HIGH SPEED RAIL DEMAND FORECASTING

IN A COMPETITIVE MARKET:

THE ITALIAN CASE STUDY

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Abstract

Recent High Speed Rail (HSR) investments in Italy, together with the entrance in the HSR market of a new private operator, competing with the national railways operator, create the conditions in the Italian national transportation market, for a unique case study to investigate the behavior of long-distance passengers. In this paper we present the framework that we developed to forecast the national passenger demand for different Italian macroeconomic, transport supply, and HSR marketing scenarios.

1 BACKGROUND

Major investments in High Speed Rail (HSR) have been carried out in Italy resulting in a current network approximately 900 Km's long. In one year, the backbone of the Italian HSR network connecting Milan to Naples/Salerno (i.e. the North-South corridor) and Turin-Milan (i.e. the North-west corridor) will be completed.

The HSR service, started in 2005 between Rome and Naples, now includes several city pairs (Fig. 1), e.g. Rome-Naples (204 Km in 1h and 10 minutes), Florence-Rome (254 Km in 1h and 28 min.), Milan-Turin (124 Km in 52 min.) and Rome-Milan with a direct service covering 720 Km's in 3 hours. These travel times are expected to be further reduced with the completion of the new stations in Naples, Florence, Turin and Rome that will allow direct service avoiding central stations in dense urban area.

Fig. 1: the Italian High Speed Rail network

(Source: www.trenitalia.it)

Moreover, starting in 2012, the new private HSR operator "Nuovo Trasporto Viaggiatori"(NTV) will be competing with the national railways operator Trenitalia. NTV's HSR service will start in

September 2011 under the name of "Italo" (www.ntvspa.it), with a fleet consisting of 25 Alstom AGV trains (i.e. the train currently holding the high speed train record) including on-board amenties.

2 METHODOLOGY

The above structural changes in the Italian national transportation market, together with the ongoing economic crisis with 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.

To forecast the Origin-Destination (OD) passenger volumes by HSR services, a methodology with the following three integrated demand models has been developed (Fig. 2):

Fig. 2: HSR demand forecasting methodology
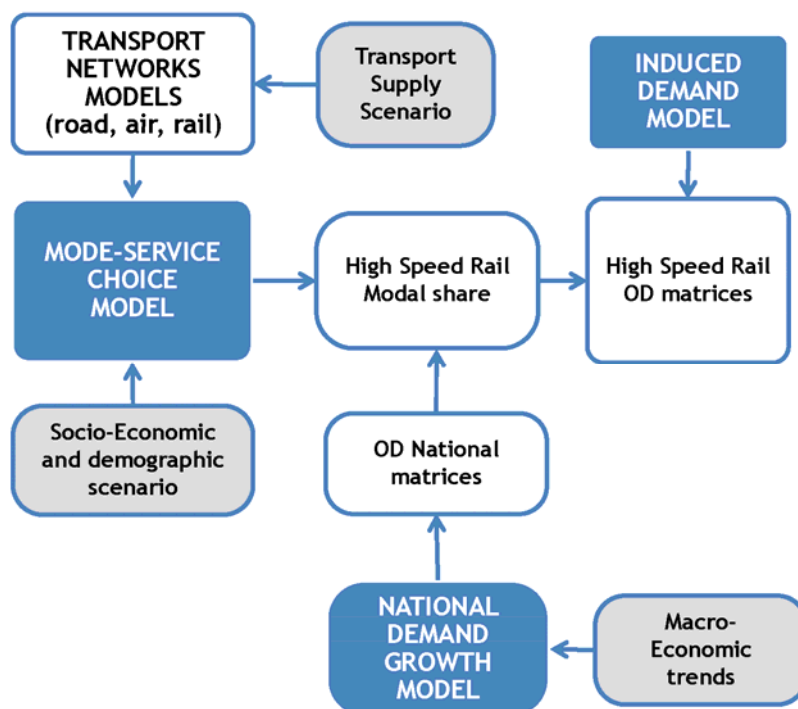
- The "National demand growth" model projects the base year total OD volumes to future years, according to assumed macroeconomics trends;

- The "mode/service choice" model estimates the market share of different inter-urban transportation modes, including alternative rail services, such as Intercity, High-Speed, 1st

and 2nd class; in other terms, this model aims at simulating the competition between modes on a given OD pair and the completion among different HSR services operated by Trenitalia and NTV on the same rail track (i.e. competition within HSR mode);

- The "induced demand" model which estimates the additional HSR demand due to the improvement of HSR level of services (i.e. new services, travel time reductions, etc.).

