การวิเคราะห์ต้นทุนฐานกิจกรรมสำหรับการบริหารคลังสินค้าห้องเย็น

นางสาวชุติพร อธิเกียรติ์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาการจัดการด้านโลจิสติกส์ (สหสาขาวิชา)
บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2555

ACTIVITY-BASED COSTING FOR REFRIGERATED WAREHOUSE MANAGEMENT

Miss Chutiporn Athikiat

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Science Program in Logistics Management

(Interdisciplinary Program)

Graduate School

Chulalongkorn University

Academic Year 2012

Thesis Title	ACTIVITY-BASED COSTING FOR REFRIGERATED WAREHOUSE MANAGEMENT
By	Miss Chutiporn Athikiat
Field of Study	Logistics Management
Thesis Advisor	Associate Professor Sompong Sirisoponsilp, Ph.D.
Thesis Co-advisor	Associate Professor Duangmanee Komaratat

Accepted by the Graduate School, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

…….. Dean of the Graduate School

(Associate Professor Amorn Petsom,Ph.D.)

THESIS COMMITTEE

…….. Chairman

(Associate Professor Pongsa Pornchaiwiseskul, Ph.D.)

……. Thesis Advisor

(Associate Professor Sompong Sirisoponsilp, Ph.D.)

…….. Thesis Co-advisor

(Associate Professor Duangmanee Komaratat)

…….. External Examiner

(Mr. Pokasarp Poompuang)

ชุติพร อธิเกียรติ์ : การวิเคราะห์ต้นทุนฐานกิจกรรมสำหรับการบริหารคลังสินค้าห้องเย็น. (ACTIVITY-BASED COSTING FOR REFRIGERATED WAREHOUSE MANAGEMENT) อ. ที่ปรึกษาวิทยานิพนธ์หลัก : รศ .ดร.สมพงษ์ ศิริโสภณศิลป์, อ. ที่ปรึกษาวิทยานิพนธ์ร่วม: รศ. ดวงมณี โกมารทัต, 69 หน้า.

ระบบต้นทุนฐานกิจกรรม เป็นแนวความคิดที่มีการนำมาประยุกต์ใช้งานวิจัย หรือในธุรกิจต่างๆ เพื่อนำมาวิเคราะห์ต้นทุนที่แท้จริงให้การปฏิบัติงาน และสามารถนำข้อมูลมาเป็นประโยชน์ให้การส่งเสริมการตัดสินใจทางธุรกิจในหลายๆด้าน โดยเฉพาะธุรกิจการให้บริการด้านโลจิสติกส์ อาทิเช่น คลังสินค้าห้องเย็น เป็นต้น ทั้งนี้ระบบต้นทุนฐานกิจกรรมยังได้มีการพัฒนาแนวความคิด โดยใช้เกณฑ์เวลาของการปฏิบัติกิจกรรม มาเป็นปัจจัยในการวิเคราะห์ต้นทุน ซึ่งวิธีใหม่นี้ได้แก้ไขปัญหาเรื่องความซับซ้อนในการประยุกต์ใช้ระบบต้นทุนฐานกิจกรรมแบบดั้งเดิม อย่างไรก็ตามต้นทุนทรัพยากรบางประเภทก็ไม่สามารถใช้เกณฑ์เวลามากระจายไปตามกิจกรรม ดังนั้นวิทยานิพนธ์ฉบับนี้จึงมีวัตถุประสงค์เพื่อให้เข้าใจถึงขั้นตอนการพัฒนาแบบจำลองระบบต้นทุนฐานกิจกรรม โดยผสมผสานระบบต้นทุนฐานกิจกรรมแบบดั้งเดิม และแบบใหม่ และการนำแบบจำลองต้นทุนฐานกิจกรรมมาประยุกค์ใช้จริง เพื่อวิเคราะห์ต้นทุนการปฏิบัติงานในคลังสินค้าห้องเย็น โดยการดำเนินการวิจัยใช้วิธีการเก็บข้อมูลต้นทุน และต้นทุนกิจกรรมที่เกิดขึ้นจากผู้ประกอบการคลังสินค้าห้องเย็นรายหนึ่งในประเทศไทย

ผลจากการวิจัยพบว่า สำหรับการบริหารคลังสินค้าห้องเย็นที่มีกิจกรรมที่หลากหลายในการให้บริการลูกค้าแต่ละราย แบบจำลองต้นทุนบนฐานกิจกรรมและเกณฑ์เวลาจะเป็นเครื่องมือในการช่วยวิเคราะห์ต้นทุนที่มีความแม่นยำมากกว่าต้นทุนแบบดั้งเดิม อีกทั้งการใช้สมการเวลาเพื่อทราบขั้นตอนของกระบวนการในคลังสินค้า และยังสามารถปรับเปลี่ยนได้ตามกระบวนการต่างๆที่มีการเปลี่ยนแปลงอยู่ตลอดเวลาตามพฤติกรรมของลูกค้า

สาขาวิชา<u>การจัดการด้านโลจิสติกส์</u> ลายมือชื่อนิสิต .....

ปีการศึกษา <u>2555</u> ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก.....

ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม .....

5287142420 : MAJOR LOGISTICS MANAGEMENT
KEYWORDS : ACTIVITY BASED COSTING / TIME-DRIVEN / REFRIGERATED WAREHOUSE / TDABC / ABC

CHUTIPORN ATHIKIAT : ACTIVITY-BASED COSTING FOR REFRIGERATED WAREHOUSE MANAGEMENT. ADVISOR : ASSOC. PROF. SOMPONG SIRISOPONSILP, Ph.D., CO-ADVISOR : ASSOC. PROF. DUANGMANEE KOMARATAT, 69 pp.

The activity-based costing concept has been applied by many researchers or by various businesses in order to acquire accurate cost information that is crucial for the management decision. Along with time, the activity-based costing concept has been developed in order to overcome the complicate method of the conventional activity-based costing, which is time-driven activity-based costing. However, this new method still has a limitation in applying to some resources. Therefore the objective of this thesis is to provide practical steps in developing an integrated model between the conventional ABC and time-driven ABC. The data and information for the case study will be gathered from a selected refrigerated warehouse in Thailand.

The research findings show that for the refrigerated warehouse management that has variation of activities in serving each customer, the activity-based costing model is a good instrument for achieving a better cost information. Moreover, the use of time equation helps to reveal the process of the operation in the warehouse and easy to adapt to any change in process required by the customer.

Field of Study : Logistics Management Student's Signature .....
Academic Year : 2012 Advisor's Signature .....
Co-advisor's Signature .....

ACKNOWLEDGEMENTS

I would like to express my gratitude to all those who had supported me during the course of this thesis.

My deepest appreciations are to my thesis advisor and co-advisor, Associate Professor Sompong Sirisoponsilp, Ph.D. and Associate Professor Duangmanee Komaratat, who have the attitude and the substance of a genius in inspiring and guiding me throughout the course, without them this thesis could never be successfully completed.

I am very grateful to my thesis committee including chairman, Associate Professor Pongsa Pornchaiwiseskul, Ph.D. and committee member, Mr. Pokasarp Poompuang, for all the recommendation. And my thanks to all the professors who have given me all the knowledge to be able to apply to this thesis.

In addition, I would like to thank my siblings and my friends for all encouragement and assistance in helping me get through the difficult times, and for all the emotional support, entertainment, and caring they provided.

Lastly, and most importantly, I wish to thank my parents, Mr. Pichai Athikiat and Mrs. Choosri Athikiat. They raised me, taught me, and did all what always best for me. To them I dedicated this thesis.

CONTENTS

List of Tables

List of Figures

CHAPTER I

Introduction

Background and significance of the problem

Food industry include the industry that use the raw materials which are the product of the agriculture sector, into the production process using different kinds of technology to produce a finished or semi-finished product that are more convenient for consumption or for the next level of production process.

In the world market the chilled and frozen processed food industry has the retail value up to US$ 250,000 million in year 2005 an has grown up to US$ 320,000 million in year 2010, while the world market for fresh food industry (i.e. seafood, fruits, meat, vegetables, eggs, nuts, pulses and sweeteners) has the volume of 1,600 million tonnes in year 2005 with the growth rate of 12 percentage for the past 4 years. (Euromonitor International, 2010)

For Thailand, the food industries had always been part of the National Economic and Social Development Plan since the first plan in year 1961. In 2011 frozen processed food in Thailand grows by 9 percent in retail volume terms and 10 percent in current value terms. The frozen processed food in 2011 has sales volume of 51,393.2 tonnes, and THB 3,016.6 million in sales value terms. (Euromonitor International, 2012) Since Thailand is provided with plenty of resources for the advantages in the development of the food industries, along with the associated industries such as refrigerated industries.

Refrigeration plays a key role in many food supply chains by preserving the initial quality of food stuff, such as vegetables, fruits, poultry and processed food, thus providing the foodstuff that are both wholesome and safe for sale or consumption.

Warehouse or Distribution Center is one of an important part in every supply chains which help deliver the customers' satisfaction as it represents the link

between manufacturers, retailers and consumers and to facility the movement of goods. A study of the logistics cost structure in Thailand by Assistant Professor Dr. Aat Pisanwanich (2010), shown that in year 2006 over all the logistics activities 0.69 percent of logistics cost contribute to warehousing activities. Whereas the study of logistics cost in the chilled or frozen seafood industry (Nittida Sutmai et al., 2007) presents that of all the logistics activities including order receive, purchase, inventory control and warehouse operation; the warehouse operation cost is ranging from 0.69 to 7.06 percent of the sales revenue.

Under the fluctuation both in productivity and in demand rate in dispersed area, business cannot manufacture or manage all the product directly to the consumers, therefore warehousing is required with the benefits of the distribution of products to the areas which are far away from the source of production with lower transportation cost or to support the customer service level.

According to IARW database, total capacity of refrigerated warehouses is estimated at 458 million cubic meters worldwide in 2010, of which 310 million cubic meters is public warehouses (for hire). The increase of public refrigerated warehousing worldwide is 20% over the two years. Currently, there are about 144 public refrigerated warehouse registered under the announcement of Ministry of Commerce of Thailand. Some of the recent pressure on logistics including increasing customer service levels, time compression and cost minimization, have unavoidably changed the position and working of warehouses within the supply chains, and under the sever competition, the companies who operate as public refrigerated warehouse have to provide high quality services with lowest possible costs. Accurate cost information is essentially needed for every aspect of business including the manager decision making and performance reviews.

As for the refrigerated warehouse management, the customer cost information would be crucial for the management decision. Therefore, understanding

true cost of providing warehouse services to specific customer is important in order to achieve the optimal profitability in the utilization of the storage capacity.

In the past year, many companies and researchers have been studying to improve the cost accounting by developing activity-based costing (ABC) systems and gradually using the model as a decision making tool with its advantages over the Traditional cost accounting (TCA) system in terms of providing the right information to the managers with regards to make a better decision on which products, or customers are more important based on an improved understanding of the cost behaviors. (Van Damme and Van der Zon, 1999; Witiya Chongruksut, 2002)

Therefore for this research, Activity-based costing (ABC) system combining with time-driven activity-based costing (TDABC) is proposed to the refrigerated warehouses management.

Research Objectives

The objectives of the thesis as the guideline of the research procedures are as per below:

1. To study relevant activities and costs of the refrigerated warehouse.

2. To study theories, concepts and researches associated with the activity-Based Costing System and time-driven activity-based costing system.

3. To apply the activity based costing and time-driven activity-based costing system for the refrigerated warehouse management of the case company.

4. To develop a guideline to increase the performance of the refrigerated warehouse management in term of storage capacity utilization.

Scope of the Study

The scope of this paper includes the study of Activity-Based Costing system applied on the operating activities and costs concerning only the warehousing part of the case company, starting from the order receipt from the customers, the receipt of goods, process of packing or freezing, keeping in storage to the loading the goods for delivery back to the customer.

This study will not include the whole chain of the food refrigeration industry and will study only on the cost assignment view of the activity-based costing model.

The results of the research will be proposed to the management of the case company which provided the support information for this study. However, the proposed guideline or methodology might not be included in the management decision in the real situation

Expected Benefits

Activity-Based Costing system require the company to understand their activities and costs behavior which enabling the management to make better decision based in the factual perspective of the duplication and waste in the operating activities, the possibility of cost reduction and the profitability of products or services provided and the ability to increase customers service level by the additional information in which the traditional costing system is lack.

The research will provide a guideline for other logistics service providers whom interest in applying the activity-based costing systems.

Research Method

The presentation of activity-based costing combining with time-driven activity-based costing for refrigerated warehouse operation management is to be presented by empirical research. Here, case study research forms a suitable approach, as it represents the intersection of theory, structures and events and attempt to ground theoretical concepts with reality (Stuart et al., 2002)

1. Study concepts and researches relevant to refrigerated warehouse operation management
2. Determining the case company processes, cost objects, resources and activities.
3. Analyze the company processes and activities by the use of Process Mapping method.
4. Apply Activity-Bases costing system for the resources which drivers are not duration driver.
5. Apply Time-driven activity-based costing system for the resources which driver is duration.
6. Integrate both systems to determine costs for costs object.
7. Model Validation by comparing to the general-ledger financial data.
8. Summarize and develop a marketing plan that will optimize cost efficient for the utilization of storage capacity.

