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Possibility of intermodal freight transport using ferry and RORO ships in Japan

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Key words: intermodal freight transport, ferry, RORO ship, the net freight flow census, transported goods, transportation services

Abstract
In Japan, it is becoming difficult to move freight long distances using only trucks, owing to a shortage in truck drivers. In this context, there is a tendency to also actively utilize ferries or roll-on/roll-off (RORO) ships. Intermodal freight transport uses two or more suitable modes of transport from the origin of goods to the destination. In order to promote intermodal freight transport, it is necessary to analyze factors such as the characteristics of transported goods, transportation services and fares, and lot sizes. In this study, we focused on ferries and RORO ships in Japan, and attempted to identify cargoes transported using different modes of transport, based on the net freight flow census. In conclusion, high volumes of "agricultural and fishery products," "metal machinery," "chemical industrial," "light industrial," and "miscellaneous manufacturing products" can be transported using ferries or RORO ships. Specifically, there is a tendency that products are segregated by transportation mode such as a truck, or a ferry and a RORO ship.

Introduction

In Japan, it is becoming difficult to deliver freight over a long distance using only trucks because of shortage of truck drivers (MLIT, 2015). Thus, relay transportation using two truck drivers and intermodal freight transport using rail or a coastal ship (a ferry or a roll-on/roll-off (RORO) ship) has attracted attention.

Intermodal freight transport is the concept of using two or more suitable modes from a point of origin to the final destination of goods (Lowe, 2015). Intermodal freight transport is defined by cargo unitization, i.e. the possibility to move goods in an intermodal transport unit (container, swap body or semi-trailer). Thus, intermodal freight transport requires complex arrangements (Hayashi & Nemoto, 2012). Notably, Hanssen et al. (Hanssen, Mathisen & Jørgensen, 2012) showed that intermodal transport methods increased generalized transportation costs due to the handling costs at terminals. Talley and Ng (Talley & Ng, 2018) showed that a hinterland transport chain choice is jointly determined by seaports, dry ports, intermodal carriers, importers and exporters and shippers seek to minimize physical distribution cost. However, Zhao et al. (Zhao, Ioannou & Dessouky, 2017) discussed that an efficient freight routing system can not only save transport time and costs of freight transport but also contribute to mobility, efficiency and sustainability for the entire urban area.

Stokland et al. (Stokland, Sund & Netland, 2010) showed that improving cooperation between the actors in the intermodal logistics network was the key to developing an efficient intermodal freight transportation network. Larranaga et al. (Larranaga, Arellana & Senna, 2017) discussed which transport policies could encourage multimodality and more

sustainable uses of available transport infrastructure; their simulation results suggested that investment in increasing the reliability of intermodal alternatives was more effective than cost reductions in encouraging intermodality.

Taesung and Yanfeng (Taesung & Yanfeng, 2014) developed a binomial logit model for two dominating modes (truck and rail) and found that the truck was the preferred choice for short distance transportation and high value products.

Intermodal freight transport using a ferry or RORO ship is an easy solution to the aforementioned problem, and is an efficient method of handling products because a truck can drive directly onto the ferry or RORO ship. A very important factor of the efficiency and competitiveness of intermodal transport is the structure of goods transported, and thus it is necessary to analyze the characteristics of transported goods, transportation services and fares, and lot sizes. In this study, we focused on ferries and RORO ships in Japan, and, based on the net freight flow census, attempted to identify cargoes transported by different modes of transport.

Existing conditions of freight transport in Japan

Trend of freight volumes in Japan

Figure 1 shows domestic freight volumes in Japan. On the freight weight (ton) basis, trucks have moved high volumes throughout the period 1965–2014. In terms of the freight weight-distance (ton-kilos) basis, the freight volumes moved by trucks and coastal ships were similar. This means that coastal ships were used for moving freight long distances. Figure 2 shows the modal share of freight by country. The ratio share of maritime transport in the EU, China and Japan exceeds 30%. Thus, coastal ships are in an important position in these countries. Figure 3 shows the details of the freight volume ratios in relation to transport and distance. It can be seen that freight with longer transport distances uses a comparatively lower share of trucks and a higher share of coastal ships. In particular, when the transport distance exceeds 300 km, the mode share of the coastal ship increases dramatically. In order to focus