The model was applied with a zoning system consisting of 220 zones (Fig. 3). It includes all the Italian regions with the exception of the islands of Sicily and Sardinia. The regions of Abbruzzo, Molise and Marche (on the Adriatic Sea) and the regions of Trentino-Alto Adige and Valle d'Aosta (in the North) are each represented by one zone. All the other Italian provinces have been split into two zones: one zone for the main city of the province and one zone for the rest of the province.

Fig. 3: the adopted zoning system of Italy

Moreover, the main Italian cities have been further divided into several zones: Rome into 13 zones (Fig. 4); Naples into 8 zones; Turin into 6 and Milan into 10 zones.

In addition, a system of transportation network and service supply models has been developed to estimate the OD level of service by road, air, and rail. The supply models includes:

- a road network consisting of a graph with 1900 nodes and 7000 links representing 35000 Km;

- a rail network consisting of a graph with 2600 nodes and 5500 links representing 14500 Km (60% with single track, 40% with double track);

In the existing transport scenario, the simulated services includes 500 daily domestic flights between major Italian airports plus the following railway services:

- o 111 High-Speed and Eurostar trains;

- o 232 intercity trains;

- o 4.466 interregional and regional trains.

**Fig. 4: the adopted zoning system of the province of Rome.**
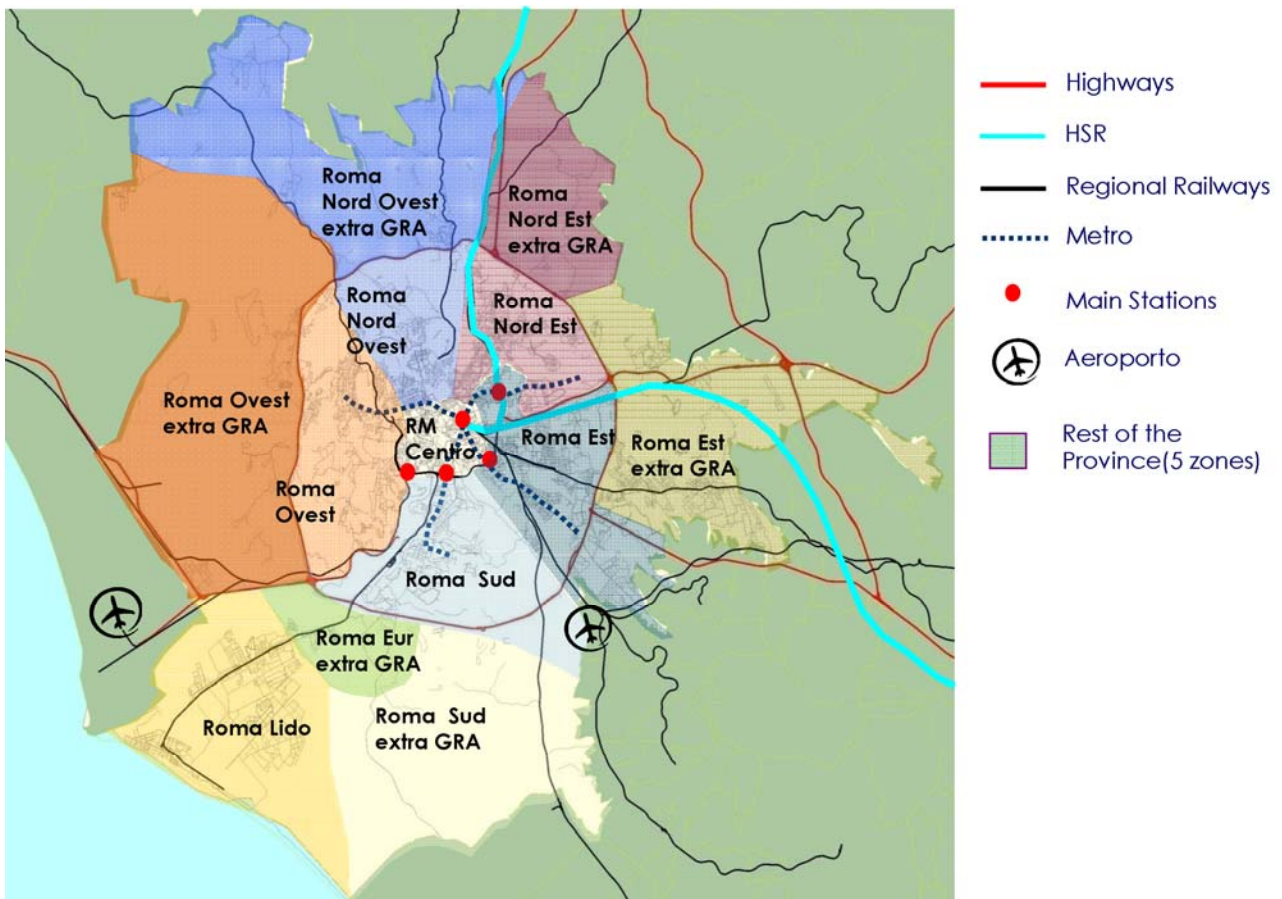
2.1 The demand growth model

