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Investigating Variations in the Deep-sea Sourcing Strategies of Car Manufacturers: Two Case studies of parts consolidation centers in Japan

Abstract

This paper investigates how two Japanese car manufacturers organize their shipments of parts from suppliers located in Japan to their overseas assembly plants. It reveals that, in addition to the well-known differences such as specific manufacturer-supplier relationships or production strategies, the organization of logistics itself constitutes a basis for persistent variations. Car manufacturers operating at a global scale are facing uncertainties in matching supply and demand, thus increasingly requiring flexibility. This flexibility is notably achieved through varying combinations of local and distant sourcing to respond to changes in market conditions, currency exchange rates, and so on. To limit the costs of distant sourcing, car manufacturers use parts consolidation centers, which are cross-docking facilities where parts are sorted and packed in sea containers depending on their final destination. Findings show that, beyond its generic purpose, the parts consolidation centers play different roles within the logistics organization of the two focal firms. In one case, they are highly integrated within the global production system; in the other, they are simply used as transfer points. These different models of utilization of parts consolidation centers imply significantly different relationships with parts' suppliers, and point to wider differences in the overall logistics systems.

Key words: Automotive industry, parts consolidation center, distant sourcing, Japan

1.Introduction

This study investigates the role of parts consolidation centers (PCC) in the logistics operations of two Japanese car manufacturers. It aims to understand how global firms sharing common elements, such as overseas markets, product orientation, and generic sourcing solutions, organize their logistics operations differently to cope with uncertainty. By focusing on the particular case of parts logistics, it contributes to the broader discussion on the uneven impacts of globalization on the organization of firms and the localities traversed by flows. While some studies in the social sciences highlighted the prominence of unitary paradigms (e.g., Vogel, 1979), others stressed the diverse effects of globalization on firms and regions (e.g., Storper, 1997; Hall, 2004; Coe et al., 2004).

The automotive industry has been one of the arenas where this debate has taken place, particularly during the late 1980s and the 1990s, at the apogee of Japanese transplants in the United States. In the book ‘The Machine that Changed the World’⁵, a group of scholars from MIT suggested that lean production would become the dominant paradigm of the industry (Womack et al., 1990). That vision was successful internationally in both professional and academic circles, but also raised criticism. Alternative views pointed out that, instead of one single successful model, a variety of profit strategies existed, whose success depended notably on labor and market conditions (Boyer and Freyssenet, 2002). Thus, there was not only one approach to success, but many. Solutions varied considerably between regions, and even between manufacturers within the same region (Freyssenet et al., 1998). The strategy which was supposed to ‘change the world’⁵ (Womack et al., 1990) did not even prevent the Japanese automotive industry, where it was allegedly born, from being hit by an economic crisis during the 1990s (Shimizu, 2002).

Within economic geography, the spatial implications of lean production prompted interesting discussions (e.g., Mair, 1993; Kenney and Florida, 1992). One of the main approaches to achieve permanent reduction in costs regardless of the sales volume is the implementation of just-in-time (JIT) systems, characterized by the frequent deliveries of small quantities of parts at the last minute. With little or no stock, it is easy to determine which suppliers find it difficult to meet production deadlines or quality norms, and to encourage them to find solutions (Shimizu, 2002). Beyond the need for reliable transport links, the proper functioning of the JIT systems requires effective communication between engineers moving back and forth between the suppliers and assembly plants, cooperative research, and joint product development. These exchanges of goods and information often require some kind of geographical proximity, with the supplier being

generally located within a radius of 50 to 250 km around the assembly plant (Mair et al., 1988; Kenney and Florida, 1992). Consequently, with the diffusion of JIT systems in Europe and the United States, policy makers viewed -and often overestimated- opportunities for regional (re)development focused on the automotive industry (Mair, 1993). Later studies relativized the importance of geographical proximity by showing that JIT deliveries could be implemented over longer distances by different transport modes (e.g., Van Egeraat and Jacobson, 2005; Kaneko and Nojiri, 2008). However, these distant JIT deliveries often required intermediary cross-docking facilities, whereas the necessary coordination between the assembly and supplier plants is difficult to obtain, given the differences in languages, cultural backgrounds, time zones, and so on (Fawcett and Birou, 1992). Thus, car manufacturers rarely adopted the JIT systems for distant sourcing, and held important -and costly- safety stocks to hedge against perturbations in the deep-sea transport leg (Lim et al., 2014).

In the last decades, because of the saturation of the traditional markets and the need to focus on emerging economies, distant sourcing has gained importance in the automotive industry. Car manufacturers have been encouraged to assemble cars and supply parts in distant countries, where qualification levels and supplier bases are often lacking. Historically, the overseas production in emerging economies was limited to the assembly of imported complete knocked down kits (CKD) (Sturgeon and Florida, 2000). However, the CKD system remains expensive, weighting heavily on the final price of the cars assembled overseas. Over time, with the expansion of car markets in emerging economies, car manufacturers were encouraged to develop more autonomous assembly plants, similar to those existing in their home countries. Instead of importing all the kits, these new plants use individual parts ordering systems, sourcing from both overseas and local suppliers. Additionally, the development of individual parts ordering has been facilitated by containerization, which improved the regularity and cost conditions of maritime transport substantially (Guerrero and Ng, 2015).

