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Article

Socioeconomic Benefits of the Shinkansen Network

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Abstract: High speed rail (HSR) networks have been an essential catalyst in stimulating and balancing regional economic growth that ultimately benefits the society as a whole. Previous studies have revealed that HSR services sustainably yield superior social values for people, especially for adults and those of working age. This has become an advantage of HSR networks over other forms of public transportation. The Shinkansen network in Japan is one of most successful HSR models. Its services bring significant social advantages to the communities it serves, such as shorter travel times and increased job opportunities. Nevertheless, the societal impact of HSR networks depends on many factors, and the benefits of HSR could also be overrated. The goal of this research is to measure the socioeconomic impacts of HSR on people of all genders and age groups. The outcomes could lead to more suitable development of HSR projects and policies. This study investigates data sets for Japanese social factors over 55 years in order to determine the impacts of HSR. The assessment model has been established using Python. It applies Pearson's correlation (PCC) technique as its main methodology. This study broadly assesses social impacts on population dynamics, education, age dependency, job opportunities, and mortality rate using an unparalleled dataset spanning 55 years of social factors. The results exhibit that younger generations have the most benefits in terms of equal educational accessibility. However, the growth of the HSR network does not influence an increase in the employment rate or labour force numbers, resulting in little benefit to the workforce.

Keywords: socioeconomic impacts; population dynamic; high-speed rail (HSR); sustainability; transport and policy

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1. Introduction

Railway transport is the safest and the most environment-friendly mode of transport. However, the socioeconomic impacts of high-speed rail (HSR) have become a global debate in various political arenas. Many experts have claimed that HSR services generate benefits to a society, but it has not been possible to evaluate the extent of the HSR's impacts. Many researchers have attempted to adopt various statistical methods to assess HSR's actual social impacts. However, the scope of research outcome is inadequate since HSR networks can be affected by various conglomerate factors, such as geography, station locations, and population incomes.

HSR networks have been considered to be a new and smart alternative form of public transportation, and have become highly competitive compared with other modes of transportation for medium-distance journeys. Japan's HSR network, the Shinkansen, is considered as one of the greatest HSR networks. The operation of Japanese HSR services has influenced the lives of residents and has ultimately offered various social benefits in terms of population dynamics and the country's workforce (especially to adults). The Shinkansen network shares the market with four other modes of transportation (i.e., buses, ferries, cars, and airplanes) and has become the most competitive service for distances between 500 and 700 km, gaining 69.1% of the total market share [1]. Similarly, other studies showed that HSRs gain the greatest market share when implemented for the

distance between 483 and 692 km [2–5]. HSR has brought the advantage of greater mobility to local communities across the service area, widening the opportunities for the society.

HSR acts as a catalyst to connect urban and suburban areas, and its service enables economic growth. The vast and seamless connections of the network are of great interest to HSR passengers. As an illustration, China's HSR network has become the most extensive network in the world, containing over 15,000 km of HSR tracks [6]. The HSR system enables Chinese people to travel across the country and links China with its borders, directly enlarging its markets. The HSR network is expected to enhance China's GDP by approximately 1–3%. Additionally, significant extension of HSR networks has also occurred in Europe, showing a growth in networks from 643 km in 1985 to 7343 km in 2013 [6], and raising the market share in most of the European countries [7]. These European HSR networks enable passengers to travel across borders and stimulate the economy by increasing productivity, growing the workforce, and enlarging markets [8,9]. The HSR services undoubtedly reflect advantages for adult commuters in terms of business and jobs. On the other hand, no study has examined the impact of HSR networks on young and elderly groups of passengers. Therefore, this research aims to fill these gaps by analysing the effects of HSR and relevant social factors on every passenger of all generations.

This research considers Japan's HSR network as a case study for evaluating the socio-economic impacts stemming from the growth of the Shinkansen network. One way to overcome issues of uncertainties within the study is to use the long-term datasets of social factors to derive a correlation with the growth of the Shinkansen network. In addition, correlation and PCC models have been established using Python. The research focuses on 12 critical factors related to socioeconomic impacts in Japan. The outcomes of this study can represent exactly how HSR networks will benefit society. Additionally, the models can be applied to HSR systems in other countries in order to measure the actual impacts of the HSR networks, which can lead to good decision-making for any future HSR development.

2. Methodology

To evaluate the social impacts of HSR services in Japan, long-term data on social factors has been collected from the World Bank [10], which is considered a reliable data source. Twelve social factors to be considered in this study have been identified, involving population dynamics, educational, local economic, and workforce issues. All 12 data sets were compiled for 55 years between 1964 and 2019. Data preprocessing has been conducted to validate the information. After identifying missing data for some of the selected social factors, a k-nearest neighbor (kNN) model was created through Python to predict missing values. A correlation analysis was then undertaken to measure the impacts of the HSR network growth on these social factors, as shown in Figure 1.

