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Issues on modal shift of freight from road to rail in Japan: Review of rail track ownership, investment and access charges after the National Railway restructuring

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Abstract

When Japanese National Railways was privatized and separated in 1987, the government established a new freight train operation scheme where rail tracks were owned by six JR Passenger companies, and JR-Freight was allowed access to the JR Passenger company's tracks by paying an access charge under the avoidable cost rule, regulated by the national government. The aim of this scheme was to reduce the track costs for JR-Freight. We found that rail freight infrastructure investment had not been high enough because it was only conducted by JR-Freight, and it only included investment in a few facilities owned by JR-Freight but excluded investment in the rail tracks owned by the JR passenger companies. Additionally, the track access charges, calculated by the avoidable cost rule, could not compensate for the track maintenance costs and would induce an undersupply of rail tracks for rail freight traffic. In conclusion, the track access charges paid from JR-Freight to the JR Passenger companies were too low, causing difficulties in the promotion of a modal shift to rail freight.

Keywords: Modal shift; Rail freight transport; Track access charge; Avoidable cost rule

1. Introduction

More than 35 years have passed since the Japanese government officially mentioned the necessity of a modal shift for freight from road to rail, or coastal shipping. In 1981, the main purpose of the modal shift was to limit fuel consumption during the second oil crisis. Since 1981, the purpose of a modal shift has been expanded to deal with global warming and a shortage of truck drivers (MLIT (2015)). However, the government could not easily promote a modal shift from road to rail. Figure 1 shows the modal split change of inland freight transport in Ton-km from 1955 to 2016. We found that the share of commercial trucks continuously increased, and its share in 2016 was 53%. On

the other hand, rail had lost its share of freight transport from 53% in 1955 to only 4% in 1985 because many short-haul cargoes had shifted from rail to commercial trucks and that share of rail freight was still 4% in 2016. Inland shipping kept their large modal share stable at about 40%, as Japan is surrounded by sea.

We review the reasons why the modal shift of freight from road to rail has not moved forward, from the point of view of the freight train supply sides of rail track ownership, investment and access charges after the Japanese National Railways (JNR) restructuring. When JNR was privatized and separated in 1987, the government established a new freight train operation scheme where rail tracks were owned by six JR Passenger companies (JRPs) and the JR-Freight company (JRF) was allowed to use the tracks by paying an access charge under the avoidable cost rule[1]. There are many studies of the intermodal relationship between road and rail, however, most of them focused not on the supply side but on the demand side of the freight train service (Woodburn (2003), Bontekoning et al. (2004) and Blauwens et al. (2006)). With reference to national railway restructuring, many studies examined the impacts of vertical separation of track management and train operation, and those of open access, on passengers' and freight shippers' surplus and operators' productivity (Drew (2009), Cantos (2010) and Mizutani and Uranishi (2013)). These studies focused on the vertical separation scheme in the EU, however, the vertical separation in Japan is different from that in the EU, since freight service is vertically separated but passenger service is vertically integrated in Japan. The JNR restructuring was implemented prior to EU railways and there are several empirical analyses, however, these studies mainly focused on passenger service but not on freight service (Mizutani and Nakamura (1996), Mizutani and Uranishi (2007)). We try to add some implications in the effects of railway restructuring on modal shift by conducting the case study of the unique vertical separation scheme for rail freight in Japan.

This paper consists of the following four sections. Section 2 shows the national railway restructuring scheme in Japan and the operating results of JRF. Section 3 and 4 review the modal shift measures from road to rail, the investment in rail freight infrastructure and the regulation of track access charges. Finally, we conclude our research in Section 5.

2. Restructuring of the National Railway System in Japan

2-1 Privatization and Separation of JNR and Rail Track Ownership[2]

JRF was established as a result of the privatization and separation of JNR. JNR had provided not only passenger service but also freight service with a nationwide network of 20,000km. In 1987, JNR was privatized and separated into six passenger companies by region (JRPs:

[1] List of abbreviations of the organizations in this paper are summarized in Table 1.

[2] The details of JNR restructuring are referred to in Mizutani and Nakamura (2004).

JR-Hokkaido, East, Central, West, Shikoku and Kyushu) and one freight company (JRF) as shown in Table 2. The JNR restructuring scheme directed that JRF should not be separated by region because many of freight trains were long haul and crossed regional borders. Additionally, the six passenger companies operate passenger trains with their own rail tracks, train stations and cars. JRF owns their freight depots, locomotives and freight cars but does not own any rail tracks, therefore, JRF must rent the rail tracks from the JRPs to operate freight trains. Figure 2 compares track ownership and track access charge schemes for four types of rail tracks. At the beginning of the JNR restructuring, there were two types, Type (1) for freight service and Type (4) for passenger service. The restructuring scheme directed that JRF should not own rail tracks in order to reduce its track infrastructure costs because the modal share of rail freight had continuously decreased, as mentioned in the previous section, and rail freight service would not be profitable after motorization in Japan. Therefore, with reference to rail freight transport, vertical separation between rail track maintenance and train operation was implemented. On the other hand, rail maintenance and train operation for rail passenger transport are integrated in Japan. As Thompson (2003) compared, the vertical separation scheme of Japan is different from that of the EU and North America. The railways in the EU were obliged to financially separate between rail infrastructure management and train operation by EU Directive 91/440 and rail infrastructure owners and train operators were organizationally separated in many EU countries. The North American scheme is more similar to Japan but the North American freight train companies own the rail infrastructure, and the passenger train companies, Amtrak and VIA Rail, use the rail tracks owned by the freight train companies.

