Social Shaping of Technological Trajectories of Shinkansen

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Abstract: The Tokaido Shinkansen began operating in 1964 and ran at globally unprecedented speeds of more than 200 kmph. Comparison with the operating speed of aircraft necessitated further improvement of the operating speed of Shinkansen. Nevertheless, there was no improvement until 20 years. During that period, the maximum speed of test cars, the highest technically feasible speed, improved. Rather than technical factors, the following social and organizational factors impeded the improvement of the operating speed. (1) The social factor was the prioritization of environmental countermeasures to improvements in speed because of the noise pollution lawsuits and noise regulation. (2) The organizational factor was the need to secure the slack time due to frequent strikes and delays when Shinkansen was managed by Japan National Railways (JNR). However, around the time of the splitting and privatization of JNR in 1987, noise regulation was relaxed and lawsuits were settled. Furthermore, the labor movement settled down with the privatization of JNR; consequently, labor unions were dismantled. These events resolved preventive factors and led to

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the improvement of operating speeds.

**Keywords:** technological trajectories, Shinkansen, social shaping of technology

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**Introduction**

The Shinkansen, or bullet train, is a world-class Japanese innovation. The Tokaido Shinkansen began operating in 1964 and generated speeds exceeding 200 kmph, which were unheard of at that time for electric trains. This made it a global breakthrough. However, progress on the Shinkansen stagnated thereafter. After running on a provisional schedule for the first year in operation, the Shinkansen schedule was revised in November 1965. The Hikari service connected Tokyo and Shin-Osaka stations in 3 hours and 10 minutes at a top speed of 210 kmph. Because the Shinkansen competed with aircraft, speed improvements were essential. Despite this, the speed of the Shinkansen did not improve further until just prior to the splitting and privatization\(^1\) of Japan National Railways (JNR) in 1987.

First, this paper overviews changes in various types of speed indicators for the Shinkansen. These speed indicators include maximum speed, scheduled speed, and test car maximum speed. The former two speeds are related to actual operations, whereas the latter is a proxy indicator of the technical limits. The

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\(^1\) The Tokaido Shinkansen, the subject of this paper, was placed under the management of a public firm called Japan National Railway (JNR) until March 31, 1987. Public railways in Japan operated as an agency of the Ministry of Transport. After 1964, JNR ran continually at a deficit and was privatized and split into seven Japan Railways firms on April 1, 1987, as a means of rebuilding the business. At the time, management of the Tokaido Shinkansen fell under the Central Japan Railway Company.
maximum speed refers to the fastest speed logged within an operating section; the scheduled speed is calculated by dividing the number of kilometers travelled within an operating section by the time required to travel that distance (including the time required to stop at stations).

Upon beginning operation in 1964, the Shinkansen ran on a provisional schedule in a wait-and-see approach; the scheduled speed was quite refrained, so even the express “Hikari” service between Tokyo and Shin-Osaka stations required 4 hours. The scheduled speed significantly improved in the following year with changes in schedule; subsequently, no changes were observed in both maximum and scheduled speeds until 1985. One may think that the reason for this is the lack of technological developments. However, according to Shinkansen professionals, “increasing the speed itself was a simple matter.” This can be verified by examining the transition of maximum speeds of test vehicles during the public railways era. Figure 1 provides a summary changes to these three speed indicators.

Please note the trend indicated in the circle. We can discover the lack of increases until mid-1980s in scheduled and maximum speeds despite the maximum speed of test vehicles. The changes in schedule in 1985 and 1986 slightly improved the scheduled and maximum speeds; subsequently, these speeds rose dramatically in the first half of the 1990s. Given this, the following two research questions are considered.

RQ1: Why no parallel efforts were made to improve speed related to speed improvements of test cars and operation?
RQ2: How were factors preventing the incorporation of technical progress into operations eliminated?

This paper responds to these research questions in order.
Factors Preventing Technical Progress

This section considers the first research question, “Why no parallel efforts were made to improve speed related to speed improvements of test cars and operation?” Primarily inhibiting factors that were uncovered in the study include 1) environmental issues and 2) labor issues.

1. Environmental issues

Because the Shinkansen operates at speeds exceeding 200 kmph and sprints through Tokyo, Nagoya, Osaka, and other areas, which are dense in population, noise pollution is a serious problem. Similar to air and water pollution that became an issue in Japan in the 1970s, noise pollution was considered to be an emerging issue. Thus, regulations were set for noise pollution in 1975 based on Basic Law
for Environmental Pollution Control. During that time, noise pollution levels were set at 70 dB or less when passing through residential areas, with a goal of achieving this level by 1985. When measuring the noise of the Tokaido Shinkansen in 1973, levels varied widely by location but were generally in the range of 80 to 100 dB. Thus, the technology group within JNR focused on research and development. They aimed at achieving the above goal by the stated deadline by making improvements to environmental performance instead of focusing on speed (Ebihara, 1997).

In addition to environmental standards, there was another preventive factor related to environmental issues—the Nagoya Shinkansen Trial. This court case was brought to the Nagoya District Court on March 30, 1974, by residents alongside 7 kilometers of the Shinkansen line within the Nagoya City limits. In the court case, residents demanded compensation from JNR as well as bans on noise pollution (i.e., reductions in speed) caused by passing cars. In the first instance of the case, a ruling was handed down on September 11, 1980. This required efforts for technical development of countermeasures for the noise pollution, in addition to payments of compensation. However, both sides objected to the ruling and filed appeals (Kondo, 2010).

As can be seen below, the existence of environmental standards and a noise pollution court case continually required serious efforts to solve environmental issues. In other words, these two factors caused JNR’s technical development division to shift its focus from improving speed to environmental countermeasures. Thus, the development of countermeasures was proposed, such as reductions in the number of pantographs, installation of pantograph covers, and creation of smooth car surfaces (Mochiduki, 2015).

