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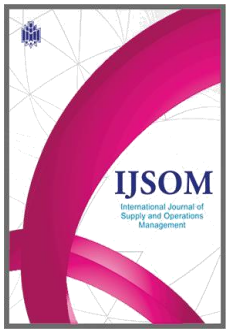


## Applying Milk-run Method to Optimize Cost of Transport: an Empirical Evidence

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### Abstract
Logistics and supply chain play important roles in supporting enterprises' operations that aim to satisfy customers' demands. Moreover, the globalization of the world economy and the emergence of the fourth industrial revolution have pushed manufacturers to optimize their operations, particularly transportation and supplying activities. The main objective is to maintain competitive advantages and guarantee the expected benefit. Milk-run, a well-known transportation approach adopted successfully in practice, is used in this study to simultaneously minimize transportation and inventory costs in a just-in-time production environment. The results of this study show that the milk-run approach helps to reduce transportation and inventory costs for the studied company. The milk-run approach, therefore, is proved to be suitable for companies that operate under the just-in-time philosophy.

**Key words:** Logistics; Supply chain; Milk-run; Case study.

### 1. Introduction

The supply of raw materials and (intermediate) products is crucial in production systems. The manufacturing of products is not only affected by production activities, but is also strongly influenced by logistics and supply chain activities. Performing good logistics and supply chain practice brings value to companies. Yet, these activities may cause high cost if companies do not operate them appropriately.

The process of producing products and services not only focuses on production activity but also is affected mostly by the supply chain, including input materials and output products management. The supply chain and logistics create added value but also significant costs. Therefore, the question on how to reduce the costs that are associated with freight transportation, to reduce the inventories, to deliver products to customers at the right time and the right place with the right quantity is needed to achieve competitive advantages and expected profits (Patel, Patel, & Vadher, 2014).

One of the important pillars in the LEAN production system is Just-in-time (JIT). This concept was developed for use in the supply of products in some cases in which the idea of supplying products at the right time with optimal costs but still ensuring the plan and production schedule is a priority (Womack, Jones, & Roos, 1990).

The manufacturers and suppliers are facing huge changes in demand-side perspective to supply only needed products and distribute them to the right places at the right time with minimum costs of warehouse storage. Thus, customers will require supplying services with higher frequency, lower quantity and on-time delivery. From the perspective of on-time production, one logistics method developed in Japan – Milk-run Logistics is considered as a suitable method to achieve the goal of on-time delivery and reducing costs (Nemoto, Hayashi, & Hashimoto, 2010).

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Peterson et al (2010) reported a milk run system implemented by a plant of the Bosch/Siemens Home Appliances Corporation located in North Carolina. The 75 most important suppliers, which make up 80% of the total shipping volume, are served on weekly or bi-weekly scheduled direct milk runs operated by a logistics service provider. The authors emphasize two advantages of the milk-run method compared to ad hoc concepts: The predictability of fixed and stable distribution patterns and the possibility to negotiate better rates (Peterson, van Hoeve, Kekre, & Debo, 2010).

Milk-run is a method that was developed based on the concept of optimization in City logistics. In this activity, the suppliers of one or several firms work together or are jointly organized by third-party logistics to deliver products. The advantage of Milk-run is to deliver different products to customers in fewest possible number of shipments to optimize all costs related to transportation, handling, and storage charges (Nemoto et al., 2010). In addition, Milk-run method also helps the production process and internal working place in firms to achieve the 7 Rights: Right product, Right quantity, Right condition, Right place, Right time, Right customer, Right cost (Mácsay, 2017).

Milk Run logistics utilizes one vehicle to conduct several pick-ups/deliveries in roundtrips, so that the pick-up/delivery points should be located in a limited area which one-day trip could cover at least. Although this area should not necessarily be urban, Milk Run seems highly beneficial for congested urban environments. Furthermore, it can be linked to the long-distance inter-urban logistics, by rail for example, in the national and world-wide network of big companies (Nemoto et al., 2010)

Automotive logistics are entity flows of automotive producer's raw materials, components, vehicle and spare parts on steps of automotive purchase, production, sales. Automotive logistics include inbound logistics of raw materials and components, garage logistics of the production process, sales logistics of the vehicle and spare parts logistics, including object purchasing, transportation, storage, loading and unloading, distribution processing delivery and information processing. In a macro way, logistics include recycling of waste, too (Liu, Huang, & Zhang, 2010). Automotive logistics are important composing parts of automotive enterprises, and are also highly complex logistic activities in the logistics industry. Compared to other logistic activities, automotive logistics have characteristics of capital-intensive, technology intensive and knowledge intensive. Automotive logistics must play a much more important role in the automotive industry, and reduction of automotive cost (Sabadka, 2015).

Besides, in the conventional system, the inventory cost rises linearly with the batch size in the conventional system. Thus, if the batch size increases, there is a reduction at the transportation cost per item, but consequently an increase in the inventory cost (De Moura & Botter, 2016). From the point of view of the Milk Run system, reducing the cost of storage would be the biggest gain since the company would supply its production with only the required parts, eliminating the variable stock in the automaker. The cost of transport would be minimized or perhaps slightly higher than the 'conventional' system because the capacity of the transport vehicle is being maximized, regardless of who is performing the operation (De Moura & Botter, 2016; Shaaban, Hudson, & Zhang, 2013).