To reduce the costs of distant sourcing of individual parts, car manufacturers rely on PCCs, which are cross-docking facilities where parts are sorted and packed in sea containers depending on their final destination. Many major car manufacturers use PCCs to organize distant shipments of parts within their global production networks (Erfurth and Bendul, 2018). In many aspects, the motivations and the ways in which major car manufacturers organize their distant sourcing logistics are similar, such as seeking economies of scale in transportation, efficient management of inventories, and management of information flows. However, there are important differences in the roles

that PCCs play within the logistics strategies of car manufacturers, even when they share a common base and partially common markets. We demonstrate the persistence of these variations using the case studies of two major Japanese car manufacturers.

Our research approach is greatly inspired by Hall(2004), who set up a compelling theoretical framework for analyzing the relationships between logistics and manufacturing systems from an economic geography perspective. By comparing the logistics operations of several car manufacturers importing finished cars into the United States, persistent variations are found. In the case of some car manufacturers, the import strategy appears to be strongly localized, relying on the autonomous local actors, not only for selling cars, but also for ordering, thus customizing cars and distributing parts to the after-market sales. In the case of other car manufacturers, the distribution of cars in the U.S. is largely kept in house and ports are merely used as transfer points “to be passed through as quick as possible” (Hall,2004, p.530). These variations indicate the diverse outbound logistics strategies implemented by car manufacturers that share similar characteristics and are subject to similar market conditions. Furthermore, they illustrate how the logistics networks of finished cars of different firms are unevenly grounded in localities such as ports.

We extend the work initiated by Hall (2004) by examining the parts logistics of two Japanese car manufacturers. Additionally, we provide an integrated approach of logistics issues to distant sourcing, beyond specific modes of transport such as land (e.g., Serrano et al,2017) or air. Comparative studies on distant sourcing strategies of firms are rare. Erfurth and Bendul (2018) analyze the parts consolidation strategies in six European car manufacturers, by focusing on the expected transaction costs and economies of scale. However, in most studies focused on distant sourcing, the transport dimension is lacking. To fill this void, we analyze the distant sourcing of parts from suppliers located in Japan to the overseas assembly plants through PCCs.

For this study, between 2015 and 2017, more than 30 interviews¹ were conducted with logistics and production managers from Japanese car manufacturers, suppliers, and logistics providers. Motor Co. and Car Co. are pseudonyms of the two Japanese car manufacturers. Their identities are disguised to maintain confidentiality.

The rest of the paper is organized as follows: In Section 2, we discuss the

¹ The interviews were conducted with two car manufactures (or assemblers, Motor Co. and Car Co.), seven major suppliers (one independent company, and three sister companies each of the two assemblers), seven large logistics providers (two independent and five sister companies of the two assemblers), two medium independent local logistics companies, and the local authorities in the primary manufacturing regions of Chubu (mainly Aichi prefecture), Kanto, and Kyushu since

importance of distant sourcing of Japanese car manufacturers to their overseas assembly plants, especially the parts provided by major suppliers. In section 3, we examine the case studies on PCCs and clarify the roles within the logistics organization of the two car manufacturers. Finally, in section 4, we present our conclusions.

2. Distant sourcing and its implications for two focal car manufacturers

2.1 Production and sales of the two focal car manufacturers

The main markets of the two focal car manufacturers lie much further away outside Japan. Tables 1 and 2 show the geographical distributions of production and sales of Car Co. and Motor Co., with the shares of domestic sales being about 10% for Car Co. and about 25% for Motor Co. The two car manufacturers assemble vehicles both within Japan and overseas. However, the importance of the domestic production varies significantly between them, representing 18% and 48% of the global volumes of Car Co. and Motor Co, respectively.

The overseas assembly activity of Car Co. has quickly developed since its start in the late 1970s (1976), reaching 50% of its global production in the second half of the 1990s. Nowadays, 82% of its global production takes place overseas with only one million vehicles assembled within Japan (Table 1). For Car Co., North America (including Mexico) and China are the most important markets and production regions.

Table 1: Car Co. production and sales in 2016 (Unit: thousand vehicles)

In 2016	Production	Sales
Domestic (Japan)	1,015 (18.0)	557 (9.9)
China	1,321(23.4)	1,355 (24.1)
North America	991(17.5)	2,130 (37.9)
Others	2,327 (41.2)	1,584 (28.2)
Mexico	864 (15.3)	-
UK	518 (9.2)	-
TOTAL	5,654	5,626

(Source) Car Co.'s HP

Comparatively, the internationalization of Motor Co.'s production started earlier in 1958, but has been more limited. The overseas assembly only reached 50% of global production in 2007, and this share has remained stable until today (more than 4 million cars are assembled in Japan). Motor Co. uses the "Made in Japan" label as a marketing tool for its luxury brand under which 0.7 million vehicles are produced, mostly within Japan. Outside Japan, the regions contributing more to the Motor Co.'s global production and sales are North America and Asia (mostly in China and Thailand).