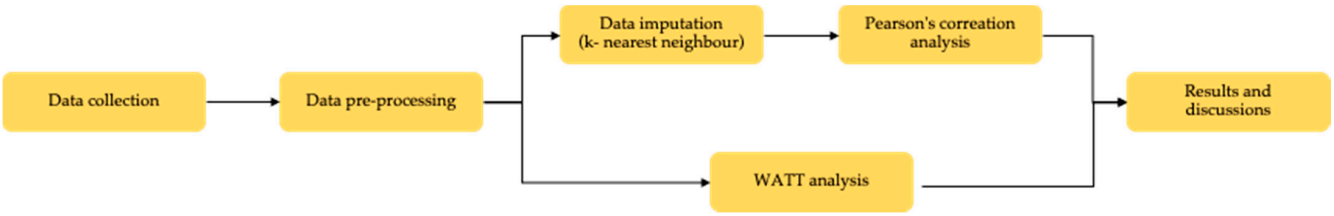

Figure 1. An overview of research's methodology to measure socioeconomic impacts of an HSR system.

2.1. K-Nearest Neighbour (kNN)

The kNN algorithm is used to replace missing values in the data sets. The concept of kNN is to substitute missing values with the most similar complete values. The k value can vary depending on the amount of complete data in the data sets. For example, when k is selected as 3 (k = 3), the three nearest data points are calculated using the selected functions (i.e., Euclidean, Manhattan, Pearson) to create and insert a new value for the missing one. However, the selection of the k value must be carefully considered because inappropriate selection can result in poor model performance in terms of estimation. A lower k-value may indicate the lack of conformity to the trend in the data set, whereas a higher k value may be included with other disturbance values [11]. The best solution for finding a k value is to test different k values in the data sets to reduce arbitrary error [12]. This study uses the standard Euclidian distance form, as shown in Equation (1).

In this study, the kNN is used to predict missing values in the World Bank's official report.

$$d(p,q) = \sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2 + \cdots + (p_n - q_n)^2} \quad (1)$$

where: d = Euclidean distance between the point p and q, $p = \{p_1, p_2, \ldots, p_n\}$, $q = \{q_1, q_2, \ldots, q_n\}$, and n = number point p and q from 0 to n.

2.2. Pearson's Correlation Analysis

Pearson's correlation coefficient has been successfully applied in various statistical studies [13–16]. It is commonly used to measure the relationship between two variables, and the results range from −1 to 1. There are multiple aspects of the data analysis of the correlation between two factors depending on the area of study; for example, the range of strong relationships is 0.7–0.9 in psychology, 0.4–0.6 in politics, and 0.8–0.9 in medicine [17]. In this research, a value in the range ±0.1 to ±0.3 means a weak relationship, ±0.3 to ±0.5 means a moderate relationship, and ±0.5 to ±1.0 means a strong relationship. A positive value means that both factors are in direct variation, whereas a negative value means both factors are in inverse variation.

In this study, the Pearson's correlation is taken to measure the correlation between social factors and the growth of the Shinkansen network, as shown in Equation (2):

$$\mathrm{P} = \frac{\sum(X_i - X)(Y_a - Y)}{\sqrt{\sum(X_i - X)^2 \ \sum(Y_a - Y)^2}} \quad (2)$$

where P = correlation coefficient; X_i = values for social factor i; X = mean of the values for social factor i; Y_a = the length of Shinkansen network in year a; Y = mean length of the Shinkansen network.

2.3. Weighted Average Travel Time (WATT)

This study uses WATT to measure accessibility in Japan. In addition, it can be used to compare conventional rail and HSR services.

$$WATT_a = \frac{\sum_{b=1}^{B} M_b * tt_{ab}}{\sum_{b=1}^{B} M_b} \quad (3)$$

where: $WATT_a$ = Weight average travel time, M_b = population density of station, tt_{ab} = travel time from origin a to b.

3. Result and Discussions

From the Pearson's correlation analysis among 12 social factors and the growth of the Shinkansen network, the outcomes represent values between −1 and 1, as described in Table 1 and Figure 2.

The benefits of HSR networks can be classified as either direct and indirect effects on a society. The core concept of HSR is to build on the improved train performance in terms of speed. The first era of rail transportation was characterized by lower train velocities. One obvious benefit of trains is the increased accessibility. Table 2 shows the WATT analysis results for the Shinkansen network of Honshu area. The results for the Shinkansen network represent time saving of at least 25% compared with conventional trains on the same routes.

Table 1. The summary of PCC results of Japan's socioeconomic factors.

Socioeconomic Factors	PCC Result
Population	0.9428
Age dependency ratio for young group	−0.9419
Age dependency ratio for elderly group	0.8751
School enrolment, primary	0.2425
School enrolment, secondary	0.9641
School enrolment, tertiary	0.9217
Progression to secondary school	0.6935
Primary completion rate	0.2378
Labour force participation rate	−0.7483
Employment to population ratio	−0.7775
Unemployment	0.6577
Proportion of seats held by women in national parliaments	0.5958

Table 2. The summary of Shinkansen services in the Honshu area and WATT analysis.

