Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 00 (2018) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2019 Mumbai 26-31 May 2019

Demand risk management of Private High-Speed Rail operators: A review of experiences in Japan and Taiwan

Nikhil Bugalia[a]*, Yu Maemura[a], Kazumasa Ozawa[a]

[a]*Department of Civil Engineering, The University of Tokyo, Tokyo, Japan*

Abstract

Demand risks are going to be critical for the involvement of private sector participants in High-Speed Rail (HSR) operations in developing countries. By examining the influence of government policies and regulations towards the factors crucial for success of the operational performance of private HSR operators in Japan and Taiwan, the study aims to identify the balance of risk sharing and control sharing to be maintained between public authorities and private HSR operators. In our analysis, continuous improvement in the quality of services is thought to be a rational strategy for operators to sustain passenger business. Crucial factors have been identified by examining the application of a continuous improvement strategy in a delay-management system utilized by one of the private HSR operators in Japan. Our study highlights the importance of integrated operations and maintenance management, technical innovation, and human capacity development towards implementing strategies for continuous service improvement. The discussion reveals how government regulations can influence the corporate governance of a private HSR operator and still potentially restrict the efficiency of continuous service improvement strategies. It is this importance of institutional factors, which makes it essential to learn from the experiences of existing HSR projects and find its applications for developing countries. Hence, the authors suggest that the independence of corporate-governance for private HSR operators should be considered thoroughly by public actors that contemplate any risk-sharing arrangement with the private sector.

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

Keywords: High-Speed Rail; Demand-risk, Operational Success; Delay management; Taiwan; Japan; private rail operator

1. Introduction

Despite the increasing number of projects involving the private sector in the transportation sector, experiences of Intercity High-Speed Railways (HSR) have been rather limited (Phang, 2007). Since 1987, only 9 Public-Private-

* Corresponding author. Tel.: +81-70-2808-5887;
E-mail address: nbugalia@ken-mgt.t.u-tokyo.ac.jp

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY

Partnership (PPP) projects were HSR projects, out of a total 27 in the rail sector (Dehornoy, 2012). Dutzik et al. (2011) argues that private sector involvement in HSR is limited due to exorbitant construction and operation costs, as well as significant demand risks. These challenges are going to be significant for developing countries, who are expected to develop most of the new HSR projects in the next decade (Asian Infrastructure Investment Bank, 2018). Researchers and policymakers have long been challenged with the question of who should shoulder the demand risk of such large scale projects between the public entity and the private partner (Phang, 2007; The World Bank, 2017).

Existing research on the abovementioned issue has largely focused on analyzing either the role of government in shouldering, or the inability of the private operator to cope with, demand risk. For example, Dehornoy (2012) demonstrated that governments could end up paying over 50% of the project costs when demand risks were transferred to private operators. This was attributed to weaker negotiating power of the government once the project had been built. Dutzik et al. (2011) suggest that availability-payment-based concessions (Build-Finance-Maintain) are gaining popularity as they alleviate demand risk from the private sector but also note how operators are likely to lose some control over scheduling and pricing in comparison to Build-Operate-Transfer agreement.

Another study goes on to highlight that with overestimated benefits and underestimated capital requirements, the initial phase (the first 5 years of operation when ridership has yet to stabilize) is crucial in determining the success or failure of the private operator in handling the demand risk (Dutzik et al., 2011). Dehornoy (2012) discuss the inability of private operators to cope with such risks because of the inherent difficulties in demand risk mitigation and the high price elasticities of railway passengers.

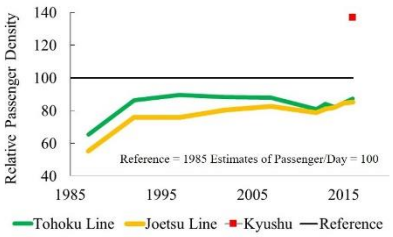
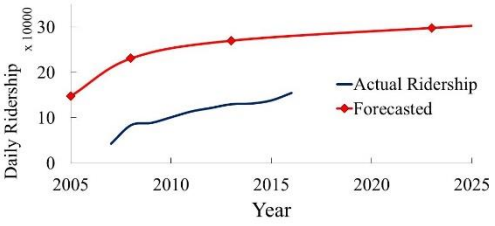
However, the operational achievements of private HSR operators facing challenges of under-performing ridership have been overlooked and merit consideration in the discussion of demand risk sharing. For example, HSR operators in Japan and Taiwan (see Table 1) have considerably improved passenger ridership in the operation phase, provided safe and reliable services, and have managed to compete with other travel modes such as airlines and automobiles despite such demand risks. The operational performance of these private HSR operators is arguably attributable not only to internal organizational factors but also to effective controls exercised by the Government. It is this importance of institutional factors, which makes it essential to learn from the experiences of existing HSR projects and find its applications for developing countries.

To further examine the impact of public and private roles on operational outcomes of HSR services, the current study presents a review of the experiences of vertically integrated private HSR operators in Asia that are managing their operational performance in the face of demand risks. The objective of the current study is to examine cases and experiences from Japan and Taiwan to identify critical factors that enable HSR operators to tackle the challenge of underperforming ridership and to clarify the role of government policies and institutions on impacting these factors. The effective balance between risk sharing and decision-making control for the public and private sectors is considered. Vertically separated HSR systems – where train-operation and asset maintenance responsibilities are vested with different organizations – such as those found in Europe are beyond the scope of this paper.

The next section provides a brief overview of HSR systems in Japan and Taiwan. Existing literature is reviewed in section 3 to describe some of the key factors that affect ridership demand and to define the strategies utilized by Japanese and Taiwanese operators to manage them. Section 4 will identify factors, which are crucial towards implementing the strategy identified in section 3. Based on insights obtained through interviews with officials from one of the private HSR Operators in Japan, section 4 presents an in-depth analysis of the application of an operational strategy, i.e., Delay-Management. Section 5 compares the role of government in HSR management before and after HSR privatization in Japan to consider the role of government in influencing the crucial factors identified in section 4. Section 6 will discuss the appropriateness of various control-sharing arrangements in the context of the Taiwanese HSR and will identify key consideration to be made for an appropriate demand risk-sharing strategy.

2. Background: A brief history of Private Sector involvement in Asia's HSR

Table 1. Overview of the HSR system in Japan and Taiwan

Items	Japan	Taiwan
Overview of Ridership		
Cases	Tohoku *Shinkansen* (JR East) Joetsu *Shinkansen* (JR East)	Taiwan HSR (THSRC)
Year of Privatization	1987	2007
Annual Ridership	Tohoku: 82.7 Million Passengers in 2012 (83% increase since privatization) Joetsu: 36.13 Million Passengers in 2012 (115 % increase since Privatization)	56.58 Million Passengers in 2016 (263.78 % increase since privatization)
*Demand Risk***		
Overview of Operational Performance		
	No. of services: Over 300 Trains per day departing Tokyo Average Delay: 0.3-0.5 min/train Passenger Fatalities : 0	140 Services per day Average Delay: 0.22 min/day Passenger Fatalities: 0
Intermodal Competition		
	Tohoku Line extension to Hachinohe and Shin-Aomori (626 KM apart) increased railway modal share from approx. 50% in 2002 to 70% in 2010. (Kojima et al., 2017) Limited impact from Express buses (Kojima et al., 2017)	100% Market Gained from Airlines (350 KM apart) Moderate Market Capture from automobiles Limited effect on Conventional Lines and High-way Bus (OH et al., 2015)
Financial Performance		
	Passenger ridership sufficient to generate operating profit Passenger profit not sufficient to cover the cost of asset acquisition Total profit **sufficient** to recover the cost of asset acquisition (Kurosaki, 2013) Operating Revenue 2,543 Billion Yen (2017) Approx. 70% from Transport Approx. 30% from Other Businesses	Passenger ridership sufficient to generate operating profit Passenger profit not sufficient to cover the cost of asset acquisition Total profit **not sufficient** to recover the cost of asset acquisition (Dutzik et al., 2011; OH et al., 2015) Operating Revenue 154 Billion Yen (2017) Approx. 97% from Transport Approx. 3% from Other Businesses
Background of Privatization		
Project Type	Full Privatization	Build-Operate-Transfer (BOT)
Asset Ownership	Owner-operator	The operator maintains an asset to be returned after the concession period.
Term for Concessions	----	Concession period lengthened to 70 years from the original 30 Years