Therefore, the main objective of this study is to consider and assess the operational characteristics of Milk-run method in the supply chain and optimization in transportation route from the perspective of JIT and LEAN. Through a case study of Milk-run application of a business to its group of domestic suppliers in Vinh Phuc province in order to see how to combine the pick-up route, the number of products needed to ensure JIT production is determined. Additionally, the results of assessment before and after applying Milk-run to costs are also displayed to see the benefits that this method can bring.

## 2. Literature Review

### 2.1. The background and application of Milk-run method

The term "Milk-run" was developed from a definition in the process of delivering milk named "Milk delivery" (Mácsay, 2017). Particularly, the milk deliverer called "Milkman" delivers full milk boxes to a fixed location and takes back the empty boxes during their delivering journey. When the customers use up two milk boxes and leave them in front of their doors, the milkman replaces those empty boxes by other two full ones. After that, the deliverer carries all those empty boxes back to the manufacturer in order to refill them and then starts the next delivering round. This process is repetitive with different locations on the delivering journey of the milkman (Mácsay, 2017; Nemoto et al., 2010). In theory, the customers use milk with small quantities; therefore, milk suppliers are unable to separate the shipments (even using the smallest trucks). They have to deliver milk to many customers in a single shipment to optimize the cost of using trucks (Nemoto et al., 2010). In other words, milk-run logistics usually use one means of transportation to connect delivery/pick up point on a journey with certain stops within a suitable area for transportation and combination.

The Milk-run Logistics method is initially applied in Japanese enterprises and being currently replicated by others over the world in the supply of input materials, internal delivery, and transport of products to the customers. Thanks to the

combination of shipments, the enterprises effectively eliminate non-value added activities significantly from unloaded trips, high level of storage, packaging, pallets and boxes returned to the suppliers. When the truck delivers products to the customers, the shipper will simultaneously return the empties to the suppliers for the next usages.

Returning to the definition of Milk-run, Baudin (2005) claims that Milk-run is "picking up and delivering products at the fixed time and the fixed location on a delivering journey". The implementation of Milk-run logistics is similar to Bus' journeys with fixed pick-up points on a journey. The stops on production lines in the internal supply of products or in that of the suppliers simulate the pick-up points of Buses (Baudin, 2005).

(Meyer, 2017) points out some basic characteristics of the Milk-run logistics, including:

- Milk-run is fixed routes with fixed pick-up and delivery time slots and fixed volumes which are executed according to a fixed cycle.
- In Milk-run logistics, there is usually more than one supplier involving in the supply of products in order to increase the efficiency of each shipment compared to each supplier who supplies products to their customers by themselves.
- Milk-run is round tours on which full and empty returnable containers are exchanged in a ratio of 1:1.
- Milk-run is planned by the consignee according to "Pull" strategy.

The important advantages that Milk-run logistics offer to enterprises encourage them to change their logistics perspective and strategy in using transportation units or self-leasing and using means of transportation to integrate the supply from the suppliers system (local) to reduce inventories, increase the capability to meet product responsiveness, increase the movement of capital, and minimize risks in supplying products.

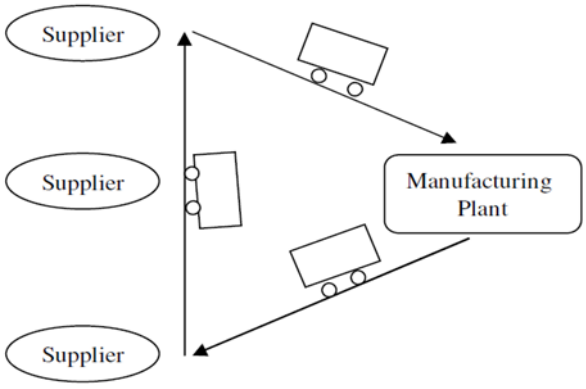


**Figure 1**. The process of operating Milk-run

### 2.2. Milk-run and its application in manufactories.

The techniques of Milk-run Logistics are applied in production plants as a strategy to create a competitive advantage in production and delivery activities (Nemoto et al., 2010). Three concepts are related to logistics to optimize the production system, including: (1) Flexible Logistics, (2) Minimize Lead time, (3) Minimize environmental impacts (Nemoto et al., 2010).

- Regarding the first concept, Logistics activities need to be flexible to cope with deman fluctuation of the customers and market. Thus, Logistics activity should be also implemented according to the "Pull" strategy from the customers. It is also necessary to pursue JIT transportation in logistics activities. Nemoto et al (2010) also noted that it is necessary to have a safe logistics system (against transportation damages, wrong items, late delivery and stock-outs). The transportation quality of Logistics is much more important than its speed or high inventory level.
- In terms of the second concept, Logistics need minimum lead time to ensure the production plan and minimize costs. The shorter the lead time is, the lower volume of the order is and the higher production responsiveness that enterprises can have. Thus, logistics costs can be reduced significantly. This is also a key reason why many manufacturers look for local suppliers to shorten lead time. When the cooperation with the local suppliers is promoted, there will be favorable conditions for applying techniques such as Milk-run.

- Regarding the third concept, Logistics activities must ensure environmental factors. The current environmental issues are concerns of businesses all over the world. In the field of logistics, the reduction of emissions from transportation as well as the use of less harmful materials in packaging, maintaining and storage are priorities.