Train Operators	Lines	Route	Distance (km)	Number of Stations	WATT Analysis (mins) [a]	
					Conventional Rail	HSR
JR West	Hokuriku	Tokyo–Kanazawa	345.4	18	240	148
	Sanyo	Shin Osaka–Hakata	553.7	19	224	137
JR Central	Tokkaido	Tokyo–Osaka	552.6	17	587	142 (Nozomi), 180 (Hikari), 240 (Kodama)
JR East	Tohoku	Tokyo–Shin Aomori	713.7	26	242	143
	Joetsu	Tokyo–Niigata	333.9	13	Inaccessible	120
	Yamagata	Tokyo–Shinjo	421.4	16	203	149
	Akita	Tokyo–Akita	670.2	16	306	229

[a] The WATT analysis used the data from official report of Shinkansen's operators [18–20].

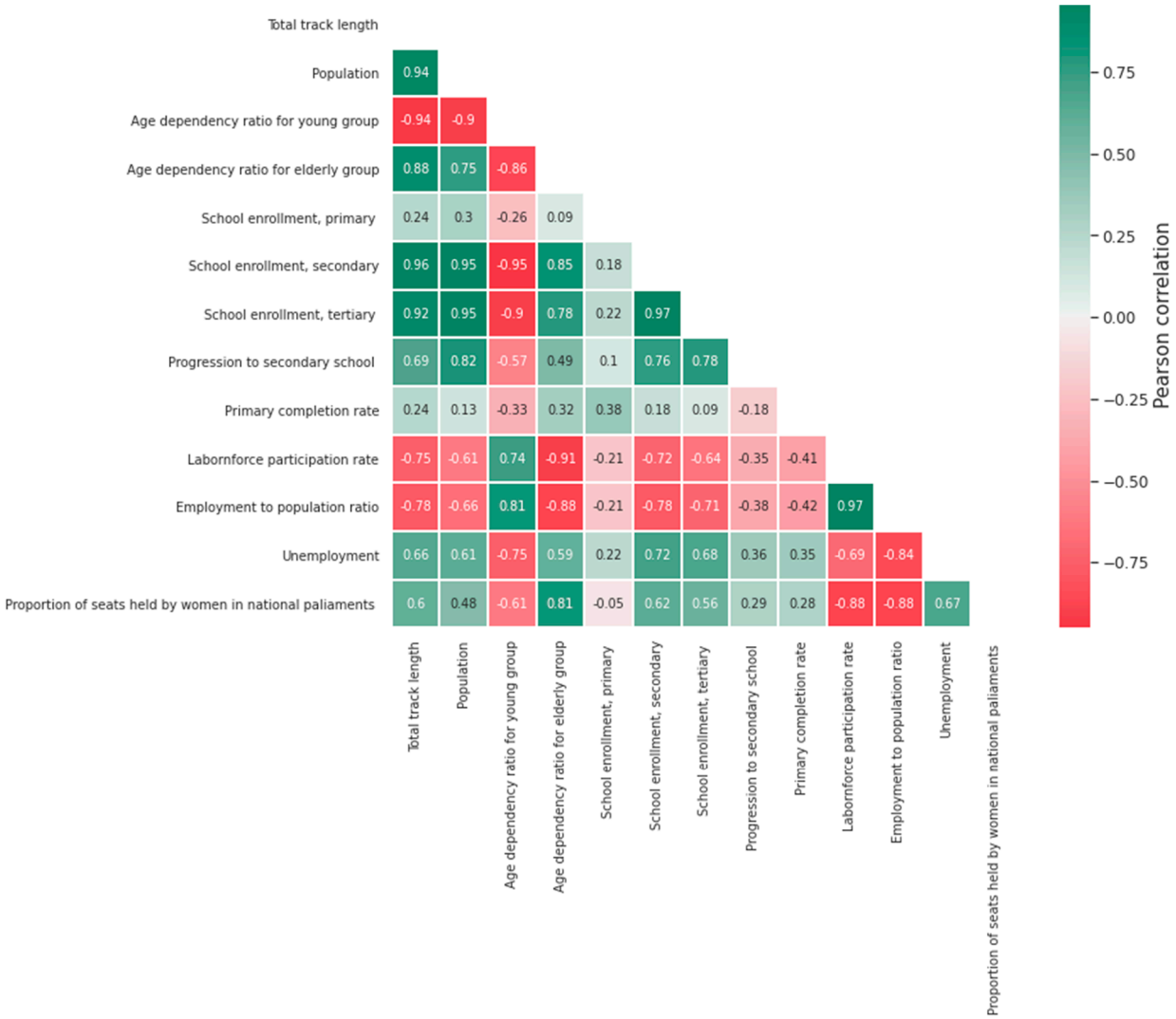

Figure 2. The PCC result of the Japanese rail network and social impacts in Japan.