**Relative Traffic Density for an HSR line is calculated as a ratio between Traffic Density (Average Passenger/day) information taken from reports of JRs and estimated figures as reported in (Straszak, 1981). Source: JR East (*http : //www.jreast.co.jp/rosen avr/*) JR Kyushu (*http : //www.jrkyushu.co.jp/company/info/data/rosenbetsu.html*). Average traffic density data for entire Tohoku Line is used for comparison against reference data (which is estimated only for Tokyo-Morioka section). Hence, series of line extensions from Morioka to Hachinohe (in 2002 and 2010) will affect the results for Tohoku line, however; authors expect the effect will still not change the general trend, as overall ridership has been relatively stable over the time-horizon compared. In addition, JR East includes information for Tokyo-Omiya section in Tohoku line's data and not in Joetsu line. Hence, authors expect that the relative estimates for Joetsu lines will be improved slightly. Estimates from 1985 (which may have been revised later) have been used for Kyushu line; hence, authors expect the relative figure to be different from that reported (in case a new estimate is available). A majority of information used in this table have been taken from the annual reports of the respective HSR companies.

2.1. Privatization of the Japanese Shinkansen

The first HSR lines in Japan (beginning as early as 1964) i.e., the *Tokaido Shinkansen* and *Sanyo Shinkansen* were developed by Japan National Railway (JNR), the nationalized railway company of Japan. The success of these lines, as reported in (Okabe, 1980; Straszak, 2014), garnered much public attention. Influenced by political demands, The Government enacted the Law for the Construction of Nation-wide High-Speed Railways in 1970. This law provided the basis for constructing the *Tohoku Shinkansen* from Tokyo to Morioka; the *Joetsu Shinkansen* from Tokyo to Niigata in the eastern zone; and the extension of the Tohoku *Shinkansen* to Aomori in the north via Hachinohe. Eiichi et al. (2000) and Straszak (1981) report that the new lines were never envisioned to attain commercial success by covering construction and operating costs with passenger revenue. These lines were rather justified to reduce regional disparities in connectivity.

In 1987, the JNR was divided into 6 privatized passenger railway companies known as JR companies – JR Central, JR East, JR West, JR Kyushu, JR Hokkaido, and JR Shikoku –operating in their specific regions (Mizutani, 1999; Sakamoto, 2012). As a result of privatization, the already completed and operating sections of Tohoku and *Joetsu* lines were purchased by JR East. A new scheme was then introduced to construct new lines (such as the extension of the Tohoku Shinkansen from Morioka to Aomori). Under this new scheme, construction risks were borne by a public entity named JRTT while the JR companies receive the operating rights for 30 years in lieu of a leasing fee (JREast, 2004). As of today, these two lines continue to underperform in terms of expected ridership. Kurosaki (2013) finds that for these two lines passenger ridership is sufficient to generate operating profit but the profit may not be sufficient to cover the capital expenditure towards the repayment of the assets purchased. It is important to note that JR East does not receive any government subsidy towards any operating-deficit. Despite this, HSR services have continuously improved over the past 30 years of operation and JR East has been successful in attracting profit-generating passengers. Kurosaki (2013) attributes their success to a range of continuous service improvement strategies and business diversification initiatives adopted by the operator. Further details on such strategies will be described through the literature (section 3) and case study (section 4).

2.2. The Taiwan High-Speed Rail Corporation (THSRC)

The rationale behind Taiwan's decision to build an HSR line in its western corridor included deteriorating transportation service quality and saturated transport capacity. In 1990, the HSR proposal, prepared by the Ministry of Transport and relevant ministries, was judged to be feasible by the finance ministry. Under the shortage of government funds, a "Build-Operate-Transfer (BOT)" model was deemed necessary to deliver the project. In 1998, the Taiwan High-Speed Rail Corporation (THSRC) was awarded a 35-year concession to Build, Operate and Transfer HSR assets to the Bureau of High-Speed Rail (BOHSR). The THSRC won the project with the lowest bid, and the financial feasibility of the project was strengthened through providing private partners with 50-year station district development rights.

However, HSR in Taiwan suffered an enormous setback when actual ridership was almost 50% below originally anticipated levels. Lower revenues, underestimated costs, high depreciation, and high-interest rates all contributed to severe financial pressure for the THSRC. The government stepped in to with several rounds of capital injection and acquired a controlling stake in the THSRC board of directors. The concession term has been extended to 70 years from the original 50 years. Station development rights have been taken away from private partners, but the concession is now non-terminable, and the THSRC has been listed for a public offering. Despite its financial difficulties, THSRC has seen a significant improvement in their ridership which has been attributed to a variety of Revenue Management strategies as well as continuous service improvement (Cheng, 2010; Taiwan High-Speed Rail Corporation, 2017). These strategies will be described in the following sections.

3. Literature Review: Factors influencing HSR ridership

3.1. Indirect Factors influencing ridership

Passenger ridership for HSR is shown to be dependent on a variety of direct and indirect factors. Indirect environmental factors have been acknowledged for their significance, as Amos et al. (2010), Feigenbaum (2013) and Vickerman (1997) have noted that HSR is suitable in regions where highly dense urban centers with strong economic conditions are appropriately spaced. Vickerman (1997) suggests that an HSR generating 12-15 million trips a year and service cities located 400-750 km apart will be profitable, and Amos et al. (2010) supports the idea of long-HSR corridors with large cities located at every 150-300 km interval.

Intermodal competition and the relative maturity of other transport modes also affect HSR ridership (Feigenbaum, 2013; Vickerman, 1997). In particular, car ownership and the abundance of road travel options are thought to be critical in determining ridership (Feigenbaum, 2013; OH et al., 2015). In addition, the accessibility of HSR with other travel-modes in developed city centers with high connectivity are known to be critical in affecting HSR ridership (Brons et al., 2009;OH et al., 2015; Vickerman, 1997). However, operators have limited power and opportunity in influencing such factors, as it is rare that that private HSR operator will be a part of HSR planning when such key-decisions of indirect factors are made.

