SYNCHRONIZING LOGISTICS PROCESS TO IMPROVE RELEVANT INVENTORY COSTS IN AN AUTOMOTIVE INDUSTRY

By
YUPPARET MEEMAK

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management
Assumption University
Bangkok, Thailand

November, 2010

SYNCHRONIZING LOGISTICS PROCESS TO IMPROVE RELEVANT INVENTORY COSTS IN AN AUTOMOTIVE INDUSTRY

By

YUPPARET MEEMAK

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management
Assumption University
Bangkok, Thailand

November, 2010

SYNCHRONIZING LOGISTICS PROCESS TO IMPROVE RELEVANT INVENTORY COSTS IN AN AUTOMOBILE INDUSTRY

By

YUPPARET MEEMAK

Submitted in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Supply Chain Management
Assumption University

Examination Committee:

1. Asst. Prof. Dr. Nucharee Supatn (Chair) .....
2. Dr. Piyawan Puttibarncharoensri (Member) .....
3. Dr. Peeratarat Ittarattanachoke (Advisor) .....

Approved for Graduation on: November 25, 2009

Martin de Tours School of Management
Assumption University
Bangkok, Thailand

November 2010

Assumption University

Martin de Tours School of Management

Master of Science in Supply Chain Management

Form signed by Proofreader of the Graduate Project

I, Asst. Prof Brian Lawrence, have proofread this Graduate Project entitled Synchronizing the Logistics Process to Improve Relevant Inventory Costs in an Automotive Industry

Ms. Yupparet Meemak

and hereby certify that the verbiage, spelling and format is commensurate with the quality of internationally acceptable writing standards for a master degree in supply chain management.

Signed _____

(Asst. Prof. Brian Lawrence

Contact Number / Email address blawrence@au.edu

Date: December 2010

Assumption University
Martin de Tours School of Management
Master of Science in Supply Chain Management

Declaration of Authorship Form

I, Ms. Yupparet Meemak declare that this thesis/project and the work presented in it are my own and have been generated by me as the result of my own original research.

Synchronizing Logistics Process to Improve Relevant Inventory Costs in an Automotive Industry

I confirm that:

1. This work was done wholly or mainly while in candidature for the M.Sc. degree at this University;
2. Where any part of this dissertation has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this dissertation is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis/project is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. Either none of this work has been published before submission, or parts of this work have been published as: [please list references in separate page]:

Signed: Yupparet M. Date 21 Dec 2010

Assumption University

Martin de Tours School of Management

Master of Science in Supply Chain Management

Student Name: Ms. Yupparet Meemak

ID: 5019387

ADVISOR'S STATEMENT

I confirm that this thesis/project has been carried out under my supervision and it represents the original work of the candidate.

Signed:

_____

(Dr. Peeratarat Ittarattanachoke)
Advisor

Date

_____Decem 22 2010_____

ABSTRACT

This study investigates the logistics process of imported parts in an automotive industry, in order to minimize the inventory cost of these parts, which is the warehouse rental cost. The problem is caused by the delivery lead time of these import parts, which does not agree with the exact timing needed. This makes 'T Motor Company' carry a high cost of excessive inventory.

This paper demonstrates the impact from the unmatched delivery lead time of imported parts, and proposes a new logistics process for these parts by synchronizing the delivery lead time of each part to agree with the JIT concept. Postponement is the significant theory that is applied in this study. The new logistics process leads to savings for the company in warehouse rental cost. After synchronizing the logistics process, T Motor Company can improve inventory management to be more efficient and achieve the objective of minimizing inventory costs of these imported parts.

ACKNOWLEDGEMENTS

I would like to take this opportunity to express my gratitude to Dr. Peeratarat Ittarattanachoke, my advisor, whose continuous support, advice, and ideas helped me to complete this project. His advice was so valuable and broadened my knowledge to apply in real life.

Most importantly, my greatest debt of gratitude is reserved for my beloved family. I would like to dedicate this paper to my parents, for supporting and inspiring me throughout my life. Also, I would like to thank my colleagues and friends for all their support and generous encouragement. Without their kind support and inspiration, my project might not have been completed.

Yupparet Meemak
Assumption University
November, 2010

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

GENERALITIES OF THE STUDY

The automobile industry has high growth and continuous development and has become the main industry in world business. In addition, the automotive industry is a place of technology that has many practices and theories which other industries refer to as the standard model and come to be many companies' methodology. The best known theories are Just-in Time, and Lean Manufacturing. These practices or theories can offer companies the way to product quality improvement, increased flexibility in the production process, reduction of waste costs, maximization of a company's profitability, and improvement in a company's position in a world class business.

Generally, there are several problematic issues in automotive manufacturing. These include greater complexity from several design structures of automobile parts, complications in production line processes, long waiting times or bottlenecks in the supply of raw materials, obsolescence of parts due to design changes without good control, excessive inventory of raw materials, or defects in finished goods. These issues cause negative influence on profitability and a company's working procedure.

The one important subject that most companies in every business pay attention to, is how to run the business efficiently at minimum cost. It has been shown in logistics surveys that companies pay 71 percent of their attention to the subject of cost control and cost reduction (Cooke, 2002). Efficient inventory management is the significant factor that helps companies reach to reach the goal of cost reduction. The right amount of inventory can increase stability in the production line process and service level of customer satisfaction,, but excessive amounts of inventory increase costs, and the, company loses profit because of these unnecessary items. Therefore, every company tries to find the best way to deal with inventory, because inventory can mean profit or loss in the company's financial statement.

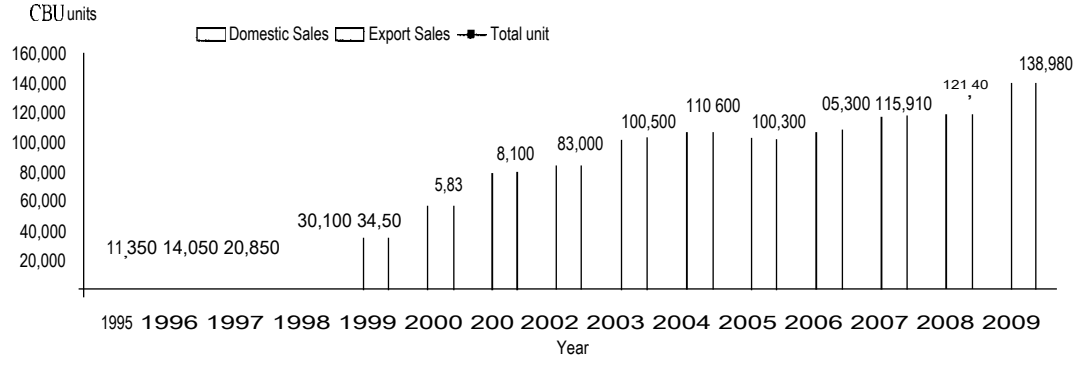
1.1 Background of T Motor Company

T Motor Company is a major assembly car manufacturer which has a continuously high growth rate of sales, and is top of competent high technology for car assembly in Asia. The company is an original equipment manufacturer (OEM) that provides a CBU passenger car (Complete Built up Unit) and CKD Part (Complete Knock down) for both domestic and export sale. The company's headquarters are in Japan, and the subsidiary manufacturing factory in Thai began operations in 1995 and now has nearly 4,000 employees, both permanent and contract employees.

The main product of T Motor Company is the CBU passenger car that has been produced for 5 models namely Ml, M2, M3, M4, and M5 models. All models are produced for both domestic and export sales. Currently, the portion of CBU domestic sales is 60 percent, while it is 40 percent for CBU export sales.

The CBU passenger car meets the quality standard in the worldwide market. T Motor Company started to produce CBU passenger car for export sale in 1998, and trend is to increase their export market in 12 countries that are Japan, Australia, Korea, India, Singapore, Indonesia, China, Philippines, Vietnam, Egypt, Saudi Arabia, and Brazil.

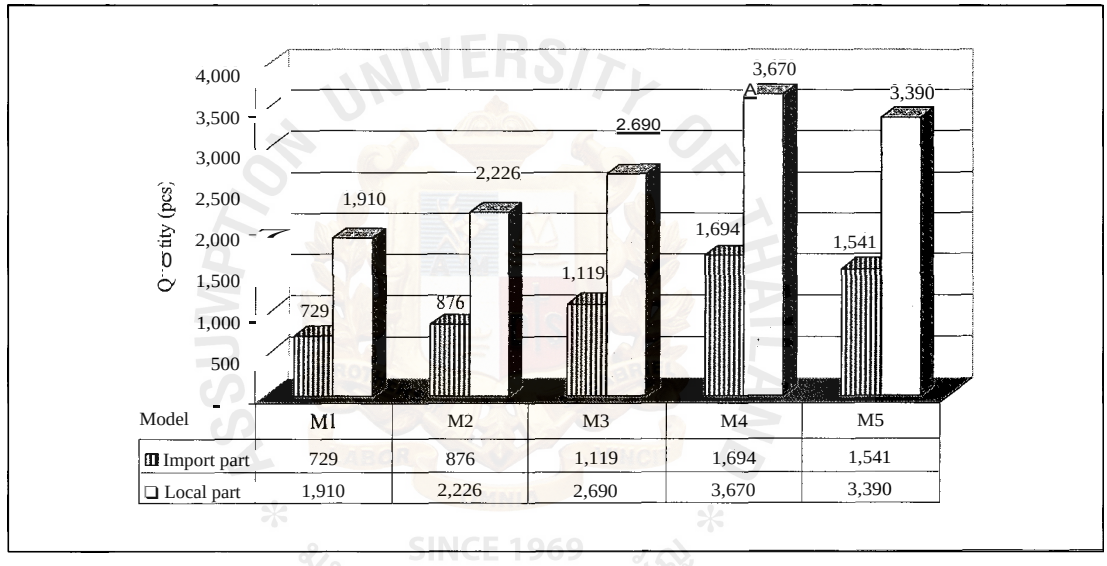
Figure 1.1: Volume of CBU Passenger Car Production for Domestic and Export Sales from 1995 - 2009



Source: T Motor Company

Currently, T Motor Company has the capacity for CBU production of 500 car units with 2 shifts per day. In the latest year, the volume of CBU production reached nearly 140,000 car units. A CBU passenger car is composed of import parts and local parts supply. Now, T Motor Company has 128 local part suppliers that provide the best quality automobile parts under the standard rule of the T Motor brand. Most local parts are engine parts, and also there are frame parts such as Front and Rear Bumper, Side Panel, and Tires.

Figure 1.2: Quantity of Import and Local Parts Supply for CBU 1 Unit

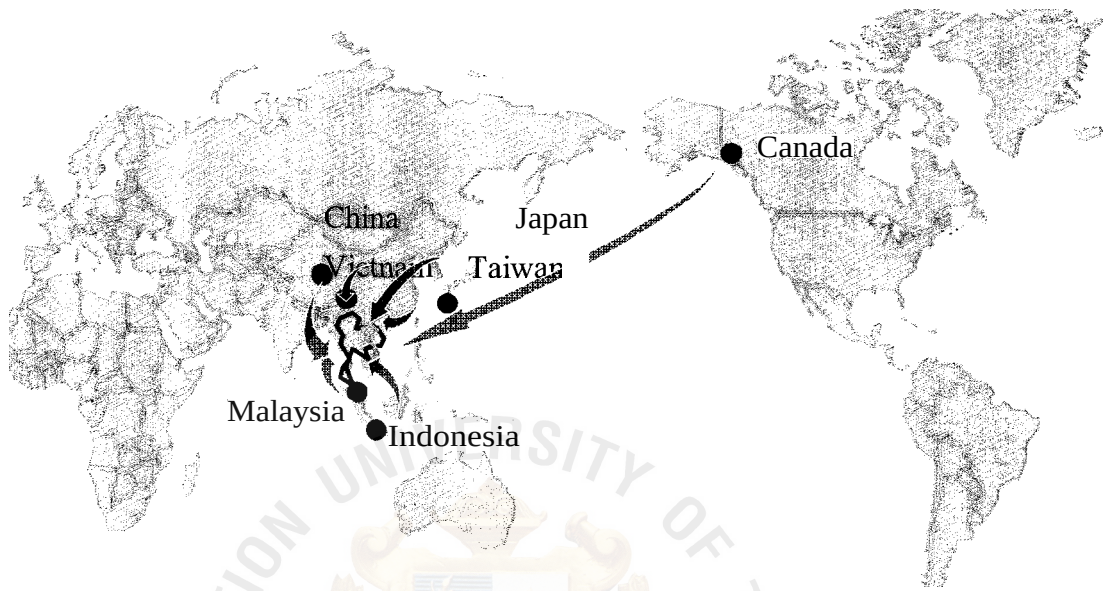


Model	M1	M2	M3	M4	M5
Import part	729	876	1,119	1,694	1,541
Local part	1,910	2,226	2,690	3,670	3,390

Source: T Motor Company

Import parts are supplied through subsidiaries of T Motor Company in 7 countries, which are Japan, Canada, Malaysia, Indonesia, Philippines, Taiwan, and China. A sample of import parts is Weight Balance, Bearing, Converter Assembly, and Light Switch Assembly.