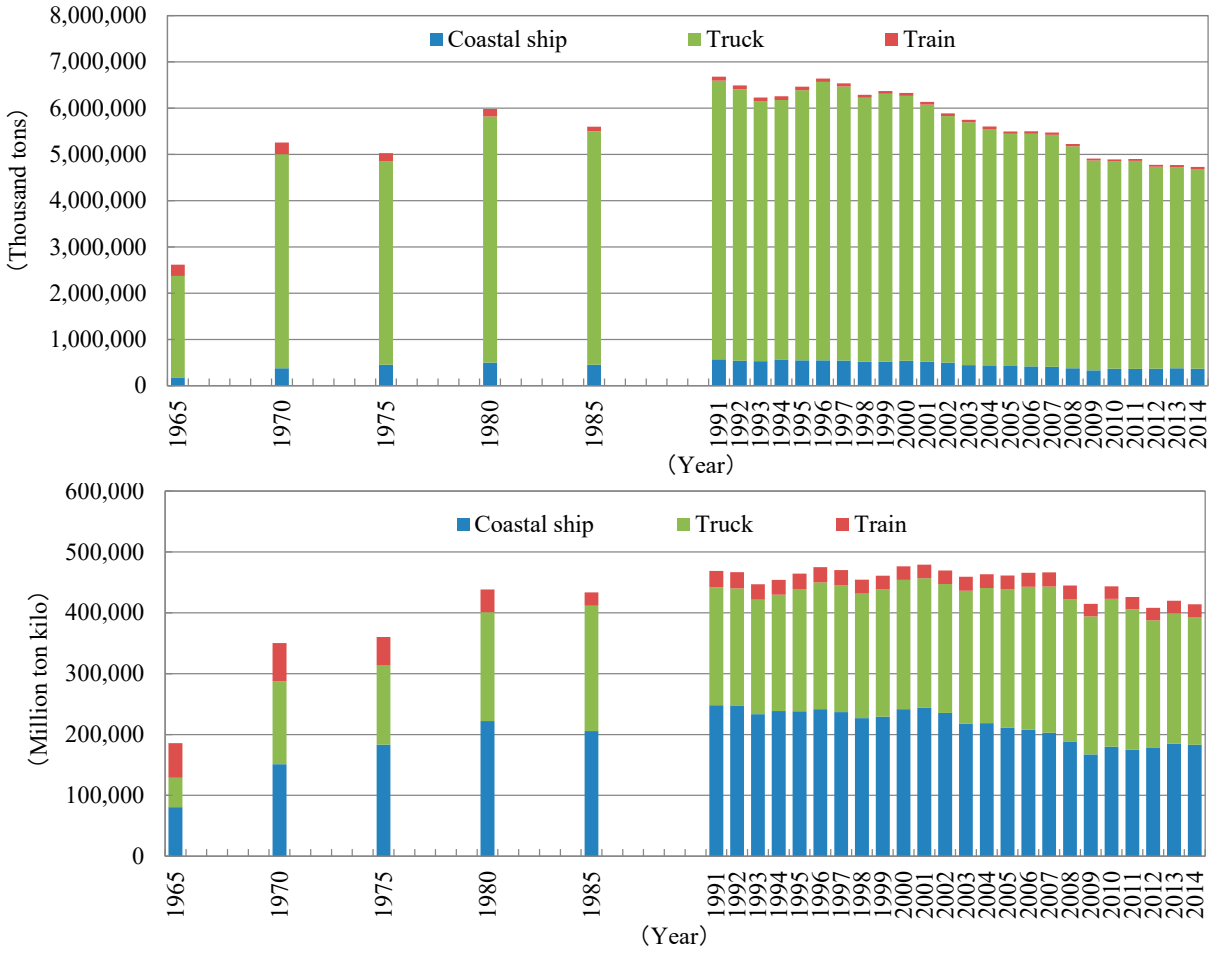

Figure 1. Freight volume by weight bases and weight-distance bases (JALoT, 2016)