3.2. Direct Factors influencing ridership

The current paper and the cases described a focus on the following direct factors, as these elements can be influenced and managed by HSR operators. In principle, there are 3 types of controls that the operator can exercise to affect ridership. These are *Price, Service Quantity, and Service Quality.* Authors will review the literature to identify the suitability of these controls towards mitigation of demand risk over the long operation life of HSR. In-depth analysis of operator's implementation towards these controls and the role of government for the efficiency of its implementation will be done later in the paper.

3.2.1. *Ticket Price*

Cheng (2010) highlights the significance of price sensitivity and segmentation by revealing the need for price differentiation between various passenger- and market-segments such as Business, Family, and Leisure travel. *Revenue Management (RM)* strategies such as price differentiation for separate classes, reserved seats, or time of day are all expected to lead to better capacity adaptations as was observed in the case of France (Abe, 2007). Pricing strategies for HSR can also be seen as a means to compete with other travel modes. Yang and Zhang (2012) conducted a review of studies and found that HSR operates in close competition with airlines. On the other hand, HSR has limited success in competing with automobiles. OH et al. (2015) reports that in Taiwan, the HSR market gained its market share from competing Airlines but had a rather limited impact on car passengers. Dehornoy (2012) has examined price sensitivity for railway passengers and found tendencies of price inelasticity among car passengers, suggesting that HSR should be priced at lower levels to compete with cars.

However, pricing strategies for HSR must also consider the sunk and variable construction and operations costs. Hence, too many heavily competitive discounts may not be a viable strategy for the long-term improvement in passenger ridership. Moreover, pricing discounts can lead to unintended consequences over the long-term, such as the Taiwan HSR experiencing a significant drop in ridership after discontinuing ticket price discounts (Jeng and Su, 2013). In addition, the rather limited use of RM in the railway sector is further discussed in detail (Armstrong and Meissner, 2010; Ogawa et al., 2008; Yasutomi, 2016). Ogawa et al. (2008) argues that the low proportion of variable costs in HSR operation has made it easier to adopt a dynamic supply (adjusting train frequency) rather than dynamic pricing, and studies of Japan and Taiwan also reveal a very limited use of RM for HSR operations (Cheng, 2010; Ogawa et al., 2008; Yasutomi, 2016).

Furthermore, Government regulations are often in place to control price hikes and limit an operator's ability to utilize RM. Japan has adopted a yardstick competition to base prices on full-cost principles (Mizutani, 1999; Yasutomi, 2016) while Taiwanese regulators also regulates the pricing. Moreover, price increases have been rare both in Japan (the only price hike was to reflect a new tax system) and Taiwan (a price hike in 2013 was reversed in 2015).

The literature thus suggests that although important, pricing strategies alone are not suitable as a long-term solution for addressing underperforming ridership. Intuitive assumptions are supported that operators will find it difficult to be price aggressive when passenger ridership is already well below expectations, and with characteristically large construction and operation costs, short-term losses could wield a significant impact on the sustainability of the whole service.

3.2.2. *Quantity of Services*

Increasing service quantity as well as transferability of tickets can increase scheduling options, strengthen flexibility in travel times, and reduced waiting time for passengers (Cheng, 2010). Fu et al. (2014) reports that the high frequency of HSR service is an important consideration for Japanese HSR passengers, and given the high proportion of fixed costs for HSR (Ogawa et al., 2008), economies of scale appear to be realized only when high capacity utilization observed in Japan is achieved.

However, service increases may show limited influence on overall performance as well as their effects are dependent upon consumer preferences. A survey conducted by Spanish Railways on the Madrid-Seville line in 1993 reported (cited in Coto-Millán et al., 2007) that only 8 percent of people chose HSR for its service schedule. In Taiwan, Li et al. (2015) report that it is still difficult to be certain of the causality of HSR service increases, i.e. whether the increased frequency is the result of an increase in demand, or whether the increase in supply allows for demand to rise. Hence, while service quantity is an important strategy its dependency on passenger preferences local to market contexts suggests it is not the most critical factor to consider for a long-term solution to address underperforming ridership.

3.2.3. *Quality of Services*

Chou et al. (2011) conducted a comprehensive review of customer satisfaction frameworks and proposed a novel index for measuring HSR service quality for Taiwan and Korea. Their study found that *Continuous Improvement in Service Quality* is related to customer satisfaction and customer loyalty. Customer loyalty was composed of a user's willingness to re-ride or recommend the service to others, and their price tolerance. With this operationalization, customer loyalty has the ability to not only retain customers but also induce new demand through recommendations. Hu et al. (2009) also find that customer satisfaction and brand image improve when companies deliver beyond the customer's expectations and strengthening customer loyalty.

Chou et al. (2011) then identifies numerous aspects of service quality such as perceptions about safety, punctuality, and the reliability of train services. Factors such as ride comfort, and services inside the train such as food, Wi-Fi, and air-conditioning were also reported as important by passengers. Cheng and Tsai (2014) further differentiates between actual service quality and perceived service quality by passengers, reporting that despite delays and cancellations of the services, the attitude of staff towards the affected passengers, apology messages from staff, availability of information about transfers, and new timetables can improve the perceived state of services and thus induce customer retention. Such passenger-oriented strategies are also advocated by the development organizations such as The World Bank (2017) for a sustained growth in passenger ridership.

Detailed discussions on the importance of customer satisfaction in the context of urban rail in Japan (Shoji, 2001) reaffirms the positive sustainable impacts of service quality. It is argued that the success of private urban rail operators could not have been possible without the continued justification of services to match passenger demands. The study highlights that transport providers must have a long-term commitment towards the community it serves and hence suggested long-term the contractual arrangements of typically 30 years for train operators. Shoji (2001) along with Saito (1997) also highlight the importance of *Business Diversification*, as adopted by private rail operators in Japan, to support the transport business with alternative revenue streams. Shoji (2001) highlights examples of utilizing *In-House diversification* and *Multi-Company diversification* to related businesses as a means to not only create new passenger demand but also offer newer services for the existing passengers. Real-estate business such as new-town developments along the railway, or commercial real-estate inside station buildings have promoted new commuting trips. In addition, the strategically built location of amusement parks or universities has been beneficial in creating travel demand flowing in the operating direction of traditional commuter trips. The concentration of retail space and restaurants inside the station can also be seen as valuable for passengers, as it offers them a variety of new services. Recently, HSR operators in both Japan and Taiwan have been offering a variety of integrated circuit (IC) cards which

can enable not only convenient payment options but allows enables access to new services such as simplified and integrated fares, and seamless transfers from HSRs to conventional railway lines or buses (Yashiro and Kato, 2018).

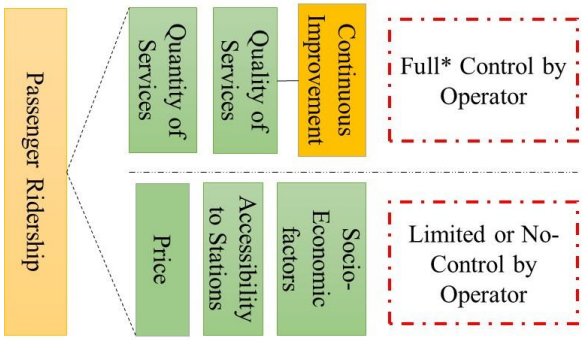


Fig. 1. Factors affecting passenger ridership for HSR

Fig. 1 summarizes the discussions from a literature review on factors affecting ridership for HSR. Authors observe that, although important, Ticket-price Management and Service Quantity management are not sufficient to yield sustained growth in passenger-ridership while, Continuous service improvement is suitable to sustain the passenger growth. In this manner, researchers and practitioners alike have discussed the benefits associated with Continuous Improvements in Service Quality, although, very little is known on how HSR operators practically achieve such service quality even for crucial factors such as Service Reliability and Punctuality.