Figure 1.3: Sourcing of Import Parts from 7 Countries



Source: T Motor Company

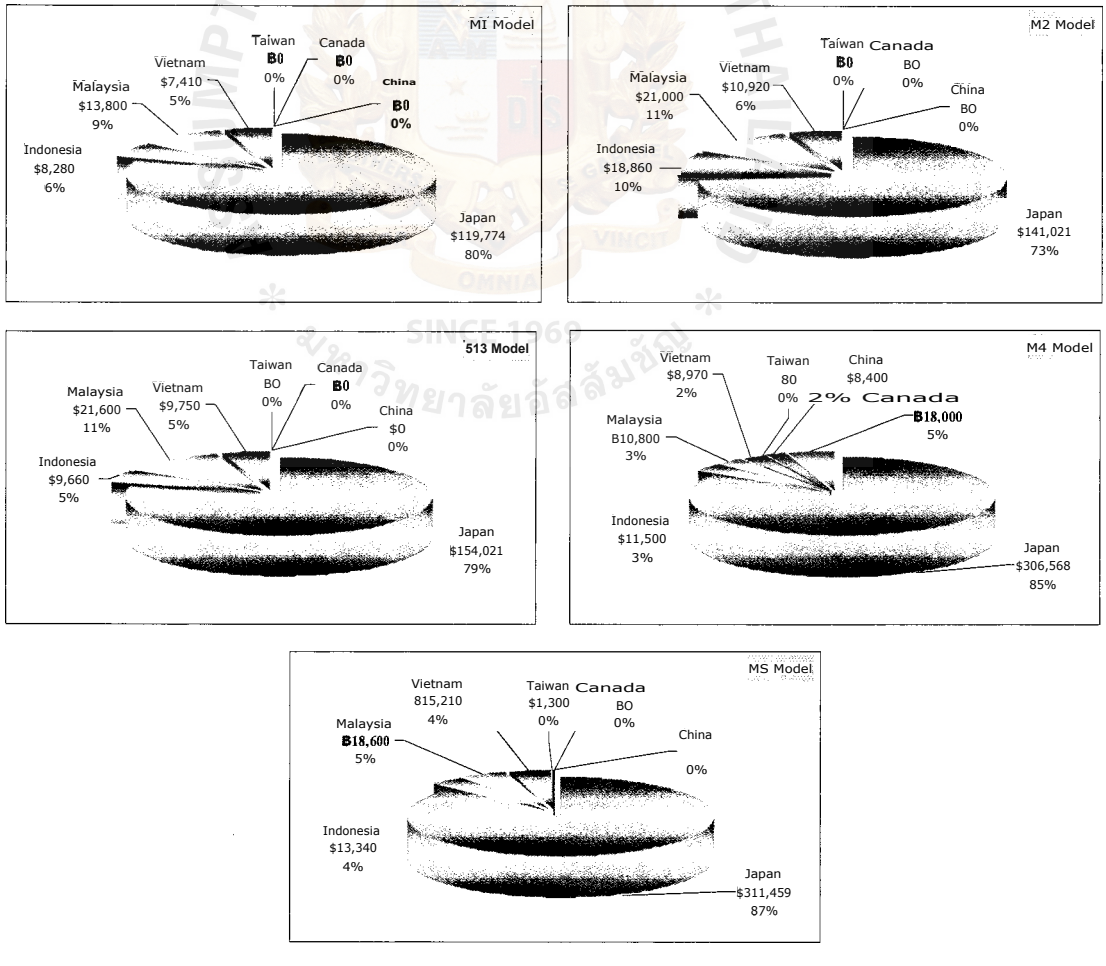
Table 1.1: Summary Quantity of Import Parts, by Sourcing Country

Import Sourcing	Quantity of Import Part (Piece)					Total
	Ml Model	M2 Model	M3 Model	M4 Model	M5 Model	
Japan	669	772	1,037	1,570	1,441	5,489
Indonesia	18	41	21	25	29	134
Malaysia	23	35	36	18	31	143
Vietnam	19	28	25	23	39	134
Taiwan	-	-	-	-	1	1
China	-	-		28	-	28
Canada	-	-	-	30	-	30
Total	729	876	1,119	1,694	1,541	5,959

Source: T Motor Company

Approximately, 90 percent of import parts for all models are supplied from Japan. The remaining small number is supplied from subsidiary factories in Asia. In Table 1.1 is shown the quantity of import parts from each sourcing country for each model. The car model that has the highest quantity of import parts is the M4 model. There are 1,694 import parts for the M4 model that equals 28 percent of all models. The second is M5 model that has 1,541 import parts; equal to 26 percent. The next is M3 model that has 1,119 import parts; equal to 19 percent. In the M2 model, there are 876 import parts; equal to 15 percent. And the last one, the M1 model, has 729 import parts; equal to 12 percent. Also, Japan is the key supplier that has the highest value of import parts from all import countries. Details are shown in Figure 1.4.

Figure 1.4: Proportion of Import Part Value, by Country



Source: T Motor Company

According to T Motor Company's procedure, the ordering of import parts is a set order method. When issuing order of import parts, it will separate only the car model and type. Then, this will be controlled by a lot number for each model. The requested arrival time of an import parts shipment to the sea port is 10 days before the production date.

T Motor Company prepares an import part order each month, separated into 2 periods. These are the 1st suffix and 2nd suffix that follow the production plan. The 1st suffix of production starts from the 1 day until the 15th day of the month, so the order of import parts for production in 1st suffix will be fixed on the 15th day of N-2; ("N" represents the month). The 2nd suffix of production starts from the 16th day until the 31st day of the month, so the order will be fixed on the 1st day of N-1 month. Lead time of a fixed order for import part is 45 days before production. The ordering lead times of import parts, and a sample of an order, are shown in Tables 1.2 and 1.3.

Table 1.2: Ordering Lead time of Import Parts

N-4	N-3	N-2	N-1	N	
15th date	15st date	15th date	1St date	1st half of month	2nd half of month
Forecast 1	Forecast 2	Fix order Suffix A01	Fix order Suffix B01	Production Suffix A01	Production Suffix B01

Source: T Motor Company

Table 1.3: Sample of Import Order for Production in August 2009

Model	Type	Lot number	Quantity of Parts	Order number	Production number
M1	4W-MA	2009-084W-M1-001	30	P0-2009-05-A01	M1-2009-08-A01
M2	4W-MB	2009-084W-M2-001	30	P0-2009-05-A01	M2-2009-08-A01
M3	4W-MC	2009-084W-M3-001	30	P0-2009-05-A01	M3-2009-08-A01
M4	4W-MD	2009-084W-M4-001	30	P0-2009-05-A01	M4-2009-08-A01
M5	4W-ME	2009-084W-M5-001	30	P0-2009-05-A01	M5-2009-08-A01

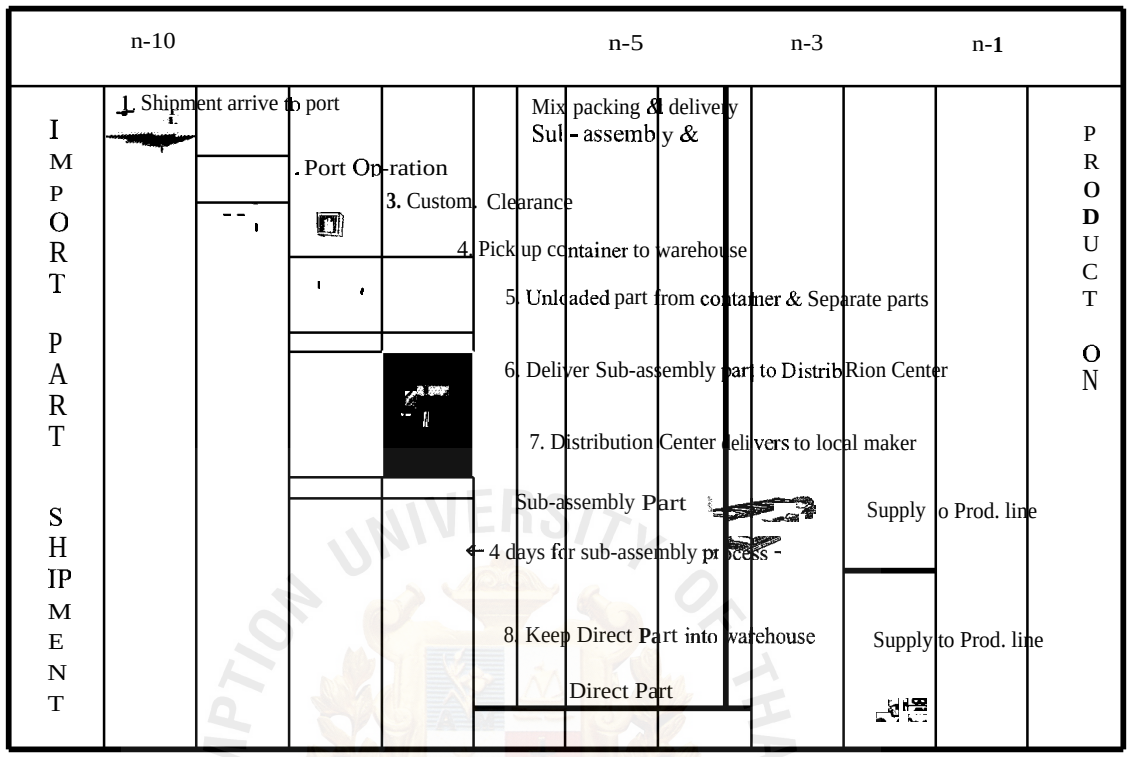
Source: T Motor Company

After the ordering process, an import shipment of parts will arrive at the sea port 10 days before production. On the 10th day backward from production, called n-10 ("n" represented the day), the import shipment will arrive at the port. After completing the process of lifting the container from the vessel by the port authority, follows the process of customs clearance and import duty payment. When that is completed, the truck will pick up the import parts container and deliver it to T Motor Company on n-7 before production. After the import parts shipment arrives at T Motor Company's warehouse, there are the processes of receiving, separating and distributing some import parts to the local maker for sub-assembly processes, but keeping some parts in the stock area.

Due to the current ordering procedure of T Motor Company that is the set order, thus an import parts shipment is separated into car model type, but there are partial import parts that have to be assembled with the partial local parts produced by local makers before being supplied to the CBU Production line. Therefore, it has to be the process of separating sub-assembly parts that are mixed with the partial parts that has no need to do anything before being supplied to the production line, so this is called Direct Parts. These Direct Parts will be stored at T Motor Company's warehouse until the production date; and this takes 4-5 days of waiting time.

The Sub-assembly Parts will be separated and delivered to local makers through a distribution center on n-6. The process of sub-assembly of parts by local makers will take around 3-4 days. After finishing the sub-assembly process, the completed set of Sub-assembly Parts already assembled with local parts will be delivered to T Motor Company's production line on n-1. At the same time, the direct parts of the same lot number will be supplied to the production line on n-1 also. The current logistics process of import parts at T Motor Company is shown in Figure 1.5.

