EFFICIENT AND GREEN LOGISTICS OF AUTOMOBILE PARTS IN URBAN AREAS

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ABSTRACT

Recently, Japanese automobile manufacturers are trying to procure parts by the so-called Milk Run logistics at most of their foreign factories even if road traffic conditions in urban areas are not favorable to perform frequent deliveries. Through a survey of Japanese automobile manufacturers in Bangkok, Thailand, it was revealed that the Milk Run logistics is being operated to achieve frequent procurement of small-lot parts, and is synchronized with the manufacturing process to reduce inventories. By introducing the Milk Run logistics, automobile manufacturers can have full control of the procurement process, resulting in the reduction of the number of trucks dispatched and CO2 emission as well.
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Keywords: automobile manufacture, Thailand, parts procurement, just in time, Milk Run, third party logistics, consolidation, real-time monitoring, environmental impacts

INTRODUCTION

Global strategies of Japanese automobile manufacturers have immensely evolved especially in the ASEAN region which has become a significant market (Seki et al., 1997)). However, ASEAN's automobile parts industry has not yet progressed and its automobile industry cluster remains undeveloped. As a result, the original model of Toyota Production System including parts procurement was modified in the ASEAN region using the Just-In-Time (JIT) concept as a basis. Its feature is that most parts are procured from local suppliers by the Milk Run logistics and the strategic parts (e.g. high-value added parts having scale economy in their production) are procured from neighboring countries under the concept of the international division of labor system in the ASEAN region (Hiraki, 2002).

Unfortunately there were conducted few studies on logistics system of auto parts in the region, although researches were made focused on the Milk Run logistics in general. For example, Gumus et al.(2004) presents principles to design the procurement system, Bowersox et al.(2002) concludes that Milk Run is an important element for an integrated lean logistics strategy, and Nojiri(2005) indicates that the Milk Run logistics is introduced to increase efficiency when the production scale of auto assembly factories is relatively small, in the range of several tens of thousands.

In this paper, Toyota Motor Corporation, an automobile manufacturer typifying Japan, is taken up as a case study, and the synchronization of production and parts procurement used by Toyota assembly firms, suppliers and third party logistics (3PL) providers in Bangkok is analyzed. The paper will reveal that the Milk Run logistics is achieved even if road congestion is especially severe, through the use of ITS (Intelligent Transport System). In addition, it will explain how zero-waste production was achieved through the synchronization of the assembling process and parts procurement. Finally, the paper will try to clarify the environmental impacts of the Milk Run logistics by calculating CO2 emission from road transportation with and without Milk Run.

TOYOTA PRODUCTION SYSTEM

Production and Procurement System of Toyota Motor Corporation

Toyota Motor Corporation is one of the biggest automobile companies in the world. It is rapidly increasing its overseas production bases to cope with the expansion of the overseas market, and in fact, now maintains 68 production bases located in 28 countries as of the end of 2009. Because it is important to procure parts, in particular low-value added or bulky ones, from the surrounding areas of these production bases, they encourage potential local suppliers to provide the parts and develop efficient pickup network to connect the suppliers in different urban traffic conditions, which is called Milk Run.

The Toyota Production System (TPS) is developed as a systematized production method employed in a manufacturing plant. In our view, however, TPS covers parts procurement and then parts pickup in urban areas as well. An important concept in TPS is JIT production which eliminates, as much as possible, wastes resulting from waiting, stock reserves, and defective parts (Monden, 2006) & (Ono, 1978). For example, if only necessary parts are produced in a small lot and transported to the assembly lines, they could reduce the stock beside the assembly lines which also minimizes the number of defective parts produced.

Another important concept is production leveling which means to minimize the difference between the amount of production and the demand. If they produce different vehicle models one-by-one in the same assembly line in order to reflect the demand, the volume of necessary parts per hour is leveled and then each truck is expected to pick up the same amount of parts regularly in Milk Run.

This type of leveling has become a mechanism to synchronize the entire process with the takt time (production speed) determined from the number of vehicle units of each model as specified in the monthly production plan and the monthly operating time. The sequencing, work procedure, and planning of personnel according to vehicle model are drawn up to complete each work process within the calculated takt time. Stock items of parts necessary for the related process are put on a shelf (called a “store”) located at the line side of the assembling process.