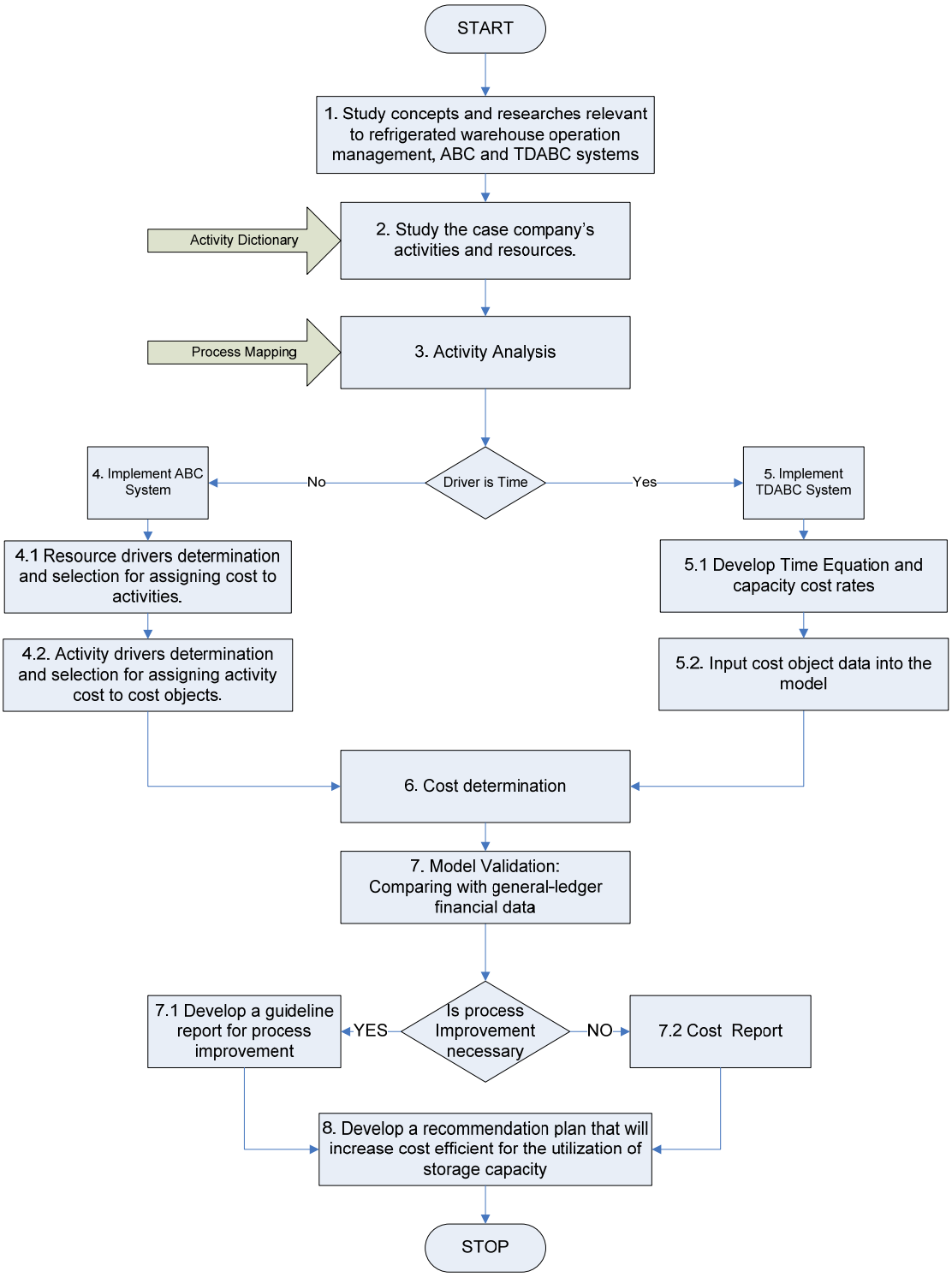


Figure 1.1 Illustration of flow of research method

The remainder of this paper is organized as follow; the second chapter presents the literature review of warehouse operation, activity-based costing system and time-driven activity-based costing system. A case study of a refrigerated warehouse is presented in chapter three. Discussion on findings on the case study and concluding comments are made in the fourth and fifth chapter.

CHAPTER II

LITERATURE REVIEW

A. Concept of Activity-Based Costing system

The traditional cost accounting (TCA) was developed around 1870-1920 during which industries are labor intensive, the variety of products or services were small and the overhead costs of the company were rather low compared to today. Cost calculation of the products or services in traditional cost accounting is based on the determination of direct cost and indirect costs and then adding them to find the individual cost of each element. Traditional cost accounting involves collecting indirect costs from departments and then allocates the costs to products and services (Tsai and Kuo, 2004). The overheads allocation to the products or services is performed by a single volume cost driver and there is generally only one stage for allocation of the overheads to the costs objects. Direct labor, machine hour or raw material usages are often used as a cost driver in TCA and a single cost driver is generally used for the distribution of overheads. Using single-volume cost driver in order to allocate indirect costs to the cost object might not be a sufficient method for a detailed cost analysis since single-volume cost driver is typically not causally related to the type and level of work consumed.

On the other hand, Activity-Based Costing (ABC) systems is a methodology that measures cost and performance of individual activities, resources and cost objects, the system includes assigning resources to activities and activities cost to cost objects such as products, customers and delivery channels on the assumption that cost object create the need for activities, and activities create the need for resources. ABC system enables the recognition of causal relationships of cost drivers to activities, whereas the allocation bases of traditional cost accounting simply allocates costs, or capacity down to the cost objects without considering any cause and effect relations.

White, T.S. (1997) expresses the terminology used in Activity-based costing system as per below:

(a) Activities are tasks or sets of tasks that require the consumption or utilization of resources and result in the completion of a specific service, or in the physical transformation of a product from one state to another;

(b) Cost object is the final good or service created as a result of the performance of an activity, or of a chain of activities;

(c) A cost driver is a variable that demonstrates a logical and quantifiable cause and effect relationship between the utilization of resources, the performance of activities, and the final cost object(s). ABC utilizes a multi-step cost assignment approach, in the first step, the resources consumed in the performance of activities are assigned to activities using resource cost drivers. In the following steps, resource costs accumulated within the activity centers are assigned to the final cost object(s) using activity cost drivers;

(d) Operational cost driver or cause of cost are those variables that determine the workload and hence explain why activities are performed. The cost object is considered the end of the trail, whereas the operational cost driver can be viewed as the start of the trail.

1. Activity-Based Costing and Activity-Based Management

Activity-based management (ABM) is a system wide, integrated approach that focuses management's attention on activities with the objective of improving customer value and the profit achieved by providing this value. ABC is a major source of information for activity-based management. And therefore present a model with 2 dimensions; a cost dimension and a process dimension. (Figure 2.1) The objective of the cost dimension is improving the accuracy cost

assignments, whereas the objective of the second dimension is cost reduction. The cost dimension transforms the expenses of resources (e.g. salaries, supplies) into the costs of the work activities and then into the final cost objects such as products, services, customers. The process management view sequences the work activities in time and accumulates the build-up of activity costs from start to end of a business process. (i.e. cost drivers to activities to performance measures)

In this paper, we will focus on the cost assignment view.

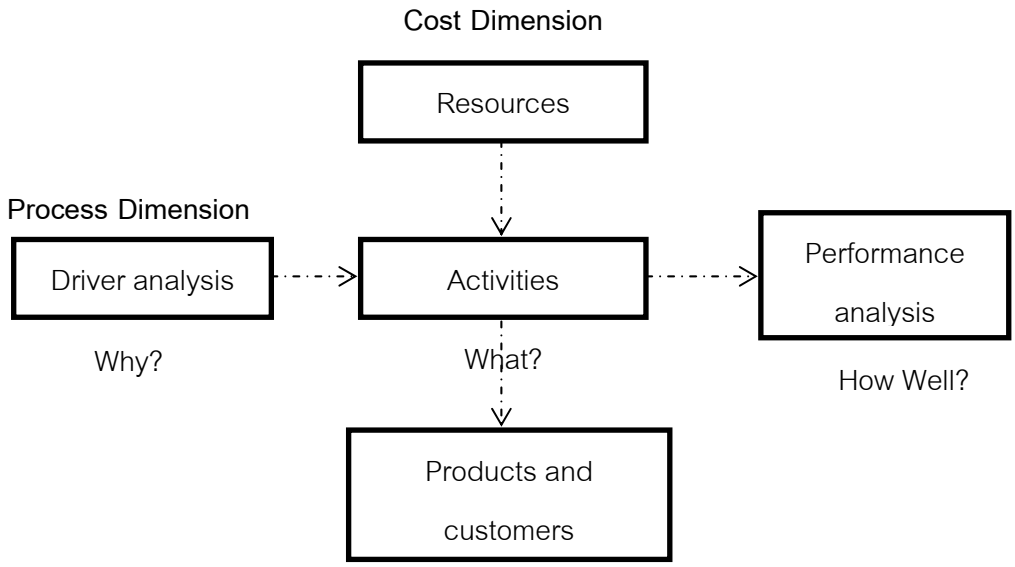


Figure 2.1 The Two-Dimensional Activity-Based Model (Hansen, D.R. and Mowen, M.M., 2007)

2. Implementation issues of ABC

Figure 2.2 shows the technique of a two-stage procedure to assign resource costs to cost objects. In the first stage, resource costs are assigned to various activities using resource drivers. Resources drivers for employees reflect the time they spend performing work activities. Resource drivers for indirect material purchased item reflect their usage by an activity such as energy's expense's kilowatts by a machine.

Each type of resource traced to an activity becomes a cost element of an activity cost pool, which is the total cost associated with an activity. An activity center is a group of related activities or tasks, usually clustered by function or process.

In the second stage, each activity cost pool is distributed to cost objects using an adequate activity driver. An Activity Driver is a measure of the output of an activity. For example, for the customer-related work activity, processing a sales order, the activity driver would be the number of orders processed. (Tsai and Kuo, 2004)

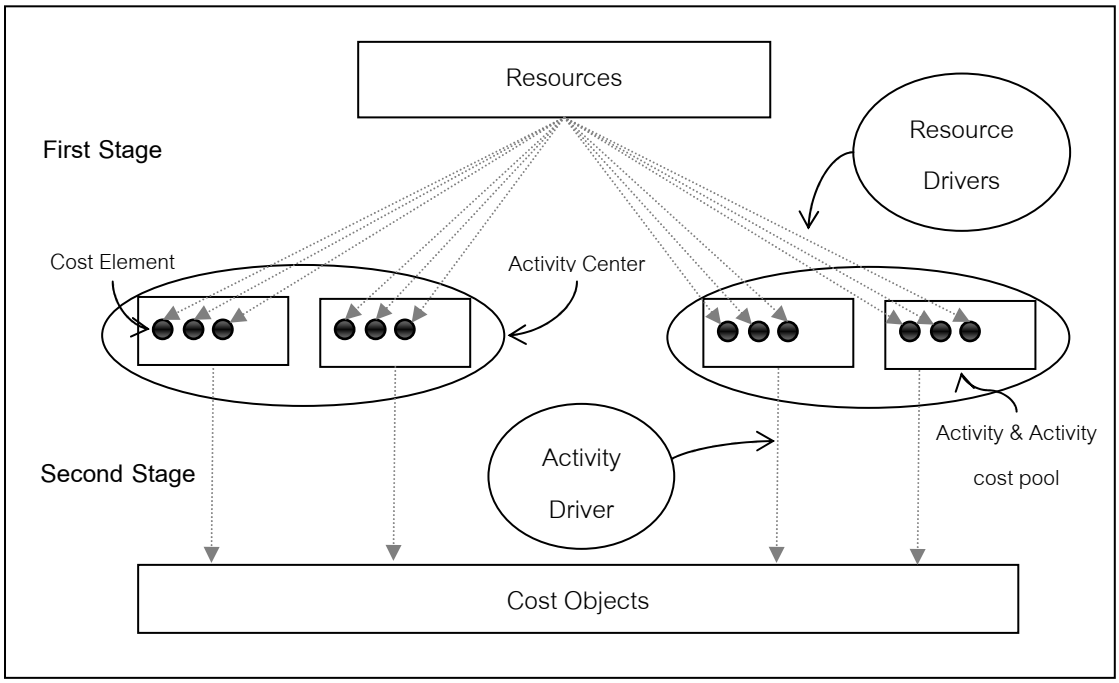


Figure 2.2 Detailed cost assignment view of Activity-Based Costing (Tsai and Kuo, 2004)

Kaplan and Atkinson (1998, Cited in Varila, Seppanen and Suomala, 2007) have classified activity drivers into three classes:

(a) Transaction drivers (e.g. the number of products or rows handled) are least expensive type of cost drivers, but they could be the least valid, as they assume that the same quantity resources is required each time an activity is performed.

(b) Intensive Driver is appropriate in case that the products consume different amounts of resources but the actual data is unavailable. Weight index is a simple way to increase the accuracy of the cost assignment. However in the reality where then number of different items and alternative ways to handle different products is large, weight indexes may over simplify the situation and updating may be time consuming.

(c) Duration drivers is convenient for the resources which are consumed directly proportional to time.

The costing principle for selection of all drivers is that the level of costs incurred should vary directly with quantity of the driver;

(a) Unit Level; the costs occur every unit that is being produced. For example, for a man to produces one unit at a time, the associated direct labor will be a unit level cost driver.

(b) Batch Level: the costs that are caused for every batch produced. For example the production planning which is done for each and every batch, and therefore the number of batches is a good driver for this case.

(c) Product Level: the drivers are triggered for every product regardless of the number of units or batches being produced. The drivers occur only by the existence of a product.

(d) Facility Level: Drivers that have no relationship with the products at all.

Varila, Seppanen and Suomala (2007) presents three factors that should be considered in selecting cost drivers;

(a) Their effect on behavior; a good driver provides the motivation to reduce costs or else a driver could direct employees toward undesired behavior.

(b) Reliability of measurement; and

(c) The costs of measurement; Increasing the number of drivers can lead to more accurate result, but at the same time the costs of acquiring driver information grow, especially if the information is acquired and entered manually.

Varila, Seppanen and Suomala (2007) has concluded that in the warehouse environment, where there is a wide variety of products with different characteristics and needs, transaction-based drivers may not be accurate enough in assigning costs of certain activities. For most resources in logistics, time drives costs, and time should be used as a driver in activity assignment.

Since activity-based costing system had been invented during the 1980s from the lack of relevant cost information of traditional cost accounting method, many companies and researchers had been studied the application of ABC in various industries; manufacturing (Schulze, Seuring and Ewering, 2012), or service industry such as airline industry (Tsai and Kuo, 2004), warehousing (Pattira Kuakim, 2007), and transportation or distribution logistics (Baykasoglu and Kaplanoglu, 2008; Sompong Panyayingyong, 2010; Suppakarn Akkarachaipanit, 2001; Lin, Collin and Su, 2001)

ABC has been applied in combination with other cost model concept. Baykasoglu and Kaplanoglu (2007) introduced a service-costing framework for land transportation service provider by integrated costing model of activity-based costing, target costing, kaizen costing and business modeling in order to truly determine service costs.

Guerreiro, Bio and Merschmann (2008) use the ABC methodology in positing cost-to-service as the cost of the administrative, commercial, and logistics activities related to customer-service delivery to facilitate customer profitability analysis.

In conclusion of Askarany, Yazdifar and Askary (2010) from the review of literature suggest that implementation of ABC can contribute for the benefit in many perspectives as follow; helping company to become more efficient and more effective; providing companies with a clear picture of where resources are being spent, customer value is being created, and money is being made or lost; offering companies a better alternative to volume-based product costing; identifying value-added activities and eliminating or reducing non-value added activities; providing companies with an understanding of cause and effect relationship between costs and the demands for activities within a process leading to better organizational performance; improving the accuracy of processes and products' cost data and obtaining the highest long-term profit by exercising complete control over overhead resources in companies; improving company process by providing decision support for conversion to the decentralized mini-storages; costing services of the land transportation company; facilitating optimal joint product mix decisions; pricing product mix and capacity expansion decisions; offering cost-estimation model; providing more accurate product-cost information and improving decision quality; offering more accurate costing of holding inventory; estimating cash flow created by supply chain tactical production planning; improving efficiency by identifying and eliminating areas of non-value added activity in supply chain processes; offering supporting decision-making concerning product modularity method for assessing the cost consequences of modularization; designing and development of activities for production; profitability modeling; Enterprise modeling and Business Process Reengineering; offering cost reduction; improving simulation models; identifying area of waste and non-value-added activities, improving productivity, quality and effectiveness in manufacturing and performance measurement systems, improving competitive position of companies, reducing costs and production time; contributing to the decision support for designers, production managers and manufacturers; planning; improving performance measurement system; improving the quality of the products' profitability information; predicting the economic consequences of production and processes actions.