With respect to JR West, the maximum reduction in travel time from that of conventional rail is 38.83% for the Sanyo Shinkansen. The Tokkaido Shinkansen, the most popular Shinkansen service, has three different train classes in services, namely Nozomi, Hikari and Kodama. The fastest train has a travel time saving of 76.15% compared to the conventional line. Overall, Shinkansen services reduce travel time by between 25.16% (Akita Shinkansen) and 40.90% (Tohoku Shinkansen) compared with JR East's conventional lines. As a result, remarkably shortened service times and increased station accessibility provide a potential impact on Japanese society.

Socioeconomic benefits are recognized as indirect effects of HSR services. With growing demand for services, an increased demand for tourists in areas with HSR services can also be expected. Figure 3 illustrates the coverage of the Shinkansen network with the total operating distance of 3066.2 km. The transportation system is one of the critical factors that induces passengers to travel [21–24]. The volume of traffic has been found to have increased by 10% in the short-term, reducing 20% of the travel time in HSR corridors [22]. Therefore, social and economic conditions can be improved as a side effect (or secondary benefit) of HSR (i.e., population growth and educational benefits).

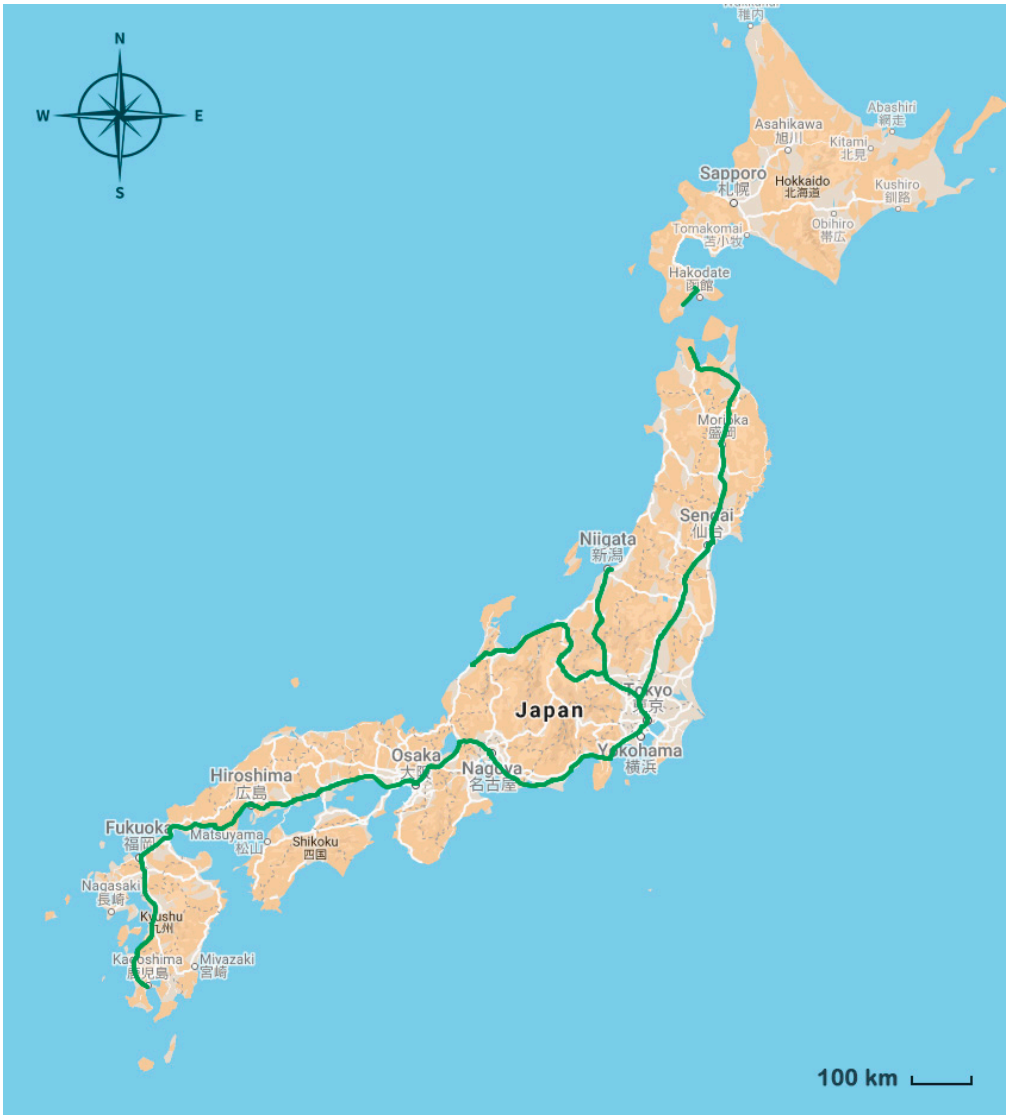

Figure 3. An overview of the Shinkansen's infrastructure.