Table 2: Motor Co. production and sales in 2014 (Unit: thousand vehicles)

In 2014	Production	Sales
Japan	4,345 (48.1)	2,365 (25.9)
North America	1,759 (19.5)	2,529 (27.7)
Europe	506 (5.6)	844 (9.3)
Asia	1,939 (21.5)	1,609 (17.7)
Others	483 (5.4)	1,769 (19.4)
TOTAL	9,032	9,116

(Source) Motor Co.'s HP

To summarize, the share of domestic market in global production varies considerably between the two car manufacturers, since Motor Co. maintains an important base of domestic production, whereas Car Co. does not. However, the overseas production regions and markets are largely common to both manufacturers.

In their overseas expansion, the Japanese car manufacturers have been followed by a selection of their home suppliers. New supplier plants were created overseas to supply locally some parts, with the rest being sourced from Japan, and to a lesser extent from other regions. As showed by Guerrero and Ng (2015), the parts that are sourced locally tend to be bulky, labor-intensive, low value-added, or involving a high variety of options. Conversely, the parts imported from home countries tend to be standardized and capital- and technology-intensive. Additionally, distant sourcing is adopted for final assembly of apparently simple components such as certain types of screws, for which the quality standards cannot always be reached by local suppliers (Guerrero and Ng, 2015).

2.2 Long-distance parts' delivery by Japanese suppliers

Maritime transport is the most common mode used for distant shipments of parts, since air transport is reserved for high-value components or emergency supplies. In some cases, when the volumes are very important, full containers can be directly shipped from a supplier plant in Japan to an overseas car assembly plant. However, given the frequency of shipments and the variety of destinations, the PCCs are intensively used.

In addition, the PCCs of car manufacturers are used by some of their selected suppliers for the consolidation of their own intra-firm shipments. These intra-firm shipments allow car manufactures to provide a wider variety of parts to their overseas assembly plants at the cost of important stocks.

Machine Vendor and Mechanics Vendor (pseudonyms) are two large suppliers specializing in key components such as transmissions and engine parts. A substantial share of their production in Japan is shipped overseas through their own production

networks. Both generate large volumes of intra-firm flows, either directly or through the car manufacturers' PCCs. In 2016, Machine Vendor² shipped about 400 twenty-foot equivalent units (TEUs) to Mexico, 150 to China, and 10 to Thailand per month. With the increase in the overseas production of the focal car manufacturers in certain countries, some of the overseas plants of Machine Vendor have been upgraded to produce a wider range of parts locally, thus reducing the overseas sourcing. Although this point has not been explicitly addressed in the interviews, a downgrade of the overseas suppliers' plants seems probable in the case of significant decrease in demand.

Mechanics Vendor uses two different canals for its overseas deliveries: one is for Motor Co.; the other is for other clients (including Mechanics Vendor overseas' subsidiaries). In the first case, Mechanics Vendor bears the cost and responsibility for delivering its parts at Motor Co.'s PCCs. In the second case, it uses its own consolidation facility next to the port of Nagoya³, for delivering about 120 TEUs per day to its other overseas clients^{4 5}. In average, the overseas plant-to-plant transport takes between two and three weeks, including customs and vessel waiting time in port.⁵

In addition to key components or high value-added parts, low value-added parts are in some cases sourced from Japan. Plastic Vendor (pseudonym) organizes its shipments in a similar fashion to the aforementioned Mechanics Vendor case. Figure 1 schematizes the procedure for the overseas transport of parts. In the first case (Figure 1, bottom section), the parts being shipped to the Car Co.'s overseas assembly plants are delivered to the Car Co.'s PCC. Unlike the former case, Car Co. takes the responsibility and bears the costs for the deliveries from the supplier's plant to the PCC. In the second case (Figure 1, upper section), the Plastic Vendor delivers the parts overseas through its own global logistics network, often passing through its overseas plants. In the latter case, it consolidates the parts into containers in one plant in Kanto, and ships them overseas through the port of Tokyo (about 4,000 TEUs per year).

² Conversely, the Japanese plants of Machine Vendor sourced parts from their overseas plants (74 TEUs from Mexico, 6 TEUs from China, 5 TEUs from Thailand, 20 TEUs from South Korea, and 12 TEUs from the U.S. per month). Overall, Machine Vendor handled about 13,000 TEUs globally in 2016.

³ For example, the imported cargo volumes of completed transmissions and intermediate parts are 35 and 8 FEUs per day, respectively (only via their PCC).