The replenishment of parts in the store is linked by instruction information through a “kanban”. The “kanban” has accomplished to move the process always in union with the items, completing each work process within the takt time, and making the entire lines synchronized. This mechanism is also similar between suppliers. The required parts must be supplied only at needed amounts coupled with necessary timing, and must neither cause any excessive parts inventory nor create any stockout in each work process.

From the viewpoint of stock reduction, the ideal situation is to decrease the number of "kanban" cards and quickly replenish the previous process as soon as parts inventory in the assembly line becomes zero. In cases when suppliers are near the assembly base such as in Japan and the scale of production for each supplier is large enough, it becomes possible to perform frequent parts delivery (i.e. JIT delivery) with the required amount and necessary timing from each supplier.

Consolidation System to Reduce Environmental Impacts

Toyota Motor Corporation is putting up a new logistics concept; a logistics with 'minimum environmental impacts'. The response to the environmental problem is a major issue not only in Japan but also on a global level. In the logistics field, an important objective is to reduce the amount of CO2 exhausts generated from the activities of transportation and to decrease the amount of packaging and wrapping materials used.

As a method to actualize this, consolidated fully-loaded distribution, through small-lot frequent pickup from each supplier and shortening of lead time, can be adopted after production leveling has been performed. It is designed to collect goods from two or more suppliers at the same time which increases the amount of cargo sufficient enough for fully-loaded distribution.

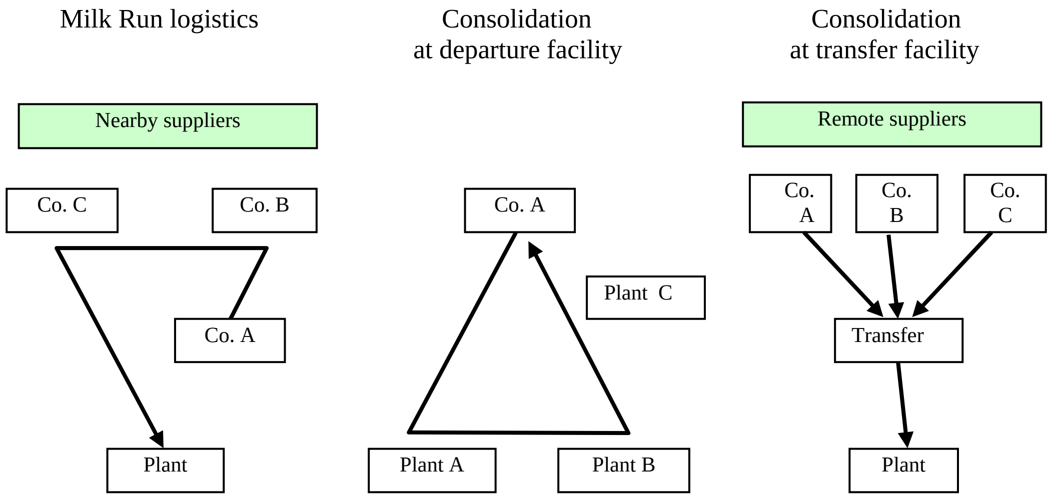
Small-lot fully-loaded frequent distribution can be classified into three types. The Milk Run collection of goods is done when procuring them from suppliers in the outskirts of the overseas plant. In Japan, it is common that the suppliers perform JIT delivery by themselves as the amount of delivery from each supplier is greater and delivery distance is not so long. In foreign countries, however, trucks do not become fully-loaded. Furthermore in many cases, transactions (ownership transfer) are made at the supplier's plant, so Toyota Motor Corporation tailors the collector trucks and performs routing to collect parts from the suppliers.

The Milk Run logistics is generally a generic name of a logistics procurement method using routing to consolidate goods by the buyer. Explaining it in detail, it is a method of goods collection in which the user (i.e. car assembly manufacturer) dispatches one truck at a specified time period to visit various suppliers (i.e. parts supplier) following a predefined route to collect parts or products, and deliver them to the factory (Figure 1). In general, the reasons why the Milk Run logistics has been widely employed are: 1) clarification of distribution cost included in the prices of parts previously in the traditional business practices, 2) reduction in transportation cost due to consolidated transportation offsetting even the use of small lot transport, 3) improvement of the assembly manufacturer's production line and greater accuracy of JIT goods delivery due to synchronization. The Milk Run logistics can provide the consolidated collection of goods necessary to improve the logistics procurement system.

