DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

ACTIVITY BASED COSTING APPLICATION IN A MEDICAL SUPPLIES MANUFACTURING COMPANY

by
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İZMİR

ACTIVITY BASED COSTING APPLICATION IN A MEDICAL SUPPLIES MANUFACTURING COMPANY

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M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled **"ACTIVITY BASED COSTING APPLICATION IN A MEDICAL SUPPLIES MANUFACTURING COMPANY"** completed by **GÜLPERİ ÖLMEZ** under supervision of **PROF. DR. HASAN ESKİ** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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ACTIVITY BASED COSTING APPLICATION IN A MEDICAL SUPPLIES MANUFACTURING COMPANY

ABSTRACT

Improvements in production technologies in addition to information and communication systems, increases in international competition and necessity of customer oriented approach cause businesses to seek for new methods in area of cost management. Today, a cost information system is expected to be restructured to satisfy the needs of changing conditions and to provide timely, accurate and reliable information for managerial decisions.

The goal of this study is to develop an Activity Based Costing (ABC) model for a company which manufactures disposable medical supplies to determine accurate sales prices and make strategical decisions. Firstly, all activities were examined and modelled with IDEF0 diagrams. After the activity costs were calculated, product costs were found. At the end of the study, product costs calculated by ABC system and current traditional costing system of the company were compared. By the help of this analysis, right pricing decisions will made to be live in competitive market and how the product costs will be reduced for target prices will be determined.

Keywords: Activity Based Costing, IDEF0 diagrams.

TIBBİ MALZEMELER ÜRETEN BİR İMALAT İŞLETMESİNDE FAALİYET TABANLI MALİYETLENDİRME UYGULAMASI

ÖZ

Bilişim ve haberleşme sistemlerine ek olarak üretim teknolojilerindeki gelişmeler, uluslararası rekabetteki artış ve müşteri odaklı yaklaşım gerekliliği şirketlerin maliyet yönetimi alanında yeni yöntemler aramasına sebep olmuştur. Bugün, bir maliyet bilgi sisteminden beklenen, değişen şartların ihtiyaçlarını karşılaması için yeniden yapılandırılması ve yönetsel kararlarda doğru ve güvenilir bilgiyi zamanında sağlamasıdır.

Bu çalışmanın amacı, tek kullanımlık tıbbi malzeme üreten bir firmada doğru satış fiyatlarını belirlemek ve stratejik kararlar almak için Faaliyet Tabanlı Maliyetlendirme modeli geliştirmektir. İlk olarak tüm aktiviteler incelenmiş ve IDEF0 diyagramları ile modellenmiştir. Aktivite maliyetleri hesaplandıktan sonra ürün maliyetleri elde edilmiştir. Çalışmanın sonunda, Faaliyet Tabanlı Maliyetlendirme sistemi ve şirketin mevcut geleneksel maliyetlendirme sistemi ile elde edilen ürün maliyetleri karşılaştırılmıştır. Bu analiz yardımıyla, rekabetçi pazarda hayatta kalabilmek için doğru fiyatlandırma kararları alınacak ve hedef fiyatlar için ürün maliyetlerinin nasıl düşürüleceği belirlenecektir.

Anahtar sözcükler: Faaliyet Tabanlı Maliyetlendirme, IDEF0 diyagramları.

CONTENTS

Page

THESIS EXAMINATION RESULT FORM ii

ACKNOWLEDGEMENTS iii

ABSTRACT iv

ÖZ v

CHAPTER ONE – INTRODUCTION 1

1.1 Introduction 1

1.2 Objective of the Research 3

1.3 Organization of the Thesis 3

CHAPTER TWO – COST ANALYSIS 4

2.1 Introduction to Costing 4

2.2 General Cost Structure 5

2.2.1 Production Costs 5

2.2.1.1 Direct Material Costs 6

2.2.1.2 Direct Labor Costs 6

2.2.1.3 General Production Costs (Overhead Costs) 7

2.2.2 Non-Production Costs 8

2.3 Comparison of Traditional Costing and Activity Based Costing 8

2.3.1 Traditional Costing 8

2.3.2 Activity Based Costing versus Traditional Costing 12

CHAPTER THREE – ACTIVITY BASED COSTING 15

3.1 Introduction to Activity Based Costing 15

3.2 Literature Review 17

3.3 Basic Concept of Activity Based Costing 20

3.4 Information Gathering Procedures 23

3.4.1 Educated Guess 24

3.4.2 Systematic Appraisal 24

3.4.3 Collection of Actual Data 25

3.5 Application Steps of Activity Based Costing 25

3.5.1 Identification of Overhead Expense Categories 25

3.5.2 Identification of Activities or Cost Pools 26

3.5.3 Identification of Expense Drivers 28

3.5.4 Assignment of Overhead Costs to Activities 29

3.5.5 Identification of Activity Drivers 30

3.5.6 Assignment of Activity Costs to Products 31

3.6 Advantages of Activity Based Costing 32

3.7 Activity Based Management 34

CHAPTER FOUR – IDEF0 DIAGRAMS FOR BUSINESS PROCESS MODELLING 38

4.1 Business Process Modelling and Techniques 38

4.1.1 Flow Chart Technique 38

4.1.2 Data Flow Diagrams 39

4.1.3 Role Activity Diagrams - RAD 39

4.1.4 Role Interaction Diagrams - RID 40

4.1.5 Gantt Chart 41

4.1.6 Coloured Petri net - CPN 41

4.1.7 Object Oriented Methods 42

4.1.8 Workflow Technique 42

4.1.9 IDEF 43

4.2 IDEF0 Concept 45

4.2.1 Introduction to IDEF0 45

4.2.2 Structure of IDEF0 46

4.2.2.1 Boxes 46

4.2.2.2 Arrows 46

4.2.3 Types of Diagrams 48

CHAPTER FIVE – AN APPLICATION IN A MEDICAL SUPPLIES MANUFACTURING COMPANY 50

5.1 General Information About the Company 50

5.2 Production System of the Company 51

5.3 Current Costing System of the Company 52

5.4 Implementation of Activity Based Costing 56

5.4.1 Identification of Expense Categories and Expense Drivers 57

5.4.2 Identification of Activities 60

5.4.3 Assignment of Overhead Costs to Activities 63

5.4.4 Assignment of Activities to Products 70

5.5 Comparison of the Results 79

CHAPTER SIX – CONCLUSION 95

REFERENCES 97

APPENDIX 100

CHAPTER ONE
INTRODUCTION

1.1 Introduction

Changes in business environment as a consequence of increased globalization have come with significant modifications in companies' products, processes and services. Companies need to adjust their products, processes and services to rapid changes in order to gain competitive advantages in the global market. As competition increases, companies aim to meet customer demands with better, cheaper and customized products. This goal supports a business environment where marketing, distribution, engineering and new production techniques become prominent. Faster response supported with improved quality and lower cost enhances the competitive advantages of companies. Therefore, accurate and up-to-date costing information is required for supporting timely and strategic decisions. Companies need a better understanding of their products and services to succeed in today's business environment.

In current competitive market, customers want high quality products with lower prices. So every company tries to organize and utilize effectively costs for materials, direct labor, utilities, supply, management, and organizational support. In general, the cost of a product can be reduced by minimized cost of the production. Decreasing scrap rate or breakdown of machines can increase productivity and output quantity. Minimizing the number of parts used in product, designing parts for ease of handling and assembly and selecting the best material/process combination for the economical manufacturing of individual parts can reduce the manufacturing cost of a product. In order to be competitive in the market, the company needs to completely understand how to organize effectively the costs of manufacturing for each department, each activity, and each product in the company. In order to understand and manage these costs, the management team needs to find the cost analysis which effectively demonstrates true costs in manufacturing and also use the cost data to plan effective strategies.

Costing systems enable managers to understand products, services, suppliers and customers and to help make strategic decisions such as mix of product line, product pricing, identifying the locations for sourcing components and assessing new technologies. However, traditional costing systems that strictly use a volume related cost driver lead to distorted product costs in today's manufacturing environment where direct labor is less frequent and overhead costs are high. The allocation of overhead costs becomes a vital problem in product costing if the proportion of overhead costs is relatively higher than direct costs. As a result of the need for a different costing system that uses multiple cost drivers including non volume related cost drivers, Activity Based Costing (ABC) was designed to trace overhead costs directly to products where traditional costing systems are not very successful.

ABC was developed as a response to changes in today's production environment and market requirements. As a result of advanced technologies in production techniques, increased diversity in products and greater importance of marketing and distribution activities in the business environment, the proportion of direct costs is decreasing as indirect or overhead costs are increasing as components of total product costs.

Unlike traditional costing systems which assume that products consume the resources, ABC assumes that activities consumes resources and then costs are allocated to products according to their demand for these activities. ABC can achieve high accuracy in product costing by using multiple cost drivers, differing from traditional costing systems which utilize a single cost driver. Traditional costing systems trace the overhead costs to the products with a volume based cost driver such as direct labor hours or machine hours. ABC utilizes both volume related cost drivers and non volume related cost drivers, such as set up hours, number of purchase orders, and maintenance hours. Design and performance of ABC systems heavily depend on cost driver selection.

ABC has an important role on improving quality and productivity. A lot of activity needs for production of every product and all activities consumes resources.

Costs must been managed very good to stay in competitive.

1.2 Objective of the Research

The objective of this study is to develop an ABC model in a medical supplies manufacturing company to make accurate sales prices forecasts. All computations made with Oracle because of the huge data and computational difficulty. Moreover, proposed model can be integrated current ERP system of the company.

1.3 Organization of the Thesis

This thesis demonstrates step by step how to design and implement an ABC system for a manufacturing company. It consists of six chapters.

In Chapter Two, necessity of cost analysis has been explained. Then, traditional costing systems and ABC system versus traditional costing have been explained briefly. In Chapter Three, application steps of ABC have been explained with examples and benefits of using ABC have been presented. In Chapter Four, business processing modeling techniques have been introduced and IDEF0 diagrams have been explained briefly to be used at activity determination stage of ABC. In Chapter Five, the ABC system has been applied to a medical supplies manufacturing company. Firstly, general information about the company has been given. Then, ABC methodology and IDEF0 diagrams have been used for the ABC implementation. Application results have been compared with company's current costing system to see differences between two systems. In Chapter Six, concluding remarks has been presented.

CHAPTER TWO
COST ANALYSIS

2.1 Introduction to Costing

It is important for the company to know the manufacturing cost. The company can thus know whether the product can be profitably manufactured and if so, at what price it should sell. The manufacturing cost helps in the make or buy decisions for parts of the product which might be outsourced. The overall profit is affected by the product mix which is manufactured by the company. As a result of knowing the manufacturing costs, decisions can be made regarding whether production of a certain product should be terminated, and quantities of each product to be made so as to maximize the utilization of resources.

Determination of cost of every product by detailed and accurately is very important in the areas such as product pricing, investment analysis and assessment, cost management and control, production, sales, investment and cash budgets. Accurate cost information must have to make proper decisions. In order to retain the competitive status, a company should be able to provide high quality services or products in a short period of time with lowest possible cost. In order to be able to provide lower costs, accurate cost information is very important and it affects the pricing policies and performance reviews.

In a competitive market place, the cost of a product can be the decisive factor regarding whether the product succeeds or fails. The market price depends on internal and external factors to the company. These include:

- Total cost to the company,
- Marketing and distribution costs,
- Price of comparable products on the market,
- Desired market share.

Generally product price is determined by cost basis. It shows lowest level of the price. Sales price is calculated with the addition profit on cost. This is cost plus profit approach.

Companies need cost information with three reasons generally;

1. To generate cost information on financial tables which are prepared for presentation of information to investors, creditors and government agencies.

2. To collect performance information that cannot be obtained from financial reports which include data related to all of the company.

3. To provide necessary costing information to management in decision making process oriented to future. For example, decision of starting to production for new products, decision of ending to production for existing products, determination of opportunity on price, quality and service, preparing budgets.

Since lots of the companies do not produce only one kind of product and sometimes production processes are very complicated, cost calculations become difficult. So companies develop cost systems which are suitable their own production environments.

2.2 General Cost Structure

Figure 2.1 shows cost elements in unit price of a product for all stages from beginning of production to sales. According to production stages, costs can be classified as follows.

2.2.1 Production Costs

Cost elements which constitute manufactured products costs can be divided into three categories.

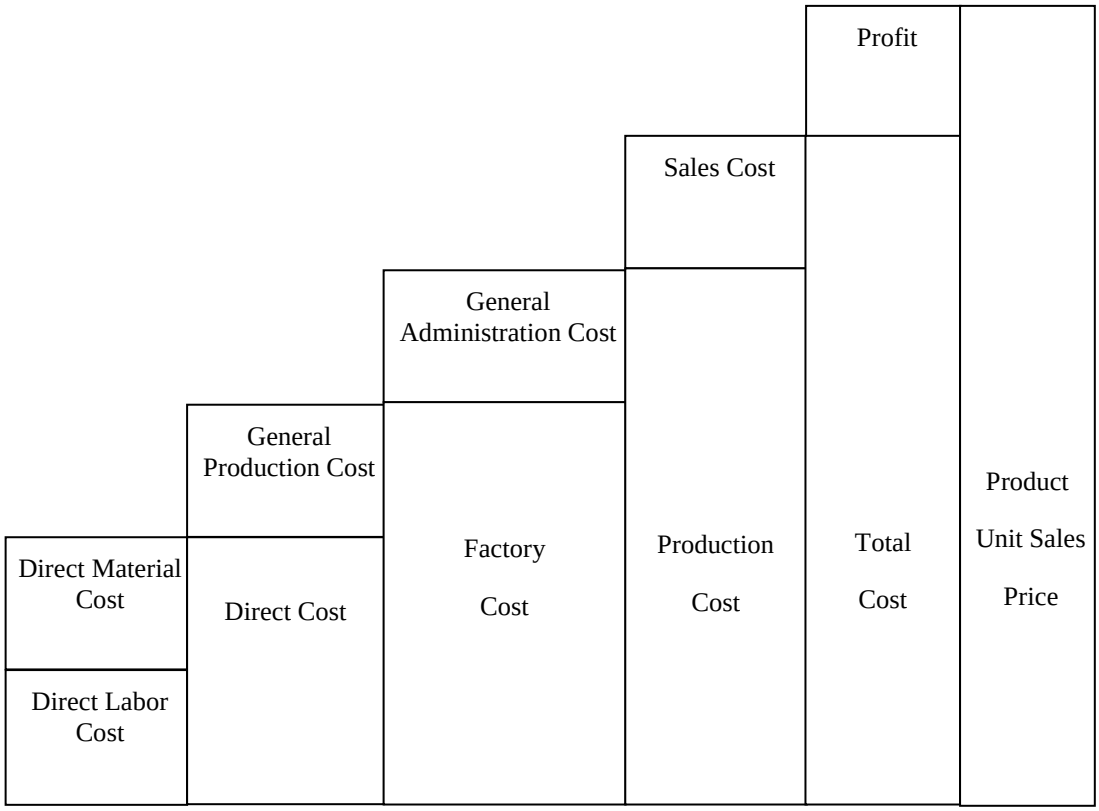

Figure 2.1 Costs according to production stages (Eski & Armaneri, 2006)

2.2.1.1 Direct Material Costs

This cost includes costs of raw materials which are used in manufacturing of a product directly. The simplest and most widely used method is to calculate average of the input prices of the materials which are enters the stock in different dates. Other methods are FIFO and LIFO.

2.2.1.2 Direct Labor Costs

This cost includes salaries of the workers who actually work in production. Salaries of indirect labors such as maintenance personnel, warehouse personnel are in general production costs.

2.2.1.3 General Production Costs (Overhead Costs)

This cost includes indirect labor costs, indirect material costs, especially depreciations, renting, insurance expenses, energy and heating expenses. Determination and distribution of general production costs creates important problems for business management. These costs should be distributed in accordance with business goals and cost politics. In practice, there is a lot of easy method for distribution of general production costs, such as direct labor costs method, direct labor hour method, direct material method (Eski & Armaneri, 2006).

The total manufacturing costs can be classified in several ways. For example, they divided into material and production costs. They may also be classified as

- *Direct costs* which include material and labor costs and can be assigned to the product. They affect product costs directly.

- *Indirect or overhead costs* such as heating and lighting which cannot be directly assigned to the product. They provide continuity of production activities.

Moreover, the costs may be divided into:

- *Variable costs* which consist of direct costs and variable overhead costs. They include material costs per unit and processing costs for each unit produced, i.e. direct labor and machine time. These costs like energy, heating increase with the increase in production volume or decrease with the decrease in production volume.

- *Fixed costs* which remain constant over a period of time. They include set-up and tooling costs for each batch produced. These costs does not increase or decrease by the amount of the production in a certain time period. (i.e. renting, depreciation, insurance and consultancy expenses)

A way of costing a product which is used by many companies is called traditional cost breakdown. Direct costs are direct labor and material costs. All other costs are collected under the name of overhead. The overhead assigned to a product is proportional to the direct labor, material cost or a combination of material and direct labor. This assignment can cause distribution of the overhead costs wrongly (Hundal, 1997).

Ben-Arieh & Qian (2003) classified cost estimation methods as intuitive, analogical, parametric and analytical methods. The intuitive methods are based on past experience of the cost estimator. The analogical methods determine the cost of a product according to similarity to other products whose cost is known. The parametric methods estimate the costs of a product from parameters, which are usually used by the designers. These parameters influence the cost with a simple equation. Analytical methods such as ABC allow evaluation of the cost of a product from a decomposition of the work into operations or activities with their related cost.

2.2.2 Non-Production Costs

This costs which are not related to production activities, should be taken into consideration in determining sales price of the product. These are general administration costs and sales costs. General administration costs include management and organization expenses related to business management. Sales costs include distribution costs of products in marketing process, advertisement and promotion expenses, sales commissions, and expenses related to salesperson (Eski & Armaneri, 2006).

2.3 Comparison of Traditional Costing and Activity Based Costing

2.3.1 Traditional Costing

Cost management systems are tools for managers to understand the performance of production systems and employees. If a costing approach which they rely on is not

suitable, then their estimation on business performance can mislead them to reject automation investment projects necessary for implementing manufacturing strategies such as Just-in-Time (JIT) manufacturing and Total Quality Management (TQM). The traditional cost management systems which were developed decades ago for costing labor intensive products can not make cost reduction of process improvements in advanced manufacturing systems. The traditional costing fails to report the process improvements and it is also unable to determine the cost of the activities being done by the organization (Chen, 1996).

In the traditional approach, unit product cost is found according to variable and fixed overhead costs. The fixed costs are allocated based on the assumption that products use overhead resources in proportion to the variable costs. So, the allocation may be proportional to the material costs or labor costs or machine time. This method can cause that higher costs are distributed to low volume products rather than high volume products (Hundal, 1997).

Traditional costing systems assume that different products produced on the same facility use overheads with proportion to their direct labor time or direct resource. This assumption is not true for modern production systems, because different types of products which are produced in the same facility may rarely use overheads with proportion to the direct labor time. Therefore, costs calculated with traditional costing may gives too much distorted information about production cost to decision makers.

Traditional costing systems provide only financial information and they are not concerned with factors such as quality and service. Non financial information such as defect rates and throughput rates in each activity is out of the scope of the traditional costing system (Gunasekaran et al., 1999).

Traditional costing method can be explained with a simple example. In this example, a company produces two types of product with similar production process. It is supposed that the company trace production costs weekly. Company has

technology intensive production system, so general production costs are distributed by machine hour driver. Total general production cost of the company is 15000 per week. In Table 2.1, necessary data for calculation of unit product costs can be seen.

Table 2.1 Production and cost data

	Product X	Product Y
Direct material cost	25	18
Direct labor cost	20	22
Machine A (min.)	15	10
Machine B (min.)	15	30
Machine C (min.)	15	5
Machine D (min.)	15	5
Total machine time / Unit product	60	50

If the company produces 100 of product X and 30 of product Y in a week, unit product costs are calculated as is seen in Table 2.2.

Table 2.2 Unit production cost for 100 of product X and 30 of product Y

	Product X	Product Y
Production amount / week	100	30
Direct material cost	2500	540
Direct labor cost	2000	660
Machine A (min.)	3000	600
Machine B (min.)	3000	1800
Machine C (min.)	3000	300
Machine D (min.)	3000	300
Total cost	16500	4200
Unit cost	165	140

If weekly production of the company decreases 20%, product X in a week will produce 80 units and product Y will produce 24 units. But general production costs will remain 15000 without change. Effects of reduction on production volume to unit product cost can be seen in Table 2.3.

As it is seen above Table 2.2 and Table 2.3, periodic (weekly) general production costs distributed by only one driver (machine usage time) in proportion to the production volume at the same period. At this method, if periodic production volume

changes, per unit installed direct material and direct labor costs does not change. But the problem occurred at the point of loading of various costs that includes important cost elements in general production costs and they are accepted constant periodically. It causes differences in unit product costs periodically. This situation can be seen in the tables. 20% reduction on weekly production volume increased unit production cost to 30 for X and 25 for Y. Because of impact of production volume fluctuations on unit product costs, management can not do short term strategic plans and produce efficient pricing and promotion decisions.

Table 2.3 Unit production cost for 80 of product X and 24 of product Y

	Product X	Product Y
Production amount / week	80	24
Direct material cost	2000	432
Direct labor cost	1600	528
Machine A (min.)	3000	600
Machine B (min.)	3000	1800
Machine C (min.)	3000	300
Machine D (min.)	3000	300
Total cost	15600	3960
Unit cost	195	165

Traditional performance measures are based on financial results which are derived from the general ledger, budget and standard costing systems. Some common problems related to traditional cost management systems are as following:

- Traditional costing systems look backward. Thus, organizations have trouble using this information to influence the future. With traditional systems, there are no answers to the question “What does it say about current or future processes and practices?”

- Traditional costing techniques fail in capturing cost. So allocation methods do not reflect the true cost across the operations of a business. As a result, operational management tends to ignore cost information.

- In a traditional costing system, reporting of costs does not reflect the true flow of processes in the business.

- A traditional costing system does not focus on customer. There is no differentiation between activity costs and added value to customers.

- Traditional costing systems do not identify key cost drivers for overhead costs. So the change and development of organizations is not examined.

- Traditional costing systems do not point out how to improve current processes.

The most important problem is that costing is only an output measure, and it is only used at the organizational level. Traditional costing focuses on gathering information for external reporting and upper management review. Consequently, there is very high level of aggregation and little low level of detailed reported. Since reports are only produced on a monthly, quarterly, or even yearly basis, there is little focus placed on how to use the financial information to improve the organization and increase profits.

2.3.2 Activity Based Costing versus Traditional Costing

In traditional costing methods, most companies produce a narrow range of products. Applying the same methods for a wide range of products causes incorrect cost information. Accurate cost information is used for management and control purposes from production to marketing. Therefore production costs and value added activities are very important. ABC aims not only to allocate overhead costs accurately, but also identifies the areas of waste. It considers that activities like purchasing, receiving, setting up and running a machine consume resources, and products consume activities. So ABC traces the cost of products according to the activities which are performed on and gives more accurate cost information with less distortion (Gunasekaran & Sarhadi, 1998).

ABC system is different from traditional system in two ways: first, cost pools are defined as activities rather than production cost centers and secondly, the cost drivers used to assign activity costs are structurally different from those used in traditional costing systems. In traditional costing systems, direct materials and direct labor are the only costs traced directly to the product. Manufacturing overhead costs are not traced, but they are allocated to the production departments. They may be traced to an activity or a service department or some other cost objective, but not to the product itself. The ABC method identifies the activities that drive costs by consuming resources. Cost drivers are items such as number of units produced, labor hours, hours of equipment time, or number of orders received. Traditional costing systems are known to distort the cost information by using traditional overhead allocation methods that rely on direct resources such as labor hours. On the other hand, ABC has gained the recognition of a more accurate cost estimation and calculation method (Ben-Arieh & Qian, 2003).

Traditional costing calculates the total cost of raw materials and direct labor and then it applies overhead costs using an arbitrary allocation factor such as the volume of production. On the other hand, ABC distributes variable, fixed, and overhead costs directly to each product or service by using the activities required to produce the product or service. The total cost of a product or service with ABC equals the cost of raw materials plus the total cost of all activities used to produce it (Rezaie et al., 2008).

ABC system based on that concept; products consume company resources on the basis of activities and so indirect expenses must be classified on the basis of activities. It is a cost and management concept which establish linear relationship on various levels regardless only production volume between product and indirect expenses. In traditional costing system, general production expenses distributed to products with a predetermined coefficient. In other words, it is assumed that there is a linear relationship between produced products or provided service volume and expenses. In ABC system, general production expenses are accumulated on the basis of activities which are necessary for continuity of production and they are distributed

to products in various activity levels via cost drivers. In the next stage, general production costs are distributed to cost objects like job, product, and service in proportion to consumed activities.

CHAPTER THREE
ACTIVITY BASED COSTING

3.1 Introduction to Activity Based Costing

Since traditional costing system is not designed to be suitable for new production environments and companies are insufficient in managerial decisions such as product pricing, product profitability analysis, new searches began. In 1980s, rapid expansion of Advance Manufacturing Technology and Japanese who moving with effective new management concepts like Just in Time (JIT) production, Total Quality Management (TQM) was posing the greatest thread for American industry. Effects of globalization in the world on American industry caused to search for new cost. First studies were made by Robert Kaplan and Robin Cooper. A small percentage of organizations adopted it. Studies on ABC expanded with emergence of the lack of traditional costing (Öker, 2003).

Since ABC was introduced by Kaplan and Cooper as an alternative to traditional costing techniques, it has been increasingly used in complex manufacturing organizations. ABC models the relationships between products and resources which are used in their production at all stages (Özbayrak et al., 2004).

