

KL-SG High-Speed Rail – a catalyst for national economic development

KL-SG HSR in navigating the economic growth

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Abstract

Purpose – In an increasingly interconnected world, transportation infrastructure has emerged as a critical determinant of economic growth and global competitiveness. High-speed rail (HSR), characterized by its exceptional speed and efficiency, has garnered widespread attention as a transformative mode of transportation that transcends borders and fosters economic development. The Kuala Lumpur – Singapore (KL-SG) HSR project stands as a prominent exemplar of this paradigm, symbolizing the potential of HSR to serve as a catalyst for national economic advancement.

Design/methodology/approach – This paper is prepared to provide an insight into the benefits and advantages of HSR based on proven case studies and references from global HSRs, including China, Spain, France and Japan.

Findings – The findings that have been obtained focus on enhanced connectivity and accessibility, attracting foreign direct investment, revitalizing regional economies, urban development and city regeneration, boosting tourism and cultural exchange, human capital development, regional integration and environmental and sustainability benefits.

Originality/value – The KL-SG HSR, linking Kuala Lumpur and Singapore, epitomizes the potential for HSR to be a transformative agent in the realm of economic development. This project encapsulates the aspirations of two dynamic Southeast Asian economies, united in their pursuit of sustainable growth, enhanced connectivity and global competitiveness. By scrutinizing the KL-SG High-Speed Rail through the lens of economic benchmarking, a deeper understanding emerges of how such projects can drive progress in areas such as cross-border trade, tourism, urban development and technological innovation.

Keywords High-speed rail, Transportation, Railways, Sustainable mobility, Socioeconomic development, Technology

Paper type Case study

1. Introduction

In an increasingly interconnected world, transportation infrastructure has emerged as a critical determinant of economic growth and global competitiveness. As shown in [Figure 1](#), high-speed rail (HSR), characterized by its exceptional speed and efficiency, has garnered widespread attention as a transformative mode of transportation that transcends borders and fosters economic development. The KL-SG HSR project stands as a prominent exemplar of this paradigm, symbolizing the potential of HSR to serve as a catalyst for national economic advancement. The convergence of urbanization, technological progress and the need for sustainable mobility solutions has

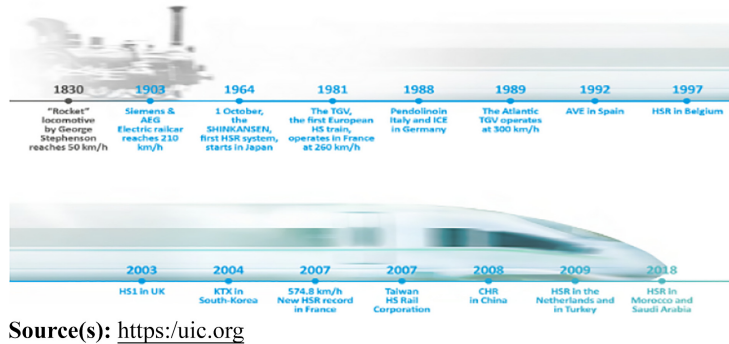
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Figure 1.
High-speed rail
developments