When there are two or more plants and the parts used in these plants are provided by a single supplier, consolidation at the supplier facility is performed. The parts are consolidated at the place of departure in such a way that they are fully loaded to the truck, transported, and unloaded to various destinations. This method is used in the delivery of goods from suppliers in remote areas not only those located in the outskirts but also from foreign countries.

Consolidation using a transfer facility is a method of goods delivery in which parts are transported fully-loaded from suppliers in remote areas to the transfer facility, sorted according to the destination plant, and then transported. Transshipment can be performed without maintaining stocks. There are international cross-dock centers in the different regions of the United States, Europe, and Asia.

These three types of consolidation system can increase the loading rates of trucks, then reducing their number on urban roads. Therefore they have the same effect as the cooperative delivery system involving many shippers or consignees with a public consolidation center, which is one of the most common city logistics policies. If there is a big shipper or consignee like a car manufacturing company, the urban traffic condition could be improved to some extent by their own consolidation efforts.



Source: Toyota Motor Corporation documents

Figure.1－Types of consolidation system

PARTS PROCUREMENT LOGISTICS IN TOYOTA MOTOR THAILAND (TMT)

Milk Run Logistics in Bangkok

Bangkok is one of the centers of Toyota Motor Corporation's global bases that exert efforts to the production of automobiles employing global strategies. Although some strategic parts used to assemble the global car are imported from the ASEAN region in which a system of mutual supplementation is already established, parts that are procured in Thailand account for about 80% (monetary base).

The Milk Run logistics is becoming one of the standard systems of an overseas version of JIT distribution. At overseas production bases, the Milk Run logistics in the local country and the above-mentioned international distribution system are combined, and a global procurement logistics system is formed. The following discusses the operations of the Milk Run logistics through an analysis of the interview surveys conducted at TMT (Toyota Motor Thailand) and the 3PL provider TTKL (TTK Logistics) (Thailand).

TMT maintains four assembly factories located in Samrong (including TAW), Gateway, and Ban Pho (Table 1), and produces 490,000 vehicles a year (in which about 200,000 are for export). This study investigated parts procurement logistics in the Samrong plant. TMT Samrong plant manufactures Innovative and International Multi-purpose Vehicles (IMV) having variations of minivans, SUVs, and trucks (two-seaters, four-seaters, and four-door types) adjusted for the market needs in each country while they share a common platform and common parts. Moreover, the Samrong plant serves as a packaging/shipment base for export to bases outside Thailand.

At TMT, parts are procured from about 150 suppliers (Figure 2). These suppliers are allocated throughout Thailand following a division of five zones in which the Milk Run logistics is performed (one run made in a range of 4 hours). Two logistics service providers undertake the Milk Run logistics. One of the larger companies undertaking the Milk Run logistics is TTK Logistics (Thailand) which is the focus of this survey.

Table I –Toyota's manufacturing plants in Thailand

	Production Capacity (veh/year)	Takt time (min)	Lot Area (1000m^2)	Building Area (1000m^2)	No. of Employ ees	Main Production Function	Vehicle Types Produced
Samrong	218,000	1.0	430	157	4,221	P,W,T,A,R, U	Hi-Lux for local market (B,C,W)
(TAW)	54,000	4.0	400	230	1,248	W,T,A	SUV, Hi-Lux (W)
Gateway	200,000	1.1	1,000	166	3,246	P,W,T,A,R, U	Sedan (Camry, Vitz, Corolla, Vios, Yaris)
Ban Pho	100,000	2.25	2,500	188	1,176	P,W,T,A,R, U	Same car model as Samrong, but for export

Notes:
Functions: P=Pressing, W=Welding, T=Painting, A=Assembling, R=Inspection, U=Knockdown models
Vehicle types: B=2 seater, C=4 seater, W=4 doors