B. Ning and C.A.Brebbia, (2010) published a collection of studies on operations-research and train punctuality in the context of Japanese and Taiwanese HSR. Individual elements such as patterns of train-rescheduling or the effect of time-table robustness have been analyzed for their effects on service reliability in the context of Japanese HSR (Tomii, 2010). Jong et al. (2010), highlight the importance of regular maintenance of the signaling system to prevent signal failure delays in the context of Taiwan HSR. However, most of these studies have been focused on a specific dimension of train punctuality, usually related to technological aspects, while very few address the question of Delay Management from the perspective of "managers" within the HSR organization. HSR operators perceive their work not only as a collection of technologies but as a "system" with interactions between technologies and its managers. For example, the basic principle of Japanese HSR management is referred to as the *Total Systems Approach* (TSA) (IHRA, 2016). As per TSA, *Tangible Aspects* include components such as core railway technologies, operational control systems, and disaster countermeasures. *Intangible Aspects* include components such as operations, maintenance, training, and human aptitude improvements. These aspects are optimally integrated together to continuously improve services through new technology development, capital investment, and management (Refer to Fig. 2a). Homer et al. (1999) attempted to address the gap between operations research and "systems" approaches in a study in which crew management and adequate maintenance were found to be important for improving the punctuality of freight trains. The current study presents a systemic view of punctuality as an application of continuous service improvement (or TSA) from the perspective of an HSR operator in TSA. Through unstructured interviews to operation-managers of JR East, one of the biggest HSR operators in Japan. The next section will outline a general set of factors identified by the practitioners as crucial factors for an HSR operator to deliver punctual performance.

4. A case study on Continuous Service Improvement by HSR Operator

4.1. Total Systems Approach

One of the key aspects of Japanese TSA is its *Integrated Operations & Maintenance Management* (IO&M), among others. Such an integrated system calls for good coordination between operation and maintenance activities. This coordination is necessary not only to handle the current traffic but also to handle the estimated future demands (Refer to Fig. 2b). TSA discussed here is more or less originated in Japan, while Taiwan also imported the similar system for

their HSR. HSR operators in Japan and in Taiwan are vertically integrated so that a single entity is responsible for both operations management and its related maintenance activity. Such integration of activities ensures that there are no misaligned incentives and lack of coordination between the two activities. The efficiency of such integration is clearly visible through the extensive information available on Japanese and Taiwanese operators. THSRC has been

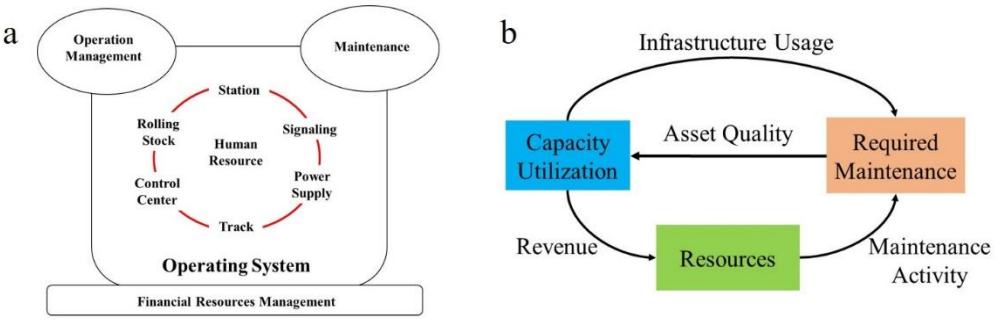


Fig. 2. Operations System of HSR (a) Integrated Operations and Management System (Doi, 2016) (b) Important relations in Integrated HSR management

able to achieve 100% of their maintenance plans since it began its operations (Taiwan High-Speed Rail Corporation, 2017). Safety-related investments including the expense of maintenance have been continuously improving for Japanese operators. Without the integration between the two activities, there can be problems of misaligned incentives. Table 2 discusses the benefits of IO&M in more detail. Details of how private HSR operators in Japan and Taiwan have been able to utilize the principles of "Total System Approach" including IO&M towards continuous improvements punctuality and delay management in their services are presented in next section.

Table 2. Benefits of Integrated Operations and Maintenance Management

Factor	Impact
Avoid misaligned incentives	• Train services cannot be increased without due consideration to effect on maintenance • Continuous investment in maintenance is made, thus avoiding service degradation (Doi, 2016; Gottschalk, 1983; Mannaerts et al., 2013) • Corresponding, quality of assets is a higher and safety concerns are limited.

Lean Management	• Operation and Maintenance activities are well coordinated
	  • High-speed Track condition monitoring trains run during normal operation hours
	  • Centralized operation control also considers the availability of assets
	• Well maintained assets, increase the infrastructure availability, leaving room for Higher capacity utilization
	• Timely maintained asset reduces the extra degradation because of backlog and thus saves Life-Cycle costs (IHRA, 2016)

4.1.1. "Delay Management" as the application of the Total System Approach

The following discussions are based on a series of interviews that the authors conducted with senior JR East officials in the operation division. Interviews were guided by the following primary question:

"Over the past 30 years, how has JR east managed to maintain their average delay performance while continuously increasing the number of daily services?"

Since its privatization in 1987, JR East has seen a significant increase in their passenger ridership (as outlined in Table 1). The number of hourly trains has also increased in correspondence with the surge in ridership. Despite these increases, the average delay has remained between 0.3-0.5 min/train between 1999 and 2006. JR East operates more

than 300 trains per day from its 4 tracks at Tokyo Station, with a remarkable turnaround time of around 12 minutes per train. Current capacity utilization is at approximately 4 trains/hour/track – over 80% of the theoretical capacity of the system. According to Abril et al. (2008) and Landex et al. (2006), there should be an inverse relationship between capacity utilization and service reliability – average delays for JR east should have increased exponentially and network reliability should have decreased under such high levels of capacity utilization. The remarkable punctuality and diminutive average delays observed here reveal a contrast between expected theoretical outcomes and real-performance levels observed in the field. The interviews aimed to reconcile the rather counter-intuitive results that were observed in practice.

Carey (1999) and Gibson et al. (2002) propose frameworks to place delays into two categories, primary and secondary delays. Primary delays are caused directly by the train or equipment itself, including delays due to equipment failure, infrastructure maintenance, slow passenger boarding, staff behavior, or delays caused external factors such as weather and natural disasters. Secondary delays or "knock-on" delays are those delays that are caused to trains not directly affected by primary delays but because of the interdependency in the schedule. This applicability of this framework was confirmed by the interviewees at JR East. Interviewees reported that secondary delays represented about 20% of total delays experienced by JR East's HSR operations. As per JR East, a train is considered delayed, when its actual arrival time is more than 30 seconds later than the scheduled arrival time, measured at stations.

