

**ECONOMIC SIGNIFICANCE OF HIGH
SPEED RAIL**

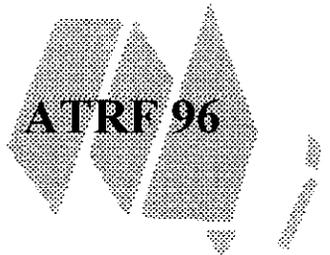
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ABSTRACT

The success of existing high speed rail systems; the Shinkansen in Japan and TGV in France, have been widely reported. Their successes have spurred on a wave of high speed rail proposals in recent times; which have swept through Europe, with a Europe-wide network planned over the next ten years, the USA, and even countries in North Asia (Korea and Taiwan) and Australia. In Australia, the interest in high speed rail has been active for the last decade. The most recent proposal is for a HSR link between Sydney and Canberra; currently in the feasibility stage. The Institute of Transport Studies as part of the major market study undertaken in 1994-95, embarked on a literature review into the economic significance of high speed rail. This paper presents evidence of the benefits of HSR as reported by studies carried out on the existing high speed rail systems. There are many benefits attributed to high speed rail systems which can be broadly classified into: Social/Public benefits; Economic benefits and Environmental benefits. While widely reported and evident, there has however been very little research carried out to quantify the benefits to the respective countries in which HSR has been introduced. Although limited, the available research does suggest a positive net benefit to the economy as a whole.

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1. Introduction

It is now more than 30 years since the first high speed rail system in the world went into operation in Japan. Since the start of its operation to the year 1989, the Shinkansen system has transported over two billion passengers (Rosen, 1989). The French joined the race in 1981 with its Paris-Lyon service. Since then the TGV has enjoyed spectacular success and it now runs throughout France; for example, TGV Atlantique. While payback on the Paris-Lyon line was expected in about 16 years, by 1988 (after 7 years of operation) the Paris-Lyon line earned \$100 million on \$680 million in revenues and attracted 17 million passengers which were far above the projections (Fairweather, 1990).

The successes of the Shinkansen in Japan and the TGV in France paved the way for renewed interest in the introduction of high speed rail in other parts of the world. There are currently major high speed projects either underway or already operating in Spain, Germany, Taiwan and Korea as well; to name a few. In addition, there is in recent times a wave of high speed rail proposals sweeping through Europe and the USA, with a Europe-wide network planned over the next ten years.

For the high speed rail system to be a socially and environmentally desirable good, besides being profitable, it has to be beneficial to the society (to users and non-users) and the economy. There are many benefits attributed to high speed rail systems. From a review of the available literature on the subject matter, it was found that the benefits of high speed rail can be broadly classified into:

1. Social/Public Benefits,
2. Economic Benefits, and
3. Environmental Benefits

This report presents evidence of these benefits; as reported by studies of the existing high speed rail systems, with an emphasis on economic benefits. It is worth noting that while the successes of the high speed rail systems are widely reported, there has been very little research carried out to quantify the benefits arising from their introduction in their respective countries.

2. Social/Public Benefits

A principal social benefit of high speed rail is that it provides a competitive form of transportation. Other important benefits are taken to be the time savings it generates and the relief of congestion and accidents associated with other modes of transport.

The Shinkansen provided proof that high speed rail was capable of competing successfully with air and road by attracting patronage that exceeded the developers' expectations. In his research, Hirota (1985) showed that the Shinkansen had a significant impact on airline services in sections where there was direct competition as shown in Tables 1 and 2 below. For example, after a year of Shinkansen operation, airline travel between Tokyo and Osaka dropped by approximately 19.7%; and a further 27% after the second year. This was in contrast with the statistics for the same corridor a year before the start of the Shinkansen; where the airline travel increased 38.5% from the previous year. Airline travel between the closer city pairs of Tokyo and Nagoya was even more severely affected (Table 1).

Table 1: Annual change in airplane passenger traffic

	Tokyo - Osaka 500 km	Tokyo - Nagoya 300 km
Oct. 1962-Sept. '63	+38.5%	+12.0%
Oct. 1963-Sept. '64	Opening of the Tokaido Shinkansen	
Oct. 1964-Sept. '65	-19.7%	-45.2%
Oct. 1965-Sept. '66	-27.4%	-68.2%

(Source: Hirota, 1985)

Table 2: Modal share in fiscal year 1983

	Shinkansen	Airplanes
Tokyo - Hakata	32%	68%
Tokyo - Shin Osaka	88%	12%
Tokyo - Nagoya	100%	-

(Source: Hirota, 1985)

While the Shinkansen competed with automobiles in the sections of 100-200 kms; where users make their choice according to their trip purpose and other related factors, for trips beyond 300 kms the Shinkansen was more likely to be used (Hirota, 1985). With trips over 800 kms, the Shinkansen would then be competing with air.