Source: TMT documents

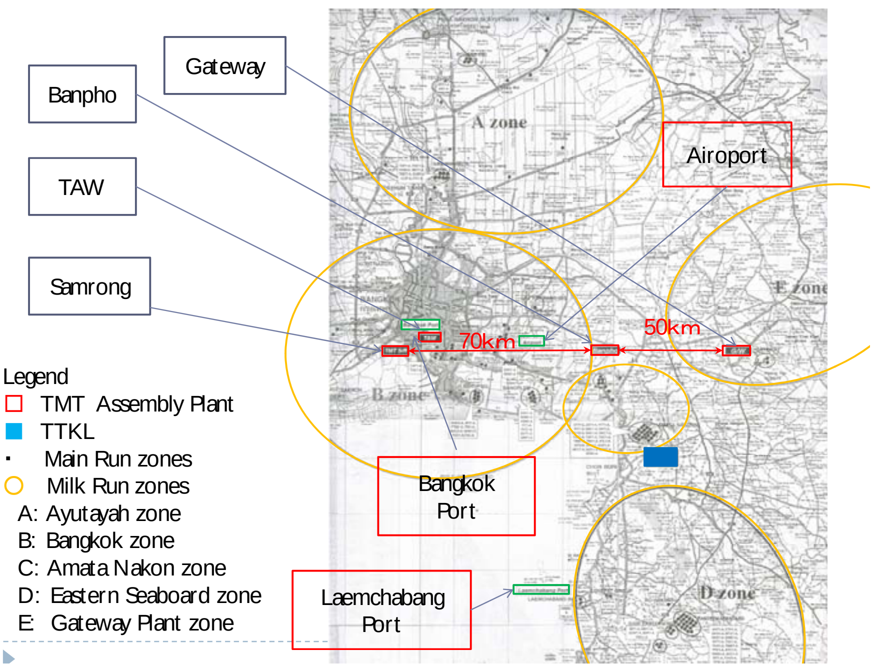


Figure.2 — Milk Run logistics in the Bangkok metropolitan area

Cooperation between TMT and TTKL (3PL)

TTKL is a logistics company established in December 2002 to manage the Milk Run logistics of TMT. Stockholder composition is 51% Toyota Tsusho Thailand, 26% Toyota Tsusho, and 23% Kimura Unity. Its activities are divided into transportation and logistics operations. The transportation operation is composed of the Milk Run logistics of locally procuring automobile parts, which is the main activity, and other activities which include optimal route planning. The logistics operation, on the other hand, consists of Complete Knock Down (CKD) parts packaging (multi-sourced parts) for export, parts consolidation (vendor to vendor), and general warehouse works. The truck centers which maintain a total of 616 trucks and 40 forklifts are located in Amata Nakorn, Samrong, Eastern Seaboard, and Gateway.

The Milk Run logistics for TMT was started by Toyota Tsusho Thailand in 2001, and succeeded by TTKL in 2003. The Milk Run logistics became full-scale with the beginning of IMV production. At present, the Milk Run logistics is being implemented for four factories of TMT. About 50 delivery routes are established to each plant, which could be changed in the case of traffic congestion. Six-wheel trucks (4.3 tons loading capacity) are usually utilized but at regions which can accommodate heavy trucks, ten-wheel trucks (12 tons loading capacity) are used.

Because the Milk Run logistics relates closely to the automobile's production plan, a close cooperative relationship between TMT, TTKL, and the suppliers is established. The Samrong factory operates two shifts, and parts are ordered through e-kanban by regularly dividing the daily amount into 36 orders per day. The production and the operational plans determined from the working plan, parts information, and information on goods delivered are transmitted by the TMT to the TTKL.

TTKL collects basic information on running times and transport distances necessary in determining the routes and provides them to TMT. TMT then calculates the transport volume everyday based on parts information, the production plan, and container sizes, and determines the routing and scheduling plan using an optimization system on operations management. Based on these results, TTKL prepares the stowage plan, truck diagram, and the schedule of the host terminal.