More accurate cost information leads to better decisions. Gupta, M. and Galloway, K. (2003) proposes that activity-based costing/management systems can support effective operations decision-making processes in six major areas: Product planning and design, quality management and control, process design and improvement, inventory management, capacity management and work force management.

Giving the above benefit of activity-based costing systems as a better cost model than most traditional costing methods, however there is some limitations for the adoption of ABC system.

ABC systems can be costly to implement as the systems require teamwork across the organization, and therefore requires employees to take time out from their day-to-day activities to assist in the ABC process which can be very time consuming.

The effect of internal politics as ABC can provide information for performance, however the employees may not accept the result for fear of losing a job position or their current status. (Lin, Collins and Su, 2001)

ABC system, with the analysis of the major resource-consuming activities, may not identify or measure some activities or resources without a significant amount of effort and cost and therefore the cost of such activities may not be calculated for pragmatic reasons. (Lin, Collins and Su, 2001)

Unitizing fixed costs can be misleading as fixed costs are often large part of the overhead costs that are allocated to activities and activities to cost objects. However the fixed costs are costs that do not change in total with changes in activity.

The benefits may not outweigh the costs, especially for the companies with one or two products or services that require very little variation in production.

Due to complexity of the activities performed within organizations, ABC may take too much time to be implemented (Kaplan and Anderson, 2004)

When activities, that contain more than one subtask with different cost drivers, are intensified, ignoring that complexity may result in the misallocation of the costs. (Kaplan and Anderson, 2004)

Since the ABC system needs to be updated regularly, it becomes too costly to re-interview and re-survey people engaged in the activities. (Kaplan and Anderson, 2004)

Kaplan and Anderson (2007b) have summarized the problems encountered when implementing conventional ABC method as per below;

- The interviewing and surveying process was time-consuming and costly
- The data for the ABC model were subjective and difficult to validate.
- The data were expensive to store, process, and report.
- Most ABC models were local and did not provide an integrated view of enterprise wide profitability opportunities.
- The ABC model could not be easily updated to accommodate changing circumstances.
- The model was theoretically incorrect when it ignored the potential for unused capacity.

B. TIME-DRIVEN ACTIVITY-BASED COSTING

1. Concept of TDABC

Time-Driven Activity-Based Costing (TDABC) is a solution to the mentioned problems with conventional ABC. The new model eliminates the need to interview and survey employees for allocating resource costs to activities before driving them down to cost objects. (Kaplan and Anderson, 2007b) Under a traditional ABC system, the costs of activity-cost pools are apportioned amongst cost objects using activity drivers (Kaplan and Cooper, 1998). On the other hand, under a TDABC system, these costs are allocated to the cost objects on the basis of time units consumed by the activities (Kaplan and Anderson, 2004). The TDABC approach requires identifying resources needed to perform the activities, as it is done under a traditional ABC. The actual time for performing an activity is estimated instead of using percentage of total time spent on it. In TDABC, time equations are developed to estimate the time needed to perform activity in the way that if an activity is driven by more than one driver, these time equations can include multiple time drivers. Therefore, the time equations of TDABC can provide larger transparency than a traditional ABC system. It also uses the practical capacity rather than the theoretical capacity of the resources supplied. Theoretical capacity equals the theoretically available working minutes, whereas practical capacity is expressed as the amount of time that employees can work without idle time (Kaplan and Anderson, 2007a). The practical capacity excludes the time that employees spend on activities (such as having a rest and taking a break) which are unrelated to actual work performance. Often practical capacity is estimated as percentage; say 80 percentage or 85 percentage of theoretical capacity. (Kaplan and Anderson, 2004, 2007b; Everaert et al., 2008)

TDABC model assigns resource costs directly to the cost objects with two sets of estimates that is the cost of supplying resource capacity and the demand for resource capacity that each cost object requires. (Kaplan and Anderson, 2007b)

Everaert, Bruggeman, and De Creus (2008) described a case in a distribution company and suggested that ignoring the complexity of activities containing more than one subtask with different time drivers, resulted in a misallocation of 54 percent of the costs when the traditional ABC system rather than a TDABC approach was used.

Schulze, Seuring and Ewering (2012) propose the use of the time-driven activity-based costing approach as they faced with the inherent complexity of an activity-based costing methodology in form of the top-down allocation of work-time capacities to the different activities, and had concluded TDABC is suitable for the context of supply chain management.

2. Implementation of Time-Driven Activity-Based Costing Model

Kaplan & Anderson (2007b) presented the implementation of Time-Driven ABC models into four phases as shown in Figure 2.3.

Phase	I. Preparation	II. Analysis	III. Pilot Model	IV. Rollout
Purpose	Develop a game plan and team for the TDABC study	Gather data and conduct department interviews	Build TDABC model template and validate	Roll out template and customize across organization
Actions	・ Formulate game plan ・ Develop model structure ・ Estimate project cost ・ Determine data requirements and availability ・ Select team composition	・ Perform time studies ・ Estimate time equations and capacity cost rates ・ Finalize data requirements ・ Finalize pilot model	・ Embed time equations into software ・ Import cost object data ・ Run model ・ Validate model	・ Develop rollout schedule ・ Educate facility team members ・ Gather data and build model by facility ・ Review findings with facility management and ABC steering committee.

Figure 2.3 Typical Time–driven ABC Implementation (Kaplan and Anderson, 2007b)

In phase 1, the model's objective is specified in order to determine the scope of model. In order to develop a Time-Driven ABC model successfully, the project team is formed in composition such that all the expertise required, for example a TDABC project needs a operational personnel to be engaged in providing data such as time spent on each activity that will be contribute to the time equation. Action plan, project costs and the sources of the data that need to be collected, are established at this step.

During phase 2, The TDABC model requires a detailed transaction and the order-level data to allow the model to capture variations from order to order and customer to customer which mean the data that describes characteristics of the individual order and customers are taking into account. The sources of data include the general ledger and appropriate transactional files from the ERP and other relevant systems.

During this step, the costs of the departments and processes to be included in the model are identified. Direct observation, accumulating the time required to process fifty to one hundred similar transactions and calculating the average time per transaction processed, interviews or surveying employees, utilizing existing process map are methods in determine the key process and activity steps, the drivers that cause variation in the capacity used by cost object and an estimates of the time required to perform the specific steps of a process which are the key input into a TDABC model.

Within each defined department and process in the model, a process time equation is developed. A time equation is a formula for modeling the time spent on each activity based on the characteristics of the activity. The characteristics are called *time-driver*, because they drive the time required to perform the activity. A Time equation can be representing as a simple algebraic expression:

Process time = sum of individual activity time

$$= (\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 \ldots + \beta_i X_i)$$

Where β_0 is the standard time for performing the basic activity (e.g., 10 minutes)

β_i is the estimated time for the incremental activity i (e.g. 2 minutes)

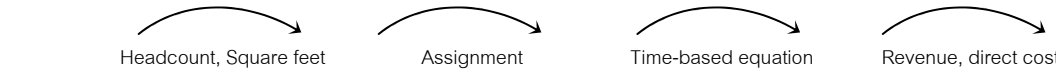
X_i is the quantity of incremental activity i (e.g. number of line items)

Next parameter that needs to be estimated is the cost of supplying a department's resource capacity. The capacity cost rate(s) is cost per time unit of supplying resource capacity. By dividing total costs of capacity supplied to perform activities in a process by practical capacity of resources supplied that actually perform work (measure by the quantity of minutes or hours) presents the capacity cost rate that use to drive resource costs down to the cost object such as orders, products, and customers.

$$\text{Cost per time unit} = \frac{\text{Total cost of resources supplied}}{\text{Practical capacity}}$$

In phase 3, the activity cost driver rate is calculated by multiplying the unit time of the activities performed for cost object with the unit capacity cost rate. This activity cost driver rates are used for calculating the costs of activities performed for the cost object, such as line items, orders, and customers.

Another step is the model validation, financially and operationally. For the financial validation, the costs assigned by the model should reconcile with the general-ledger financial data. As shown in figure 2.4 for the example of the flow of expenses to total up the same at each state. For the operational validation, the time equation can be check for its accuracy by reconcile the total process or departmental times calculated by the model against the available time, estimated by the number or employees or machines in the department.



General Ledger		Departments		Processes		Cost Objects		Calculate Profitability
• Rent • Utilities • Salaries • Supplies • Advertising • Meals • Entertainment • Travel	→ → →	• Sales • Design • Warehouse • Shipping • Accounting • Purchasing	→ → →	• Submitting bids • CAD design • Burning • Cutting • Slitting • Delivery • Billing • Stock purchasing	→ → →	• Customers • Orders • Products	→ → →	• Corporate Metrics • Customer P&L • Product P&L • Territory P&L • Vendor P&L • What-ifs
$ 1.2 million		$ 1.2 million		$ 1.2 million		$ 1.2 million		$ 1.2 million

Figure 2.4: Time-Driven Process and Validation (Kaplan, and Anderson, 2007b)

Finally for phase 4, the pilot model is rollout to the enterprise model using the same steps that Kaplan and Anderson (2007b) had summarized:

a) Drive the general-ledger financial data to departments

b) Drive fully loaded department costs to one or more processes

c) Load transaction data

d) Embed the time estimates and time equations for each process.

e) Drive fully loaded process costs to cost objects via time equations

This phase includes training and consulting to other part of the company which the pilot project team could becomes the company's consulting group.

3. Limitation of Time-Driven Activity-Based Costing

TDABC uses time as its primary cost driver since most resources, such as personnel and equipment, have capacities that can be readily measured by the

amount of time they are available to perform work. Some resources, however, have to apply other cost driver, as shown in Table 2.1.

Table 2.1: Example of resources which can not apply in TDABC Model. (Kaplan and Anderson, 2007b)

Resource	Capacity Measure
Vehicle capacity (volume), warehouse space	Cubic Meter
Vehicle capacity (weight)	Kilograms

Therefore, in this case study for refrigerated warehouse, the combination of ABC approach and TDABC approach is proposed.

CHAPTER III

RESEARCH METHOD

Based on the research process of Stuart et al. (2002), who proposes a five stage process for case study research, the implication of ABC and TDABC for the case refrigerated warehouse show in table 3.1 to provide the basic information on the case study research conducted.

Table 3.1 Case study research process

Dimensions	Categories
Stage 1: Research Question	
Theoretical aim	Exploration
Stage 2 : Instrument development	
Case	A case study of a refrigerated warehouse: a service provider in Thailand including the storage for frozen product, freezing, thawing, packaging and labeling.
Case Selection	Convenience and purposive case: the accessibility to the internal information of the case company is crucial. Revelatory case: Research in refrigerated warehouse operations often suffers from a lack of empirical evidence.
Stage 3 : Data gathering	
Data gathering technique	- Semi-structured interview - Access to company internal document - Direct observation
Stage 4: Data analysis	
Data analysis	Process Mapping: Data was transcript in flow charts backed up with a detailed description of procedures, documents and data for each identified process/activity.
Stage 5 : Dissemination/overall process	
Case quality	Model validation: comparing with general-ledger financial data.

A. The case company

Our study in the case refrigerated warehouse started in January 2011 and ends in December 2011. The company authorizes the study on the condition that its name and customers remain confidential for commercial reasons. The data that presents in this case study represents real figures gathered throughout the one year period. All the data presented in this study are express in THB. The cost data are compiled during a one-month period (September 2011). In order to compile consistent data regarding the activities performed in the warehouse and the time spend on the activities needed for deriving the time equations used in the TDABC model, the procedures and work instruction documents are studied and direct observations of the personnel while they are performing the tasks several times, are taken out. Then, the follow-up interviews with the supervisors and the warehouse manager are conducted in order to verify and validate the accuracy of the data. By comparing the obtained results at different times, the average times for each of the activities are calculated. All the mentioned case study applications are conducted with the following theoretical background and literature.

Regarding the costing method that is currently used by the warehouse's accountants and detailed costs of the warehouse operations, semi-structured interviews with the accountant manager and documentation collection are used as data-collection methods.

The case refrigerated warehouse is a service provider in Thailand; employs 95 personal of which 73 employees are working under warehouse operations. The services provided by the case refrigerated warehouse include the storage for frozen product, blast freezing, thawing, packaging and labeling.

Cold storage service includes the receipt of goods which are frozen products that require core temperature below -18 degree Celsius. The case company provides the cold room setting the temperature at coil at -22 degree Celsius. When

goods are arrived at the warehouse, checker will inspect the truck and container before allowing the worker to open the container for unloading and arrange the goods on the pallet or basket. During the process, the checker will inspect each items and keep record on both the amount and condition of the packaging before attached a tag onto the pallet/basket. The tag shows the information of goods that are put in the pallet/basket. Any item that does not meet the required standard will be separated and recorded for report. After the pallet/basket is full and wrapped with plastic film to prevent the goods from collapsing, the operator will move the pallet/basket using forklift to the specified location in the cold room. The service for the storage of goods ends when the customer orders to take out totally or partially of the inventory kept in the storage. The stock controller will then print out picking list for the operator to prepare the goods. Then for the checker and the workers will inspect the goods and load into the truck until the container door is closed and sealed.

Freezing service includes the receipt of goods from the customers in which the goods will arrive at the warehouse at ambient temperature. The workers will arrange the goods onto the freezing trays while the checkers inspect for the condition and number of goods. The trays will be put on the shelves where the worker will use a hand lift to move the shelves into the freezing room when the room's temperature reaches -10 degree Celsius. The goods will be kept in the freezing room which set the temperature below -40 degree Celsius for 6 to 9 hours or until the goods' core temperature reaches the required level, usually at -18 degree Celsius. After the core temperature reach the required level. The goods will be put out of tray into pallet/basket then moved into cold storage.

The Thawing service usually occurs before the outbound process, when the customer order the warehouse to take out their frozen goods out of the cold storage and to rearrange the goods into the basket in the way that the air can flow to every parts of goods so that the temperature will increase at the same rate. The basket will be kept in thawing room at ambient temperature and the checker will check the core

temperature of the goods until the temperature reach the customer requirement before loading into truck.

Packing and labeling process is depend on the customer requirement on type of package that goods have to be packed in and labels to be put on the package of goods.

B. Product segments of the case refrigerated warehouse

An analysis of the provided services led to the identification of 4 product groups processed in the warehouse that use activities, and therefore resources, differently.

1. Fresh Meat – normally require blast freezing service before storage and thawing service before loading out. This group of product normally uses a basket as equipment for storage. The greatest share (42 percent) of the warehouse storage in term of kilogram belonged to this group.

2. Frozen finished product– such as ready-to-eat product, cooked chicken. Generally requires storage and repackaging service. In case of exporting, the goods require extra caution in quality control and inspection. This group had utilized 21 percent of storage capacity.