Similar results were seen with the TGV where it has contributed to an overall growth in rail traffic of 75% at a time when intercity rail travel elsewhere in France was stagnating (Nash, 1991). Surveys carried out suggested that of this traffic some 33% had diverted from air, 18% from road and 49% were induced demand (Bonnafoous,

1987). The amount of traffic diverted from the conventional train was however not quantified by these surveys.

The greater speed of high speed rail brings about its most immediate advantage - time savings. Sugawara (1988) estimated that the effect of the reduction in travelling time in traffic volume converted from conventional lines totalled 300 million hours or more a year. Given the GDP per hour per worker at that time of 1260 yen/hour, this resulted in a total time benefit of well over 380,000 million yen. Another study (Thompson, 1992) estimated the time savings by shinkansen riders in the period October 1964 to March 1976 to be equivalent to one full year of work-time for 1.22 million people with two days off per week. Therefore, the introduction of high speed rail services is very beneficial to users as the time savings could be used instead for other purposes. This is also a great contribution to economic development especially if the time saved is put into work in the case of business travel.

The Shinkansen proved the superiority of high speed rail in terms of safety compared to the other modes of transport. As mentioned previously, since its inauguration to the year 1988, the Shinkansen had carried more than 2 billion persons. During this period, there was no accident involving personal injury (Sugawara, 1988). Table 3 below shows a comparison of the number of people killed and injured for each 1 billion passenger kilometre in various modes of transport as compiled by Sugawara (1988). In another comparison, it was discovered that over a recent decade the number of road deaths in Japan has been 46,500 while the conventional rail system, performing slightly more passenger kilometres than road, recorded 190 deaths (VFT Concept Report, 1988). A similar unblemished record has been reported by the TGV in France since its inauguration in 1981 (VFT Concept Report, 1988 and Dom, 1995).

Table 3: Number of people killed in accidents by mode of transport

Year	Narrow-gauge lines			Automobiles		
	Number of people killed A	Passenger-kilometres (1,000 M) B	Rate of Deaths A/B	Number of people killed A	Passenger-kilometres (1,000 M) B	Rate of Death A/B
1975	620	161.9	3.230	10,792	360.3	29.947
1980	410	151.3	2.709	8,760	431.6	20.293
1985	280	142.0	1.971	9,261	489.2	18.929

Table 3 (Cont'd): Number of people killed in accidents by mode of transport

Year	Aircraft			Shinkansen		
	Number of people killed A	Passenger-kilometres (1,000 M) B	Rate of Deaths A/B	Number of people killed A	Passenger-kilometres (1,000 M) B	Rate of Death A/B
1975	11	19.1	0.574	0	53.3	0
1980	11	29.6	0.371	0	41.8	0
1985	530	33.1	16.006	0	55.5	0

(Source: Sugawara, 1988)

Another advantage of high speed rail is the relief it would bring to the gridlock problem in air and highway travel. This is an important advantage because the delay due to congestion in airports and highway is very costly. For example, in USA the cost of air delays for passengers and airlines nationwide has been estimated to total \$5 billion in 1986 while the cost of highway congestion nationwide is estimated to be about \$80 billion per year (Thompson, 1992). The introduction of the Shinkansen has been reported to have led to the avoidance of a deadlock resulting from a lack of transport capacity in the Shinkansen corridor (Black, 1989). It was also reported that the main aim of the introduction of the TGV was to provide relief on the existing Paris-Lyon line (Chambliss, 1983). However, quantification of this benefit contributed by the existing systems were not found in the literature available.

3. Economic Benefits

From the literature reviewed, the major economic benefits of high speed rail are taken as the promotion of regional development, expansion of areas of business activities and the promotion of tourism and other industries.