Fig. 3 is a conceptual diagram representing a key causal relationship as described by interviewees providing information on JR East's delay management strategy. The operators exhibited an acute awareness of how demand increase place increased pressure on existing infrastructure, affecting the system's ability to manage both primary and secondary delays. This pressure took various forms, such as congestion inside stations, the enhanced degradation of asset quality caused by intensive usage, and passenger conflicts

In the absence of delay-management strategies, such a situation could lead to a negative spiral, with primary and secondary delays and eventual train cancellations. Over the long term, poor service reliability and punctuality would increase passenger inconvenience and ultimately reduce passenger demand for HSR services. Hence, authors conclude that this is a balancing feedback loop that will eventually lead to a stable level of passenger ridership. In that our expectation of the qualitative behavior is different from Abril et al. (2008) and Landex et al. (2006). The exponential increase in delay is still expected when the capacity utilization grows, but it will reach a steady state where increasing more number of trains will not be possible because passengers will not be willing to ride them. However, in presence of delay-management strategy, the theoretical behavior from the same feedback loop is similar to what is observed in performance levels of JR East. The key features of Delay-management strategy are described in the next paragraph.

Delay-Reduction strategies are utilized to reduce the number of the incidents that could cause primary delays. Efforts are made to maintain the asset quality (both physical infrastructure and rolling stock) so that incidents related to equipment failures can be reduced. JR East officials consider it as a direct *result of the IO&M framework*. The impacts are significant because equipment failure is considered one of the most significant sources of delays. These impacts can somewhat be verified from publically available data. From 2007 to 2016, there has been an 18% increase in passenger-km traveled, while the number of incidents caused by internal factors has remained rather constant (Data from MLIT Home-Page in 2017). Additionally, extensive measures are taken to design smooth passenger flow within stations so that passenger boarding and alighting delays can be minimized. Furthermore, JR East has implemented a number of *technical improvements* to minimize the impact of external factors such as weather conditions (snow, rain, and wind) and natural disasters such as Earthquakes. These measures include a large network of sensors continuously monitoring external conditions, automatic emergency brakes to prevent derailment during earthquakes, and technical improvements such as heated switches in snow-affected areas.

Delay-Management efforts are implemented to minimize the impact of Primary delays and to stop them from spreading throughout the network. A centralized operation control system (known as COSMOS) assists timetable managers to quickly adjust operations while simultaneously coordinating with other relevant divisions. Another factor that contributes toward managing delays is effective coordination between. A high level of coordination was also observed between train drivers and the Operation Control Center, with an emphasis on *Human Resources Development* efforts. All staff are required to complete periodic training, lasting anywhere from between several hours to several days. "On-the-Job Training" is utilized to help employees prepare for a variety of emergencies that have been managed by the operators in the past. It is also used to enable operators to gain experience identifying the numerous decisions that need to be made in bringing the network "back on schedule".

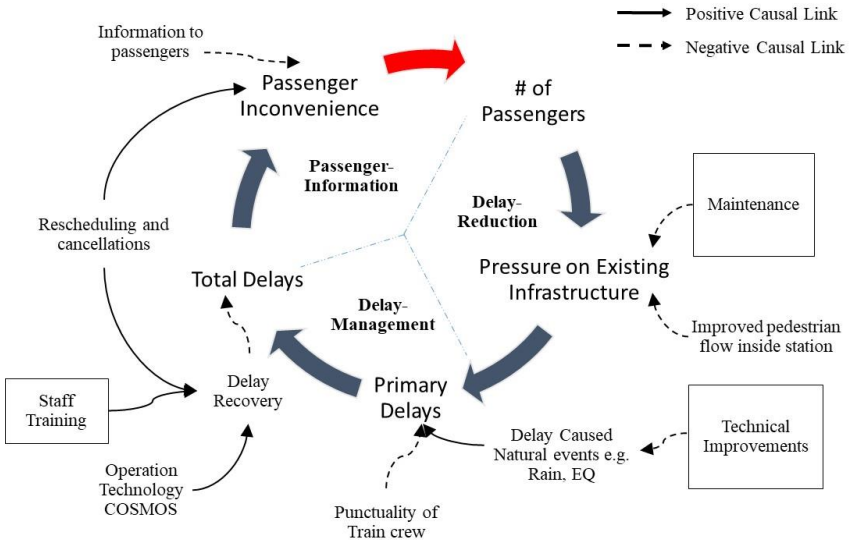


Fig. 3. Punctuality and Delay management strategy for JR East

Passenger Information efforts are aimed to improve the customer's experience and convenience even when the operations are disrupted. Passenger information systems are available on board and inside stations, and reflect information about the status of delayed and canceled services, new services, and connections for further journeys. JR East also collaborates with other HSR and public transit operators to identify the best suitable connections for their passengers. In some cases, the timetable for connecting public transit lines is also altered to ensure passenger convenience. Ticket refund requests and grievance readdressing are all handled to maintain passenger satisfaction.

Through implementing delay-reduction, delay-management, and passenger information measures, JR East has achieved a higher level of capacity utilization while maintaining the asset quality and customer satisfaction. Hence, it is possible that while in principle, the theoretical framework of the inverse relationship between capacity utilization and service reliability still holds true, the disruptions in service quality have not been observed in JR East operations because of their ability to maintain and manage high asset-quality.

A descriptive analysis of actual delay-management strategies utilized by HSR operators in Japan highlights the importance of **passenger oriented business strategies and continuous service improvements** to maintain the long-term competitiveness of HSR. Our analysis reveals the three pillars that support strategies for continuous service improvement. These are integrated O&M system, continuous technical innovation, and human capital development

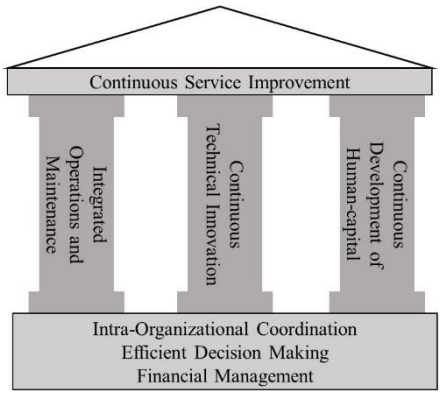


Fig. 4. Generalized framework for continuous service improvement

(See Fig. 4). Factors such as intra-organizational coordination, efficient financial management, and efficient decision management are also identified as crucial factors for the effective implementation of service improvement strategies.

5. Role of the government towards Continuous Service Improvement

This section will highlight the impact of government institutions and regulations on the factors affecting continuous service improvement (as proposed in the framework, refer to Fig. 4) through an in-depth analysis of Japanese railway reforms that occurred alongside privatization. It has been generally argued that financial performance, managerial efficiency, and labor productivity have all improved for private HSR operators in Japan compared to when they were a public entity pre-1987 (Mizutani, 1999; Terada, 2001; van de Velde, 1999). The current paper adopts the framework developed by Mizutani (1999) to focus on competitive pressures and factors which are influenced by the government and are *external* to the operator (Table 3).