Logistics activities in particular and supply chain management in general have become integral parts of the manufacturing process of enterprises. The system also includes activities outside the plant's area such as component procurement and the supply of products. Milk-run method is applied in manufacturing plants early for three reasons: (1) reducing transportation costs by carrying products with full truck load, (2) supplying products on time and in a systematic manner with assembly lines in small quantities in a set (set part supply), (3) separating transportation costs from purchasing costs. In the past, transportation costs were often added directly to the price of each component, and the suppliers were responsible for shipping the products to the customers' factory. However, according to the Milk-run method, the factories can control the purchasing quantity and the cost of transportation when applying the Milk-run by themselves. There are three methods of collecting products which are commonly used to optimize the capacity and the load of shipments in order to reduce the number of trips on the road, including: 1) milk-run logistics, 2) consolidation at departure facility, and 3) consolidation at transfer facility (Nemoto et al., 2010). However, Milk-Run logistics is a method of goods collection in which the user dispatches one truck at a specified period of time to visit various suppliers following a predefined route to collect parts or products, and deliver them to the factory. In general, the reasons why Milk-Run logistics have 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 costs 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. Milk-Run logistics can provide consolidated collection of goods necessary to improve logistics systems.

## 3. Research methodology

Through a case study of Toyota Motor Vietnam (TMV) researching applying Milk-run method to the supply of products and components from the suppliers and customers in Vinh Phuc Province - Vietnam, this study points out the implementation method and the advantages of Milk-run application for manufacturers in Vietnam.

Toyota Motor Vietnam is an automobile manufacturer founded in Vinh Phuc province, Vietnam from 1995. Currently, TMV has a completed production line with five main processes including Stamping – Welding – Painting – Assembly – Inspection. TMV is producing and assembling three sedan models of Camry, Corolla Altis, and Vios and one model of Multi-Purpose Vehicle (MPV) named Innova. Total number of employees in TMV in 2018 was nearly 1,800 members with 1,300 operators and delivery members. TMV is holding the leading position in the Vietnamese automobile market with the capacity of more than 50,000 units per year in 2017 with two working shifts a day. Average Takt time up to April, 2018 for sedan line was 6.7 minutes and MPV line was 16 minutes. In 2018, TMV had 25 local suppliers and 10 foreign suppliers from Japan, Thailand, Indonesia, Malaysia, Taiwan etc., with more than 300 components and parts (TMV documents). TMV is a large manufacturer in Vietnam.

Currently, TMV has 4 suppliers for parts supply (Utech, Ngoc Ha, Sao Viet, Toyota Hiroshima Vinh Phuc Province), one supplier for water supply (Miru), and one dealer in the area of Vinh Phuc province. In this study, the authors conducted a milk supply combination between suppliers and dealer in a cluster of Vinh Phuc Province to show the before-after result by the cost of transportation and supply quantity.

## 4. Case Study

In the area of Vinh Phuc Province, five routes of parts supply and water supply are separated individually by trucks rented from the transport company. Because all trips for part delivery are started from the transport company in the same method, empty trucks from the transport company drive to suppliers/vendors to load parts and goods, then deliver them to TMV, and then return to the start point unloaded. Therefore, there are many wastes in transportation. In addition, each type of part supply is loaded by one truck, thus the amount of supply is increased. Besides, the stock level in the TMV warehouse of service parts and GPS parts are up to 14 production days. Figure 2 shows the details of five routes of part supply from vendors to TMV and from TMV to dealer and customer.

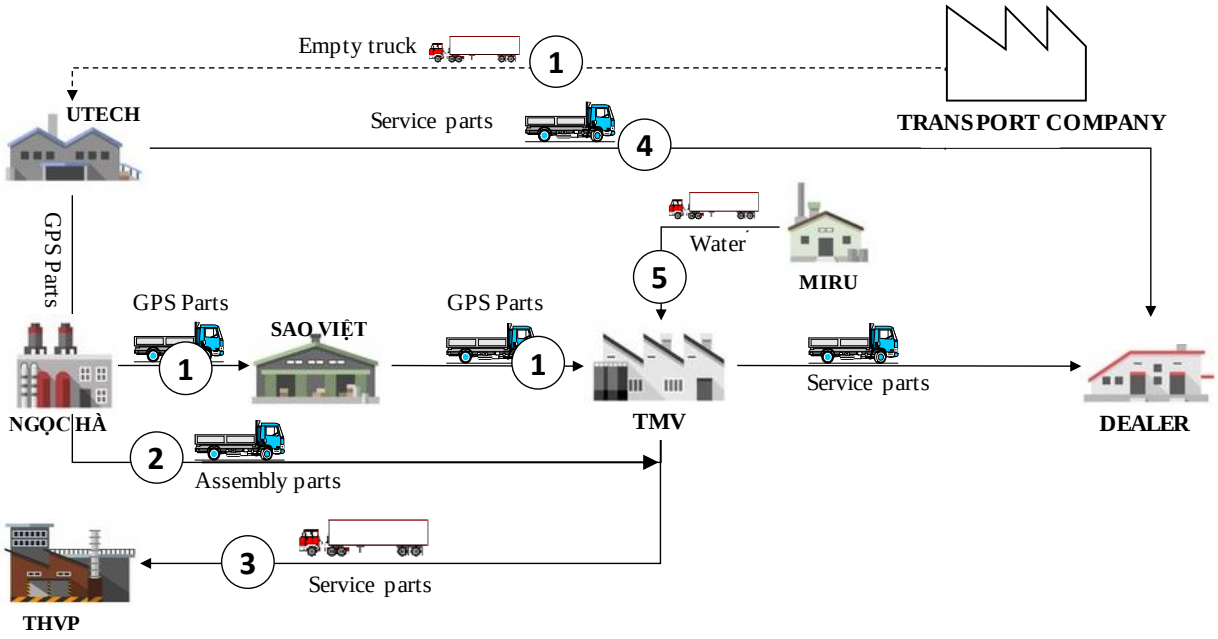


**Figure 2.** The current status of Logistics of the suppliers and agencies of A company in the area.

*(Source: TMV's source)*

The shipments are carried on separate routes as shown in Figure 2 from Route 1 to Route 5 as follows:

**Route ①: Transport Company → UTECH Company → NGOC HA Company → SAO VIET company → TMV:**

Regarding the first trip, the empty truck is sent to Utech Company by the ttransportation company to take components that will be supplied to GPS (General Production Store) warehouse of TMV. After that, this truck continuously drives to Ngoc Ha and Sao Viet company to take some components. Then, it goes back to supply those components to GPS warehouse of TMV. Total distance from the transport company to Utech and Ngoc Ha, Sao Viet, TMV is 72.5 km for one trip per day. Because of volume of truck and optimizing the cost of transport and the number of parts for one trip of supply from Utech, Ngoc Ha, and Sao Viet to TMV for two-week production and the average cost for a month on this route is 564 USD. Figure 3 shows the route of transportation for trip ①.

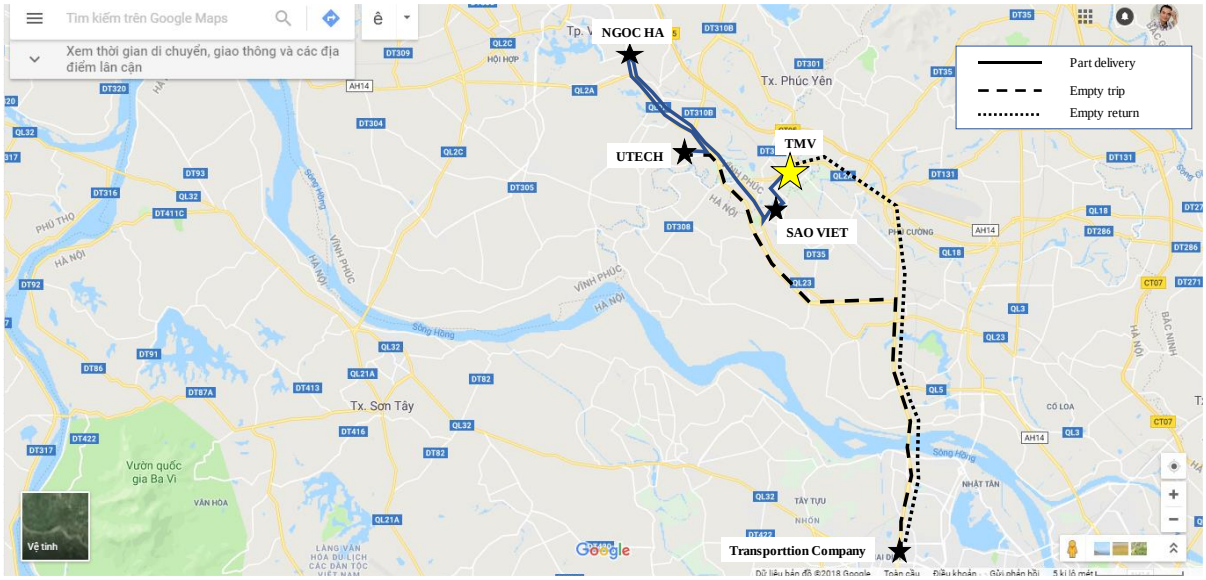


**Figure 3**. Move route No.1 of parts delivery from Ngoc Ha, Utech, Sao Viet to TMV

**Route ②: NGOC HA Company → TMV:**

The second trip takes responsibility for shipping car's tool kit from Ngoc Ha supplier to the warehouse of TMV by another truck starting from Ngoc Ha Company to TMV and returning to Ngoc Ha unloaded. The frequency of this trip for the capacity of 1.5 tons truck is every 10 days. The total cost of this trip in a month is about 190 USD. Figure 4 shows the transportation route of trip ②.