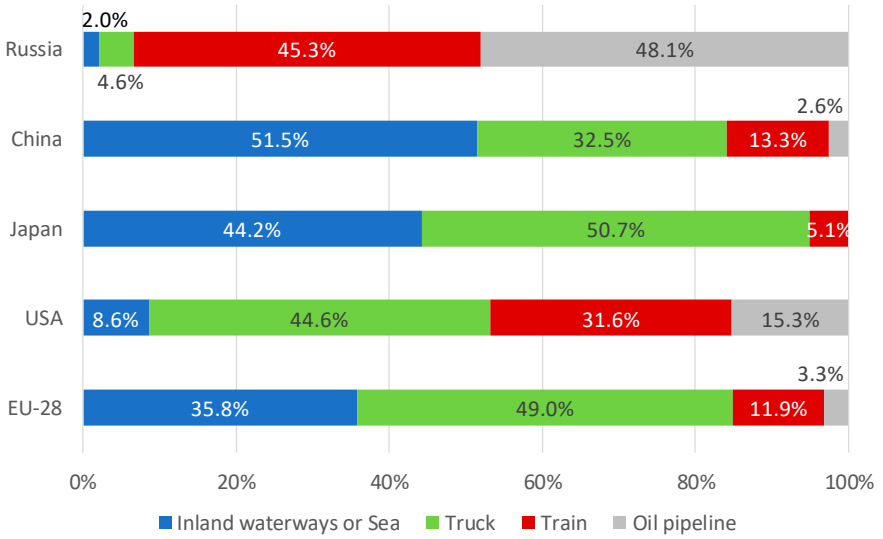

Figure 2. Modal share of freight by country (Office of the EU, 2017)

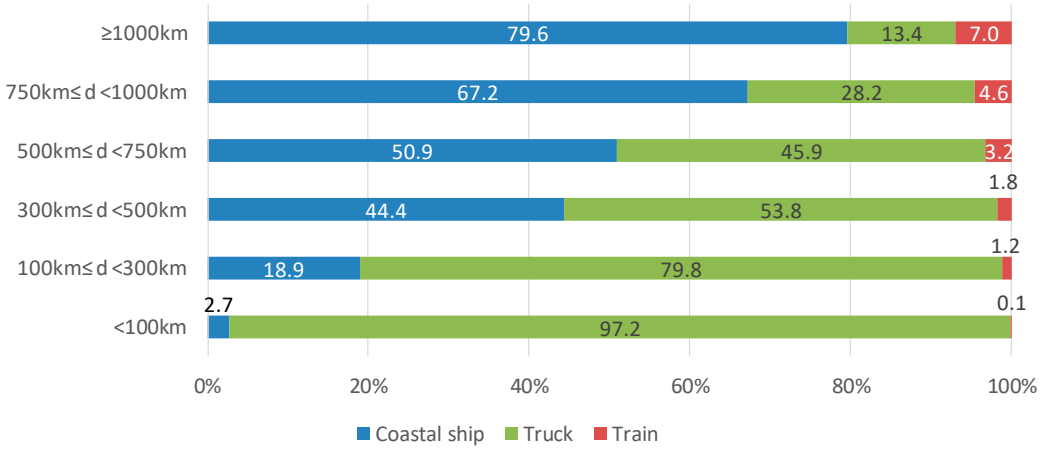

Figure 3. Mode share of freight volume by distance (JALoT, 2016)

on coastal ferry and RORO ship transport, this study targeted freight traveling more than 300 km.

Ferry and RORO ship network in Japan

In Japan, domestic ferries and RORO ships are mainly used in addition to trucks for intermodal freight transport. According to the Long-Distance Ferry Association (The Long-Distance Ferry Association, 2017), the number of long-distance routes of more than 300 km is 14, as shown in Figure 4, including those between Hokkaido and Kyushu. RORO ships are also used on other routes. According to the Naiko RORO ship guide (Nikkan-Kaijitsushin-sha, 2015), the number of long-distance routes of more than 300 km is 23. Japanese intermodal freight transport is supported by long-distance ferries and RORO ships. The analysis of this study focuses on transport between Kyushu/Shikoku and Kansai/Chubu/Kanto