Table 3. Factors responsible for performance improvement in private HSR operators in Japan, modified from (Mizutani, 1999)

	Competitive Pressure	Practical Point of View
Internal to Operator	Private **Ownership** Entrepreneurial behaviour from **Managers**	Organizational Structure Management of Organization Labour-Saving Options Performance-based incentives for employees Rail-Service strategies
External to Operator	Demand for better rail services from **Rail Users** Competition with **other Travel Modes** Yardstick Regulation in fare, Full-Cost principle, No subsidy from **Regulator**	Relationship with Regulators Political Interference Management-labor relationship

5.1. JNR reform and factors internal to the operator

Post JNR reform, organizational and ownership structures of the new JR companies were significantly changed. Song and Shoji (2016) describe how newly privatized ownership created two roles for the rail operators, i.e., to provide efficient public transportation services and to pursue profit maximization. The balance between these two objectives is clearly reflected in a passenger-centric approach to continuously improve the level of services, contrasted with the previous system only mandated to provide service for a given level of demand. JR took on reforms to rid the organization of various hierarchies and centralize decision-making, leading to increased *efficiency in decision-making and intra-organizational coordination* (Fig. 4). For example, Mizutani (1999) discusses that the 4-level hierarchy system (division, section, section vice, subsection managers) changed to the 3-level hierarchy system (division, section, subsection managers) during JNR reform, thus shortening the decision-making time. Mizutani (1999) notes that as a public entity, JNR required approval from 20-30 bureaucrats for most approvals. Under the new decentralized organization, branch offices are able to exercise their own judgment, which has also improved adaptation to local needs (Mizutani, 1999). Employee incentives post-privatization were also modified from an age-based seniority system to a system utilizing performance-based indicators.

5.2. JNR reform and factors external to the operator

Yardstick competition fares, the full-cost principle, and lack of subsidies by the government are all measures utilized by government bodies to enable operators to focus on improving management. As per the full-cost principle, the revenue for operators is expected to be sufficient to cover the costs of service provision while gaining a profit margin. The yardstick (calculated as “the standard cost” for all HSR operators, based on data collected from all HSR operators every year) then incentivizes operators to reduce their internal costs so that they are eligible for a fare hike

(operator is eligible for fare hike if its actual cost is less than "the standard cost"). Mizutani et al. (2009) highlights that yardstick competition has worked for other private operators but its effect on HSR operators, although likely, is not yet confirmed.

Post-1987, the relationship between the operator's Corporate Governance and the regulators have evolved from strict control to monitoring. Under the new law, JR companies must have approval from the Ministry of Transport for corporate management plans including the budget, as well as the appointment of representative directors. As a public institution, the appointment of the JNR director in the past was largely a political decision. In addition, key financial decisions such as the budget-process would require approval from the National Diet, making it difficult for JNR to prioritize investments quickly and receiving timely approvals (Straszak, 2014, 1981). Post-privatization, independence in financial management has enabled JR companies to prioritize investments based on needs identified internally. The priority areas for investment for JR companies have been *technical innovation and maintenance* rather than service expansion (Mizutani, 1999; Terada, 2001). Interviewees confirmed that under the new system, the budget approval process for regular maintenance activities is significantly faster.

Additional influencing factors including the freedom to diversify businesses and asset ownership, which are provided to Japanese HSR operators, will also be crucial in financial management for continuous service improvement (see Fig. 4). Under Japanese law, cross-subsidizing the transport sector with revenues from diversified businesses is prohibited, however, the opportunity to operate railway-related businesses leaves room for realizing economies of scope (Saito, 1997; Shoji, 2001). Further, when diversified businesses can be utilized to increase the passenger ridership, ridership may increase to a level where operators can benefits from economies of scale within the passenger segment realized(Ogawa et al., 2008). The ownership status of HSR infrastructure also allows operators to form long-term relationships with community businesses, as well as discount costs over the longer period. Furthermore, HSR operators in Japan must adhere to regulations on safety standards according to the Railway Business Act and Railway Operations Act (Song and Shoji, 2016), which act as safeguards against deteriorating safety performance. Fig. 5 represents a summary of the role of government in HSR operation in Japan and its influence towards the strategy of service improvement.

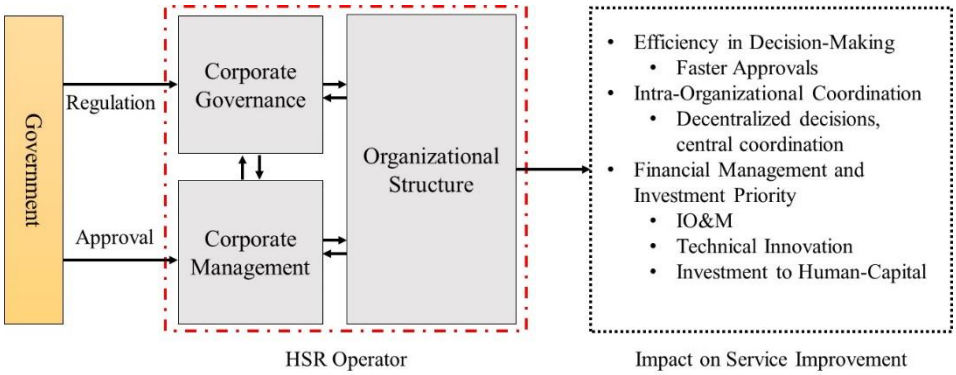


Fig. 5. Structure of Government Control for private HSR operators in Japan

The THSRC began as a private organization and authors expect similarities between the HSR management of the JRs and the THSRC. The organizational structures of the new HSR operators in Japan and that of THSRC are very similar (Both are M type, in which a firm is separated into several semi-autonomous units, which are controlled by the center). Labor-productivity for THSRC after 10 years of operation is very similar to that of JRs after their 10 years in operation, at approximately 3905 train-km operated per employee (calculated using figures from Taiwan High-Speed Rail Corporation (2017)). JR companies were at a similar level in 1995 (8 years after privatization), at 4059 km/employee (Mizutani and Nakamura, 2004). Although factors internal to an organization will have a larger impact towards service improvement strategies, recent developments in Taiwan become relevant in terms of corporate governance and organizational structure. In October 2015, the Taiwanese government became the majority shareholder and joined the Board of Directors of THSRC after a series of capital injections. As per the current

shareholding schemes, the Taiwanese Government and affiliated entities control approximately 60% of the company (Taiwan High-Speed Rail Corporation, 2017). Under the latest reforms, various measures were incorporated to improve business sustainability for the operator. These include immediate capital injections to support basic operations, an increase in the concession term, organizing a public listing, abandoning the non-termination clause of the original contract, and revoking station area development rights are among some of the salient features of the new reform.

6. Discussions

6.1. Financial sustainability in Japan vs cost-recovery in Taiwan

The current situation of private HSR operators in Japan and Taiwan need to be understood under the context of which private sector involvement was adopted in both countries. In Japan, at the time of privatization, policymakers were knowledgeable about the issue of underperforming ridership (Kurosaki, 2013). Thus the purpose of privatization was to ensure the long-term financial sustainability of the new HSR operators (Mizutani, 1999; Sakamoto, 2012). During the reforms, financial and managerial independence of the new organizations were prioritized. Reforms were aimed at reducing the financial burden of new organizations, and permission to diversify business were also granted to support financial sustainability and competitiveness for the new operators.

In Taiwan, the private sector became involved when the cost of the project was considered too high to be funded by the public exchequer. Under this scenario, when ridership risk materialized, the project was too-big-to-fail and the government took steps to save the project from going bankrupt. The salient features of the reform in Taiwan appear to be motivated primarily by cost-recovery both for the private operator and for the government. For example, the increase in concession terms and removal of the non-termination clause provide the operator with more time and protection to recover costs. Returning development rights for stations to the government could provide an opportunity for the government to capitalize on benefits brought by the HSR and to recover the costs of its capital injections.