Figure 1.5: Current Logistics Process of Import Parts at T Motor Company



Source: T Motor Company

1.2 Statement of Problem

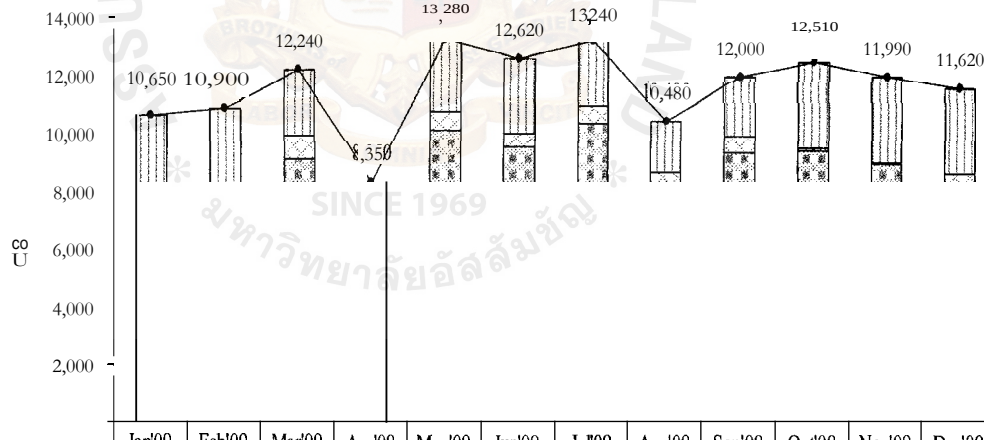
The current logistics process of import parts at T Motor Company shows that both Sub-assembly Parts and Direct parts are delivered at the same lead time; n-10.This creates a long waiting time of direct parts in the warehouse. This situation occurs from the set ordering method that separate only type and car model, so all parts of that model type will be delivered entirely.

But in practice, these parts are needed in different lead times. Sub-assembly parts require a longer lead time than direct parts, because some import parts have to be sub-assembled with the main local parts, which takes 3-4 days. This means that direct parts are delivered earlier than when exactly needed, around 4-5 days. It makes T Motor Company hold direct parts in the warehouse for a long time. This point shows that delivery of import parts does not agree with the exact needs. It causes the following problems for T Motor Company:

1. High stock of import parts, due to same time ordering of Sub-assembly and Direct Parts, but different times of need
2. Inefficient inventory management, due to unsynchronized import parts inventories which have not been delivered at the right time

A summary of CBU production unit for all models in 2009; is shown in Figure 1.6. It reflects that T Motor Company holds a high level of assets in import part inventory from unsynchronized delivery lead time of some import parts items. This research selected a study of import parts that are supplied from Japan, because Japan is the key supplier that has the highest volume of import part among 7 import sourcing countries. The approximate value percentage of Japan's supply equals 80 percent, and this is also the highest portion of inventory level.

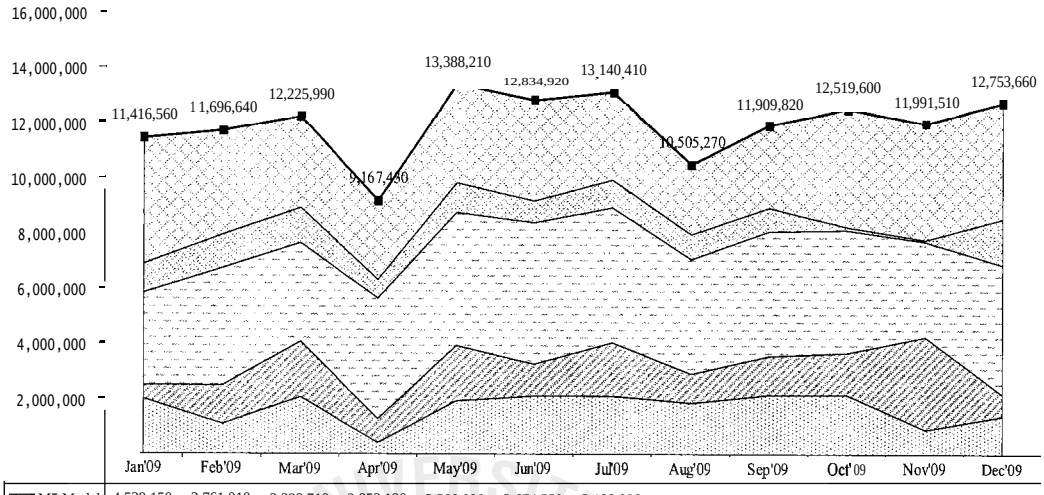
Figure 1.6: Summary of CBU Production Unit, January-December 2009



	Jan'09	Feb'09	Mar'09	Apr'09	May'09	Jun'09	Jul'09	Aug'09	Sep'09	Oct'09	Nov'09	Dec'09
M5 Model	3,150	2,610	2,310	1,980	2,490	2,550	2.220	1.770	2,070	2,970	2,940	2,940
M4 Model	690	780	810	450	660	510	630	570	540	90	30	1,050
M3 Model	3,180	4,080	3,420	4,160	4,680	4,920	4,750	4,000	4,380	4,290	3,330	4,500
M2 Model	660	1,800	2,580	1,130	2,570	1,490	2,460	1,380	1,800	1,920	4,350	1,050
MI Model	2,970	1,630	3,120	630	2,880	3,150	3,180	2,760	3,210	3,240	1,340	2,080
Total	10,650	10,900	12,240	8,350	13,280	12,620	13,240	10,480	12,000	12,510	11,990	11,620

Source: T Motor Company

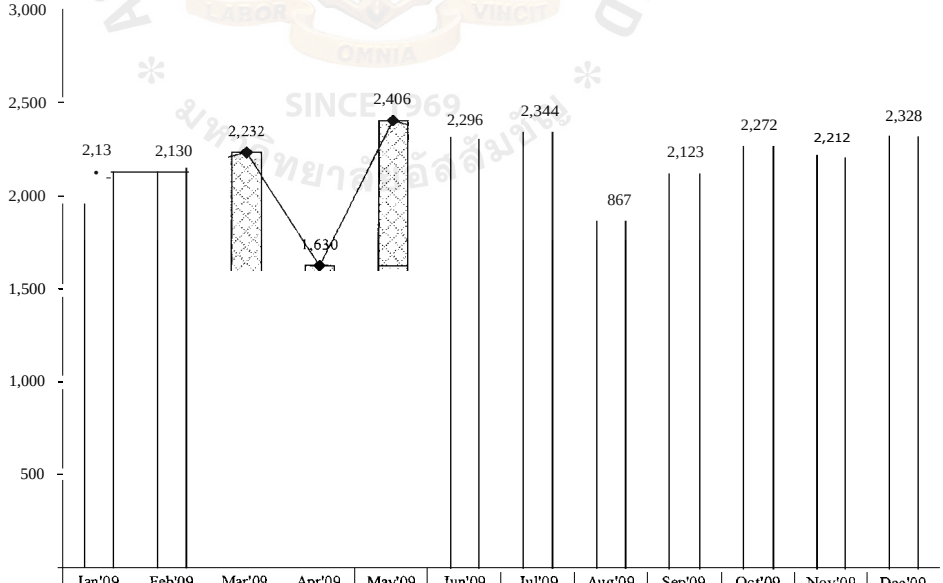
Figure 1.7: Quantity of Import Part Inventory from Japan, Jan-Dec 2009



	Jan'09	Feb'09	Mar'09	Apr'09	May'09	Jun'09	Jul'09	Aug'09	Sep'09	Oct'09	Nov'09	Dec'09
M5 Model	4,539,150	3,761,010	3,328,710	2,853,180	3,588,090	3,674,550	3,199,020	2,550,570	2,982,870	4,279,770	4,236,540	4,236,540
M4 Model	1,083,300	1,224,600	1,271,700	706,500	1,036,200	800,700	989,100	894,900	847,800	141,300	47,100	1,648,500
M3 Model	3,297,660	4,230,960	3,546,540	4,313,920	4,853,160	5,102,040	4,925,750	4,148,000	4,542,060	4,448,730	3,453,210	4,666,500
M2 Model	509,520	1,389,600	1,991,760	872,360	1,984,040	1,150,280	1,899,120	1,065,360	1,389,600	1,482,240	3,358,200	810,600
MI Model	1,986,930	1,090,470	2,087,280	421,470	1,926,720	2,107,350	2,127,420	1,846,440	2,147,490	2,167,560	896,460	1,391,520
Total	11,416,560	11,696,640	12,225,990	9,167,430	13,388,210	12,834,920	13,140,410	10,505,270	11,909,820	12,519,600	11,991,510	12,753,660

Source: T Motor Company

Figure 1.8: Value of Import Part Inventory from Japan, Jan-Dec 2009



	Jan'09	Feb'09	Mar'09	Apr'09	May'09	Jun'09	Jul'09	Aug'09	Sep'09	Oct'09	Nov'09	Dec'09
MS Model	981	813	719	617	776	794	691	551	645	925	916	916
M4 Model	212	239	248	138	202	156	193	175	166	28	9	322
M3 Model	490	628	527	641	721	758	732	616	675	661	513	693
0 M2 Model	93	254	364	159	362	210	347	195	254	271	613	148
MI Model	356	195	374	75	345	377	381	331	384	388	160	249
Total	2,131	2,130	2,232	1,630	2,406	2,296	2,344	1,867	2,123	2,272	2,212	2,328

Source: T Motor Company

1.3 Research Questions

This study intends to answer these questions:

1. What is the appropriate strategy to be used to solve the problem of high inventory of import parts that is caused by the unmatched lead times of delivery with the exact times of usage?
2. If the strategy that is selected can solve the problem of high inventory of import parts, how much inventory cost can the company save?

1.4 Research Objectives

Due to delivery lead times of import parts not agreeing with the exact timing of need, this makes T Motor Company bear the high cost of excessive inventories.
Therefore, the objectives of this graduate project are:

1. To identify the impact of unmatched delivery lead times of import parts
2. To propose a new business process to match all import part requirements for the production line
3. To minimize the cost of import part inventory by a synchronized schedule of import parts shipment
4. To analyze and calculate cost savings after improvement

1.5 Scope of the Research

This research studies the logistics process of import parts from Japan, based on the current procedure and historical data from January to December 2009 of T Motor Company. This study aims to identify the impact of unsynchronized import parts shipments and an appropriate methodology for T Motor Company to improve its logistics process of import parts that will increase its efficiency and profitability.

1.6 Limitations of the Research

This study focuses on the logistics process of import parts supply to T Motor Company, based on collected data for January-December 2009 only. There may be some circumstances or processes which are different in other companies in the same industry or business. Moreover, the limitations of this research are parts packing, load size, transportation mode, timing of vessel arrival, ordering system method and bill of materials.

1.7 Significance of the Study

This study proposes an idea to improve logistics process in an automotive industry that concentrates on inventory cost reduction. It presents the impact from holding high inventory, and suggests how to manage inventory efficiently through the JIT concept and through applying the theory of postponement. This paper is a valuable case study for anyone who is interested in conducting research in the area of inventory cost improvement in the automotive industry.

1.8 Definition of Terms

1. **Complete Knock down or CKD** refers to a completed kit set of component parts that are assembled together with all sets parts, and finally will become a completed built up unit or a finished car product

2. **Complete Built up Unit or CBU** refers to finished goods of a car product that complete the manufacturing processes with all sets of component parts

3. **Direct Part** refers to the kind of automobile part that can be supplied directly to the main production line without a sub-assembly process with other parts; for example Automatic Transmission, and Seat

4. **Just-in-Time or JIT** refers to the well-known theory that originates from

Japan, which has the concept of eliminating wastes that occur from working processes or any activities such as bottleneck and long waiting time.