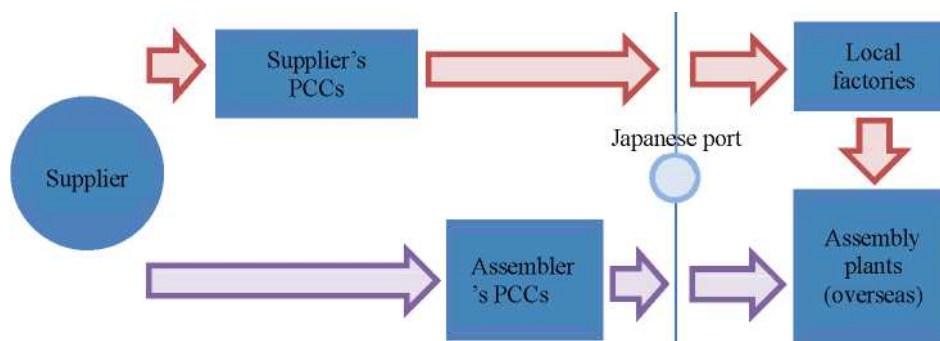
⁴ Given their heavy weight transmission systems, they are generally exported in 20' containers (TEU), size according to the Japanese weight limitations for trucks.

⁵ In general, the volumes of inventories at their overseas factories are quite large because of the slowness of maritime transport (Thun and Hoenig, 2011; cited by Erfurth and Bendul, 2018). For example, it is about 30 days in Mexico, 25 days in China, and 39 days in Thailand, which also depends on the ship's schedule (based on interviews).

Figure 1: The part delivery to overseas factory

:Assembler's operation

:Supplier's operation



(Source) Based on interviews with Car Co.'s managers and its suppliers

To summarize, home suppliers use different methods for organizing the overseas supplies of parts, which are largely complementary. On the one hand, they deliver parts using the car manufacturers' PCCs. On the other hand, they use their own logistics and production networks to supply parts to the car manufacturers' overseas plants. Thus, there are important variations in the car manufacturers' consolidation activities.

3. Consolidation strategies of Motor Co. and Car Co.

We look at the PCCs' functions within the logistics networks of the focal car manufacturers. The operations of focal car manufacturers are examined and compared.

3.1 Motor Co.

In Japan, Motor Co. uses two PCCs for overseas shipments. Each PCC is specialized in specific regions. PCC1 is oriented to North America, Europe, Oceania, and Thailand, whereas PCC2 is oriented to China, Russia, Southeast Asia, Latin America, Africa (South Africa), and other emerging economies. PCC1 is located within a broader logistics area of the focal firm, which is a 30-minute distance from the port of Nagoya, while PCC2 is a 10-minutes distance from the port of Nagoya by trucks.

The Motor Co.'s PCC was established in the first half of the 1980s, when Motor Co. started to assemble cars in California, U.S. Since then, the PCC activity has expanded both in volume and in the number of destinations in 1984. In 2016, the logistics area including PCC1 handled 160,000 TEUs.⁶ Beyond overseas consolidation, Motor Co. also

⁶ The standard container used for the overseas deliveries of parts is the 40 feet equivalent unit (FEU).

uses a domestic PCC for its domestic deliveries.

The use of Motor Co.'s PCCs is not limited to exports, as some imports are handled as well, though the weight in the overall PCC activity is low. The next section focuses on the export operations of Motor Co. from PCC1 and PCC2.

Information flows

Following the same model used for deliveries within Japan, Motor Co. shares with suppliers the production plans of its overseas assembly plants three months in advance (see Figure 2). The final orders from overseas plants are centralized by the parts logistics division at the headquarters of Motor Co. in Japan four days before the consolidation operations at PCCs (or N-4). For example, if the consolidation of parts is conducted on Friday, the order to suppliers is fixed on Tuesday night (N-3). Most of the suppliers (80%) should receive the final order at N-3, which is earlier than that for the domestic assembly deliveries (N-1.5 or N-2.0).

In general, the lead time of exported parts varies between 15 to 20 days (2-3 weeks) for Asia and about 1.5 months (6 weeks) for North America. To limit the risk of supply disruption in the case of vessel delay, Motor Co. holds a significant amount of safety stock of parts equivalent to the number of parts shipped in one single vessel. For example, if a container service to a particular destination is weekly, then the equivalent number of shipped parts of 1 week should be stocked at the overseas assembly plants or in their surroundings.

Material flows

The activity of Motor Co.'s PCCs is organized in a single shift (8:30-17:30). However, the arrivals of auto parts are divided in two shifts, following the production schedules of part suppliers. The evening shift is reserved for the in-house parts, or key components, which represent 50% of the outbound volumes of Motor Co.⁷

The deliveries of other types of parts to the PCCs are organized in eight daily slots. Suppliers generally rely on external third-party logistics (3PL operators to organize their shipments of parts within the slots designated by Motor Co. at least 60 minutes in advance. This organization is similar to the JIT system used for supplying the Motor Co.'s domestic plants. For each supplier, the number of deliveries depends on the total daily volume⁸; thus, Motor Co. spreads the deliveries throughout the day to optimize the utilization of

⁷ One specificity of Motor Co. is that most of the engines and transmissions are made in Japan.