ABC operates on a simple concept of two stage assignment of costs; resources are consumed by activities and activities are consumed by products or services to satisfy customer demands. ABC takes a two stage approach to allocating overhead costs to products based on multiple cost drivers at various levels of activity. In the first stage, overhead costs are assigned to cost pools within an activity centre based upon activity driven cost drivers. In the second stage, overhead costs are allocated from the cost pools to the products based on the product's consumption of indirect activities. During the moving from ABC to an Activity Based Management (ABM) system, there is also a transition from a cost assignment view (i.e. from resources → activities → cost objects) to a process management view (i.e. cost drivers → activities → performance measures) as shown in Figure 3.1. The vertical section

includes the strategic view that measures the cost and performance of related activities and the products and service that uses those activities. The horizontal section is the operational view that focuses on managing the activities and their processes. While an activity based approach is used for both strategic ABC and operational ABM, it is used in differing ways.

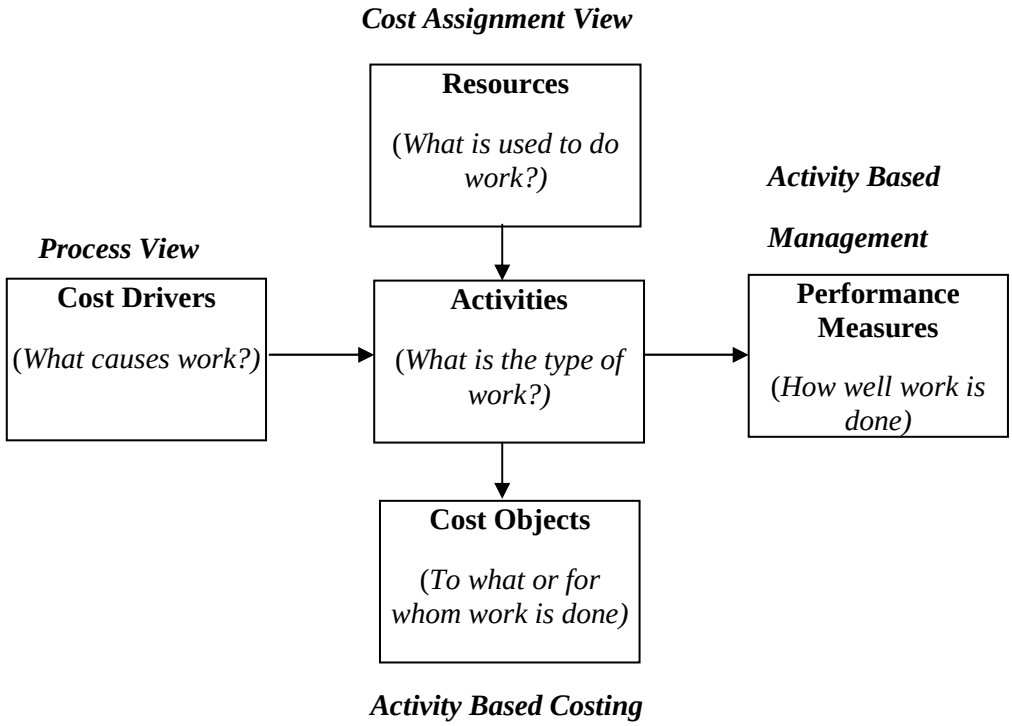

Figure 3.1 Activity Based Costing/Management information system (Gupta & Galloway, 2003)

ABC focuses on the strategic view of cost which is called the cost assignment view. It gives information such as product costing, and distribution channel costing. As noted in the Figure 3.1, the assignment of costs is done with a two stage driver model that goes first from resources to activities (stage 1) and then from activities to cost objects (stage 2). Because of these assignments, an activity driver represents a line item on the bill of activities for a particular cost object like a product or customer. A bill of activities lists each activity, activity drivers, number of units, unit cost per driver, and extended cost compose the total for any particular cost object.

Moreover ABM focuses on the operational view of cost which is often called the process view. It provides information such as activity attributes for cost reduction

opportunities, cost of quality statements, and performance improvement ideas. ABM deals with cost drivers instead of activity drivers.

3.2 Literature Review

There is a wide variety of research about ABC. In most of the research, traditional costing systems and ABC were compared. While they were giving failures of traditional costing systems, advantage of ABC was highlighted with examples.

Chen (1996) pointed out the need for using ABC and implementation guidelines for justifying advanced factory management systems with an example.

Hundal (1997) described cost structures and costing methods. A comparison of traditional costing and ABC was made with an example. The example shows that larger lot size leads to lower cost.

Gunasekaran & Sarhadi (1998) gave a framework for the implementation of ABC. Some cases for five Finnish companies from different sectors were presented to show implementation of ABC in their organizations. Steps of implementation process for ABC are identification the cost objects, analyzing the activities, identification cost allocation methods and monitoring implementation.

Gunasekaran et al. (1999) investigated the cost management practices in small and medium enterprises and gave a framework in implementation of ABC. Implementation steps include top management commitment, organization of ABC program, seminar on ABC, incentive to motivate participation, education and training on ABC, analysis of the critical activities, identify value adding and non-value adding activities, and monitor the implementation.

Gunasekaran & Singh (1999) made an application in a small company that produces machines for photo framing industry. The objective is to develop an ABC system that will produce more accurate cost information and provide information to a

make or buy decision for parts and implication of ABC on the operations control and the performance of the whole company.

Rasmussen et al. (1999) presented an integrated simulation and activity based approach for determining the best sequencing scheme for processing a part family through a manufacturing cell. An example was given to determine the best part sequence in a U-shaped manufacturing cell.

Gunasekaran et al. (2000) made an application of ABM in a company to make accurate strategical decisions. Performance measurement at activity level was pointed out. A model was developed to describe components of the ABM.

Ben-Arieh & Qian (2003) presented a methodology of using ABC to evaluate the cost of design and development activity for machined parts. The activities were analyzed using IDEF0 methodology. The application of ABC towards analysis of the design and development costs was demonstrated. An example for ABC implementation was given for design and development of rotational parts.

Gupta & Galloway (2003) discussed how an Activity Based Costing/Management (ABC/M) systems can support effective operations in decision making processes such as production planning and design, quality management and control, process design and improvement, inventory and procurement management, capacity and investment management, work force management, empowerment and accountability, roles and responsibilities, performance measures. Some managerial implications of ABM systems and implementations for operations managers were given.

Needy et al. (2003) presented the results of a study involving the implementation of ABC in three small manufacturing companies with less than 100 employees. Costing system needs and implementation methodology were discussed. ABC implementation process consists of four phases; cost system evaluation, ABC design, ABC implementation and system evaluation and validation.

Nachtmann & Al-Rifai (2004) developed an ABC system in an air conditioner manufacturing company. In this study, the company's main problem is the current traditional costing accounting system that is not accurately representing their product cost behavior. The research objective is comparison of proposed ABC system and current costing system which allocated overhead costs using direct labor hours as the single cost driver and pointing out that ABC system can provide more accurate indirect cost information and helps in making product, process improvement decisions. In assignment of overhead costs to cost pools, an expense activity dependence matrix was used.

Özbayrak et al. (2004) gave a model to estimate the manufacturing and product costs by using ABC and simulation in an advanced manufacturing system that is run under either a push or pull system. Manufacturing activities were described alongside a mathematical model which calculates the unit costs of manufactured products using ABC analysis and provides basic data for simulation model. An experimental study was done to demonstrate calculation of product costs under different manufacturing scenarios.

Roztocki et al. (2004) proposed a procedure for transition from traditional costing system to ABC system for especially small companies. In this method, overhead expenses such as administration, rent, utilities, are compiled into product cost information using newly developed matrices. Using these matrices, calculations related to costs become easy and overhead costs are traced without difficulty to the cost objects. The use of proposed procedure is illustrated using actual data from a small manufacturing company.

Baykasoğlu & Kaplanoğlu (2008) presented an application of ABC to a land transportation company. Business process modelling and analytical hierarchy approach were proposed with ABC. The results obtained from the ABC analyses are also compared with the traditional cost accounting practice of the company in order to see if there is a difference.

Park & Simpson (2008) presented a production cost estimation framework to design cost effective product families. A case study was given to demonstrate the proposed use of ABC system. Activity costs were mapped to individual parts in the product family with the name of cost modularization.

Qian & Ben-Arieh (2008) proposed a cost estimation model which links ABC with parametric cost representations of design and development phases of machined rotational parts. Different parametric models were also presented to apply at design phase by using part's geometrical parameters. Design activities were modeled with IDEF0 diagrams. Product cost estimation methods in the product family design supports decisions, such as supply chain selection, price decision, and optimal platform in one product family.

Rezaie et al. (2008) proposed a model for the implementation of ABC using the product cost tree concept for flexible manufacturing systems. An application was done in a forging industry. A comparison between ABC and traditional costing was carried out from the case study.

3.3 Basic Concept of Activity Based Costing

The basic concept behind product costing in an ABC system is that the total cost of a product equals the cost of all value adding activities to produce it. According to the ABC system while some of the overhead resources increase in proportion to the volume of products produced, the rest of the overhead resources do not. The ABC system has the following cost allocation bases or cost drivers (Gunesakaran & Sarhadi, 1998):

- Unit-level bases, which assume that inputs increase in proportion to the number of units produced (e.g. material, direct labor, machine costs, energy),

- Batch-level bases, which assume that inputs vary in proportion to the number of batches produced (such as machine set-up, purchase orders, inspection, material handling),

- Product-level bases, which assume that inputs are necessary to support the production of each different type of product (e.g. product and process engineering),

- Facility level bases, which simply sustain a facility's general manufacturing process (e.g. building, utilities, and general management).

ABC can be used to identify non-value adding activities and eliminate them with the objective to improve the performance of a manufacturing system. An activity cost is the summation of costs of resources that are used by that activity. The basic concept in ABC;

Product cost = Raw material cost + Activities cost

ABC model has two stages as shown in Figure 3.2. In the first stage, costs are assigned to cost pools within an activity center based on a cost driver. There is no equivalent step in a traditional costing approach. In the second stage, costs are allocated from the cost pools to a product based on the product's consumption of the activities. This stage is similar to a traditional costing approach except that the traditional approach solely uses volume related characteristics of the product without consideration for non-volume related characteristics such as number of setups, setup hours and number of orders (Roztocki et al., 2004).

Cost calculation of the products or services is based on the determination of direct costs and indirect costs and then summing them to find the individual cost of each element. Traditional costing involves collecting indirect costs from departments and then allocates them to products or services. The overheads distribution 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 cost objects. It is not a sufficient method for a detailed cost analysis. On the other hand, the main premise behind ABC is to classify overheads and to allocate them to end products based upon the activities required to produce these products. (Baykasoğlu & Kaplanoğlu, 2008)

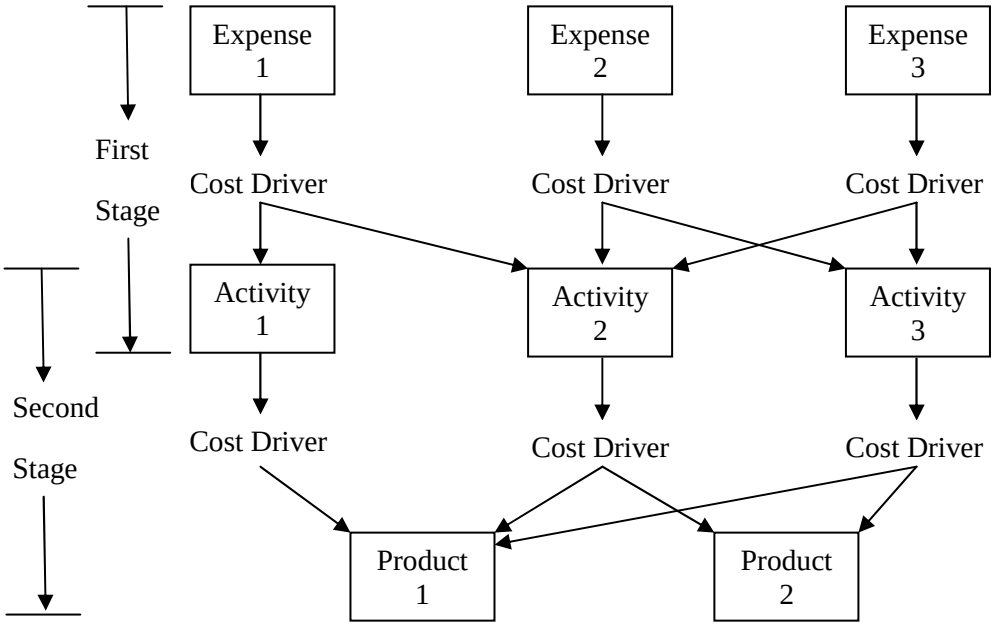

Figure 3.2 Relationship among expense categories, activities, and products (Roztocki et al., 2004)

ABC systems examine all activities which are relevant to the production of a product and try to determine what portion of each resource is consumed. The information which comes from ABC/M systems can help determine which products are profitable, which customers are the most valuable, whether processes are value-added or not, and where efforts toward improvement should be made (Gupta & Galloway, 2003).

If the example about traditional costing in previous chapter is discussed with ABC approach, first of all weekly general production costs that is 15000 must be examined. Each four machines can be considered as different activities. In the second phase, share of total general production costs for every activity (machine) can be studied. Thirdly, a driver that is independent of real production volume must be determined for every activity. In this example, weekly production capacity for every

machine can be a driver for full capacity production. Table 3.1 gives calculation of cost driver for all activities.

Table 3.1 Capacity and cost data

	cost/week	capacity (min)	cost/unit
Activity A	750	3000	0.25
Activity B	12000	2400	5.00
Activity C	1000	2500	0.40
Activity D	1250	2500	0.50

As it is seen in Table 3.2, unit product costs are generated with usage rate of different activities that constitute general production costs. Thus, unit product costs does not effect from periodic fluctuations on production volume and more stable decisions of pricing, sales, promotion are made. Company management can do efficient applications in cost management and control as a result of examining of different cost factors that constitute general production costs indivually.

Table 3.2 Unit product costs according to ABC

	cost/unit (X)	cost/unit (Y)
Direct material cost	25	18
Direct labor cost	20	22
Machine A	3.75	2.50
Machine B	75	150
Machine C	6	2
Machine D	7.5	2.5
Unit cost	137	197

3.4 Information Gathering Procedures

Gathering information is necessary in order to increase accuracy of final product costs. An important part of the required data is the proportions needed in each stage of an ABC system. Each activity consumes a portion of an expense category. Similarly, each product consumes a portion of an activity. For instance, quote preparation activity consumes 10% of administration expenses. There are many ways to obtain these proportions and the selected procedure will impact the desired accuracy. Three levels of data accuracy can be used in estimating these proportions:

educated guess, systematic appraisal, and collection of real data (Roztocki et al., 2004).

3.4.1 Educated Guess

If real data cannot be obtained or data collection cannot be succeed financially, an educated guess can be made in order to generate proportions. These guesses should be done collaboratively by management, financial organizers and operational employees who are associated with the costing center. Thus an educated guess of the proportions of costs allocated in both stages of ABC methodology is provided. The level of accuracy obtained is based on a combination of the teams' diversity and their knowledge of the cost center.

3.4.2 Systematic Appraisal

A more scientific way to obtain the proportions for tracing costs is using a systematic technique such as Analytic Hierarchical Process (AHP).

AHP is a suitable tool for pulling subjective individual opinion into more representative information. For example, AHP could be used if the allocation of a gasoline expense is needed between three cost pools which are sales, delivery and maintenance. By asking the departments that consume this resource to evaluate what percentage of mileage they accumulate in a certain period of time, AHP can generate the percentage of this expense and allocate it to the appropriate cost pool.

A second area in which AHP can be used is to allocate the expense from the cost pool to each product. At this step it is important to determine an appropriate cost driver in order to achieve the desired level of accuracy. For example, suppose we wish to trace the sales cost pool to each product. One approach is to estimate the level of sales activity needed for each of the individual products. For example, a company produces five products. Product A is a very well established product requiring minimal effort from the sales representatives when they talk to potential

consumers. On the other hand, products B, C, and D are in the middle of their life cycle. Finally, product E is a new product that consumes a lot of the sales representatives' time. Instead of allocating an equal amount of sales expenses to each of the products, AHP can provide an estimation that would allow the company to trace this cost more accurately to the products. The methodology followed by AHP requires first a determination of the factors that account for cost relationships between activities and products. Locations of travel for sales and time spent with the client discussing each individual product may be some examples of these factors. Secondly, the sales representative assigns a ranking among products according to the distance needed to support them. A second ranking among products is established in proportion to the time spent with the customer. Finally, the subjective rankings of sales representatives are combined by AHP and ratios for sales expenditure among the five products are obtained.

3.4.3 Collection of Actual Data

The most accurate procedure for computing proportions is the collection of real data. In most cases, a data collection procedure must be developed and data collection equipment may need to be purchased. Moreover, collection of the data will need to be timely and skilled collectors may be required. The results often have to be analyzed using statistical methods. For example, job sampling can be used to estimate the proportion of time dedicated to supervise the manufacturing of a particular product. In this case, the supervising engineer is asked, at random time intervals, to specify the product being currently supervised. Based on this data, the information needed can be obtained (Roztocki et al., 2004)

3.5 Application Steps of Activity Based Costing

3.5.1 Identification of Overhead Expenses Categories

Identifying the overhead cost categories, such as rent, insurance, labor is the most important step in developing an ABC system. Expenses vary from department to

department so it is necessary to investigate each department separately and identify what indirect resources are consumed and by how much. This cost data can be obtained from accounting.

According to an example that is given by Roztocki et al. (2004), the overhead costs of a typical small manufacturing firm can be seen in Table 3.3. The example uses the average of actual costs which are classified from several small manufacturing companies to represent the costs of a typical small business enterprise.

Table 3.3 Expense categories and their respective cost drivers (Roztocki et al., 2004)

Expense Category	Cost ($)	Cost Drivers
Administration	270000	Time (hours)
Depreciation	180000	Dollar use of resources ($)
Rent and utilities	150000	Space (ft^2)
Office expenses	70000	Level of use of office resources (%)
Transport	50000	Distance (miles)
Interest	45000	Cost of the activity ($)
Product shipment	45000	Weight (lbs.)
Business travel	45000	Distance (miles)
Business insurance and legal expenses	40000	Cost of resource used by the activity ($)
Advertising	40000	Level of benefit
Entertainment	20000	Level of importance of customer (%)
Miscellaneous expenses	45000	None

3.5.2 Identification of Activities or Cost Pools

Activities are undertaken for many purposes. Some of them directly manufacture products, while others indirectly support manufacture, such as the quality department and material handling. Some activities support the business as a whole, such as recruitment and training or the parts of the IT department that keep the network running. Other activities are directly associated with customers, such as the sales

force or more indirectly within the credit control department. Other parts of the business are working on activities to create a better future, such as new product development and others are working on influencing potential customers, such as marketing and advertising.

The complete business process should be divided into a set of activities to implement ABC. In order to establish the needed activities for ABC, homogeneous processes must be grouped together (Roztocki et al., 2004). There can be a lot of activities performed to produce end products in practice. For example, a setup punching machine process can be decomposed into numerous micro activities such as identifying tools required, cutting tools for each shape and size, going to tool crip, selecting the tool, bring tool to the machine, etc. Such a detailed process description is not practical in the development of an ABC system. Activities should be aggregated into cost pools based on similar cost driver behavior (Nachtmann & Al-Rifai, 2004).

There are two factors which drive the cost of measurement associated with the number of cost pools in an ABC system. The first one is that the system designer must specify the resources consumed by each activity and how many times the same activity is used for the same output. If the number of outputs is high, identifying numerous activities can lead to a huge data collection task. Second, if the number of cost pools gets larger, the activity-output relationships become more difficult and costly to measure. In order to reduce complexity, key activities that are most important and highly related to indirect resource consumption should be identified (Nachtmann & Al-Rifai, 2004).

In small and medium enterprises, generally the number of activities in a business may range from 10 to 200. It is not possible to analysis all of them at once due to limited time and resources. The key is then to focus on the most critical activities that will help the effective operation of the business. Table 3.4 shows main activities for the example given by Roztocki et al. (2004).

Table 3.4 Main activities and their second stage cost drivers (Roztocki et al., 2004)

Activity	Cost Driver
Customer contact	Number of customer contacts
Quote preparation	Number of quotes
Engineering work	Engineering hours
Material purchasing	Number of purchase orders
Production preparation	Number of production runs
Material receiving and handling	Number of receptions
Production management and supervision	Product complexity
Quality assurance	Product complexity
Product shipping	Distance
Customer payment administration	Number of payments
General management and administration	Intensity of activities

It is aimed to determine all major activities and their relationships by making use of process modelling study. A process model is effective for better work assignment, effective organization and cost estimation. Developed process models increased the efficiency of ABC implementation considerably (Baykasoğlu & Kaplanoğlu, 2008). All processes from purchasing raw material to delivering finished products to customers must be examined in detail and activities which generate cumulative process and their costs must be determined for full and accurate general production costs. Business process modelling techniques will be examined in the next chapter.

3.5.3 Identification of Expense Drivers

After the main activities have been defined, a total cost of each activity can be calculated. Firstly, the expense categories related to each activity are identified. Cost drivers have to be identified for each expense category to properly trace the expenses to each activity (Roztocki et al., 2004). Table 3.3 also gives expense drivers which are first stage cost drivers for sample company.

Cost drivers are used also as a part of the performance management system. The performance measures chosen should assist in monitoring the progress of controlling activity costs. They should be reviewed periodically. Everyone should be able to understand the performance measures. Daily operations should be managed on the basis of these key measures. The evaluation of employees should be linked to the performance indicators selected. Selection of these indicators is a critical process in ABC.

3.5.4 Assignment of Overhead Costs to Activities

After the cost pools have been identified, indirect resources must be mapped to these cost pools according to the rate in which their associated activities consume these resources. Indirect resource consumption can be assigned to activities in three ways: direct charging, estimation, and arbitrary allocation. Direct charging involves the measurement and tracking of the actual consumption of the resources by the activities. This method requires large investments of time and effort and is rarely practical or economically justified. ABC system designers typically estimate the resources consumed by each activity cost pool through surveys and interviews of key personnel.

Roztocki et al. (2004) provide an efficient and systematic method for estimating cost pool resource consumption through the use of an expense activity dependence matrix. The activities that contribute to each expense are identified and expense-activity dependence (EAD) matrix is created. The expense categories represent the columns of the EAD matrix, whereas the activities represent the rows. If the the activity i contributes to the expense category j, a checkmark is placed in cell i, j (Table 3.5). After this step, each cell that contains a checkmark is replaced by a proportion which is estimated. Each column of the EAD matrix must add up to 1. The following equation is applied to obtain the values of each activity (Table 3.6).

$$TCA\ (i) = \sum_{j=1}^{M} Expense\ (j) * EAD\ (i, j)$$

where

TCA (i) = Total cost of activity *i*

M = Number of expense categories

Expense (j) = Value of expense category *j*

EAD (i, j) = Entry *i, j* in expense activity dependence matrix.

Table 3.5 Expense-activity dependence (EAD) matrix (Roztocki et al., 2004)

	Expense Category											
Activities	Administration	Depreciation	Rent and Utilities	Office Expenses	Transport	Interest	Product Shipment	Business Travel	Business Insurance and Legal Expenses	Advertising	Entertainment	Miscellaneous Expenses
Customer Contact	√		√	√				√		√	√	√
Quote Preparation	√		√	√								√
Engineering Work	√	√	√	√				√				√
Material Purchasing	√		√	√		√						
Production Preparation	√		√	√								√
Material Receiving and Handling	√		√	√	√				√			√
Production Management	√		√	√								√
Quality Assurance	√	√	√	√								√
Product Shipment	√		√	√	√		√		√			√
Customer Payment	√		√	√					√			√
General Management	√		√	√		√		√	√	√	√	√

3.5.5 Identification of Activity Drivers

In the second stage, activities are traced to products using activity drivers which are second stage cost drivers. Activity drivers measure the frequency and intensity of the demand placed on activities by cost objects. They are a one to one relationship with the activity. Table 3.4 also shows cost drivers with related activities.

Table 3.6 Expense-activity dependence (EAD) matrix (Roztocki et al., 2004)

	Expense Category											
Activities	Administration	Depreciation	Rent and Utilities	Office Expenses	Transport	Interest	Product Shipment	Business Travel	Business Insurance and Legal Expenses	Advertising	Entertainment	Miscellaneous Expenses
Customer Contact	0.06		0.01	0.24				0.63		0.64	0.58	0.10
Quote Preparation	0.10		0.05	0.14								0.10
Engineering Work	0.10	0.70	0.12	0.08				0.14				0.10
Material Purchasing	0.08		0.09	0.09		0.80						
Production Preparation	0.04		0.11	0.03								0.10
Material Receiving and Handling	0.05		0.09	0.06	0.40				0.11			0.10
Production Management	0.20		0.13	0.01								0.10
Quality Assurance	0.10	0.30	0.20	0.02								0.10
Product Shipment	0.05		0.12	0.05	0.60		1.00		0.23			0.10
Customer Payment	0.04		0.01	0.08					0.46			0.10
General Management	0.18		0.07	0.20		0.20		0.23	0.20	0.36	0.42	0.10

3.5.6 Assignment of Activity Costs to Products

In this step, the activities consumed by each product are identified and the activity-product dependence (APD) matrix is created. The activities represent the column of the APD matrix, whereas the products represent the rows. If the product i consumes the activity j, a checkmark is placed on the cell i, j. Then each cell that contains a checkmark is replaced by a proportion which is estimated as shown in Table 3.7. Each column of the APD matrix must add up to 1. The following equation is applied to obtain the values of each product.

$$OCP\ (i) = \sum_{j=1}^{N} TCA\ (j) * APD\ (i, j)$$

where

OCP (i) = Overhead cost of product *i*

N = Number of activities

TCA (j) = Value of activity *j*

APD (i, j) = Entry *i, j* in activity product dependence matrix.