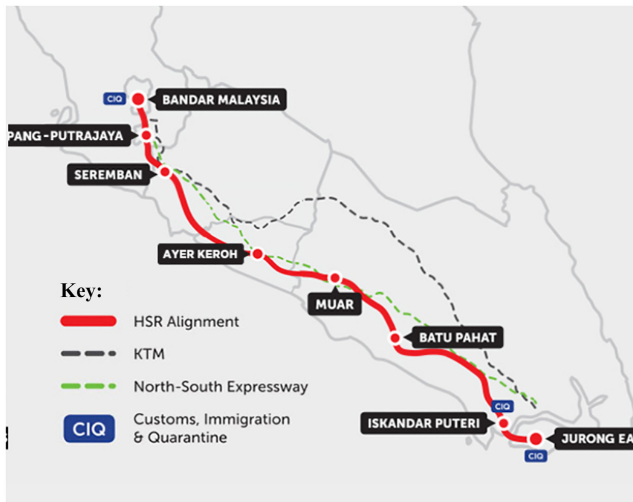
repositioned HSR as a strategic instrument for enhancing connectivity, promoting trade and attracting investments. Historically, countries that have successfully harnessed the capabilities of HSR networks have experienced notable economic benefits, with these systems becoming barometers for measuring economic progress on a global scale. As nations endeavour to solidify their positions in the competitive global arena, the quest for effective benchmarks to gauge their economic development has intensified. In this context, the KL-SG HSR emerges as a pertinent case study, encapsulating the interplay between transportation infrastructure and economic advancement. Geographically positioned at the optimum distance where rail travel could overcome the benefit of air travel, the KL-SG HSR route is expected to contribute to both nations' economies. A successful HSR network enhances a country's image on the global stage, positioning it as a technologically advanced, modern and forward-looking nation. This branding can influence tourism, trade relations and global competitiveness. Boehm, Arnz, and Winter (2021) had also highlighted that HSR can be used as an option for the significant shift to more efficient electrified transport modes and decarbonized energy generation, limiting the global temperature to increase above 1.5 °C. According to Levinson (2012), the HSR system in most countries has complemented an existing, serviceable regional passenger rail system and evolved from that network, replacing elements of existing routes link by link.

The key benefit of the KL-SG HSR lies in the total time savings from the journey components (i.e. travel time, waiting time, check-in time, access time and interchange time) as compared to other modes of transport. The KL-SG HSR also needs to be integrated with other modes of transport to ensure accessibility of the HSR station and seamless connectivity. The KL-SG HSR network (Figure 2) can act as a much-needed stimulus to both countries' economies. The indirect spillover effect of the economy shall provide return from construction and operations activities, trigger development and catalyse output impact in international tourism. In addition, HSR can be used as a catalyst to value rail infrastructure investments as low-carbon transport and investment in HSR, which will create strong economic opportunities. For example, France's TGV network has enabled the diversification of Lille into a developed economic geolocation.

2. Literature review

2.1 China case

China's construction of high-speed rail is evidence of the country's capacity to dream big and make such aspirations come true. Yang, Du, Wang, Wang, and Zhang (2023) stated that due



Source(s): <https://myhsr.com.my>

Figure 2. KL-SG HSR network

to its quick construction, HSR has significantly raised travel demand since it entered the Chinese market in 2003. China's HSR networks (Figure 3) will make up two-thirds of the world's total mileage by 2020, reaching a total length of 379,000 km. Eight vertical and horizontal HSR networks are expected to be built by the end of 2030. Its fast-moving railway network has not only revolutionised passenger transport, but it has also vaulted the country to the forefront of HSR technology. China's experience provides a remarkable case study in ambition, creativity and the transformational impact of infrastructure development as other nations look to the future of transportation.

Wang, Zhou, Guo, and Mao (2023) highlighted that HSR improves the development of the tourism economy in Northeast China, an underdeveloped region. The authors find that HSR has a positive and significant impact on the tourism economy and the effect becomes stronger over time. They also find that the impact varies by city type, with central cities and deficient-resource cities benefiting more from HSR than ordinary cities and rich-resource cities. This suggests that cities should seize the opportunity of HSR to promote the balanced development of regional tourism and avoid the negative effects of HSR, such as spatial polarization and resource crowding. They also call for more attention to the specific economic and geographical conditions of different regions when studying the impact of HSR on tourism.

The study conducted by Chen and Guo (2023) on the relationship between HSR and innovation suggests that HSR connections lead to technical specialisation or diversification. It also provides evidence that the HSR connection influences innovation through intra-industry information spillovers. Furthermore, the varied effects of the HSR link on technological variety across various city groupings offer fresh perspectives on the connection between innovation and better transportation.

In addition to the above, Sun, Razaq, Kizys, and Bao (2022) suggested that whilst HSR plays a catalyst role in fostering sustainable economic development, investing in HSR transport infrastructure also enhances business productivity and efficiency, fosters economic growth, deepens regional trade integration and, through spillover effects, raises national revenue. Additionally, it boosts labour allocation through mobility, quickens the movement



Figure 3.
HSR networks in China

Source(s): <https://uic.org>

of talent, capital and products between cities, encourages the expansion of urban employment and deepens specialisation.

