42nd ERSA CONGRESS

August 27th-31st, 2002 - Dortmund

HIGH SPEED/HIGH CAPACITY RAILWAY AND REGIONAL DEVELOPMENT: EVALUATION OF EFFECTS ON SPATIAL ACCESSIBILITY

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In the last decade the theme of high speed infrastructure in Italy has been deeply debated, with different political and technical opinions, which have expanded the time for projects and constructions.

As a consequence of this long debate, a redefinition of the whole system, moving from high speed to high speed/high capacity railway system (HS/HC) has been agreed. This new model can be considered more suitable especially for the northern Italy corridor, which is highly populated and densely urbanised.

Moreover, while the environmental effects of transportation facilities and of high speed infrastructure are relatively well known in literature since the Environmental Impact Assessment (EIA) procedure has been applied to several study cases, the effects on economical and geographical structure are less studied and so quite often misunderstood or underestimated.

According to a *demand-side* approach, infrastructure investments will follow mobility needs by the economical system, while from a *supply-side* approach infrastructure are a crucial means of regional growth.

This paper presents a study case in northern Italy (the Milan-Verona track, of about 140 km of lenght), and it shows how spatial effect of a transport network can spread off far from the line, determining a new regional hierarchy and new location opportunity in a wide and highly populated area.

A comparison has been made between the original high speed model and the most recent high speed/high capacity model. In the two cases the work investigates what is the area where the new infrastructure shows effects, at short and long term.

With a spatial interaction model, used to represent residential location in relation to the distribution of workplaces, HS/HC line efficiency by accessibility calculus has been measured, showing several important results.

Those results may be of interest even in similar European context where the HS programme is developing.

The Italian High Speed/High Capacity Network

The Italian H.S. railway system started in the ‘80s, following the pressing need of doubling the most important railway connections, that is along the east-west and north-south directions, where since a long time traffic capacity is close to saturation (the Milan-Naples and the Turin-Venice line are underdimensioned to face and increase in freight and passengers traffic).

Another important reasons is the necessity of adapting the Italian railway system to the European standard, as the Turin-Venice line plays a strategic role in the Italian and International roadway and railway network.

While a common project of H.S. railway network at European level is on going, technical and management solutions are far from being unified. At least three different H.S. railway systems can be detected in Europe:

- the French system, for passengers only, based on new lines at 300km/h speed standard and non-stop relationship among main metropolitan areas;
- the German system, for freight and passengers, developed to serve middle-sized towns with trains at different speed, being the highest value at 250km/h: this system is mainly based on the existing railway network;
- the English system, which provides more inter-city fast train service (hourly links with each destinations are provided), being the max speed 200÷250km/h.

The Italian Government opted for a mixed system (both freights and passengers services), as the German Government did.

The two countries show similar territorial patterns, with a broad presence of urban and industrial nucleuses, while in France the economic and territorial system is based on a small number of very important poles.

The Italian project will tend to provide the 300km/h speed standard for new infrastructures, while the most important aspect of the Italian H.S. project lies in the strong interconnection with the historic railway network and, as a consequence, with existing urban areas.

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H.S./H.C. infrastructures and regional development: a measure of impact with accessibility index

While the environmental effects of transportation facilities and of high speed infrastructures are relatively well known in literature, since the Environmental Impact Assessment (EIA) procedure has been applied to several study cases, the effects on economical and geographical structure has been applied to several study cases, the effects on economical and geographical structure are less studied and so quite often misunderstood or underestimated.

This paper presents a study case in northern Italy, which shows how spatial effects of a transport network can spread far from the line, determining a new regional hierarchy and new location opportunity in a wide and highly populated area.

In fact time saving is one of the benefits of a new transport infrastructure and at long term it can cause diverging effects, in terms of more or less employment for example, that implies broader consequences on housing demand, services, etc.

So, if we agree that transportation facilities are a fundamental precondition to economical development, the key issues is the role the regional distribution of costs and benefits plays in the new equilibrium.

The analysis of H.S./H.C. effects has been done by using the accessibility index deriving from spatial interaction models, which have often been used to represent residential location in relation to the distribution of workspaces.

The analysis focuses on travel time reduction in every existing connection, aiming to identify the area of influence of the new transportation service. It is a short term analysis to let area wide plans taking into account the new transportation network, and as a consequence the different growing potentials.