Table 3.7 Activity-product dependence (APD) matrix (Roztocki et al., 2004)

	Activities										
Products	Customer Contact	Quote Preparation	Engineering Work	Material Purchasing	Production Preparation	Material Receiving and Handling	Production Management	Quality Assurance	Product Shipment	Customer Payment	General Management
Product 1			0.20	0.14	0.21	0.12	0.34	1.00	0.32	0.21	0.33
Product 2	0.53	0.60	0.10	0.34	0.27	0.41	0.27		0.26	0.38	0.33
Product 3	0.47	0.40	0.70	0.52	0.52	0.47	0.39		0.42	0.41	0.34

3.6 Advantages of Activity Based Costing

ABC brings a holistic perspective to company activities and improves coordination and communication between all units in the company. Many business opportunities appeared after development of ABC. Some of the advantages of ABC include the following:

- ABC provides a clear picture of where resources are being spent, customer value is being created, and the money is being made or lost.

- ABC support customer/product focus by helping a company identify and measure two types of activities: those that add value to the customer/product and those that do not. ABC identifies value added activities and eliminates or reduces non-value added activities.

- ABC improves the accuracy and relevance of products costing, provides timely cost information suitable for decision-making and allows more detailed tracking of indirect costs.

- ABC is a management tool that provides insights into the cost performance of an organization at all levels to manage performance effectively.

- An ABC system can provide useful insight into product design decisions.

- ABC is flexible enough to analyze costs by cost objectives other than products such as processes, area of managerial responsibility and customers.

- ABC aids identification and understanding of cost behavior and thus it has the potential to improve cost estimation. It allows more accurate reporting and analysis of overhead costs.

- ABC provides more accurate product costing information by reducing arbitrary cost allocations.

- ABC eases the tracking process of allocating indirect costs to specific products.

ABC also supports the 80/20 rule. Typically 20% of the organization's customers are creating 80% of profits and in the same rule, 20% of the organization's products cause 80% of costs. Utilizing ABC, these activities can be studied and analyzed, thus allowing more accurate and efficient decisions to be made regarding products and their related costs.

The main advantage of ABC is that the indirect costs are more accurately reflected in the costs of the various products of the company. But its main disadvantage is the difficulty of obtaining accurate information which would enable the proper allocations (Hundal, 1997). It requires additional effort in obtaining the information required for the analysis.

Some shortcomings of the ABC methods are doing little to change old management behavior, not driving companies to change their fundamental views about how to organize work and to satisfy customers efficiently. Other failures are following;

- Employee resistance/skepticism, particularly where education and training has been inadequate or where other major organizational changes are also taking place.

- The ABC project seen as an accounting project by other functional managers.

- Underestimating the cost of data gathering.

- Shortage of appropriate resources, particularly people skills.

ABC is an important tool in providing accurate cost information for strategic decision making procedures. It has been developed considering current manufacturing practices. So it is a more reliable costing system. It traces cost from resources according to the way they are consumed by products, rather than some arbitrary bases. ABC provides more than a product pricing system. It improves the visibility of costs and shows how costs are passed down to products by activities. As a result, ABC is a valuable information tool which provides management with an unrivalled insight into the workings of the manufacturing system. (Özbayrak et al., 2004)

3.7 Activity Based Management

Accurate cost information is critical for every aspect of a business from its pricing policies to its product designs and performance reviews. So ABC/M which is a new type of costing system has been gained acceptance. ABC/M systems represent a shift from a strictly financial perspective to a whole system perspective because they include both financial and non-financial data in its reporting. ABC/M examines

processes and work flows to identify actual activities that add costs. This wider and more realistic view of costs allows managers to base strategic decision on more accurate information, which should improve the quality of those decisions. (Gupta & Galloway, 2003)

ABC performs the arithmetic to provide accurate cost information and ABM is focused on using this information to manage activities. Improving business based on the information which is obtained from ABC is called as ABM. ABM is a management analysis that brings the full benefits of ABC to an organization. ABC provides accurate cost information and ABM uses this information to initiate improvements. (Gunasekaran et al., 2000)

ABC system which provides more accurate cost information based on activities is a tool that gives support to company management. One of the most important functions of managing a company is to make future decisions which affect positively company. ABM which is briefly database of approach is created with ABC system. ABM enables managers to understand product and customer profitability, the cost of business processes, and how to improve them.

ABM focuses on the company's processes. If the processes are understood then failure activities can be eliminated from those processes. Value adding activities can be examined to see whether better methods can be used. Time delays and quality issues can be addressed at the point in the process where they occur. ABM is the management of improvement through the analysis of business processes and their associated activities (Plowman, 2001). ABM is an approach that involves many people within the organization, and is:

- a vehicle for creating process improvement,
- a model to show how costs are created through processes and activities,
- a means of measuring the company's progress in the key areas of the business that need change and improvement.

There are two complementary elements in ABM which are operational and strategical ABM. Operational ABM reduces costs and improves efficiency with the use of assets in hand in the best possible way. In this approach, demand is accepted as a data and met with minimum resource usage. Capacity increase is achieved with operational ABM or decrease in spending is provided through reduction of unit activity costs. Strategic ABM accepts activity efficiency as data and request to modify activity demand which is one way to increase profitability. For instance, income from a product, a service or a customer is less than cost, the activities are evaluated and this negativity is fixed by reduction of non-value added activities. ABM system has database which is necessary for profitability analysis and company management may lead to profitable products with using this data (Öker, 2003).

Finally, company management operates certain number of activities with lower costs with ABM approach and also tries to choose products which will create more contribution with less activity. ABM uses ABC information to focus efforts on continuously improving the organization's ability to perform the mission more efficiently while improving the products and services provided to the customers.

Companies choose to implement ABC/M for a number of reasons ranging from strategic to operational in nature. They include:

- Ability to Improve Customer, Product or Service Analysis :
    - Customer/product profitability,
    - Identification of hidden costs
    - Redesign of unprofitable products/customers.

- Operations Performance Analysis :
    - What-if analysis,
    - Cost management,
    - Cost of capacity,
    - Cost of quality.

- Organization Reengineering :
    - Business diagnostic,
    - Support staff rationalization,
    - Charge intercompany service costs,
    - Asset management,
    - Interplant benchmarking,
    - Explore outsourcing.

CHAPTER FOUR
IDEF0 DIAGRAMS FOR BUSINESS PROCESS MODELLING

4.1 Business Process Modelling and Techniques

Shen et al. (2004) define business process as following: “A business process is a set of one or more linked procedures or activities which collectively realize a business objective or policy goal, normally within the context of an organizational structure defining functional roles and relationships.” Business process modelling enables a common understanding and analysis of a business process which is the combination of a set of activities within an enterprise with a structure describing their logical order. An enterprise can be analyzed and integrated through its business processes. Using the right model involves taking into account the purpose of the analysis and knowledge of the available process modelling techniques and tools.

There are many classifications of business processes which have own advantages and disadvantages. The following are the most frequently used and therefore they are considered as the main techniques (Aguilar-Savén, 2004).

4.1.1 Flow Chart Technique

A flow chart is a formalized graphic representation of a program logic sequence, work or manufacturing process, organization chart, or similar formalized structure. Symbols which represent operations, data or flow direction, are used in flow chart for the definition, analysis, or solution of a problem. The main characteristic of flow charts is their flexibility. So a process can be described in a wide variety of ways. When a flow chart representation is looked, it is easy to recognize the processes it describes. Figure 4.1 shows an example by using a flow chart.

The weakness of the standard is that it is too flexible. The boundary of the process may not be clear and flow charts tend to be very big. Since there is no difference between main and sub-activities, it makes the chart hard to read. It is easier to follow the flow of events, but the risk of getting lost is high. Visualizing the process with a

flow chart can quickly help identify bottlenecks or inefficiencies where the process can be improved. Although the best use of flow chart technique is when it is used to deal with processes that need a high level of detail, it is not very good for giving an overview.

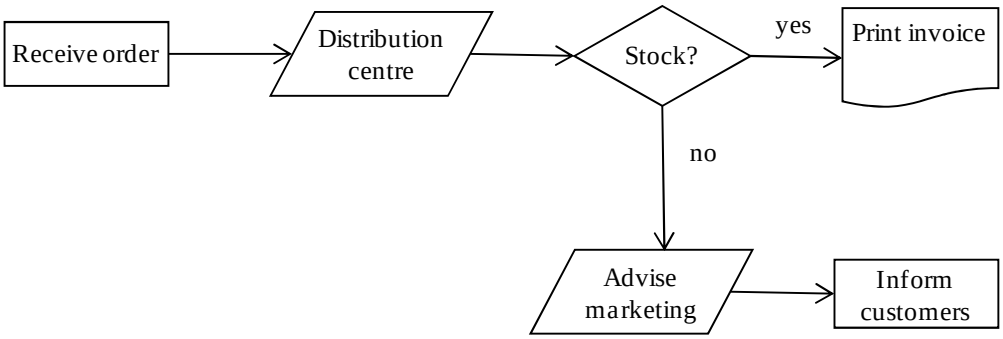

Figure 4.1 Example of flow chart

4.1.2 Data Flow Diagrams

Data flow diagrams (DFD) show the flow of information from one place to another. It describes processes which show how the processes link together through data stores and how the processes relate to the users and the outside world. A process can be specified at the logical level by using DFD. It is aimed to describe what a process will do, rather than how it will be done. DFD are used to specify the meaning of operations, constraints and functional dependencies. It shows how information enters and leaves the process, what activities change the information, where information is stored within the process, and the organizational function to which the activity belongs. Figure 4.2 shows a DFD for the example in Figure 4.1.

4.1.3 Role Activity Diagrams - RAD

Role activity diagrams (RADs) which are a graphic view of the processes from the perspective of individual roles, concentrate on the responsibility of roles and the interactions between them. RADs are easy and intuitive to read and understand. They present a detailed view of the process and permit activities in parallel. With careful modelling, RADs might define the degrees of empowerment within the business and

demonstrate how processes interact. They also describe how a role object changes state as a result of the actions and interactions.

Disadvantage of RAD is that the technique excludes business objects, which are manipulated by the process. The process is presented as a sequence of activities. It does not let a decomposition of the process and thus it makes an overview difficult.

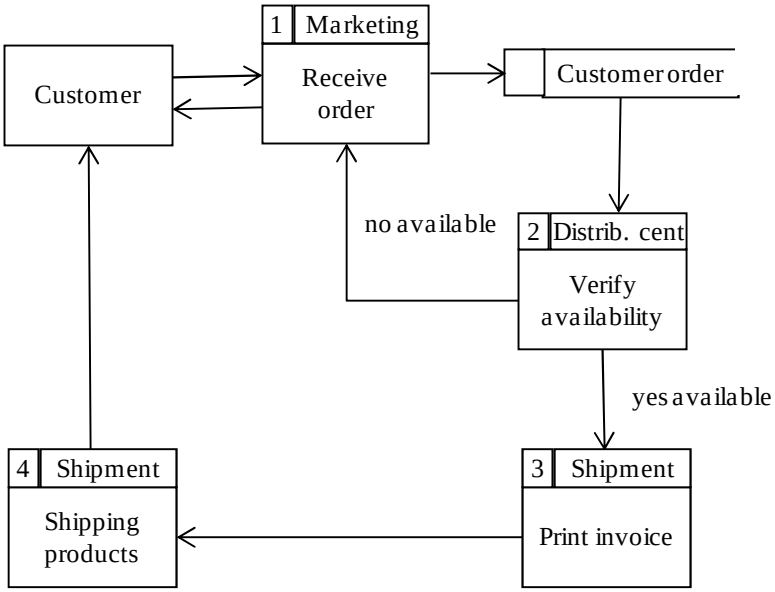

Figure 4.2 Example of data flow diagram

4.1.4 Role Interaction Diagrams - RID

Role interaction diagrams (RIDs) are a graph of a process so that activities are connected to roles in a type of matrix. Activities are shown vertically on the left axis and the roles are shown horizontally at the top. Text and symbols are used together in order to represent the process. Horizontal lines show human interactions. Figure 4.3 shows a DFD for the example in Figure 4.1.

Although RIDs are more complex than flow diagrams, they are fairly intuitive to understand, easy to read but they tend to be messy with many arrows pointing left and right. So they are quite hard to build. Since inputs to activities and outputs from the activities are not modeled, important information is lost. When editing an existing diagram, it can be hard to insert new activities or roles.

RIDs are not as flexible as flowcharts. They have quite rigid notation. But if it is compared with other modelling techniques, RIDs are nevertheless flexible. Due to their notation and ability to break down activities, very complex processes can be displayed. The best use of RIDs is in workflow design. RIDs are primarily used for processes that involve coordination of interrelated activities.

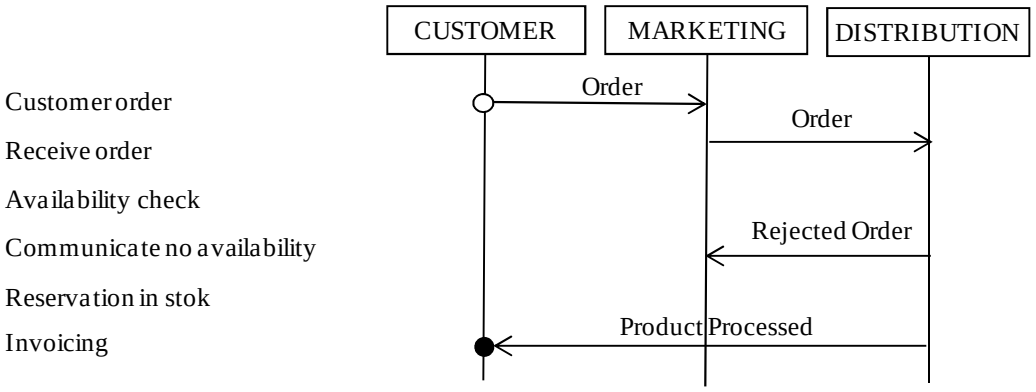

Figure 4.3 Example of a RID

4.1.5 Gantt Chart

A Gantt Chart is a matrix which lists all tasks or activities on the vertical axis to be performed in a process. Each row contains a single activity identification which consists of a number and a name. The horizontal axis is headed by columns indicating estimated activity duration, skill level needed to perform the activity and the name of the person assigned to the activity. A list of activities is related to a time scale and thus they might be used to represent a process graphically and control its current situation of performance. They are very simple graphic representations but they do not show clear dependencies between activities.

4.1.6 Coloured Petri-net - CPN

Coloured Petri nets are a graphical oriented language for design, specification, simulation and verification of systems. It is suited for the systems that consist of a number of processes which communicate and synchronize.

Coloured nets are extended Petri nets in which symbols are differentiated by ‘‘COLOURS’’. A CPN model consists of a set of modules. Each of them contains a network of places, transitions and arcs. The graphical representation makes it easy to see the basic structure of a complex CPN model. It helps to understand how the individual processes interact with each other. CP-nets have a formal, mathematical representation with a well-defined syntax and semantics. This representation is the foundation for the definition of the different behavioral properties and the analysis methods. The behavior of a CPN model can be analyzed, either by means of simulation or by means of more formal analysis methods.

4.1.7 Object Oriented Methods

It is used to describe a system that deals primarily with different types of objects. Thus, object oriented methods might be defined as methods to model and programme a process described as objects which are transformed by the activities along the process. The fundamental construct is the object which combines both data structure (attributes) and behavior (operations) in a single entity. This method is based on three concepts: (i) objects that represent a real-world entity, (ii) behavior which reflects state changes, (iii) class which is a set of similar objects.

There are many different techniques based on object oriented methods. Unified Modelling Language (UML) is considered the standard object oriented modelling language. UML is a language for specifying, visualizing, constructing and documenting the structure of software systems, as well as for business modelling and other non-software systems. The UML covers conceptual things such as business processes and system functions, and concrete things such as programming-language classes, database schemas, and reusable software components.

4.1.8 Workflow Technique

Workflow is a flow of tasks between computer applications or people in an organization. Two or more members of a workgroup to reach a common goal can

define workflow as well as any task performed in series or in parallel. Workflow is more than a technique to model a process. It is a method to analyze and improve a process, including its modelling.

The workflow development process uses workflow models to capture the relevant information of the processes. This process consists of four stages: information gathering, business process modelling, workflow modelling and implementation, verification and execution. Figure 4.4 shows the basic concepts used in workflow and their relationships. Some advantages are shorter learning time, data transfer, process improvement, easier to make changes, decentralization, using in combination with other systems. Disadvantages are lost human contact, lack of motivation and feeling controlled.

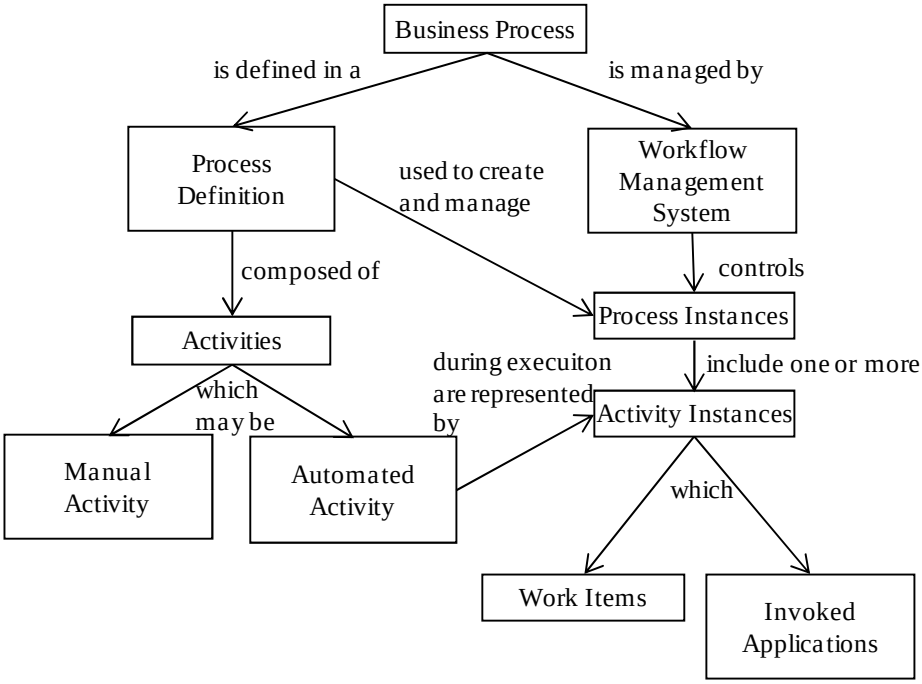

Figure 4.4 Concepts of workflow

4.1.9 IDEF

The Integrated Definition for Function Modelling (IDEF) is a family of methods. IDEF's roots began when the US Air Force, in response to the identification of the need to improve manufacturing operations, established the Integrated Computer-Aided Manufacturing (ICAM) program in the mid-1970s. The requirement to model

activities, data, and dynamic elements of the manufacturing operations resulted in the initial selection of the Structured Analysis and Design Technique (SADT). It is a whole methodology to be used as a regimented approach to analyzing an enterprise. The IDEF family is used according to different applications. The most important parts are: IDEF0, IDEF1, IDEF1X, IDEF2, IDEF3, IDEF4 and IDEF5. However, for business process modelling, the most useful versions are IDEF0 and IDEF3.

IDEF0 is a modelling technique used for developing structural graphical representations of processes or complex systems. They show the high level activities of a process indicating major activities and the input, control, output, and mechanisms associated with each major activity. The processes can be decomposed to show lower level activities. These models are composed of three types of information: graphical diagrams, text and glossary. These three types are cross-referenced to each other. The major component is the graphical diagram, containing boxes and arrows. An example IDEF0 diagram is shown in Figure 4.5.

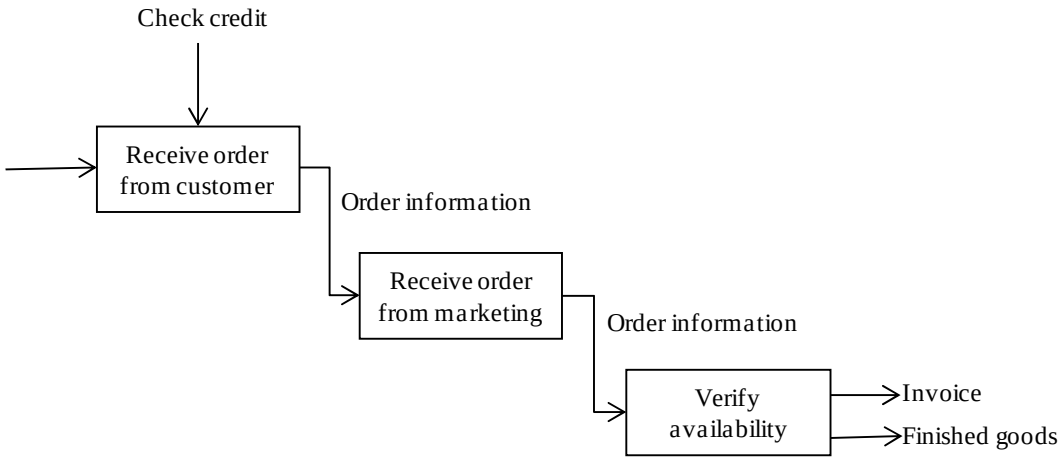

Figure 4.5 IDEF0 graphical diagram's components

The IDEF0 standard is the most popular process modelling. By working backwards along the chain from output to inputs, much data and control can be defined. Thus it can be analyzed and improved. The hierarchical structure facilitates quick mapping at a high level. One weakness is the tendency of IDEF0 models to be interpreted as representing a sequence of activities. The activities may be placed in a left to right sequence within decomposition and connected with the flows. It is

natural to order the activities left to right because, if one activity's output is used as input by another activity, drawing the activity boxes and concept connections is clearer. Thus, activity sequencing can be embedded in the IDEF0 model.

4.2. IDEF0 Concept

4.2.1 Introduction to IDEF0

Systems whose parts can be any combination of things which includes people, information, software, processes, equipment, products, or raw materials, are composed of interdependent parts that work together to perform a useful function. The model which is a representation of a set of components of a system is developed for understanding, analysis, improvement or replacement of the system. The model describes what a system does, what controls it, what things it works on, what means it uses to perform its functions, and what it produces. IDEF0 is a modeling technique based on combined graphics and text that are presented in an organized and systematic way to gain understanding, support analysis, provide logic for potential changes, specify requirements, or support systems level design and integration activities.

IDEF0 is an engineering technique for performing and managing needs analysis, benefits analysis, requirements definition, functional analysis, systems design, maintenance, and baselines for continuous improvement. The IDEF0 model reflects how system functions interrelate and operate just as the blueprint of a product reflects how the different pieces of a product fit together.

IDEF0 Model is a graphic description of a system which is developed for a specific purpose and from a selected viewpoint. A set of one or more IDEF0 diagrams which shows the functions of a system or subject area with graphics, text and glossary. IDEF0 (Integration DEFinition language 0) includes both a definition of a graphical modeling language and a description of a comprehensive methodology for developing models.

IDEF0 may be used to model a wide variety of automated and non-automated systems. For new systems, IDEF0 may be used first to define the requirements and specify the functions, and then to design an implementation that meets the requirements and performs the functions. For existing systems, IDEF0 can be used to analyze the functions of the system and to record the mechanisms by which these are done. In addition to definition of the IDEF0 language, the IDEF0 methodology also describes procedures and techniques for developing and interpreting models, including ones for data gathering, diagram construction, review cycles and documentation.

4.2.2 Structure of IDEF0

The components of the IDEF0 are boxes and arrows, rules, and diagrams. Boxes represent functions which are defined as activities, processes or transformations. Arrows represent data or objects related to functions. Rules define how the components are used, and the diagrams provide a format for depicting models graphically. The format also provides the basis for model configuration management.

4.2.2.1 Boxes

A box provides a description of what happens in a function. A typical box is shown in Figure 4.6.

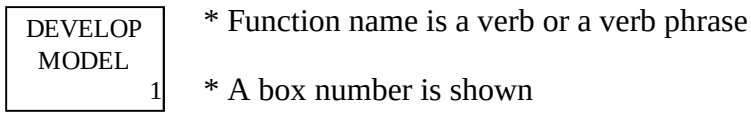

Figure 4.6 Box syntax

4.2.2.2 Arrows

An arrow is composed of one or more line segments. As shown in Figure 4.7, arrow segments may be straight or curved (with a 90^0 arc connecting horizontal and vertical parts), and may have branching (forking or joining) configurations. Arrows

do not represent flow or sequence as in the traditional process flow model. Arrows convey data or objects related to functions to be performed. The functions receiving data or objects are constrained by the data or objects made available.

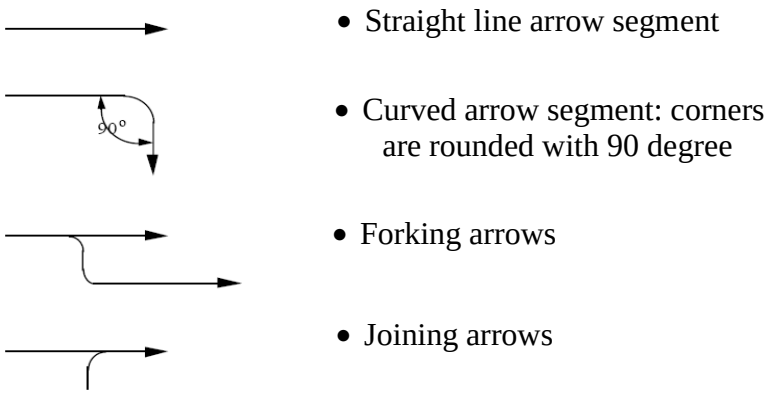

Figure 4.7Arrow syntax

Standard arrow positions are shown in Figure 4.8. Control arrow is the class of arrows that express IDEF0 Control, i.e., conditions required to produce correct output. Call arrow is a type of mechanism arrow that enables the sharing of detail between models (linking them together) or within a model. Mechanism arrow is the class of arrows that express IDEF0 mechanism, i.e., the means used to perform a function; includes the special case of Call arrow. Input arrow is the class of arrows that express IDEF0 Input, i.e., the data or objects that are transformed by the function into output. Output arrow is the class of arrows that express IDEF0 output, i.e., the data or objects produced by a function.