According to the JNR restructuring scheme, the state-owned corporation, Japan National Railway Settlement Corporation (JNRSC) was established to manage the assets and debts of the JNR in 1987. The JNRSC owned all of the JR companies' stocks in 1987. The JNRSC and another state-owned corporation, Japan Railway Construction Public Corporation (JRCC) had merged together and become the national agency, Japan Railway Construction, Transport and Technology Agency (JRTT) in 2003. The JRCC was established in 1964 to construct rail tracks and lease them to the railway companies, which included not only JR but also other private railways. The aim of the JRCC was to promote large rail infrastructure investments more quickly. The JRTT sold all its stocks of four of the six passenger companies (JR-East, Central, West and Kyushu) on the stock market, and now these companies are completely privatized. On the other hand, the JRTT still holds all stocks of the remaining two passenger companies (JR-Hokkaido, Shikoku) and JR-Freight.

2-2 New Rail Track Ownership Scheme according to the HSR Network Extension

A new rail track ownership scheme for High Speed Rail (HSR: Shinkansen in Japanese) was implemented when Hokuriku Shinkansen was opened in 1997. The HSR network originally opened in 1964 between Tokyo and Osaka (Tokaido Shinkansen) and gradually expanded. The older

HSR tracks opened before the JNR restructuring (Tokaido, Sanyo, Joetsu and a part of Tohoku routes) and are owned by each JR passenger company. On the other hand, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) decided that track infrastructure for the new HSR routes should be built and owned by the national agency, JRTT (JRCC until 2003) and that the JRPs could use the new HSR tracks by paying HSR track access charges to JRTT as Type (3) in Figure 2. Table 3 summarizes the relationships between HSR track owners, track maintenance managers and train operators. This scheme aimed to promote quicker HSR extension due to the fact that the national agency would build the rail infrastructure. What actually happened was that the new HSR infrastructure that opened after 1997 is still owned by JRTT and the JRPs that use the new HSR tracks have to pay JRTT to access the tracks, and these JRPs also have to maintain the tracks by themselves. At the same time, MLIT decided that after 1997, the JR conventional lines, which ran parallel to the newly opened HSR, were separated from the JR network, and owned and operated by the newly established railway companies, which were public (local government) - private joint ventures as Type (2) in Figure 2. From the point of view of profitability, it would be difficult for the JRPs to serve both the HSR and the conventional lines on the overlapping routes. Therefore, these conventional lines should be separated from the JRPs administration, and local government should be responsible for operating the conventional lines while HSR should be operated by the JRPs. As a result, eight new railway companies were established and a total of 675.9 km of rail line had been transferred from JRPs to the new companies as shown in Table 4. Ida and Suda (2004) supported this separation scheme of the HSR lines and the conventional lines, since they estimated the cost function of the JRPs and did not find economies of scope between HSR and conventional line operation. On the other hand, the other conventional lines, which do not run parallel to the new HSR, and the old HSR are still owned and maintained by the JRPs (Type (1) for freight and Type (4) for passengers in Figure 2).

2-3 Operating Results of JR-Freight

By Act, the JRPs tracks are open not only for JRF but also for other potential entrants if an entrant satisfies the criteria for licensing set by MLIT. But, as no new freight train operator has entered, only JRF has a nationwide rail freight network. JRF accounts for 99% of total rail freight transport in Japan in ton-km, while sixteen other rail freight companies, with their own tracks, exist as short feeders to the JRF depots. Figure 3 shows that bulk cargo in Japan in 2016 was 75% less than in 1987, while container cargo had increased from 1987 to 1990, and has been stable since 1990. The share of container cargo is calculated at 60% in 1987 and 94% in 2016. Woodburn (2015) analyzed the composition of the cargo trains and mainly focused on the bulk cargo in the UK. Unfortunately, the bulk cargo train network in Japan is too small to analyze. Total ton-kms transported are stable between 1987 and 2016, however, the number of freight trains decreased by

more than 40% in the same period. It was suggested that each freight train should have more freight cars on average.

Additionally, Japan's freight train network has become smaller. The freight network length in 2016 was 22% shorter than that in 1987, shown in Figure 3. The rail network of the JR group in 2017 is geographically illustrated in Figure 5 and JRF covers only 40% of the JR network. The JRF network depends on not only a license issued by MLIT, but also on the contract between JRPs and JRF, based on the demand for rail freight. If JRF quit freight train operation on a line, JRF could not restart the train operation on the same line because the JRPs, the owners responsible for the upkeep of the rail tracks, would downgrade their track maintenance from heavier freight train levels to lighter passenger train levels after a JRF train left, and JRPs did not want to make a new contract for JRF trains by upgrading their track maintenance again.

The freight trucking industry experienced deregulation of entry and pricing in 1990, and the fares for commercial trucks declined after deregulation. The fares for rail freight also declined corresponding to the decline of trucking fares. Mizutani (2007) estimated a cross elasticity of freight transport demand between commercial truck and rail in Japan and found a substitutive relationship between them. We could say that JRF faces a very competitive freight transport market even though JRF is a monopolist in the rail freight market, and deregulation of the trucking industry indirectly induced declining fares for rail freight. Figure 4 shows that while JRF reduced operating costs corresponding to the decline of operating revenue, they still operated in the red until 2015 and then at almost break-even in 2016.