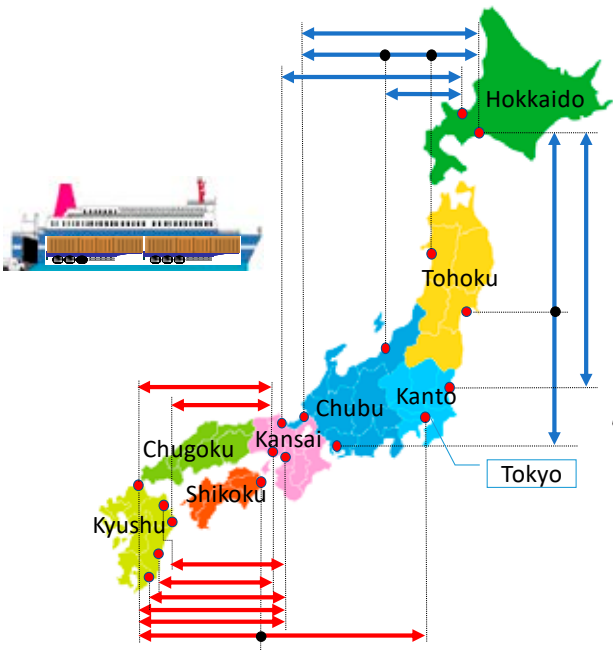

Figure 4. Ferry network in Japan

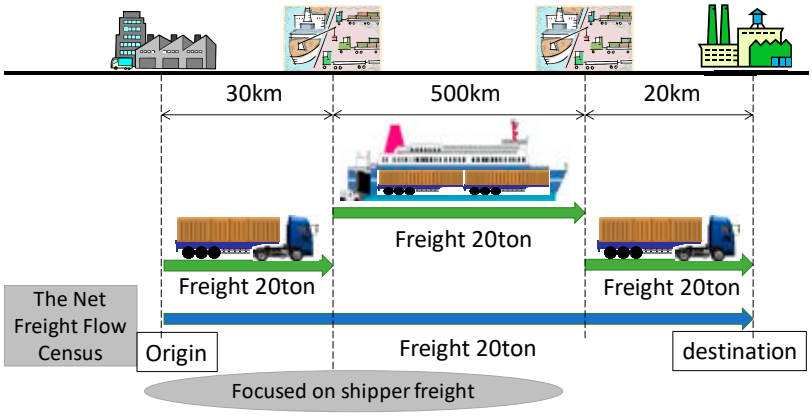

Figure 5. Image of net freight flow

where many ferries and RORO ships are in service, as indicated in red in Figure 4. Because it is impossible to move cargo to and from Hokkaido by truck alone, we did not include those routes in the analysis.

The net freight flow census in Japan (logistics census)

Many of statistics on freight movement in Japan are official statistics provided by the government (Kawasaki, 2015). The net freight flow census is one of the surveys conducted by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). This survey is conducted once every five years via a questionnaire sent to shippers. The survey investigates the movement of freight from the points of origin to the final destinations as one-way flow. Figure 5 shows an image of net freight flow. This census focuses on the freight data but not on transportation mode. In this data, the representative transportation mode is defined as the mode used for long-distance transportation, and the freight data is aggregated by the representative transportation mode.

Trends in transport volume by transport mode

Figure 6 shows freight volumes by mode of both directions between Kyushu/Shikoku and Kansai/Chubu/Kanto. Truck freight volume showed a rapid increase from 2000 to 2005. From 1995 to 2000, the truck freight volume from Kansai/Chubu/Kanto to Shikoku/Kyushu was higher than in the opposite direction. However, since 2005 the opposite has been true (truck freight volume from Kyushu/Shikoku to Kansai/Chubu/Kanto was higher). The freight volumes on ferries and RORO ships gradually decreased from 1995 to 2005 due to high fares. However, from 2006, shippers have been obliged to report to the government on such matters as "creation of energy saving plan" and "regular report of energy usage" from the viewpoint of modal shift. Therefore, the use of ships increased slightly in 2010.