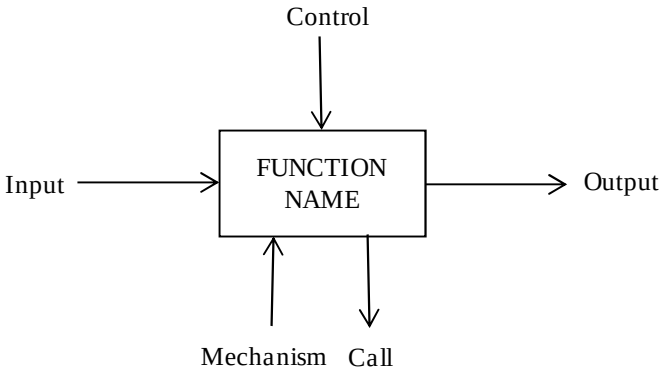

Figure 4.8 Arrow positions

4.2.3 Types of Diagrams

IDEF0 models are composed of three types of information: graphic diagrams, text, and glossary. These diagram types are cross-referenced to each other. The graphic diagram which contains boxes, arrows, box/arrow interconnections and associated relationships, is the major component of an IDEF0 model. Boxes represent each major function of a subject. These functions are decomposed into more detailed diagrams, until the subject is described at a level necessary to support the goals of a particular project. The top-level diagram in the model provides the most general or abstract description of the subject represented by the model. This diagram is followed by a series of child diagrams providing more detail about the subject. This hierarchical structure helps the practitioner to keep the scope of the model within the boundaries represented by the decomposition of the activity (Kim & Jang, 2002). Figure 4.9 shows decomposition of the diagram.

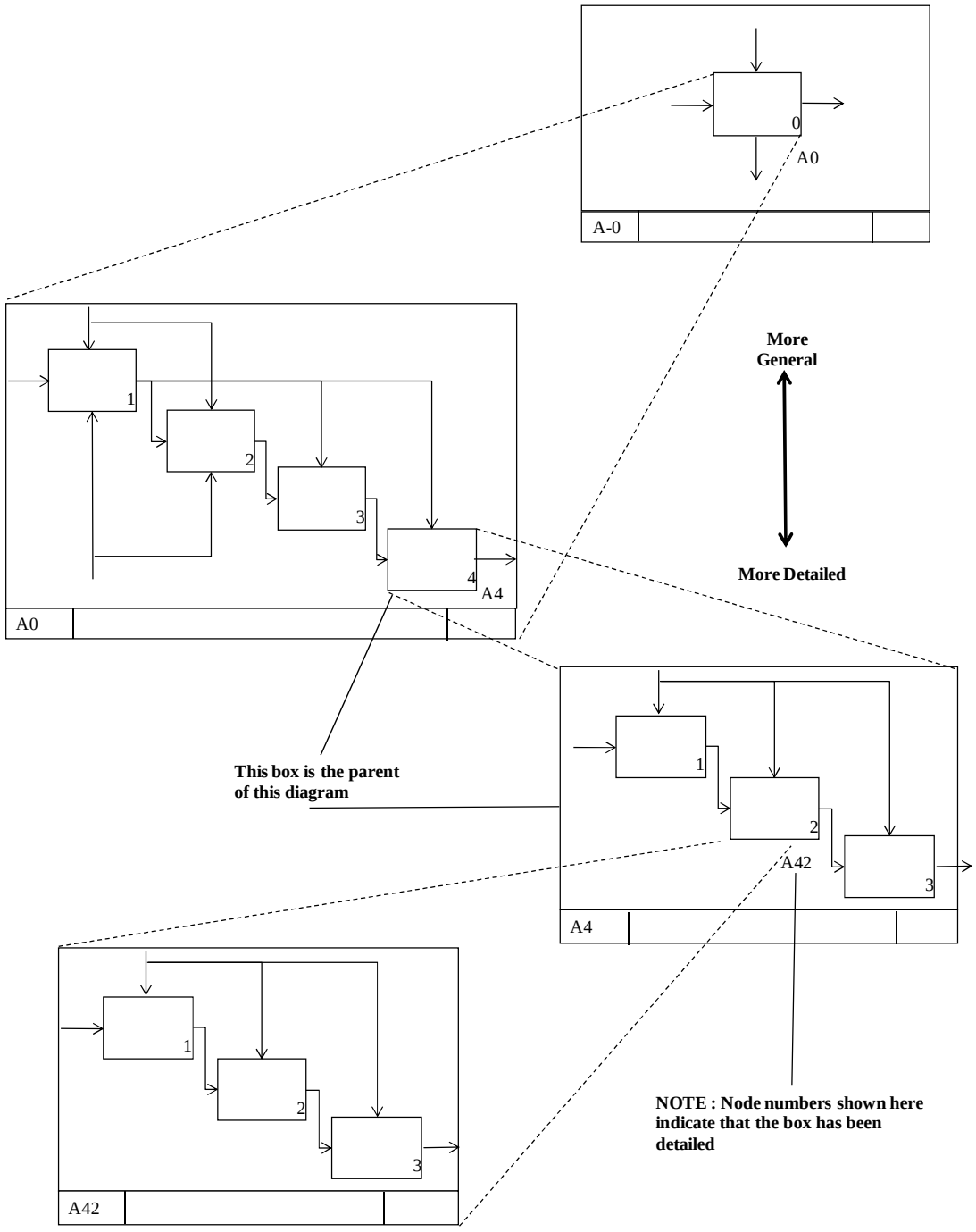

Figure 4.9 Decomposition structure

CHAPTER FIVE
AN APPLICATION IN A MEDICAL SUPPLIES MANUFACTURING COMPANY

5.1 General Information About The Company

The company that is the manufacturing firm of a Group of Companies was founded in 1999. It is operating in medical supplies manufacturing sector with over 50 workers and is located in Izmir, Turkey. It produces disposable medical consumables with own brand. The companies' unique customization capability provides an endless number of product type configurations for all patient monitoring requirements. In addition to the supply of its own branded products, the company also offers contract manufacturing services to the medical supplies manufacturing industry. Finished products are exported to 59 countries by means of vendors. Domestic sales are done with another company that is a member of the same Group of Companies. End user sales for government and university hospitals are done by means of tenders and private hospital sales are done with hospital demands by this distributor.

The company produces a variety of breathing circuits including tubing, filters, connectors, water traps, masks, breathing bags. Some parts are manufactured in-house such as catheter mounts, filters, water traps, tubings, connectors, while others are purchased from outside suppliers such as special accessories, breathing bags, masks. In Figure 5.1, a breathing circuit with accessories can be seen. Although company's main product group is breathing circuit, there is a considerable market for other sub-parts (i.e. filters, catheter mounts etc.)

A breathing circuit is defined as an assembly of components which connects the patient's airway to the anesthesia/ventilator machine that creates an artificial atmosphere between machine and the patient breathes. Breathing circuits are products which are used for ventilation treatment in intensive care or before surgery during anesthesia. They are used for patients who can not breathe by themselves for

mechanical ventilation application. Breathing circuits in various designs ensure transfer of necessary air from machine to patient. Circuit types which are used for different purposes are Anesthesia Circuits, Ventilation Circuits, IPPB Circuits, Proximal Line Circuits, Heated Wire Circuits, Cpap and Bpap Circuits.

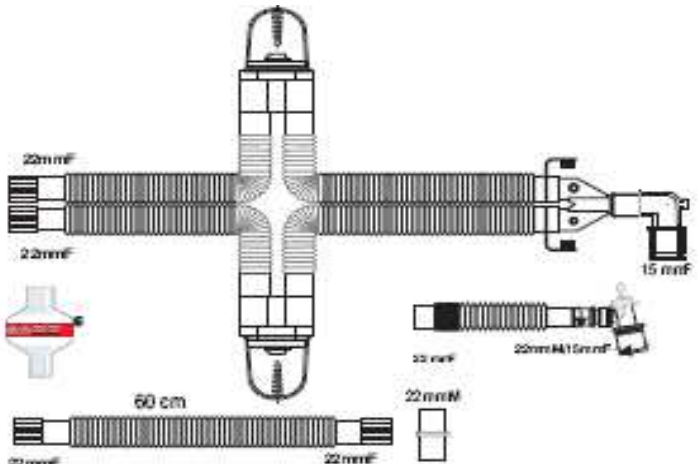

Figure 5.1 A sample breathing circuit.

5.2 Production System of the Company

Production has been done in clean rooms which have international standards. These clean rooms provide 10000 class hygiene. It means number of particle in a meter cube can be maximum 10000 by standard. Measurements have been done periodically in this facility, shows that this number is between 2000 and 3000.

Main processes of the company for production;

- Assembly : Labor intensive assembly, Automated filter assembly
- Injection : Automated production of connectors, masks, water traps and filter parts
- Extrusion : Automated production of tubing
- Sterilization: Sterilization procedure of finished products.

Make to stock strategy is followed for semi-finished products that are used by most of the finished products. Make to order strategy is followed for finished

products. Because finished product designs can change according to customer demands. There are approximately 1000 products only for breathing circuit product group and bill of material of these products can change with any demand.

5.3 Current Costing System of the Company

All cost information is taken from general ledger in the company. Expenses are assigned to cost groups in the ledger with the following principle.

Direct material costs are assigned to products with FIFO principle according to bill of material. If a raw material is an imported product, purchasing costs like freight, insurance, customs are added to direct material cost. There is no problem in assignment of direct material costs.

Direct labor costs include wage, clothing, and food expenses for workers who are employed in the production. These expenses are recorded worker by worker. So cost of any worker can be reached.

General production costs include expenses of the employees in the production department who contribute to production indirectly. These costs also contain other production expenses like electricity, depreciation, maintenance etc. Capacity usage ratios are determined according to changes on production volume and unused capacity costs are calculated for machine depreciations. This cost is reflected to idle capacity expenses and it does not add unit product cost.

Marketing and sales costs consist of expenses of the marketing department like customer representative wages, travel, fair, advertisement etc.

General management costs include expenses of the quality, logistic and accounting departments, transportation, insurance, telephone, security, taxes etc.

Financial costs include interests and other banking expenses. These costs ignored because they are also related to other companies of the group.

Only direct material costs, direct labor costs and general production costs are reflected to product costs. Direct labor and general production costs are distributed to products by production hour. Marketing and sales, general management and financial costs are considered as operating expenses.

According to this cost groups, 75% of total expenses is reflected to product costs, rest (25%) is considering as operating expenses. Generally, the share of direct material costs in product costs is 70%, the share of direct labor costs is 7% and the share of general production expenses is 23%. This ratios change product to product.

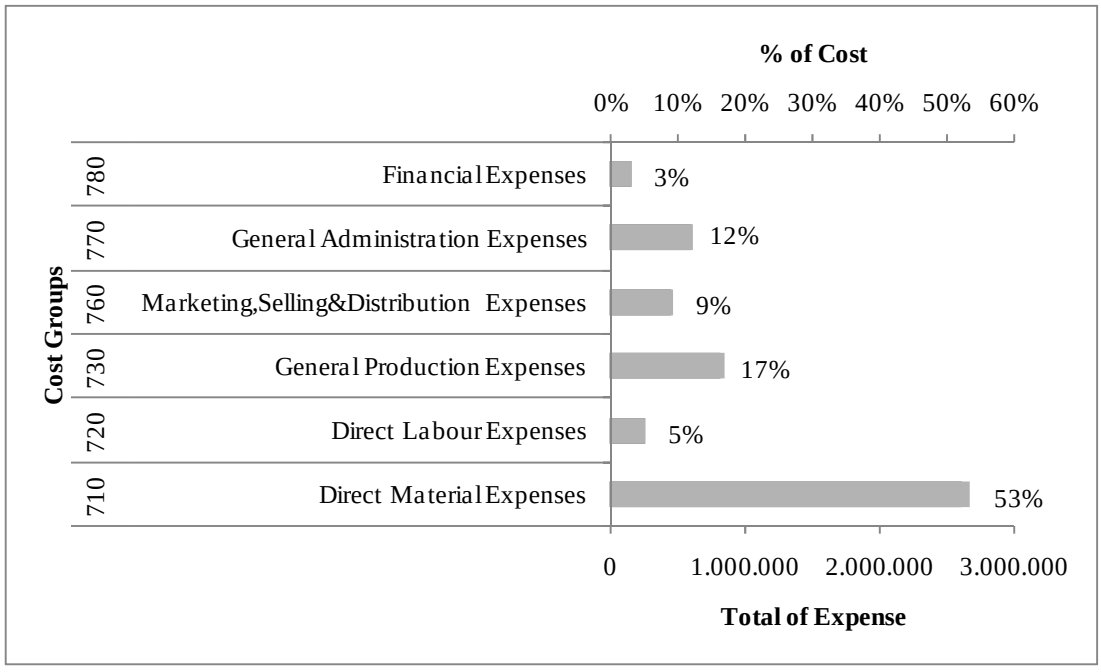

Figure 5.2 Company expense distribution

Table 5.1 gives costs of the products calculated with traditional costing system and percentage ratios of direct material, direct labor and general production costs in total cost.

Table 5.1 Production costs of some products

Assembled Product		
Direct Material Cost	2.585	85%
Direct Labor Cost	0.125	4%
General Production Cost	0.335	11%
Total Cost	3.045	
Assembled Filter		
Direct Material Cost	0.491	91%
Direct Labor Cost	0.013	2%
General Production Cost	0.035	7%
Total Cost	0.539	
Semi-product (injection)		
Direct Material Cost	0.027	77%
Direct Labor Cost	0.002	6%
General Production Cost	0.006	17%
Total Cost	0.035	
Tubing		
Direct Material Cost	0.098	74%
Direct Labor Cost	0.005	4%
General Production Cost	0.029	22%
Total Cost	0.132	
Thin Tubing		
Direct Material Cost	0.188	62%
Direct Labor Cost	0.015	5%
General Production Cost	0.098	33%
Total Cost	0.302	

Table 5.1 Production costs of some products (continued)

Sterile Assembled Product		
Direct Material Cost	5.183	90%
Direct Labor Cost	0.149	3%
General Production Cost	0.392	7%
Total Cost	5.724	

Pak. Packaged Products		
Direct Material Cost	0.401	84%
Direct Labor Cost	0.007	2%
General Production Cost	0.067	14%
Total Cost	0.476	

Some of the problems in current costing system are as follows;

- Existing costing system was not adequate and appropriate decisions could not be made due to insufficient information. Cost reduction and pricing studies are very hard because of this.
- Some costs related to the production such as quality, logistic labor are not distributed to product costs.
- There is no additional cost for sterilized products. So sterile and non-sterile products have same cost. Whereas sterilization procedure includes labor, device, consumables is costly.
- Most of the cost pools are known when an expense has occurred but expenses is entered in general cost pools and this expense is distributed to products according to labor hour. For example, electricity expense is very high and this expense is distributed to all products according to production hour. In fact, injection creates most of this expense.

- When expenses are carefully examined, high maintenance and repair costs are realized. Failures that cause these costs are not followed in detail and they are not in ERP system. So, all costs are distributed to all products. In this cases, maintenance costs can be distribute to labor intensive products.

- Depreciation costs must be updated. Some costs like material handling devices, quality control devices are in general administration costs and they are not in total cost of a product.

- General accounting system takes all necessary information from current costing system and does not deal with single product costs. It looks that sum of direct material costs, direct labor costs and general production costs in general accounting equals to total production costs.

5.4 Implementation of Activity Based Costing

The company's business is highly competitive. High quality is expected in the market and the primary criteria in bid selection by customers is price. The management believes that the current cost information provided by traditional costing system is unreliable and leads them to poor decision making. They feel that an accurate costing system is essential to survive and be competitive in the future. ABC is most suitable method for the costing. It also helps to make price forecasts. The management supported to apply new costing system.

The application steps of ABC which are presented in detail in Chapter Three were used. Moreover, IDEF0 diagrams described in Chapter Four was used in activity determination stage. ABC model was prepared in Oracle environment.

At data collection stage, general ledger which shows current cost of the company and expense budget were analyzed in detail and converted to a useful data set that can be utilized by ABC. Interviews were made with the personnel who are most knowledgeable about inner workings. Also procedures, instructions and work

definitions with company quality handbook were examined for determining activities.

5.4.1. Identification of Expense Categories and Expense Drivers

All the cost terms, which are considered as overheads, are shown in Table 5.2. There are many different types of overheads in the company. Therefore, overheads were grouped based on their similarity to each other and expense amounts were taken from expense budget which is prepared according to forecasts. Twenty eight overhead categories were identified and presented in Table 5.2 along with their corresponding cost drivers.

Table 5.2 Expense categories and expense drivers

	Expense Categories	Expense driver	%	Cumulative %
1	Labor expenses	percentage	28%	28%
2	Exportation	negligible	11%	39%
3	Electricity	kw-hr	9%	48%
4	Interest & banking	direct	7%	56%
5	Machine depreciation	machine hour	6%	62%
6	Shipment	negligible	4%	66%
7	Mold depreciation	percentage	3%	69%
8	Facility depreciation	area (m2)	3%	73%
9	Marketing	direct	3%	76%
10	Legal expenses	direct	3%	79%
11	Renting	percentage	2%	81%
12	Machine maintenance	machine hour	2%	83%
13	Social assistances	percentage	2%	85%
14	Other material expenses	percentage	2%	87%
15	Security	area (m2)	2%	89%
16	Vehicle	percentage	2%	91%
17	Other depreciations (fixture)	percentage	2%	92%
18	Consultancy	direct	1%	94%

Table 5.2 Expense categories and expense drivers (continued)

	Expense Categories	Expense driver	%	Cumulative %
19	Mold maintenance	direct	1%	95%
20	Utilities	percentage	1%	96%
21	Quality	percentage	1%	97%
22	Facility insurance	area (m2)	1%	97%
23	Other expenses	direct	1%	98%
24	Machine insurance	machine hour	1%	99%
25	Sterilization materials	direct	1%	99%
26	Analysis & Test	percentage	1%	100%
27	Other insurance (fixture)	percentage	0%	100%
28	Facility maintenance	area (m2)	0%	100%

When expenses were examined and similar expenses were grouped, it was seen that 80% of total expenses consists of 10 expense category, 20% of them consists of 18 expense category (Figure 5.3).

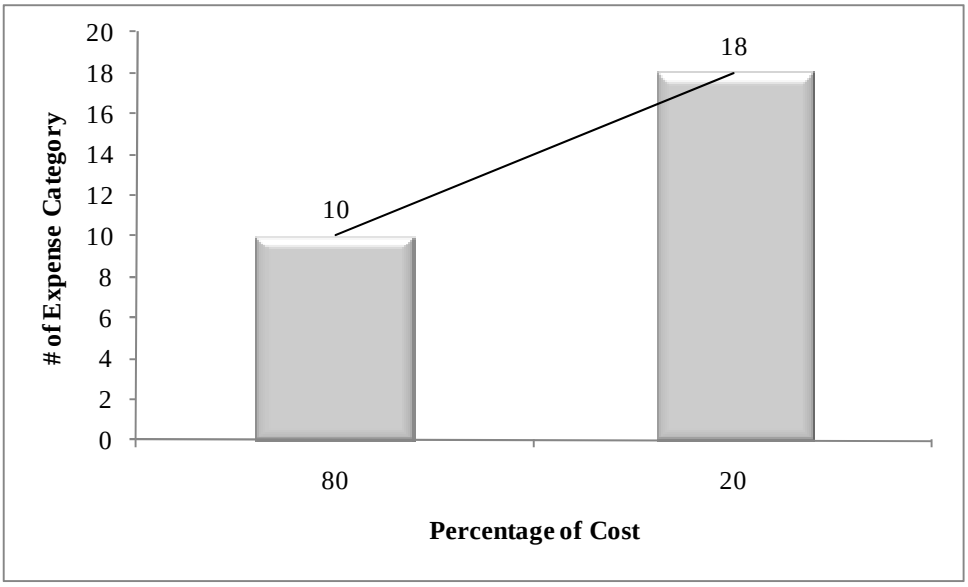

Figure 5.3 Distribution of expense categories

First of all, top level expenses must be analyzed for minimizing costs. For example, the biggest cost item is salaries. Since 90% of assembly operations is labor

intensive, labor expenses are high depending on the number of workers. The second cost is exportation costs but according to the agreements which are done with most of the customers, exportation costs like customs, insurance, freight are reflected to customers. So these costs are compensated. The third cost is electricity because of the special clean room and air conditioning system and also extruders. The fourth cost item is interest and banking expenses. These are related to cash flow. The fifth cost item is depreciation. Injection and extrusion have machine intensive operations. Company started to production in 1999, so depreciation costs are too high.

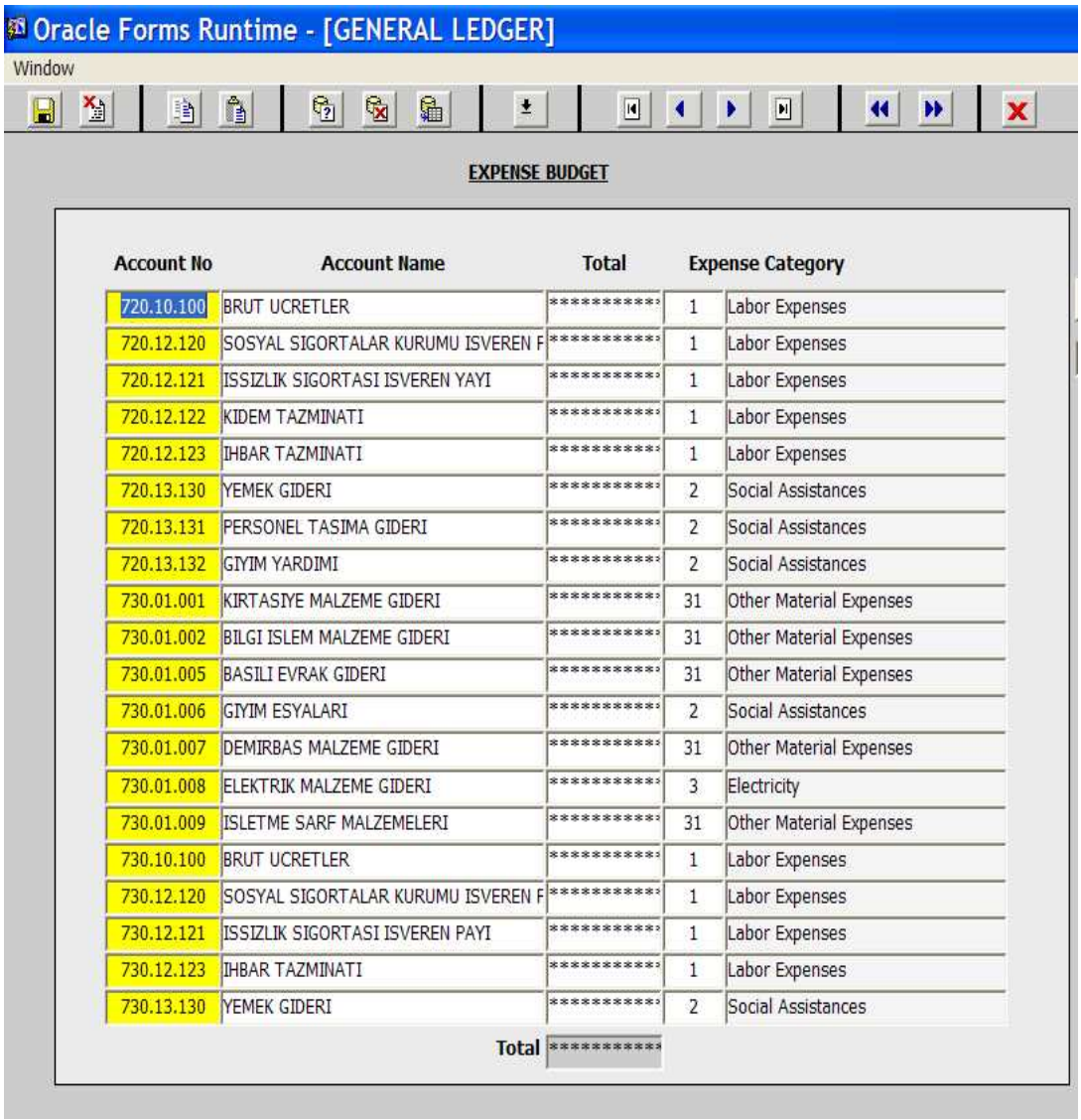

Figure 5.4 Definition of expense categories

Figure 5.4 shows expense budget comes from company's ERP system. In this stage, expense categories for all accounts were defined. According to Figure 5.5, expense budget for every expense category was calculated.