The cost-recovery measures adopted through the 2015 reform may have various consequences for the future of demand-risk management at Taiwan HSR. Additional limitations on opportunities to diversify businesses may restrict the ability to hedge against investments to increase ridership for HSR in Taiwan. As a Special Purpose Vehicle, THSRC is restricted in terms of the businesses it can operate, and transferring development rights for five station development areas back to the government takes several of its limited options away. THSRC should face more difficulty in attracting more passengers through this front, in comparison to JR companies. HSR operators in Japan are free to participate in real-estate development within their station and can own various businesses. JR companies have ventured in to established universities or “new towns” to induce more travel demand. On the other hand, the increased concession term (from 35 years to 70 years) may provide an opportunity for the THSRC to increase ridership by developing long-lasting relationships with the passengers to which it serves, which is similar to the situation in Japan where HSR operators either own the assets or have long-term concession contracts. THSRC will be able to justify efforts for continuous service improvements by rationalizing the costs of these services over a longer period.

Post 2015 reform, the government of Taiwan is now a majority stakeholder of the THSRC. As part of the corporate governance structure, the THSRC’s management is now exposed to political risks which could restrict the efficiency of demand-risk management strategies. The new governance structure theoretically could favor public sector obligations excessively, and may undermine decisions necessary for profitability. For example, a decision to increase prices, adopted in 2013was reversed after the 2015 reform.

While there is no denying that the capital injection from the government was a necessary step to sustain the troubled HSR business in Taiwan, excessive or hasty measures to ensure cost-recovery have the potential to jeopardize the efficiency of demand risk-management strategies for an HSR operator. Likelihood for such government decisions in developing countries makes it essential to learn from the experiences of existing HSR projects. Limited control in station development could limit the possible risk-management strategies, which can further be restricted by excessive control by public partners. Government oversight is essential to ensure compliance and accountability on matters of public interest such as safety, but sufficient care must be taken to ensure that an operator’s independence over investment priorities and decision approval processes are not excessively restrained.

6.2. Short-term Incentives vs long-term control

At privatization, JNR was divided into 6 rail companies and one Freight Company. Three JR companies i.e., JR Central, JR East, and JR West bought their assets and controlled lines which generated sufficient profits for the company. However, the three other companies, i.e., JR Kyushu, JR Hokkaido, and JR Shikoku have faced financial difficulties. Hence, A *Management Stabilization Fund (MSF)* was thought as necessary by the government at the time of HSR privatization in Japan (Mizutani, 1999). The government had put a fixed amount in MSF such that interest earned by this fund will compensate for the operating losses of the HSR operator. This system is different from Minimum Revenue Guarantees or subsidies on operating losses as the total cost for government remains fixed. However, interest rate risks significantly influence the sufficiency of this fund, as it was observed in the case of Japan (Mizutani, 1999). The three remaining JR companies have utilized this fund very efficiently. JR Kyushu has made significant progress in establishing itself in the real-estate market and in generating overall profits, easing the pressure operating losses have on overall performance. As the MSF matured in 2016, JR Kyushu is now eligible for a public listing. Since the MSF prevented further intervention from the government, JR Kyushu was able to maintain the independence of its management while essentially receiving significant government support.

As Dehornoy (2012) and Dutzik et al. (2011) highlighted in their study, the first few years of operations are very crucial for HSR operators. Overestimated benefits, underestimated costs, and additional capital investments can all create problems for the private sector before ridership reaches a level where benefits are realized from economies of scale. Short-termed support from public entities, such as MSF in Japan, may then be necessary, which caps the maximum risk borne by the government and while providing the private sector an opportunity to work independently.

Experiences from Japan and Taiwan suggest that efficient intra-organizational coordination and efficiency in decision-making are necessary conditions for the efficient functionality of HSR and a virtuous cycle of continuous improvement in service quality components such as punctuality, convenience, and safety. While it is important to note that factors internal to an organization (such as organizational hierarchies, decentralized decision-making) will have a larger impact towards the efficiency of management, these internal organizational factors are often dependent on the independence of top-management and corporate-governance structures. Hence, authors advocate that the independence of corporate-governance for private HSR operators should be considered thoroughly while preparing for any risk-sharing arrangement with the private sector.

7. Conclusions

This paper has outlined the strategies used in practice by private HSR operators in Japan and Taiwan for managing underperforming ridership. It has been found that the strategy of *continuous service improvement* is crucial for operators to sustain operations through lower-than-expected demand, as it can enable efforts for the HSR operator to attract new passengers, retain existing ones, and help maintain long-term competitiveness.

An example of the Delay Management strategy from the perspective of HSR “managers” in Japan has been presented, revealing the three pillars that support strategies for continuous service improvement: an integrated O&M system, continuous technical innovation, and human capital development. Factors such as intra-organizational coordination, efficient financial management, and efficient decision management are also identified as crucial factors for the effective implementation of service improvement strategies.

The role of government institutions and policies in Japan and Taiwan have shown that regulations have had minimal influence on internal organizational procedures such as organizational structure, HR management, and decentralized decision-making. However, recent developments in Taiwan reveal how government regulations can influence the corporate governance of a private HSR operator and still potentially restrict continuous service improvement strategies of operators performing poorly overall.

Both cases highlight how any arrangement for sharing demand risk between the government and the private partners should consider carefully the influence of public authorities towards the corporate governance of private operators. The case of JNR privatization advocates for the strong independence of corporate governance for the HSR operator, while the THSRC management now possesses political risks as the government has gained a majority stake.

Further scholarly work on analyzing the impact of factors internal to railway operators towards the efficiency and effectiveness of various strategies is necessary. An approach that considers the HSR not only as a collection of

technologies, but as a "system" with interactions between technologies and its managers will be valuable for those that wish to learn from, understand, and apply HSR management.

References

Abe, I., 2007. Revenue Management in the Railway Industry in Japan and Portugal: A Stakeholder Approach.

Abril, M., Barber, F., Ingolotti, L., Salido, M.A., Tormos, P., Lova, A., 2008. An assessment of railway capacity. Transp. Res. Part E Logist. Transp. Rev. 44, 774–806.

Amos, P., Bullock, D., Sondhi, J., 2010. High-speed rail: The fast track to economic development. World Bank 1–28.

Armstrong, A., Meissner, J., 2010. Railway revenue management: overview and models.

Asian Infrastructure Investment Bank, 2018. Transport Sector Study.

B.Ning, C.A.Brebbia, 2010. Computers in Railways XII: Computer System Design and Operation in Railways and Other Transit Systems. WIT Press.

Brons, M., Givoni, M., Rietveld, P., 2009. Access to railway stations and its potential in increasing rail use. Transp. Res. Part A Policy Pract. 43, 136–149.

Carey, M., 1999. Ex ante heuristic measures of schedule reliability. Transp. Res. Part B Methodol. 33, 473–494.

Cheng, Y.-H., Tsai, Y.-C., 2014. Train delay and perceived-wait time: passengers' perspective. Transp. Rev. 34, 710–729.