In order to estimate the travel demand evolution (all modes) a growth model is used. This model forecasts, using a linear regression model, the evolution of traffic between two years based on the Gross Domestic Product (GDP) and the oil price evolution between two successive years.

The model was calibrated using time series (1970-2007) data of GDP, expressed in constant 2000 Euro, provided by ISTAT, Italian Institute of Statistics, and the yearly Average Oil price, also expressed in 2000 Euro , and provided by Italian Ministry of Economic Development. We estimated the model using both the full time series (38 observations) and the reduced set for 1980-2007 (28 observations), the latter giving more significant estimates.

The model is used to derive elasticity's of demand with respect to GDP growth for periods of increasing economy and for periods of recession. Different assumptions have been made to identify the threshold between those periods. Starting from 0% (the threshold which typically identifies periods of economic recession), we have found out that a 1% threshold is the most appropriate value in reproducing the traffic estimates and in terms of goodness of fit. In facts, the multiplier of the GDP evolution has two values: a low value "alpha1" if the growth is below 1% and a high value "alpha2" otherwise (GDP growth greater than 1%). The R_squared of the regression is 0,56. The fit to the historical data is depicted in the figure 5.

Fig. 5: Observed vs. (backcasting) estimated travel demand growth in Italy.
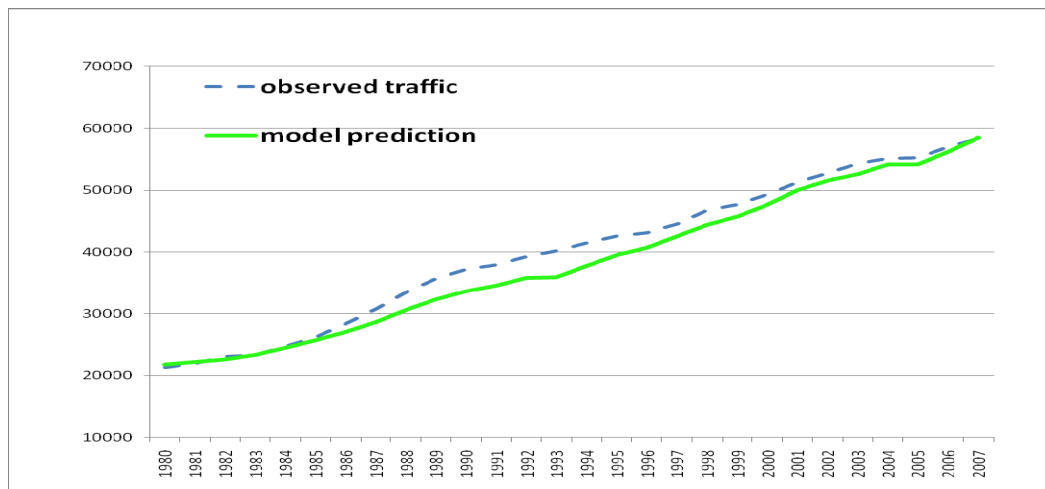
By applying the model to years 2008 and 2009 using the GDP delta% values of -0,9% and -4,7%, the model predicts a reduction of travel demand of -0,5% for year 2008 and of -2,7% for 2009. These values are comparable to those observed: -0,5% (AISCAT, 2008); -2,4% (AISCAT, 2009) and -2,3% (ENAC, 2010). Moreover, the resulted elasticity's on GDP and oil price is consistent with those used in Spain and France (Cabanne, 2003).

2.2 The mode-service choice model

The mode-service choice model is a set of nested logit models (see Ben-Akiva and Lerman, 1985; and Cascetta, 2009) with 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, NTV vs. HighSpeed Trenitalia (AVTR).

