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Views & Comments

High-Speed Rail: Opportunities and Threats

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The objective of this article is to analyze the impacts that changes in society may have on high-speed rail (HSR) activity and development. We are now in a transitional period between the second and the third industrial revolutions, as described by Rifkin [1]. The new revolution emerged from beneath the surface at least 15 years ago, and will take at least another 15 years to be fully fledged. Such a long transitional period is the result of many worldwide evolutions initiated by two main causes—the digital revolution and global climate warming—and we must confess to our inability to forecast their final outcomes. Thus, we have a strong motivation to try to understand what is at stake and to unravel the various trends and breaks that are presently active in the open as well as under cover. No field of activity will be shielded from the coming tsunami of change. The railway community is naturally involved in this irresistible move. Will HSR benefit or suffer from it? What attitude should we adopt in order to turn threats into opportunities?

There is no denying that the past 15 years have witnessed a boom in HSR development. After many years operating its first high-speed (HS) lines, Japan has at last been followed by European countries (mainly France, Italy, Germany, Spain, Belgium, the Netherlands, and the UK) and by other Asian countries and regions (Republic of Korea and Taiwan of China). By the year 2000, the HS network was about 5000 km long. It was more than six times longer (34 679 km[†]) 17 years later, principally, but not exclusively, because of China. New countries and regions are implementing this transport mode: Morocco, Saudi-Arabia, and California in the US. Other countries have plans for it, such as Indonesia, Iran, and Poland, to name just a few. A worldwide expansion is underway. In addition, and just taking into account the lines that are presently under construction, an almost 50% increase in the HS network length (15 790 km) is expected by 2022. Fig. 1[‡] shows the past, current, and projected worldwide HSR route length.

HSR ridership has steadily increased over the past half century (since 1964, to be more precise, when the first Shinkansen started its revenue services). Very few fields of activity can boast such a continuous growth.

How can we account for such a commercial and technical longevity? This dynamism is based on six quite strong assets:

Asset #1: The mobility market has been constantly growing.

Asset #2: By definition, HSR is very rapid, and provides customers with very competitive travel time and high service frequency.

Asset #3: Many railway stations were built many years ago and are now in the core of the cities they serve.

Asset #4: HSR is a mass transport system.

Asset #5: HSR is environmentally friendly.

Asset #6: HSR is reliable and safe.

Throughout previous decades, prophets of doom have been ringing alarms foretelling a reduction in mobility. Initially, the scaremongers argued that the telephone would dry up market mobility because people would no longer have to move to talk to each other. Reality has disproved their thesis in the best possible way. Not only has the telephone not, in any way, reduced passenger traffic volume; in itself, the telephone has evolved from fixed to mobile. By becoming mobile, the telephone has enabled people to travel more because they do not need to remain in one place to be informed or to give information and orders. Apparently, this was not enough of a lesson to silence the whistle blowers. With video conferencing, the business trip market was prophesied to shrink dramatically. Air transport, the most commonly

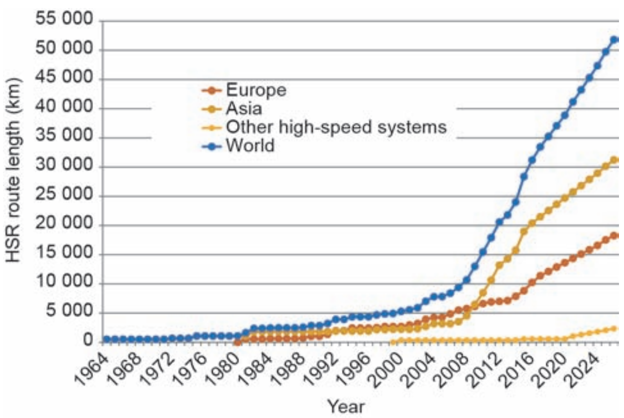

Fig. 1. Worldwide high-speed rail (HSR) route length.

[†] According to the International Union of Railways (UIC) Passengers Department statistics.
[‡] Source: UIC.

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used method of long-distance business travel, has sky-rocketed even while the video conference has become a standard in many companies. The two major airplane builders have never had such a 5–10 years' backlog as they do now. The Internet was also supposed to curb mobility. Nowhere can a negative correlation between the extension of connectivity and mobility be objectively shown. And now, to cut a long story short, some ecologists are predicting or suggesting that mobility should be moderated and even checked in order to reduce greenhouse gas emissions. If such political measures were to be enforced, as they are in some cities where alternate circulation is imposed[†], HSR is likely to be one of the last transport modes on which volume constraints would be laid. It would rather be the other way round: People would be incited to use the rail mode instead of road and air modes. At the end of the day, such measures could favor rail and particularly HSR.

Thus, it is obvious that HSR rides the wave of mobility, and that this is probably one of the best and most solid points (Asset #1) HSR should continue to build on.