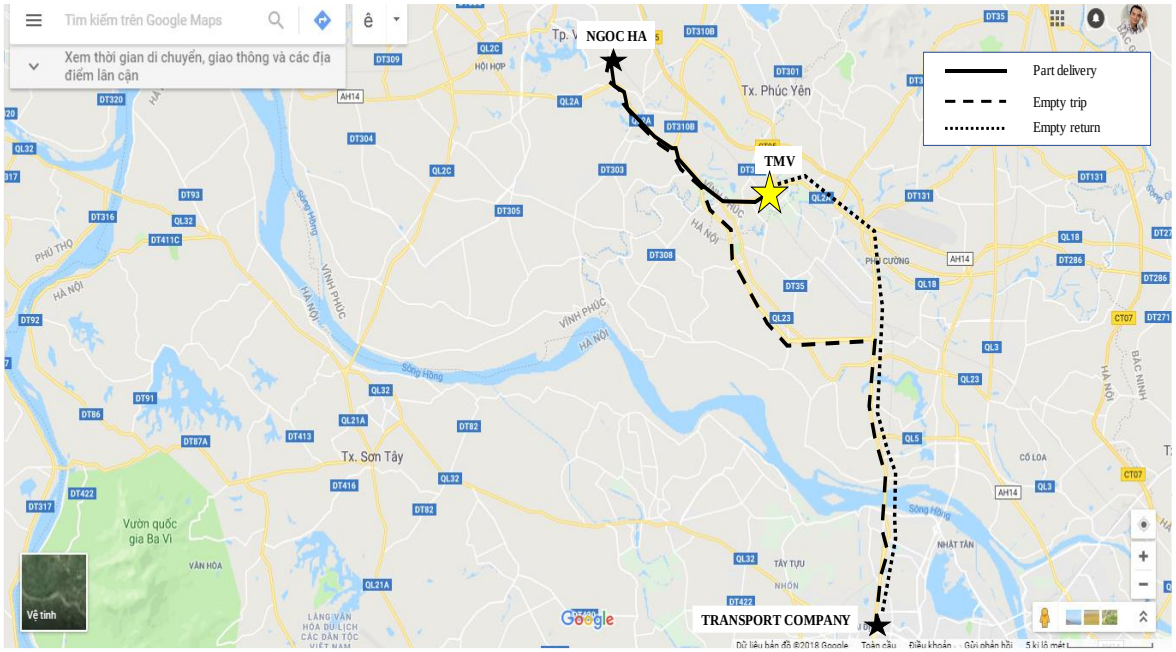


**Figure 4**. Move route No.2 of parts delivery from Ngoc Ha to TMV

**Route ③: TMV → Toyota Hiroshima Vinh Phuc (THVP):**

The third trip starts from the component warehouse of TMV to transport assembly components to THVP day-to-day. After supplying assembly spare parts from TMV to THVP, the empty truck will go back to TMV to prepare for another trip to the dealer. The total transportation cost of this trip in a month is 1977 USD. Figure 5 shows the distance of delivery from TMV to THVP.

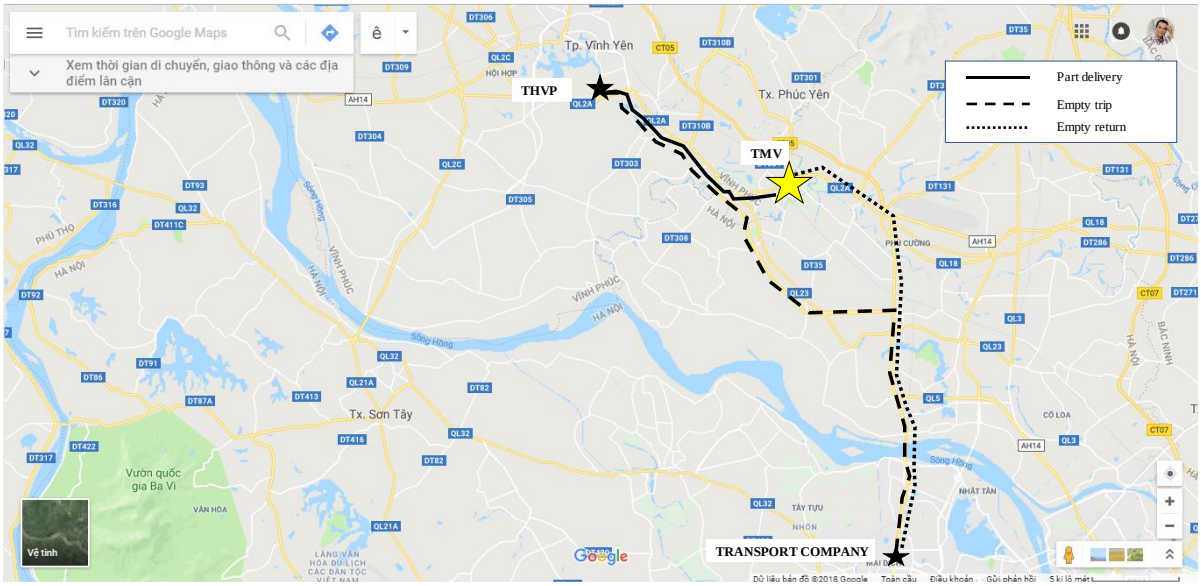


**Figure 5**. Move route No.3 of parts delivery from TMV to THVP

**Route ④: UTECH Company → DEALER:**

The fourth trip transports components for cars from the Utech Company to the Dealer of TMV directly. Assembly parts from Utech are supplied to TMV daily for assembling in production lines. Some of these spare parts are not supplied for TMV, but move to TMV's Dealer directly for the repairing service. The distance from Utech to Dealer for spare parts delivery is 44.3 km. TMV rents a truck for this activity of delivery with the total cost of transportation in a month is 1691 USD. Figure 6 shows the daily delivery from Utech to TMV's Dealer.