Travelers are assumed to have the following 8 alternatives:

1) Auto

2) Air

3) High Speed Trenitalia 1st class (AVTR1)

4) High Speed Trenitalia 2nd class (AVTR2)

5) Intercity Trenitalia 1st class (ESIC1)

6) Intercity Trenitalia 2nd class (ESIC2)

7) High Speed NTV 1st class (NTV1)

8) High Speed NTV 2nd class (NTV2)

The model leads to a hierarchy in mode-services choices which is based on 4 levels (Fig. 6):

- at the first level, it is supposed that the travelers chose the transportation mode (air, car, rail), based on the quality of the offer, on his own profile and on the specificities of the mode.

- at the second level is, a traveler who selected rail as a mode, chooses between High Speed Rail services (HSR) or Intercity (IC), based on the same criteria as level 1.

- at the third level: a traveler who selected High Speed Rail, select between the operators, NTV vs. Trenitalia (AVTR); a traveler who selected Intercity, select between first and second class;

- at the fourth level, a traveler who selected High Speed select between first and second class.

The models were estimated for two trip purposes (i.e. "Business" and "Non-Business") using Maximum Likelihood method. The estimation was based on disaggregate data gathered in a RP-SP survey carried out during April-May 2009.

Fig. 6: nesting structure of the mode-service choice model.
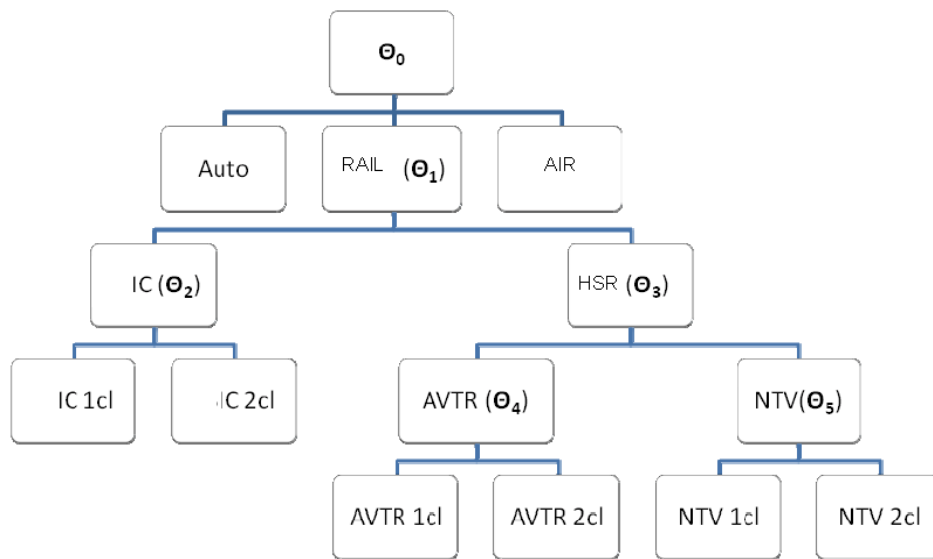
The following attributes of the systematic utility of the alternatives resulted to be statistically significant:

- Level of service attributes:

    o Travel time

    o Travel cost, by 4 categories of travelers (travel alone vs. party, reimbursed vs. not reimbursed)

    o Access/egress time, for Air and Rail

    o Service frequency, for Air and Rail

- Socio-economic attributes:

    o Professional condition (high vs. low)

    o Degree (yes vs. no)

    o Travel frequency

2.3 The induced demand model

The induced demand model is based on a relationship between existing HSR demand (dependent variable) to existing HSR travel times and costs. The covariates include socioeconomic variables related to population and employment in the zones connected by the HSR services. This model was

calibrated by mean of a before and after study carried on travel in the Naples-Rome corridor, when the new HSR services was introduced.

APPLICATION

The application of the models system to hypothetical transportation scenarios has shown the following elasticity's:

- (Direct) elasticity of HSR demand to <u>HSR travel cost</u> between -0,41 and -0,49 for 1st class travelers and between – 0,34 nad -0,38 for 2nd class travelers;

- (Cross) elasticity of HSR demand to <u>travel cost by car</u> equal to +0,14;

- (Cross) elasticity of HSR demand to HSR <u>travel time by car</u> between +0,55and +0,51 for 1st class travelers and between +0,45 and +0,48 for 2nd class travelers;

- (Cross) elasticity of HSR demand to <u>AIR processing time</u> at the airport (check-in, security pass, …) equal to +0,03;

The model will be applied to predict the impacts on national passenger volumes, of the new HSR services and operators as of 2012. Different scenarios will be tested for different macroeconomic assumptions and marketing strategies of the main passenger transportation competitors on the long distance (i.e. NTV vs. Trenitalia and HSR operators vs. airlines).

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