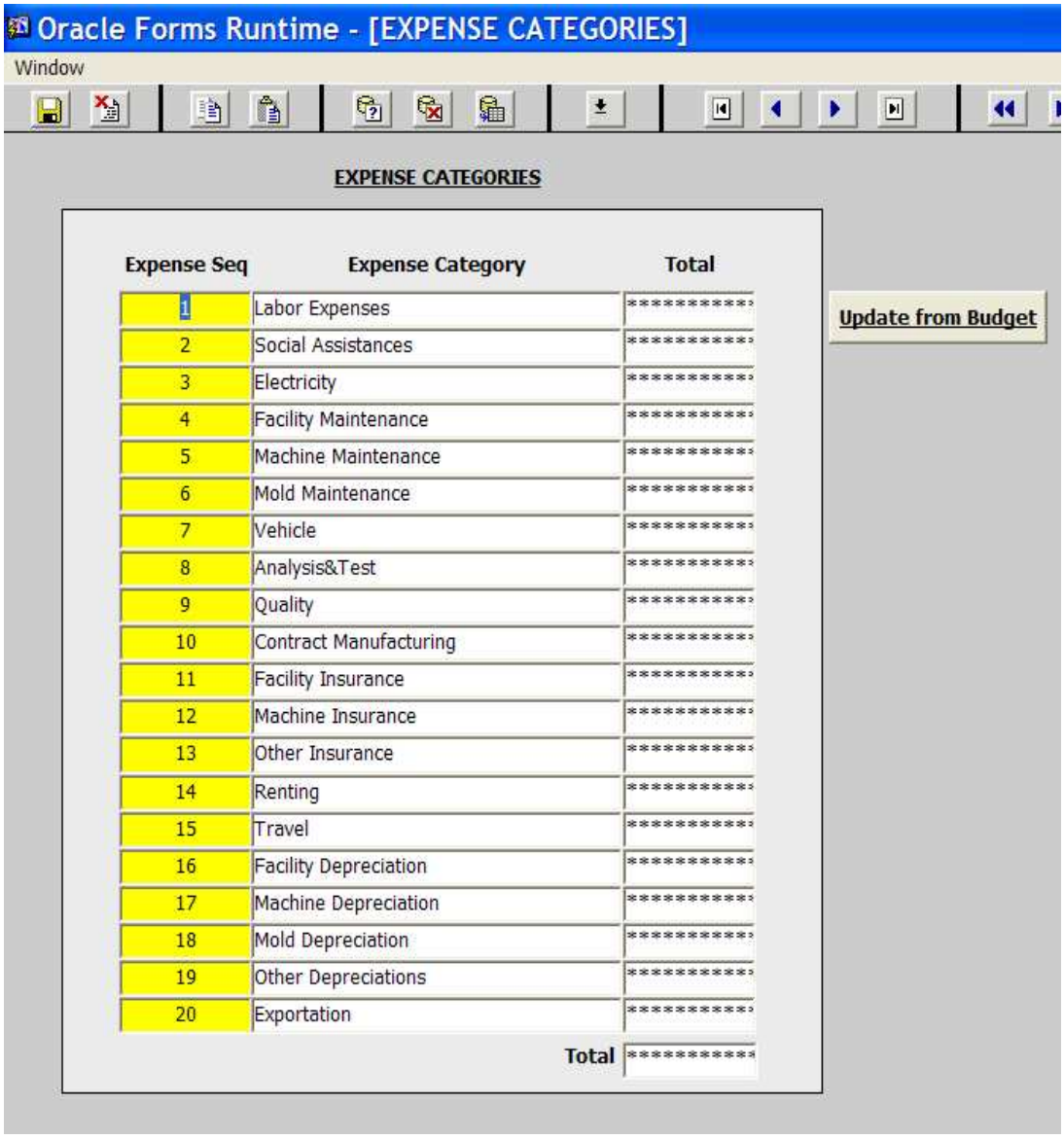

Figure 5.5 Generation of expense categories

5.4.2. Identification of Activities

First of all, the main processes, sub-processes and all related activities of the company were determined as a result of interviews with employees. Also quality handbook was very useful tool which explains all job definitions and procedures. All

activities were analyzed using IDEF0 diagrams. Appendix presents also the corresponding IDEF0 diagrams.

The main processes and sub-processes of the company with IDEF0 ID are shown in Table 5.3. Activities analyzed department by department and some of the similar activities were grouped during the study in order to increase the effectiveness and reduce the cost of implementing ABC. The activity list which is shown in a sequential order in Table 5.4 will be the base for ABC calculations. Figure 5.6 shows activity determination stage for all departments on Oracle.

Table 5.3 Activities for each department and related IDEF0

Logistic Activities	***IDEF0 ID***
Receive & control material	A8
Carry materials inside of factory	A3
Warehouse	A5
Dispatch finished product	A7
Sales Activities	***IDEF0 ID***
Receive & process orders	A1
Dispatch finished product	A7
Marketing Activities	***IDEF0 ID***
Marketing	A12
Production Chef Activities	***IDEF0 ID***
Make production plan	A2
Control & audit production	A9
Quality Activities	***IDEF0 ID***
Certify	A10
Receive & control material	A8
Dispatch finished product	A7
Control & audit production	A9
Sterilize	A4

Table 5.3 Activities for each department and related IDEF0 (continued)

Technical Service Activities	***IDEF0 ID***
Maintain & repair	A11
Production	***IDEF0 ID***
Operate Injection	A621
Operate Extrusion for Tubing	A6221
Operate Extrusion for Thin Tubing	A6222
Operate Filter Assembly	A623
Operate Pakform Packaging	A624
Assembly	A61

Table 5.4 Activities and activity drivers.

	Activities	***Activity drivers***
1	Assembly	labour hour (asm.hr)
2	Carry materials inside of factory	# of bom order 60%, # of job order 40% (bom.job)
3	Control & audit production	production hour (prd.hr)
4	Dispatch finished product	# of deliver (delivery)
5	Maintain & repair	machine hour (mch.hr)
6	Make production plan	# of job order (job.order)
7	Marketing	sales budget (budget)
8	Operate Extrusion for Tubings	machine hour (ext.hr)
9	Operate Extrusion for Thin Tubings	machine hour (rec.hr)
10	Operate Filter Assembly	machine hour (filt.hr)
11	Operate Injection	machine hour (inj.hr)
12	Operate Pakform Packaging	machine hour (pak.hr)
13	Receive & control material	# of receipt (receipt)
14	Receive & process orders	# of order (cust.order)
15	Sterilize	# of cycle (cycle)
16	Certify	# of product (product)
17	Warehouse	safety stock amount (safety stock)

Oracle Forms Runtime - [ACTIVITIES]

Window

ACTIVITIES

Activity Seq	Activity Name	Activity Group	Row
1	Assembly	Production Process Activities	1
2	Operate Filter Assembly	Production Process Activities	1
3	Operate Injection	Production Process Activities	1
4	Operate Extrusion for Tubings	Production Process Activities	1
6	Operate Extrusion for Thin Tubings	Production Process Activities	1
7	Operate Pakform Packaging	Production Process Activities	1
8	Control&Audit Production	Production Chef Activities	2
9	Make Production Plan	Production Chef Activities	2
11	Maintain & Repair	Technical Service Activities	3
14	Warehouse	Logistic Activities	4
15	Receive&Control Material	Logistic Activities	4
16	Dispatch Finished Product	Logistic Activities	4
17	Carry Materials inside of Factory	Logistic Activities	4
18	Receive&Process Orders	Sales Activities	6
20	Dispatch Finished Product	Sales Activities	6
21	Marketing	Marketing Activities	7
22	Sterilize	Quality Activities	5
23	Receive&Control Material	Quality Activities	5
24	Control&Audit Production	Quality Activities	5
25	Dispatch Finished Product	Quality Activities	5

Figure 5.6 Definition of activities

5.4.3. Assignment of Overhead Costs to Activities

In this step, the activities that contribute to each expense were identified, and the expense-activity-dependence (EAD) matrix was created. The expense categories represent the rows of the EAD matrix, whereas the activities identified in previous step represent the columns. If the activity j contributes to the expense category i, the cell i, j contains a proportion which is estimated using actual data and educated guesses. Each row of the EAD matrix adds up to 1.

To study with real values in the assignment of overhead costs to activities improves accuracy of results. In this study, annual data was examined detailed and determined percentage distribution key. Percentages for some expenses were determined by making conversations with employees and previous detailed cost information. Percentages for other expenses were determined with some expense drivers.

In literature, there are a lot of expense drivers. For example labor expenses can be distributed with employee number. The highest value in labor expenses is wages for the company and if distribution of wages is not stabile, this driver is not sufficient. So wages and then percentages for every activity were computed employee by employee. But as there is no detail for some expenses, expense drivers were used.

For the machine hour based expense driver, expenses like machine depreciation, insurance, maintenance were distributed according to Table 5.5.

Table 5.5 Machine hour based expense driver distribution

Activity name	**Machine hour**	**Percentage**
Operate Injection	24806	70%
Operate Extrusion for Tubing	3715	11%
Operate Extrusion for Thin Tubing	3690	10%
Operate Pakform Packaging	1714	5%
Operate Filter Assembly	1302	4%
Total	**35227**	**100%**

For the area (m^2) based expense driver, expenses like facility depreciation, insurance, maintenance, security were distributed according to Table 5.6.

Figure 5.7 shows assignment of expense categories to activities on Oracle. All expenses distributed to activities according to related expense drivers. In this stage, EAD matrix was generated.

Table 5.6 Area based expense driver distribution

Activity name	Area (m2)	Percentage
Warehouse	2767	66%
Assembly	608	15%
Operate Injection	313	7%
Maintain & Repair	195	5%
Operate Extrusion for Tubing	140	3%
Operate Extrusion for Thin Tubing	70	2%
Operate Filter Assembly	40	1%
Operate Pakform Packaging	40	1%
Total	**4193**	**100%**

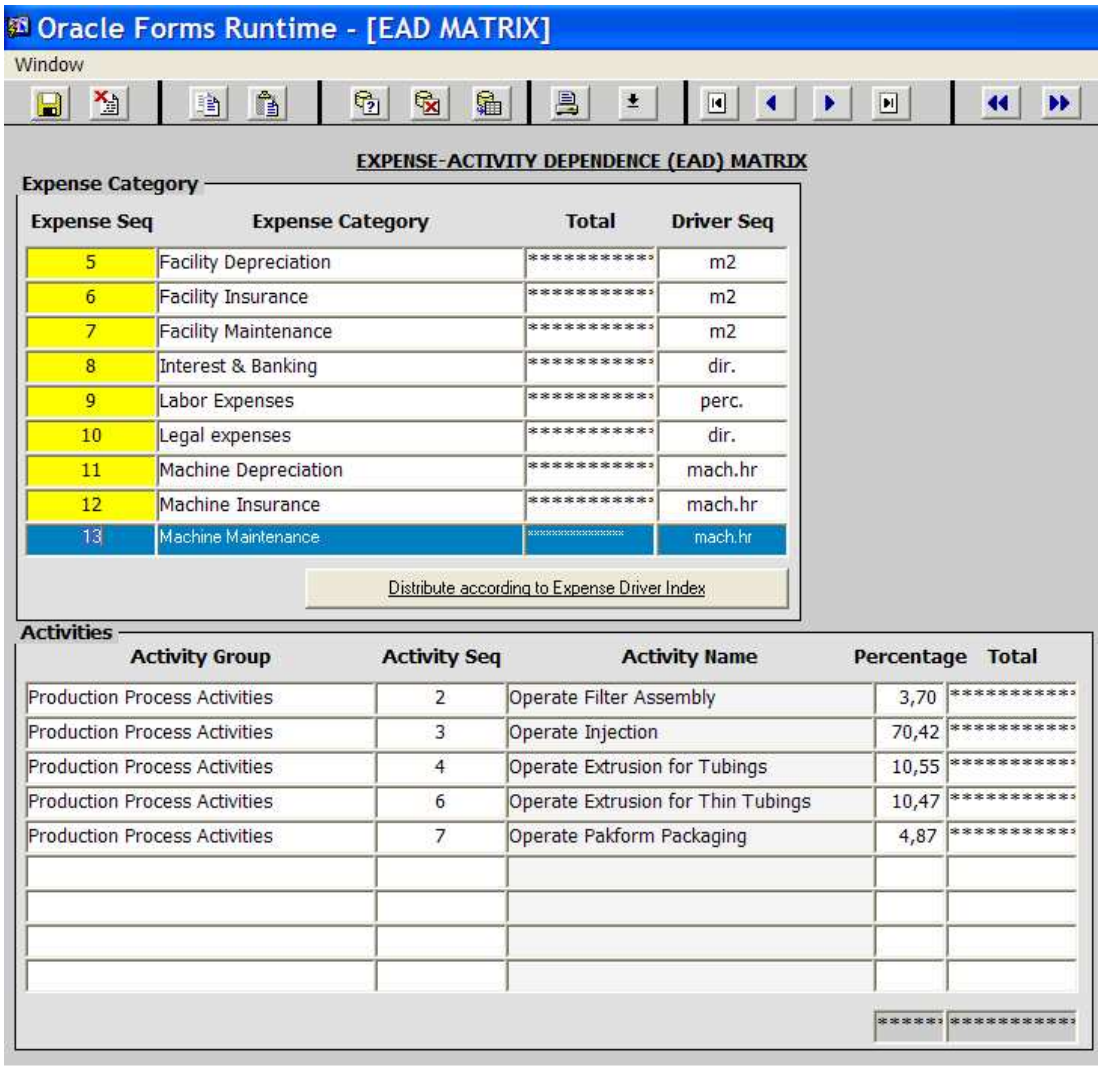

Figure 5.7 EAD Matrix

Percentages for distribution of all expenses to activities can be seen in Table 5.7. These percentages determined according to previous year data and current year budget. After the activity costs were calculated, activity cost driver quantities were determined according to related activity drivers.

According to expense-activity dependence matrix which is given in Table 5.7, all expenses were distributed to products except exportation and shipment expenses. Because this costs are valid for export customers and these expenses are taken from customers according to their agreements. For domestic sales, all shipment costs like cargo belong to recipients.

To calculate the total amount consumed by each activity, each consumption rate is multiplied by the value of the expense and then summed across each category. An example calculation for the assembly cost pool is provided below.

Total cost for Assembly activity = (0.17 * Labor expenses) + (0.30 * Electricity)
+ (0.15 * Facility depreciation) + (0.47 * Social assistances)
+ (0.09 * Other material expenses) + (0.15 * Security)
+ (0.11 * Other depreciations) + (0.20 * Utilities)
+ (0.15 * Facility insurance) + (0.15 * Facility maintenance)

In Table 5.8, total of activities costs and their related activity drivers are given and unit activity cost driver quantities are calculated with below formula.

Unit activity cost driver quantity = Total cost of activity / Total activity cost driver rate

For example, activity driver for control & audit production activity is production hour which is 67954 hour and total activity cost is 39908.

Unit activity cost driver quantity = 39908 / 67954 = 0.5873

Table 5.7 Expense-activity dependence matrix

		Production Process Activities						***Production Chief Activities***		***Tech. Act.***	***Logistics Activities***				***Quality Activities***					***Sales Activities***		***Mrk. Act.***	***Other Activities***	
Expense Categories	**Expense driver**	Operate Injection	Operate Extrusion for Tubings	Operate Extrusion for Thin Tubings	Operate Filter Assembly	Operate Pakform Packaging	Assembly	Make production plan	Control & audit production	Maintain & repair	Receive & control material	Carry materials inside of factory	Warehouse	Dispatch finished product	Certify	Receive & control material	Dispatch finished product	Control & audit production	Sterilize	Receive & process orders	Dispatch finished product	Marketing	General Administration	Finance
Labor expenses	Percentage	0.15	0.02	0.02	0.01	0.01	0.17	0.09	0.04	0.04	0.01	0.04	0.01	0.03	0.00	0.01	0.01	0.02	0.03	0.02	0.01	0.13	0.13	0.00
Exportation	Direct																							
Electricity	kw-hr	0.50	0.06	0.03	0.02	0.03	0.30	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Interest & banking	Direct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Machine depreciation	machine hour	0.70	0.11	0.10	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shipment	Direct																							
Mold depreciation	Percentage	0.68	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Facility depreciation	area (m2)	0.07	0.03	0.02	0.01	0.01	0.15	0.00	0.00	0.05	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marketing	Direct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
Legal expenses	Direct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Renting	Percentage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.46	0.00
Machine maintenance	machine hour	0.70	0.11	0.10	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.7 Expense-activity dependence matrix (continued)

		Production Process Activities						***Production Chief Activities***		***Tech. Act.***	***Logistics Activities***				***Quality Activities***					***Sales Activities***		***Mrk. Act.***	***Other Activities***	
Expense Categories	**Expense driver**	Operate Injection	Operate Extrusion for Tubings	Operate Extrusion for Thin Tubings	Operate Filter Assembly	Operate Pakform Packaging	Assembly	Make production plan	Control & audit production	Maintain & repair	Receive & control material	Carry materials inside of factory	Warehouse	Dispatch finished product	Certify	Receive & control material	Dispatch finished product	Control & audit production	Sterilize	Receive & process orders	Dispatch finished product	Marketing	General Administration	Finance
Social assistances	percentage	0.10	0.02	0.02	0.02	0.02	0.47	0.05	0.02	0.04	0.02	0.05	0.01	0.03	0.00	0.01	0.01	0.02	0.02	0.03	0.02	0.02	0.00	0.00
Other material expenses	percentage	0.02	0.00	0.00	0.00	0.09	0.09	0.04	0.02	0.12	0.02	0.05	0.01	0.03	0.00	0.00	0.01	0.01	0.19	0.00	0.00	0.24	0.06	0.00
Security	area (m2)	0.07	0.03	0.02	0.01	0.01	0.15	0.00	0.00	0.05	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vehicle	percentage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.19	0.00
Other depreciations (fixture)	percentage	0.02	0.01	0.00	0.00	0.03	0.11	0.00	0.00	0.05	0.03	0.35	0.09	0.03	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.18	0.08	0.00
Consultancy	direct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Other expenses	direct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Mold maintenance	direct	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Utilities	percentage	0.04	0.01	0.01	0.01	0.01	0.20	0.11	0.05	0.06	0.01	0.04	0.01	0.03	0.01	0.01	0.02	0.02	0.05	0.03	0.02	0.13	0.11	0.00
Quality	percentage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.03	0.05	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Facility insurance	area (m2)	0.07	0.03	0.02	0.01	0.01	0.15	0.00	0.00	0.05	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.7 Expense-activity dependence matrix (continued)

		Production Process Activities						***Production Chief Activities***		***Tech. Act.***	***Logistics Activities***				***Quality Activities***					***Sales Activities***		***Mrk. Act.***	***Other Activities***	
Expense Categories	**Expense driver**	Operate Injection	Operate Extrusion for Tubings	Operate Extrusion for Thin Tubings	Operate Filter Assembly	Operate Pakform Packaging	Assembly	Make production plan	Control & audit production	Maintain & repair	Receive & control material	Carry materials inside of factory	Warehouse	Dispatch finished product	Certify	Receive & control material	Dispatch finished product	Control & audit production	Sterilize	Receive & process orders	Dispatch finished product	Marketing	General Administration	Finance
Machine insurance	machine hour	0.70	0.11	0.10	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sterilization materials	direct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Analysis & Test	percentage	0.00	0.00	0.00	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00
Other insurance (fixture)	percentage	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.28	0.06	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00
Facility maintenance	area (m2)	0.07	0.03	0.02	0.01	0.01	0.15	0.00	0.00	0.05	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.8 Activity cost driver quantity calculation

Activities	Total cost of activities	Activity driver	Total Activity cost driver rate	Unit Activity cost driver quantity
Assembly	223505	asm.hr	33650	6.6421
Carry materials inside of factory	45589	bom.job	6097	7.4773
Control & audit production	39908	prd.hr	67954	0.5873
Dispatch finished product	43627	delivery	4580	9.5255
Maintain & repair	56693	mch.hr	34304	1.6527
Make production plan	62997	job.order	7751	8.1276
Marketing	191983	sales budget	5315235	0.0361
Operate Extrusion for Tubings	76350	ext.hr	3628	21.0447
Operate Extrusion for Thin Tubings	42556	rec.hr	3659	11.6305
Operate Filter Assembly	28834	filt.hr	1302	22.1459
Operate Injection	429325	inj.hr	24091	17.8210
Operate Pakform Packaging	28680	pak.hr	1623	17.6710
Receive & control material	18821	receipt	819	22.9799
Receive & process orders	15266	cust.order	4869	3.1353
Sterilize	70635	cycle	141	500.9574
Certify	20933	product	819	25.5592
Warehouse	110925	safety stock	950415	0.1167

Activity driver for general administration costs is value added to product which is the sum of activities costs. After total cost of activities except general administration cost was calculated, general administration cost was distributed to products.

5.4.4 Assignment of Activities to Products

In this step, the activities consumed by each product are identified, and the activity-product-dependence (APD) matrix is created. The activities represent the columns of the APD matrix, whereas the products represent the rows. If the product i consumes the activity j, the cell i, j contains a checkmark. Table 5.9 shows product groups and their related activities. Figure 5.8 also shows distribution of activity costs

to all products according to related activity drivers on Oracle. The company has about 1000 product and the computation is very difficult except Oracle. First, activity cost driver quantities for every product was calculated and then, product costs were generated according to activity cost driver rate.

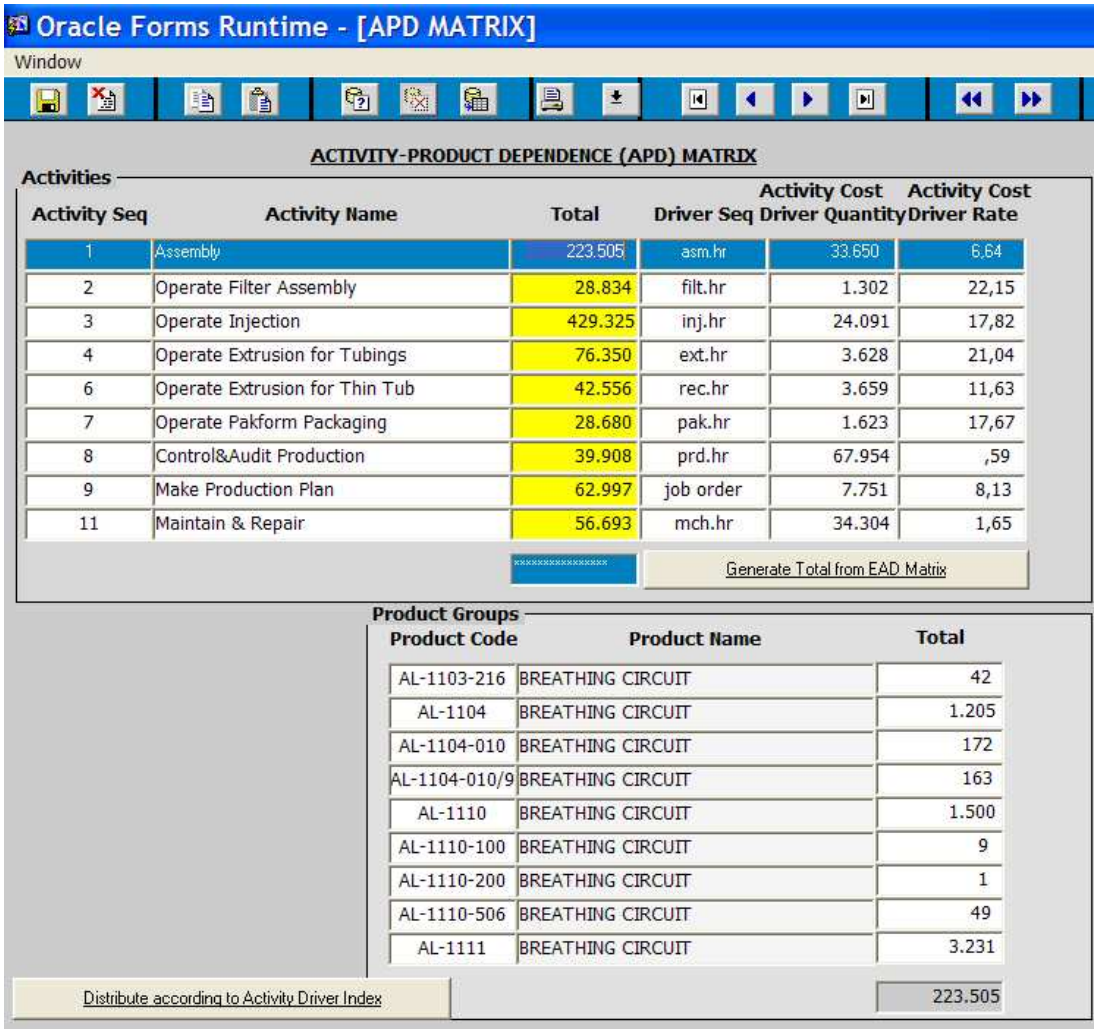

Figure 5.8 APD Matrix

Product costs were calculated from semi-finished products to products. Because a product can consist of raw material and semi-finished products. After the semi-finished product cost which is sum of direct material costs and indirect costs is computed, finished product cost can be determined.

Table 5.9 Activity product dependence matrix

			Product Groups						
Activities	**Activity driver**	**Activity cost driver quantity**	**Assembled products**	**Assembled Filter**	**Semi-products (injection)**	**Tubings**	**Thin Tubings**	**Pak. Packaged Products**	**Sterile assembled products**
Assembly	asm.hr	6.6421	√					√	√
Carry materials inside of factory	bom.job	7.4773	√	√	√	√	√	√	√
Control & audit production	prd.hr	0.5873	√	√	√	√	√	√	√
Dispatch finished product	delivery	9.5255	√					√	√
General Administration	value added	0.1537	√	√	√	√	√	√	√
Maintain & repair	mch.hr	1.6527		√	√	√	√	√	
Make production plan	job.order	8.1276	√	√	√	√	√	√	√
Marketing	sales budget	0.0361	√					√	√
Operate Extrusion for Tubings	ext.hr	21.0447				√			
Operate Extrusion for Thin Tubings	rec.hr	11.6305					√		
Operate Filter Assembly	filt.hr	22.1459		√					
Operate Injection	inj.hr	17.8210			√				
Operate Pakform Packaging	pak.hr	17.6710						√	
Receive & control material	receipt	22.9799	√	√	√	√	√	√	√
Receive & process orders	cust.order	3.1353	√					√	√
Sterilize	cycle	500.9574							√
Certify	product	25.5592	√	√	√	√	√	√	√
Warehouse	safety stock	0.1167	√	√	√	√	√	√	√

There are some samples for most manufactured products for every product group. For a breathing circuit from assembled products group, cost is calculated as follows.