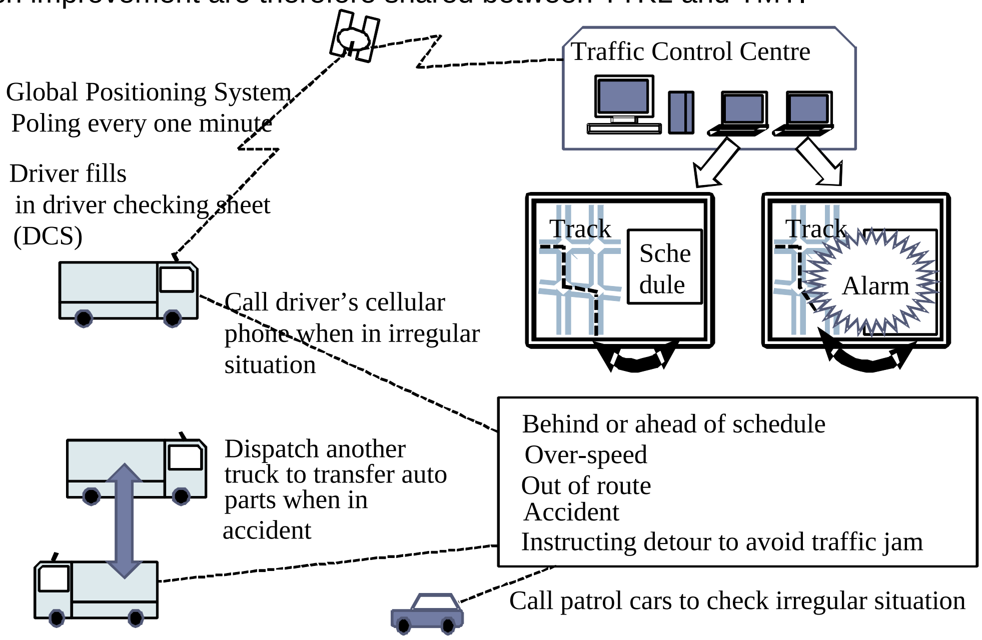
MILK RUN LOGISTICS OPERATIONS

Operational plan and management of Milk Run

In actual operation, a guide containing the driver check sheet, route code card, terminal card, and container label is prepared by the TTKL's operations manager for easy understanding of the operational plan. The operation manager assigns a driver for each route, and registers the route information in a geographic information system (Figure.3).

The driver fills-in the check sheet at each stage of operation. During the operation, monitoring is performed every minute and the operations manager acquires GPS information and manages the movement of the truck. In cases of non-conformities with the schedule, such as delay or over-speed, or if there are differences in the route, the information are displayed in the computer terminal of the operation center and the operation manager rectifies the situation by calling the driver on his cellular phone. In cases of traffic congestion, a detour is selected from the alternative routes set beforehand. Furthermore, in cases of accidents, an emergency truck is dispatched to the site and goods are transshipped and delivered to the destination in accordance with the scheduled delivery time.

At TTKL, it was evaluated that the investment in GPS was appropriate taking account of fuel efficiency, accident reductions, and insurance rate discounts. Trucks do not require on-board computers, and management is simple by just filling-in the check sheet. It is possible to sufficiently manage the operations by comparing the GPS data and the check sheets. It is also possible for the driver to be guided accordingly. The benefits produced by such improvement are therefore shared between TTKL and TMT.



Source: TTKL

Figure.3 − Fleet management using GPS

The parts supplier loads the parts packed in returnable containers to the designated places on the trucks based on a stowage plan. In order to prevent the collapse of goods during transportation, TTKL protects the goods with protective boards and safety belts. Goods are collected from several parts suppliers according to a collection schedule, and delivered to a specified truck bay in the TMT plant. Allowed arrival times are within plus or minus ten minutes of the scheduled time. For example, if the arrival time is about 15 minutes over the scheduled time, the event is recognized as compliance deviation concerning schedule. The rate of compliance deviation concerning schedule, which is one of Key Performance Indicators (KPI), is around 5% in TTKL.

The driver unloads the parts to the receiving and checking area using a forklift, and loads empty containers instead. Once the processing of the documents is completed, the driver exchanges the forklift key with the truck key, and returns to the TTKL terminal. The returning driver then confirms the contents of the check sheet with the operation manager. If there is no irregularity, the operation is succeeded to the next driver.

Flow of Parts in the Plant and Synchronization Mechanism

Parts collected by the Milk Run logistics are carried into the host terminal. As for small parts delivered in returnable containers, several e-kanban orders are delivered collectively based on loading efficiency and operational schedule. These orders are divided and placed according to P (progress) lanes (Figure 4). The P-lane serves two functions: lot division and progress adjustment for synchronization. For example, one order is composed of parts for 20 vehicles with ordering frequency of 36 times a day, while 9 e-kanban orders (180 parts) are delivered in the same Milk Run (4 times to the supplier a day). The functions are accomplished by dividing the orders into e-kanban order, putting them into the 36 lines, and bringing them to the assembly line in order to synchronize the production schedule.