2.2 Spain case

Sanchis, López, Franco, Fernández, and Zuriaga (2023) highlighted that the high-speed railway network in Spain was envisioned in the 1980s as a brand-new rail system that would be built for international gauge and largely apart from the rest of the rail network. Over 50 bn euros have been invested from the start to connect 80 major and medium-sized cities with electrified lines operating at 25 kV and 50 Hz, allowing for maximum speeds of up to 300 km/h. There are four primary routes in this network shown in Figure 4 that link Madrid, the nation's capital, to other interior and coastal locations.

Damián and Zamorano (2023) draw attention to a number of the environmental advantages of HSR construction in Spain. For example, after 40 years of operation, the average GHG emissions for passenger travel between Madrid and Toledo will be 21% lower than in the scenario if no HSR line is constructed. Additionally, the line's greenhouse gas emissions are offset 19–23 years after it begins operations. This is primarily because passengers switch to more environmentally friendly modes of transportation, which reduces emissions and because trains have been running exclusively on renewable energy since 2019.

According to Guirao (2013), the majority of the development over the past 20 years in Spain has come from Spanish innovation and research centres. This sector is highly valued



Source(s): <https://uic.org>

Figure 4. HSR networks in Spain

globally and has progressed to a significant degree of specialisation and experience. All phases of the development of HSR railways are covered by consulting, engineering, construction and industrial firms: research studies, design construction, rolling stock systems and operation and maintenance services. Spanish businesses have improved their managerial expertise and industrial know-how along the complete HSR investment value chain. Railway projects (consultancy, design, project management, work monitoring, operations and maintenance) account for 27% of exports from Spanish engineering firms.

2.3 France case

France is a pioneer in HSR development, known for its iconic TGV (Train à Grande Vitesse) system. The inception of France's HSR journey dates back to 1981, when the first TGV service connected Paris and Lyon. The Paris–Lyon HSL was commissioned in 1981. It was the first in Europe, and 40 years later, it is still a success, with 44 m passengers in 2019 on the 430 km-long route (Laroche, 2023). The TGV was revolutionary, showcasing unprecedented speed and efficiency in rail travel.

France has invested heavily in developing cutting-edge technology for high-speed trains. The TGV trains were designed to reach remarkable speeds, initially operating at around 270 km/h (168 mph) and later achieving even higher speeds. France expanded its HSR networks (Figure 5) to connect major cities across the country (Laroche, 2023). Several innovations have been provided to increase capacity, such as the implementation in 1981 of a standard for a new signalling system (TVM 300), its improvement in 2001 to reduce the buffer time between each train to four minutes and, in recent years, investment in the implementation of the European Railway Traffic Management System (ERTMS Level 2) by 2030. The objective is to increase commercial capacity by 30%. The success of the Paris–



Figure 5.
HSR networks in
France

Source(s): <https://uic.org>

Lyon route paves the way for additional lines, linking cities like Marseille, Lille, Strasbourg and Bordeaux. This comprehensive network has made it convenient for passengers to travel quickly between key urban centres. France plays a crucial role in the development of HSR as a transnational system. The TGV network extends beyond French borders, connecting with neighbouring countries like Belgium, Germany, Switzerland and Spain. This integration enhances international mobility and strengthens economic ties within Europe. The TGV network has had a significant impact on the French economy. It has reduced travel times between cities, fostering economic development and business opportunities. Additionally, the shift from air and road travel to HSR has contributed to environmental sustainability by reducing carbon emissions. France continues to invest in HSR innovations. Newer generations of TGV trains have been introduced, incorporating advancements in speed, energy efficiency and passenger comfort. Ongoing research and development projects aim to keep France at the forefront of HSR technology. France envisions further expansion of its HSR network, connecting additional cities and regions. Plans for international collaborations and the integration of HSR into broader European transportation networks are also on the agenda. France's HSR development, spearheaded by the TGV system, has set a global

benchmark for efficient, fast and sustainable rail travel. The success of the TGV is not only a testament to France's engineering prowess but also a symbol of the transformative impact that HSR can have on a nation's connectivity, economy and environmental footprint.