3. Frozen Juice, fruit or vegetable – Mostly come as drum or bin, requires mostly storage service. This group of product covers 31 percent of storage capacity.

4. Other – have 6 percent of storage capacity. This includes all other small customers, such as ice cream, drinking water etc.

In this case study the data are collected and analyzed for only three major customers of the case refrigerated warehouse. These customers are determined as follow;

Customer A; This customer is a manufacturer of frozen poultry meat. The greatest share (30 percent) of the warehouse storage in term of kilogram belongs to this customer. This customer generally requires storage, freezing, thawing and sorting service. The company earns 20.19 percent of total sale income from customer A.

Customer B; this customer is a manufacturer of fruit products. The product that is kept at the storage is concentrated fruit juice contained in drum. The 4 drums are arranged on pallet then moves into the storage area. This customer also requires labeling for each drum. Customer B earns 26.28 percent of the warehouse storage, and has 17.45 percent of total sale income.

Customer C; this customer is a manufacturer of frozen ready-to-eat products and have 18.92% of the all the goods stored in the warehouse. The goods come in as carton stacking on pallet and then rearrange onto a slip sheet before dispatch. Customer C has 32.03 percent of the company's total sale income.

In studying of the case company's activities for each service the company provides for the customer, process mapping is used for activity analysis. The process map gives a qualitative picture of activities and their relationship as shown in figure 3.1 and 3.2. From the interviews with the warehouse supervisor and field observations, the activity definition that defines the activities and their processing time is developed, then a time equation is developed for each process in algebraic expression as shown in table 3.4.

The data regarding to the activities that are performed to each customer during September, 2011, are collected from the database in warehouse management system and the case company's document files for each customer order. The data are gathered in the form according to the factors used in the time equation. (Appendix A)

C. The traditional costing system of the case company

Currently the accountant of the case company divides the cost into 2 groups that is costs concern the warehouse, and costs for sale and management. For this case study, only the costs concerning the warehouse operations will be analyzed.

Table 3.2 Costs concern the warehouse operations in percentage of total cost.

Cost centers	Percentage
Salary and wages for warehouse department	37%
Facilities	50%
Machinery Costs	9%
Supplies used and Miscellaneous expenses	3%
Insurance premium	1%

In studying of the case company's resources' costs, the cost driver is defined to each cost. The cost driver is determined on the basis of a logical and quantifiable cause and effect relationship between the utilization of resources, the performance of activities, and the final cost objects. The resource that drives costs by duration (time) will be applied with Time-driven activity-based costing model, while other will be applied with the conventional activity-based costing model. The conventional activity-based costing method utilizes a two-step cost assignment approach, in the first step, the resources consumed in the performance of activities are assigned to activities using resource cost driver. In second step, resource costs that are accumulated within the activity centers are assigned to the final cost objects using activity cost drivers. The determination of cost drivers are shown in table 3.3.

Table 3.3 Determining cost allocation method for each resource

Resources	Labor Cost	Facilities	Machinery Costs	Supplies used and Miscellaneous expenses	Insurance premium
Method	Time-Driven ABC	Conventional ABC	Time-Driven ABC	Conventional ABC	Conventional ABC
Resource Driver	Time Consumed	Cubic meter	Time Consumed	Number of Order for each activity	Estimated Value of Inventory
Activity Driver		Number of Volume (KG)/ Number of order		Number of Order for each customer	

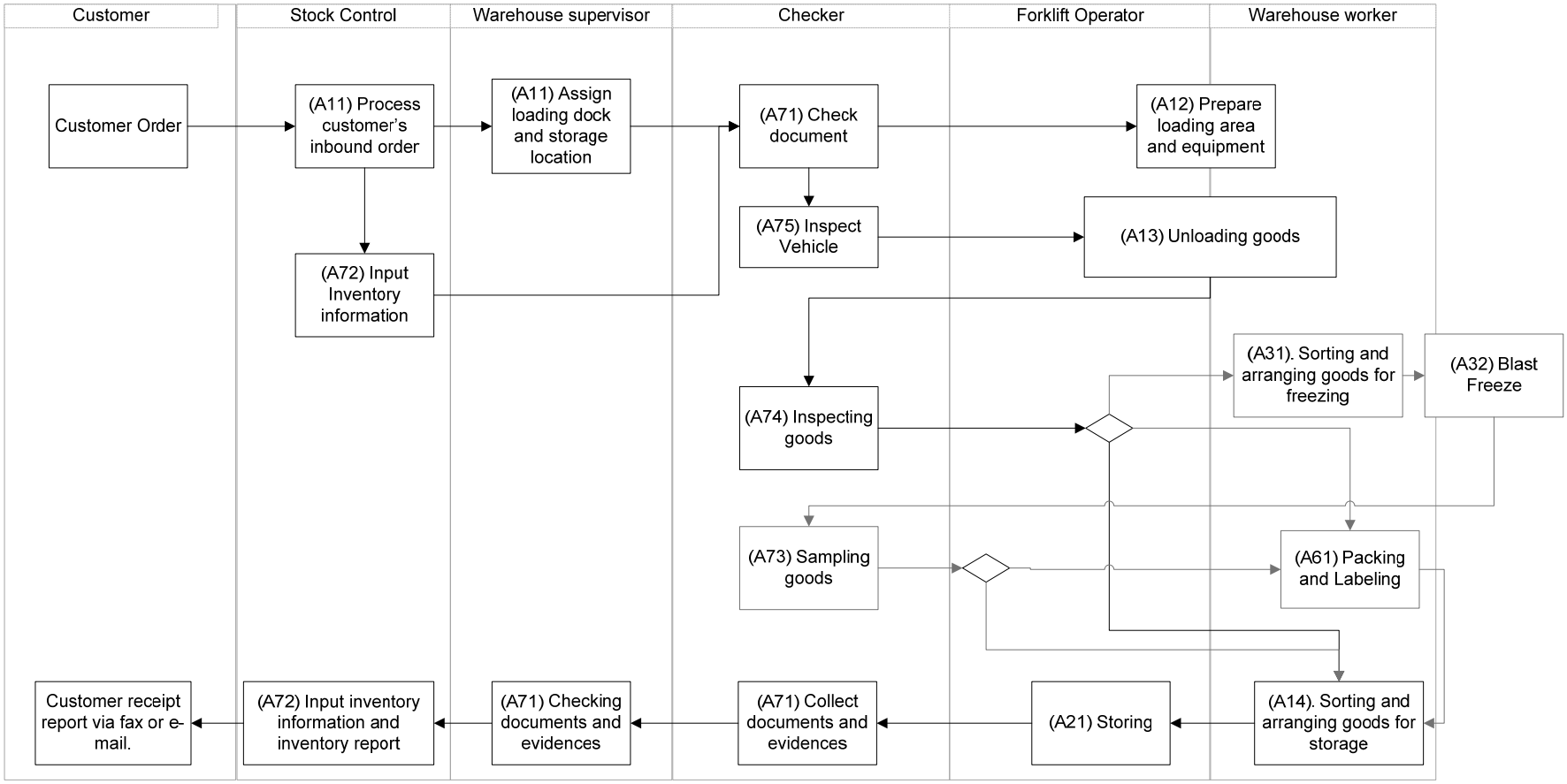


Figure 3.1 Process Mapping for Inbound, Freezing, Packaging, labeling and Storage

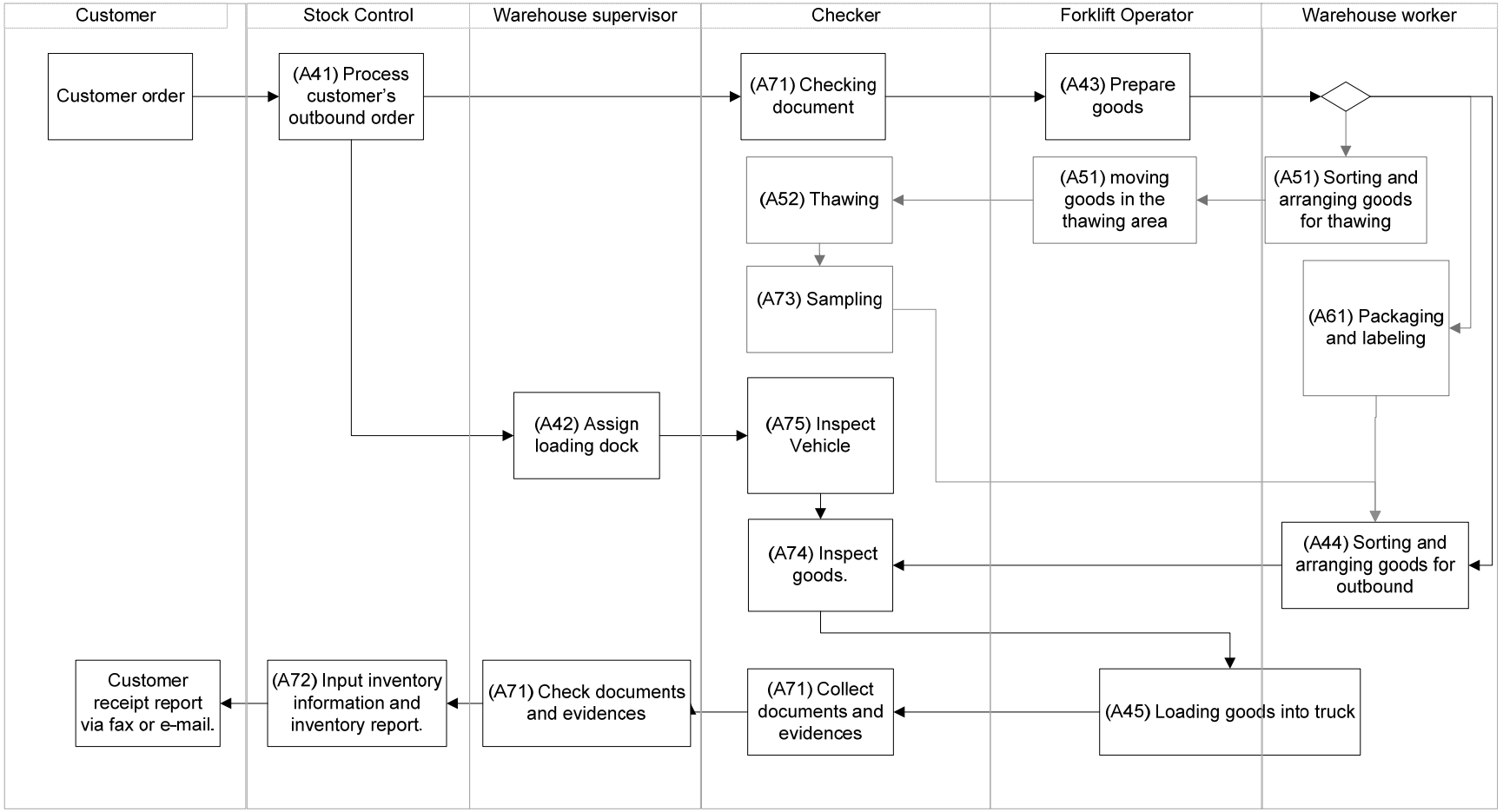


Figure 3.2 Process Mapping for Outbound, Thawing, Packaging and labeling

Table 3.4 Activity Dictionary

Code	Activity	Definition	Time Equation
		INBOUND PROCESS	
A11	Process Customer's Inbound order	Stock controller take 3 minutes to check the document receive from the marketing department or the customer before the actual arrival of the goods. If the document came with the driver, it takes extra 1 minute to confirm the goods details with the customer via telephone.	Inbound Order processing Time per order = $3.5X_{10} + X_{91} + 0.1\,X_{12} + X_{92} + X_{93} + 4\,X_{14}$
		Stock controller input general information (0.5 minutes per order) and the item details (0.1 per warehouse lot number) into the system in order to create booking lot and print out the booking lot from the computer system. For the **new customer**, it takes 1 minute to enter the customer detail into the database. And for the **new product**, it takes another 1 minutes to enter the information into the database.	
		Stock controller announce for the vehicle to enter the truck scale platform, then record the vehicle weight from the truck weighting system, before announce to the driver that he can drive off the platform. This takes 3 minutes per vehicle. Warehouse supervisor assign the available dock for the truck and the location for the operator to put the goods in the cold room. The communication takes 1 minute per vehicle.	
A12	Prepare loading area and equipment	Operators clear the loading area and prepare the basket or pallet to be arranged on, it takes 1 minute to arrange each pallet or basket on to the loading. Workers take 2 minutes to bring out the conveyor or table on to the loading area. It takes 2 minutes for the workers bring out the plastic film and card board from the storage. It takes 1 minute for each basket or pallet to cover the equipment with card board.	Prepare loading area and equipment time = $2\,X_{15} + 2\,X_{16} + 2\,X_{17} + 2\,X_{18} + 2\,X_{10} + 5X_{94}$
		For Freezing process, the workers take 5 minutes to prepare equipment for freezing process.	
A13	Unloading goods	If the incoming goods are arrived in batches which could unload by forklift and directly put on the pallet or basket, it would take 1 minute per pallet or basket. For the vehicle that not allow the forklift to drive-in, the worker have to take extra 1 minutes per pallet or basket to tied the rope and pull the goods out of truck by forklift.	Unloading goods time = $X_{15}X_{98} + X_{16}X_{98} + X_{15}X_{98}X_{99} + X_{98}X_{16}X_{99} + 0.1X_{915}X_{13}$
		The goods are arrived as box, pack, bag in which the workers take 0.1 minutes to unload each item out of truck manually.	

A14	Sorting and Arranging goods for storage	When unload as box, the box will then be sorted by goods name, lot or batch, damaged goods and arrange onto basket, pallet. **Each full pallet or basket takes 3 minutes.** A full pallet will then be moved to an area where a worker will wrap film around the pallet to prevent from falling down during moving and checker will then attached a tag onto the pallet or basket this take another **1 minute for each basket or pallet.**	Sorting and arranging for storage time = $= 4X_{15} + 4X_{16} + 0.5X_{13}\,X_{94}$
		For freezing service, after the shelve are move out of the freezing room, the worker take **extra 0.5 minute to sort the goods out of** freezing tray into pallet or basket according to size, product name or lot number.	
STORAGE			
A21	Storing	The operator move the pallet or basket into the storage at the assigned locationMoving from load 1 to room 1, or 2, takes 1 minute; to room 3, 4, or 5 takes 2 minutes; to room 6 or 7 takes 5 minutes;Moving from load 2 to room 3, 4 or 5 takes 1 minute; to room 6 or 7 takes 4 minutes; to room 1, or 2 takes 3 minutes;Moving from load 4 to room 6, or 7 takes 1 minute; to room 3, 4, or 5 takes 4 minutes; to room 1, or 2 takes 5 minutes.	Storing time = $X_{15}(1X_{910} + 2X_{911}+3X_{912} + 4X_{913} + 5X_{914}) + X_{16}(1X_{910} + 2X_{911}+3X_{912} + 4X_{913} + 5X_{914})$
FREEZING PROCESS			
A31	Sorting and Arranging goods for freezing	For Freezing service, the goods will be arranged onto trays before putting onto shelves by the worker. Each shelves requires 4 minutes to fill and then each shelve takes another 2 minutes to be moved into the freezing room by the hand lift. Checker change the freeze room status from “available” to “occupied” then instruct the engineer to run the compressor.	Sorting and arranging for freezing time = $6X_{25}$
A32	Freeze	The goods left to be frozen till reach the required temperature	
OUTBOUND PROCESS			
A41	Process Customer's Outbound order	Stock controller received customer orders; enter order manually after a phone conversation with customer. It takes 3 minutes to check the document receive from the marketing department or the customer before the actual arrival of the goods. If the document came with the driver, it takes extra 2 minutes to confirm the goods details with the customer via telephone. Then a Stock controller requires 0.5 minute checking the inventory for each line item and printing out the picking list.	Process Customer's outbound order time $= 3X_{30} + 2X_{91} + 0.5X_{32} + X_{34}$
A42		Warehouse supervisor assign the available dock for the truck for loading goods. The communication takes 1 minute per vehicle.	