3. Investment in Rail Freight Infrastructure

Rail freight transport flow is concentrated to a trunk line between (A) Tokyo and (F) Fukuoka, through the Tokaido, Sanyo and Kagoshima lines as illustrated in Figure 5 and 6. For instance, 40% of freight tons are carried on the Tokaido line and 30% are on the Sanyo line. After the JNR restructuring, JRF did not own the rail track infrastructure and had to rent the rail tracks from the JRPs. But JRF owns some facilities along the trunk route and has continuously invested in these facilities in order to deal with longer freight trains. Investment was made to increase the capacity of the electrical substations, to improve the signal equipment, and to improve freight station facilities such as extension of the sidetracks and freight handling tracks. Funahashi (2009) reported that the total cost for the facilities improvement projects was 25 billion yen (12.4 billion yen for the Tokaido line, 3.4 billion yen for the Sanyo line and 9.2 billion yen for the Kagoshima line). The investment in the Kagoshima line included the large construction cost of the new Kitakyushu freight terminal station. The national government gave subsidies to JRF of 3.8 billion yen (1 billion yen for the Sanyo line, and 2.8 billion yen for the Kagoshima line but no subsidy was given for the Tokaido line).

The facilities infrastructure investment on the Tokaido line was completed in October 1998, on the Sanyo line in March 2007, and on the Kagoshima line in March 2011. Figure 6 compares rail freight flows in tons at the four cross sectional points between (A) Tokyo and (F) Fukuoka in 1992 and 2017, and shows that freight flows had slightly decreased over the period. JRF invested 25 billion yen for the infrastructure to deal with longer trains, and the governmental subsidies of 3.8 billion yen were included in the investments of 25 billion yen. But, unfortunately, the investments were not enough to promote a higher volume of rail cargo on the busiest corridor. The investments had increased the maximum train length by only two cars, from 24 cars to 26 cars. JRF could not afford to invest more heavily in its infrastructure because it did not generate enough profit, and the government subsidies were not enough. The JRPs have heavy passenger train traffic in the three largest metropolitan areas, Tokyo, Osaka and Nagoya. The JRPs have quadruple tracks with more capacity for freight trains in Tokyo and Osaka while they have only double tracks in Nagoya. Essentially, investment should have been made to expand the rail track capacity in Nagoya, and then the bottleneck congestion would have been resolved, thus allowing for an increase in the number of freight trains and freight tons[3]. But subsidies are not given to JRPs, the owners of the rail tracks. JRPs would have no incentive to improve their infrastructure for the heavy weight freight trains because JRPs operate only light weight passenger trains. When the feasibility of the expansion of freight transport capacity was considered, JRF had to choose to invest in its own small facilities and not to increase the number of trains but to make each train longer (Aoki (2009)). The lack of investment in rail tracks might be caused by Japan's vertical separation scheme that rail track maintenance and passenger train operations are integrated, and only freight train operation is separated. Moreover, forty-foot high cube containers (9 ft 6 in. high), which are the international standard size since 2005, are one foot taller than traditional forty-foot containers (8 ft 6 in. high), and cannot go through the tunnels on the trunk lines. Very few routes are available for the high cube containers, therefore, it would be difficult to promote sea and rail intermodal transport as Woodburn (2012) proposed.

4. Track Access Charge Scheme

4-1 Track Access Charge on JRP Routes: Avoidable Cost

The JR Companies Act was established to regulate the privatized JR companies in 1986, just before the JNR restructuring in 1987. The JR Companies Act implemented the avoidable cost rule for track access charges paid by JRF to the JRPs (Type (1) in Figure 2). The aim of the avoidable cost rule was to reduce the track infrastructure costs for JRF and to expand the rail freight

[3] In the UK, Woodburn (2017) reported that investment in a new track, Doncaster North Chord, had significantly enhanced freight train performance.

transport market by offering lower fares to shippers. Actually, the avoidable cost rule had been adopted prior to the JNR restructuring to balance the accounts between the freight service section and the track maintenance section within the JNR. With reference to the train slot, the timetable of JRF trains in 1987 was set based on the timetable in 1986. JRPs and JRF had to keep the JNR avoidable cost rule and timetable even after the JNR separation. The Act literally defined the avoidable cost of track infrastructure as the decreased track maintenance cost for the JRPs if JRF marginally reduced its freight train traffic. But the avoidable cost rule is not mathematically formulated. If we interpret the literal definition into a mathematical formula, it could be defined as Avoidable Cost = $-\Delta C / -\Delta Q$ (C: Cost for track maintenance, Q: Traffic). And we could consider avoidable cost as equal to marginal cost because marginal cost is written as Marginal Cost = $\Delta C / \Delta Q$.

Ozawa (2004) reported that a track access charge for each JRF train is calculated by following these four steps;

1. Track access charge is divided into five charge type groups
2. Charge for each group is calculated by the following equations;
   (1) Rail charge = Unit price * Locomotive-km
   (2) Electric line charge = Unit price * Trolley-km
   (3) Electric substation charge = Unit price * Load amount of the substation facility
   (4) Signaling system charge = Unit price * Train-km
   (5) Telecommunication line charge = Unit price * Number of communication transactions
3. Five groups of charge types are summed up
4. Track access charge for each train is calculated by the sum of the above five charge types multiplied by 1.01

Under the avoidable cost rule, the track access charge is defined as the avoidable cost multiplied by 1.01, which means that 1% of the avoidable cost is an incentive for the JRPs to lend their rail tracks to JRF more often. The unit price for each charge is negotiated annually between JRF and the JRPs. Unfortunately, further details on the calculation procedure, such as unit prices, are not disclosed. However, it seems that the above rule is not practically kept as we show later that track access charges paid by JRF to the JRPs is much lower than track maintenance costs borne by the JRPs. In 2001, the JR Companies Act was revised to exclude three of the JRPs, JR-East, Central and West, because their complete privatization was scheduled for 2002[4]. However, MLIT gave directions that these three companies should keep the avoidable cost rule even after their exclusion from the JR Companies Act. The Act and the MLIT direction do not prevent new train operators from entering

[4] JR-Kyushu was also excluded in 2015 for its complete privatization in 2016.

but they order that JRPs should adopt the avoidable cost rule for JRF, but JRPs do not have to adopt the avoidable cost rule for other freight operators. Only JRF has the privilege of lower track access charges, and the fact that potential entrants cannot enjoy the avoidable cost rule could be a reason why we do not have any new rail freight operators.