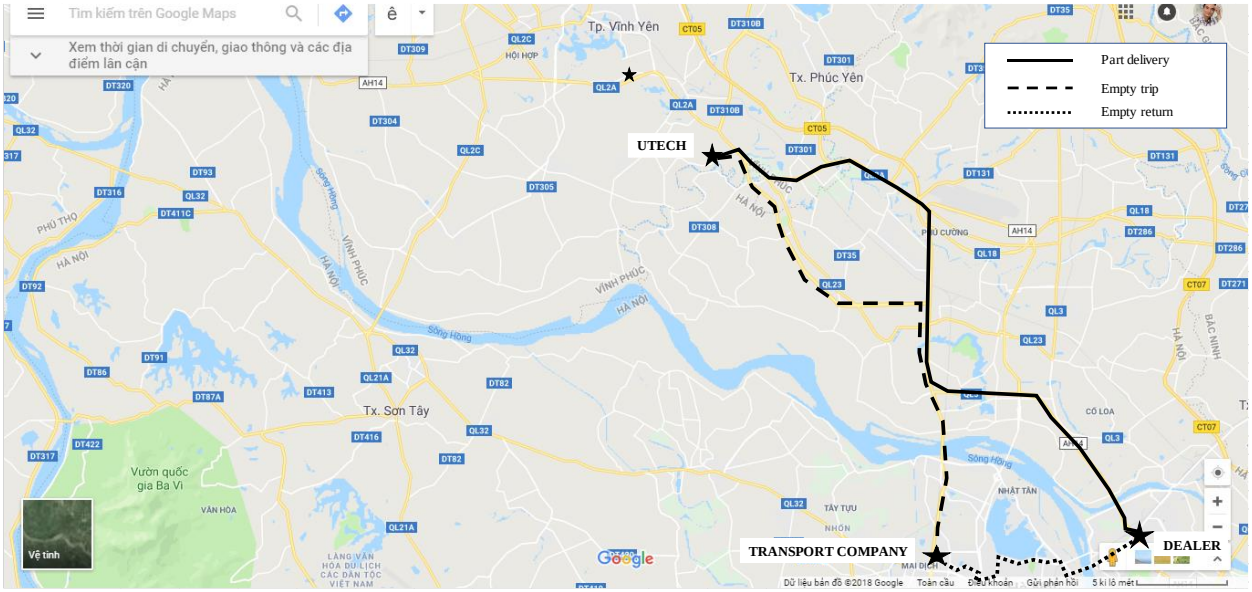


**Figure 6**. Move route No.4 of parts delivery from Utech to TMV Dealer

**Route ⑤: MIRU Water Company → TMV:**

The fifth trip transports drinking water from Miru Water Company to TMV every day. The average amount of daily water demand for drinking in summer for factories is about 150 bottles (3,000 liters). For this trip, the first round for water supply is a full truck trip, however, the return trip is an empty round. Therefore, the total cost for water delivery in one month is 620USD. Figure 7 shows the routing of water transport from Miru to TMV daily.

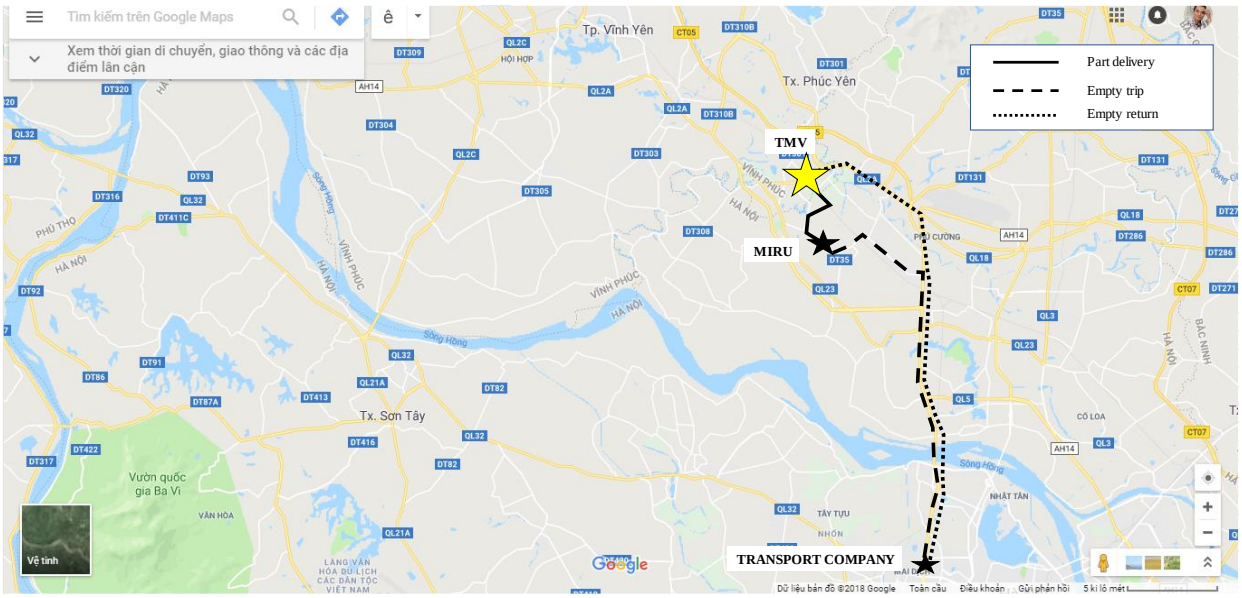


**Figure 7**. Move route No.5 of parts delivery from Miru to TMV

In summary, monthly Logistics activities of 4 suppliers (Ngoc Ha, Utech, Sao Viet, Miru), 1 customer (THVP), 1 Dealer and transportation company in Vinh Phuc province and the neighbourhood with transportation costs are displayed in Table 1.