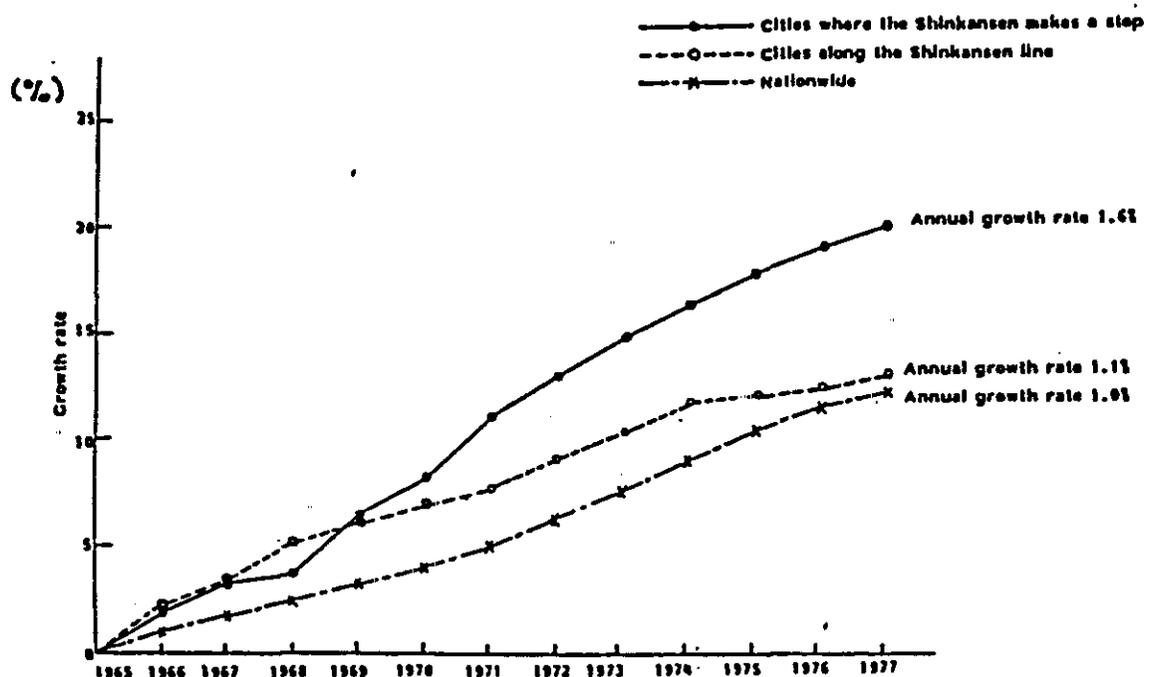
Promotion of Regional Development

This particular benefit has been the basis of argument for the development of many high speed rail systems. Several studies have been undertaken into the effect of the existing high speed rail systems on regional development. The following sections present the findings of these studies.

Changes in Population

There were greater population growth in cities where the Shinkansen passes or stops than for Japan as a whole. Hirota (1985), in comparing the rate of population increase in cities along the Tokaido Shinkansen from 1965 to 1977, found that the average population growth rate in Japan was 1% p.a. while the average growth in cities along the route of the Shinkansen was 1.1%, and in cities where the Shinkansen makes a stop, it was 1.6% p.a. (Figure 1).

Figure 1: Rate of Population increase in cities along the Tokaido Shinkansen.



(Source: Hirota, 1985).

Nakamura and Ueda (1989) studied the change in population microscopically at the level of 735 municipalities in the 10 prefectures in Japan. They found that among the municipalities along the Shinkansen lines, significant increases of population were found in the municipalities near the capital city of the prefecture or other regional centres as well as in municipalities with or neighbouring Shinkansen stations. It was also found that the share of the age group between 18 and 24 years, which tends to migrate to larger cities for higher education, had shown a declining trend before the opening of the Shinkansen in most of the observed prefectures. However, after the opening of the Shinkansen, it increased in some Shinkansen municipalities while a decrease was observed in most of the non-Shinkansen municipalities in which the total population declined.

Changes in economic growth

Differences in economic progress have been appearing between cities that have Shinkansen stations and cities along the Shinkansen route but where the Shinkansen does not stop. For the industry sectors and the residential sector, Hirota (1985) compared the economic growth of cities with and without Shinkansen, before and after the opening of the Tokaido Shinkansen. The results are summarised in Table 4.