Through the PCC analysis, 12 social factors have been evaluated, and can be split into three groups: population dynamics, educational, and local economics/workforce.

3.1. Population Dynamics

The dynamics of population relate to accessibility of urbanization, relocation, and other relevant factors such as accommodation and workplaces. It is found that the trend in population growth has been marginally higher along HSR lines after the Tokkaido Shinkansen came into service [24,25], and those cities with HSR stations have 22% higher growth than cities without HSR [23,26]. Moreover, half of those prefectures contain at least one HSR station, and had a population growth higher than the national average. The Tohoku HSR line's effects are shown to represent a population growth of 32% in cities close to HSR stations, whereas the remaining areas have shown no significant population growth [27].

The benefits of increasing regional accessibility are revealed from the time-space convergence effect [28]. Also, HSR services increase spatial disparity in a region, with long-term connectivity benefits to people who live in areas close to HSR stations [29,30]. Moreover, the provision of HSR services increases the quality of affected residential areas, because they serve people's need for accessible travel, which enhances visits or work travel between places. This has been evidenced by the increased in property prices around

stations. Buildings can therefore gain a positive connectivity impact from their locations close to stations. It is noted that commercial properties within 0.25 miles of stations are 12.2% more expensive than other residential properties. Also, there is a variation of 4.2% in prices shown between areas close to railway stations and other business zones [31]. In addition, the areas close to railway stations connected to central business districts (CBD) have received the most significant impacts on property prices [32]. The statements above precisely show that HSR services have positive effects on quality of life.

A strong positive relationship (R = 0.924) has been found between the development of Shinkansen networks and the benefits to Japanese residents. Similarly, the potential impact on population dynamics due to Shinkansen services is shown in some areas [33]. In terms of age dependency, the younger and older generations have been investigated. The outcome for the younger generation is −0.9419, and for the older generation is 0.8751. It is interesting to note that the advent of the Shinkansen network has offered more benefits to the elderly than to younger age groups.

3.2. Educational Factors

Access to proper education is one of the crucial factors that have driven society forward. This research measures the opportunities for children to attend three school levels (primary, secondary, and tertiary). These factors demonstrate how HSR services can impact the younger generation. In fact, children in developing countries have faced problems because of the lack of educational opportunities [34]. Some studies have revealed that many children must walk to/from school for up to six hours daily because their homes are so far from the nearest school. Additionally, this issue still prevails in the suburban areas of developed countries, since children require a higher standard of education equivalent to that of city children. Therefore, the development of the HSR networks can remove the barriers to a standard education system.

Hence, the benefits of HSR services for the young generation should be measured by the school attendance rate that reflects educational opportunities. This research has collected information from the school enrolment data for the primary, secondary, and tertiary levels in Japan, demonstrating the positive relationships with the growth of Shinkansen networks. It is worth discussing these promising outcomes revealed by the enrollment rate results for secondary and tertiary school, which are 0.9641 and 0.9217, respectively. Moreover, the result of the progression to secondary school is 0.6935. This can be interpreted to mean that the Shinkansen networks provide benefits to the younger generation in order to enhance their educational opportunities.

3.3. Local Economic Benefit and the Workforce

With respect to the economy in Japan, Shinkansen services seem to have only affected the labor market at the beginning of their operational periods. Many researchers had evaluated the Shinkansen network's impacts on population dynamics as including the effects on employment and the labor force. Cities with HSR stations have gained 16–34% higher employment growth. Growth rates are found to be 1.8% in areas connected to HSR stations, but they are only 1.3% in those areas without HSR stations [35]. Reportedly, the employment rate has decreased through the following years. While the result has showed an overall fall of only 2.8% in 1989, it has reduced by 3.6% in the areas without HSR. In comparison, the information technology (IT) sector has risen to 22% [36]. These comparison imply that the Shinkansen network's impact is associated with a very limited part of the labor market. The businesses involved, such as food retailing and the accommodation sector, need a higher degree of accessibility to stations [26,36,37]. On the other hand, the HSR network has increased job opportunities for women [37,38]. This study has investigated the proportion of seats held by women in the national parliament as a factor in this study. The outcome is 0.5958, which illustrates a strong positive relationship with the HSR network. However, job opportunities for women can also be measured in other sectors. This assumption might be addressed in future studies.

However, the outcomes of this study in terms of the labor force and employment rate are −0.7483 and −0.7775, respectively. Moreover, the result for the unemployment rate is 0.6577. This reveals that the overall advantage of the Shinkansen network for the Japanese labor market has decreased, as shown in specific sectors and locations. Similarly, the study's PCC result for employment is 0.1375, indicating a low positive correlation with the growth of the Shinkansen network.

In Figure 4, the PCC results exhibit that the quality of living, the educational and local economics, and the workforce pillars are 0.0800, 0.4120 and 0.1375, respectively. The results raise the average PCC of all factors to 0.2098, which implies that the Shinkansen network has relatively small socioeconomic benefits.