2.4 Japan case

The Shinkansen, Japan's vast and effective HSR networks of [Figure 6](#), are well-known worldwide. Just in time for the Tokyo Olympics, the Tokaido Shinkansen, the first Shinkansen line, opened for business in 1964. Since then, the network has grown, and major cities all throughout the nation are now connected by a number of Shinkansen lines. The Shinkansen is praised for its comfort, safety and timeliness. The trains are among the fastest in the world since they can go at speed of up to 320 km/h (200 mph). The system is a representation of Japan's commitment to transportation innovation and technical superiority. For example, the Tokaido Shinkansen connects Tokyo and Osaka, travelling 515 km in roughly 2 h and 30 min. Because it makes travelling quick and easy, the Shinkansen has had a big impact on how Japan's social and economic environment has developed. It is more than simply a means of transportation; it is a symbol of the country's dedication to technological advancement and excellence.

Japan has built many Shinkansen routes that link to Tokyo both directly and indirectly. When examining how the establishment of a transport network affects population



Source(s): <https://uic.org>

Figure 6. HSR networks in Japan

movement, route design plays a significant role (Hiramatsu, 2023). One element that influences the expansion of the regional economy is the existence of intermediate stations. New activity centres are unlikely to emerge at the minor or intermediate nodes of the network, as the main nodes are expected to receive priority from the HSR linkages. Miwa, Bhatt, Morikawa, and Kato (2022) stated that regional innovation has been sparked by HSR development in towns that have HSR stations or are close to them. More chances for information transfers among human capital may be produced by HSR's greater accessibility. Such an influence on regions might enhance their level of exposure to fresh outside information, supporting the well-liked regional innovation process of learning by interaction.

3. Finding and analysis

It becomes evident that HSR, being the transformative mode of transportation, has transcended its role as a mere conveyance system, assuming a pivotal position in shaping the socioeconomic and environmental landscapes of nations. The extensive networks and remarkable speeds achieved by HSR have not only compressed travel times between major urban centres but have also acted as catalysts for regional development. As we navigate through the data and insights, it is essential to uncover the advantages that HSR brings to the table – ranging from economic stimulation through increased connectivity to a reduction in carbon emissions as travellers opt for a more sustainable mode of transport. The finding and key focus area will shed light on the interdependence between efficiency, environmental consciousness and economic prosperity, illustrating how HSR has emerged not just as a conveyance of people but as a catalyst for economic growth in the case of the KL-SG corridor specifically.

The ability of HSR systems to enhance connectivity, stimulate investments, rejuvenate local economies and foster cultural exchange underscores their role as robust benchmarks for measuring economic growth on the international stage. In the pages that follow, this research paper delves into the multifaceted impact of the KL-SG HSR, unravelling the intricate connections between transportation infrastructure and national economic advancement. HSR has the potential to act as a transformative economic spine, intertwining various sectors of the economy and driving Gross Domestic Product (GDP) growth. Through enhanced connectivity, urban development, trade facilitation, tourism and innovation, HSR networks can foster a multiplier effect that reverberates throughout the economy, creating a foundation for sustained economic advancement. However, it is crucial to emphasize that successful implementation requires meticulous planning, effective governance and a comprehensive understanding of the specific economic, social and geographical context of each country.

3.1 Enhanced connectivity and accessibility

HSR networks bridge distances and eliminate geographical constraints, fostering the efficient movement of people, goods and ideas. This heightened connectivity stimulates regional integration, reduces travel times and facilitates access to markets, thereby augmenting trade volumes and economic transactions. HSR facilitates swift and frequent business travel, enabling professionals to engage in face-to-face meetings and negotiations across different cities. This strengthens business ties and promotes cross-border trade, fostering economic growth.

3.2 Attracting foreign direct investment (FDI)

Malaysia can attract foreign direct investment (FDI) for the development of HSR projects through a number of targeted channels, including infrastructure investment, logistics

optimization, partnerships with international companies and participation in the private sector.

There are opportunities for global infrastructure corporations to invest in Malaysia during the HSR project's construction phase. International companies with expertise in engineering, technology and rail systems may collaborate on the project or make direct investments. HSR stations and their surrounding areas become prime locations for real estate development. Foreign investors, particularly in the real estate sector, may see opportunities to invest in commercial, residential and mixed-use developments around HSR stations, driven by the increased connectivity and economic activity. With the HSR facilitating faster travel, there's potential for increased tourism. Foreign investors in the hospitality, tourism and entertainment sectors may explore opportunities to invest in hotels, resorts, theme parks and other amenities to cater to the growing number of visitors.