Table 4: Comparison of principal economic growth indices with and without Shinkansen stations

Industry Sector	Annual increase ratio					
	before Shinkansen			after Shinkansen		
	(A1) Cities with Station	(B1) Cities without Station	(C1) A1/B1	(A2) Cities with Station	(B2) Cities without Station	(C2) A2/B2
Wholesale	12.9%	20.8%	0.621	11.63%	8.70%	1.34
Retail	10.1%	13.5%	0.748	9.96%	8.58%	1.16
Industrial production	13.7%	14.2%	0.967	9.48%	7.81%	1.21
Construction work in area	13.8%	14.9%	0.926	8.01%	6.37%	1.26
Population (Residential)	2.64%	3.39%	0.777	1.88%	1.55%	1.22

Note:

(1) Growth indices are annual averages over the 10 years before and after the opening of the Shinkansen.

(2) Growth indices after the opening of the Shinkansen are consistently smaller than those before the opening of the Shinkansen, reflecting stagnant economic conditions.

(Source: Hirota, 1985)

There has been a substantial increase in relative growth rates in all the sectors in cities with a Shinkansen station (Table 4). While the cities with the Shinkansen stations had growth rates that were significantly less than the average in each sector in the decade before the Shinkansen, they had substantially higher growth rates than average in each sector after the Shinkansen began operation. This is despite a period of reduced overall economic growth in the second observed period. Thus, the induced growth rates were able to substantially reverse the growth rate trends between the two sets of cities; particularly in the wholesale, retail and population sectors.

Changes in economic activities

In this section, the evidence from Japan will be presented, based on the work of Nakamura and Ueda (1989), followed by the findings by Bonnafous (1987) on the impact of the TGV.

Results (Table 5 and 6) from the comparison of rate of change in income per capita and the rate of change of employees engaged in the retail sector in the period 1981-1985 in regions classified with/without Shinkansen and with/without an expressway suggested that high speed rail can stimulate economic activities (Nakamura and Ueda, 1989).

Table 5: Rate of change of income per capita in the period 1981-1985

		Shinkansen	
		With	Without
Expressway	With	9.5	6.4
	Without	2.6	-2.7

Table 6: Rate of change of employees engaged in retail sector in the period 1981-1985

		Shinkansen	
		With	Without
Expressway	With	2.8	1.2
	Without	0.4	-3.6

The question is what industries are significantly stimulated? From a comparison of changes in the number of employees engaged in each industrial sector in the Shinkansen and expressway regions, it was found that the Shinkansen regions have significantly grown in the total number of persons engaged in information, investigation and advertising services. There were also increases in the number of employees engaged in the banking services, real estate agencies and some other service businesses such as R&D and higher education and political institutes. The researchers called this group of industries "information exchange industries"; where the common characteristics of each sector are their activities' strong dependence on communication for the exchange and acquisition of information and knowledge, and the need for persons with knowledge and skills for such activities.

It was further concluded that in regions where commodity promotion industries such as agriculture or manufacturing are dominant, the impact of the Shinkansen is not prominent. As such, the impact on regional growth is not significant if the share of employees in these industries is large in the regions concerned.

The principal conditions for population growth in a region were identified as follows (Nakamura and Ueda, 1989):

- (1) "Information exchange industries" are prominent in the region.
- (2) Sufficient opportunities for higher education are provided.
- (3) The local accessibility of the Shinkansen station is good.

The conditions that restrain regional development were:

- (1) The share of commodity production industries in the region is large.
- (2) The age group of 65 years and over constitutes a large part of the population.

The estimated coefficients of the discriminant functions are shown in Table 7. The authors reported that the possibility of population growth in the regions caused by the Shinkansen could be predicted with a goodness of fit of more than 90 per cent.

Table 7: Estimated coefficients of discriminant function

Analysis	Independent Variable	Coefficient	F-value
1	Share of employees in "information exchange industries"	0.8	6.8
	University students/population (15-17 years of age)	3.7	3.1
	Access time to Shinkansen station ¹	-1.0	2.5
	Access time to interchange of expressway ²	-0.1	0.2
Percentage of correct estimation = 91%			
2	Share of employees in commodity producing industries ³	-6.6	12.5
	Share of aged population (65 years and over)	-1.0	3.2
	Access time to interchange of expressway	-1.7	3.3
Percentage of correct estimation = 94%			

(Source: Nakamura and Ueda, 1989)

¹ travel time from centre of the largest municipality in the region

² average running time from each municipality in the region

³ agriculture, fisheries, manufacturing, mining

What is interesting is that similar trends were also reported in France. Surveys of business journeys undertaken about 4 years after the TGV started operation showed that there are more transactions related to services than transactions related to products. Overall, the proportion of journeys with the object of purchasing or selling services rose from 15% to 21% (Bonnafous, 1987). Consultancy was found to be the predominant activity that the business travellers were engaged in.