Table 5.10 Product cost for sample breathing circuit

Activities	**Activity driver**	**Unit cost driver**	**Activity cost driver quantity**	**Total**
Assembly	asm.hr	6.6421	1831	12164.78
Carry materials inside of factory	bom.job	7.4773	143	1072.24
Control & audit production	prd.hr	0.5873	1831	1075.59
Dispatch finished product	delivery	9.5255	108	1028.76
Make production plan	job.order	8.1276	144	1170.37
Receive & control material	receipt	22.9799	22	505.00
Receive & process orders	cust.order	3.1353	134	420.14
Certify	product	25.5592	1	25.56
Warehouse	safety stock	0.1167	12201	1424.00
Marketing	sales budget	0.0361	333675	12052.13
General Administration Cost	value added	0.1537	30939	4755.29
Total Activities Cost				35693.87
Production Amount				73259
Unit Activities Cost				0.49
Direct Material Cost				2.88
Total Cost with ABC				3.37
Total Cost with TC				3.04
Bias				11%

According to sample calculation in Table 5.10, cost for assembled products can be determined by the following formula.

Total cost for assembled products = assembly hour * 6.6421 + (0.6*number of bom order + 0.4*number of job order) * 7.4773 + assembly hour * 0.5873 + number of delivery * 9.5255 + number of job order * 8.1276 + number of receipt * 22.9799 +

number of customer order * 3.1353 + 25.5592 + safety stock amount * 0.1167 + sales budget * 0.0361 + value added to product * 0.1537

Table 5.11 Product cost for sample assembled filter

Activities	**Activity driver**	**Unit cost driver**	**Activity cost driver quantity**	**Total**
Carry materials inside of factory	bom.job	7.4773	52	385.83
Control & audit production	prd.hr	0.5873	492	288.69
Maintain & repair	mch.hr	1.6527	492	812.42
Make production plan	job.order	8.1276	51	414.51
Operate Filter Assembly	filt.hr	22.1459	492	10886.50
Receive & control material	receipt	22.9799	11	251.00
Certify	product	25.5592	1	25.56
Warehouse	safety stock	0.1167	10727	1252.00
General Administration Cost	value added	0.1537	14317	2200.46
Total Activities Cost				16516.96
Production Amount				176969
Unit Activities Cost				0.09
Direct Material Cost				1.03
Total Cost with ABC				1.12
Total Cost with TC				0.54
Bias				108%

According to sample calculation in Table 5.11, cost for assembled filters can be determined by the following formula.

Total cost for assembled filters = (0.6*number of bom order + 0.4*number of job order) * 7.4773 + machine hour * 0.5873 + machine hour * 1.6527 + number of job order * 8.1276 + machine hour * 22.1459 + # of receipt * 22.9799 + 25.5592 + safety stock * 0.1167 + value added to product * 0.1537

Table 5.12 Product cost for sample semi-finished product for injection

Activities	**Activity driver**	**Unit cost driver**	**Activity cost driver quantity**	**Total**
Carry materials inside of factory	bom.job	7.4773	68	505.46
Control & audit production	prd.hr	0.5873	1412	829.37
Maintain & repair	mch.hr	1.6527	1412	2333.93
Make production plan	job.order	8.1276	145	1178.50
Operate Injection	inj.hr	17.8210	1412	25167.13
Receive & control material	receipt	22.9799	3	59.00
Certify	product	25.5592	1	25.56
Warehouse	safety stock	0.1167	7823	913.00
General Administration Cost	value added	0.1537	31012	4766.57
Total Activities Cost				35778.52
Production Amount				1016595
Unit Activities Cost				0.04
Direct Material Cost				0.03
Total Cost with ABC				0.07
Total Cost with TC				0.04
Bias				86%

According to sample calculation in Table 5.12, cost for semi-products for injection can be determined by the following formula.

Total cost for semi-finished products for injection = (0.6*number of bom order + 0.4*number of job order) * 7.4773 + machine hour * 0.5873 + machine hour * 1.6527 + number of job order * 8.1276 + machine hour * 17.8210 + number of receipt * 22.9799 + 25.5592 + safety stock * 0.1167 + value added to product * 0.1537

According to sample calculation in Table 5.13, cost for tubing can be determined by the following formula.

Total cost for tubing= (0.6*number of bom order + 0.4*number of job order) * 7.4773 + machine hour * 0.5873 + machine hour * 1.6527 + number of job order * 8.1276 + machine hour * 21.0447 + number of receipt * 22.9799 + 25.5592 + safety stock * 0.1167 + value added to product * 0.1537

Table 5.13 Product cost for sample tubing

Activities	**Activity driver**	**Unit cost driver**	**Activity cost driver quantity**	**Total**
Carry materials inside of factory	bom.job	7.4773	27	203.38
Control & audit production	prd.hr	0.5873	369	216.90
Maintain & repair	mch.hr	1.6527	369	610.38
Make production plan	job.order	8.1276	47	382.00
Operate Extrusion for Tubings	ext.hr	21.0447	369	7772.42
Receive & control material	receipt	22.9799	3	78.00
Certify	product	25.5592	1	25.56
Warehouse	safety stock	0.1167	6726	785.00
General Administration Cost	value added	0.1537	10074	1548.33
Total Activities Cost				11621.97
Production Amount				277000
Unit Activities Cost				0.04
Direct Material Cost				0.08
Total Cost with ABC				0.12
Total Cost with TC				0.13
Bias				-8%

According to sample calculation in Table 5.14, cost for thin tubings can be determined by the following formula.

Total cost for thin tubings = (0.6*number of bom order + 0.4*number of job order) * 7.4773 + machine hour * 0.5873 + machine hour * 1.6527 + number of job order * 8.1276 + machine hour * 11.6305 + number of receipt * 22.9799 + 25.5592 + safety stock * 0.1167 + value added to product * 0.1537

Table 5.14 Product cost for sample thin tubing

Activities	Activity driver	Unit cost driver	Activity cost driver quantity	Total
Carry materials inside of factory	bom.job	7.4773	87	647.53
Control & audit production	prd.hr	0.5873	1842	1081.87
Maintain & repair	mch.hr	1.6527	1842	3044.49
Make production plan	job.order	8.1276	179	1454.84
Operate Extrusion for Thin Tubings	rec.hr	11.6305	1842	21425.36
Receive & control material	receipt	22.9799	7	163.00
Certify	product	25.5592	1	25.56
Warehouse	safety stock	0.1167	9134	1066.00
General Administration Cost	value added	0.1537	28909	4443.29
Total Activities Cost				33351.94
Production Amount				336050
Unit Activities Cost				0.10
Direct Material Cost				0.33
Total Cost with ABC				0.43
Total Cost with TC				0.30
Bias				42%

According to sample calculation in Table 5.15, cost for pakform packaged assembly products can be determined by the following formula.

Total cost for pakform packaged assembled products = assembly hour * 6.6421 + (0.6*number of bom order + 0.4*number of job order) * 7.4773 + production hour * 0.5873 + # of delivery * 9.5255 + machine hour * 1.6527 + number of job order * 8.1276 + machine hour * 17.6710 + # of customer order * 3.1353 + number of receipt * 22.9799 + 25.5592 + safety stock * 0.1167 + sales budget * 0.0361 + value added to product * 0.1537

Table 5.15 Product cost for Pakform Packaged assembly products

Activities	Activity driver	Unit cost driver	Activity cost driver quantity	Total
Assembly	asm.hr	6.6421	13	86.01
Carry materials inside of factory	bom.job	7.4773	64	480.04
Control & audit production	prd.hr	0.5873	284	167.00
Dispatch finished product	delivery	9.5255	103	981.13
Maintain & repair	mch.hr	1.6527	271	448.57
Make production plan	job.order	8.1276	66	536.42
Operate Pakform Packaging	pak.hr	17.6710	271	4796.26
Receive & process orders	cust.order	3.1353	105	329.21
Receive & control material	receipt	22.9799	5	105.00
Certify	product	25.5592	1	25.56
Warehouse	safety stock	0.1167	103	12.00
Marketing	sales budget	0.0361	126534	4570.33
General Administration Cost	value added	0.1537	12538	1927.03
Total Activities Cost				14464.57
Production Amount				170621
Unit Activities Cost				0.08
Direct Material Cost				0.55
Total Cost with ABC				0.63
Total Cost with TC				0.48
Bias				33%

According to sample calculation in Table 5.16, cost for sterilized products can be determined by the following formula.

Total cost for sterilized assembled products = assembly hour * 6.6421 + (0.6*number of bom order + 0.4*number of job order) * 7.4773 + assembly hour * 0.5873 + # of delivery * 9.5255 + number of job order * 8.1276 + # of customer order * 3.1353 + number of receipt * 22.9799 + # of sterilization cycle * 500.9574 +

25.5592 + safety stock * 0.1167 + sales budget * 0.0361 + value added to product * 0.1537

Table 5.16 Product cost for sterilized assembly products

Activities	Activity driver	Unit cost driver	Activity cost driver quantity	Total
Assembly	asm.hr	6.6421	252	1671.14
Carry materials inside of factory	bom.job	7.4773	13	97.20
Control & audit production	prd.hr	0.5873	252	147.76
Dispatch finished product	delivery	9.5255	6	57.15
Make production plan	job.order	8.1276	13	105.66
Receive & process orders	cust.order	3.1353	13	40.76
Receive & control material	receipt	22.9799	4	101.00
Sterilize	cycle	500.9574	20	10019.15
Certify	product	25.5592	1	25.56
Warehouse	safety stock	0.1167	1028	120.00
Marketing	sales budget	0.0361	57235	2067.28
General Administration Cost	value added	0.1537	14453	2221.39
Total Activities Cost				16674.06
Production Amount				7676
Unit Activities Cost				2.17
Direct Material Cost				7.20
Total Cost with ABC				9.37
Total Cost with TC				5.72
Bias				64%

5.5 Comparison of the Results

After the activities were distributed to all products, results were compared with current traditional costing system of the company. Table 5.17 shows differences between two costing system for most manufactured products. By looking at the results, it is concluded that there are significant differences between product costs

obtained by ABC and traditional costing. Total absolute difference is 1487779 and 112 products which are 20% of products create 80% of the differences.

ABC analysis proved that some products are overcosted and some of them are undercosted or same. The differences of two systems can be explained as following main reasons.

- Non-production costs like sales, marketing and general administration costs were distributed to all products with ABC unlike traditional costing system. In the determination of product sales price, non-production costs must be taken into account.

- Quality and logistic costs were distributed to all products with ABC unlike traditional costing system.

- All expenses were distributed on the basis of activities. So expenses which are allocated on product groups were obtained more accurate. Traditional costing system is distributed to all products on the basis of production hours. But if product and process variety is too much, traditional costing system fails.

ABC will help to make more accurate sales price forecast. Sales prices can be determined easily with the addition of target profit rate on the product cost. If sales price is not enough to stay in the market,

(i) new raw materials which will not affect product quality should be searched,
(ii) decision of purchasing of end-product from outside should be made or
(iii) activities that increase cost should be reviewed.

ABC is also a useful tool in product cost reduction decisions. It is easy to determine with ABC which of the products consumed activities most and which of the activities cost highly. It helps strategical decisions on products and operational decisions on activities.

Table 5.17 Comparison of TC and ABC in terms of cost

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 1	166804	0,65	0,23	-0,42	-65%	70482	5%
Product 2	170621	0,41	0,65	0,24	60%	41544	8%
Product 3	336050	0,35	0,26	-0,09	-25%	29153	9%
Product 4	104460	0,56	0,83	0,27	48%	28197	11%
Product 5	122350	0,88	1,10	0,22	25%	27058	13%
Product 6	7676	6,04	9,43	3,39	56%	26053	15%
Product 7	39291	1,39	0,75	-0,64	-46%	24999	17%
Product 8	33179	2,96	2,23	-0,73	-25%	24202	18%
Product 9	520080	0,04	0,09	0,05	101%	23527	20%
Product 10	118964	0,40	0,58	0,18	47%	21963	21%
Product 11	73259	3,13	3,43	0,30	9%	21726	23%
Product 12	1016595	0,04	0,06	0,02	55%	21611	24%
Product 13	599740	0,03	0,07	0,04	103%	21297	26%
Product 14	73956	0,47	0,19	-0,28	-59%	20620	27%
Product 15	336560	0,60	0,54	-0,06	-10%	20471	28%
Product 16	23491	2,71	1,92	-0,79	-29%	18659	30%
Product 17	212104	0,07	0,15	0,08	117%	17184	31%
Product 18	5002	16,67	20,10	3,43	21%	17133	32%
Product 19	569904	0,03	0,06	0,03	100%	17115	33%
Product 20	12073	5,65	6,98	1,33	24%	16066	34%
Product 21	466048	0,08	0,11	0,03	45%	16022	35%
Product 22	87100	0,35	0,53	0,18	53%	15992	36%
Product 23	166453	0,29	0,38	0,09	30%	14440	37%
Product 24	17554	0,93	0,12	-0,81	-87%	14173	38%
Product 25	176969	0,54	0,62	0,08	15%	14078	39%
Product 26	34013	0,52	0,92	0,40	78%	13755	40%
Product 27	35006	0,44	0,83	0,39	89%	13683	41%
Product 28	28221	1,06	0,58	-0,48	-46%	13678	42%
Product 29	65664	0,39	0,59	0,20	52%	13177	43%
Product 30	46943	0,60	0,88	0,28	47%	13112	44%
Product 31	148100	0,33	0,42	0,09	26%	12919	45%
Product 32	204910	0,07	0,13	0,06	93%	12804	45%
Product 33	13297	0,89	1,84	0,95	108%	12695	46%
Product 34	8259	2,91	1,43	-1,48	-51%	12199	47%
Product 35	202635	0,07	0,13	0,06	85%	12080	48%
Product 36	463500	0,03	0,06	0,03	77%	12068	49%
Product 37	46850	0,52	0,78	0,26	49%	12063	50%
Product 38	75986	0,20	0,36	0,16	77%	11859	50%
Product 39	192600	0,33	0,39	0,06	18%	11680	51%
Product 40	295644	0,06	0,10	0,04	65%	11626	52%

Table 5.17 Comparison of TC and ABC in terms of cost (continued)

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 41	41162	0,44	0,17	-0,27	-62%	11307	53%
Product 42	200550	0,23	0,17	-0,06	-25%	11212	53%
Product 43	39424	1,45	1,73	0,28	19%	10952	54%
Product 44	148836	0,47	0,54	0,07	14%	9768	55%
Product 45	485807	0,03	0,05	0,02	67%	9753	56%
Product 46	517450	0,02	0,04	0,02	89%	9718	56%
Product 47	455150	0,03	0,05	0,02	74%	9652	57%
Product 48	188668	0,08	0,13	0,05	64%	9596	57%
Product 49	159450	0,36	0,30	-0,06	-16%	9279	58%
Product 50	312160	0,06	0,09	0,03	48%	9103	59%
Product 51	30430	0,47	0,74	0,27	59%	8340	59%
Product 52	65131	1,00	0,87	-0,13	-13%	8281	60%
Product 53	285568	0,04	0,07	0,03	61%	7544	60%
Product 54	273370	0,09	0,12	0,03	30%	7506	61%
Product 55	487500	0,02	0,04	0,02	62%	7491	61%
Product 56	314800	0,13	0,15	0,02	18%	7332	62%
Product 57	141230	0,12	0,17	0,05	42%	7145	62%
Product 58	19538	0,42	0,78	0,36	87%	7096	63%
Product 59	4503	6,70	8,27	1,57	23%	7079	63%
Product 60	83750	0,09	0,17	0,08	94%	6917	64%
Product 61	37268	0,29	0,47	0,18	64%	6867	64%
Product 62	24270	0,41	0,69	0,28	69%	6859	65%
Product 63	32372	1,26	1,47	0,21	17%	6803	65%
Product 64	290150	0,03	0,05	0,02	87%	6761	66%
Product 65	71510	0,12	0,21	0,09	81%	6723	66%
Product 66	11300	1,00	1,59	0,59	59%	6653	66%
Product 67	3702	8,05	9,83	1,78	22%	6602	67%
Product 68	154470	0,04	0,08	0,04	112%	6515	67%
Product 69	103050	0,08	0,14	0,06	79%	6349	68%
Product 70	12626	3,28	2,82	-0,46	-14%	5843	68%
Product 71	25700	0,37	0,60	0,23	60%	5789	69%
Product 72	792260	0,02	0,03	0,01	31%	5684	69%
Product 73	14834	0,48	0,86	0,38	80%	5664	69%
Product 74	29410	0,33	0,52	0,19	58%	5589	70%
Product 75	23302	4,85	4,62	-0,23	-5%	5302	70%
Product 76	17213	0,54	0,85	0,31	56%	5261	70%
Product 77	102500	0,06	0,11	0,05	86%	5222	71%
Product 78	60784	0,17	0,26	0,09	49%	5204	71%
Product 79	49709	0,85	0,95	0,10	12%	5194	71%
Product 80	15074	2,24	1,91	-0,33	-15%	4959	72%

Table 5.17 Comparison of TC and ABC in terms of cost (continued)

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 81	2502	5,00	6,97	1,97	40%	4939	72%
Product 82	9804	1,45	0,95	-0,50	-35%	4933	72%
Product 83	1459	5,76	9,06	3,30	57%	4821	73%
Product 84	48000	0,41	0,51	0,10	24%	4754	73%
Product 85	5759	3,55	2,74	-0,81	-23%	4677	73%
Product 86	32500	0,26	0,40	0,14	54%	4579	74%
Product 87	59851	0,18	0,26	0,08	42%	4579	74%
Product 88	2200	7,65	9,72	2,07	27%	4553	74%
Product 89	11604	0,44	0,83	0,39	87%	4486	75%
Product 90	28760	0,74	0,59	-0,15	-21%	4408	75%
Product 91	5365	1,47	2,28	0,81	55%	4346	75%
Product 92	291000	0,03	0,04	0,01	59%	4299	76%
Product 93	2500	5,35	7,03	1,68	31%	4202	76%
Product 94	2323	2,81	4,62	1,81	64%	4197	76%
Product 95	80442	0,78	0,83	0,05	7%	4192	76%
Product 96	9550	2,89	2,46	-0,43	-15%	4124	77%
Product 97	8545	1,83	1,35	-0,48	-26%	4107	77%
Product 98	48000	0,10	0,19	0,09	81%	4083	77%
Product 99	10004	1,02	1,42	0,40	39%	4022	77%
Product 100	34885	0,25	0,13	-0,12	-47%	4015	78%
Product 101	86390	0,09	0,13	0,04	52%	3863	78%
Product 102	17584	0,78	0,99	0,21	27%	3692	78%
Product 103	1206	6,14	8,99	2,85	47%	3443	78%
Product 104	501	10,16	3,53	-6,63	-65%	3322	79%
Product 105	24468	2,99	3,13	0,14	5%	3320	79%
Product 106	10950	0,48	0,78	0,30	63%	3309	79%
Product 107	13101	1,31	1,56	0,25	19%	3264	79%
Product 108	8931	0,57	0,21	-0,36	-63%	3207	80%
Product 109	1500	5,20	7,33	2,13	41%	3200	80%
Product 110	3250	3,78	2,80	-0,98	-26%	3189	80%
Product 111	5456	0,79	1,36	0,57	73%	3130	80%
Product 112	11003	1,15	0,87	-0,28	-25%	3111	80%
Product 113	28496	0,51	0,62	0,11	21%	3101	81%
Product 114	68700	0,07	0,11	0,04	69%	3073	81%
Product 115	67250	0,07	0,12	0,05	61%	3049	81%
Product 116	2338	3,13	4,41	1,28	41%	2987	81%
Product 117	1863	3,01	1,41	-1,60	-53%	2983	81%
Product 118	625	11,88	16,64	4,76	40%	2974	82%
Product 119	76136	0,13	0,17	0,04	29%	2921	82%
Product 120	2618	3,53	2,42	-1,11	-32%	2915	82%

Table 5.17 Comparison of TC and ABC in terms of cost (continued)

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 121	3784	1,30	2,07	0,77	59%	2906	82%
Product 122	1938	10,33	11,82	1,49	14%	2888	82%
Product 123	66950	0,05	0,09	0,04	90%	2859	83%
Product 124	3600	2,40	1,61	-0,79	-33%	2855	83%
Product 125	22100	0,31	0,44	0,13	41%	2816	83%
Product 126	2503	4,31	3,21	-1,10	-26%	2763	83%
Product 127	19030	0,39	0,25	-0,14	-36%	2714	83%
Product 128	83500	0,22	0,19	-0,03	-14%	2663	84%
Product 129	65000	0,08	0,12	0,04	51%	2650	84%
Product 130	602	20,64	25,01	4,37	21%	2631	84%
Product 131	2006	1,46	2,75	1,29	89%	2592	84%
Product 132	5710	1,61	1,16	-0,45	-28%	2563	84%
Product 133	15002	0,26	0,09	-0,17	-65%	2502	84%
Product 134	4100	0,69	1,29	0,60	88%	2474	85%
Product 135	3001	5,76	4,94	-0,82	-14%	2465	85%
Product 136	11623	1,36	1,57	0,21	16%	2457	85%
Product 137	2201	8,83	9,94	1,11	13%	2448	85%
Product 138	2200	3,87	2,77	-1,10	-28%	2429	85%
Product 139	3653	5,70	6,36	0,66	12%	2414	85%
Product 140	255800	0,02	0,03	0,01	45%	2392	86%
Product 141	1002	6,85	9,22	2,37	35%	2375	86%
Product 142	3947	1,03	1,62	0,59	58%	2340	86%
Product 143	6502	1,16	1,52	0,36	31%	2316	86%
Product 144	52100	0,35	0,31	-0,04	-12%	2293	86%
Product 145	11994	1,05	1,24	0,19	18%	2289	86%
Product 146	1231	6,44	8,30	1,86	29%	2286	86%
Product 147	8022	0,57	0,29	-0,28	-49%	2257	87%
Product 148	160	24,25	10,29	-13,96	-58%	2234	87%
Product 149	856	7,70	10,26	2,56	33%	2192	87%
Product 150	4311	1,69	1,18	-0,51	-30%	2183	87%
Product 151	1003	4,90	7,05	2,15	44%	2159	87%
Product 152	6040	2,23	1,88	-0,35	-16%	2133	87%
Product 153	1604	4,67	5,99	1,32	28%	2118	88%
Product 154	1619	5,17	6,46	1,29	25%	2084	88%
Product 155	277000	0,13	0,12	-0,01	-6%	2040	88%
Product 156	63350	0,03	0,06	0,03	115%	2033	88%
Product 157	1460	7,45	8,84	1,39	19%	2033	88%
Product 158	26101	0,86	0,94	0,08	9%	1993	88%
Product 159	19503	0,26	0,36	0,10	39%	1972	88%
Product 160	18820	0,11	0,21	0,10	99%	1968	88%

Table 5.17 Comparison of TC and ABC in terms of cost (continued)

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 161	17200	0,36	0,25	-0,11	-31%	1919	89%
Product 162	38250	0,07	0,12	0,05	70%	1892	89%
Product 163	7000	0,50	0,23	-0,27	-54%	1885	89%
Product 164	3306	0,61	1,16	0,55	90%	1817	89%
Product 165	7801	1,49	1,72	0,23	15%	1788	89%
Product 166	296200	0,03	0,02	-0,01	-23%	1757	89%
Product 167	41859	0,35	0,39	0,04	12%	1746	89%
Product 168	4614	1,26	1,64	0,38	30%	1740	89%
Product 169	483	8,03	11,62	3,59	45%	1735	90%
Product 170	77150	0,03	0,05	0,02	81%	1722	90%
Product 171	2006	1,10	1,93	0,83	76%	1667	90%
Product 172	4516	0,67	1,03	0,36	54%	1626	90%
Product 173	1102	2,61	4,04	1,43	55%	1577	90%
Product 174	20570	0,12	0,20	0,08	60%	1544	90%
Product 175	9218	0,36	0,52	0,16	46%	1502	90%
Product 176	8500	0,45	0,28	-0,17	-38%	1479	90%
Product 177	11000	0,73	0,60	-0,13	-18%	1474	90%
Product 178	200	35,71	43,02	7,31	20%	1461	91%
Product 179	5510	0,92	1,18	0,26	28%	1433	91%
Product 180	1200	3,96	2,79	-1,17	-30%	1408	91%
Product 181	4602	0,47	0,77	0,30	65%	1394	91%
Product 182	1503	4,19	3,27	-0,92	-22%	1383	91%
Product 183	1001	7,28	8,61	1,33	18%	1332	91%
Product 184	30690	0,07	0,11	0,04	63%	1299	91%
Product 185	1002	3,36	4,66	1,30	38%	1298	91%
Product 186	14005	0,30	0,21	-0,09	-31%	1298	91%
Product 187	19887	0,38	0,44	0,06	17%	1275	91%
Product 188	3977	4,73	5,05	0,32	7%	1258	91%
Product 189	266	11,54	16,18	4,64	40%	1234	91%
Product 190	1994	2,36	1,75	-0,61	-26%	1208	92%
Product 191	380	6,11	9,29	3,18	52%	1207	92%
Product 192	350	12,26	15,65	3,39	28%	1186	92%
Product 193	873	11,93	13,26	1,33	11%	1159	92%
Product 194	573770	0,04	0,04	0,00	5%	1150	92%
Product 195	2608	0,99	1,43	0,44	44%	1141	92%
Product 196	16880	5,50	5,57	0,07	1%	1129	92%
Product 197	21850	0,05	0,10	0,05	107%	1127	92%
Product 198	7003	2,83	2,99	0,16	6%	1115	92%
Product 199	6302	0,38	0,56	0,18	46%	1114	92%
Product 200	1763	3,10	3,72	0,62	20%	1102	92%

Table 5.17 Comparison of TC and ABC in terms of cost (continued)