**Table 1.** Monthly transportation costs of Vinh Phuc area of TMV

| **Pickup Route** | **Cost** |
|---|---|
| Transport Company → UTECH Company → NGOC HA Company → SAO VIET company → TMV | 564 USD |
| NGOC HA Company → TMV | 190 USD |
| TMV → Toyota Hiroshima Vinh Phuc (THVP) | 1977 USD |
| UTECH Company → TMV's DEALER | 1691 USD |
| MIRU Water Company → TMV | 620 USD |
| **Total costs** | **5042 USD** |

*(Source: Statistics of PC-Logistics division - TMV)*

After analyzing and evaluating Logistics issues from these suppliers, the firm realizes that all suppliers are within short distance; therefore, it is not necessary to use private truck loaded fully 1.5 tons and 3 tons from each supplier. Besides, separate supply of each supplier will increase the company's inventory. After researching essential volume for each component, product from the suppliers, the project team conducted a calculation of combining routes and collecting products to optimize costs. A 5.0-ton truck is suitable for loading all of the parts including service parts, assembly part, and GPS part for the one-day production. The combined route is shown as follows: ①: TRANSPOTATION COMPANY→ ②: MIRU → ③: TMV → ④: THVP → ⑤: NGOC HA → ⑥: UTECH → ⑦: SAO VIET → ⑧: TMV →⑨: DEALER.

Kanban system is applied for the new milk-run route. The Kanban card on a milk run with a pick-up frequency of one time per day scheduled at 9:00 a.m. It is assumed that the reproduction of the parts triggered by the Kanban arriving at 10:00 P.M of the last night is possible until the next vehicle arrives. The quantity of Kanban for each part is calculated by the following formula.

$$\textbf{Number of Kanban} = \frac{\text{Amount used for 1 day} \times (\mathbf{X}) \times \left[\frac{(\mathbf{Z}) + 1}{(\mathbf{Y})} + \text{Safety factor}\right]}{\text{Number of parts for 1 Kanbans}}$$

Include: X – Leadtime

Y – Number of trips in one day

Z – Number of cycles for next supply

In reality, the combination of routes is conducted every day with a plan of supplying products that are done regularly and stably for the whole month. The new combination route is shown in Figure 4 below.