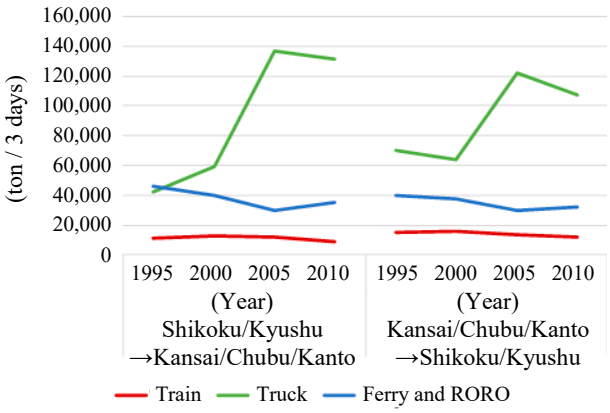

Figure 6. Freight volumes by mode between Kyushu/Shikoku and Kansai/Chubu/Kanto

To understand the changes, we analyzed the freight volumes on trucks and ferries and RORO ships in each segment. These volumes are shown in Figures 7 and 8, respectively.

From Kyushu to Kanto, from Kyushu to Chubu, and from Kansai to Kyusyu, the truck freight volume was remarkably high in 2005, as shown in Figure 7. Conversely, in the same segments in 2005, the freight volume moved by ferries and RORO ships was not so high, as shown in Figure 8. This means that the ferry and RORO ship mode could not successfully capture the freight during this period.

Possibilities for intermodal freight transport

Figure 9 shows the freight volume ratio, by freight product type, between Kyushu/Shikoku