5. **"n"** represents the day that used in the related production process of T Motor Company, such as: n-Production means that the production day, and n-10 means 10 days before production

6. **"N"** represents the month used in the related production process of T Motor Company, such as: N-Production means that production month, and N-1 means 1 month before production

7. **Original Equipment Manufacturer or OEM** refers to the company that produces or manufactures products under its own brand name

8. **Postponement** refers to the strategy which uses delays in the final production or assembly process until the exact timing needed. An example of postponement is delaying the arrival of some materials until the production date (Van Hoek, 1998)

9. **Sub-assembly Part** refers to a kind of automobile part. It calls the part that has the sub-process of assembling two parts together before delivery to the main production line for the main process of car assembly. For example, Panel Assembly Part is a Sub-assembly Part that has to be assembled with a CD player before being supplied to the main production line

10. **Sub-assembly Process** refers to the sub-process of assembling two or more parts together before supplying the completed set of assembly part to the main production line

11. **Unit** refers to the specific quantity of car that have completed the manufacturing process, such as CBU car 1 unit

CHAPTER II

REVIEW OF RELATED LITERATURE

The related literature and research can provide ways to define the root cause of the inventory problem, and they will be the guideline to what practices or theories are suitable for the company's methodology for inventory management.

2.1 Inventory Management

In global competitive business today, one of the success factors that companies concentrate on is inventory management linked to JIT theory that prevents inventory loss. It has been explained that the top three methods that are used to control and reduce inventory costs are the periodic inventory method, the ABC inventory classification method, and the entire supply chain management (Johnson, 1993).

The objectives of inventory management are to achieve a customer service level at minimum cost of ordering and holding inventory. The functions of inventory are to keep sales opportunities from uncertainty demand, to support the smooth running of production, to avoid stocks-out, to gain advantage from order cycles, to be a barrier against raw material price increases, and others. The two types of inventory are classified as dependent and independent demand.

Dependent demand is certain. It is based on the demand for finished goods in which raw materials are used; for example; raw material, subassemblies and component parts. Independent demand is uncertain, arising from seasonal, trends and market conditions; it cannot be obtained from demand for other items

2.2 Just-in-Time (JIT) – The Philosophy of Waste Elimination

The "just-in-time" idea is one of the well-known Japanese production systems. The concept of "just-in-time" (JIT) was introduced by Taiichi Ohno, executive vice president of Toyota Motor Company. Toyota started to implement JIT in the early 1970s; this then expanded to other Japanese companies in the late 1970s. By the early 1980s JIT became a famous theory of manufacturing innovation in many Western and other Asian countries (Schonberger, 1982). It has been reported (Monden, 1983) that JIT is the key factors, including the Kanban system, for setup time reduction.

Flynn (1995) described JIT as based on the concept of eliminating waste through the simplification of manufacturing processes. This simplification includes the elimination of excessive inventory and lot sizes that are too big, which cause long cycle times. JIT theory highlights the necessity for delivery of any part in the necessary quantity and at the right time. JIT delivery has been an important step in lean manufacturing implementation for most companies.

Sakakibara (1997) described the JIT production system's purpose to support a company's increased profitability by achieving goals of minimizing cost and time in the manufacturing process and eliminating waste in terms of material movement, and work-in-process inventory.

Also, Heizer and Barry (1996) insisted that the purpose of JIT is to reduce cost by eliminating waste, and using all resources efficiently. Excessive inventory and time are removed, so unnecessary cost will not be incurred.

Several researchers mention that JIT is a method that has the significant objective to get rid of all kind of wastes that have a negative influence on a company's profitability and performance. This kind of wastes in inventory can be unnecessary items of raw material and finished goods. It also includes scrap parts, reworked products, wasted time in setting up a machine, non-value adding activities, and non-productive machines. Moreover, these wastes derive from problems of quality of materials, manpower, machine and quality controls method. The assumption of JIT as

constructed by Toyota in Japan are: quality production leads to satisfying customer requirements; a close relationship between supplier, manufacturer and customers; minimized levels of inventory (reduced cost of inventories); and effects of inflation, obsolescence, damage and waste.

Sakakibara (1997) presented the dimensions of JIT practices as below:

1. Set up time reduction
2. Small-lot sizes
3. JIT delivery from suppliers
4. Supplier quality level
5. Multi-function workers
6. Small-group problem solving
7. Training
8. Standard rule of daily schedule
9. Repetitive master scheduling
10. Preventive maintenance
11. Equipment layout
12. Product design simplicity
13. Kanban
14. Pull system.

These 14 dimensions are reduced to 4 JIT practice categories as

1. Major contributing factors of equipment layout,
2. Pull system support
3. Supplier quality
4. Kanban

To reach the goal of the JIT philosophy, it has been presented by (Hirana, 1998) that there are five steps to implement JIT that include:

Step 1: Awareness Revolution – This is the initial stage of taking out the old traditional ways and starting to think with the new improvement concept of JIT. Then, review all current processes and resources.

Step 2: Concept for workplace improvement - Identify which are necessary points and unnecessary needs. Then maintain proper location maintenance and make the workplace clean. Set up schedules and keep to rules.

Step 3: Flow Manufacturing – Prepare machines in continuous order. After that arrange training programs and follow up cycle times. Use the appropriate size of machine and set up production line in "U" shapes

Step 4: Standard Operations – This is related to quality, safety and less costly operation rules, method, goods, and machine preparation. Four bases of standard operations include total cycle time, standard stock on hand, using operation charts and working schedules.

Step 5: Multi-Process Operating – Create a good workplace that should be "U" shaped. Set up multi-skilled workers, multi-machine handling and multi-process handling.

It has been mentioned that JIT would be a cost favored purchasing approach to inventory management (Chyr, 1990). Hearn (1988) prepared simulation to analyze the advantages of JIT. It can be applied to be the solution to control materials flow and reduce work- in-process inventory in a complex environment.

Schwartz and Andrew (1998) showed that companies in several industries achieved benefit from JIT implementation.

Many automobile companies use JIT methods to reduce ordering automobile parts at only enough quantity through short production timing. Also, a well-known computer company showed that waste was reduced from 28 percent to 1 percent, inventory turns were two times the industry average, the need to use warehouse space was reduced by 35 percent, and labor productivity was increased by 60 percent. In addition, a well known motorcycle factory showed that inventory was reduced by 50

percent, scrap and rework products were reduced by 50 percent too. And productivity rate was increased by 32 percent.

2.3 Advantages of **JIT**

Wafa and Yasin (2001) said that JIT helps a company to reduce production lead times and set-up times. Also, Petersen (2002) described it as that leading to ways of reducing operations and raw materials handling costs, and maximizing the use of warehouse space. The significant indicators that showed how effective JIT implementation is as a way of making to order or pull-based system be related to inventory management to reduce inventory cost and over all costs (Yeh, 2000).

Lieberman and Demeester (1999) described how the JIT method can help a company reduce the quantity of raw materials which leads to an immediate reduction. At the same time, work in process is also reduced, since inventory holding cost and concerned activities have an influence on the entire cost reduction. Finally, it will reflect on the level of the finished goods inventory, as that can be reduced. All of these good results came from the improvements in process reliability and reduced cycle times.

Aghazadeh (2001) described that JIT inventory system purposes as to eliminate waste by the concept of right part delivery at the right time that minimizes space in the warehouse and holding cost. Moreover, JIT has the good point from small lot size, reduce time and cost in storage, setup and production.

It has been presented that companies which utilize push-based systems frequently attempt to minimize risk by postponing final product assembly until the products reach local distributors who are responsible for final product configurations (Papadakis, 2003)

Yasin (2001) explained that JIT also provides good control of the on-time delivery of material supply from makers. It is efficient in purchasing work, to set up better

preventive maintenance; encourage workers to participate in improvement activities, and leads to quality product improvement and efficient management of manpower utilization, machine equipment and raw materials, and creates the situation of practice and competition while routine tasks are reduced.

Stevenson (2002) said that to achieve the goal of improving profitability through eliminating wastes, the JIT production system consists of 4 building blocks.

The first one is product design, which includes standardized parts, modular design and quality.

The second is process design, which includes ordering in small quantities by reducing lot size, reduction in lead time set up, decreasing size of manufacturing, restricted work-in-process, increased improvement in quality of product, increasing flexibility in the production process and keeping small quantities of inventory

The third building block of JIT is improvement in the function of the manpower control structure in an organization, which is composed of assignment for workers development by setting up training program for continuous improvement in the human resources function, and assigns good control of cost accounting, and pushes employee into leadership of project management.

The last building block is manufacturing planning and control. It includes level loading, pull systems, visual systems, close vendor relationships, and reduced transaction processing.

Schermerhorn (1996) suggested how to implement JIT to reach the goals with effectiveness. It depends on good support from all related functions, for example; high quality of raw materials supply from suppliers; strong management commitment; good connections with the supplier network; and convenient location; All of which lead to better control and cost of transportation; and raw materials distributions.

Many researchers presented the JIT philosophy as giving a lot of advantages to make profits for companies. For example, improvement in the working process and quality of product, serving customers needs rapidly, decreasing inventory holding levels, and better relationship with suppliers (Aghazadeh, 2002).

According to the results of these researches, the JIT practice is more importantly associated with process flexibility rather than cost efficiency. Many JIT flow practices are founded as improvements in process mobility. Moreover, JIT flow is also associated with new product flexibility. But there are some limitations to implementing JIT. People like to work in the old ways, and do not like to change to new styles, such as some factories like to keep high stock to serve production running and customer needs (Aghazadeh, 2002).

The researches above show that JIT has been accepted by almost all industries. And almost all companies gain benefits from JIT implementation, both increased efficiency and flexibility in the production process and especially in cost saving.

2.4 Postponement Strategy

The concept of postponement has been discussed for over 50 years (Alderson, 1950). It has been explained (Bucklin, 1965) that postponement is an adaptive supply chain strategy that makes a company reduce its level of inventory and relevant costs, and at the same time increase its customer service level.

Zin, Pagh and Cooper (1998) presented different types of postponement in the supply chain, which are: postponement in labeling, packaging, assembly, manufacturing and time postponement. Zin et al, (1998) presented simple conceptual models as four strategies that include full consideration, logistics postponement, manufacturing postponement and full postponement.

Postponement entails the implementation of specific inventory strategies to deploy inventory farther away from the customer while fulfilling service level objectives and

reducing inventory costs and minimizing risk. The purpose of postponement is moving product differentiation to agree with the pull concept. The good benefits that will be received are decreasing lead time of raw material supply, and redesigning production processes and products. In conclusion, it is the way to delay product differentiation (Fisher & Lee, 1994).

Sigronelli and Hesket (1984) provided an example of a business that has used postponement strategy. Benetton is a well known clothing company that applied the technique of postponement to produce fashion products that have a high rate of quick changes. For fast moving trends about color, shape or style, Benetton uses un-dyed cord to knit half a clothes product, and postpones the coloring and dying process until the last stage. When receiving demands with fixed colors, Benetton can produce the process of coloring according to the actual demands. This offers many advantages to Benetton to save cost and avoid obsolescence.