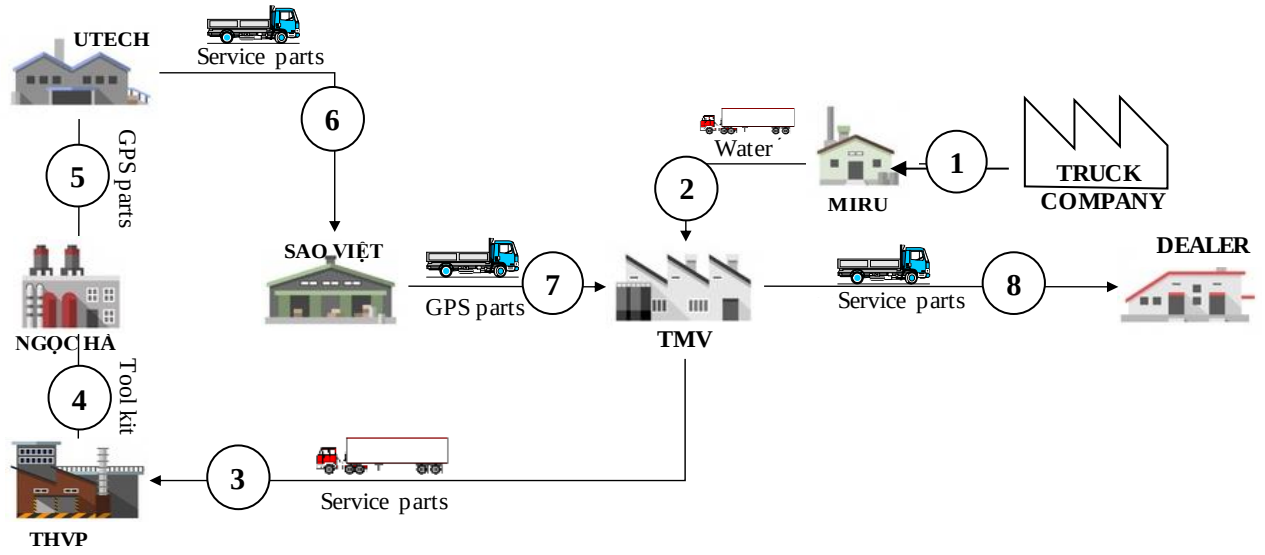


**Figure 4.** The application of Milk-run in combining routes

*(Source: Proposed by the authors)*

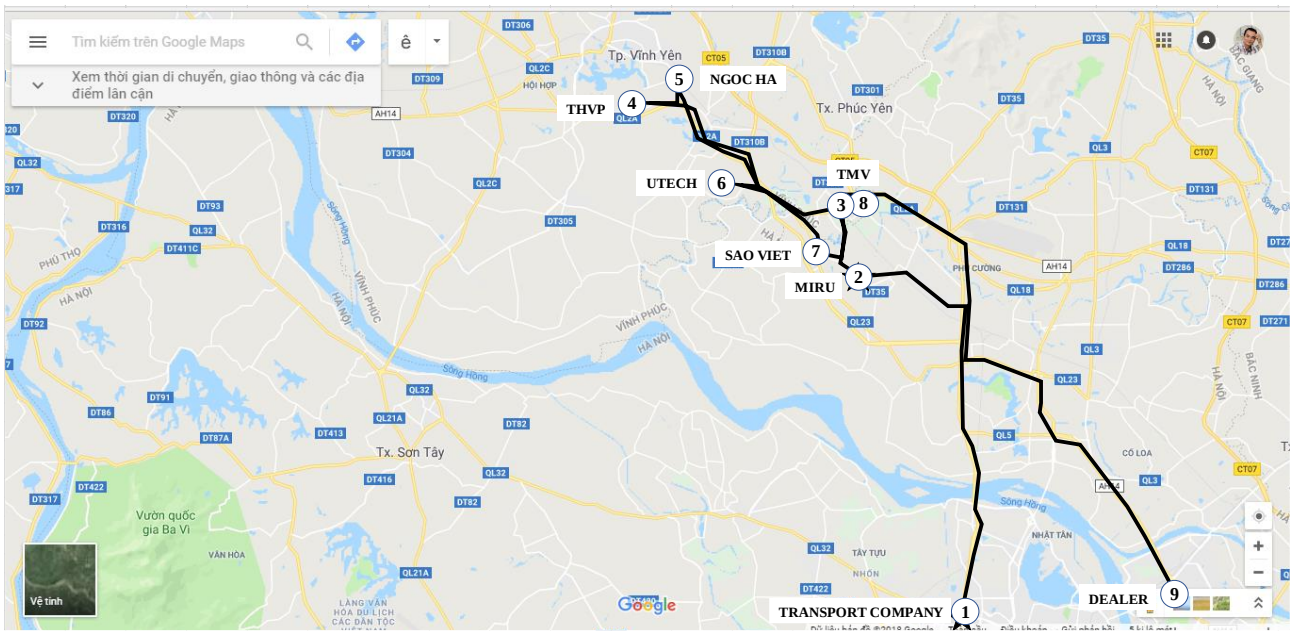


**Figure 5.** Transportation routes after applying Milk-run

After the calculation, the total transportation costs reduced by 2377 USD per month (from 5042 USD/month to 1665 USD/month). Additionally, the inventory amount of components also decreased by 45%.

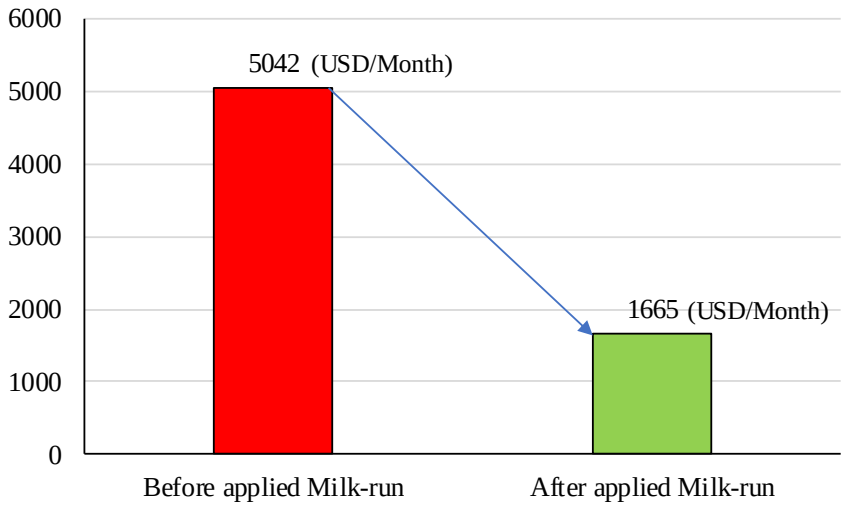


**Figure 6.** Reduction of transportation costs after applying Milk-run

*(Source: Calculated by the authors)*

Besides, total distance for parts delivery from vendors to TMV reduced from 8,800 kilometers a month to 2,637.5 kilometers a month. Table 2 reports the detailed results after changing the delivery route by milk-run combination.

**Table 2.** Distance reduction after applying Milk-run

| **Before** | | | | | **After** | |
|---|---|---|---|---|---|---|
| Route | Frequency | Distance per trip (km) | Empty return truck (km) | Total distance per month (25 working days per month) | Daily round | Distance per day (km) |
| 1 | Daily | 72.5 | 37 | 2737.5 | Transport company to Miru company | 35 |
| 2 | Every 10 days | 15 | 82 | 242.5 | Miru to TMV | 4 |
| 3 | Daily | 15 | 80.5 | 2387.5 | TMV to THVP | 15 |
| 4 | Daily | 44.3 | 46 | 2257.5 | THVP to Ngoc Ha company | 1 |
| 5 | Daily | 4 | 67 | 1175 | Ngoc Ha company to Utech company | 7 |
| | | | | | Utech company to Sao Viet Company | 5.5 |
| | | | | | Sao Viet company to TMV | 1.5 |
| | | | | | TMV to Dealer | 36.5 |
| Total distance per month | | | | **8,800 km** | Total distance per month (25 working days per month) | **2,637.5 km** |

*(Source: Calculated by the authors)*

Finally, the most important result of this combination is the reduction of storage level.

**Table 3.** Stock reduction after applying Milk-run

| **Parts/components stock level** | **Before milk-run** | **After milk-run** |
|---|---|---|
| General Production Store parts | 14 production days | 1 production day |
| Tool kit | 10 production days | 1 production day |
| Service parts, spare parts | 1 production day | 1 production day |
| Assembly parts | 1 production day | 1 production day |
| Water bottle | 1 production day | 1 production day |

*(Source: Calculated by the authors)*

## 5. Conclusion and Discussion

Milk-run, which is one of the popular combination methods in the transportation of products, has been widely applied in many enterprises around the world. This method is especially suiltable for transpotation companies, products distribution centers with its advantages. The product provider systems which have an advantageous geographical location with each other usually apply Milk-run method. Through a case study of a company in Milk-run project on the suppliers and partners in Vinh Phuc Province and in the neighborhood, this study displays a basic methodology and the way to implement Milk-run in order to achieve the goal of reducing costs and inventory.

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