4-2 Track Access Charge on ex-JRP Routes: Avoidable Cost plus Subsidy

As shown in Section 2, after 1997, the JR conventional lines, which ran parallel to the extended HSR route, were separated from the JR network, and owned and operated by the newly established railway companies. Two of the new rail companies shown in Table 4, IGR and Aoimori, claimed that the track access charges calculated by the avoidable cost rule would be too low to recover their track maintenance costs. Moreover, they could not afford to conduct cross subsidization from their passenger service to freight service because both of them operate in only rural areas and profitable long-haul passengers do not use their service, instead using HSR operated by JR-East. In 2002, MLIT established an indirect subsidy scheme from HSR to the new railway companies to compensate for the difference between the access charges and their maintenance costs. Figure 2 compares money flow schemes between JRPs (Type (1)) and the new railways (Type (2)). The Japanese government accepted that JRTT would give subsidies to JRF to compensate for the (negative) difference between track access charges and track maintenance costs. JRF pays a track access charge, which includes the avoidable cost and the subsidy, to the new railway companies. Passengers of the new HSR routes indirectly bear the difference through this scheme. However, the JRPs and the oldest of the eight new companies, Shinano, are not included in this subsidization scheme. This means that the JRPs and Shinano would need to have cross subsidization from their rail passenger service to rail freight service.

4-3 Calculation of Track Maintenance Costs and Track Access Charges

We calculated the average track access charge and the average track maintenance cost of the JRPs and Iwate Galaxy Railway (IGR) using published data from 2006 to 2016. The results of the calculations are shown in Table 5. As detailed in the footnote for Table 5, we calculated the average track lending revenue per freight train-km and considered it as the unit price of the track access charge for freight trains under the avoidable cost rule. The average maintenance cost of the track and electric line, per total train-km, of both passenger and freight trains is adopted as the average cost of track supply for JRF trains. Nash (2005) summarized track access charge schemes in Europe. With reference to rail track access charges and rail track maintenance costs, he found that in the majority of European countries the most common system for track access is a simple charge per train-km, and he found that rail maintenance and renewal costs are generally considered to be the main cost elements of marginal cost. Maintenance costs and renewal costs were included for

marginal cost estimation by ten of the eighteen countries studied, while only maintenance costs were adopted by seven countries, and the remaining country, Italy, did not use either measurement. In our case, only maintenance cost is included and renewal cost is excluded because we exclude depreciation costs. If Japan's calculation procedures for track access charges and maintenance costs are compared with European access charge schemes, we could conclude that Japan's procedures are reasonable, and similar to many of the European countries. Unfortunately, we could not extract the maintenance cost for only freight trains, from total maintenance cost, because of data constraints. The weight of freight trains is generally heavier than that of passenger trains and as Wheat and Smith (2008) reported, the marginal cost of track maintenance per freight train-km is much higher than per passenger train-km. Therefore, we must note that the average cost per train-km of our study is underestimated, and the absolute value of the negative difference (for JRPs), calculated by the subtraction of costs from revenue, can be recognized at the smallest level, in contrast, the absolute value of the positive difference (for IGR) can be recognized at the largest level. Additionally, it is impossible to discuss revenue and cost for each JRP because we could not extract the train-kms for JRF trains by each JRP, but only by the total of the six JRPs.

In Table 5, the average revenue from rail track lending by the JRPs had been about three hundred yen per train-km while that of IGR had been more than one thousand yen per train-km, and recently more than two thousand yen per train-km. The average rate paid by JRF to the JRPs was only one ninth of that paid by JRF to IGR in 2016, while average track maintenance costs for both the JRPs and IGR had been about nine hundred yen per train-km. As a result, the differences between average revenue and costs were negative for the JRPs while positive for IGR. Importantly, the access charge paid by JRF to the JRPs would compensate for less than one third of the JRPs maintenance costs. Annually, the total difference is calculated as the average difference multiplied by annual freight train-kms. The difference amounted to negative 38 billion yen for the JRPs in 2016. This corresponds to a loss of 4% of total operating profit for the JRPs' railway sector, and it was not negligible for their business management. Shown as Type (2) in Figure 2, there is a subsidy scheme for IGR and we suggest that the subsidy should be estimated as the difference between the average revenue of IGR and the average revenue of the JPRs. We find that including the average subsidies in the average revenue for IGR accounted for more than 80% of its track revenue as shown in Table 5, and that the total difference for IGR would have been negative without the subsidizing scheme. Furthermore, the total subsidies compare to 50% of total operating revenue including passenger revenue for IGR. This means that the subsidies are critical for IGRs business[5].

[5] It is difficult to access the true amount of the subsidy each year, however, it was 1,150 million yen for IGR in 2008 according to the minutes of the meeting of the National Diet (Kusunoki (2012)). Our estimated subsidy for IGR in 2008 was 1,117 million yen as shown in Table 5, and therefore we consider that our calculation procedure is not unreasonable.