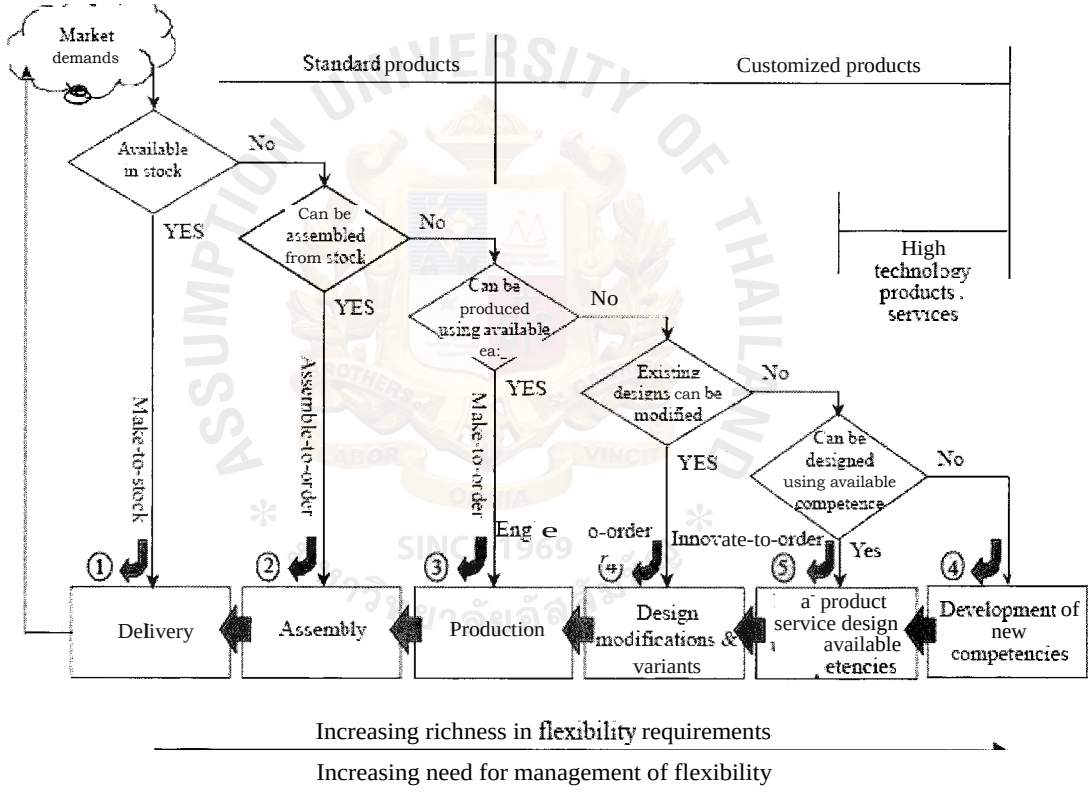
Also, in automotive business adopted postponement strategy in the manufacturing processes. Wadha (2006) explained the circumstance in an automobile factory. There are different components and assemblies of parts which are different product types and assembly processes. Automobile parts are used in several stages. There are numerous kinds of automobile parts that are used at difference stages, such as sub-assembly parts, assembly parts, and component parts.

Van Hoek (1998) described automotive companies such as BMW. They adopted the postponement strategy to decrease lead time and increase flexibility in the production process at the same time. BMW implemented a project of Customer Orientated Sales and Production Process (COSP) by reducing the lead time between orders is being placed and delivered to the customer within 10 days.

It is important to apply the postponement options based on different manufacturing supply chain scenarios that are shown in Figure 2.1. Wadha and Rao (2000) insisted that an automobile company can get more benefits and increased flexibility for car production by changing the production method from make-to-stock to assemble-to-

order using postponement strategy. There are advantages in product mix flexibility and volume mix flexibility by applying postponement strategy. It needs collaboration with related departments especially the sales department and the factory when applying the postponement method to the assembly process for some parts at the final stage, and finishing the product when the actual demand is received.

Figure 2.1: Manufacturing Method and Postponement Options



Source: Adapted from Wadha and Rao (2000)

2.5 Summary

Currently, many manufacturers need to implement useful activities into production processes and aim to get rid of unnecessary activities that create loss or waste. Manufacturers consider a suitable strategy for production according to customer requirements. Especially in automobile manufacturing circumstances, there are

several stage of part usage and complexity both in part structure and the manufacturing process. If there is not good control for automobile parts supply, there will be problems in the production line process and make the company lose profitability.

At T Motor Company, the ordering process of import parts for production of CBU 1 unit is the set order or modular method. It means that all of parts for CBU 1 unit are grouped in one set and delivered at the same time, because it is easy to control whole import parts for CBU 1 unit and avoid the situation of parts shortage. But lead times of ordering and delivery of import parts are the important factors that affect inventory.

Therefore, to solve the problem of excessive import parts inventory, postponement is the only interesting strategy to deal with this inventory problem for T Motor Company. The key point of this inventory problem is that it is caused by unsynchronized lead time of ordering and delivering import parts.

Postponement strategy provides a useful technique to manage the problems of unmatched delivery lead time with the exact time of usage. It can decrease the excess stock of import parts and reduce inventory costs. Thus, it is the appropriate strategy that makes the company operate with lowest cost under the condition of production running smoothly.

CHAPTER III

RESEARCH METHODOLOGY

This chapter presents the methods and methodology that are appropriate to apply to improvement of inventory management in an automotive manufacturing company.

3.1 Research Design

This paper uses the case study method to investigate a real situation of inventory management at T Motor Company. The inventory problem arises from a section of the import parts supply that is unmatched in delivery timing with the actual production needs. This paper uses information from historical data of the company from January —December 2009 to design a new logistics process for direct parts to agree with the exact time of need. The increase in efficiency in inventory management and the minimizing of inventory cost of import parts are the objectives of this study.

3.2 Collection of Data

This study focuses on the logistics process and inventory of import parts that are supplied from Japan to T Motor Company. The collection of data is obtained from historical data of T Motor Company, which includes:

1. Summary of CBU production in 2009
2. List of import parts which are supplied from Japan; Model Ml, M2, M3, M4, and M5 in 2009
3. Value of import parts which are supplied from Japan; Model M1, M2, M3, M4, and M5 in 2009
4. Ordering schedule of import parts in 2009
5. Summary of inventory costs of import parts supplied from Japan
6. Warehouse rental area and cost of import parts in 2009

3.3 Inventory Impacts from Current Logistics Process of Import Parts at T Motor Company

Regarding the ordering process of import parts for CBU production, the fixed order lead time is 45 days before production. Forecast and fixed orders are made 2 times per month in the same production plan. The 1st suffix starts from the 1st day until the 15th day of the month, and the 2nd suffix starts from the 16th day until the 31st day of the month. The current ordering method is separated by CBU model type, and controlled by lot number of each model only. This is the set order method.

After a fixed order, import shipments are delivered at the port 10 days before production. When an import shipment arrives at the port, there is the process port operation, customs clearance, and then truck delivery of import containers to the company's warehouse 7 days before production. When an import part shipment arrives at the warehouse, there are the processes of receiving, separating and distributing some parts items to the local maker for sub-assembly processes, and these are called Sub-assembly Parts.

For the remaining parts items of that lot number, there is no need for any processes before production, and they will be stored at the company's warehouse until the production date: these are called Direct Parts. The Storage time that Direct Part have to be kept in the company's warehouse waiting for production, is around 5 or 6 days. It shows that Direct Pars are delivered earlier than the exact, and this makes the T Motor Company carry excessive inventory of direct parts.

After reviewing the current logistics process of import parts from Japan, there are many points in the current procedure that have to be identified and improved. The analysis and improvement are related to proper lead times for order and delivery of Sub-assembly and Direct Parts.

Currently, T Motor Company prepares an order for import parts by a set order method. A current order shows only the car model, type, lot number, quantity, order

number, and production number. When input this data is input into the order system, the order system will interface with data from the Bill of Material, which lists all parts items of that model type, then converts the data into an ordering structure. After that, oversea suppliers will receive orders that indicated all part items of that model type. Then, import parts of that model type's order will be delivered all at the same time.

But in practice, all items of import parts of such model type are not used at the same time, which causes a high import parts inventory for T Motor Company. Therefore, to help the company reduce inventory and improve the logistics process of import parts, the first step to deal with is arrangement of usage timing of import parts to support the ordering procedure, then the delivery lead time of each group of parts can be arranged.

At T Motor Company, there is different timings of import parts usage. Thus, it has to separate import parts delivery into 2 lead times.

1. Lead time of delivery n-10 for Sub-assembly Parts
2. Lead time of delivery n-7 for Direct Parts

After arranged the type of import parts into timing of parts usage, these are a lead time of delivery of n-10 for Sub-assembly Parts, and a lead time of delivery of n-10 for Direct Parts. The proportion of quantity and value of Direct and Sub-assembly Parts is shown in Table 3.1. This table shows that the quantity and value of Direct Parts are higher than Sub-assembly Parts in every model. The average percentage of value of Direct Parts is 84%, while Sub-assembly Parts is 16%. For example, M1 model has 544 Direct Parts and the total value of these parts is 101,343 Baht. Also, the quantity of Sub-assembly Parts is 125 parts and total value of these parts is 18,431 Baht. This information can imply that the main burden of import parts cost is in the Direct Parts.

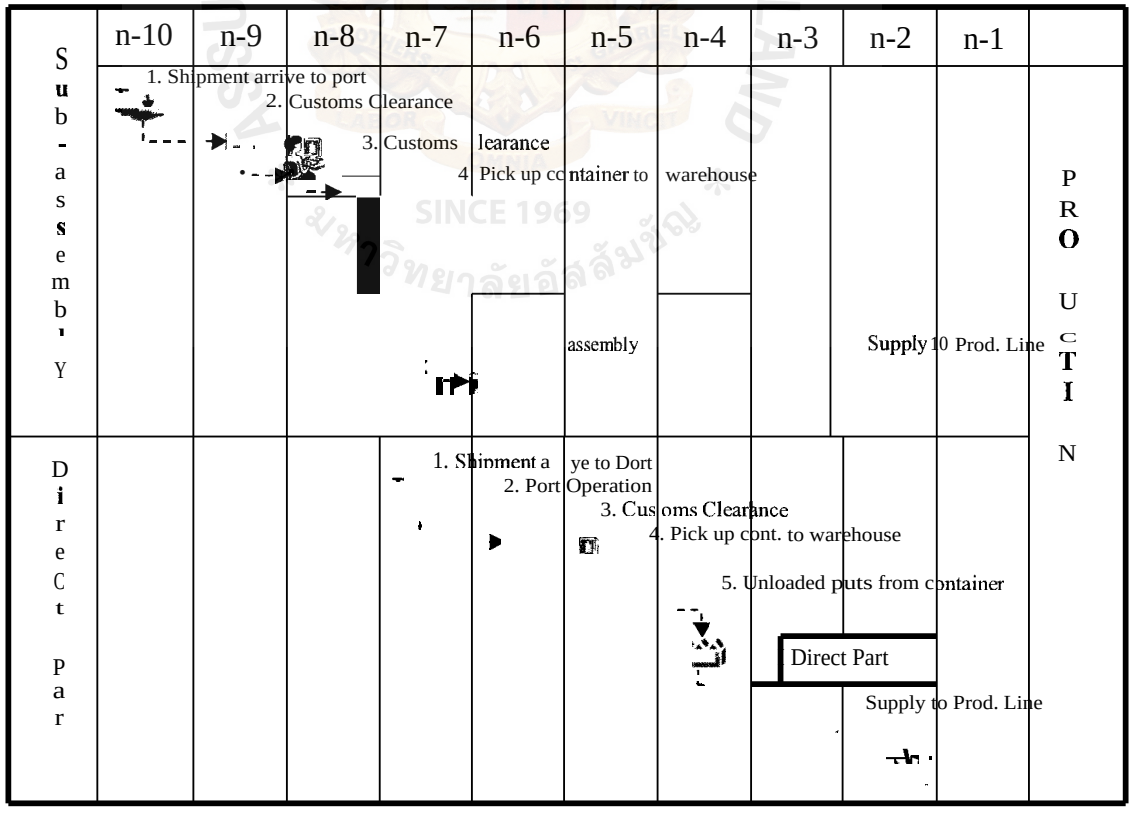
Table 3.1: Portion of Quantity and Value of Direct and Sub-assembly Parts

Import Parts	M1 Model			M2 Model			M3 Model			M4 Model			M5 Model		
	Quantity of Part	Value (฿)	% of Value	Quantity of Part	Value (฿)	% of Value	Quantity of Part	Value (฿)	% of Value	Quantity of Part	Value (฿)	% of Value	Quantity of Part	Value (฿)	% of Value
Direct Parts	544	101,343	85	625	121,772	86	926	125,638	82	1,422	258,572	84	1,243	256,127	82
Sub-assembly Parts	125	18,431	15	147	19,249	14	625	28,383	18	148	47,996	16	198	55,332	18
Total	669	119,774	100	772	141,021	100	1,551	154,021	100	1,570	306,568	100	1,441	311,459	100

3.4 Re-design Logistics Process of Direct Parts at T Motor Company

Referring to the current logistics process in Figure 1.5, there are many problems that affect inventory management and make the company carry a high inventory of import parts. Thus, the logistics process of import parts should be improved to be that in Figure 3.1.