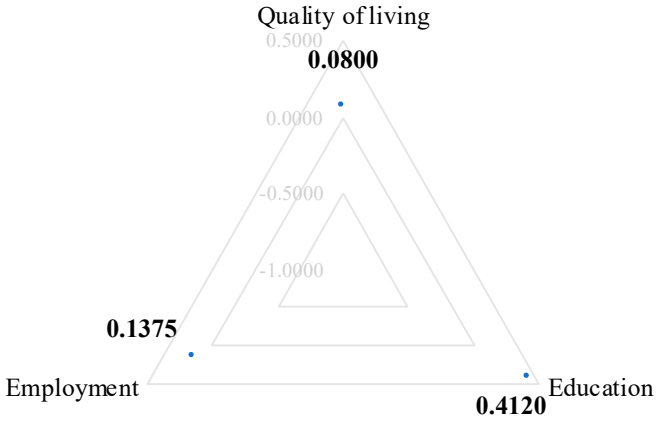

Figure 4. The comparison on the radar charts of quality of living, education, and employment in Japan.

4. Policy Implications

This study suggests that the government can increase opportunities for adults and the workforce through a suitable and robust design of sustainable development policies related to the Shinkansen network.

First, the development of business areas and office space close and connected to HSR stations can increase job opportunities. HSR stations close to central business districts are able to increase job rates because secured and convenient services are offered to workers [21,38–40]. Also, workplaces within walking distance of HSR stations can become an essential criterion for job seekers and new businesses for greener urban innovation towards net zero or even negative emissions [41,42].

Next, special weekday tickets for workers should be considered. Most rail authorities offer specially priced tickets for children and the elderly. However, the authorities should also offer weekday access to workers who regularly travel between their workplaces and homes. This study underpins that the affordable connectivity strategy can generate better long-term benefits for the workforce and the country's economy. HSR station can act as a hub for services and can build on synergies that attract secondary and tertiary revenues [43,44].

Lastly, the HSR timetable should be rescheduled to support workers' demands, especially in the suburban areas. This would be an extraordinary benefit for people who require on-demand access to early and late services to be timetabled.

5. Conclusions

This study determines the social impacts of the Shinkansen network on Japan's residents and the economy. The research aims to evaluate social benefits that can lead to sustainable development policies for future HSR networks. This study is the world's first study to provide quantitative evidence underpinning the socioeconomic benefits stemming from an HSR network. Some scholars have highlighted the social impacts of HSR services, but most previous studies had focused only on adults. Such studies cannot truly reflect a

society in its entirety. This study has produced unparalleled long-term datasets collected for 12 social factors in Japan since 1964. Although the collected data sets have some missing information, the data imputation method (kNN) has been used to predict those missing values. This study has also established a new evaluation model based on Pearson's analysis as a critical methodology.

Our new findings indicate that Japanese HSR services contribute to the social impact differently, especially when considering different generations. Previous studies had suggested that HSRs can benefit workers and stimulate the Japanese economy. However, this study is the first to illustrate that the younger and adult generations enjoy greater opportunities than the adult or worker groups. The social impacts are evidenced by school enrolments. The primary, secondary, and tertiary enrolment rates demonstrate a strong relationship with the growth of the HSR network. This can be confirmed by an increase in the average PCC value for educational factors of 0.4120.

On the other hand, the impact on the adult workforce and the availability of job opportunities has not been significant. The results illustrate that the average value of employment opportunities for all genders is -0.7278, which denotes a strong negative relationship. However, this study also reveals that HSR generates clear benefits in terms of women's job opportunities; for instance, in the national parliament.

6. Study Limitations and Future Works

This research assesses the socioeconomic benefits of the Shinkansen network in Japan by cross-investigating 12 socioeconomic factors. The results are presented with reference to Pearson's correlations. However, some limitations of this research should be noted.

First, the socioeconomic factors were recorded between 1964 and 2019, enabling a comprehensive data set. Nevertheless, any adjustment of the dataset (e.g., evaluation period, variables) will in turn change these socioeconomic impacts. Second, the study focuses only on the impact of HSR on Japanese society. The findings and policy implications are related only to Japan. Therefore, an analysis using local data sets is necessary to develop a suitable framework for other countries.

For future works, the review of the socioeconomic benefits can be implemented for other countries such as China, France, South Korea, and Spain. The results could be compared to indicate cultural differences between Asian and European countries. Lastly, an in-depth analysis of job opportunities in each sector could be conducted with respect to the expansion of HSR networks. The outcomes could lead to sustainable development suitable for each particular network.