Cheng, Y.H., 2010. High-speed rail in Taiwan: New experience and issues for future development. Transp. Policy 17, 51–63. https://doi.org/10.1016/j.tranpol.2009.10.009

Chou, J.-S., Kim, C., Kuo, Y.-C., Ou, N.-C., 2011. Deploying effective service strategy in the operations stage of high-speed rail. Transp. Res. Part E Logist. Transp. Rev. 47, 507–519.

Coto-Millán, P., Inglada, V., Rey, B., 2007. Effects of network economies in high-speed rail: the Spanish case. Ann. Reg. Sci. 41, 911–925.

Dehornoy, J., 2012. PPPs in the rail sector-A review of 27 projects. Munich Pers. RePEc Arch.

Doi, T., 2016. Interaction of Lifecycle Properties in High Speed Rail Systems Operations. Massachusetts Institute of Technology.

Dutzik, T., Schneider, J., Baxandall, P., 2011. High-Speed Rail: Public, Private or Both? Assessing the Prospects, Promise and Pitfalls of Public-Private Partnerships. US PIRG Educ. Fund.

Eiichi, A., Imashiro, M., Kato, S., others, 2000. A History of Japanese Railways. 1872-1999. Tokyo East Japan Railw. Cult. Found. 198.

Feigenbaum, B., 2013. High-Speed Rail in Europe and Asia : Lessons for the United States.

Fu, X., Oum, T.H., Yan, J., 2014. An analysis of travel demand in Japan's intercity market empirical estimation and policy simulation. J. Transp. Econ. Policy 48, 97–113.

Gibson, S., Cooper, G., Ball, B., 2002. Developments in transport policy: The evolution of capacity charges on the UK rail network. J. Transp. Econ. Policy 36, 341–354.

Gottschalk, P., 1983. A system dynamics model for long range planning in railroad. Eur. J. Oper. Res. 14, 156–162.

Homer, J.B., Keane, T.E., Lukiantseva, N.O., Bell, D.W., 1999. Evaluating strategies to improve railroad performance—A system dynamics approach, in: Proceedings of the 31st Conference on Winter Simulation: Simulation---a Bridge to the Future-Volume 2. pp. 1186–1193.

Hu, H.-H., Kandampully, J., Juwaheer, T.D., 2009. Relationships and impacts of service quality, perceived value, customer satisfaction, and image: an empirical study. Serv. Ind. J. 29, 111–125.

IHRA, 2016. International High-Speed Rail Association, Fact Book.

Jeng, C.-R., Su, C.-H., 2013. The predicament of domestic airline service after the introduction of Taiwan High-Speed Rail. Transp. J. 52, 134–143.

Jong, J.C., Lin, T.H., Lee, C.K., Hu, H.L., 2010. The analysis of train reliability for the Taiwan High Speed Rail. WIT Trans. Built Environ. 114, 169–180.

JREast, 2004. On Track for World No. 1, Annual Report 2004.

Kojima, Y., Matsunaga, T., Yamaguchi, S., 2017. The impact of new Shinkansen lines (Tohoku Shinkansen (Hachinohe–Shin-Aomori) and Kyusyu Shinkansen (Hakata–Shin-Yatsushiro)). Transp. Res. procedia 25, 344–357.

Kurosaki, F., 2013. Shinkansen investment before and after JNR Reform. Int. Transp. Forum, OECD.

Landex, A., Kaas, A.H., Schittenhelm, B., Schneider-Tilli, J., 2006. Practical use of the UIC 406 capacity leaflet by including timetable tools in the investigations. WIT Trans. Built Environ. 88.

Li, Y.-T., Schmöcker, J.-D., Fujii, S., 2015. Demand adaptation towards new transport modes: the case of high-speed rail in Taiwan. Transp. B Transp. Dyn. 3, 27–43. https://doi.org/10.1080/21680566.2014.946456

Mannaerts, A., Van Daalen, C., Van Luipen, J., Meijer, S.A., 2013. Supporting policy analysis in the Dutch rail sector using System Dynamics, in: Proceedings of the 31st International Conference of the System Dynamics Society, Cambridge, Massachusetts, USA, 21-25 July 2013.

Mizutani, F., 1999. An assessment of the Japan Railway companies since privatization: performance, local rail service and debts. Transp. Rev.

19, 117–139.

Mizutani, F., Kozumi, H., Matsushima, N., 2009. Does yardstick regulation really work? Empirical evidence from Japan's rail industry. J. Regul. Econ. 36, 308.

Mizutani, F., Nakamura, K., 2004. The Japanese experience with railway restructuring, in: Governance, Regulation, and Privatization in the Asia-Pacific Region, NBER East Asia Seminar on Economics, Volume 12. University of Chicago Press, pp. 305–342.

Ogawa, H., Kawai, S., Kojima, Y., Goto, M., Shoji, H., 2008. Day-to-day tuning of the Tokaido Shinkansen timetable--carried out for every single operating hour throughout the year. WIT Trans. Built Environ. 103, 515–524.

OH, J., KWON, Y., KIM, Y., TERABE, S., TOMARI, N., 2015. International Comparison on High-Speed Railway Impacts and Station Area Development : Japan, Taiwan and Korea.

Okabe, S., 1980. Impact of the Sanyo Shinkansen on local communities. Shinkansen high-speed rail Netw. Japan 11–20.

Phang, S.-Y., 2007. Urban rail transit PPPs: Survey and risk assessment of recent strategies. Transp. Policy 14, 214–231.

Saito, T., 1997. Japanese private railway companies and their business diversification. Japan Railw. Transp. Rev. 2.

Sakamoto, R., 2012. High Speed Railway Productivity: How Does Organizational Restructuring Contribute to HSR Productivity Growth. Massachusetts Institute of Technology.

Shoji, K., 2001. Lessons from Japanese experiences of roles of public and private sectors in urban transport. Japan Railw. Transp. Rev. 29, 12–18.

Song, Y.-J., Shoji, K., 2016. Effects of diversification strategies on investment in railway business: The case of private railway companies in Japan. Res. Transp. Econ. 59, 388–396.

Straszak, A., 2014. The Shinkansen High-Speed Rail Network of Japan: Proceedings of an IIASA Conference, June 27-30, 1977. Elsevier.

Straszak, A., 1981. The Shinkansen program: transportation, railway, environmental, regional and national development issues. Institute for Applied Systems Analysis.

Taiwan High-Speed Rail Corporation, 2017. Annual Report 2017.

Terada, K., 2001. Railways in Japan--public and private sectors. Japan Railw. Transp. Rev. 27, 48–55.

The World Bank, 2017. Toolkit for Improving Rail Sector Performance. Washington, DC, World Bank.

Tomii, N., 2010. How the punctuality of the Shinkansen has been achieved. WIT Trans Built Env. 114, 111–120.

van de Velde, D., 1999. Changing Trains. Railway reform and the role of competition: the experience of six countries.

Vickerman, R., 1997. High-speed rail in Europe: experience and issues for future development. Ann. Reg. Sci. 31, 21–38. https://doi.org/10.1007/s001680050037

Yang, H., Zhang, A., 2012. Effects of high-speed rail and air transport competition on prices, profits and welfare. Transp. Res. Part B Methodol. 46, 1322–1333.

Yashiro, R., Kato, H., 2018. The Intermodal System in the Intercity Passenger Transportation Market: A Case Study in Miyazaki B&S, Japan.

Yasutomi, R., 2016. An Examination on Viable Pricing Strategies for the Chuo Shinkansen maglev in Japan.