A43	Prepare goods	For Operator to search for the stored goods in the cold room according to the picking list requires 2 minutes for each pallet or basket, then the operator moves the goods out to loading area. Time requires depend on the distance as per below; Moving from room 1, or 2 to load 1 takes 1 minute; to load 2 takes 3 minutes; to load 4 takes 5 minutes; Moving from room 3, 4, or 5 to load 1 takes 2 minutes; to load 2 takes 1 minute; to load 4 takes 4 minutes; Moving from room 6 or 7 to load 1 takes 5 minutes; to load 2 takes 4 minutes; to load 4 takes 1 minute.	Prepare goods for outbound time $= 2X_{35} + 2X_{36} + X_{35}(1X_{918} + 2X_{919}+3X_{920} + 4X_{921} + 5X_{922}) + X_{36}(1X_{918} + 2X_{919}+3X_{920} + 4X_{921} + 5X_{922})$
A44	Sorting and arranging goods for outbound	Worker sorting the goods according to the picking list. If the goods are going out as partial item from each basket or pallet, worker spent an additional 10 seconds finding and picking each line item in the order. It requires additional 3 minutes, If the shipment require to rearrange cases into full stack (slip sheet).	Sorting and arranging goods for outbound $= 1/6X_{33}X_{923} + 3X_{312}X_{916}$
A45	Loading goods into truck	Operator takes 1 minutes to load each stack (slip sheet) or pallet into truck by forklift Worker requires 0.1 minute to load each item of goods as box, pack, bag into truck manually	Loading goods time $= X_{98}X_{312} + 0.1X_{923}X_{33}$
THAWING PROCESS			
A51	Sorting and arranging goods for Thawing	For Thawing service, If the goods are going out as partial item from each basket or pallet, worker spent an additional 10 seconds finding and picking each line item in the order. Each basket requires 3 minutes for the workers to rearrange the goods so that the air can flow through all the items evenly, then the operator will move the basket in and out of thawing area.	Sorting and arranging for Thawing = $1/6X_{43}X_{923}X_{97} + 3X_{45}X_{97}$
A52	Thaw	The goods are left at the thawing area with temperature controlling at 25 degrees Celsius. Until the goods temperature reach 0 to 4 degrees Celsius or as customer request.	
PACKING AND LABELING			
A61	Packaging & labeling	Extra services as per customer requirement for packaging take 1 minute and labeling take 0.1 minute for each item.	Packing and labeling time $= X_{53}X_{95} + 0.1X_{53}X_{96}$

INSPECTING AND DOCUMENTATION			
A71	Check document and Collect evident	Before load or unload: Checker receives the booking lot and all the relevant documents (Goods reception checking form, TAG, etc.) Checker takes 3 minutes to check the document for details of the customer orders.	Check and collect documents time $=8X_{10} + 8X_{30} + X_{20} + X_{40}$
		Freeze or thawing: Checker takes additional 1 minutes to prepare documents for thawing or freezing.	
		After load or unload: Checker uses 5 minutes to collect all forms and photo for the stock controller.	
A72	Input inventory information and inventory report	Stock controller will receive the documents for the reception or release of goods from the checker to be input into the computer system, it takes 1 minute to input the general information of the event, and require additional 0.1 minutes for each line item. After that the Stock Controller take 1 minute to prepare and print out inventory report for warehouse supervisor to check and then send to the customer by e-mail or fax.	Input inventory information and report time $= X_{10} + X_{30} + X_{40}+X_{20} +0.1(X_{12}+X_{22}+X_{32} +X_{42}) + 1(X_{19} + X_{29} +X_{39} + X_{49})$
A73	Sampling	During Inbound process, Checker require 1 minute sampling goods item for weight and the temperature of goods and record onto the document.	Sampling time = $1(X_{111}+X_{211}+X_{311}+X_{411})$
		During Freezing or Thawing process, Checker will take 1 minute to sample the goods to check temperature every 2 hours and record on report.	
A74	Inspect goods	Checker takes 0.1 minutes to inspect goods item for condition of packaging, number, name, lot/batch by looking and additional 0.5 minute taking each photograph.	Inspecting goods time= $0.1(X_{13}+X_{23}+X_{33}+X_{43}) + 0.5(X_{110}+X_{210}+X_{310}+X_{410})$
A75	Inspect vehicle	Checker takes 2 minutes to check for car license, seals, temperature of container, container number in general and takes additional 3 minutes to inspect container 7 points check for customer requesting C-TPAT term.After finished loading, checker requires 2 minutes to take photo with one door closed, and then take photo with two doors closed before locked seal and take photo with seal number.	Inspect vehicles time= $4(X_{14}+X_{34}) + 3X_{917}$

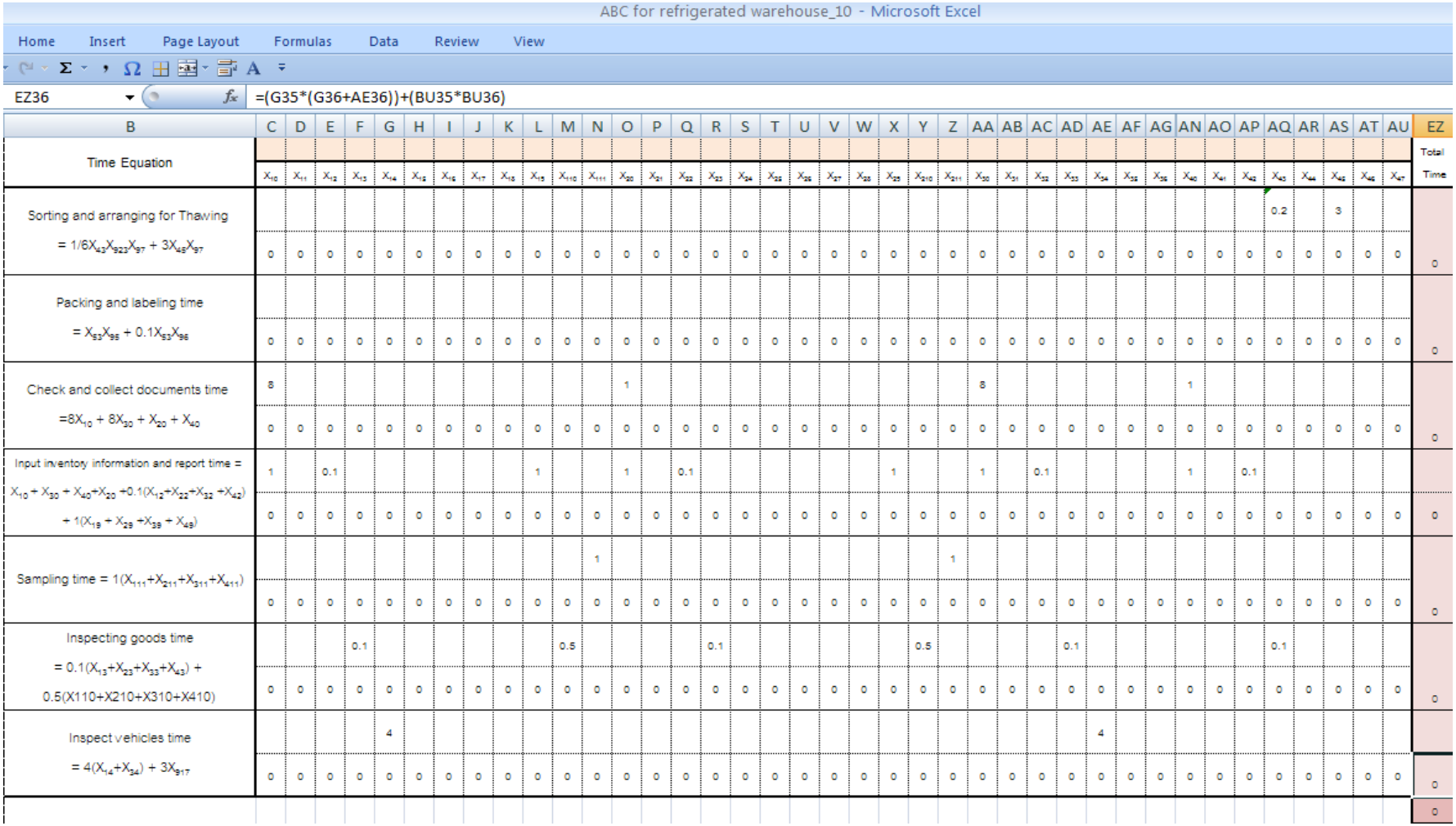


Figure 3.3 Sample of Microsoft Excel Program for calculates time equation.

D. The capacity cost rate

Next step is to estimate the cost of supplying a department's resource capacity by applying the below equation;

$$\text{Cost per time unit} = \frac{\text{Total cost of resources supplied}}{\text{Practical capacity}}$$

To apply TDABC, it is necessary to establish the practical capacity of the resource supplied. As mentioned in chapter 2, the practical capacity for this case study is assumed to constitute 80 percent of the theoretical capacity.

Due to some reason for workload management of the case company, the workers are required to do extra hour each day, excluding the overtime data will lead to more distortion in the calculation, therefore for the labor resources, the practical capacity will be constitute 80 percent of the theoretical capacity and the overtime.

E. Analyzing results from the ABC model

As explained in chapter 2 concerning the two-dimensional activity-based model, this case study will concern only the cost dimension. The integrated model is divided into the conventional part and time-driven part. The costs from each part will be combined in order to determine the costs of serving to the three different customers, in order to further interpret and develop a recommendation plan that will increase cost efficient for the utilization of storage capacity.

Furthermore, the costs that are determined by the model will be compared with the case company traditional method to interpret the differences between the two methods.

CHAPTER IV

RESEARCH FINDING

In September, 2011, the case company has supported totally 1,765 of customers' orders, and out of which 542 orders are from customer A, 51 orders are from customer B, and 333 orders are from customer C.

The data for all factors in time equation of each customer order is put in the spreadsheet in order to calculate process time, as shown in figure 4.1. Then the total process time for each classifies customers are shown in table 4.2.

Table 4.1 Number of customer order and volume of goods in September 2011

Activity		Number of order	Volume (Kg)
Inbound	(1)	706	3,871,869.36
Blast Freeze	(2)	46	138,219.10
Outbound	(3)	945	3,368,916.96
Thaw	(4)	50	241,468.80
Packing	(5)	18	165,978.40
Total	(1)+(2)+(3)+(4)+(5) = (6)	1,765	7,786,452.62
Beginning inventory (Kg)	(7)		4,558,918.71
Ending inventory (Kg)	(8)		4,912,064.85
Average Volume in storage (Kg)	(7)+(8)/2 = (9)		4,735,491.78
Total Movement (Kg)	(6)+(9) = (10)		12,521,944.40

Next step is the allocation of the cost of warehouse operating activities to each customer by under Time-driven activity-based costing or conventional activity-based-costing method.

Table 4.2 Number of customer order in September 2011

Customer	Process Time (Minute)			Total process time (minute) (1)+(2)+(3)=(4)	Number of Order					Total Number of Order (5)+(6)+(7)+(8)+(9)=(10)
	In (1)	Out (2)	Thaw (3)		In (5)	Freeze (6)	Out (7)	Thaw (8)	Pack/ Label (9)	
Customer A	25,029.20	28,925.73	2,541.50	**56,496.43**	266	0	226	50	0	**542**
Customer B	9,424.80	1,918.80	0	**11,343.60**	36	0	15	0	0	**51**
Customer C	62,308.70	78,400.73	0	**140,709.43**	231	0	102	0	0	**333**
Other Customers*	N/A	N/A	N/A	**N/A**	173	46	602	0	18	**839**
Total	N/A	N/A	N/A	**N/A**	706	46	945	50	18	**1765**

Customer	Volume (kg)								Total Movement (Kg) (11)+(12)+(13)+(14)+ (15)+(18)=(19)
	In (11)	Freeze (12)	Out (13)	Thaw (14)	Pack/Label (15)	Beginning Inventory (16)	Ending Inventory (17)	Average Inventory (16)+(17)/2=(18)	
Customer A	552,624.00	0	504,981.41	241,468.80	0	1,455,315.16	1,476,768.46	1,466,041.81	**2,765,116.02**
Customer B	717,039.28	0	265,388.40	0	0	839,826.96	1,291,017.84	1,065,422.40	**2,047,850.08**
Customer C	1,941,434.99	0	1,861,136.74	0	0	922,269.26	929,471.50	925,870.38	**4,728,442.11**
Other Customers	660,771.09	138,219.10	737,410.41	0	165,978.40	1,341,507.33	1,214,807.05	1,278,157.19	**2,980,536.19**
Total	3,871,869.36	138,219.10	3,368,916.96	241,468.80	165,978.40	4,558,918.71	4,912,064.85	4,735,491.78	**12,521,944.40**

* Due to the collection of data on the factors that are needed for calculating the process time, would be time consuming and will exceed the research time schedule, therefore for this case study will emphasize only on the cost assignment data for the three major customers, so the processing times for other customers are not available.