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References

1. Kojima, Y.; Matsunaga, T.; Yamaguchi, S. The impact of new Shinkansen lines (Tohoku Shinkansen (Hachinohe—Shin-Aomori) and Kyusyu Shinkansen (Hakata—Shin-Yatsushiro)). *Transp. Res. Procedia* **2017**, *25*, 344–357. [CrossRef]
2. Albalate, D.; Bel, G. High-Speed Rail: Lesson for Policy Maker from Experiences Aboard. *Public Adm. Rev.* **2012**, *72*, 336–349. [CrossRef]
3. MLIT (Ministry of Land, Infrastructure, Transport and Tourism Government of Japan). Inter-Regional Travel Survey in Japan. Available online: http://www.mlit.go.jp/common/001005633.pdf (accessed on 4 March 2021).
4. Chen, Z.; Wang, K.; Ai, Y.W.; Gao, H.; Fang, C. The effects of railway transportation on the enrichment of heavy metals in the artificial soil on railway cut slopes. *Environ. Monit. Assess.* **2010**, *186*, 1039–1049. [CrossRef]
5. Gundelfinger, C.; Coto-Millán, P. Intermodal competition between high-speed rail and air transport in Spain. *Util. Policy* **2016**, *47*, 12–17. [CrossRef]
6. European Paliament. High-Speed Rail in the EU. Available online: http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568350/EPRS_BRI(2015)568350_EN.pdf (accessed on 12 March 2018).
7. E.U. Transport in Figure Statistic Pocketbook 2014. Available online: https://ec.europa.eu/transport/sites/transport/files/facts-fundings/statistics/doc/2014/pocketbook2014.pdf (accessed on 12 March 2018).
8. Chen, C.L.; Vickerman, R.W. *Quantifying the Economic and Social Impacts of High-Speed Rail: Some Evidence from Europe and the People's Republic of China, Working Paper Nr 962*; Asian Development Bank Institute: Tokyo, Japan, 2021; Available online: https://www.adb.org/publications/quantifying-economic-and-social-impacts-hsr-evidence-europe-prc (accessed on 5 March 2021).
9. Chen, H.; Sun, D.; Zhu, Z.; Zeng, J. The Impact of High-Speed Rail on Residents' Travel Behavior and Household Mobility: A Case Study of the Beijing-Shanghai Line, China. *Sustainability* **2016**, *8*, 1187. [CrossRef]
10. World Bank. World Bank Open Data. 2020. Available online: https://databank.worldbank.org/home.aspx (accessed on 31 December 2020).
11. *Secondary Analysis of Electronic Health Records*; Springer: Basingstoke, UK, 2016. [CrossRef]
12. Beretta, L.; Santaniello, A. Nearest neighbor imputation algorithms: A critical evaluation. *BMC Med Inform. Decis. Mak.* **2016**, *16*, 197–208. [CrossRef] [PubMed]
13. Hwang, S.H.; Yoon, C.S.; Ryu, K.N.; Paik, S.Y.; Cho, J.H. Assessment of airborne environmental bacteria and related factors in 25 underground railway stations in Seoul, Korea. *Atmos. Environ.* **2011**, *44*, 1658–1662. [CrossRef]
14. Huang, Y.; Lu, S.; Yang, X.; Zhao, Z. Exploring Railway Network Dynamics in China from 2008 to 2017. *ISPRS Int. J. Geo-Inf.* **2018**, *7*, 320. [CrossRef]
15. Zemp, S.; Stauffacher, M.; Lang, D.J.; Scholz, R.W. Classifying railway stations for strategic transport and land use planning: Context matters! *J. Transp. Geogr.* **2011**, *19*, 670–679. [CrossRef]
16. Akoglu, H. User's guide to correlation coefficients. *Turk. J. Emerg. Med.* **2018**, *18*, 91–93. [CrossRef] [PubMed]
17. Yao, E.; Morikawa, T. A study of an integrated intercity travel demand model. *Transp. Res. Part A Policy Pract.* **2005**, *39*, 367–381. [CrossRef]
18. Central Japan Railway Company. Available online: https://global.jr-central.co.jp/en/company/ir/annualreport/ (accessed on 3 April 2021).
19. EAST Japan Railway Company. Available online: https://www.jreast.co.jp/e/investor/ar/2019/ (accessed on 3 April 2021).
20. WEST Japan Railway Company. Available online: https://www.westjr.co.jp/global/en/ir/library/annual-report/ (accessed on 3 April 2021).
21. Litman, T. Evaluating Transport Economic Development Impacts: Understanding How Transport Policy and Planning Decisions Affect Employment, Incomes, Productivity, Competitiveness, Property Value and Tax Revenue. *Vic. Transp. Policy Inst.* **2010**. Available online: http://www.dphu.org/uploads/attachements/books/books_3286_0.pdf (accessed on 4 March 2021).
22. Amano, K.; Nakagawa, D. *Study on Urbanization Impacts by New Stations of High-Speed Railway*; Korean Transportation Association: Dejeon City, Korea, 1990.
23. Sinha, K.C.; Labi, S. Social Impacts of Transportation Projects. In *Transportation Decision-Making: Principles of Project Evaluation and Programming*; Wiley: Hoboken, NJ, USA, 2007.
24. Okada, H. Features and Economic and Social Effects of The Shinkansen, 30 Years of High-Speed Railways. *Jpn. Railw. Transp. Rev.* **1994**, *3*, 9–16.
25. Hirota, R. Present situation and effects of the Shinkansen. *Transp. Policy Decis. Mak.* **1985**, *3*, 255-27.
26. Obermauer, J.B. Indirect impacts of high-speed tail: The case of Japan. *Transp. Eng. Aust.* **2000**, *6*, 19–31.
27. Spiekermann, K.; Wegener, M. The Shrinking Continent: New Time—Space Maps of Europe. *Environ. Plan. B Plan. Des.* **1994**, *21*, 653–673. [CrossRef]