As discussed above, the avoidable cost rule for track access charges had been conceptually designed to include an incentive to lend more track capacity to JRF but it actually forced the JRPs to set JRF access charge rates much lower than their maintenance costs. The negative difference between revenue and cost for track access should become a disincentive for the JRPs to lend more track capacity to JRF. In fact, the number of JRF trains on the JRPs' tracks had decreased by 20% between 2006 and 2016 (Figure 3), and the total negative difference of the JRPs had deceased from minus 50 billion yen to minus 38 billion yen, as shown in Table 5. We can easily understand that fewer freight trains improve the JRPs' profitability, and ultimately zero freight trains is best for the JRPs.

Originally, the aim of the avoidable cost rule for track access charges was to decrease the track infrastructure cost for JRF and to promote more rail freight transport. Unfortunately, at the same time, an unforeseen side effect is that the avoidable cost rule may have induced an undersupply of rail tracks for rail freight traffic. Moreover, our anonymous interview survey of shippers and freight forwarders gave further evidence of an undersupply of rail tracks. Even if some shippers and forwarders had a willingness to use rail freight and had asked JRF to arrange new freight trains, it was too difficult for JRF to get new train slots from the JRPs, and the shippers and forwarders had to choose trucks in many cases. Further evidence is that, in 2002, JRF had developed a new high-speed freight train, Super Rail Cargo, which could run at 130km/h. However, one of the track owners, JR-Central expressed their anxiety about safety and opposed operating Super Cargo Rail despite other track owners, JR-East and West accepting it. In 2004 JR-Central finally approved operating Super Rail Cargo on their tracks however only in the night-time and at less than 110km/h (Container Age (2007)).

5. Conclusions

We reviewed the possible reasons why the modal shift of freight from road to rail has not happened. As a result of the JNR restructuring in 1987, the government established a new freight train operation scheme that moved rail track ownership to the six JRPs, and that allowed JRF to use the JRPs tracks by paying an access charge under the avoidable cost rule. The aim of this scheme was to reduce the track costs of JRF, and this was in fact achieved. But this rule displeased the JRPs and induced an undersupply of rail tracks for freight traffic as track access charges, determined by the avoidable cost rule, were much lower than the actual maintenance costs on average. JRPs and JRF are separated, therefore it is natural that cross subsidization among the independent companies would be refused. Actually, the annual reports of the completely privatized JRs (JR-East, Central, West and Kyushu) made the excuse to their shareholders that they had no choice in accepting the avoidable cost rule because of government direction. Furthermore, the JRPs had no incentive to invest in their rail tracks for more freight traffic, hence making it very difficult to develop new

freight markets. On the other hand, JRF could not afford to pay the access charge under the full cost rule. As shown in Figure 7, if the avoidable cost rule were abolished, the total operating costs of JRF would increase by 28% and track access charges would be the largest cost category. Moreover, it might be difficult for JRF to raise its freight charge due to the competition with trucks.

In conclusion, subsidization to JRPs could be one solution to the current avoidable cost rule issue, since the newly separated railway companies are paid higher track access charges with the subsidies. However, we should discuss the source of the subsidy. The new railways are subsidized from the fares of the HSR passengers because the new railways were separated from the JR network according to the HSR extension agreement. We should continue the discussion about the source of the subsidy but realistically, subsidizing from the point of view of prevention of global warming might be socially accepted, if we consider the purpose of a modal shift. For instance, in 2016, according to the annual reports of the Ministry of Finance and the Ministry of Internal Affairs and Communications, the total car fuel tax was 3.6 trillion yen while our calculation result of the JRPs' increased cost burden was 38 billion yen. We think there would be room for a discussion about subsidizing the track maintenance costs from the car fuel tax, though the subsidy would only partially cover the negative difference.

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Table 1 List of Abbreviations of the Organizations

IGR	IGR Iwate Galaxy Railway Company
JNR	Japanese National Railways
JNRSC	Japan National Railway Settlement Corporation
JRCC	Japan Railway Construction Public Corporation
JRF	Japan Freight Railway Company
JRPs	JR Passenger Companies (JR-Hokkaido, JR-East, JR-Central, JR-West, JR-Shikoku, JR-Kyushu)
JRTT	Japan Railway Construction, Transport and Technology Agency
MLIT	Ministry of Land, Infrastructure, Transport and Tourism of Japan

Table 2 Profile of JR companies

	Company			Route-km[1] (km)	Train-km[1] (million)	Passenger-km or Ton-km[1] (million)
1	JRPs	JR-Hokkaido	Passenger train operator and rail track owner in each region	2,552.0	31.4	4,313 [pax-km]
2		JR-East		7,457.3	254.9	135,098 [pax-km]
3		JR-Central		1,970.8	110.0	62,269 [pax-km]
4		JR-West		5,008.7	188.0	58,272 [pax-km]
5		JR-Shikoku		855.2	20.3	1,465 [pax-km]
6		JR-Kyushu		2,273.0	67.1	9,191 [pax-km]
7	JRF	JR-Freight	Nationwide freight train operator	35.3[2]	59.4	20,955 [ton-km]

Note) 1. The numbers of Route-km, Train-km, Passenger-km or Ton-km are in 2016.

2. JR-Freight has its own tracks of some feeder routes.

Source) Annual rail statistics in Japan (Tetsudo tokei nempo).