Large-sized parts are composed of those that are put into the assembly line directly, those that are divided into lots via the P-lane and put into the line, and those that are put into the sequential area. In the sequential area, large-sized parts and parts in case units are set in the vehicles based on an instruction sheet at the assembly line, and put into the mixed flow production line after undergoing ordering and synchronization.

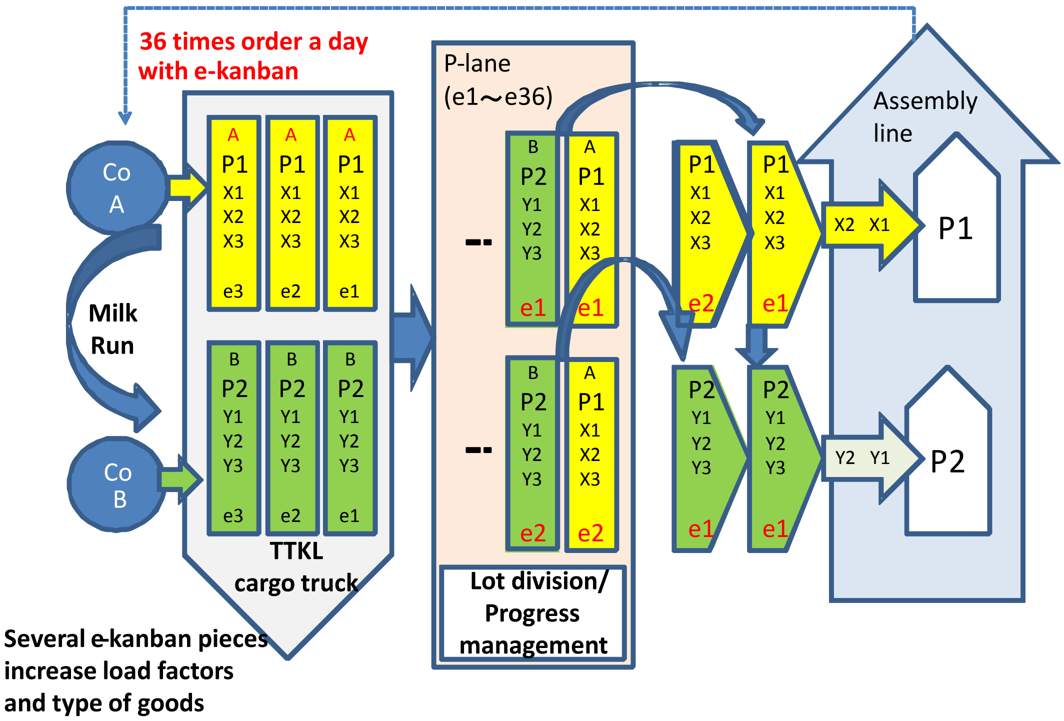


Figure .4－Milk Run logistics and the Progress-lane system

ENVIRONMENTAL IMPACTS OF MILK RUN

Estimating CO2 Emission from Road Transportation

The Milk Run logistics utilizes the trucks efficiently, where the average loading factor in terms of truck space utilization becomes very high. It results in less environmental impacts including CO2 emission. High loading factor is realized partly because the trucks bring not only necessary auto parts but also the returnable containers to pack the parts. The empty containers get back to the original suppliers just before picking up new parts in the next run.

CO2 emission from the trucks to pick up the parts is estimated by the following formula based on Rizet et al.(2009):

$$CO2 = TR \times FE \times (D \div 100) \times EF \qquad (1)$$

Where:

CO2=CO2 emission (kg)

TR=number of TRucks (vehicles)

FE=Fuel Efficiency or average fuel use (litres/100km)

D=Distance travelled (km/vehicle)

EF=Emission Factor in CO2-kg (kg/liter)

(EF is 2.951 kg/ liter in the case of diesel fuel)

Reduction of CO2 Emission with Milk Run

We conducted a calculation of CO2 emission from the trucks delivering auto parts to the Samrong Plant with and without Milk Run by assuming a very simple situation. The assumptions are:

-150 parts factories located at the distance of 20 to 100 km

-auto parts are picked up 4 times a day

In the case of with Milk Run, there are additional assumptions:

-50 Milk Run routes are introduced with 3 designated parts suppliers for each,

-trucks make 3 trips a day with 100 km distance for 4 hours averagely,

-trucks run 40 km before arriving at the first supplier, 10 km before the next supplier, 10 km before the next supplier, and 40 km before returning to the plant, and

-the loading rate is 100 %.