TX37 =SUM(TX4:TX36)

	A	B	C	D	E	F	G	K	L	M	N	CY	CZ	DA	DB	DH	DI	DJ	GU	GV	GW	GX	GY	HD	HE	HF	KQ	KR	KS	KT	KU	KV	KZ	LA	LB	TX
1																											1	3,804.20	1	334		7	1	3	3	Total Time
2		**Time Equation**	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{18}	X_{19}	X_{110}	X_{111}	X_{20}	X_{21}	X_{22}	X_{23}	X_{29}	X_{210}	X_{211}	X_{30}	X_{31}	X_{32}	X_{33}	X_{34}	X_{39}	X_{310}	X_{311}	X_{40}	X_{41}	X_{42}	X_{43}	X_{44}	X_{45}	X_{49}	X_{410}	X_{411}	
27		Check and collect documents time $= 8(X_{10} + X_{30}) + 1(X_{20} + X_{40})$ $=8X_{10} + 8X_{30} + X_{20} + X_{40}$	8									1							8								1									
28			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3804.2	1	334	0	7	1	3	3	1.00
29		Input inventory information and report time $= X_{10} + X_{30} + X_{40} + X_{20} + 0.1(X_{12} + X_{22} + X_{32} + X_{42}) +$ $1(X_{19} + X_{29} + X_{39} + X_{49})$	1		0.1				1			1		0.1		1			1		0.1			1				1		0.1				1			
30			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3804.2	1	334	0	7	1	3	3	2.10
31		Sampling time = $1(X_{111} + X_{211} + X_{311} + X_{411})$									1							1								1										1	
32			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3804.2	1	334	0	7	1	3	3	3.00
33		Inspecting goods time $= 0.1(X_{13} + X_{23} + X_{33} + X_{43}) +$ $0.5(X110 + X210 + X310 + X410)$				0.1				0.5					0.1		0.5					0.1			0.5					0.1					0.5		
34			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3804.2	1	334	0	7	1	3	3	36.40
35		Inspectvehicles time $= 4(X_{14} + X_{34}) + 3X_{917}$					4																4														
36			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3804.2	1	334	0	7	1	3	3	-
37																																				42.50

Figure 4.1 sample of the process time calculation for one customer order for outbound

A. Assigning Overhead cost to each customer

1. Assigning labor cost to customer

As determined in table 3.3, the cost driver for labor cost is the time consumed by each customer. The capacity cost rate is calculated by dividing total cost of resources supplied by the practical capacity. The total labor cost of the case company in September, 2011 was THB 1,000,958.04. The practical capacity is measured by the quantity of minutes that employees are available to perform the actual work in the warehouse. The data for the working time and over time of the employees of the case company can be easily acquired from the human resource management system. For September, 2011, the practical capacity of the case company is calculated by 80 percent of the theoretical capacity* (886,080 minutes) and total over time of 80,871 minutes, which is equal to 773,560.8 minutes. Therefore the labor cost per time unit is calculated as shown below;

$$\text{Labor Cost per time unit} = \frac{\text{THB } 1{,}000{,}958.04}{773{,}560.8 \text{ minutes}} = \text{THB } 1.29 \text{ per minute}$$

The refrigerated warehouse's capacity cost rate equals THB 1.29 per minute. This rate is applied to the worked performed in the warehouse during the month and is based on the time equation for each transaction i.e. customers' orders. Referring to table 4.2, the total process time for all transactions of each customer on the basis of the time equation is applied with the capacity cost rate given the labor cost assigned to the activity for each customer as shown in table 4.3.

---

*The assumption concerns the practical capacity that is equal to 80 percent of the theoretical capacity, is based from the literature review (Chapter 2, page 17). There is no in-depth research on the actual working time of the employees in proportion theoretical available time for this case company.

Table 4.3 Assigning Labor cost by process time of each customer

Customer	Capacity Cost rate (THB/Min) (1)	Inbound		Outbound		Thawing		Total process time (2)+(4)+(6) =(8)	Total Cost (3)+(5)+(7) =(9)
		Process Time (min) (2)	Cost (THB) (1)x(2)=(3)	Process Time (min) (4)	Cost (THB) (1)x(4)=(5)	Process Time (min) (6)	Cost (THB) (1)x(6)=(7)		
Customer A	1.29	25,029.20	32,386.83	28,925.73	37,428.79	2,541.50	3,288.60	56,496.43	73,104.22
Customer B	1.29	9,424.80	12,195.33	1,918.80	2,482.85	0	0	11,343.60	14,678.18
Customer C	1.29	62,308.70	80,625.07	78,400.73	101,447.55	0	0	140,709.43	182,072.62

2. Assigning Machine cost to customer

As determined in table 3.3, Time-driven activity-based costing method is applied for assigning machine cost to the customer. The machinery cost of the case company includes the rental cost and maintenance of the machine operating in the warehouse. For September, 2011, the machine cost is THB 287,300. The practical capacity is measured by the quantity of machine time available for work after subtracting 20 percent for downtime or maintenance and repair. Therefore with 8 units of machinery operate 24 hours a day, which gives 345,600 minutes theoretically, the practical capacity is then 276,480 minutes. The capacity cost rate is calculated as per below;

$$\text{Machinery Cost per time unit} = \frac{\text{THB } 287{,}300}{276{,}480 \text{ minutes}} = \text{THB } 1.04 \text{ per minute}$$

The refrigerated warehouse's capacity cost rate is equal to THB 1.04 per minute. This rate is applied to the total process time performed in the warehouse referring to table 4.2, given the machine cost assign to each customer as shown in table 4.4.

Table 4.4 Assigning Machine cost by process time of each customer

Customer	Capacity Cost rate (THB/Min) (1)	Inbound		Outbound		Thawing		Total process time (2)+(4)+(6)=(8)	Total Cost (3)+(5)+(7)=(9)
		Process Time (min) (2)	Cost (THB) (1)x(2)=(3)	Process Time (min) (4)	Cost (THB) (1)x(4)=(5)	Process Time (min) (6)	Cost (THB) (1)x(6)=(7)		
Customer A	1.04	25,029.20	26,008.71	28,925.73	30,057.74	2,541.50	2,640.96	56,496.43	58,707.41
Customer B	1.04	9,424.80	9,793.64	1,918.80	1,993.89	0	0	11,343.60	11,787.53
Customer C	1.04	62,308.70	64,747.14	78,400.73	81,468.93	0	0	140,709.43	146,216.07

3. Assigning facility costs to customer

Referring to table 3.3, the allocation of facility costs to each customer is applied under conventional activity-based costing method with area used (cubic meter) as the resource driver and number of order or volume as the activity driver. At the first level, costs are assigned to activity center, as shown in table 4.5.

Table 4.5 Assigning facility costs to Activities

Activity	Total area (M^3) (1)	%Area available (2)	Facility Cost (THB) (3)
Inbound/Outbound	3,066.43	6%	166,329.06
Blast Freezing	600.00	1%	32,545.20
Storage	37,944.00	79%	2,058,158.26
Thawing	1,080.00	2%	58,581.35
Packing	1,742.16	4%	94,498.23
Office	3,423.00	7%	185,670.35
Total	**47,855.59**	**100%**	**2,595,782.46**

The total facility cost in September, 2011, is THB 2,595,782.46 with total area of 47,855.59 cubic meters. The total area is divided into cubic meter of space available for each group of activity. As shown in table 4.5 (column 1), the inbound and outbound activity are carry out in 4 loading areas with 3,066.43 cubic meter, 2 room for blast freezing with 600 cubic meter, 7 cold storage rooms with totally 37,944 cubic meter, 1 thawing room of 1,080 cubic meter, a packing room of 1,742.16 cubic meter and the warehouse office with 3,423 cubic meter. The proportions of space available are then applied to the total facility cost in order to assign cost to each activity group.

For the second level, the area in which the activities are involved directly to the goods will be applied with volume of goods in Kilograms as cost driver to the customers, where about the activity in the office will be assigning cost by applying number of customer order as cost driver to the cost object, as shown in table 4.6.

Table 4.6 Assigning facility cost from warehouse operation to customer

Activity:	Inbound/Outbound			Blast Freezing			Storage		
Customer	Volume (KG) Inbound/ Outbound (1)	% of work (2)	Facility cost (THB) (3)	Volume (KG) Freeze (4)	% of work (5)	Facility cost (THB) (6)	Average Inventory in Storage (7)	% of work (8)	Facility cost (THB) (9)
Total	7,240,786.32	100%	166,329.06	138,219.10	100%	32,545.20	4,735,491.78	100%	2,058,158.26
Customer A	1,057,605.41	15%	24,294.39	0	0%	0	1,466,041.81	31%	637,176.92
Customer B	982,427.68	14%	22,567.48	0	0%	0	1,065,422.40	22%	463,058.12
Customer C	3,802,571.73	53%	87,349.38	0	0%	0	925,870.38	20%	402,405.46
Other Customers	1,398,181.50	19%	32,117.81	138,219.10	100%	32,545.20	1,278,157.19	27%	555,517.76

Activity:	Thawing			Packing/Label			Office				Total Facilities cost (THB) (3)+(6)+(9)+(12)+(15)+(18)=(19)
Customer	Volume (KG) Thaw (10)	% of work (11)	Facility cost (THB) (12)	Volume (KG) Pack (13)	% of work (14)	Facility cost (THB) (15)	Total Number of order (16)	% of work (17)	Facility cost (THB) (18)		
Total	241,468.80	100%	58,581.35	165,978.40	100%	94,498.23	1765	100%	185,670.35		2,595,782.46
Customer A	241,468.80	100%	58,581.35	0	0%	0	542	31%	57,016.05		777,068.72
Customer B	0	0%	0	0	0%	0	51	3%	5,364.98		490,990.57
Customer C	0	0%	0	0	0%	0	333	19%	35,030.16		524,785.00
Other Customers	0	0%	0	165,978.40	100%	94,498.23	839	48%	88,259.16		802,938.17

4. Assigning supplies used and miscellaneous expenses to each customer

Referring to table 3.3, the allocation of supplies used and miscellaneous expenses to each customer is applied under conventional activity-based costing method with number of order as the cost driver.

Table 4.7 Allocating supplies used and miscellaneous expenses to activity centers

Activity	Number of order (1)	% of work (2)	Supplies used and miscellaneous expenses(THB) (3)
Inbound	706	40%	35,933.41
Freeze	46	3%	2,341.27
Outbound	945	54%	48,097.83
Thaw	50	3%	2,544.86
Packing	18	1%	916.15
Total	1,765	100%	89,833.52

At the first level of conventional activity-based costing method, the costs are assigned to each activity center. As shown in table 4.4, the total number of customer orders is 1,765 orders, out of which 40 percent are orders for inbound, 3 percent are orders for blast freezing, 54 percent are orders for outbound, 3 percent are for thawing and other 1 percent are for packing service. Then, the cost of supplied used and miscellaneous expenses is allocated according to the percent of work to each activity.

The second level of conventional activity-based costing method is to allocate the cost from the activity center to the cost object, which in this case the customer A, customer B and customer C, as shown in table 4.8. For example, in September, 2011, customer A has 266 orders for inbound goods into the warehouse; therefore 38 percent (266/706) of total supplied used and miscellaneous expense for the inbound activity are assigned to customer A. (38 percent of THB 35,933.41 is THB 13,539)

Table 4.8 Allocation of supplies used and miscellaneous expenses to customer

Activity:	Inbound			Blast Freezing			Outbound			Thawing			Packing/Label			Total cost (THB) (3)+(6)+(9)+ (12)+(15)=(16)
Customer	Number of Order In (1)	% of work (2)	Cost (3)	Number of order Freeze (4)	% of Work (5)	Cost (6)	Number of order out (7)	% of work (8)	Cost (9)	Number of order thaw (10)	% of work (11)	Cost (12)	Number of order Pack (13)	% of work (14)	Cost (15)	
Total	706	100%	35,933	46	100%	2,341	945	100%	48,098	50	100%	2,545	18	100%	916	89,833.52
Customer A	266	38%	13,539	0	0%	0	226	24%	11,502.76	50	100%	2,544.86	0	0%	0	27,586.27
Customer B	36	5%	1,832	0	0%	0	15	2%	763.46	0	0%	0	0	0%	0	2,595.76
Customer C	231	33%	11,757	0	0%	0	102	11%	5,191.51	0	0%	0	0	0%	0	16,948.76
Other Customers	173	25%	8,805	46	100%	2,341	602	64%	30,640.10	0	0%	0	18	100%	916.15	42,702.73

5. Assigning insurance premium cost to customer

The allocation of insurance premium cost to each customer is applied under conventional activity-based costing method. The cost driver is the proportion of the estimated value of the total capacity of the inventory assigned to each customer.

As mentioned in table 4.9, the total value of inventory insured is THB 400,000,000, the insurance premium for September, 2011, was THB 24,998.22. The proportion of value for each customer's inventory is applied directly in order to assign the cost to the customer.

Table 4.9 Assigning insurance premium cost to customer

Customer	Value insurance (1)	% of total insured (2)	Insurance Cost (3)
Customer A	100,000,000.00	25.00%	6,249.56
Customer B	120,000,000.00	30.00%	7,499.47
Customer C	120,000,000.00	30.00%	7,499.47
Other Customer	60,000,000.00	15.00%	3,749.73
	400,000,000.00	**100.00%**	**24,998.22**

B. Analysis of result

Table 4.10 consolidates all the resources cost that is assigned to each customer by the method explained in the previous section. Customer A was assigned the highest cost at THB 942,716.18, especially for facilities cost of THB 777,068.72, as it has the highest average inventory kept in storage of 1,466,041.81 Kg. This customer has totally 542 orders in the period of one month gave an average cost of THB 1,739.33 per order. This could be explained to the character of this customer for most of the transaction is a small shipment, normally concerned only 4-wheels truck. As for the cost per total volume of goods movement including all inbound, freezing, storage, thawing and outbound activities, is equals to THB 0.34 per Kg, comparing to the revenue per Kg of THB 0.38 per Kg, gave margin of THB 0.04 per Kg.

Customer B having 51 orders and average inventory in storage of 1,065,422.40 Kg; was given costs at THB 527,551.51, which gave the highest cost per order of THB 10,344.15, as most transaction concern big shipment as containers or 10-wheels truck. The total volume movement for one month period was 2,047,850.08 Kg, which gives cost THB 0.26 per Kg, comparing to the revenue per Kg of THB 0.44 per Kg, the margin equal to THB 0.18 per Kg, which is the highest from other customers.

Customer C was assigned THB 877,521.92 for 333 orders, given cost per order of THB 2,635.20 per order and average inventory of 925,870.38 Kg, which is the smallest proportion that is kept in the storage. This customer has the highest labor cost assigned as it required highest processing time which should be mostly due to the extra time in sorting and arranging each carton on to the slip sheet before wrapping with plastic film. However, Customer C has the lowest cost per Kg or THB 0.19 per Kg. Even thou, this customer have the lowest average inventory, but the total volume movement is the highest, up to 4,728,442.11 Kg. The margin of this customer comparing to the revenue of 0.35 per Kg, is THB 0.16.

This information could be use as a guideline for the sale person and the warehouse manager in planning the proportion of capacity in the warehouse and the pricing of the service. The customer A has the highest inventory kept in the storage. However the customer yields the smallest margin. The negotiation for a raise should be carried out. Whereas for the customer B and customer C have the high margin, could be offered the higher capacity to be kept in the storage. For customer C, the warehouse manager could further study the process in order to reduce the process time to yield a better margin.