At short time, the effects in the territorial system are shown by assuming only changes in the values of the impedance function, whereas at long term, analysis should take into account that this change involves a redistribution of economical activities and housing, and consequently a change of the degrees of interest of the areas.

We used the accessibility index that could be said as “potential of the opportunities in the interaction” (Hansen, 1959), deriving from double-constrained gravity model, which formulation is:

$$T_{ij} = \frac{A_i B_j O_i D_j}{f(d_{ij})}$$

where

T_{ij} = interaction between zone i and zone j;

$A_i = \frac{1}{\sum_{j=1}^{N} \frac{B_j D_j}{f(d_{ij})}}$ $B_j = \frac{1}{\sum_{i=1}^{N} \frac{A_i O_i}{f(d_{ij})}}$ = factors of proportionality of the model;

O_i, D_j = total interaction flow respectively originated and attracted from zone i and j;

$f(d_{ij})$ = travel time function with dij=distance from zone I to zone j;

The accessibility of a *zone i* is proportional to the weighting masses of the *j zones* (so that attractiveness) grows when activities in zone j increase) and proportional to the inverse of distance from zone I to zone j, therefore the longer the distance between *i* and *j* is, the smaller the number of trips will be. The mathematical form of accessibility index is:

$$X_i = \sum_{\substack{j=1 \\ i \neq j}}^{N} \frac{M_j}{f(d_{ij})}$$

Through the impedance function $f(d_{ij})$ it is possible to catch the influence of those quantitative but also qualitative elements, linked to the organisation of transportation supply, and also to the different problematic aspects and typologies of inter-city mobility.

The multimodal trip

The accessibility of a zone is function of the different means of transport when considered separately, but also of the so called multimodal transport. The more realistic hypothesis is to consider the least travel time, depending on the comparison among different means of transport.

The multimodal matrix contains the least travel time by comparing private vehicular trip, railway travels and vehicular+railway journeys (multimodal). So in a multimodal trip both the means of transport are used, when the correspondent length is the shortest.

The travel time is obtained by summing times for each mode. Two different matrixes have been calculated: one for the current situation and one for the future situation, on the hypothesis that the H.S./H.C. system will be realised.

The Milan-Verona H.S./H.C. stretch

The Turin-Venice line constitutes a strategic element of the Italian and International roadway network. This work focuses on the Milan-Verona stretch, which can reasonably be studied independently from the other portion of the line.

Because of the remarkable impact of the commuting traffic, the line is already underdimensioned and the FS programs foresee some short term improvement interventions, mainly consisting in doubling nearly half of the section from Milan to the west.

Figure 1 – The Italian system in the Trans-European system network

At the beginning three alternative project solutions were considered and evaluated by FS. A first alternative hypothesis (*doubling and speed increasing of the historic line*) consisted of two new tracks parallel to the existing ones, so increasing the capability of the line, with the same stations of the historic line. A second alternative hypothesis (*H.S. line with interconnection to medium-sized cities*) consisted in a new H.S. standard infrastructure, with a totally new layout, so that a 300km/h speed could be allowed, with the interconnection of Milan, Brescia, Verona (and then Vicenza, Padua and Mestre). The third alternative hypothesis (*line with less interconnections*) consisted in a new H.S. standard infrastructure, with a totally new layout far from the historic and mainly long

runs train, for a strong national and international demand, while short-link services would remain on the historic line.

After a long debate, in order to reduce territorial impact of the new infrastructure, they decided for a line which will be closed to already existing or projected infrastructures.

Moreover interconnections with medium-sized cities will be realised.

The choice has been taken according to the character of the area: to the north, the Alpine chain and the Subalpine arc show very low population density and a prevalence of agricultural and tourist activities, while in the central-southern wide lowland a higher population density and intense agricultural activities coexist with the greatest industrial concentration in the country. Wide systems of economical activities and urban and metropolitan areas have grown in the area: the Milan metropolitan area (being the largest in Italy) at west and the urban systems of Bergamo, Brescia and Verona at east.

The Padania region, and Lombardy in particular, has always been interested by traffics from central and southern Italy and also from Europe. Milan is the centre into which many lines converge: from Adriatic region, from Liguria, Piemonte (and so from France), from the north of Europe (Germany, Austria, east Europe), but also from the whole regional area. Nowadays the situation of the railway infrastructures is critical. Figure 2 illustrates the saturation degree of railway system in Lombardy, where the line from Milan to Brescia is completely filled.