The improved transportation infrastructure provided by the HSR can attract foreign companies looking to optimize their logistics and supply chain operations. Investors in distribution centres, warehouses and logistics services may find Malaysia an attractive location due to its enhanced connectivity. HSR stations can become hubs for business and innovation. Foreign investors, especially those in the technology and innovation sectors, may consider investing in or establishing research and development centres, innovation hubs and startup incubators in proximity to HSR stations.

The Malaysian government can encourage FDI through joint ventures and partnerships with international companies. This can involve collaboration in the development, operation and maintenance of the HSR system, fostering technology transfer and knowledge exchange. Malaysia can offer specific incentives and policies to attract foreign investors interested in contributing to or benefiting from the HSR project. Establishing trade and economic zones along the HSR route can attract foreign investors looking for strategic locations to set up manufacturing facilities or regional headquarters. These zones can benefit from the efficient transportation facilitated by the HSR.

The Malaysian government can explore PPP models to fund and operate the HSR. Engaging private sector participation, both domestic and foreign, can bring in investment for the project whilst ensuring efficient operations and maintenance. Malaysia can position itself as a regional hub by leveraging HSR connectivity to neighbouring countries. This can attract foreign investors looking for a strategic base to access and serve the broader Southeast Asian market.

3.3 Revitalizing regional economies

HSR projects are magnets for foreign investors, drawn by the promise of improved logistics, reduced operational costs and increased market access. The presence of a robust HSR system signals a nation's commitment to modernization, innovation and its openness to global collaboration. Improved accessibility brought about by HSR can lead to a more equitable distribution of economic opportunities. Residents of smaller cities and towns can access better education, healthcare and employment opportunities in larger urban centres without the constraints of long travel times.

3.4 Urban development and cities regeneration

HSR stations often become focal points for urban development. The accessibility and convenience offered by these stations attract investments in the real estate, commercial spaces and hospitality sectors. As a result, new economic nodes emerge around HSR stations, leading to the creation of jobs, the growth of local businesses and increased tax revenues. The development of vibrant urban clusters can act as catalysts, infusing momentum into the overall economy and boosting GDP. Moreover, HSR is a remedy for disparities, channelling

growth to underserved areas and promoting equitable development. Rural regions are becoming integrated with urban cores, gaining access to better resources, education and economic prospects. This balanced approach is narrowing the divide between regions, fostering a more inclusive and harmonious national landscape.

The implementation of the KL-SG HSR project can be tailored to address the country's unique urban development challenges and opportunities by leveraging Kuala Lumpur as the primary HSR hub and enhancing its status as a regional economic and transportation hub. KL-SG HSR can contribute to developing the areas around the HSR stations with mixed-use developments, including business districts, commercial spaces and cultural amenities. Integration of the HSR system with existing and planned transportation infrastructure in Greater Kuala Lumpur is essential as well. This connectivity can stimulate urban development in the surrounding areas, such as Cyberjaya and Putrajaya, creating interconnected and accessible urban nodes. The planning should align the HSR with the Iskandar Malaysia development in Johor, creating opportunities for economic growth and urban regeneration in the southern region. When designing the station, it is envisaged that mixed-use developments around the HSR station, such as in Iskandar Puteri, will foster a vibrant urban environment.

KL-SG HSR should develop tourism corridors along the HSR route, connecting popular tourist destinations and enhancing urban development in cities like Seremban and Malacca to capitalize on increased tourism, create job opportunities and support local economies. By leveraging the HSR project, the options for the implementation of smart city initiatives in HSR-connected cities, such as deploying advanced transportation systems, smart grids and digital infrastructure, can be further explored. This can position Malaysia as a leader in smart city development and attract technology-focused investments. The rail plan also needs to prioritize eco-friendly urban design around HSR stations, incorporating green spaces, energy-efficient buildings and sustainable transportation options. This aligns with Malaysia's commitment to environmental sustainability and green urban planning. The alignment shall identify and develop regional economic clusters around HSR stations, focusing on sectors where Malaysia has a competitive advantage. This can include technology parks, innovation hubs and specialized industrial zones, attracting foreign investments and fostering economic diversity. By tailoring the HSR project to the specific needs and aspirations of Malaysian cities and regions, the country can unlock the full potential of urban development and regeneration, creating sustainable and resilient urban centres.