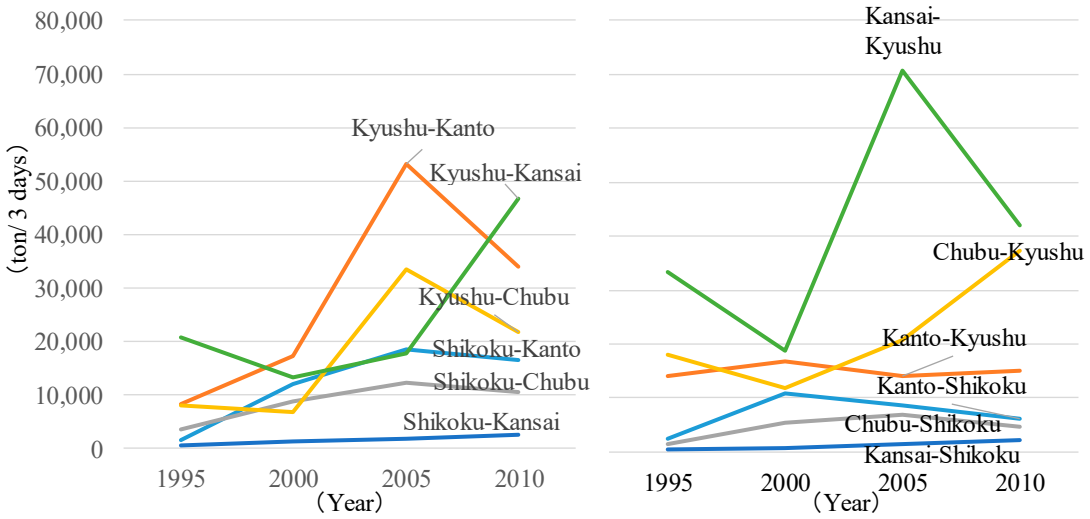

Figure 7. Truck freight volumes by segment

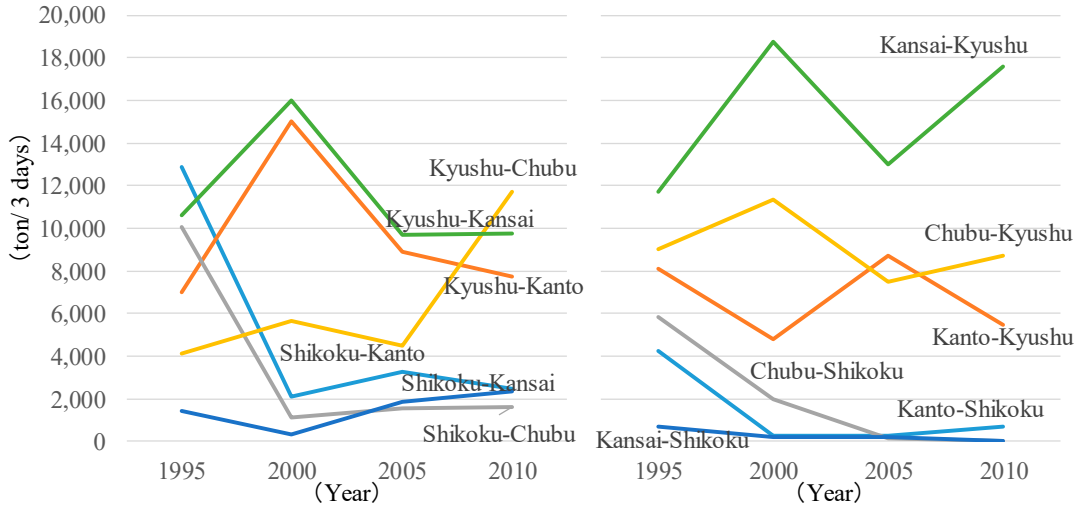

Figure 8. Ferry and RORO ship freight volumes by segment

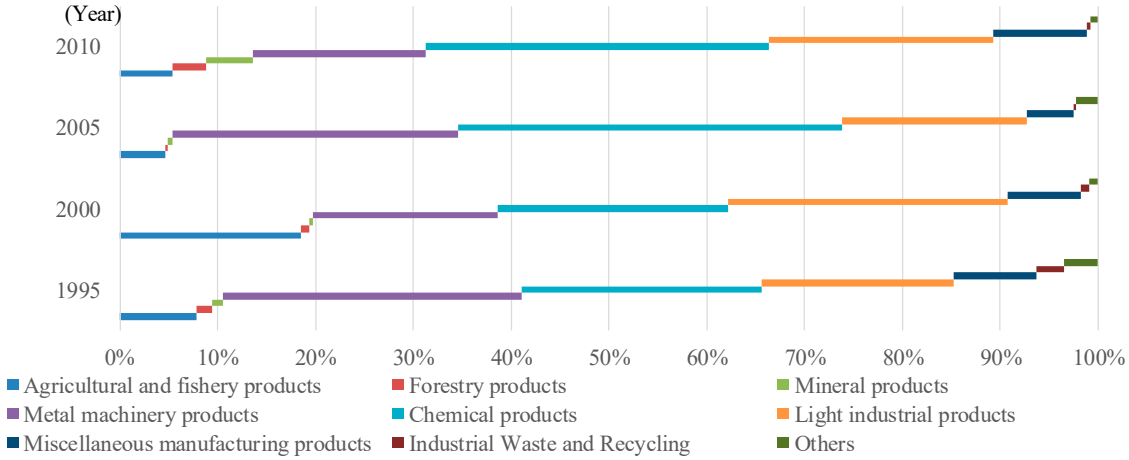

Figure 9. Volume ratio by freight category (more than 300 km)

and Kansai/Chubu/Kanto. Although the freight volume ratios vary each year, “agricultural and fishery,” “metal machinery,” “chemical industrial,” “light industrial,” and “miscellaneous manufacturing products” all have high freight volumes. Therefore, it is necessary to target these five freight categories for the promotion of intermodal freight transport.

Table 1. Respective products list in the net freight flow census

Product type	Product item	Product type	Product item	Product type	Product item
(1) Agricultural and fishery products	Wheat	(3) Chemical products	Cement	(4) Light industrial products	Pulp
	Rice		Fresh concrete		Paper
	Vegetables and fruits		Cement products		Thread
	Wool		Glass products		Fabric
	Other livestock products		Ceramics		Sugar
	Fishery product		Other ceramic products		Other food industry products
	Cotton		Heavy oil		Beverages
	Other agricultural products		Volatile oil	(5) Miscellaneous manufacturing products	Book, printed matter and recorded matter
(2) Metal machinery products	Steel		Other petroleum		Toys
	Nonferrous metals		LNG/LPG		Clothes and personal belongings
	Metal products		Other petroleum products		Stationery
	Industrial machinery products		Coke		Furniture and fitments
	Electric machine products		Other coal products		Other daily necessities
	Finished cars		Chemical agents		Wood products
	Automobile parts		Chemical fertilizers		Rubber products
	Other transportation machinery products		Dyes, pigments and paints		Other manufacturing industrial products
	Precision machinery products		Synthetic resin		
	Other machinery products		Animal and vegetable oils		
	Other machinery products		Other chemical industrial products		

Table 1 indicates the respective products of the five freight categories used in the net freight flow census. In this study, we analyzed abrupt changes in freight volume of segments.