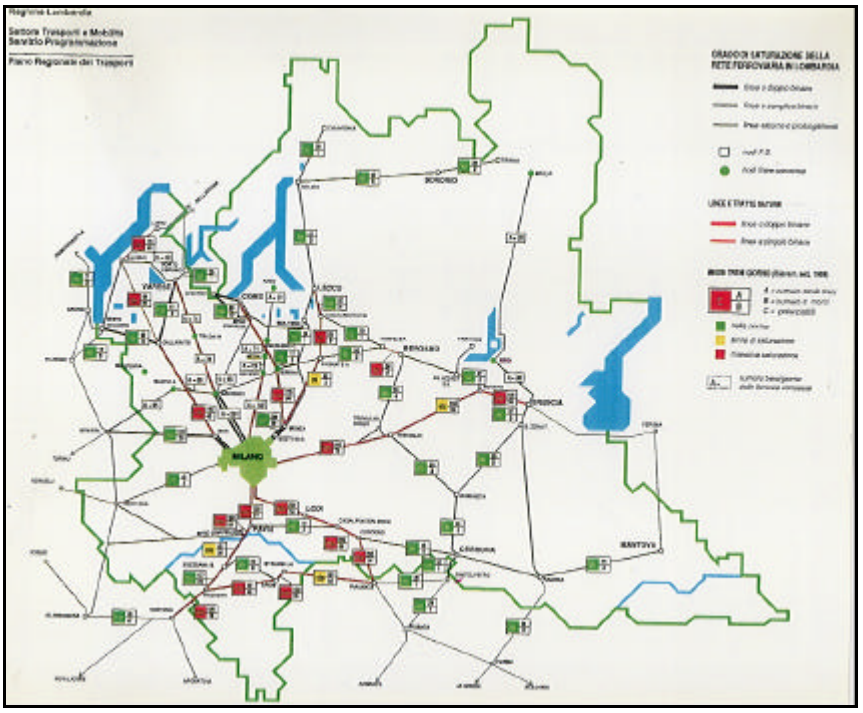

Figure 2 – Plan of transport of Lombardy Region - saturation degree of the railway system,

EVALUATION OF EFFECTS ON SPATIAL ACCESSIBILITY

The H.S./H.C. plan have been assessed versus the situation at the present, measuring the accessibility index for study area, which has been divided into zones, following general criterion like dimensional homogeneity (in terms of population and surface); homogeneity in terms of accessibility to the communication network and administrative subdivision (Municipality, Mountain Community, metropolitan area).

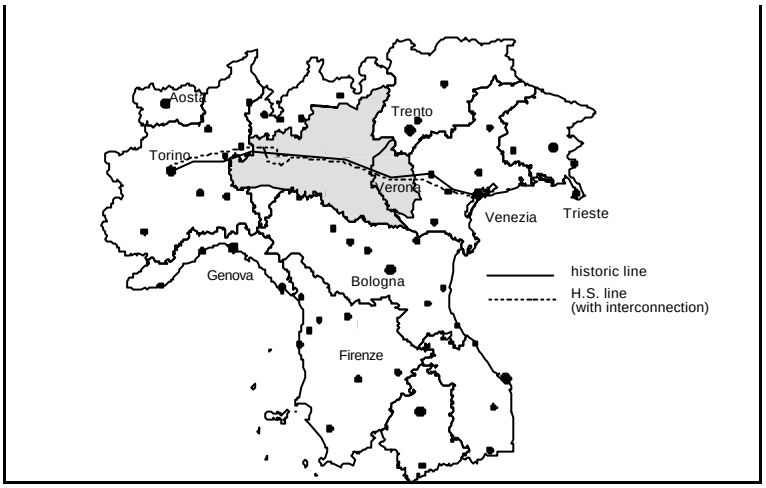

Figure 3 - The study area: Turin-Venice line and the H.S./H.C. project

The accessibility index values of each zone, with the hypothesis of H.S./H.C. line with interconnections to middle-sized towns, is remarkably higher with respect to the current situation, where a high accessibility band extends from Milan to the east, while the marginal zones are those of the mountain valleys (north of the chart) and of the lowland south-east Provinces.

The most accessible zones (west part of the region; figure 3) show none or slight improvements by the realisation of the H.S./H.C. plan.