Figure 3.1: Proposed New Logistics Process of Direct Parts at T Motor Company



Before proposing the new logistics process of import parts, Sub-assembly and Direct Parts are ordered to be delivered at the same time, but actually the timing of needing parts is different. The reason why the company is faced with this problem is the ordering method. When the company orders CKD parts to assemble CBU cars, the order is separated only into car model and type, and then all parts of that model type will be delivered entirely, at the same time. This leads to excess in import parts inventories.

Therefore, to solve the problem of import part inventories, there is a need to synchronize the requested time of the order and delivery lead time of each part, to agree with the actual usage. To achieve this with the JIT concept is to eliminate any wastes. More than concentrating on delivery with the necessary quantity of parts, it should also focus on the delivery aspect, to be at the right time.

As to the Sub-assembly Part group that has to be delivered for the sub-assembly process with the main parts being produced by the local maker, the Sub-assembly Parts require more lead time than normally. In practice, only 7 days are enough for logistics activities of import parts. But these sub-assembly parts require 3 days more than normally. Therefore, the requested time arrival of Sub-assembly Parts should be n-10; which means the import shipment should arrive at the port 10 days before production.

The group of Direct Parts does not need any processes before production. Only logistics processes of 7 days are required. But in the current logistics procedure of T Motor Company, in Figure 1.5, this direct part is delivered with a lead time of n-10, the same as the sub-assembly part. It causes waste of time and cost because of this earlier delivery before the exact need. This unsuitable lead time of delivery has the effect that T Motor Company carries a large big amount of direct parts inventory. Therefore, it should improve the lead time of this Direct Part to agree with the exact production need by making the required lead time of delivery to be n-7. It is the method to synchronize timing of Direct Part delivery and eliminate waiting time which keeps excessive inventory in the warehouse.

In this new logistics process, Direct Parts are postponed to be delivered from 10 to be 7 days before production, because there is no sub-assembly process as is the case for the Sub-assembly Parts. This postponement of Direct Parts leads to a decrease of the waiting time and no excessive quantity of import parts in the warehouse

3.5 Summary

As to this improvement by postponed order for delivery of Direct Parts from n-10 to be n-7 before production, it shows that the logistics process of Direct Parts at T Motor Company is synchronized. This new proposal has the effect of a reduction from 3 days of waiting time that occurred before improvement. This study expected that T Motor Company could reduce warehouse rental and other costs. At the same time, the processes of separating sub-assembly parts and direct parts are deleted too. Both Sub-assembly and Direct Parts are supplied at the right time for the production schedule. It implies that T Motor Company can solve the problem of high inventory of import parts with the benefit of inventory cost reduction.

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

The delivery lead time of import parts does not synchronize with the exact time of need; and this makes the company carry high inventory cost. Thus, to minimize the cost of import parts inventory, there is a new logistics process to match all import parts requirements with the production line. This chapter will present and discuss the results of import parts inventory costs after synchronizing the logistics process. There are three findings: saving of warehouse rental cost, saving of loan interest charge, and total cost saving of each car model.

4.1 Saving of Warehouse Rental Cost for Direct Part Inventory

In the current logistics process, the delivery lead time of Sub-assembly Parts and Direct Parts are at the same time. The Sub-assembly Parts and Direct Parts are ordered to be delivered at the sea port 10 days before production day, but the timing of usage of these parts is different. The Sub-assembly Part requires a longer lead time than the Direct Parts, because the Sub-assembly Part have to be assembled with the main local parts before delivery to the production line, while the Direct Parts can be delivered to the production line without any pre-processes. It is this situation which makes T Motor Company carries this Direct Parts inventory in the warehouse while waiting for the completed of Sub-assembly Parts. Also, it indicates that the Direct Parts are delivered earlier than the exact timing of need, which makes T Motor Company pay a high cost to store the Direct Parts in the warehouse.

In the new logistics process, the import parts have a separated delivery lead time to fit the timing of parts usage. The delivery lead time of Sub-assembly Parts inventory is 10 days before production, as previously, while the Direct Parts are postponed to be delivered to the sea port, from 10 to be 7 days. Thus, the waiting time of Direct Parts in the warehouse is decreased and the warehouse rental cost of Direct Parts inventory is decreased too. This postponement of Direct Parts can save warehouse rental costs

of Direct Parts for 3 days per week, or 12 days per month. To achieve the saving of warehouse rental cost of Direct Parts, we have first to know the warehouse rental area of Direct Parts.

The warehouse rental area of import parts inventory depends on the measurement and the quantity of parts. The assembly of 1 CBU car is composed of supply of local parts and import parts. The proportion of the local parts equals 60%, with 40% for the import parts. In the import parts section, these are combined in Sub-assembly with Direct Parts. As to the data in the import parts list, the quantity of the Direct Parts from all models is 4,760 parts, equal to 79%, while the quantity of Sub-assembly Parts from all models is 1,243 parts, equal to 21%. The quantity and percentage of the Sub-assembly and the Direct Parts for each model are shown in Table 4.1.

Table 4.1: Quantity and Percentage of Sub-assembly and Direct Parts for CBU 1 unit

Import Parts Type	Ml Model		M2 Model		M3 Model		M4 Model		M5 Model		All Models	
	Quantity of Part	% of Quantity	Quantity of Part	% or Quantity	Quantity of Part	% of Quantity	Quantity of Part	% of Quantity	Quantity of Part	% of Quantity	Total Quantity	% of Total Quantity
Sub-assembly Parts	125	15	147	14	625	18	148	16	198	18	1,243	21
Direct Parts	544	85	625	86	926	82	1,422	84	1,243	82	4,760	79
Total	669	100	772	100	1,551	100	1,570	100	1,441	100	6,003	100

Source: T Motor Company

The other factor that affects the warehouse rental area is the measurement of parts. As to the new logistics process, the delivery lead time of import parts is separated by the timing of part usage, in which the lead time of Sub-assembly Parts is n-10, while lead time of Direct Parts is change to be n-17. Thus, the warehouse space area is separated into two portions, for Sub-assembly Parts and Direct Parts. In each model, the proportion of the Sub-assembly and Direct Part are different. It depends on the different measurement and quantity of parts in each model. As to the proportion of warehouse rental area of Sub-assembly and Direct Parts for CBU 1 unit, this shows the total quantity of warehouse rental area of Direct Parts from all models is 3.15

square meters, equal to 63%, while Sub-assembly Parts is 1.85 square meter, or 37%. The details of warehouse rental areas for each model are shown in Table 4.2.

Table 4.2: Proportion of Warehouse Rental Areas of Sub-assembly and Direct Parts for CBU 1 unit

Import Part Type	MI Model		· M2 Model		M3 Mr del		M4 Model		M5 Model		All Models	
	Area	%	Area	%	Area	%	Area	%	Area	%	Total Area	% of iota! Area
Sub-assembly Part	0.25 ma	33	0.30 ma	40	0.35 ma	35	0.45 ma	36	0.50 ma	40	1.85 m²	37
Direct Part	0.50 ma	67	0.45 ma	60	0.65 m^2	65	0.80 ma	64	0.75 ma	60	3.15 ma	63
Total	0.75 m²	100	0.75 m²	100	1.00 m²	100	1.25 m²	100	1.25 m'	100	5.00 m²	100

Source: T Motor Company

Regarding the current CBU production capacity, the quantity of car production for each model depends on the order of customers in each period. The quantity of car production for January-December 2009 is shown in Table 4.3.

Table 4.3: Quantity of Car Production, January-December 2009

Month	Production of Car by Model (Unit)					
	M1	M2	M3	M4	M5	Total
Jan'09	2,970	660	3,180	690	3,150	**10,650**
Feb'09	1,630	1,800	4,080	780	2,610	**10,900**
Mar'09	3,120	2,580	3,420	810	2,310	**12,240**
Apr'09	630	1,130	4,160	450	1,980	**8,350**
May'09	2,880	2,570	4,680	660	2,490	**13,280**
Jun'09	3,150	1,490	4,920	510	2,550	**12,620**
Jul'09	3,180	2,460	4,750	630	2,220	**13,240**
Aug'09	2,760	1,380	4,000	570	1,770	**10,480**
Sep'09	3,210	1,800	4,380	540	2,070	**12,000**
Oct'09	3,240	1,920	4,290	90	2,970	**12,510**
Nov'09	1,340	4,350	3,330	30	2,940	**11,990**
Dec'09	2,080	1,050	4,500	1,050	2,940	**11,620**
Total per year	**30,190**	**23,190**	**49,690**	**6,810**	**30,000**	**139,880**
Average per month	**2,516**	**1,933**	**4,141**	**568**	**2,500**	**11,657**

Source: T Motor Company

To get the result of warehouse rental area of Direct Parts, we have to calculate use the proportion of warehouse rental area for CBU 1 unit and the quantity of car production. The formula to get the result of warehouse rental area of Direct Parts is shown as follows:

Warehouse Rental Area of Direct Part for CBU 1 unit * Quanity of Car Production

where:

Warehouse rental area of Direct Parts for CBU Car 1 unit is referred from Table 4.2

Quantity of car production is referred from Table 4.3

For example: To find the warehouse rental area of Direct Parts for Ml model in January 2009, it uses these parameters from Tables 4.2 and 4.3 as follows:

Warehouse rental area of Direct Parts for M1 model 1 unit from Table 4.2 is 0.50 m^2

Quantity of car production for M1 Model in January 2009 in Table 4.3 is 2,970 car units

$0.50\ m^2 * 2{,}970$ car units $= 1{,}485\ m^2$

From this example calculation, the warehouse rental area of Direct Parts for M1 model in January 2009 is 1,485 m^2.

In addition, the results of warehouse rental area of Direct Parts for all models in January-December 2009 are shown in Table 4.4.

Table 4.4: Warehouse Rental Area of Direct Parts, January-December 2009

(Based on the Current Logistics Process of Import Parts)

Month	Warehouse Rental Area of Direct Parts (Square Meter)					
	M1 Model	M2 Model	M3 Model	M4 Model	M5 Model	Total
Jan'09	1,485.00	297.00	2,067.00	552.00	2,362.50	**6,763.50**
Feb'09	815.00	810.00	2,652.00	624.00	1,957.50	**6,858.50**
Mar'09	1,560.00	1,161.00	2,223.00	648.00	1,732.50	**7,324.50**
Apr'09	315.00	508.50	2,704.00	360.00	1,485.00	**5,372.50**
May'09	1,440.00	1,156.50	3,042.00	528.00	1,867.50	**8,034.00**
Jun'09	1,575.00	670.50	3,198.00	408.00	1,912.50	**7,764.00**
Jul'09	1,590.00	1,107.00	3,087.50	504.00	1,665.00	**7,953.50**
Aug'09	1,380.00	621.00	2,600.00	456.00	1,327.50	**6,384.50**
Sep'09	1,605.00	810.00	2,847.00	432.00	1,552.50	**7,246.50**
Oct'09	1,620.00	864.00	2,788.50	72.00	2,227.50	**7,572.00**
Nov'09	670.00	1,957.50	2,164.50	24.00	2,205.00	**7,021.00**
Dec'09	1,040.00	472.50	2,925.00	840.00	2,205.00	**7,482.50**
Total per year	**15,095.00**	**10,435.50**	**32,298.50**	**5,448.00**	**22,500.00**	**85,777.00**
Average **per month**	**1,257.92**	**869.63**	**2,691.54**	**454.00**	**1,875.00**	**7,148.08**

The results of finding the warehouse rental area of Direct Parts, in square meters, and month of each model, are presented in Table 4.4. These results can be multiplied with the warehouse rental cost per square meter. Currently, the warehouse rental cost that T Motor Company pays is 130 baht for 1 square meter per month.