Beyond its physical infrastructure, HSR embodies a spirit of collaboration and integration. As stakeholders ranging from local governments to private entities unite for HSR projects, the culture of cooperation extends beyond the rail lines, influencing how infrastructural initiatives are approached on a broader scale.

3.5 Boosting tourism and cultural exchange

HSR facilitates swift and convenient travel between major cities and tourist destinations, promoting cross-border tourism. This influx of visitors stimulates local economies, stimulates cultural exchange and fortifies the tourism sector. HSR networks enable swift and convenient travel between tourist destinations and cultural hubs. This stimulates tourism by attracting both domestic and international visitors. The influx of tourists fuels demand for hospitality services, entertainment, dining and retail, contributing to the growth of the services sector and, subsequently, GDP. HSR significantly reduces travel times between major cities and tourist destinations. What used to be hours-long journeys by road or conventional rail can be shortened to a fraction of the time, making it more feasible for travellers to visit multiple places in a single day or take short getaways. The speed and

efficiency of HSR allow tourists to take day trips or weekend getaways to nearby destinations. This promotes regional tourism and encourages people to explore new places without the hassle of extended travel times. HSR networks often connect both major cities and lesser-known destinations. This opens up opportunities for tourists to explore a diverse range of locales, contributing to the growth of secondary and tertiary tourism markets. HSR offers a more comfortable and stress-free travel experience than air travel or long road trips. Tourists can enjoy spacious seating, onboard amenities and scenic views, all of which contribute to a more pleasant journey. HSR offers a more comfortable and stress-free travel experience compared to air travel or long road trips. However, the impact extends beyond economic growth. HSR is redefining how business is conducted and cultures are shared. Professionals can now undertake journeys that were once deemed unfeasible, engaging in face-to-face interactions, nurturing collaborations and expanding market reach across regions. This newfound proximity enriches not only their work lives but also contributes to a broader economic landscape. Culturally, HSR is inspiring a new chapter. The ease of travel is encouraging people to explore beyond their localities, fostering a unique cross-pollination of traditions, viewpoints and lifestyles. In this sense, HSR serves as a conduit, weaving together the diverse threads of a nation's identity. As people from varied backgrounds connect, learn and appreciate each other's differences, a newfound sense of unity emerges.

3.6 Human capital development

HSR projects can contribute to attracting and retaining talents and a skilled workforce within a country by creating an environment that offers enhanced mobility, better job opportunities and an improved quality of life. HSR networks connect distant cities and regions, making it easier for talented and skilled individuals to commute between their residences and workplaces. This mobility reduces the geographical barriers that might have otherwise limited their career options. HSR projects link major urban centres, economic hubs and industrial zones. This connectivity opens up a wider range of job opportunities for talented and skilled workers, enabling them to explore positions in different cities or regions without the need for relocation. Talented and skilled workers may prefer to live in more affordable or desirable areas whilst working in larger urban centres. HSR enables them to commute quickly and comfortably, maintaining a work-life balance and benefiting from the advantages of both locations. HSR stations can become hubs of economic activity, leading to urban development and the growth of businesses around the station areas. This creates job opportunities and attracts talent to regions that might have been less attractive for work previously. Shorter travel times via HSR allow talented and skilled workers to spend more time with their families and pursue recreational activities. This improved work-life balance can be a significant draw for individuals considering where to live and work. HSR networks can facilitate specialized employment in fields where expertise is concentrated in specific cities or regions. Professionals in sectors such as technology, research and finance can leverage HSR to access their niche job markets. HSR projects often bring together experts from different regions for conferences, workshops and collaborative projects. This fosters knowledge exchange, innovation and networking opportunities for talented and skilled workers. HSR can discourage the migration of talents to foreign countries by providing attractive opportunities within the country. Talented individuals are more likely to stay or return when they perceive the presence of a robust job market and enhanced connectivity. As talented and skilled workers are attracted to areas with strong economic prospects, HSR's role in promoting economic development can indirectly contribute to job creation and talent retention. The improved connectivity and accessibility provided by HSR can make a significant difference in retaining and attracting talent within a country, thereby contributing to its economic and social growth.