Table 3 Ownership Scheme of Shinkansen Lines

	Line (phase)		Route-km (km)	Opened or Extended in	Track owner	Track maintenance manager	Train Operator
1	Tokaido line		552.6	1964	JR-Central	JR-Central	JR-Central
2	Sanyo line	(1)	180.3	1972	JR-West	JR-West	JR-West
		(2)	442.0	1975			
3	Tohoku line	(1)	535.3	1982	JR-East	JR-East	JR-East
		(2)	96.6	2002	JRTT		
		(3)	81.8	2010			
4	Joetsu line		303.6	1982	JR-East	JR-East	JR-East
5	Yamagata line[1]	(1)	87.1	1992	JR-East	JR-East	JR-East
		(2)	61.5	1999			
6	Akita line[1]		127.3	1996	JR-East	JR-East	JR-East
7	Hokuriku line	(1)	117.4	1997	JRTT	JR-East	JR-East
		(2)	228.1	2015		JR-East JR-West	JR-East JR-West
8	Kyushu line	(1)	137.6	2004	JRTT	JR-Kyushu	JR-Kyushu
		(2)	151.3	2011			
9	Hokkaido line		148.8	2016	JRTT	JR-Hokkaido	JR-Hokkaido

Note) 1. Yamagata and Akita lines are shared by both of conventional trains and Shinkansen trains while the other lines are dedicated to Shinkansen trains.

Source) Annual report of each company.

Table 4 Newly Separated Railways (ex-JR conventional lines) and Related Shinkansen Extension

	Company	Route-km (km)	Opened in	Extended Shinkansen Line (phase)	
1	Shinano Railway Co., Ltd.	102.4	1997	Hokuriku line	(1)
2	Echigo TOKImeki Railway Company	97.0	2015		(2)
3	Ainokaze Toyama Railway Co., Ltd.	100.1			
4	IR Ishikawa Railway Co.,Ltd.	17.8			
5	IGR Iwate Galaxy Railway Company	82.0	2002	Tohoku line	(2)
6	Aoimori Railway Company	121.9			(2),(3)
7	Hisatsu Orange Railway Co., Ltd.	116.9	2004	Kyushu line	(1)
8	South Hokkaido Railway Company	37.8	2016	Hokkaido line	

Source) Annual report of each company.

Table 5 Calculation of Revenue from Rail Track Lending and Cost of Rail Track Maintenance of JRPs and IGR

	JR passenger companies (Total of six companies)					IGR (Iwate Galaxy Railway)				
	Average revenue and cost per train-km (JPY)			Train-km operated by JRF (mill.)	Total difference[3] (mill. JPY)	Average revenue and cost per train-km (JPY)			Train-km operated by JRF (mill.)	Total difference[3] (mill. JPY) [included subsidy[5]]
Year	Revenue[1]	Cost[2]	Difference			Revenue[1] [included subsidy[4]]	Cost[2]	Difference		
2006	226	903	△677	74.46	△50,398	1,145 [919]	763	382	1.24	473 [1,140]
2007	248	953	△705	72.77	△51,283	1,129 [881]	733	396	1.21	479 [1,066]
2008	262	905	△643	72.38	△46,521	1,185 [923]	738	447	1.21	541 [1,117]
2009	263	885	△622	70.23	△43,715	1,107 [844]	698	409	1.21	495 [1,021]
2010	252	935	△683	66.26	△45,265	1,187 [935]	745	442	1.21	532 [1,127]
2011	267	919	△652	64.20	△41,827	1,682 [1,415]	689	993	1.27	1,258 [1,791]
2012	275	921	△646	64.61	△41,754	1,932 [1,657]	753	1,179	1.15	1,352 [1,899]
2013	274	815	△541	63.72	△34,449	2,235 [1,961]	820	1,415	1.06	1,500 [2,080]
2014	285	842	△557	62.50	△34,837	2,474 [2,189]	886	1,586	1.11	1,758 [2,424]
2015	288	875	△587	61.55	△36,102	1,885 [1,597]	923	962	1.08	1,036 [1,721]
2016	291	928	△637	59.40	△37,829	2,534 [2,243]	967	1,567	1.08	1,689 [2,417]

Note) Each figure is calculated as follows.

1. Average track lending revenue per train-km = Total track lending revenue / freight train-kms
2. Average track maintenance cost per train-km = Total track maintenance cost / (freight train-kms + passenger train-kms)
3. Total difference = Average difference per train-km * freight train-kms
4. Subsidy = Average revenue of IGR - Average revenue of JRs
5. Total Subsidy = Subsidy per train-kms * train-kms

Source) Calculated with the annual rail statistics in Japan (Tetsudo tokei nempo).

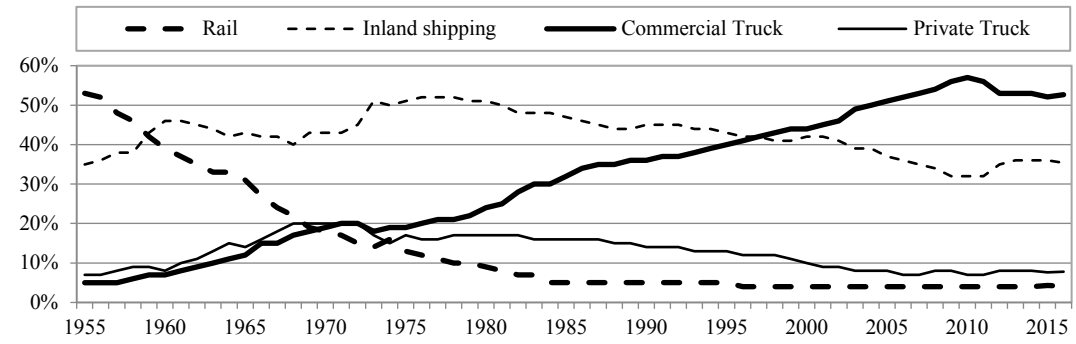

Fig. 1 Modal Split of Inland Freight Transport in Ton-km

Note) Air is excluded.
Source) Transportation Statistics Handbook in Japan (Kotsu keizai tokei yoran).