(1) Agricultural and fishery products

Figure 10 shows the freight volumes of "agricultural and fishery products" transported from Kyushu to Kanto. The majority of the freight volume was "vegetables and fruits".

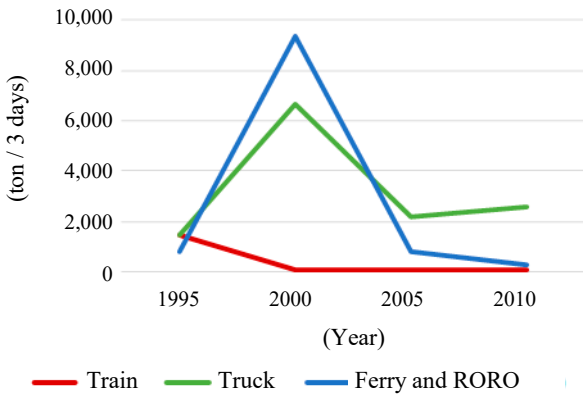

Figure 10. Freight volumes of "agricultural and fishery products" from Kyushu to Kanto

(2) Metal machinery products

Figure 11 shows the freight volumes of "metal machinery products" moving from Kansai to Kyushu. The truck freight volume increased in 2005 due to increases in "steel" and "electric machine products". However, in 2010, the truck freight volume decreased slightly, and the ferry and RORO ship freight volume increased dramatically. The high freight volume was mainly "steel". It seems that an increase in the ferry and RORO ship freight volume

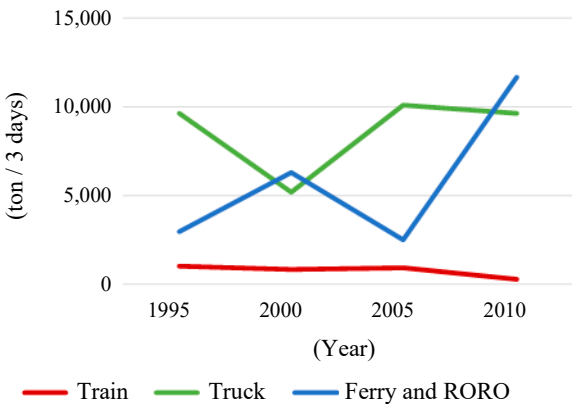

Figure 11. Freight volumes of "metal machinery products" from Kansai to Kyushu

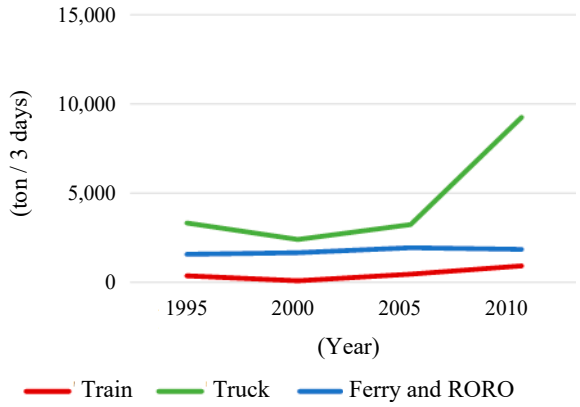

Figure 12. Freight volumes of "metal machinery products" from Kyushu to Chubu

follows, with some time lag, an increase in truck freight volume.

Furthermore, as Figure 12 shows, the truck freight volume of "metal machinery products" between Kyushu to Chubu abruptly increased in 2010. The high freight volume was caused by "finished cars". Conversely, the "finished cars" could not be seen in the data for the ferries and RORO ships, but the "automobile parts" could be seen in this data.

(3) Chemical products

Figure 13 shows the freight volumes of "chemical products" from Kyushu to Kansai. The truck freight volume increased abruptly in 2010 because of an increase in "other chemical industrial products" such as cosmetics, medicines, agricultural chemicals, printing ink, etc. Conversely, "other chemical industrial products" were not transported by ferries or RORO ships. In addition, "chemical agents" such as inorganic industrial chemicals, high pressure gas, etc. and "other petroleum" such as kerosene, lubricants, etc. were transported using trucks.