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2 Speed reductions were rejected as a result of comparisons between the public utility of the Shinkansen and the tranquility of residents living along the Shinkansen line.
2. Labor-management relations

Next is the issue of labor-management relations. In the period when JNR operated the Shinkansen, the labor unions had power and frequently invoked the work-to-rule and strikes to create advantageous conditions during negotiations. Strikes means that workers refused to do their work in groups. The work-to-rule is almost the same as slowdown. An example of this is running trains at speeds slower than speed limits for “safety” reasons or stopping trains for safety checks due to crows or other animals on the rails. These actions intentionally created chaos in schedules and frequent delays when JNR managed the railways. The Shinkansen was not an exception either (Masuda, 2011), as can be seen in Figure 2 below.

Of course, JNR wanted to hold to the schedule as much as

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**Figure 2.** Average delay time per train of Shinkansen

*Source:* compiled by the author using materials from a lecture given by Hiromi Soejima at the 7th Railway Technical Research Institute Lectures.

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3 Descriptions in this section, particularly those without a source are based on interviews with those in JNR at the times described.
possible. Because JNR acted as an agency of the Ministry of Transport, they, as bureaucrats, tended to adhere to formalities (in this case, the train schedules). Thus, they created schedules with certain allowances that enabled them to make up for a certain amount of delays. Because of the ongoing strikes and struggles with labor unions in the 1960s and 1970s, revising the schedules and making these allowances reduced are thought to be accompanied by some risk.

Train schedules are created with a certain amount of slack time to cope with train delays. This enables them to adhere to schedules even if trains have to run at somewhat slower speeds. However, reducing the slack time and improving scheduled speeds in actuality increased the likelihood of delays beyond the slack times in the event of slow speed operation created by struggles with labor unions. In addition, speeding up trains and reducing planned operating times between stations also increased the likelihood of delays due to the work-to-rule of the labor unions. As can be seen in the following diagram, Figure 3, actual times tend to become longer due to the work-to-rule. Even if the basic operating time or slack time is reduced,

![Figure 3. Risk by shortening times](image)

Figure 3. Risk by shortening times
the possibility of delay will increase.

Under these circumstances, no schedule revisions were made that incorporated reductions through shorter arrival times or higher speeds for the Shinkansen. Uncertainty in the labor movement created the perceived need for schedule slack by management, which disallowed any improvements in performance as measured by speed.

**Resolving Preventive Factors**

The schedule revisions implemented in March 1985 and November 1986 resolved these circumstances. In particular, the revisions of 1986 were last made by JNR and were modified with the motive of shifting to the newly privatized JR. For the first time, these schedule changes shortened the actual travel time between Tokyo and Shin-Osaka stations for the Tokaido Shinkansen since it began operation. These speed improvements were made possible in part by resolving the preventive factors of environmental and labor-management issues described above.

Environmental constraints were removed with deregulation in 1985 and settlement of the lawsuit with the plaintiff in 1986. The previous environmental standard for noise pollution was raised from 70 dB to 75 dB; even that was treated as a provisional standard, with sections of rail to meet that standard being gradually expanded. Thus, compared with the former requirement to meet the noise pollution goal by 1985, the new standard was much relaxed (Akiyama, 2012).

Further, a ruling was handed down in an appeals court for the Nagoya Shinkansen Trials on April 12, 1985, and the residents who acted as the plaintiff in the case had their compensation reduced from the first instance, as the appeals court recognized the efforts of JNR in taking environmental countermeasures. Moreover, because the case took so long, the plaintiff did not take the case to the Supreme Court to protect the lifestyles of the residents at the
time. They sought a settlement with JNR based on the appeals court decision. This resulted in efforts by both JNR and the plaintiff residents to reduce noise pollution and a settlement of 480 million yen (Kondo, 2010).

With regard to labor-management issues, the existence of JNR itself was shaken because the argument about privatization and splitting of the entity began to surface around 1982. This created the need for labor union members to consider their positions and dampened further union struggles. Further, the labor union was dissolved in the privatization and split; thereafter, the labor union was newly formed within the Central Japan Railway Company, which managed the Tokaido Shinkansen. This union was much more moderate and, therefore, did not impact Shinkansen operations. In this manner, the need to pad schedules was reduced, and improvements in Shinkansen speed were introduced after privatization (from an interview with a JNR official).

**Conclusion**

This paper used the case of the Tokaido Shinkansen in identifying reasons for long-term stagnation. It was found that social and organizational factors influence technical developments. For social issues, environmental problems and their regulations were the influencing factors; for organizational problems, the labor movement and securing slack in relation to labor movement struggles were the influencing factors. Constraints were eliminated through the deregulation of environmental standards, court settlements, and removal of labor issues by the privatization of JNR. These actions enabled speed improvements in the closing days of JNR and after the privatization of JNR.

This differs from the view of technical determinism proposed by Thompson (1967) and Perrow (1967) with regard to organizational
structures being decided prior to technical specifications. This suggests the view that in the field of social shaping of technology, organizations and other social phenomena influence technological development (Ayabe, 2006; Callon, 1986, 1987; Hara, 2007; Miyao, 2013; Pinch & Bijker, 1987). Studies such as that by Ogami (2015) assumed a patent system and revealed that S-shaped curve formations are due to management determinations. As part of empirical studies in the field of the social shaping of technology, the findings of this paper also suggest that managers can dynamically manage technology and develop their corporation.4

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4 Kikuchi and Iwao (2016) emphasized the autonomy of managers in discussing those managers that create results. Sato (2015) focused on the exercise of power by managers creating innovations in organizations.
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