Thus, the calculation to get the results of warehouse rental cost for Direct Parts is shown as follows:

Warehouse Rental Area of Direct Part * Warehouse Rental Cost per 1 m^2

where:

Warehouse rental area of Direct Parts is referred from Table 4.4

Warehouse rental cost per 1 m^2 equals to 130 Baht per month

For example: To find warehouse rental cost of Direct Part for M1 model in January 2009, it uses these parameters from the Table 4.4 and the current warehouse rental cost 130 Baht per 1 m^2

Warehouse rental area of Direct Parts for M1 model in January 2009 from Table 4.4 is 1,485 m^2

Warehouse rental cost per 1 m^2 is 130 Baht

$$1{,}485\ m^2 * 130\ \text{Baht} = 193{,}050\ \text{Baht}$$

From this example calculation, the warehouse rental cost of Direct Parts for M1 model in January 2009 is 193,050 Baht.

In addition, the results of warehouse rental cost of Direct Parts for all models for January-December 2009 are shown in Table 4.5.

Table 4.5: Warehouse Rental Cost of Direct Part, January-December 2009 (Based on the Current Logistics Process of Import Parts)

Month	Warehouse Rental Cost of Direct Parts (Baht)					
	M1 Model	M2 Model	M3 Model	M4 Model	M5 Model	Total
Jan'09	193,050	38,610	268,710	71,760	307,125	**879,255**
Feb'09	105,950	105,300	344,760	81,120	254,475	**891,605**
Mar'09	202,800	150,930	288,990	84,240	225,225	**952,185**
Apr'09	40,950	66,105	351,520	46,800	193,050	**698,425**
May'09	187,200	150,345	395,460	68,640	242,775	**1,044,420**
Jun'09	204,750	87,165	415,740	53,040	248,625	**1,009,320**
Jul'09	206,700	143,910	401,375	65,520	216,450	**1,033,955**
Aug'09	179,400	80,730	338,000	59,280	172,575	**829,985**
Sep'09	208,650	105,300	370,110	56,160	201,825	**942,045**
Oct'09	210,600	112,320	362,505	9,360	289,575	**984,360**
Nov'09	87,100	254,475	281,385	3,120	286,650	**912,730**
Dec'09	135,200	61,425	380,250	109,200	286,650	**972,725**
Total per year	**1,962,350**	**1,356,615**	**4,198,805**	**708,240**	**2,925,000**	**11,151,010**
Average per month	**163,529**	**113,051**	**349,900**	**59,020**	**243,750**	**929,251**

When the delivery's lead time of Direct Parts shipments is reduced from 10 to be 7 days before production, it can save warehouse rental cost of Direct Parts of 3 days per shipment. As the frequency of delivery shipment is 4 times per month, so the total saving is 12 days per month.

To get the saving of warehouse rental cost of Direct Parts per month, the calculation is as follows:

The 1st step: For 1 shipment, it can save 3 days, so the saving of warehouse rental cost of Direct Parts for 1 shipment, can be calculated by this formula.

$$\text{Warehouse Rental Cost of Direct Parts per Month} * \frac{\text{Total Saving days for 1 Shipment}}{\text{Total days of Month}}$$

The 2nd step: In one month, the frequency of delivery is 4 shipments per month, so we can calculate the saving of warehouse rental cost of Direct Parts per month by this formula.

$$\text{Saving of Warehouse Rental Cost of Direct Part for 1 Shipment} * \text{Frequency of Shipment per Month}$$

where:

Warehouse rental cost of Direct Part per month is referred from Table 4.5

Total saving days for 1 shipment is referred from the results in the new logistics process of Direct Parts

Total days of the month is 30 days

Frequency of shipment is 4 Shipments per month

For example: To find the saving of warehouse rental cost of Direct Part for M1 model in January 2009, it uses these parameters.

Warehouse rental cost of Direct Part in Jan'09 of M1 model from Table 4.5 is 193,050 Baht

Total saving days for 1 shipment referred from the results in the new logistics process of Direct Parts is 3 days

Total days per month equal 30 days

Frequency of shipment per month is 4 Shipments per month

The 1st step: To get the saving cost of warehouse rental cost of Direct Part for 1 shipment, it comes from this calculation.

$$193{,}050 \text{ Baht} * \frac{3 \text{ days}}{30 \text{ days}} = 19{,}305 \text{ Baht}$$

The 2nd step: The known saving in cost of warehouse rental cost of Direct Parts for 1 shipment is 19,305 Baht. We can multiply this result with the frequency of shipment per month, which will reveal the saving of warehouse rental cost of Direct Parts per month through this calculation.

$$19{,}305 \text{ Baht} * 4 \text{ shipments} = 77{,}220 \text{ Baht}$$

From this example calculation, the saving of warehouse rental cost of Direct Parts for Ml model in January 2009 is 77,220 Baht.

In addition, the saving of warehouse rental cost of Direct Parts for all models during January-December 2009 is shown in Table 4.6

Table 4.6 Saving of Warehouse Rental Cost of Direct Parts, Jan-Dec'09

Saving of Warehouse Rental Cost of Direct Parts (Baht)						
Month	**M1 Model**	**M2 Model**	**M3 Model**	**M4 Model**	**M5 Model**	**Total**
Jan'09	77,220	15,444	107,484	28,704	122,850	**351,702**
Feb'09	42,380	42,120	137,904	32,448	101,790	**356,642**
Mar'09	81,120	60,372	115,596	33,696	90,090	**380,874**
Apr'09	16,380	26,442	140,608	18,720	77,220	**279,370**
May'09	74,880	60,138	158,184	27,456	97,110	**417,768**
Jun'09	81,900	34,866	166,296	21,216	99,450	**403,728**
Jul'09	82,680	57,564	160,550	26,208	86,580	**413,582**
Aug'09	71,760	32,292	135,200	23,712	69,030	**331,994**
Sep'09	83,460	42,120	148,044	22,464	80,730	**376,818**
Oct'09	84,240	44,928	145,002	3,744	115,830	**393,744**
Nov'09	34,840	101,790	112,554	1,248	114,660	**365,092**
Dec'09	54,080	24,570	152,100	43,680	114,660	**389,090**
Total per year	**784,940**	**542,646**	**1,679,522**	**283,296**	**1,170,000**	**4,460,404**
Ave**rage per month**	**65,412**	**45,221**	**139,960**	**23,608**	**97,500**	**371,700**

With the postponement in the new logistics process of Direct Part, it can be summarized that the total saving of warehouse rental cost of Direct Parts during January-December 2009 from all models is 4,460, 404 Baht, This means that the total warehouse rental cost of Direct Parts after improvement is decreased by 40% from 11,151,010 Baht. The summary of warehouse rental cost and the savings of Direct Parts for January-December 2009 are presented in Table 4.7.

Table 4.7: Summary of Warehouse Rental Cost and the Saving of Direct Parts, January-December 2009

Model	Cost (Baht)	Jan'09	Feb'09	Mar'09	Apr'09	May'09	Jun'09	Jul'09	Aug'09	Sep'09	Oct'09	Nov'09	Dec'09	Total
M1	Before	193,050	105,950	202,800	40,950	187,200	204,750	206,700	179,400	208,650	210,600	87,100	135,200	1,962,350
	After	115,830	63,570	121,680	24,570	112,320	122,850	124,020	107,640	125,190	126,360	52,260	81,120	1,177,410
	Saving	77,220	42,380	81,120	16,380	74,880	81,900	82,680	71,760	83,460	84,240	34,840	54,080	784,940
M2	Before	38,610	105,300	150,930	66,105	150,345	87,165	143,910	80,730	105,300	112,320	254,475	61,425	1,356,615
	After	23,166	63,180	90,558	39,663	90,207	52,299	86,346	48,438	63,180	67,392	152,685	36,855	813,969
	Saving	15,444	42,120	60,372	26,442	60,138	34,866	57,564	32,292	42,120	44,928	101,790	24,570	542,646
M3	Before	268,710	344,760	288,990	351,520	395,460	415,740	401,375	338,000	370,110	362,505	281,385	380,250	4,198,805
	After	161,226	206,856	173,394	210,912	237,276	249,444	240,825	202,800	222,066	217,503	168,831	228,150	2,519,283
	Saving	107,484	137,904	115,596	140,608	158,184	166,296	160,550	135,200	148,044	145,002	112,554	152,100	1,679,522
M4	Before	71,760	81,120	84,240	46,800	68,640	53,040	65,520	59,280	56,160	9,360	3,120	109,200	708,240
	After	43,056	48,672	50,544	28,080	41,184	31,824	39,312	35,568	33,696	5,616	1,872	65,520	424,944
	Saving	28,704	32,448	33,696	18,720	27,456	21,216	26,208	23,712	22,464	3,744	1,248	43,680	283,296
MS	Before	307,125	254,475	225,225	193,050	242,775	248,625	216,450	172,575	201,825	289,575	286,650	286,650	2,925,000
	After	184,275	152,685	135,135	115,830	145,665	149,175	129,870	103,545	121,095	173,745	171,990	171,990	1,755,000
	Saving	122,850	101,790	90,090	77,220	97,110	99,450	86,580	69,030	80,730	115,830	114,660	114,660	1,170,000
All models	Before	879,255	891,605	952,185	698,425	1,044,420	1,009,320	1,033,955	829,985	942,045	984,360	912,730	972,725	11,151,010
	After	527,553	534,963	571,311	419,055	626,652	605,592	620,373	497,991	565,227	590,616	547,638	583,635	6,690,606
	Saving	351,702	356,642	380,874	279,370	417,768	403,728	413,582	331,994	376,818	393,744	365,092	389,090	4,460,404

4.2 Summary

As the results from the new logistics process of import part that proposed to synchronize the lead time of delivery of Direct Parts to agree with the right time of usage, this can help T Motor Company achieve large savings from the warehouse rental cost of Direct Parts. The cost saving of warehouse rental cost is varied by dependence on the total quantity of car production and the cost of rental warehouse area per 1 m^2.

The total cost of Direct Parts of each model in Table 4.8 is summarized from all car productions, and the total warehouse rental cost of Direct Part in the year 2009.

Table 4.8: Summary of Total Car Production and Saving of Warehouse Rental Cost of Direct Parts in 2009

Details	Summary of Total Cost of Direct Part **(Baht)**					
	M1 Model	M2 Model	M3 Model	M4 Model	M5 Model	Total
Car Production in 2009 (Unit)	30,190	23,190	49,690	6,810	30,000	139,880
Saving of Warehouse Rental Cost	784,940	542,646	1,679,522	283,296	1,170,000	4,460,404

For example: To find the total cost of Direct Parts for M1 Model, it is referred from the information as follows:

where:

Summary total car production for M1 model in the 2009 referred from the Table 4.3 is 30,190 units

Total Warehouse rental cost for M1 model in 2009 from Table 4.5 is 1,962,350 Baht

Total saving of days to rent warehouse for Direct Parts is 12 days per month, thus 144 days per year

$$\text{Total warehouse rental cost in year 2009} * \frac{\text{Total saving days per year}}{(30 \text{ days} * 12 \text{ months})}$$

$$1{,}962{,}350 \text{ Baht} * \frac{(144 \text{ Saving days})}{360 \text{ days}} = 784{,}940 \text{ Baht}$$

From this example calculation, it can be summarized that there is 30,190 of M1 car production and the saving of warehouse rental cost is 784,940 Baht per year.

T Motor Company achieves the highest saving of 1,170,000 Baht from the car M5 model. The second is M3 model that saves 1,679,522 Baht. Then, M1 model produces a total cost saving of 784,940 Baht, with 542,646 Baht for M2 model. The last one is M4 model that saves 283,296 Baht. It can be summarized that the total cost saving of warehouse rental cost from all models in 2009 is 4,460,404 Baht.