It was also concluded from an analysis of some enterprises in the Rhone-Alps region before and after the opening of the TGV that the "regional expansionist" enterprises have particularly benefited from the TGV by establishing themselves on the Parisian market. For example, in the field of publicity, several enterprises of the Rhone-Alps region have accessed the national market in which 70% were represented by the Parisian market. With specialised enterprises whose market is outside the bounds of the region and who had to pass through Paris where most contacts are established, the necessity of moving to Paris sooner or later is no longer there as Paris has become easily accessible. There is an emergence of a pattern which involves looking for custom and contacts in Paris and carrying out the work in the calm of the province, with its quality of life. On the question of the impacts on relocation of industries, Bonnafous (1987) drew two conclusions from surveys of ten cities in the Rhone-Alps region and Burgundy. First, certain movements such as government interventions in depressed industrial areas seem to play a much larger role in the location or relocation of industries than factors attached to the TGV. Secondly, in certain cases the TGV played a certain role in the selection of location but it is only exceptionally a determining factor. Very often, the availability of the TGV was regarded as a "bonus", although this bonus increased in importance when the location is free of other spatial constraints.

Promotion of commercial and business activities

The effect that high speed rail infrastructure have on economic growth is first apparent near the stations with the promotion of commercial and business activities and expansion of spheres of activities. For example, the Sanyo Shinkansen operating between Shin-Osaka and Okayama and Okayama and Hakata, had a great influence on city functions in Okayama and Hakata while revitalising the area around the Shin-Osaka station. This area was deserted when the station was first constructed, but now, after more than 20 years, the city functions of Osaka are rapidly developing into the Shin-Osaka Station (Sugawara, 1988).

At the terminus in Hakata, the number of hotels increased from 20 with 2,060 rooms to 40 with 5,320 rooms in the period from 1972 to 1974 in anticipation of the start of the service in 1975. On the other hand, the number of branch offices of enterprises set up in Okayama increased from 202 (before commencement of the service) to 378 (after commencement of the service).

Another example; a more recent one, is that of the medium-sized city of Kakegawa which is on the Tokaido Shinkansen route with a population of 72,000 and about 230 km west of Tokyo. In 1988, a Shinkansen station was constructed in Kakegawa. After the station opened, production and sales in the industrial and commercial sectors showed a remarkable increase (Okada, 1994). This was in contrast to the situation before where the city did not benefit from being just on the Shinkansen route. Tables 8 and 9 show the changes in employment and production recorded in Kakegawa.

Table 8: Trend in Employment and Sales in Commercial Fields

Year	1985	1988	1991
Employment	88.8	100.0	106.9
Sales	85.4	100.0	139.2

(Source: Okada, 1994)

Table 9: Trend in employment and production in Industrial fields

Year	1985	1986	1987	1988	1989	1990	1991	1992
Employment	96.0	98.6	96.8	100.0	101.5	103.5	103.2	108.1
Production	100.1	96.0	98.1	100.0	105.2	110.4	109.5	137.6

(Source: Okada, 1994)

In France, similar effects have been noticed around the many TGV stations. For example, around the Montparnasse station in Paris, office buildings, hotels and retail plazas have sprung up while the Pasteur Station has attracted a vast real estate development which involved the extensive refurbishment of the neighbourhood and a vast building programme (Mathieu and Pradayrol, 1995).

Finally, there is evidence that there would be a positive impact on the commercial attractiveness of the regions served by high speed rail. In the case of the Shinkansen, the average increase in land prices was 67 per cent in the regions with growing population served by the Shinkansen, while it was 42 per cent in the regions with growing population served by the expressway in the period 1980 to 1985 (Nakamura and Ueda, 1989).