Based on these assumptions, we need 67 trucks for Milk Run operations (=(150 suppliers *4 pickups)/(3 stops *3 trips)), and each of them runs 300 km a day (= 100 km * 3 trips).

In the case of without Milk Run, there are additional assumptions:

-trucks are dispatched to each supplier independently,

-trucks make 4 round trips a day with 80 km for 3 hours averagely,

-trucks run 40 km on the way to the suppliers and another 40 km on the return, and

-the loading rates decrease to 33 %.

Based on these assumptions, we need 150 trucks for round trip operations (=(150 suppliers *4 pickups)/(4 trips)), and each of them runs 320 km a day (= 80 km * 4 trips).

We can calculate CO2 emission with and without Milk Run by:

$$CO2_1 = TR_1 \times FE_1 \times (D_1 \div 100) \times EF \qquad (2)$$

$$CO2_2 = TR_2 \times FE_2 \times (D_2 \div 100) \times EF \qquad (3)$$

Where:

$CO2_1$=CO2 emission in kg with Milk Run

$CO2_2$=CO2 emission in kg without Milk Run

TR_1=67 trucks with Milk Run

TR_2=150 trucks without Milk Run

FE_1=20 litres/100km with 100 % loading factor[1]
FE_2=18 litres/100km with 33 % loading factor
D_1=300 km with Milk Run
D_2=320 km without Milk Run
EF=2.951 kg/litre

Based on these data, CO2 emission with Milk Run ($CO2_1$) is 11863 kg and CO2 emission without Milk Run ($CO2_2$) is 25497 kg, so that the Milk Run reduces 13634kg CO2 emission or by 53%, which has 27300 yen in value a day for the Samrong Plant assuming that the unit price of CO2 trading is 2000 yen/1000kg.

Total volume of CO2 reduction is not so large because the number of trucks involved is small, which is negligible compared to the number of vehicles on the roads in Bangkok. However if this kind of practice becomes common among private companies in Bangkok, the accumulated effects are sufficient enough to change the traffic situation and environmental impacts there.

CONCLUSIONS

The paper discussed the current state of logistics procurement of TMT in Bangkok which focused on the Milk Run logistics. It was revealed that TMT has established an advanced procurement system that synchronizes with the production process based on the JIT concept. This was accomplished even when faced with conditions that are totally different from that of Japan, especially the more serious problem of road congestion in urban areas. The economic features of the Milk Run logistics are enumerated below.

First, they established a system which synchronized production processes owing to close coordination with logistics companies. In the Milk Run logistics, high reception frequency of goods (4 times a day) is performed to maintain small-lot frequent delivery to the assembly lines as much as possible (36 times a day). In addition, a P-lane has been installed in order to reduce the gap between transport frequency and production leveling.

Second, in order to synchronize the parts procurement process and the production line operations, the actual operations and the progress of the Milk Run logistics are monitored real-time through the use of a GPS installed in the vehicle. In addition, the synchronized procurement results in eliminating waste and maintaining speed as much as possible. A transport system related to modularization which considers container size and truck's space dimensions is also being developed to increase transport efficiency and transport quality.

The Milk Run, which puts the assembly plant at its core, is a frequent parts procurement system implemented in an urban area, or a virtual expanded factory yard. Its policy implications are:

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[1] Based on the data of fuel efficiency of 0.25 litres/km for commercial ordinary trucks and 0.12 litres/km for commercial small trucks. Source: Ministry of Land, Infrastructure, Transport and Tourism(2009)

First, Milk Run logistics has been planned to improve loading rates at possible levels and reduce the number of trucks and travel distances. As a result, it is an excellent transport method in which CO2 from trucks can be reduced by 53% under our assumptions. Therefore, the promotion of Milk Run logistics can be highly evaluated from the viewpoint of environmental policy, too.

Second, Milk Run logistics is performed through close coordination and linkages between the automobile manufacturer, parts supplier, and logistics service provider, and its influence on regional transportation system becomes more significant if the scale of the Milk Run logistics becomes larger. In other words, Milk Run logistics is purely private efforts with economic motivation, but it has positive external effects in society as well. For this case, public involvements may be required for planning Milk Run logistics which include the cooperation of local governments and affected stakeholders.

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