Table 4.10 Consolidation of resources costs assigned to the customers

	Activity-based costing model							
Resource	Customer A		Customer B		Customer C		Other Customers	
Labor (1)	73,104.22	7.8%	14,678.18	2.8%	182,072.62	20.7%	731,103.02	44.3%
Facilities (2)	777,068.72	82.4%	490,990.57	93.1%	524,785.00	59.8%	802,938.17	48.6%
Machine (3)	58,707.41	6.2%	11,787.53	2.2%	146,216.07	16.7%	70,588.98	4.3%
Supplies used and miscellaneous Expense (4)	27,586.27	2.9%	2,595.76	0.5%	16,948.76	1.9%	42,702.73	2.6%
Insurance (5)	6,249.56	0.7%	7,499.47	1.4%	7,499.47	0.9%	3,749.73	0.2%
Total Cost (1)+(2)+(3)+(4)+(5)=(6)	**942,716.18**	**100%**	**527,551.51**	**100%**	**877,521.92**	**100%**	**1,651,082.63**	**100%**
Total Order (7)	542		51		333		839	
Cost per order (6)/(7)=(8)	**1,739.33**		**10,344.15**		**2,635.20**		**1,967.92**	
Total Volume movement (9)	2,765,116.02		2,047,850.08		4,728,442.11		2,980,536.19	
Cost per Kg (6)/(9)=(10)	**0.34**		**0.26**		**0.19**		**0.55**	
Revenue (11)	1,037,017.40		896,551.70		1,645,283.02		1,010,740.60	
Revenue per Kg (12)	**0.38**		**0.44**		**0.35**		**0.34**	

Table 4.11 summarizes all the resources costs into the activity center then assigned to the cost object (customers). The detail table that shows how each resources cost are assigned to each activity center and customer, is in Appendix B. Due to the difficulty in manually gathering the data for all transactions, which is time consuming and as this case study aims on the cost assignment to the three main customers, therefore the processing times for the other customers are not collected and so the total cost of each activity center cannot be determined.

The storage cost has the highest proportion of the total cost for all the customers. The differences in the cost between each customer reflect the amount of the inventory that is kept in the storage, in which customer A has the highest storage cost of THB 643,426.47. However, the distribution of the total cost to the storage cost is not the highest (68.25 percent) comparing to customer B (89.20 percent). This could be interpreted that the nature of customer A's transactions use the warehouse as a distribution center. Customer A keeps high inventory in the warehouse, but also have high activity for distributing and replenishing of the goods inventory. The figures for customer C reveal a similar case, but keep much less inventory. For these two customers, the warehouse supervisors will have to manage the workload carefully to support the activity of inbound and outbound. As for customer B, the figures show the character of the inventory much like a dead stock.

Table 4.11 Cost of activity centers for each customer

Cost object	Customer A		Customer B		Customer C	
Activity Center	Cost (THB) (1)	% of total cost (2)	Cost (THB) (3)	% of total cost (4)	Cost (THB) (5)	% of total cost (6)
Inbound	112,610.64	11.95%	44,079.52	8.36%	226,026.62	25.76%
Storage	643,426.47	68.25%	470,557.58	89.20%	409,904.93	46.71%
Thawing	72,315.56	7.67%	0	0.00%	0	0.00%
Outbound	114,363.51	12.13%	12,914.41	2.45%	241,590.37	27.53%
Total	**942,716.18**	**100.00%**	**527,551.51**	**100%**	**877,521.92**	**100.00%**

C. Comparing between volume cost method and integrated ABC model

In order to allocate cost to the customer, the case company used the traditional cost method which concerns only the average inventory in the storage, by using the below formula;

$$\text{Average inventory in the storage} = \frac{(\text{Beginning inventory}) + (\text{Ending inventory})}{2}$$

As mentioned in table 4.1, in September, 2011, the beginning inventory was 4,558,918.71 Kg and the ending inventory was 4,912,064.85 Kg, therefore the average inventory in the storage is 4,735,491.78 Kg ((4,558,918.71+4,912,064.85)/2). The average cost per unit for each resource is calculated by dividing the resource cost by the average inventory in the storage as shown in table 4.12. For example the labor costs for September, 2011, is THB 1,000,958.04, divided by the average inventory of 4,735,491.78 Kg, equals to THB 0.21 per Kg.

Table 4.12 Cost per unit for the traditional volume-cost method

Cost	THB per kg
Labor costs	0.21
facilities	0.55
Machinery costs	0.06
Supplies uses and miscellaneous expenses	0.02
Insurance premium	0.005

Then the average cost per Kg of each cost is multiplied with the average inventory in the storage for each customer, shown in table 4.13 to give the result of resource cost for each customer in table 4.14.

Table 4.13 Average Inventory in the storage for each customer in September 2011

	Customer A	Customer B	Customer C	Other Customer
Average inventory (kg)	1,466,041.81	925,870.38	1,065,422.40	1278157.19

Table 4.15 and Table 4.16 compare the results of cost allocation by traditional method and the activity-based costing model. The traditional cost accounting allocated the resources costs directly to the customers with single driver, in this case, the average inventory in the storage. The standard costs did not reflect the effects of different operation according to different requirements of each customer. In table 4.14 shows that in traditional method the costs are equally allocated 31 percent of the total cost for customer A, 20 percent for customer B and 22 percent for customer C. Whereas the activity-based costing model, each resource is assigned to the cost object base on the cost driver in which reflect the nature of the cause and effect relationship between the resources, the activities and the cost objects. The labor costs for the customer A in the traditional costing method comparing with activity-based costing method shows that the cost is over allocated by 76 percent. The machine cost for customer C, the cost is under allocated by 56 percent.

Table 4.14 Total costs, for each customer by Traditional costing method

Resource	Customer A		Customer B		Customer C		Other Customers	
Labor (1)	309,882.56	25.0%	225,202.19	25.0%	195,704.57	25.0%	270,168.71	25.0%
Facilities (2)	803,617.83	64.9%	584,016.38	64.9%	507,520.28	64.9%	700,627.97	64.9%
Machine (3)	88,944.05	7.2%	64,638.66	7.2%	56,172.11	7.2%	77,545.18	7.2%
Supplies used and miscellaneous expense (4)	27,811.20	2.2%	20,211.34	2.2%	17,564.00	2.2%	24,246.98	2.2%
Insurance (5)	7,739.10	0.6%	5,624.27	0.6%	4,887.58	0.6%	6,747.27	0.6%
Total Cost (1)+(2)+(4)+(5)=(6)	1,237,994.74	100%	899,692.84	100%	781,848.55	100%	1,079,336.12	100%

Table 4.15 Comparing resource costs between Traditional method and ABC model (with percentage to total cost of each resource)

	Traditional Method								Activity-based costing model							
Resource	Customer A		Customer B		Customer C		Other Customers		Customer A		Customer B		Customer C		Other Customers	
Labor	309,882.56	31%	195,704.57	20%	225,202.19	22%	270,168.71	27%	73,104.22	7%	14,678.18	1%	182,072.62	18%	731,103.02	73%
Facilities	803,617.83	31%	507,520.28	20%	584,016.38	22%	700,627.97	27%	777,068.72	30%	490,990.57	19%	524,785.00	20%	802,938.17	31%
Machine	88,944.05	31%	56,172.11	20%	64,638.66	22%	77,545.18	27%	58,707.41	20%	11,787.53	4%	146,216.07	51%	70,588.98	25%
Supplies used and miscellaneous expense	27,811.20	31%	17,564.00	20%	20,211.34	22%	24,246.98	27%	27,586.27	31%	2,595.76	3%	16,948.76	19%	42,702.73	48%
Insurance	7,739.10	31%	4,887.58	20%	5,624.27	22%	6,747.27	27%	6,249.56	25%	7,499.47	30%	7,499.47	30%	3,749.73	15%
Total Cost	1,237,994.74	31%	781,848.55	20%	899,692.84	22%	1,079,336.12	27%	942,716.18	24%	527,551.51	13%	877,521.92	22%	1,651,082.63	41%
Revenue	1,037,017.40		896,551.70		1,645,283.02		1,010,740.60		1,037,017.40		896,551.70		1,645,283.02		1,010,740.60	
Turnover	0.8377		1.1467		1.8287		0.9364		1.1000		1.6995		1.8749		0.6122	

Table 4.16 Comparing resource costs between Traditional method and ABC model (with percentage to total cost)

	Traditional Method								Activity-based costing model							
Resource	Customer A		Customer B		Customer C		Other Customers		Customer A		Customer B		Customer C		Other Customers	
Labor	309,882.56	25.0 %	225,202.19	25.0 %	195,704.57	25.0 %	270,168.71	25.0 %	73,104.22	7.8%	14,678.18	2.8%	182,072.62	20.7 %	731,103.02	44.3 %
Facilities	803,617.83	64.9 %	584,016.38	64.9 %	507,520.28	64.9 %	700,627.97	64.9 %	777,068.72	82.4 %	490,990.57	93.1 %	524,785.00	59.8 %	802,938.17	48.6 %
Machine	88,944.05	7.2%	64,638.66	7.2%	56,172.11	7.2%	77,545.18	7.2%	58,707.41	6.2%	11,787.53	2.2%	146,216.07	16.7 %	70,588.98	4.3%
Supplies used and miscellaneous expense	27,811.20	2.2%	20,211.34	2.2%	17,564.00	2.2%	24,246.98	2.2%	27,586.27	2.9%	2,595.76	0.5%	16,948.76	1.9%	42,702.73	2.6%
Insurance	7,739.10	0.6%	5,624.27	0.6%	4,887.58	0.6%	6,747.27	0.6%	6,249.56	0.7%	7,499.47	1.4%	7,499.47	0.9%	3,749.73	0.2%
Total Cost	1,237,994.74	100%	899,692.84	100%	781,848.55	100%	1,079,336.12	100%	942,716.18	100%	527,551.51	100%	877,521.92	100%	1,651,082.63	100%

CHAPTER V

SUMMARY/SUGGESTION

A. Summary

This thesis has achieved all the research objectives in studying the concept of activity-based costing system and time-driven activity-based costing system, then to apply both to a case refrigerated warehouse for achieving better cost information, giving more understanding in each phrase of the model development.

In the course of model developing, the uses of process mapping for activity analysis and time equations helps to understand the relevant activities and their connections of the refrigerated warehouse operation. However, for the assumption of the practical capacity is equal to 80 percent of theoretical capacity, bases only on theory from other research. There is no study of the actual working time of the employee comparing to their total available working time, or whether the cases from other research are relatively applicable to this case study so that the same assumption can be applied.

In the stage of gathering data and information through the interviews, observations and documentation from the case company, then apply to the developed model; have created an understanding in implanting theory concept into more practical way. The data that gathered from the company's warehousing management system were not in the format that can be directly applied into the time equation. The data have to be cross checked with the document and manually in put into the spreadsheet, which take too much time, and therefore some useful information such as the total process time of all transactions and customers are lacking. Also, in the process of rolling out the pilot model to include with all other customers of the case company, the time equation may have to be reviewed regarding the different in each customer's requirements. The internal warehouse operation such as transit activity or internal stock counting should be added to the model, in order to analyze the total processing time in term of overall warehouse management.

By determining the costs capacity rate and finally assigned the costs to each customer, including interpreting the results help to comprehend more about the use of ABC information for the use of strategies management and in developing a guideline to improve the process and increase cost efficient for the use of resources.

In comparing the result of traditional costing method with the ABC method can be summarized in Figure 5.1. The traditional costing method of the case company used average inventory level as an allocation base for allocating resources cost to the cost object. This cost accounting method is inaccurate and misleading as it often assign too much cost to one customer but not enough to another. Whereas the ABC method consider the nature of the consumption of resources by activities performed in order to serve the customer.

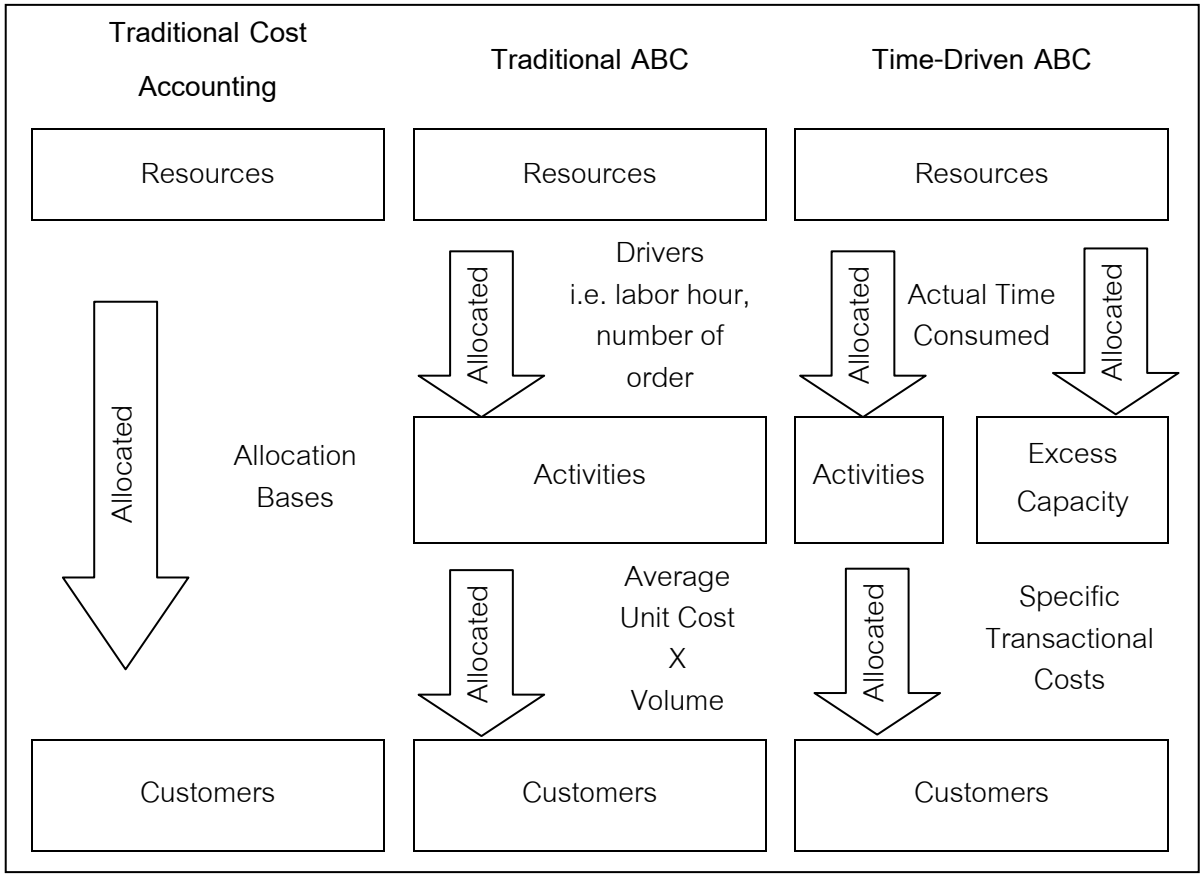


Figure 5.1 Comparisons of Traditional Cost Accounting, Traditional ABC and TDABC

B. Suggestions

This integrated ABC model is carried out under the simplified method and lower cost using Microsoft Excel program, in which the entrepreneurs can simply apply to their business, however the model is convenient for only SMEs level where the processes are not too complex or to be used as a pilot model before making a decision for the use of Activity-based costing concept, in which the use of customized software would facilitate the implementation, and the delivery of useful data for analysis.