⁸ For example, one time for less than 1 m³, two times between 1 to 2 m³, four times between 2 to 4 m³, and eight times for more than 4 m³ (the total handling volumes for the center per day).

the PCC⁵'s limited capacity. The reception area of the PCC is divided in different areas depending on the destination and the size of parts.

Given the strong time constraints imposed by Motor Co., the parts are commonly delivered from external warehouses operated by 3PL operators. In the case of Motor Co., the need for 3PL external warehouses is accentuated by the small size of many suppliers.

Motor Co. formulates its PCCs⁵ operational plans one month in advance with no change for maintaining standardization. This regularity facilitates the work of 3PL operators of suppliers, who can easily manage the levels of inventory. Delivery costs to PCCs, including holding costs of inventories, are borne by suppliers. Therefore, Motor Co. should pay for the cost, insurance, and freight (CIF) pricing to the suppliers. Thus, it becomes the owner of parts, when the parts arrive at the edge of the PCCs⁵ receiving areas.

The operations at the PCCs are as follows. After reception by trucks, the parts are sorted according to their destination. Most of parts are delivered in boxes. As an order of magnitude, 70,000 boxes are handled daily at Motor Co.⁵'s PCC2. The boxes are automatically sorted by modules. A 40⁵ container has thirty modules,⁹ ten modules per layer with three layers. In general, a module has 96 boxes¹⁰ (returnable boxes owned by Motor Co.). Accordingly, a 40⁵ container has 2,880 boxes. Suppliers can use their own returnable boxes or Motor Co.⁵'s ones. The latter are particularly adapted to the automatic sorting by modules. When the parts are delivered within the suppliers⁵ boxes, they should be repacked in Motor Co.⁵'s boxes to achieve a high fill rate.¹¹ The contents of each module are planned three days in advance (N-3).

Some small suppliers use pallets (parts on a pallet) for their deliveries. Compared to deliveries in standard boxes, pallets require a significant extra work within the PCCs. This work implies resorting, repacking, scanning, and editing of new invoices.¹² Other parts that require repackaging are the bulky ones such as engines and transmissions. Repackaging allows a better utilization of the sea container's capacity and adjustment to the space limitations at overseas assembly plants.

⁹ Returnable modules, boxes, and pallets are managed by a specific team at Motor Co. This team keeps them in the warehouse adjacent to Motor Co.'s PCC2, in the port of Nagoya, and accommodates them in their global network.

¹⁰ In addition, they use a smaller box (192 boxes' size in a module) and a much smaller box (384 boxes' size in a module) depending on the volumes of parts in a shipment, as they combine various sizes of boxes in a module.

¹¹ They can reduce the cubic volumes to 70% of the original size by suppliers. The refilling cost of parts is charged to the suppliers. Therefore, a supplier can judge which box is more economical for its delivery. Partially, they use (one-way) cardboard boxes for large size parts and a higher fill rate.

¹² If the number of parts in a module is different from the scanned list of the invoice, the workers have to check and repack them again from the start of the module.

Once the parts are consolidated within 30 modules, a vaning order is sent to Motor Co.'s affiliated 3PL operator. The operation of vaning starts within 60 minutes after the order, then the container departs from the PCC to a port within 90 minutes. The 3PL operator arranges the modules in the 40' container, taking in account their weights and balances. The parts delivered to the PCCs are generally repacked in 40' containers within two hours.

The container is loaded on a container vessel within 1-2 days after a vaning operation, depending on the frequencies of vessels in each route. At the overseas assembly plants, containers are devanned in front of the assembly lines at once; afterwards, the parts are delivered to the temporary stock area of each line. The temporary stock area applies a first-in first-out system beside the lines. In general, the domestic factories of Motor Co. have only two- or four-hour inventories based on the parts' characteristics. However, the overseas factories have about eight-hour inventories in the factories, with the same amount of parts delivered by the container ship at warehouses close to the assemblers, considering the delay of the vessel. In the next part, we summarize the specific operations at the two centers (PCC1 and PCC2) as a reference.