28. Monzon, A.; Hernandez, S.; Cascajo, R. Quality of Bus Services Performance: Benefits of Real Time Passenger Information Systems. *J. Transp. Telecommun.* **2013**, *14*, 155–166. [CrossRef]
29. Jin, F. *Infrastructure System and Socio-Economic Spatial Organization*; Science Press: Beijing, China, 2013.
30. Debrezion, G.; Pels, E.; Rietveld, P. The impact of railway stations on residential and commercial property value: A meta-analysis. *J. Real Estate Financ. Econ.* **2007**, *35*, 161–180. [CrossRef]
31. Bowes, D.; Ihlanfeldt, K. Identifying the impacts of rail transit stations on residential property values. *J. Urban Econ.* **2001**, *50*, 1–25. [CrossRef]
32. Garmendia, M.; Ureña, J.M.; Ribalaygua, C.; Leal, J.; Coronado, J.M. Urban residential development in isolated small cities that are partially integrated in metropolitan areas by high-speed train. *Eur. Urban Reg. Stud.* **2008**, *3*, 265–280. [CrossRef]
33. The United Nations Educational, Scientific and Cultural Organization. One in Every Five Children, Adolescents and Youth Is Out of School Worldwide. Available online: https://en.unesco.org/news/one-every-five-children-adolescents-and-youth-out-school-worldwide (accessed on 4 March 2021).
34. Nakamura, H.; Ueda, T. The impacts of the Shinkansen on regional development. In Proceedings of the Fifth World Conference on Transport Research, Yokohama, Japan, 10 July 1989; Volume 3.
35. Brotchie, J. Fast rail networks and socio-economic impacts. In *Cities of the 21st Century: New Technologies and Spatial Systems*; Brotchie, J.F., Batty, M., Hall, P., Newton, P., Eds.; Longman Cheshire: Melbourne, VIC, Australia, 1991; pp. 25–37.
36. Okabe, S. Impact of the Sanyo Shinkansen on local communities. In *The Shinkansen High-Speed Rail Network of Japan*; Straszak, A., Tuch, R., Eds.; Pergamon Press: Oxford, UK, 1980; pp. 11–20.
37. MacDonald, H.; Peters, A.H. Distance and labour force participation: Implications for urban and rural women. In Proceedings of the Women's Travel Issues Second National Conference, Baltimore, MD, USA, 23 October 1996.
38. Rungskunroch, P.; Yang, Y.; Kaewunruen, S. Does high-speed rail influence urban dynamics and land pricing? *Sustainability* **2020**, *12*, 3012. [CrossRef]
39. Rungskunroch, P.; Jack, A.; Kaewunruen, S. Benchmarking on railway safety performance using Bayesian inference, decision tree and petri-net techniques based on long-term accidental data sets. *Reliab. Eng. Syst. Saf.* **2021**, *213*, 107684. [CrossRef]
40. Dindar, D.; Kaewunruen, S.; An, M. Rail accident analysis using large-scale investigations of train derailments on switches and crossings: Comparing the performances of a novel stochastic mathematical prediction and various assumptions. *Eng. Fail. Anal.* **2019**, *103*, 203–216. [CrossRef]
41. Rungskunroch, P.; Shen, Z.-J.; Kaewunruen, S. Getting it right on the policy prioritisation for rail decarbonisation: Evidence from whole-life CO_{2e} emissions of railway systems. *Front. Built Environ.* **2021**, *7*, 638507. [CrossRef]
42. Kaewunruen, S.; Sussman, J.M.; Matsumoto, A. Grand challenges in transportation and transit systems. *Front. Built Environ.* **2016**, *2*, 4. [CrossRef]
43. Sresakoolchai, J.; Kaewunruen, S. Comparative studies into public private partnership and traditional investment approaches on The High-Speed Rail Project Linking 3 Airports in Thailand. *Transp. Res. Interdiscip. Perspect.* **2020**, *5*, 100116. [CrossRef]
44. Liu, R.; Li, D.; Kaewunruen, S. Role of railway transportation in the spread of the coronavirus: Evidence from Wuhan-Beijing railway corridor. *Front. Built Environ.* **2020**, *6*, 590146. [CrossRef]