The model should be continuously reviewed to be consistent with the processes in the operation which always changes in response to the customers or other factors. The accuracy of the data collection is also crucial. Even if the model is correctly developed, but the data input into the model are distorted, the results would become distorted too. Varila, Seppanen and Suomala (2007) recommend the use of Automatic data collection (ADC) methods to support cost accounting in order to increase the accuracy and versatility of accounting.

This research is concentrate only on the model development and determining the costs for the three main customers to be compared with the traditional method. For further study, there could be an opportunity for research deals with the use of ABC information to support Customer profitability analysis (Smith and Dikolli, 1995; Guerreiro, Bio and Merschman, 2008), and further into the process dimension of activity-based-management (ABM).

For further research, the study of how to estimate practical capacity which will be more accurate and reliable would be useful, especially the working time of employee within the service industry.

Furthermore, this thesis concerns only a case study of internal operation of one refrigerated warehouse. There are still lacks of research papers that propose methods on how to deal with, calculate and distribute costs in inter-firm relationships as in aspects of supply chain management. (Shulze, Seuring and Ewering, 2012)

REFERENCES

Thai

นิษฐิดา สุดใหม่, ฐิติพร ปานมา, พนิดา แซ่มช้าง, และ พรเพ็ญ ทิพยนา. 2550. การจัดการและต้นทุนโลจิสติกส์ของอุตสาหกรรมส่งออกอาหารทะเลแช่เย็นแช่แข็ง. ใน รายงานการประชุมสัมนาเชิงวิชาการประจำปีด้านการจัดการโซ่อุปทานและโลจิสติกส์ ครั้งที่ 7, หน้าที่ 386-397.

ภัทรธิรา เกื้อกิม. 2550. การวิเคราะห์ต้นทุนฐานกิจกรรม (Activity based costing) สำหรับการดำเนินงานคลังสินค้า กรณีศึกษา : อุตสาหกรรมบรรจุภัณฑ์พลาสติกอ่อน. วิทยานิพนธ์ปริญญามหาบัณฑิต สาขาวิชาการพัฒนาความสามารถทางการแข่งขันเชิงอุตสาหกรรม สถาบันวิทยาการหุ่นยนต์ภาคสนาม มหาวิทยาลัยเทคโนโลยีพระจอมเกล้าธนบุรี.

ศุภกานต์ อัครชัยพานิชย์. 2544. การวิเคราะห์ต้นทุนกิจกรรมสำหรับธุรกิจขนส่งด้วยรถบรรทุก. วิทยานิพนธ์ปริญญามหาบัณฑิต สาขาวิชาวิศวกรรมโยธา ภาควิชาวิศวกรรมโยธา คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย.

สมพงษ์ ปัญญายิ่งยง. 2553. การวิเคราะห์ระบบต้นทุนฐานกิจกรรม: กรณีศึกษาผู้ให้บริการรับจ้างขนส่ง. สารนิพนธ์ปริญญามหาบัณฑิต สาขาวิชาการจัดการทางวิศวกรรม บัณฑิตวิทยาลัย มหาวิทยาลัยศรีนครินทรวิโรฒ.

อัทธ์ พิศาลวานิช. 2553. การศึกษาโครงสร้างต้นทุนโลจิสติกส์ของไทยและการวิเคราะห์ผลกระทบจากราคาน้ำมัน. วาราสารวิชาการ มหาวิทยาลัยหอการค้าไทย 30(1) : 38-53.

English

Askarany, D., Yazdifar, H., and Askary, S. 2010. Supply chain management, activity-based costing and organizational factors. Int. J. Production Economics 127 : 238-248.

Baykasoglu, A., and Kaplanoglu, V. 2007. A service-costing framework for logistics companies and a case study. Management Research News 30(9) : 621-633.

Baykasoglu, A., and Kaplanoglu, V. 2008. Application of activity-based costing to a land transportation company: A case study. Int. J. of Production economics 116 : 308-324.

Everaert. P., Bruggeman. W., and De Creus. G. 2008. Sanac Inc.: From ABC to time-driven ABC (TDABC) – An instructional case. Journal of Accounting Education 26 : 118-154

Frozen processed food in Thailand[Online]. 2012. Euromonitor International. Available from: http://www.euromonitor.com/frozen-processed-food [2012, June 15]

Guerreiro, R., Rodrigues Bio, S., and Merschmann, E.V.V. 2008. Cost-to-serve measurement and customer profitability analysis. Int. J. of Logistics Management 19(3) : 389-407.

Gupta, M., and Galloway, K. 2003. Activity-based costing/management and its implications for operations management. Technovation 23 : 131-138.

Hansen, D.R., and Mowen, M.M. 2007. Managerial Accounting. 8th ed. Ohio, USA : Thomson South-Western,

Kaplan, R.S., and Anderson, R.S. 2004. Time-driven activity-based costing. Harvard Business Review 82(11) : 1-8.

Kaplan, S.R., and Anderson, R.S. 2007a. The innovation of time-driven activity-based costing. Cost Management 21 : 5-15.

Kaplan, R.S., and Anderson, R.S. 2007b. Time-driven activity-based costing: A simpler and more powerful path to higher profits. Boston. MA: Harvard business School

Kaplan, R.S., and Atkinson, A.A. 1998. Advanced Management Accounting. Upper Saddle River, NJ: Prentice-Hall. Cited in Varila, M., Seppanen, M., and Suomala, P. 2007. Detailed cost modeling: a case study in warehouse logistics. Int. J. of Physical Distibution & Logistics Management 37(3) : 184-200.

Kaplan, R.S., and Cooper, R. 1998. Cost and Effect: Using Integrated cost systems to drive profitability and performance. Boston, MA : Harvard Business School Press,

Lin, B., Collin, J. and Su, R. 2001. Supply chain costing: an activity-based perspective. Int. J. of Physical Distribution & Logistics Management 31(10) : 702-713.

Packaged Food: Euromonitor from trade sources/national statistic[Online]. 2010. Euromonitor International. Available from: http://www.euromonitor.com/frozen-processed-food [2010, August 28]

Salin, V. 2010. Global Cold Storage Capacity Report. 2nd ed. Virginia: International Association of Refrigerated Warehouses.

Schulze, M., Seuring, S., and Ewering, C. 2012. Applying activity-based costing in a supply chain environment. Int. J. Production Economics 135 : 716-725.

Smith, M., and Dikolli, S. 1995. Customer profitability analysis: an activity-based costing approach. Managerial Auditing Journal 10(7) : 3-7.

Stuart, I., McCutcheon, R., Handfield, R., McLanchlin, R., and Samson, D. 2002. Effective case research in operations management: a process perspective. Journal of Operations Management 20 : 419-433.

Tsai, W.H., and Kuo, L. 2004. Operating costs and capacity in the airline industry. Journal of Air Transport Management 10 : 271-277.

Van Damme, D.A., and Van der.Zon F.L.A. 1999. Activity Based Costing and Decision Support. The Int. J. of Logistics Management 10 : 71-82.

Varila, M., Seppanen, M., and Suomala, P. 2007. Detailed cost modeling: a case study in warehouse logistics. Int. J. of Physical Distibution & Logistics Management 37(3) : 184-200.

White, T.S. 1997. The 60 minute ABC book – Activity-based costing for operations management. Bedford, Texas, USA: Consortium For Advanced Manufacturing-International. Cited in Thermido, I., Arantes, A., Fernandes, C. and Guedes, A.P. 2000. Logistic costs case study – and ABC approach. Journal of the Operational Research Society 51 : 1148-1157.

Witiya Chongruksut. 2002. The adoption of Activity-based costing in Thailand. Doctor's thesis, School of Accounting and Finance, Faculty of Business and Law, Victoria University.

APPENDICES

Appendix A List of factors for Time Equation

Factor	Description	type of data
X_{10}	Number of order for goods reception (Inbound)	Discrete
X_{11}	Volume of goods inbound (kg)	Continuous
X_{12}	Number of warehouse lot number ; number of line item for inbound	Discrete
X_{13}	number of item inbound	Discrete
X_{14}	Number of inbound Vehicle	Discrete
X_{15}	Number of pallet for storage	Discrete
X_{16}	Number of basket for storage	Discrete
X_{17}	Number of conveyor	Discrete
X_{18}	Number of table	Discrete
X_{19}	Number of report	Discrete
X_{110}	Number of photograph taken on goods	Discrete
X_{111}	Number of sampling item	Discrete
X_{20}	Number of order for freezing service	Discrete
X_{21}	Volume of goods freeze (kg)	continuous
X_{22}	Number of warehouse lot number ; number of line item for freeze	Discrete
X_{23}	number of item for freeze	Discrete
X_{25}	number of shelve for freeze	Discrete
X_{29}	Number of report	Discrete
X_{210}	Number of photograph taken on goods	Discrete
X_{211}	Number of sampling item; checked item	Discrete
X_{30}	Number of order for withdrawing goods (outbound)	Discrete
X_{31}	Volume of goods outbound (kg)	continuous
X_{32}	Number of warehouse lot number ; number of line item for outbound	Discrete
X_{33}	number of item loaded out.	Discrete

Factor	Description	type of data
X_{34}	Number of Vehicle for outbound	Discrete
X_{35}	Number of pallet for outbound	Discrete
X_{36}	Number of basket for outbound	Discrete
X_{37}	Number of conveyor	Discrete
X_{38}	Number of table	Discrete
X_{39}	Number of report	Discrete
X_{310}	Number of photograph taken on goods	Discrete
X_{311}	Number of sampling item; checked item	Discrete
X_{312}	Number of unit loaded (outbond) : stack/slipsheet/pallet	Discrete
X_{40}	Number of order for thawing service	Discrete
X_{41}	Volume of goods for thawing (kg)	continuous
X_{42}	Number of warehouse lot number ; number of line item for thaw	Discrete
X_{43}	Number of item thaw	Discrete
X_{45}	Number of basket for thawing	Discrete
X_{49}	Number of report	Discrete
X_{410}	Number of photograph taken on goods	Discrete
X_{411}	Number of sampling item; checked item	Discrete
X_{50}	Number of order for packing	Discrete
X_{51}	Volume of packing goods (kg)	Continous
X_{52}	Number of warehouse lot number ; number of line item for packing	Discrete
X_{53}	number of item packed	Discrete
X_{57}	Number of conveyor	Discrete
X_{58}	Number of table	Discrete
X_{59}	Number of report	Discrete
X_{510}	Number of photograph taken on goods	Discrete
X_{511}	Number of sampling item; checked item	Discrete

Factor	Description	type of data
X_{91}	{document come in with driver?}	Indicator
X_{92}	{New Customer?}	Indicator
X_{93}	{New Product?}	Indicator
X_{94}	{Freeze?}	Indicator
X_{95}	{Repack?}	Indicator
X_{96}	{Label?}	Indicator
X_{97}	{Thawing?}	Indicator
X_{98}	{load by forklift?} for inbound	Indicator
X_{99}	{can drive-in?}	Indicator
X_{910}	{L1:R1,2 or L2:R3,4,5 or L4:R6,7} for inbound	Indicator
X_{911}	{L1:R3,4,5} for inbound	Indicator
X_{912}	{L2:R:1,2} for inbound	Indicator
X_{913}	{L2:R6,7 or L4:R3,4,5} for inbound	Indicator
X_{914}	{L1:R6,7 or L4:R1,2} for inbound	Indicator
X_{915}	{Handle by item?} for inbound	Indicator
X_{916}	{Full stack?}	Indicator
X_{917}	{7-point check?}	Indicator
X_{918}	{L1:R1,2 or L2:R3,4,5 or L4:R6,7} for outbound	Indicator
X_{919}	{L1:R3,4,5} for outbound	Indicator
X_{920}	{L2:R:1,2} for outbound	Indicator
X_{921}	{L2:R6,7 or L4:R3,4,5} for outbound	Indicator
X_{922}	{L1:R6,7 or L4:R1,2} for outbound	Indicator
X_{923}	{Handle by item?} for outbound	Indicator
X_{924}	{load by forklift?} for outbound	Indicator

Appendix B Consolidating resources costs into Activity centers

Resources		Labor	Facility	Machine	Supplies & miscellaneous	Insurance	total cost
Activty	Customer						
Inbound	Customer A	32,386.83	40,676.45	26,008.71	13,538.65	-	112,610.64
	Customer B	12,195.33	20,258.25	9,793.64	1,832.30	-	44,079.52
	Customer C	80,625.07	68,897.16	64,747.14	11,757.25	-	226,026.62
	Other customers	n/a	33,377.51	n/a	8,805.21	-	n/a
Blast Freezing	Customer A	n/a	-	n/a	-	-	-
	Customer B	n/a	-	n/a	-	-	-
	Customer C	n/a	-	n/a	-	-	-
	Other customers	n/a	37,384.20	n/a	2,341.27	-	n/a
Storage	Customer A	-	637,176.92	-		6,249.56	643,426.47
	Customer B	-	463,058.12	-		7,499.47	470,557.58
	Customer C	-	402,405.46	-		7,499.47	409,904.93
	Other customers	-	555,517.76	-		3,749.73	559,267.49
Thawing	Customer A	3,288.60	63,841.14	2,640.96	2,544.86	-	72,315.56
	Customer B	-	-	-	-	-	-
	Customer C	-	-	-	-	-	-
	Other customers	n/a	-	n/a	-	-	n/a
Outbound	Customer A	37,428.79	35,374.22	30,057.74	11,502.76	-	114,363.51
	Customer B	2,482.85	7,674.21	1,993.89	763.46	-	12,914.41
	Customer C	101,447.55	53,482.38	81,468.93	5,191.51	-	241,590.37
	Other customers	n/a	80,266.94	n/a	30,640.10	-	110,907.04
Packing/ Labeling	Customer A	n/a	-	n/a	-	-	-
	Customer B	n/a	-	n/a	-	-	-
	Customer C	n/a	-	n/a	-	-	-
	Other customers	n/a	96,391.76	n/a	916.15	-	97,307.91
total of allocated costs		269,855.02	2,595,782.46	216,711.02	89,833.52	24,998.22	3,197,180.24
total of cost unable to allocate		731,103.02	-	70,588.98	-	-	
Total costs		1,000,958.04	2,595,782.46	287,300.00	89,833.52	24,998.22	3,998,872.24

BIOGRAPHY

Miss Chutiporn Athikiat was born on 5th January 1986. Her birth place is in Samutprakarn province, Thailand. She had graduated in Department of International Business Management from Assumption University in year 2006 and has working experience in freight forwarding business for 2 years. Currently Miss Chutiporn is working as Management Representative at the refrigerated warehouse in Chachoengsao, Thailand.