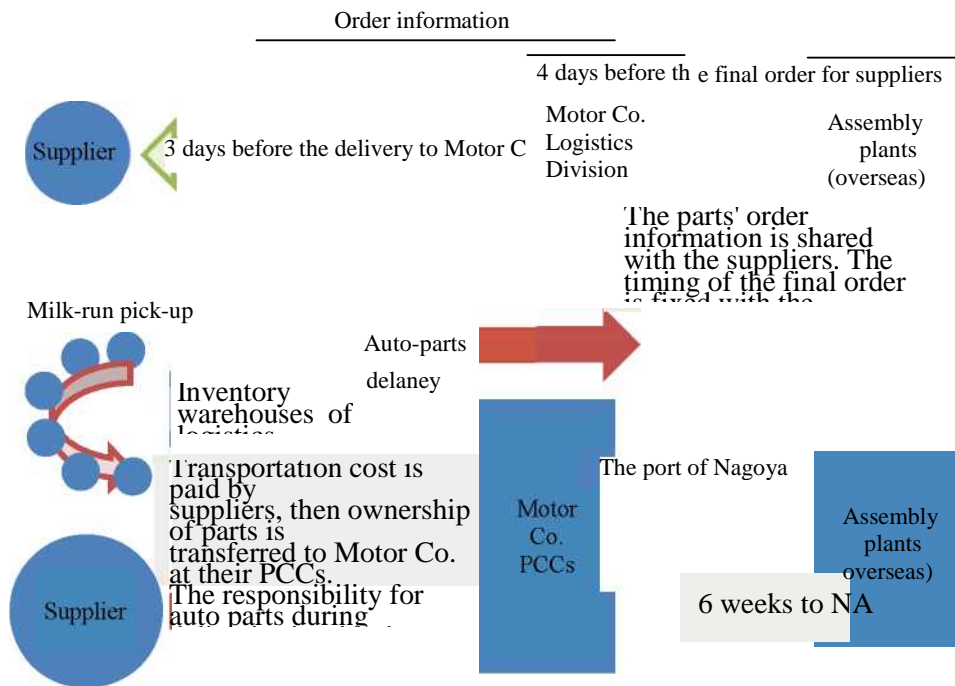
The cases of Motor Co.'s PCC1 and PCC2

Each one of the two Motor Co.'s PCCs handles around 100 FEUs a day. Nevertheless, PCC1 handles parts for a large variety of destinations, whereas PCC2 is strongly oriented toward China and Russia.

More than 200 suppliers, who are mostly in the Aichi prefecture (Chubu region), deliver their auto parts to PCC1. Additionally, PCC1 receives more than 400 trucks at about 1200 times per day because of its operational efficiency due to the number of gates at the center. Moreover, about 400 employees of Motor Co. work in the center; however, the vaning operations of modules into containers are performed by subcontracting logistics providers.

PCC2 has about 300 suppliers for overseas production. The center receives 660 trucks a day, and delivers auto parts to 28 enterprises in 16 countries, with about 60% of the parts are sent to China and Russia. The auto parts at PCC2 characteristically have more large-size parts than those at PCC1 because of lower localization in Russia. The total handling volumes and frequencies are smaller than those in PCC1; however, the varieties of auto parts handled are much wider because of lower localization.

Figure 2: The flows of demand/supply at Motor Co.



(Source) Based on interviews with Motor Co.'s managers and its suppliers

3.2 Car Co.

Car Co. has three PCCs within Japan (Kanagawa, Aichi, and Fukuoka) and seven in other countries. In this study, we focus on the PCC in Yokohama (Kanagawa Prefecture).

Car Co.'s PCC is part of a broader logistics area also used for imports of parts and exports of finished vehicles. The storage capacity is about 200 containers. Within the Yokohama PCC, two buildings are used for exports and one for imports.

The transfer of custodial rights of auto parts from the suppliers to Car Co. takes place at the pick-up point or at the suppliers' facility. The 3PL providers are responsible for the exterior package (or box) used for transportation; however, suppliers are responsible for the auto parts inside the box.¹³ Most of the parts are collected from suppliers through milk-run deliveries. After the inspection of auto parts at the PCC, the ownership of parts is transferred from suppliers to Car Co. In general (except for large suppliers), Car Co. uses the free on board (FOB) incoterm for its purchases to clearly distinguish between parts and logistics costs.

The sourcing system of Car Co. has changed in the recent years. Previously, for

¹³ Who has the ownership of auto parts (inside a box) during the delivery? An interviewee could not answer this question in our interview.

example, for a rear-glass module assembled in China, glass was produced in Japan, while rubber parts and wipers were produced in Europe. The Car Co. supply chain policy was strongly focused on parts cost reduction. However, in the recent years, transport cost reduction has been increasingly integrated into the procurement policy. Additionally, Car Co. has a plan to procure completed engines from local suppliers in emerging economies. This is a different supply chain strategy than that of Motor Co.

Information flows

The demand for auto parts in the overseas assembly plants is managed by the logistics division, located at Car Co.⁵'s headquarters (see Figure 3). Considering the case of the parts exported from Japan to Car Co.⁵'s assembly plants in North America, the American plants provide an estimation of the parts needed for production 3 months in advance. This information is updated day-to-day, with the final production schedule provided 2 months prior to production. Therefore, the parts needed should be estimated before customers' orders, since the lead time for customers' orders is 2 months. Car Co.'s American assembly plants order electronically the auto parts imported from Japan weekly.