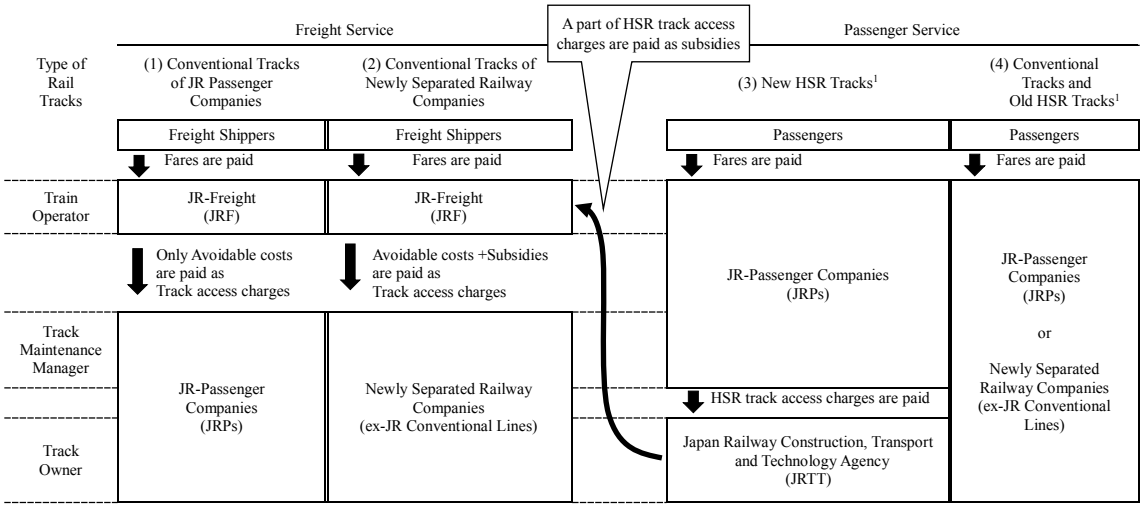

Fig. 2 Comparison of Track Ownership and Track Access Charge Schemes

Note) 1. HSR is dedicated to passenger service. HSR tracks opened until 1997 are classified into the Old tracks and after 1997 into the New tracks.

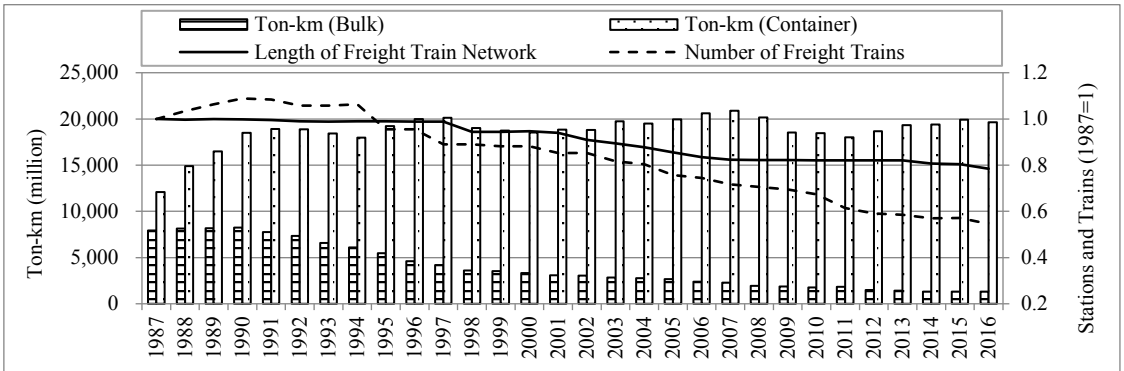

Fig. 3 Freight Volume, Network and Trains of JRF

Source) Transportation Statistics Handbook in Japan (Kotsu keizai tokei yoran),
Logistics in Numbers in Japan (Suji de miru Butsuryu).

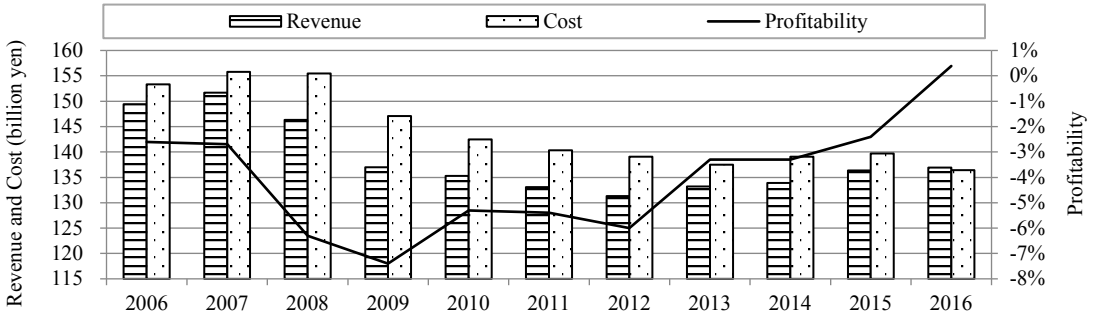

Fig. 4 Operaring Revenue, Cost and Profitability of JRF (Rail Transport Division)

Note) Revenue and cost are at nominal price. Profitability of JRF as a whole has been disclosed since 1987, however, that of only rail transport division had not been disclosed until 2005.
Source) Annual rail statistics in Japan (Tetsudo tokei nempo).