It is also important to emphasise how many zones even not directly served by the Milan-Verona line show an important increase of accessibility. The most improved zone is Verona.

According to the simulation hereby described, the presence of many important medium-sized towns with a short-run traffic level is still one of the prominent question of the impact assessment of the east-west H.S./H.C. infrastructure in northern Italy.

The analysis is based on the multimodal travel time, that is combined trip with the quickest mode for each section.

Following our assumption, we are far from estimating modal split, but the time matrixes allow a simple estimation of the means of transport (private car, railway or combined

transportation) which assure the least time for each relation, by comparing the travel time before and after the new H.S./H.C. line is on service.

The matrix of travel time in the present situation has been built by calculating the least path both considering the shortest connection and the most efficient mode. In most cases car is the *best* means of transport, but several situations change, both because of speed increase in some tracks and the higher service frequency, when H.S. is considered:

- car sections moves from 86.5 to 79.4% of cases;
- railway rate from13.1 to 17.4%;
- multimodal trip rate from 0.4 to 3.2 %.

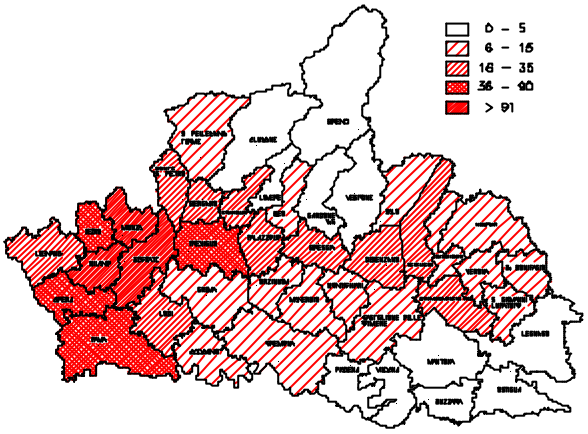

Figure 4 Classes of accessibility index (Xi) in the present situation

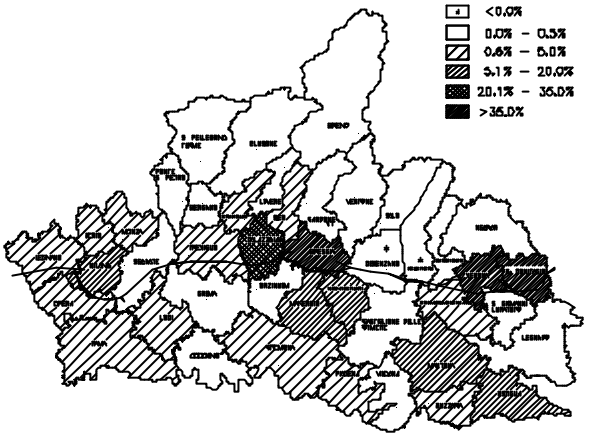

Figure 5 Variations [%] of accessibility index (Xi) after the introduction of H.S./H.C. with respect to the present situation

SOME CONCLUSIVE REMARKS

The present work analyses only passenger transportation service, according to studies that focused on the considerably increasing business mobility, which involves growing number of activities (Gorla et al., 1993).

Based on a very simple interaction model, the measure of a H.S./H.C. line efficiency by accessibility calculus, has shown several important aspects. In the environmental impact analysis (CEPAV2, 1992) these aspects are mostly neglected, while one of the main concern of the local authorities confronting with the project is the rail travel supply improvement, even and foremost for local services.

In particular, H.S./H.C. convenience in the east-west corridor shows less evidence than the main north-south direction in the Italian H.S. system, but no less importance from an European point of view and due to the overcoming congestion.

What can be shown is the impact of the new line in a much larger area than the narrow band across the line: relevant effects are felt also in the zones where a secondary level railway system is present (i.e. the south-east Provinces).

So, even in far distant areas, the new railway system can split the private vehicular mode to railway, mainly because of the higher number of trains per day, rather than for the higher speed. This is a prominent result confirming the new trim of the entire railway system the Italian H.S./H.C. program aims to be.

A further step should be to assess, at the same territorial scale, the influence of travel costs in order to obtain a more precise information about the foreseen modal split, which is - both for passenger and overall for freight services - a main concern for the most dense and highly congested urban area in Italy. That could be done even by running a very simple interaction model, since land-use and transportation are two interrelated major concerns of urban planners.

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