In Car Co.'s headquarters in Japan, based on an order from the American assembly plants, the logistics department formulates a plan for the stowage of cargo (per module, steel box) inside the container first because of the high fill rate of containers.¹⁴ Afterwards, the parts are ordered from Car Co. with the shipping plans. In general, the stowage plan is devised using software; however, at the end, minor adjustments are made manually to improve the fill rate. Sometimes delivery schedules are arranged with the managers of overseas assembly plants, since containers cannot be shipped every day. The average weekly volume shipped to North America through the PCC is about 100 FEUs.¹⁵

Once the order of parts is transmitted, the supplier should deliver the parts to the PCC five days later (or N-5). At the PCC, the parts are packed as a module and put in a container within four hours after the parts' delivery on average. The container headed to North America is shipped through the port of Yokohama; afterwards, it is kept at the container terminal for a (theoretical) maximum of one week until the ship calls.¹⁶ The container travels from the port of Yokohama to a West coast American port in two weeks, then until the final destination, totaling at least four weeks from the Japanese port.

¹⁴ For example, the average fill rate of a container is about 95% (or $67\text{m}^3/72\text{m}^3$ in a high cube FEU container).

¹⁵ The cargo volumes imported from NA to Japan are fewer than ten containers a week.

¹⁶ Since Car Co. is an authorized economic operator (AEO) company, the container is delivered to the container terminal directly by a transporter with no inspection.

Material flows

Car Co. relies on 3PL operators for the milk-run collection of parts from suppliers mostly located within the Kanto region. Every day, more than 200 trucks are used for collecting parts. As usual in the Japanese automotive industry, the trucks⁵ drivers also handle the pallets of parts from the trucks to the suppliers⁵ dedicated areas at the PCC. Suppliers use rental pallets for their deliveries to the PCC, then the pallets are returned to a depot of rental pallets from the PCC. For export from the PCC, Car Co. uses its original pallets and boxes for modules.¹⁷ Daily deliveries from parts suppliers should be completed before 16:00, with four slots a day (every two hours) or two time slots in the morning (8:00-12:00) and two time slots in the afternoon (12:00-16:00). The working time of the PCC is 16 hours; however, employees may work overnight at peak periods. In fact, the yard operation inside the PCC is outsourced to two subcontracting companies from Car Co. (works in a company at the case of Motor Co.), with the vaning/devanning operated by a logistics provider. In general, half of the parts are just in transit, and do not require repacking, with less than 20% of them are outer-packaged. Finally, only 20% of them are repacked at the PCC. Therefore, the conditioning operations carried at Car Co.'s PCC are very different (much simpler operations) from those of Motor Co.

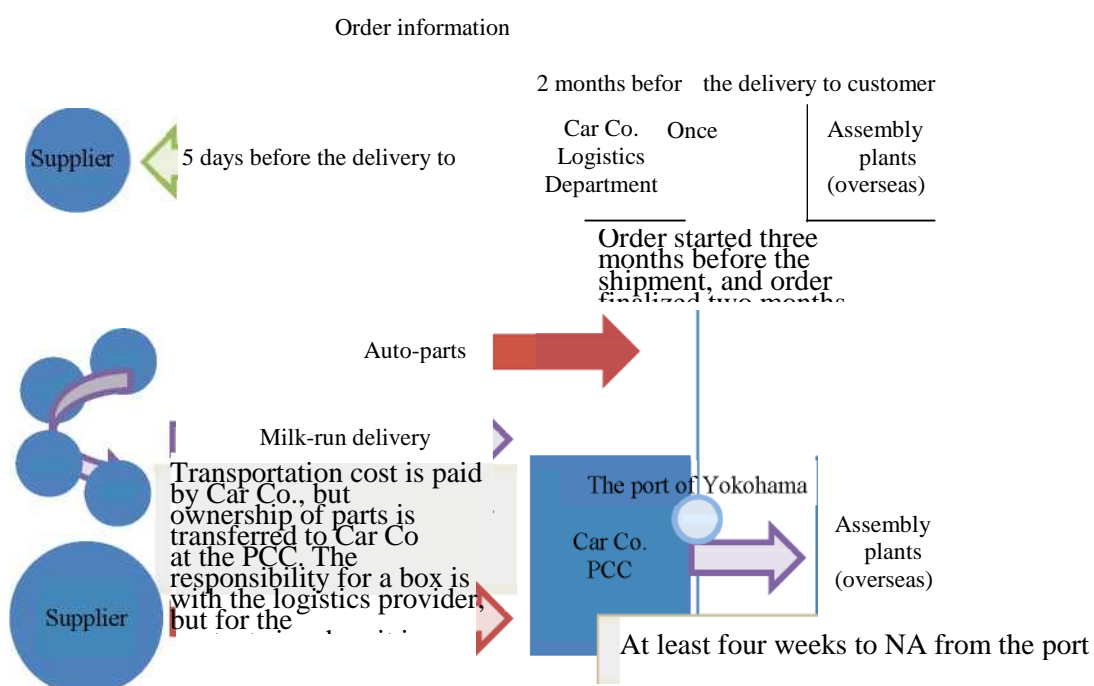
After reception at the PCC, parts are manually repacked into modules and containers depending on the destinations. During this operation, workers check the list of parts by portable scanner and wrap the boxes for stability, with various types of boxes used for the parts. Finally, the boxes are put into a container after the final check with a list of modules. The vaning operation is conducted within 30 minutes. The maximum weight of a container should be less than 26 tons to comply with the Japanese road transport regulations, with the containers mainly shipped from the port of Yokohama and secondarily from Tokyo, depending on the destinations. Since the delivery of parts to the PCC, the container is loaded on a vessel within three days, so the inventories held at the PCC do not exceed two days.