3.7 Regional integration

HSR networks facilitate the easy movement of people and resources between regions. This encourages regions to specialize in their comparative advantages, leading to more efficient resource allocation and increased productivity. Industries can focus on their strengths whilst relying on other regions for complementary resources, thereby stimulating economic diversification and augmenting GDP growth. HSR stations are typically integrated into existing transportation networks, allowing travellers to seamlessly transfer between different modes of transportation, such as buses, metros and airports. This “last-mile” connectivity ensures a smooth travel experience from origin to destination. HSR networks connect cities and regions that were previously separated by long travel times. This regional integration can stimulate economic collaboration, joint development projects and more efficient resource allocation, leading to increased economic activity and cooperation. What sets HSR apart is not only its velocity but also its potential for forging connections. HSR stations, arising as focal points of activity, serve as gateways where bustling urban centres meet previously untouched landscapes. Around these stations, vibrant ecosystems of commerce, hospitality and culture flourish, infusing life into previously overlooked areas. Suddenly, regions that were once labelled as underdeveloped find themselves at the crossroads of progress, benefiting from investments, job opportunities and a chance to thrive.

3.8 Environmental and sustainability benefits

HSR projects often have a lower carbon footprint compared to other modes of transportation, especially air travel and road transportation. This aligns with sustainable development goals and resonates positively with environmentally conscious investors and travellers. HSR systems contribute to the reduction of carbon footprints through several mechanisms that make them more environmentally friendly than other modes of transportation, such as air travel and road transportation. HSR trains are designed for high-speed travel with minimal air resistance and their streamlined shape reduces energy consumption per passenger-kilometre compared to conventional trains and cars. Additionally, HSR trains often use regenerative braking systems, which convert kinetic energy back into electrical energy, reducing overall energy consumption. HSR systems have the capacity to carry a large number of passengers in a single train, leading to a higher number of passengers per unit of energy consumed. This results in lower carbon emissions per passenger-kilometre travelled than individual cars or aeroplanes. HSR helps alleviate congestion on roads and at airports by offering an efficient and competitive alternative for medium-distance travel. As more people choose HSR over cars and domestic flights, there is a reduction in emissions associated with road congestion and air travel. HSR encourages a shift from other modes of transportation that are more carbon-intensive, such as short-haul flights and long car journeys. As passengers choose HSR over these alternatives, carbon emissions are reduced. HSR networks are often powered by electricity, which can be generated from renewable or low-carbon sources such as wind, solar, hydro or nuclear power. This reduces the emissions intensity of HSR operations compared to fossil-fuel-powered vehicles. HSR requires less land and infrastructure than expanding roadways and building additional airports. This minimizes land degradation and deforestation, both of which contribute to carbon emissions. The environmental benefits of HSR can lead to increased public awareness about the carbon footprint of transportation choices. This can encourage individuals to choose more sustainable travel options, including HSR.

4. Conclusion

The KL-SG HSR, linking Kuala Lumpur and Singapore, epitomizes the potential for HSR to be a transformative agent in the realm of economic development. This project encapsulates the aspirations of two dynamic Southeast Asian economies, united in their pursuit of sustainable growth, enhanced connectivity and global competitiveness. By scrutinizing the KL-SG HSR through the lens of economic benchmarking, a deeper understanding emerges of how such projects can drive progress in areas such as cross-border trade, tourism, urban development and technological innovation.

The KL-SG HSR project serves as a symbol of the region's dedication to enhancing connectivity, fostering economic growth and promoting cross-border collaboration. Upon its completion, the project is positioned to revolutionize regional transportation, exerting a substantial influence on travel, commerce and tourism dynamics between Malaysia and Singapore.

The implementation planning of HSR's needs to be carefully examined from the perspective of environmental constraints. The detailed execution planning needs to consider the forecast socioeconomic benefits for the urban and regional areas. In the current government's financial condition, the best procurement method and financial model need appraisals. The selection of the most suitable governance structure and processes needs to be put in place to ensure that the delivery will be scheduled on time. As the global community becomes increasingly interconnected, the significance of transportation infrastructure in shaping national economies becomes incontrovertible. There will be a need to evaluate the broader socioeconomic impact of the deployed HSR system and more attention should also be paid to the evaluation of technological, financial and operational sustainability.