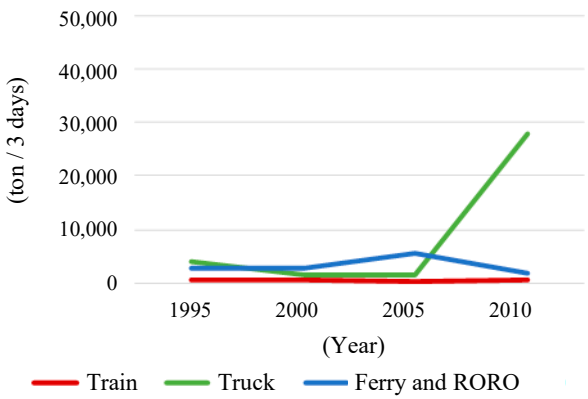

Figure 13. Freight volumes of "chemical products" from Kyushu to Kansai

(4) Light industrial products

Figure 14 shows the freight volumes of "light industrial products" from Kansai to Kyushu. The freight volume moved by trucks increased abruptly in 2005 as "other food industry products" and "beverages" increased, but few of these products were transported via ferries or RORO ships. Similarly, in 2010, most of the "other food industry products" and "beverages" were transported by trucks, but not by ferries or RORO ships. From Kyushu to Kanto and from Kyushu to Kansai, it was also the case that most of the "other food industry products" and "beverages" were transported by truck.

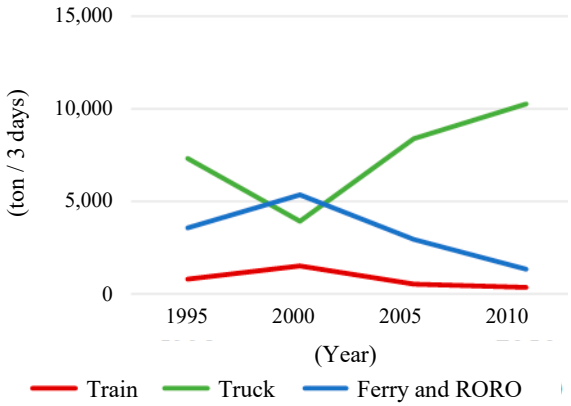

Figure 14. Freight volumes of "light industrial products" from Kansai to Kyushu

(5) Miscellaneous manufacturing products

Figure 15 shows the freight volumes of "miscellaneous manufacturing products" from Chubu to Kyushu. The truck freight volume increased abruptly in 2010 as the volume of "furniture and fitments" increased. Similarly, from Kyushu to Chubu and from Kyushu to Kansai, most of the "furniture and fitments" were transported by truck.

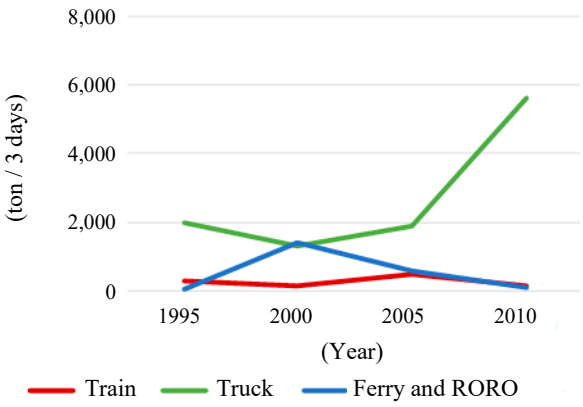

Figure 15. Freight volumes of "manufacturing products" from Chubu to Kyushu

Conclusions

We analyzed five high-volume freight categories: "agricultural and fishery products," "metal machinery products," "chemical industrial products," "light industrial products," and "miscellaneous manufacturing products". Based on our study, "vegetables," "fruits," "steel products," "finished cars," "other chemical industrial products," "other food industry products," and "beverages" could be shifted to ferries or RORO ships. However, the "industrial chemical products" and "other petroleum products" are unsuitable for this because these items are considered hazardous materials for transportation purposes. In addition, abrupt changes in freight volumes were only seen in the truck mode; the ferry and RORO ship mode cannot cope with abrupt changes in freight volume because of problems of timewise connections.

This study clarified the relationship between freight items and transportation modes, and explained which freight items could be shifted from trucks to ferries and RORO ships.

Acknowledgments

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