR demand generated volumes or in terms of HSR modal share variations. In the first case, we estimated the elasticity of the overall HSR demand volumes (including all three components reported in Tab. 7). Such elasticity values were calculated by dividing the observed percentage variations

Tab. 8: Modal Split Evolution between 2005 and 2010 on the Rome–Napoli Line (average daily city-to-city flow estimates).

Travel means	**2005**		**2007**		**2008**		**2009**		**2010**	
Auto	10.933	*61.5%*	10.855	*56.3%*	8.237	*52.8%*	6.472	*49.7%*	6.719	*41.5%*
HSR/Eurostar	3.741	*21.0%*	5.181	*26.9%*	4.828	*30.9%*	4.384	*33.7%*	7.185	*44.4%*
Intercity	3.108	*17.5%*	3.241	*16.8%*	2.549	*16.3%*	2.161	*16.6%*	2.287	*14.1%*
	17.783	100.0%	19.277	100.0%	15.614	100.0%	13.018	100.0%	16.192	100.0%

	Weekday	**Saturday**	**Sunday**
Passengers not having changed frequency and mode	53.7%	40.1%	42.1%
Passengers having changed frequency and/or mode	46.3%	59.8%	57.9%
New demand	*12.5%*	*13.6%*	*8.8%*
Increasing frequency	*15.4%*	*12.7%*	*1.6%*
Diversion to HSR from other modes	*6.9%*	*11.6%*	*14.0%*
Diversion to HSR from other rail services	*11.5%*	*21.9%*	*19.5%*

Tab. 9: HSR Demand Segmentation on the Rome–Napoli Line (2008).

Purpose of trip	**Weekday**	**Saturday**	**Sunday**
Business	57.4%	68.5%	38.7%
Commuting (i.e. residential re-location)	6.2%	0.0%	5.4%
Education-related purposes	6.2%	8.7%	3.4%
Other purposes	30.2%	22.8%	52.5%
	100.0%	100.0%	100.0%

Tab. 10: Segmentation of HSR Demand on the Rome–Napoli Route by Trip Purpose (2008).

between 2010 and 2009 of the demand, d^{HSR}, differentiated by OD, by the relative changes in HSR travel time, *tt*:

$$e_{tt}^{OD,HSR} = \frac{\dfrac{d_{2010}^{OD,HSR} - d_{2009}^{OD,HSR}}{d_{2009}^{OD,HSR}}}{\dfrac{tt_{2010}^{OD,HSR} - tt_{2009}^{OD,HSR}}{tt_{2009}^{OD,HSR}}}$$

In the computation of the elasticities, we have considered an average reduction of travel time for each OD pair, weighted on the frequency of the Rome–Milan direct HSR service and those calling at Bologna and Florence.

On average, if we consider the overall increase of demand volume from 2009 to 2010 (i.e. including the demand growth, induced and diverted components) between the main cities connected by HSR (see Tab. 6), we estimate an increase of HSR passengers from 6.6 million to 10.9 million (+65%) and of HSR passenger-km from 2.4 billion to 3.9 billion (+63%). Such percentages give rise to an overall elasticity value ranging from –1.6 to –2.1 in terms of passengers and from –1.5 to –2.0 in terms of passenger-km (Tab. 11).

Looking more in depth at single OD pairs, we observed that the variations of HSR demand vary significantly with the OD distance: for example, between Florence and Bologna (79 km) after the introduction of HSR services (which reduced travel time by 37%), there was a 91% increase in demand corresponding to an elasticity of –2.5. Between Milan and Napoli (720 km) after the introduction of the HSR services (which, on average, reduced travel time by 28%), there was a 41% increase in demand corresponding to an elasticity of –1.46. This suggests that the induced demand effect is higher for short distances.

We also estimated the elasticities in HSR modal share with respect to HSR travel time. Such elasticity values were calculated by dividing the observed percentage variations between 2010 and 2009 of the HSR modal share, $\%^{HSR}$, differentiated by OD, by the relative changes in HSR travel time, *tt*:

$$e_{tt}^{OD,HSR} = \frac{\dfrac{\%_{2010}^{OD,HSR} - \%_{2009}^{OD,HSR}}{\%_{2009}^{OD,HSR}}}{\dfrac{tt_{2010}^{OD,HSR} - tt_{2009}^{OD,HSR}}{tt_{2009}^{OD,HSR}}}$$

The percentage variation of HSR modal shares of passengers (+32%) and passenger-km (+29%) (Tab. 6), compared to the reductions in HSR travel times, ranging from 20%–40% (see Tab. 1), allow us to estimate an HSR modal share elasticity with respect to travel time, ranging from –0.81 to –1.1 in terms of passengers and from –0.71 to –1.0 in terms of passenger-km (Tab. 11).

Tab. 11: Observed HSR Demand Direct Elasticities with Respect to Travel Times.

	HSR Modal Shares	HSR Total Volumes
Passengers	–1.1 ÷ –0.81	–2.2 ÷ –1.6
Passenger-km	–1.0 ÷ –0.71	–2.0 ÷ –1.5

The elasticities reported here are very substantial; they are comparable with the elasticities reported in the literature for studies of the type presented here (Yao, Morikawa 2005; Park, Ha 2006; Roman et al. 2007).

It must be noted that such values are calculated under the assumption that all the other parameters are constant. Although the overall comfort of the HSR service is more or less unchanged (i.e. the HSR rolling stock between 2010 and 2009 remained the same), the same is not completely true for prices and frequency: the first have risen and the second have been improved; moreover such variations differ from segment to segment. This would mean that the above calculation, limited to travel time, hides the effect of these two important parameters and could in principle be biased. However, the increases of frequency due to the completion of the Bologna–Florence segment and the urban penetration of Naples and Rome (see section 2) were not substantial for most of the OD trips in the study area since the new HSR service mainly replaced the already existing Eurostar services (operated with the same rolling stock). The same cannot be said for the travel costs, which actually increased on average by 15–25% between 2009 and 2010, depending on the OD pair. The fact of not having considered the increasing costs, leads us to consider that the calculated travel time elasticities may be underestimated, but should be referred to as lower bound estimates.

5 Conclusions and Current Research Areas

The empirical evidence from the Italian HSR market presented in this paper show an outstanding increase of passenger-km between 2009 and 2011 (about 40%) on the Italian HSR network. This is partly due to increased HSR modal share and partly due to the additional demand induced by HSR.

Compared to the variation of travel time (ranging from 20% to 40% depending on the OD), direct elasticity values of HSR demand with respect to travel time significantly greater than 1 (in absolute value) were observed. Such values are very substantial, but are also comparable to those reported in the literature. Moreover, an inverse relationship of the elasticity values has been observed with the distance parameter, i.e. the lower the OD distance, the higher the elasticities of HSR demand, suggesting non-linear effects of induced demand which need to be verified more in depth and possibly quantified.

On the other hand, the RP-SP survey carried out within the project have allowed us to develop a modeling framework of the national passenger demand, presenting a nesting structure to capture higher degrees of substitutions among specific subsets of modal alternatives, particularly the HSR alternatives provided on the same route by different operators, i.e., NTV vs. Trenitalia (for more details see Cascetta, Coppola 2012).

Further investigations will focus on the impact of the increasing HSR market due to the new operator (NTV) in terms of fares, passenger volume and induced demand.

Notes

1 We have only considered city-to-city trips, excluding trips generated from the zones of the catchment area outside the city.

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