Promotion of Tourism

The promotion of tourism and recreational activities and increases in hotel construction in cities served by the Shinkansen was identified as the spin-off economic effects from the Shinkansen's operation as a result of its high speed and convenience. The six prefectures of the Tohoku district served by the Tohoku Shinkansen, experienced increases in the number of tourists. This is especially so in the Iwate Prefecture where the growth of the tourism industry was a remarkable one; experiencing an increase from less than 20 million tourists in 1976 to more than 30 million in 1985 (Sugawara, 1988).

In the case of the TGV, the hotel business was found to be characterised by two contradictory effects. First, there was a drop in the number of overnight stays as more day-return journeys were made possible. Secondly, there was a development of tourist packages using the TGV (Bonnafous, 1987). It was also observed that while there was a

decrease in hotel stays in big cities, small towns experienced a significant increase in tourist numbers. For example, the Abbaye of Fontenay which is 5 km away from Lyon saw the number of its visitors rise by nearly 40% in three years.

4. Environmental Benefits

Advocates of high speed rail have claimed that it is the more energy efficient and the most environmentally friendly alternative to air and highway travel. The benefits arising from its introduction include reduced pollution compared with the hydrocarbon emitting cars, buses and planes, especially through the diverted demand from these other modes.

High speed rail consumes electricity while the other modes consume fossil fuels (oil, kerosene, etc.) which is one of earth's limited resources. Therefore a significant diversion of traffic from road or air to rail would contribute towards conserving these petroleum reserves.

The fact that high speed rail is the most energy efficient mode is evidenced in several studies. Studies in Japan (Okada, 1994) to compare the energy consumption of the various modes of transport suggest that for the travel from Tokyo to Osaka, the Shinkansen is more than four and a half times more energy efficient than automobile and more than five times more efficient than the plane. Similar conclusions; although of different magnitude, were also reported by the study carried out by the French environmental and energy management agency. With the French study, the TGV is two and a half times more efficient than the private car and four times more efficient than the plane (Mathieu and Pradayrol, 1995) (see Table 10).

Table 10: Comparison of Energy Consumption

	Modes		
Japan:	Shinkansen	Automobile	Aeroplane
Energy Consumption (kcal/100 million passenger-km)	136	631	714
Ratio	100	464	525
France:	TGV	Private Car	Plane
Energy Consumption (goe/passenger-km)	12.1	29.9	51.1
Ratio	100	247	422

Note: goe - Grammes of Oil Equivalent.
(Source: Okada, 1994 and Mathieu and Pradayrol, 1995)

On comparison with other modes of transport, the 1993 White Paper on Transport by Japan's Ministry of Transport reported that the Shinkansen hardly emits any CO₂ (the

main greenhouse gas), NO_x and other harmful gases (Okada, 1994). Another statistic reported was that the amount of CO₂ per passenger-kilometres directly produced by the Shinkansen is only about 16% that of passenger cars even though the Shinkansen has 80% share of the total transportation volume; measured in terms of passenger-kilometres, between Tokyo and Osaka (Okada, 1994) (see Table 11).

Table 11: Emission of CO₂ Per Capita by Transport Mode between Tokyo and Osaka

	Shinkansen	Automobile	Aeroplane
Index	100	547	631

(Source: Okada, 1994)

A study into the environmental impact of the European High Speed Train network in the year 2010 (Dom, 1995) also observed that an HST has lower emissions of pollutants (CO₂, CO, HC and NO_x). Therefore, high speed rail can be considered an effective answer to reducing air pollution for the same transport performance of existing modes.

5. Conclusion

The immediate benefit of high speed rail services is the enjoyment of fast, comfortable, reliable and safe transport by the users. The success of the existing high speed rail systems is largely contributed by this benefit, which has made high speed rail a competitive form of transportation. In Japan, France, Germany and Spain ridership has in many instances exceeded the projections of their developers.

Indirectly, high speed rail is believed to contribute positively to society and the economy. From the evidence available to date, travel time and accident cost savings, promotion of regional development, the extension and creation of commercial and business activities in areas along the route, increased tourism demands, and energy savings are among the benefits of high speed rail. In the short-term, there is also the spin-off economic effects of construction expenditure from the construction of the high speed rail and related urban projects that will be enjoyed by the local economies. The benefits in high speed rail corridors have to be matched against any possible loss of benefits in other locations through the diversion of resources. On balance, the limited evidence suggests a positive net benefit to the economy as a whole.

While evidence of these benefits are present, there is still a lack of quantification of the effects being undertaken; which if available, would bring to light even more the benefits of high speed rail systems.

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