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 201	253	14,86	19,12	4,26	29%	1078	92%
Product 202	107100	0,17	0,16	-0,01	-6%	1049	92%
Product 203	2632	1,10	1,49	0,39	36%	1039	93%
Product 204	1250	8,34	9,17	0,83	10%	1033	93%
Product 205	1162	5,25	6,14	0,89	17%	1032	93%
Product 206	1001	5,29	6,32	1,03	19%	1029	93%
Product 207	15900	0,42	0,36	-0,06	-15%	1021	93%
Product 208	41125	0,09	0,11	0,02	29%	1019	93%
Product 209	49800	0,06	0,08	0,02	34%	1017	93%
Product 210	957	5,30	6,35	1,05	20%	1006	93%
Product 211	1861	2,79	2,26	-0,53	-19%	992	93%
Product 212	20000	0,21	0,26	0,05	23%	979	93%
Product 213	27000	0,04	0,08	0,04	83%	977	93%
Product 214	36803	0,15	0,18	0,03	17%	976	93%
Product 215	266700	0,24	0,24	0,00	-1%	962	93%
Product 216	2401	1,15	1,55	0,40	34%	953	93%
Product 217	1000	3,27	2,32	-0,95	-29%	950	93%
Product 218	409	5,98	8,30	2,32	39%	949	94%
Product 219	400	3,51	5,87	2,36	67%	944	94%
Product 220	20000	0,07	0,12	0,05	64%	941	94%
Product 221	23600	0,34	0,38	0,04	11%	923	94%
Product 222	62400	0,03	0,04	0,01	58%	917	94%
Product 223	1520	3,14	3,74	0,60	19%	916	94%
Product 224	824	10,92	12,01	1,09	10%	895	94%
Product 225	3000	0,51	0,22	-0,29	-57%	871	94%
Product 226	15900	0,06	0,11	0,05	99%	871	94%
Product 227	601	22,71	24,15	1,44	6%	868	94%
Product 228	2825	3,17	3,48	0,31	10%	867	94%
Product 229	3804	5,96	6,19	0,23	4%	864	94%
Product 230	750	3,59	4,72	1,13	31%	846	94%
Product 231	4504	0,54	0,73	0,19	34%	841	94%
Product 232	35360	0,46	0,48	0,02	5%	829	94%
Product 233	5005	0,67	0,50	-0,17	-25%	828	94%
Product 234	2399	2,52	2,19	-0,33	-13%	794	94%
Product 235	853	1,61	2,53	0,92	57%	785	95%
Product 236	4420	1,13	1,31	0,18	16%	780	95%
Product 237	401	22,43	24,37	1,94	9%	778	95%
Product 238	12200	0,06	0,12	0,06	110%	768	95%
Product 239	203	7,03	10,77	3,74	53%	760	95%
Product 240	511	4,26	5,72	1,46	34%	748	95%

Table 5.17 Comparison of TC and ABC in terms of cost (continued)

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 241	300	2,60	5,09	2,49	96%	747	95%
Product 242	3575	0,46	0,25	-0,21	-45%	737	95%
Product 243	49400	0,16	0,15	-0,01	-9%	731	95%
Product 244	3500	4,02	3,81	-0,21	-5%	722	95%
Product 245	502	3,90	5,33	1,43	37%	719	95%
Product 246	402	4,96	6,73	1,77	36%	711	95%
Product 247	2136	4,40	4,73	0,33	8%	711	95%
Product 248	875	2,06	2,87	0,81	39%	709	95%
Product 249	25088	0,20	0,23	0,03	14%	702	95%
Product 250	11500	0,37	0,31	-0,06	-16%	696	95%
Product 251	600	3,13	1,98	-1,15	-37%	690	95%
Product 252	31600	0,10	0,08	-0,02	-21%	685	95%
Product 253	1107	6,18	6,78	0,60	10%	660	95%
Product 254	899	2,11	2,84	0,73	34%	655	95%
Product 255	294	3,87	6,08	2,21	57%	650	96%
Product 256	2011	1,32	1,00	-0,32	-24%	645	96%
Product 257	3752	0,32	0,49	0,17	54%	642	96%
Product 258	155060	0,18	0,18	0,00	2%	633	96%
Product 259	1000	8,25	8,88	0,63	8%	630	96%
Product 260	2001	1,33	1,64	0,31	24%	630	96%
Product 261	9500	0,71	0,64	-0,07	-9%	624	96%
Product 262	1498	3,01	3,42	0,41	14%	620	96%
Product 263	2770	3,36	3,58	0,22	7%	619	96%
Product 264	301	6,88	4,82	-2,06	-30%	619	96%
Product 265	6667	0,51	0,42	-0,09	-18%	614	96%
Product 266	3260	0,23	0,42	0,19	80%	608	96%
Product 267	1200	4,19	4,69	0,50	12%	596	96%
Product 268	655	4,99	5,88	0,89	18%	586	96%
Product 269	588	7,94	8,93	0,99	12%	583	96%
Product 270	2000	1,87	2,16	0,29	15%	579	96%
Product 271	208	22,44	19,66	-2,78	-12%	579	96%
Product 272	753	11,01	11,78	0,77	7%	577	96%
Product 273	5003	0,19	0,07	-0,12	-62%	577	96%
Product 274	2501	6,64	6,41	-0,23	-3%	576	96%
Product 275	1772	1,34	1,66	0,32	24%	568	96%
Product 276	793	1,76	2,47	0,71	40%	560	96%
Product 277	576	1,87	2,84	0,97	52%	560	96%
Product 278	1153	5,89	5,41	-0,48	-8%	559	96%
Product 279	2515	3,64	3,42	-0,22	-6%	552	96%
Product 280	26370	0,02	0,04	0,02	109%	550	97%

Table 5.17 Comparison of TC and ABC in terms of cost (continued)

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 281	3250	0,34	0,51	0,17	48%	538	97%
Product 282	24453	0,30	0,28	-0,02	-7%	529	97%
Product 283	2800	1,00	1,19	0,19	19%	529	97%
Product 284	5000	1,19	1,30	0,11	9%	527	97%
Product 285	865	1,79	2,40	0,61	34%	526	97%
Product 286	623	1,51	2,33	0,82	55%	512	97%
Product 287	25910	0,04	0,06	0,02	49%	511	97%
Product 288	1204	5,98	5,56	-0,42	-7%	511	97%
Product 289	2500	0,36	0,56	0,20	56%	500	97%
Product 290	301	6,19	7,85	1,66	27%	500	97%
Product 291	481	6,02	7,06	1,04	17%	499	97%
Product 292	443	1,69	0,57	-1,12	-66%	494	97%
Product 293	44700	0,10	0,09	-0,01	-11%	488	97%
Product 294	500	5,31	6,28	0,97	18%	487	97%
Product 295	3000	0,95	1,11	0,16	17%	481	97%
Product 296	501	9,03	9,98	0,95	11%	476	97%
Product 297	416	2,22	3,35	1,13	51%	470	97%
Product 298	942	4,93	5,43	0,50	10%	468	97%
Product 299	1002	13,07	13,53	0,46	4%	462	97%
Product 300	20650	0,03	0,05	0,02	81%	461	97%
Product 301	28200	0,19	0,17	-0,02	-9%	460	97%
Product 302	315	2,74	4,20	1,46	53%	459	97%
Product 303	201	4,83	7,09	2,26	47%	453	97%
Product 304	111010	0,06	0,06	0,00	7%	452	97%
Product 305	12000	0,15	0,19	0,04	25%	451	97%
Product 306	251	5,29	3,51	-1,78	-34%	447	97%
Product 307	740	5,42	4,83	-0,59	-11%	440	97%
Product 308	1800	0,23	0,47	0,24	106%	436	97%
Product 309	1606	0,26	0,53	0,27	103%	431	97%
Product 310	6000	0,48	0,55	0,07	15%	428	97%
Product 311	1953	3,10	2,88	-0,22	-7%	422	98%
Product 312	2700	0,76	0,92	0,16	20%	422	98%
Product 313	1407	0,67	0,37	-0,30	-44%	417	98%
Product 314	252	5,16	3,52	-1,64	-32%	413	98%
Product 315	10600	0,20	0,16	-0,04	-19%	410	98%
Product 316	2000	0,52	0,32	-0,20	-39%	407	98%
Product 317	751	5,78	5,24	-0,54	-9%	407	98%
Product 318	350	5,12	6,28	1,16	23%	406	98%
Product 319	2001	7,73	7,53	-0,20	-3%	405	98%
Product 320	1000	0,87	1,27	0,40	46%	401	98%

Table 5.17 Comparison of TC and ABC in terms of cost (continued)

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 321	400	4,19	5,19	1,00	24%	399	98%
Product 322	501	6,72	7,50	0,78	12%	393	98%
Product 323	254	5,72	7,23	1,51	26%	384	98%
Product 324	503	6,28	7,04	0,76	12%	383	98%
Product 325	315	3,93	2,72	-1,21	-31%	382	98%
Product 326	6000	0,06	0,12	0,06	110%	378	98%
Product 327	2600	2,20	2,06	-0,14	-7%	377	98%
Product 328	312	3,67	4,88	1,21	33%	376	98%
Product 329	485	3,69	4,47	0,78	21%	376	98%
Product 330	112	3,54	6,87	3,33	94%	373	98%
Product 331	8000	0,30	0,25	-0,05	-16%	367	98%
Product 332	1013	1,26	1,62	0,36	29%	366	98%
Product 333	7600	0,23	0,28	0,05	21%	364	98%
Product 334	699	2,78	3,30	0,52	19%	364	98%
Product 335	881	5,20	4,79	-0,41	-8%	363	98%
Product 336	152540	0,29	0,29	0,00	1%	352	98%
Product 337	18000	0,29	0,27	-0,02	-7%	351	98%
Product 338	3000	0,28	0,39	0,11	40%	335	98%
Product 339	250	4,67	6,00	1,33	29%	333	98%
Product 340	500	5,36	6,02	0,66	12%	328	98%
Product 341	200	6,65	8,22	1,57	24%	313	98%
Product 342	1200	1,24	1,50	0,26	21%	313	98%
Product 343	13000	0,03	0,05	0,02	92%	312	98%
Product 344	1001	17,53	17,84	0,31	2%	310	98%
Product 345	102	14,29	17,31	3,02	21%	308	98%
Product 346	401	7,36	8,13	0,77	10%	308	98%
Product 347	9100	0,47	0,50	0,03	7%	308	98%
Product 348	2278	2,97	3,10	0,13	5%	307	98%
Product 349	742	4,72	5,13	0,41	9%	302	98%
Product 350	137	4,40	6,56	2,16	49%	296	98%
Product 351	3000	0,38	0,48	0,10	26%	294	98%
Product 352	750	1,01	1,40	0,39	39%	293	98%
Product 353	6753	0,97	0,93	-0,04	-4%	291	99%
Product 354	101	14,00	16,80	2,80	20%	283	99%
Product 355	345	6,21	7,03	0,82	13%	282	99%
Product 356	476	3,80	4,38	0,58	15%	276	99%
Product 357	3000	0,39	0,48	0,09	24%	275	99%
Product 358	3600	0,48	0,40	-0,08	-16%	275	99%
Product 359	1050	1,48	1,74	0,26	18%	274	99%
Product 360	106	5,00	7,59	2,59	52%	274	99%

Table 5.17 Comparison of TC and ABC in terms of cost (continued)

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 361	201	5,72	7,08	1,36	24%	273	99%
Product 362	1500	0,57	0,75	0,18	31%	267	99%
Product 363	1500	0,50	0,68	0,18	35%	267	99%
Product 364	33100	0,11	0,10	-0,01	-7%	264	99%
Product 365	3001	0,40	0,31	-0,09	-22%	260	99%
Product 366	9300	0,04	0,07	0,03	67%	260	99%
Product 367	72000	0,33	0,33	0,00	-1%	257	99%
Product 368	11975	1,05	1,03	-0,02	-2%	255	99%
Product 369	700	7,40	7,04	-0,36	-5%	252	99%
Product 370	16250	0,01	0,03	0,02	107%	252	99%
Product 371	1301	4,53	4,34	-0,19	-4%	246	99%
Product 372	19820	0,02	0,03	0,01	71%	246	99%
Product 373	501	2,07	2,56	0,49	24%	245	99%
Product 374	152	7,21	8,81	1,60	22%	243	99%
Product 375	9644	0,04	0,06	0,02	71%	240	99%
Product 376	1500	0,54	0,38	-0,16	-29%	234	99%
Product 377	18000	0,16	0,15	-0,01	-8%	233	99%
Product 378	514	16,09	15,64	-0,45	-3%	232	99%
Product 379	203	1,90	0,77	-1,13	-60%	230	99%
Product 380	23600	0,19	0,20	0,01	5%	229	99%
Product 381	110	5,07	7,11	2,04	40%	224	99%
Product 382	385	3,21	2,63	-0,58	-18%	223	99%
Product 383	18420	0,02	0,03	0,01	66%	221	99%
Product 384	111	2,77	4,71	1,94	70%	215	99%
Product 385	50000	0,04	0,04	0,00	12%	214	99%
Product 386	316	3,37	4,04	0,67	20%	212	99%
Product 387	603	0,55	0,90	0,35	63%	210	99%
Product 388	2226	3,75	3,84	0,09	2%	208	99%
Product 389	215	3,62	2,66	-0,96	-27%	207	99%
Product 390	701	3,79	3,50	-0,29	-8%	206	99%
Product 391	301	3,60	4,28	0,68	19%	205	99%
Product 392	2000	2,18	2,28	0,10	5%	202	99%
Product 393	304	4,73	5,39	0,66	14%	201	99%
Product 394	190	5,11	6,16	1,05	21%	200	99%
Product 395	1500	0,49	0,36	-0,13	-27%	199	99%
Product 396	1300	1,57	1,72	0,15	10%	199	99%
Product 397	1001	3,52	3,33	-0,19	-5%	185	99%
Product 398	600	8,08	7,77	-0,31	-4%	184	99%
Product 399	501	3,57	3,93	0,36	10%	181	99%
Product 400	1500	2,95	3,07	0,12	4%	180	99%

Table 5.17 Comparison of TC and ABC in terms of cost (continued)

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 401	103	8,11	9,85	1,74	21%	179	99%
Product 402	1150	5,18	5,33	0,15	3%	175	99%
Product 403	500	0,60	0,95	0,35	57%	173	99%
Product 404	5600	0,06	0,09	0,03	52%	171	99%
Product 405	300	6,07	6,64	0,57	9%	171	99%
Product 406	49500	0,16	0,16	0,00	-2%	169	99%
Product 407	120	6,30	7,70	1,40	22%	169	99%
Product 408	101	5,19	6,85	1,66	32%	168	99%
Product 409	1125	2,11	1,96	-0,15	-7%	163	99%
Product 410	176	3,51	4,42	0,91	26%	160	99%
Product 411	1652	5,12	5,22	0,10	2%	158	99%
Product 412	1000	5,58	5,42	-0,16	-3%	155	99%
Product 413	15620	0,01	0,02	0,01	96%	153	99%
Product 414	301	8,86	8,35	-0,51	-6%	153	99%
Product 415	2848	0,29	0,34	0,05	18%	150	99%
Product 416	160	5,18	6,11	0,93	18%	149	99%
Product 417	815	0,49	0,67	0,18	36%	143	99%
Product 418	11370	0,18	0,17	-0,01	-7%	143	99%
Product 419	7367	0,19	0,21	0,02	10%	143	99%
Product 420	250	1,41	1,98	0,57	40%	142	99%
Product 421	8000	0,29	0,27	-0,02	-6%	142	99%
Product 422	300	8,54	9,01	0,47	5%	140	99%
Product 423	1765	3,54	3,62	0,08	2%	137	100%
Product 424	1000	1,18	1,31	0,13	11%	135	100%
Product 425	160	4,85	5,69	0,84	17%	134	100%
Product 426	15000	0,29	0,28	-0,01	-3%	134	100%
Product 427	101	3,84	5,16	1,32	34%	133	100%
Product 428	2300	0,28	0,34	0,06	20%	133	100%
Product 429	20570	0,24	0,23	-0,01	-3%	129	100%
Product 430	2600	0,43	0,48	0,05	11%	128	100%
Product 431	29800	0,27	0,27	0,00	2%	123	100%
Product 432	480	2,83	2,57	-0,26	-9%	123	100%
Product 433	1000	0,29	0,17	-0,12	-42%	121	100%
Product 434	2000	0,37	0,43	0,06	16%	120	100%
Product 435	300	0,88	1,28	0,40	45%	119	100%
Product 436	300	0,58	0,96	0,38	64%	113	100%
Product 437	150	0,65	1,34	0,69	105%	103	100%
Product 438	1500	0,41	0,34	-0,07	-17%	103	100%
Product 439	490	0,83	1,04	0,21	25%	103	100%
Product 440	832	0,22	0,34	0,12	57%	103	100%

Table 5.17 Comparison of TC and ABC in terms of cost (continued)

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 441	4150	0,18	0,20	0,02	14%	103	100%
Product 442	1166	5,61	5,52	-0,09	-2%	100	100%
Product 443	102	3,83	2,85	-0,98	-26%	100	100%
Product 444	501	6,53	6,33	-0,20	-3%	98	100%
Product 445	211	1,82	1,36	-0,46	-25%	97	100%
Product 446	750	0,83	0,96	0,13	15%	95	100%
Product 447	500	0,33	0,52	0,19	57%	94	100%
Product 448	500	0,66	0,84	0,18	28%	92	100%
Product 449	295	5,85	6,16	0,31	5%	92	100%
Product 450	28730	0,16	0,16	0,00	-2%	90	100%
Product 451	980	0,90	0,81	-0,09	-10%	89	100%
Product 452	500	1,18	1,35	0,17	15%	87	100%
Product 453	4600	0,12	0,10	-0,02	-16%	87	100%
Product 454	201	2,29	2,72	0,43	19%	87	100%
Product 455	8000	0,03	0,04	0,01	37%	87	100%
Product 456	300	0,67	0,96	0,29	43%	86	100%
Product 457	751	0,63	0,74	0,11	18%	86	100%
Product 458	2970	0,37	0,40	0,03	8%	86	100%
Product 459	1003	0,34	0,42	0,08	25%	85	100%
Product 460	950	0,09	0,18	0,09	98%	85	100%
Product 461	136	2,12	2,74	0,62	29%	84	100%
Product 462	7000	0,42	0,43	0,01	3%	84	100%
Product 463	300	4,11	3,84	-0,27	-7%	82	100%
Product 464	2200	1,31	1,35	0,04	3%	82	100%
Product 465	500	0,34	0,50	0,16	48%	81	100%
Product 466	10178	4,84	4,85	0,01	0%	81	100%
Product 467	950	0,34	0,43	0,09	25%	81	100%
Product 468	500	0,52	0,68	0,16	31%	80	100%
Product 469	180	4,14	4,58	0,44	11%	79	100%
Product 470	600	0,34	0,47	0,13	38%	77	100%
Product 471	550	1,58	1,45	-0,13	-8%	73	100%
Product 472	300	0,52	0,76	0,24	45%	71	100%
Product 473	101	3,19	3,89	0,70	22%	70	100%
Product 474	121	2,00	2,58	0,58	29%	70	100%
Product 475	132	4,53	4,01	-0,52	-11%	68	100%
Product 476	2025	0,29	0,32	0,03	11%	67	100%
Product 477	1823	4,16	4,20	0,04	1%	65	100%
Product 478	501	8,80	8,67	-0,13	-1%	64	100%
Product 479	500	0,22	0,35	0,13	57%	64	100%
Product 480	152	6,04	6,45	0,41	7%	62	100%

Table 5.17 Comparison of TC and ABC in terms of cost (continued)

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 481	10000	0,08	0,07	-0,01	-8%	62	100%
Product 482	1560	8,42	8,46	0,04	0%	61	100%
Product 483	2000	0,35	0,38	0,03	9%	61	100%
Product 484	1650	0,39	0,43	0,04	9%	61	100%
Product 485	201	0,46	0,75	0,29	64%	59	100%
Product 486	1010	0,42	0,36	-0,06	-13%	56	100%
Product 487	200	7,58	7,31	-0,27	-4%	54	100%
Product 488	300	1,46	1,28	-0,18	-12%	54	100%
Product 489	300	2,58	2,76	0,18	7%	54	100%
Product 490	200	0,23	0,49	0,26	116%	53	100%
Product 491	2006	3,46	3,43	-0,03	-1%	51	100%
Product 492	9500	0,53	0,52	-0,01	-1%	50	100%
Product 493	500	2,98	2,88	-0,10	-3%	49	100%
Product 494	152	4,79	5,10	0,31	6%	47	100%
Product 495	500	0,24	0,33	0,09	40%	47	100%
Product 496	101	3,39	3,84	0,45	13%	45	100%
Product 497	201	2,92	2,70	-0,22	-8%	45	100%
Product 498	250	0,34	0,52	0,18	51%	44	100%
Product 499	250	0,34	0,52	0,18	51%	44	100%
Product 500	6000	0,27	0,28	0,01	3%	41	100%
Product 501	216	3,98	4,17	0,19	5%	41	100%
Product 502	5000	0,16	0,15	-0,01	-5%	39	100%
Product 503	500	0,23	0,31	0,08	33%	38	100%
Product 504	500	0,35	0,42	0,07	22%	37	100%
Product 505	1000	0,76	0,80	0,04	5%	37	100%
Product 506	202	0,50	0,68	0,18	36%	36	100%
Product 507	1320	0,68	0,71	0,03	4%	35	100%
Product 508	131	1,95	1,69	-0,26	-13%	34	100%
Product 509	2502	0,41	0,42	0,01	3%	33	100%
Product 510	2140	0,09	0,11	0,02	17%	33	100%
Product 511	130	3,52	3,77	0,25	7%	32	100%
Product 512	200	0,28	0,44	0,16	57%	32	100%
Product 513	151	0,80	1,01	0,21	26%	32	100%
Product 514	17000	0,17	0,17	0,00	-1%	31	100%
Product 515	201	6,16	6,03	-0,13	-2%	27	100%
Product 516	300	3,32	3,40	0,08	3%	25	100%
Product 517	200	7,48	7,36	-0,12	-2%	24	100%
Product 518	791	1,83	1,86	0,03	2%	23	100%
Product 519	2020	1,20	1,21	0,01	1%	23	100%
Product 520	1000	1,03	1,01	-0,02	-2%	23	100%

Table 5.17 Comparison of TC and ABC in terms of cost (continued)

Product Code	Production Amount	Cost with TC	Cost with ABC	Difference	Bias %	Total Difference (Absolute)	Cumulative %
Product 521	4700	0,13	0,13	0,00	-4%	22	100%
Product 522	202	1,24	1,35	0,11	9%	22	100%
Product 523	502	0,39	0,43	0,04	11%	22	100%
Product 524	201	9,39	9,29	-0,10	-1%	21	100%
Product 525	4000	0,13	0,12	-0,01	-4%	21	100%
Product 526	500	2,92	2,88	-0,04	-1%	21	100%
Product 527	1001	2,60	2,58	-0,02	-1%	19	100%
Product 528	1202	0,45	0,46	0,01	3%	18	100%
Product 529	151	9,39	9,51	0,12	1%	17	100%
Product 530	26300	0,26	0,26	0,00	0%	17	100%
Product 531	8850	0,31	0,31	0,00	-1%	17	100%
Product 532	282	2,95	3,01	0,06	2%	16	100%
Product 533	201	3,53	3,60	0,07	2%	15	100%
Product 534	300	3,54	3,49	-0,05	-1%	14	100%
Product 535	102	3,33	3,20	-0,13	-4%	13	100%
Product 536	840	2,95	2,94	-0,01	-1%	13	100%
Product 537	302	1,18	1,22	0,04	3%	11	100%
Product 538	3000	0,26	0,26	0,00	-1%	10	100%
Product 539	760	3,04	3,05	0,01	0%	9	100%
Product 540	200	9,24	9,28	0,04	0%	9	100%
Product 541	601	4,90	4,91	0,01	0%	9	100%
Product 542	1000	0,60	0,61	0,01	1%	8	100%
Product 543	152	3,13	3,18	0,05	2%	8	100%
Product 544	39800	0,11	0,11	0,00	0%	6	100%
Product 545	6000	0,32	0,32	0,00	0%	4	100%
Product 546	700	0,48	0,48	0,00	-1%	3	100%
Product 547	1000	0,29	0,29	0,00	1%	3	100%
Product 548	2000	0,87	0,87	0,00	0%	3	100%
Product 549	1600	0,29	0,29	0,00	0%	2	100%
Product 550	501	4,13	4,13	0,00	0%	0	100%
TOTAL						1487779	

CHAPTER SIX
CONCLUSION

Rapid development of technology and globalization has brought intense competition. Companies that want to achieve their objectives should use their decision making mechanisms effectively to be live in the intense competitive environment and maintain competitive advantage. So companies should take into account all factors which effect decision making process and search accuracy and reliability of all factors.

Intensification of competition on price requires more emphasis to the factors that determine product price. Although factors effecting pricing decisions are market structure, place of the product on product life cycle and situation of the competitors, main determinant is cost. So cost elements which determine product price should be obtained in an accurate and realistic way.

Companies need information which will guide about decisions to provide competitive advantage and organize activities better. Most important resource of this information is cost information system. ABC as a costing system is very useful tool in decision making process. It facilitates strategic management decisions like how to increase profits, which product and which customer more profitable or which products should be produced. ABC system presents more accurate product costs and also increases power of competition of the company with reliable and correct information. It has long term perspective and provides wider information for cost analysis in stages of development of new products, make or buy decisions, new investments in production process and determination of product sales price. Expense and activity drivers can be used also as performance criteria.