About 70,000 FEUs are handled each year at the PCC, but this volume has been decreasing in recent years because of the increase in local sourcing of overseas plants. The destinations of parts shipped from Japan are Russia (17%), China (14%), Mexico (12%), Thailand (9%), and the U.K. (9%) (volume-based). Most of the parts shipped from Japan are high value-added or key components such as gearboxes, transmissions, engine

¹⁷ The pallets are standardized ones with alliance members; however, they never share pallets with them. In addition, because of the small volumes of cargo shipped to developing countries, they choose wooden or one-way boxes.

components, and some panels. Regarding imports, the main origins are China (57%), the European Union (13%), and Thailand (11%). The main imported components are interior and exterior, which are generally the bulky or low value-added ones. Imported parts are not repacked at PCC, but directly shipped to the assembly plants or surrounding warehouses. For example, the assembly plant of Car Co. at Kyushu has five neighboring warehouses for organizing regular deliveries of imported parts.

Figure 3: The flows of demand/supply at Car Co.



(Source) Based on interviews with Car Co.'s managers and its suppliers

4. Conclusion

This paper investigates how two Japanese car manufacturers serve overseas assembly plants using PCCs. We find that, in addition to the well-known differences such as specific manufacturer-supplier relationships or production strategies, the organization of logistics itself constitutes a basis for persistent variations.

Car manufacturers operating at a global scale are facing uncertainties in matching supply and demand, hence increasingly requiring flexibility. This flexibility is notably achieved through varying combinations of local and distant sourcing to respond to changes in market conditions, currency exchange rates, etc. To limit the costs of distant sourcing, car manufacturers use PCCs, which are cross-docking facilities where parts are

sorted and packed in sea containers depending on their final destination. Findings show that, beyond its generic purpose, the PCCs play different roles within the logistics organization of the two focal firms. In one case, they are highly integrated within the global production system; in the other, they are simply used as transfer points. These different models of utilization of part consolidation centers imply significantly different relationships with parts⁵ suppliers and point to wider differences in the overall logistics systems.

Based on the interviews, it appears that the operations carried out at the PCCs vary considerably between Motor Co. and Car Co, with Table 3 summarizing these differences. The main objective of Motor Co. is to level auto parts in containers considering the operational efficiency of the overseas assembly plants; for example, the parts⁵ delivery to domestic final assemblers, except for the longer lead time. However, the work rates at the centers of Motor Co. are much higher. Conversely, the main objective of Car Co. is to reduce the total delivery cost, rather than the leveling of the parts⁵ volumes in containers and at the foreign assembly factories. Therefore, operations at the Car Co.'s PCC are much simpler.

Table 3: Comparing the operations of Motor Co. and Car Co.

	Motor Co. PCC	Car Co. PCC
Final order	3 days ago (N-3)	5 days ago (N-5)
Intervals of named hours	1 hour	2 hours
Number of trucks a day	(total)1,000	200
Frequency of delivery	Depends on volumes	Once a day
Delivery costs to (dry) port	Supplier	Assembler
Volumes (container) a day	(total)200 FEUs	100 FEUs
Passing cargo	Very few	A half of volumes
Layout of center	Sophisticated	Simpler
Worker	In a company	Outsourced
Equipment	Conveyer	Lifter
Time of operation for parts	2 hours	4 hours

(Source) Based on our interviews with assemblers and suppliers.

The logistics and procurement system of auto parts⁵ shipment to overseas assembly factories is much more complex. However, assemblers need a smooth, sophisticated process to reduce the work burden at the assembly factories and streamlining and shorten the production lines (Motor Co.). Additionally, the PCCs connecting ports make shipments of more than 100 containers per day. The auto-parts delivery from suppliers to the center occurs once a day because of the limited cargo volumes per supplier and the efficient and simple vaning process at the center (Car Co.). Moreover, the process of vaning/devanning becomes very complex in a limited

workspace, with a long lead time for shipping auto parts to overseas factories (more than one month). However, the limited space of assembly factories and their inventory levels of auto parts, not their lead time, can be managed by conducting advanced parts handling operations at the centers.

Because of the expansion of the car market in emerging economies and the relocation of assembly factories to consuming areas, the supply chain of the car industry has been geographically getting longer for the regional specialized supply of parts. Thus, regardless of logistics policies (total delivery cost reduction or seamless production systems), the function of supply chain supported by PCCs will be expanding, even with the progress of electric and hybrid cars, because of the cross-border transport for common key components.

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