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter will discuss the summary findings and conclude the results after answering the research questions. Moreover, recommendations for further study are provided.

5.1 Summary of Findings and Answers to Research Questions

T Motor Company is faced with high import parts inventories that are caused by the unsynchronized logistics process of import parts, which affects the company costs for carrying with excess inventory. A new logistics process for import parts is proposed by synchronizing lead time of delivery of direct parts to agree with the exact time for their usage. The findings of the improvement mean that T Motor Company can achieve its objectives to reduce the cost of import parts inventory. Thus, the answers to the research questions are described below.

The first research question: What is the appropriate strategy that can be used to solve the problem of high inventory of import parts caused by an unmatched lead time of delivery with the exact time of usage?

The appropriate strategy that can solve this high inventory problem of import parts is postponement strategy.

In the new logistics process, delivery of Direct Parts is postponed from 10 days to 7 days before production, because there is no sub-assembly process as there is in the Sub-assembly Parts. This postponement of Direct Part leads to decreasing of the waiting time and of an excessive quantity of import parts in the warehouse.

The second research question is: If the strategy that is selected can solve the problem of high inventory of import parts, how much inventory cost can the company save?

After the improvement by a synchronized logistics process of import parts to agree with the exact time of usage, T Motor Company achieves the saving of the warehouse rental cost of 4,460,404 Baht by the postponement of Direct Parts.

5.2 Discussion and Conclusions

T Motor Company has the problem of high inventory of Direct Parts caused by the delivery lead time not agreeing with the exact timing of usage; this makes the company carry a high cost of excessive inventories. Therefore, it is proposed that a new logistics process of import parts be implemented which postpones delivery of Direct Parts to agree with the exact time of usage of those parts. From this new logistics process, T Motor Company can minimize relevant inventory costs of import parts. The factors that affect the cost saving are the quantity of car production, the saving of days to store Direct Parts, and the warehouse rental cost per 1 square meter.

The cost of warehouse rental depends on storage days and the rental areas of each model. The total warehouse rental cost of Direct Parts from all models for January-December 2009 based on the current logistics process is 11,151,010 Baht. After delivery of Direct Parts is postponed, from 10 to be 7 days, this can save 3 days per shipment. When summarized, the result for 2009 show that the warehouse rental cost of Direct Parts is only 6,690,606 Baht: it decreased by 40% from 11,151,010 Baht. It can be summarized that the total saving of warehouse rental cost from all models in January-December 2009 is 4,460,404 Baht. The details are shown in Figures 5.1 and 5.2.

Figure: 5.1 Summary Saving of Warehouse Rental Cost of Direct Parts in 2009

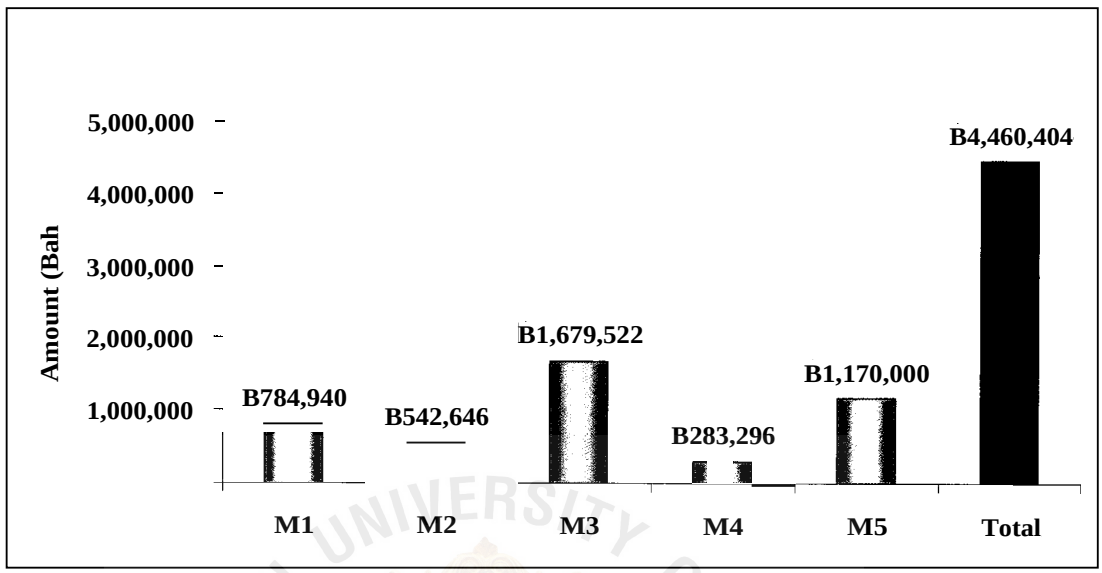
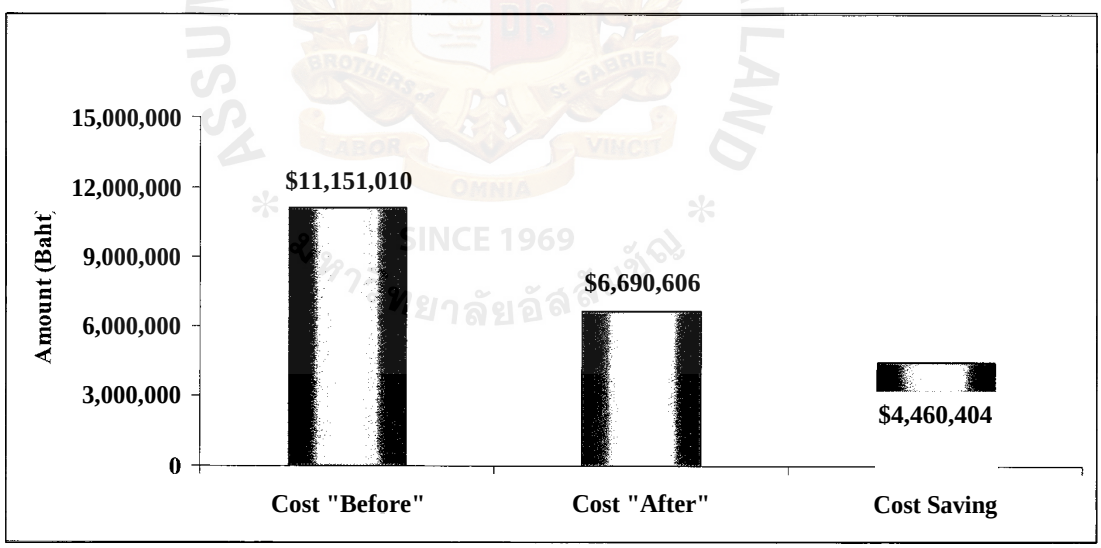


Figure: 5.2 Comparison Warehouse Rental Cost of Direct Parts for all Models in 2009



5.3 Recommendations and Further Study

Efficient inventory management is an important factor that helps companies to achieve the target of cost reduction. The amount of inventory can increase stability in production, and the service level of customer satisfaction, but the excess amount of inventory also increase costs and make the company lose profit. Inventory can imply

profit or loss; therefore to achieve the target of cost reduction that will be total cost decrease, inventory should control and managed properly as a company procedure.

Besides the Postponement strategy that used in this study, to solve this kind of excessive inventory in an automotive industry, another alternatives strategy is the concurrent ordering in a JIT production system. The automobile production system has many stages in the production process and inventory points. It will be better if there is planning of production quantity for each production process, and allocation of buffer stock for each inventory point. Also, the part by part ordering method is an interesting strategy to improve inventory level through the ordering arrangement.

Another possible saving that the company will gain from this postponement of Direct Parts is the saving in financing. If the company takes a loan for investment, it means that the company has to pay loan interest charges for this Direct Parts proportion. It may be possible to save the loan interest charge for this proportion value of Direct Parts, but it needs a detailed study of the financial conditions that are used in the company.

In addition, the limitations of this study are that information was gathered for only one year. A further study should gather information for several years of car model production, around four years. Other constraints that should to be considered in further study are the load size, and packaging layout design. It will be more efficient and reduce total cost if these are improved at the same time. Moreover, in the automotive industry, there are complications in controlling parts. If there are part shortages, this will produce many problems for all concerned operations, especially the production line process. Thus, parts controlling system, Bill of Materials or any other concerns are also in need of improvement.

BIBLIOGRAPHY

Aghazadeh, S. (2001). A comparison of just-in-time inventory and the quantity discount model in retail outlets. *Logistics Information Management,* 14.

Aghazadeh, S. (2002). Implementation of total quality management in the managed car industry. *The TQM Magazine,* 14(2).

Alderson, W. (1950). Marketing efficiency and the principle of postponement. *Cost and Profit Outlook,* 3.

Chyr, F., Lin, T. & Ho, C. (1990). Comparison between just-in-time and EOQ systems. *Engineering Costs and Production Economics,* 18(3), 233-240.

Cooke, *J.* (2002). Inventory velocity accelerates. *Logistics Management,* 42(9), 33-38.

Fisher, M. Hammond, *J.* Obermeyer, W. & Raman, A. (1994), Making supply meet demand in an uncertain world. *Harvard Business Review,* 83-93.

Flynn, B., Sakakibara, S. & Schroeder, R. (1995). Relationship between JIT and TQM: Practice and performance. *Academy of Management Journal,* 38(5), 1325-1360.

Hearn, D. (1998). Simulation-taking the risk out of investment. *Proceedings of the Fourth International Conference on simulation in Manufacturing* (pp.233-240). London: IFS.

Heizer, *J.* & Barry, R. (2004). *Production Operations Management.* Upper Saddle River, NJ: Pearson Prentice Hall.

Lee, H. & Billington, C. (1994). Designing product and process for postponement, management of design: Engineering and management perspective. Boston: Kluwer Academic Publishers.

Lieberman, M.B. & Demeester, L. (1999). Inventory reduction and productivity growth: A Comparison of Japanese and U.S. automotive sectors. *Management Science,* 18, 73-85.

Monden, Y. (1983). Toyota production system: Practical approach to production management. *Institute of Industrial Engineers.*

Pagh, J. & Cooper, M. (1998). Supply chain postponement and speculation strategies: How to choose the right strategy. *Journal of Business Logistics,* 19(2), 13-33.

Papadakis, I. (2003). On the sensitivity of configure-to-order supply chains for personal computers after component market disruptions. *International Journal of Physical Distribution & Logistics Management,* 33(10), 934-950.

Petersen, P. (2002). The misplaced origin of just-in-time production methods. *Management Decision,* 40(1), 82-88.

Sakakibara, S., Flynn, B., Schroeder, R. & Morris, W. (1997). The impact of just-in-time manufacturing and its infrastructure of manufacturing performance. *Management Science,* 43(9), 1248-1257.

Schonberger, R. (1982). *Japanese manufacturing techniques.* New York: The Free Press.

Schwartz, M. & Andrew, F. (1998). Just in time inventories in old Detriot. *Business History,* 40.

Sigronelli, S, & Hesket, J.L. (1984). Benetton (A), Case9-685-014. *Harvard Business School,* MA: Cambridge.

Stevenson, W. (2002). *Operations Management.* McGraw-Hil. 7 edition.

Van Hoek, R. (1998). Logistics and virtual integration-postponement: Outsourcing and flow of information. *International Journal of Physical Distribution and Logistics Management,* 28(7).

Wadhwa, S. & Rao, K. (2000). Flexibility: and emerging meta-competence for managing high technology. *International Journal of Technology Management,* 19 (7/8), 820-845.

Wadhwa, S. & Bhoon, K. (2006). Postponement strategies through business process redesign in automotive manufacturing. *Industrial Management and Data Systems, 106(3).* Retrieved from http://www.emeraldinsight.com/0263-5577.htm.

Yasin, M., Wafa, A. & Small. H. (2001). Just-in time implementation in the public sector: An empirical study. *International Journal of Operations & Production Management,* 21(9), 1195-1204.

Zinn, W. & Levy, M. (1998). Speculative inventory management: A total channel perspective. *International Journal of Physical Distribution and Materials Management,* 18, 34-39.