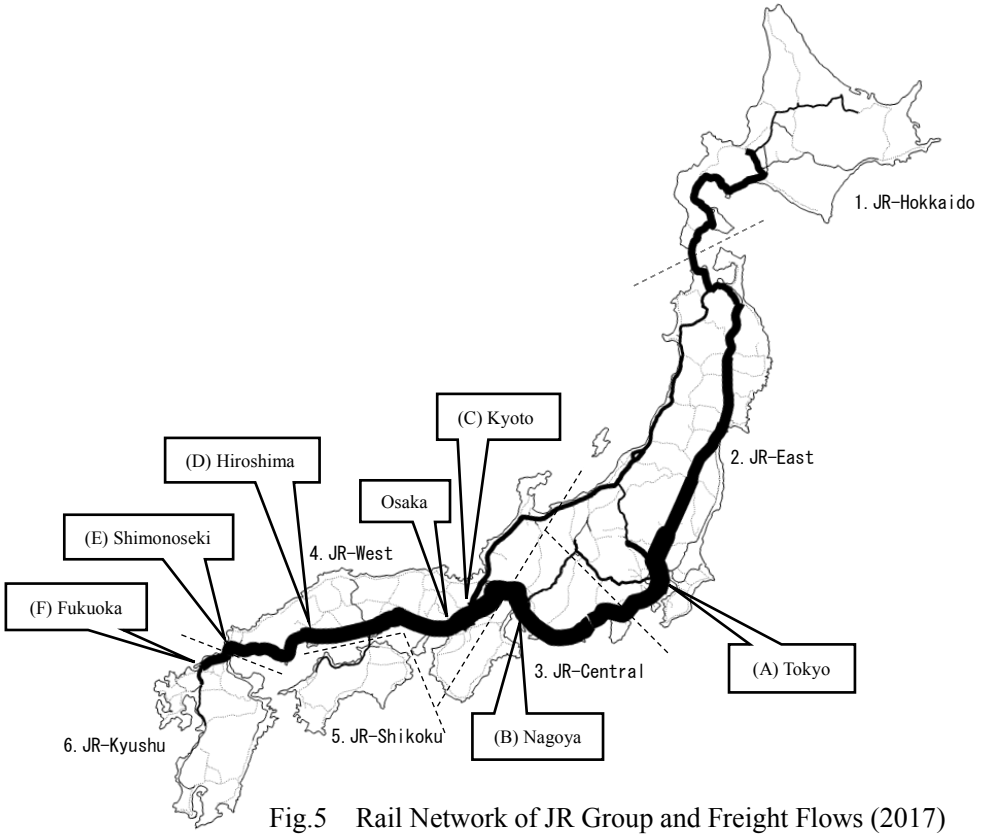

Fig.5 Rail Network of JR Group and Freight Flows (2017)

Note) Network of JRF is illustrated by black lines and thickness of line reflects the volume of freight flows.

Gray lines indicate the network for only passenger service.

Dotted lines indicate the borders of six JR passenger companies.

Source) Materials provided by JRF.

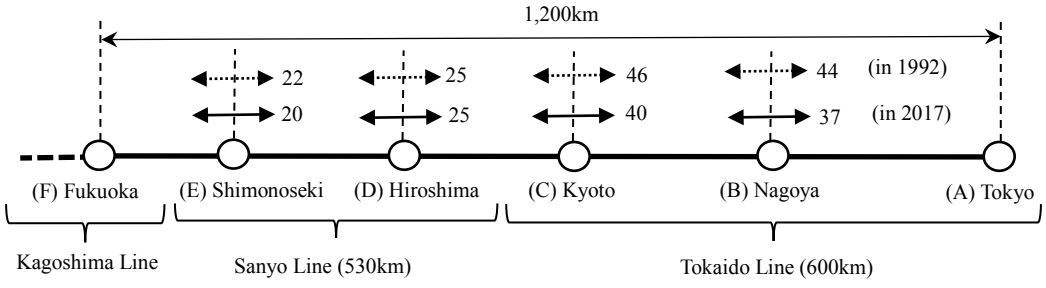

Fig. 6 Cross Sectional Freight Flows on the Busiest Corridor (thousand tons per day)

Source) Materials provided by JRF.

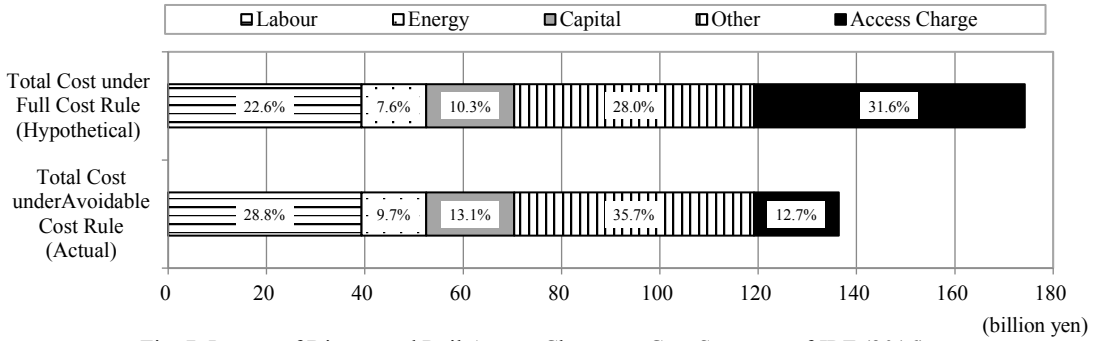

Fig. 7 Impact of Discounted Rail Access Charge on Cost Structure of JRF (2016)

Source) Annual rail statistics in Japan (Tetsudo tokei nempo).