References

- Boehm, M., Arnz, M., & Winter, J. (2021). The potential of high-speed rail freight in Europe: How is a modal shift from road to rail possible for low-density high value cargo? *European Transport Research Review*, 13(1), 4. doi: [10.1186/s12544-020-00453-3](https://doi.org/10.1186/s12544-020-00453-3).
- Chen, J., & Guo, G. (2023). Diversification or specialization: Measuring the impact of high-speed rail connection on technological diversity in China. *Journal of Innovation and Knowledge*, 8(1), 100306. doi: [10.1016/j.jik.2023.100306](https://doi.org/10.1016/j.jik.2023.100306).
- Damián, R., & Zamorano, C. I. (2023). Life cycle greenhouse gases emissions from high-speed rail in Spain: The case of the Madrid – Toledo line. *Science of the Total Environment*, 901, 166543. doi: [10.1016/j.scitotenv.2023.166543](https://doi.org/10.1016/j.scitotenv.2023.166543).
- Guirao, B. (2013). Spain: Highs and lows of 20 years of HSR operation. *Journal of Transport Geography*, 31, 201–206. doi: [10.1016/j.jtrangeo.2013.05.010](https://doi.org/10.1016/j.jtrangeo.2013.05.010).
- Hiramatsu, T. (2023). Inter-metropolitan regional migration galvanized by high-speed rail: A simulation analysis of the linear Chuo Shinkansen line in Japan. *Socio-Economic Planning Sciences*, 85, 101268. doi: [10.1016/j.seps.2022.101268](https://doi.org/10.1016/j.seps.2022.101268).
- Laroche, F. (2023). Goodbye monopoly: The effect of open access passenger rail competition on price and frequency in France on the high-speed Paris–Lyon line. *Transport Policy*, 147, 12–21. doi: [10.1016/j.tranpol.2023.09.019](https://doi.org/10.1016/j.tranpol.2023.09.019).
- Levinson, D. M. (2012). Accessibility impacts of high-speed rail. *Journal of Transport Geography*, 22, 288–291. doi: [10.1016/j.jtrangeo.2012.01.029](https://doi.org/10.1016/j.jtrangeo.2012.01.029).
- Miwa, N., Bhatt, A., Morikawa, S., & Kato, H. (2022). High-speed rail and the knowledge economy: Evidence from Japan. *Transportation Research Part A: Policy and Practice*, 159, 398–416. doi: [10.1016/j.tra.2022.01.019](https://doi.org/10.1016/j.tra.2022.01.019).

-
- Sanchis, I. V., López, M. R. A., Franco, R. I., Fernández, P. M., & Zuriaga, P. S. (2023). The liberalisation of high-speed rail services in Spain: Ticket price in the Madrid-Barcelona corridor. *Transportation Research Procedia*, 69, 608–615. doi: [10.1016/j.trpro.2023.02.214](https://doi.org/10.1016/j.trpro.2023.02.214).
- Sun, Y., Razaq, A., Kizys, R., & Bao, Q. (2022). High-speed rail and urban green productivity: The mediating role of climatic conditions in China. *Technological Forecasting and Social Change*, 185, 122055. doi: [10.1016/j.techfore.2022.122055](https://doi.org/10.1016/j.techfore.2022.122055).
- Wang, S., Zhou, Y., Guo, J., & Mao, J. (2023). Did high speed rail accelerate the development of tourism economy? – Empirical analysis from Northeast China. *Transport Policy*, 143, 25–35. doi: [10.1016/j.tranpol.2023.09.004](https://doi.org/10.1016/j.tranpol.2023.09.004).
- Yang, H., Du, D., Wang, J., Wang, X., & Zhang, F. (2023). Reshaping China’s urban networks and their determinants: High-speed rail vs air networks. *Transport Policy*, 143, 83–92. doi: [10.1016/j.tranpol.2023.09.007](https://doi.org/10.1016/j.tranpol.2023.09.007).

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