Another favorable aspect comes from the analysis of the respective market shares of HSR and air mode. Many corridors have been under scrutiny, and it has become a constant in HSR history that the market shares of these two competing modes are strongly linked to rail travel time. Fig. 2[‡] indicates the HSR market share on the Rail + Air market; for a sample of origin-destination (OD) pair, follow the same sharing pattern based on rail travel time in all countries operating HSR. Points under the curve correspond to OD pairs, with airports located particularly close to the served city or well linked to it, whereas points situated above the curve correspond to cases where the airport is far from the city or badly linked to it.

For travel times up to 2 h (120 min), rail is extremely competitive and sometimes capture more than 90% of the market. Residual air traffic is mainly due to connecting flights. For travel times in the range between 2 h and 4 h, rail is the dominant mode. Beyond 4 h, air takes the lead. And beyond 6 h, rail plays a marginal role on the market.

This split of the market is now well known, and nobody challenges it since it is proven worldwide. However, how can we account for such performances? It seems paradoxical that rail occupies the highest traffic volume when its travel time is between 2.5–3.5 h, whereas the same trip normally only needs 1 h by air! Is this situation due to the difference in ticket prices? No, that is not the obvious cause; when rail was operated with conventional rail, although it was cheaper than air, it did not hold the major share. Thus, price is not enough of an explanation, particularly since low-cost air companies sometimes propose cheaper tickets than HSR operators. There are two likely reasons why passengers select HSR and reject airplanes in this range of travel times.

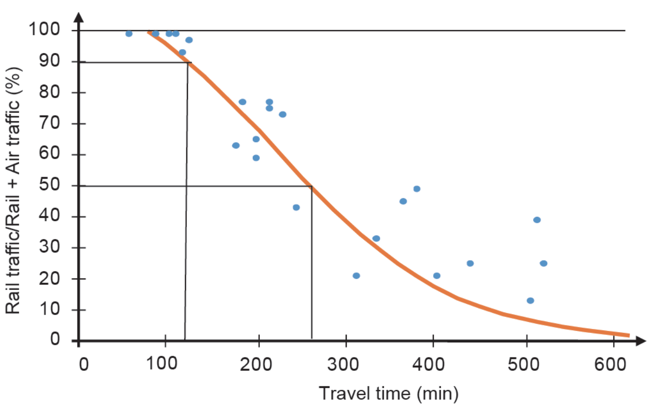

Fig. 2. Rail market share according to the best rail travel time.

The first reason is that, within this range of rail journey times, the door-to-door travel times by air and by rail are generally of the same magnitude. The second reason is that the time spent while traveling on rail can be used more easily than the time spent while traveling by air. Fig. 3 depicts the door-to-door travel times by rail and by air for a trip between Paris and Marseille, in France. Over a 700 km distance such as this one, the train is much more comfortable than an airplane. By analyzing this diagram, it is easy to understand that both Assets #2 and #3 jointly contribute to capturing the market.

Similarly, when it comes to competition with road, HSR can perform very well on the city-to-city trip market; as in France[††], for example, where HSR holds over 50% of the market (Fig. 4).

One of the reasons why HSR fares so well is that most car trips are run by people driving alone in their own car, which is more expensive and more time-consuming than travel by train.

However, it is understood that there is no permanent certainty regarding such things. Leaving aside the mobility aspects that support the HSR fare-box revenues, then, let us focus on the investment and operating costs. These lead us to the rail production function.

In neoclassical micro-economics, the production function states the quantity of output (Q) that a firm can produce as a function of the quantity of inputs. Most often, two kinds of production inputs, called factors of production, are considered: capital (K) and labor (L). Other production factors may be identified, such as land and raw materials. Land is rarely integrated into the calculation, except when land is of the essence in the production process (e.g., agriculture). Raw materials are often ignored because their cost is mainly composed of capital (machines for extraction and transportation) and labor. However, when addressing the rail production function, it is difficult not to mention energy (E) as a production factor, particularly because its cost is largely independent of the rail production process and may vary according to external and unpredictable causes. And finally, while extrapolating the present situation over the next 50-year period, we must consider an immaterial production input, the data (D).

$$Q = f(K, L, E, D) \tag{1}$$

As far as HSR is concerned, capital is mainly composed of linear infrastructure (by and large the costlier item), stations (or part of them when shared with other rail services), maintenance depots and sidings, track maintenance tools and machines, computing devices, and rolling stock.

At a given moment, in order to increase production, several options are possible:

- Increasing the occupancy rate of trains;
- Increasing train capacity (this option is only available by coupling two train sets);
- Increasing the number of trips of the train sets (generally, however, the operator has committed to a particular fleet size, so there is not much leeway in rolling stock productivity increase);
- Replacing one-deck with double-decker trains;
- Buying additional train sets (there is a several-year gap from drafting a request for proposal to the rolling stock delivery);

[†] The effect on mobility is not direct, since vehicle occupation may increase.

[‡] Chart initially established by French National Railway Company (SNCF) Mobility and regularly updated with data coming from SNCF and UIC. Last version was released in 2015.

[††] Source: SNCF Mobility.