In this thesis, shortages of traditional costing system which has unreliable cost data have been given. ABC system in product costing was introduced to overcome these problems. Because ABC analyzes and evaluates costs of manufacturing and it helps company to understand actual production costs as well as explains the costs of

each activity. An application was made to develop an ABC Model for a company which manufactures disposable medical supplies to determine accurate sales prices. All activities were examined and modelled with IDEF0 diagrams. After the activity costs were calculated, product costs were found. At the end of the study, product costs for ABC and current traditional costing system of the company were compared and cost differences for two systems were calculated. According to total absolute differences, products which create most difference were determined. All computations were made with a simple program which was developed on Oracle database and development tools. This program can be integrated into the company's ERP system that also uses Oracle. Thus, computational difficulties and consuming time can be eliminated. By the help of this analysis, right pricing decisions will be made to be live in competitive market and how the product costs will be reduced for target prices will be determined.

As a result, ABC is not only a costing system which includes cost decisions and product cost management but also a management and planning system which works with all parts of the business.

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APPENDIX

Appendix A. IDEF0 Diagrams for process modelling:

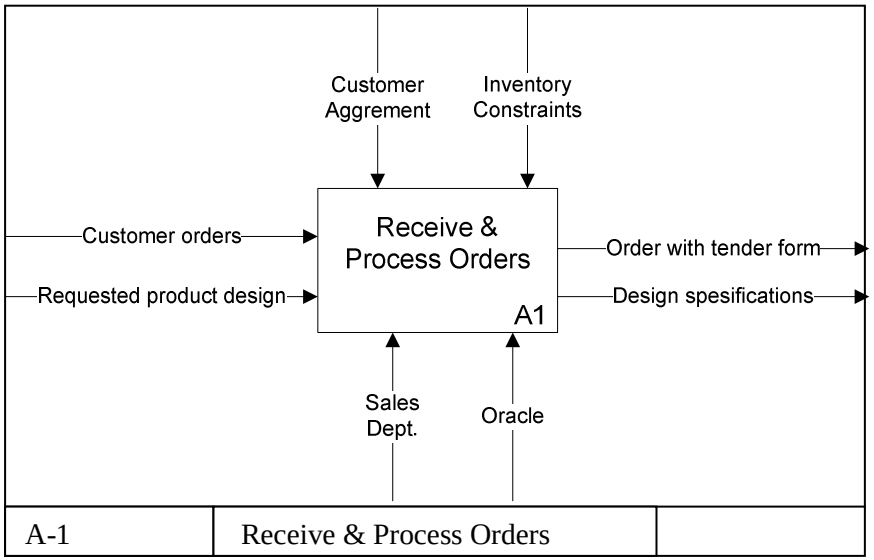

Figure A.1 Receive & Process Orders activity centre (Node A-1)

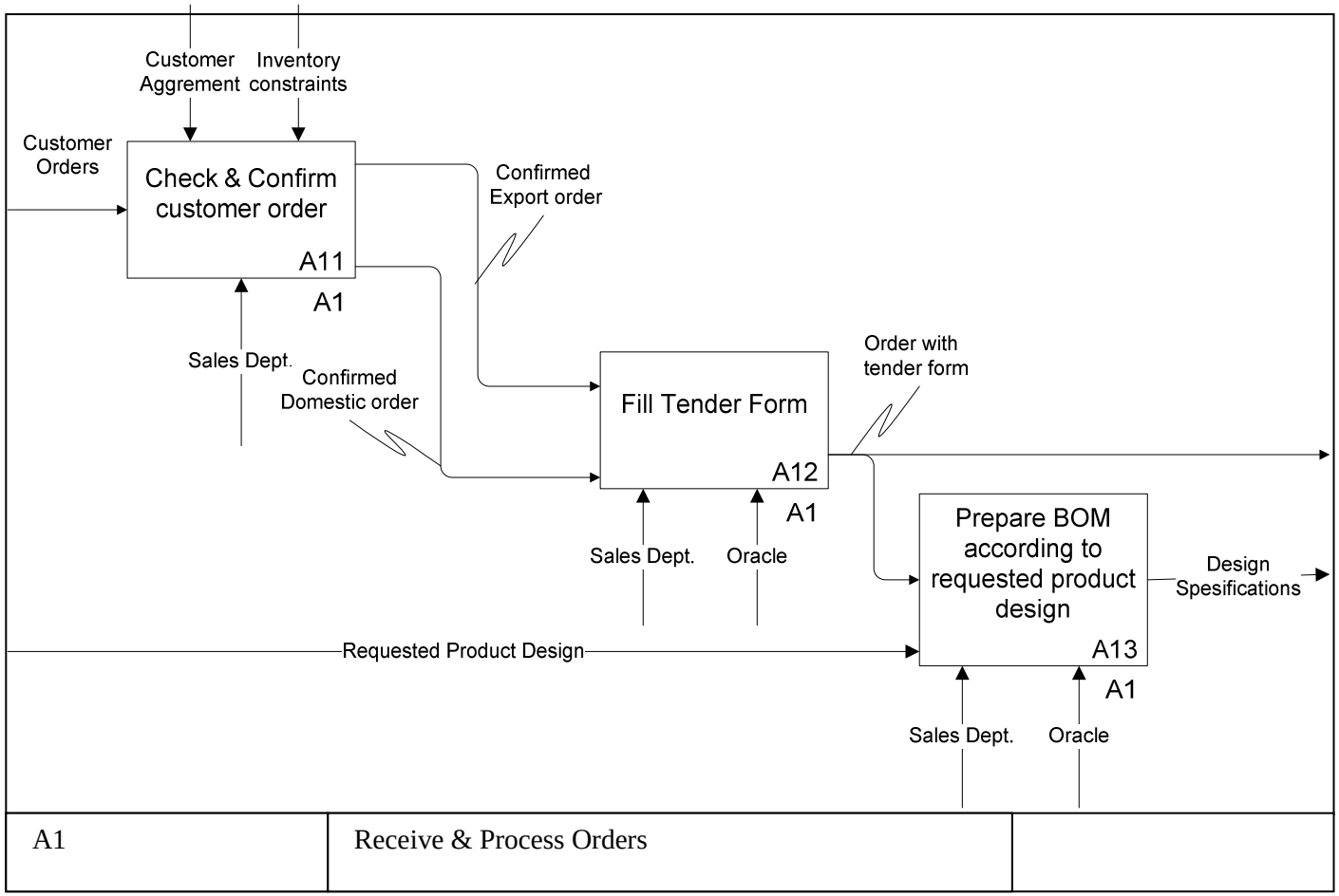

Figure A.2 Receive & Process Orders sub-activities (Node A1)

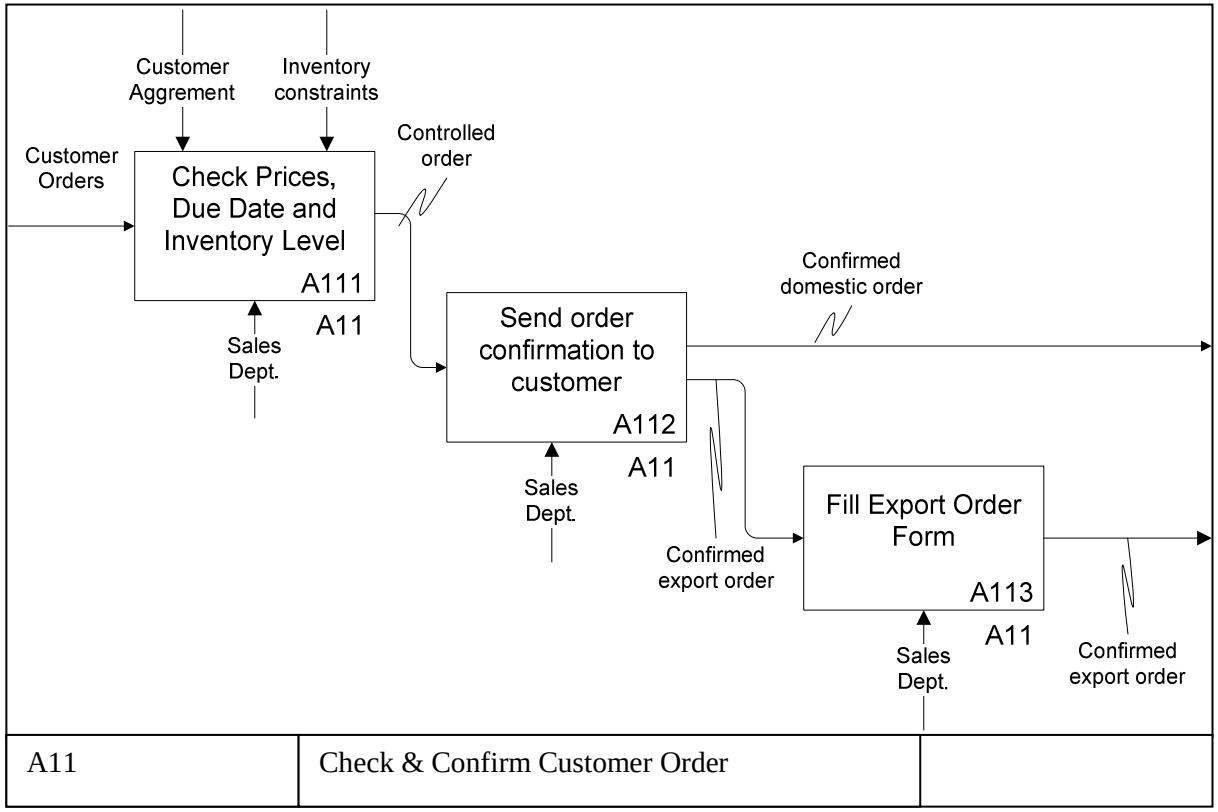

Figure A.3 Check & Confirm Customer Order sub-activities (Node A11)

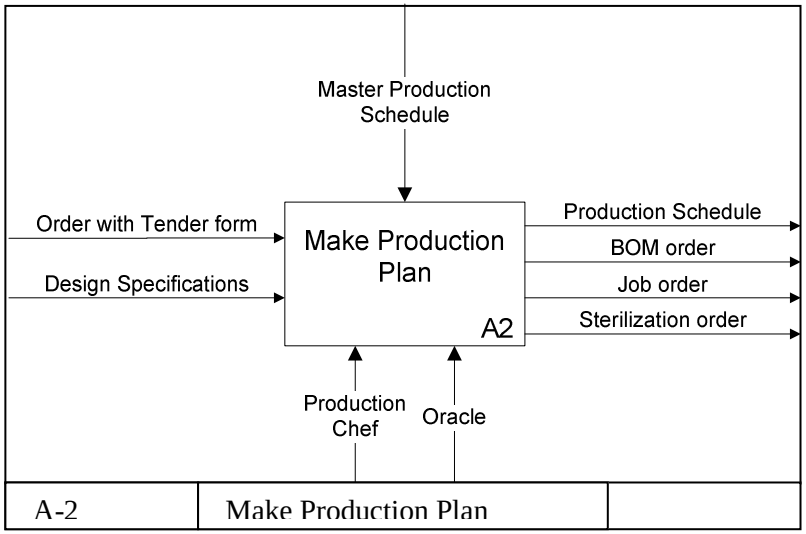

Figure A.4 Make Production Plan activity centre (Node A-2)

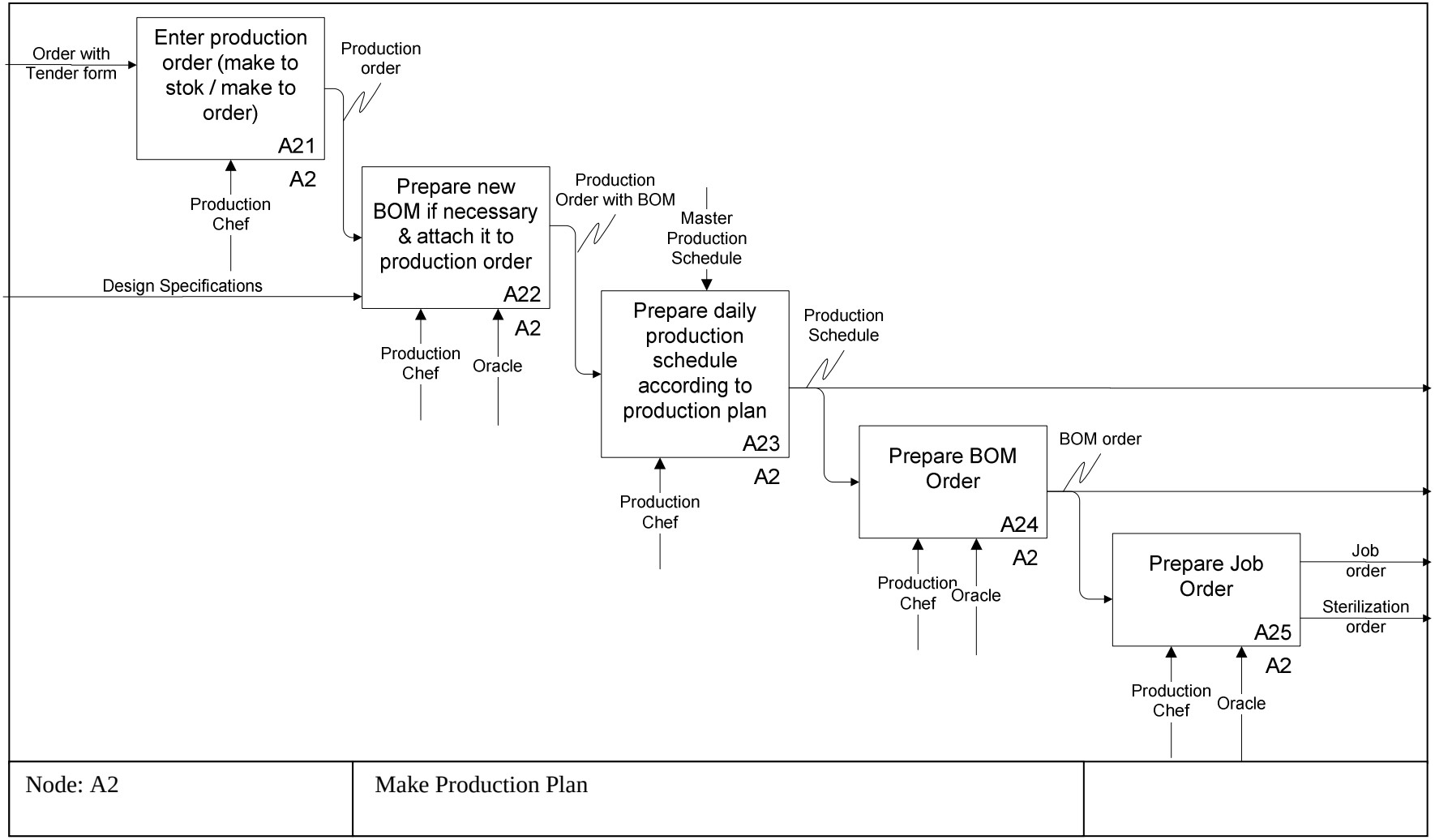

Figure A.5 Make Production Plan sub-activities (Node A2)

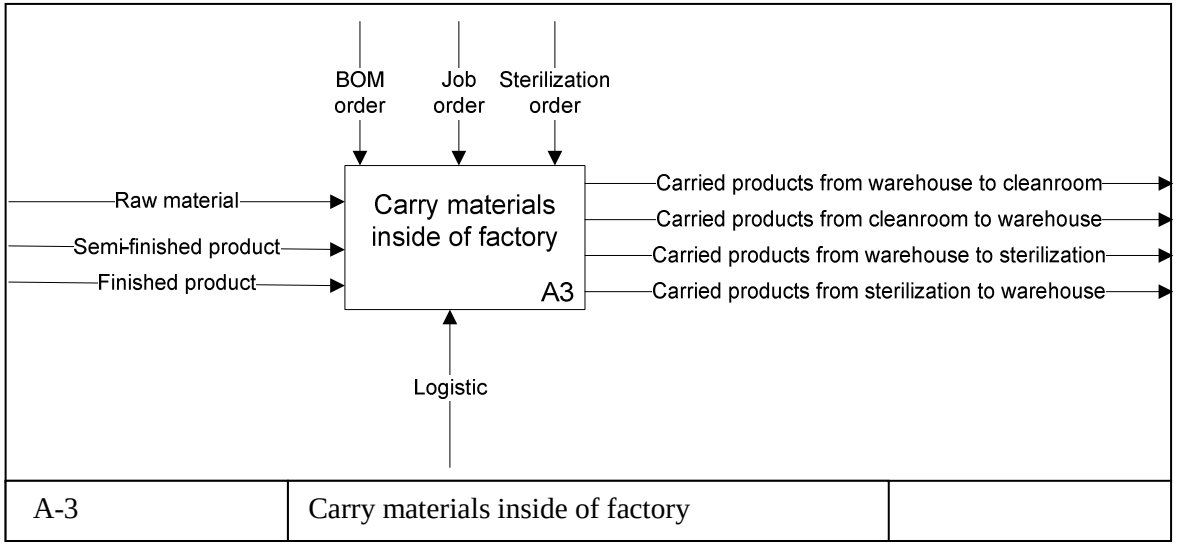

Figure A.6 Carry Materials Inside of Factory activity centre (Node A-3)

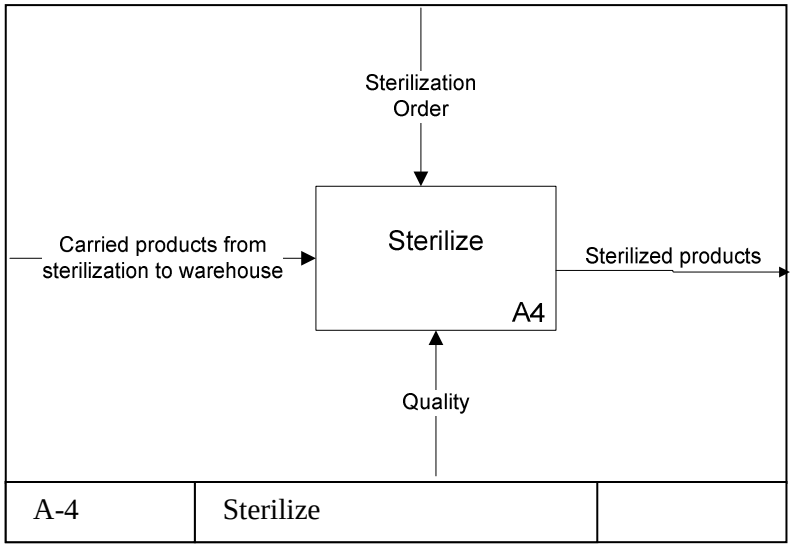

Figure A.7 Sterilize activity centre (Node A-4)

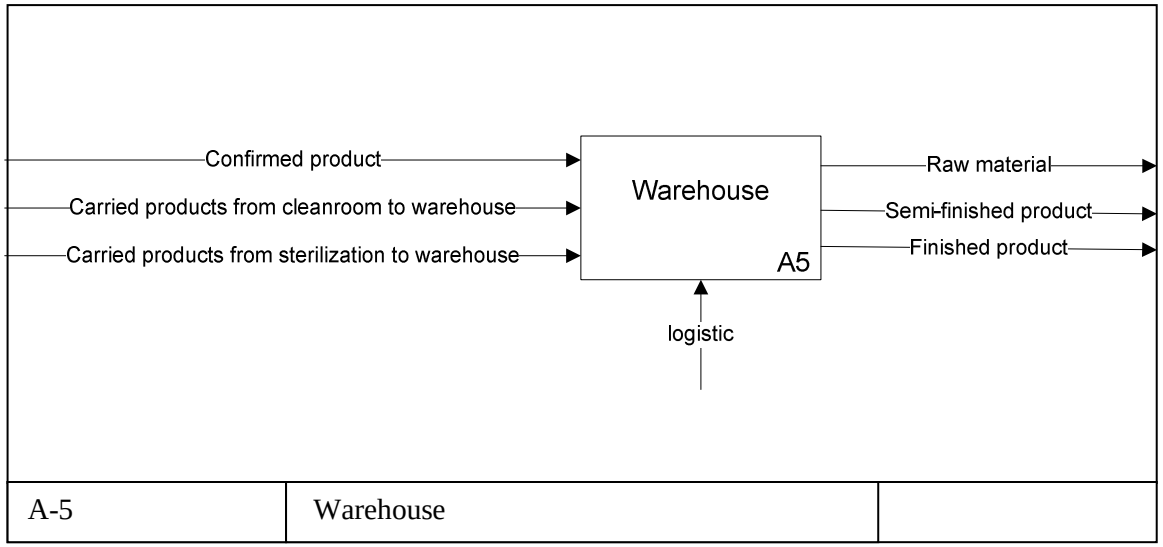

Figure A.8 Warehouse activity centre (Node A-5)

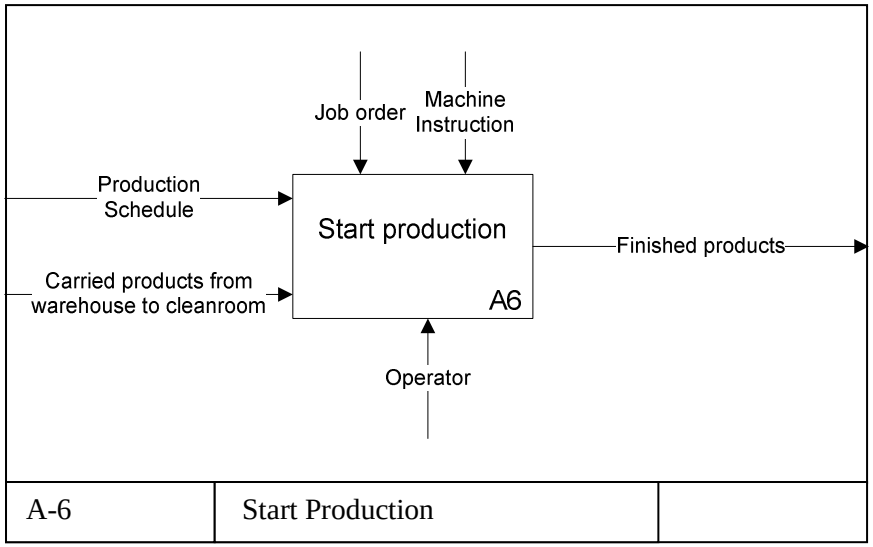

Figure A.9 Start Production activity centre (Node A-6)

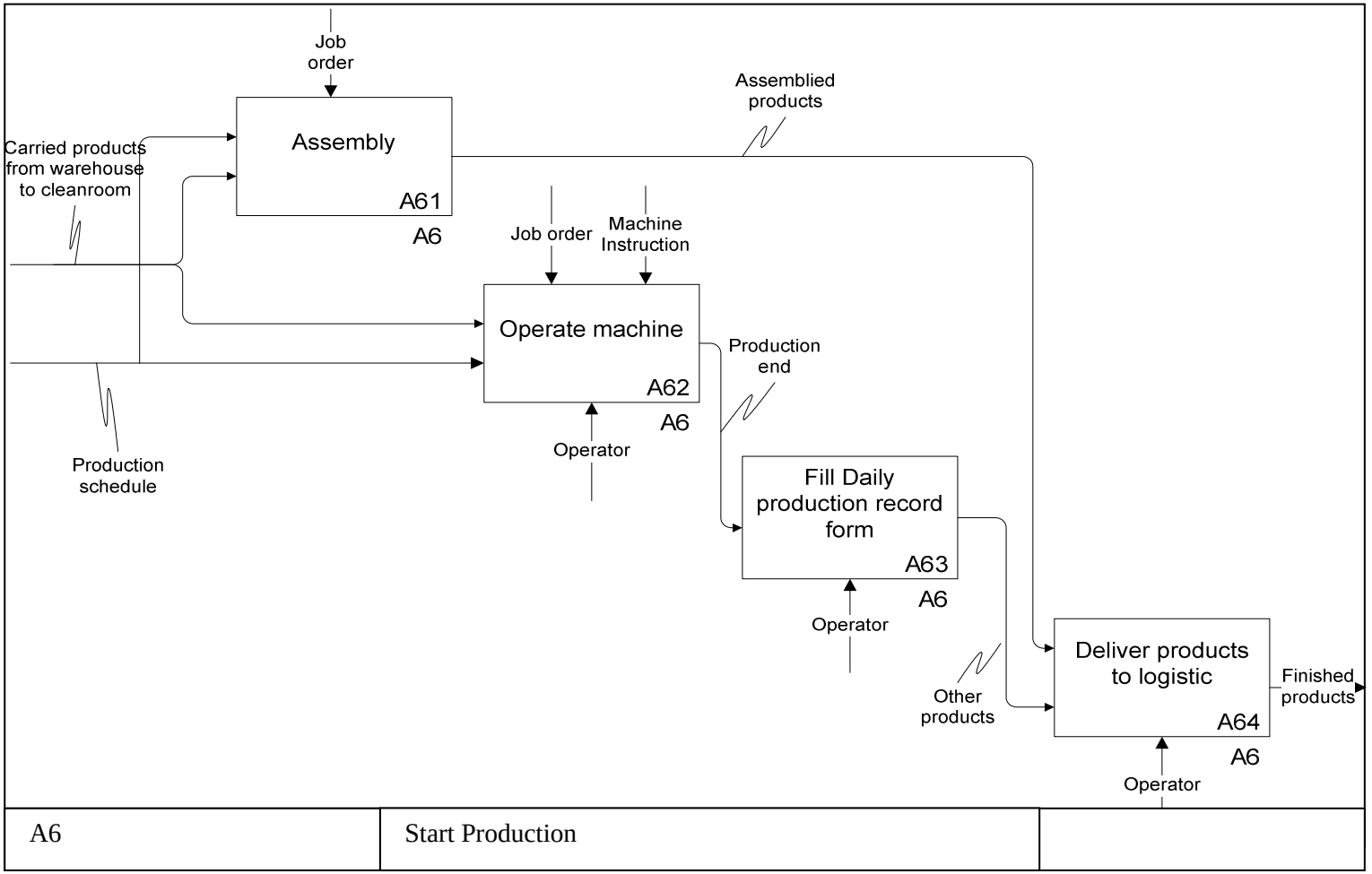

Figure A.10 Start Production sub-activities (Node A6)

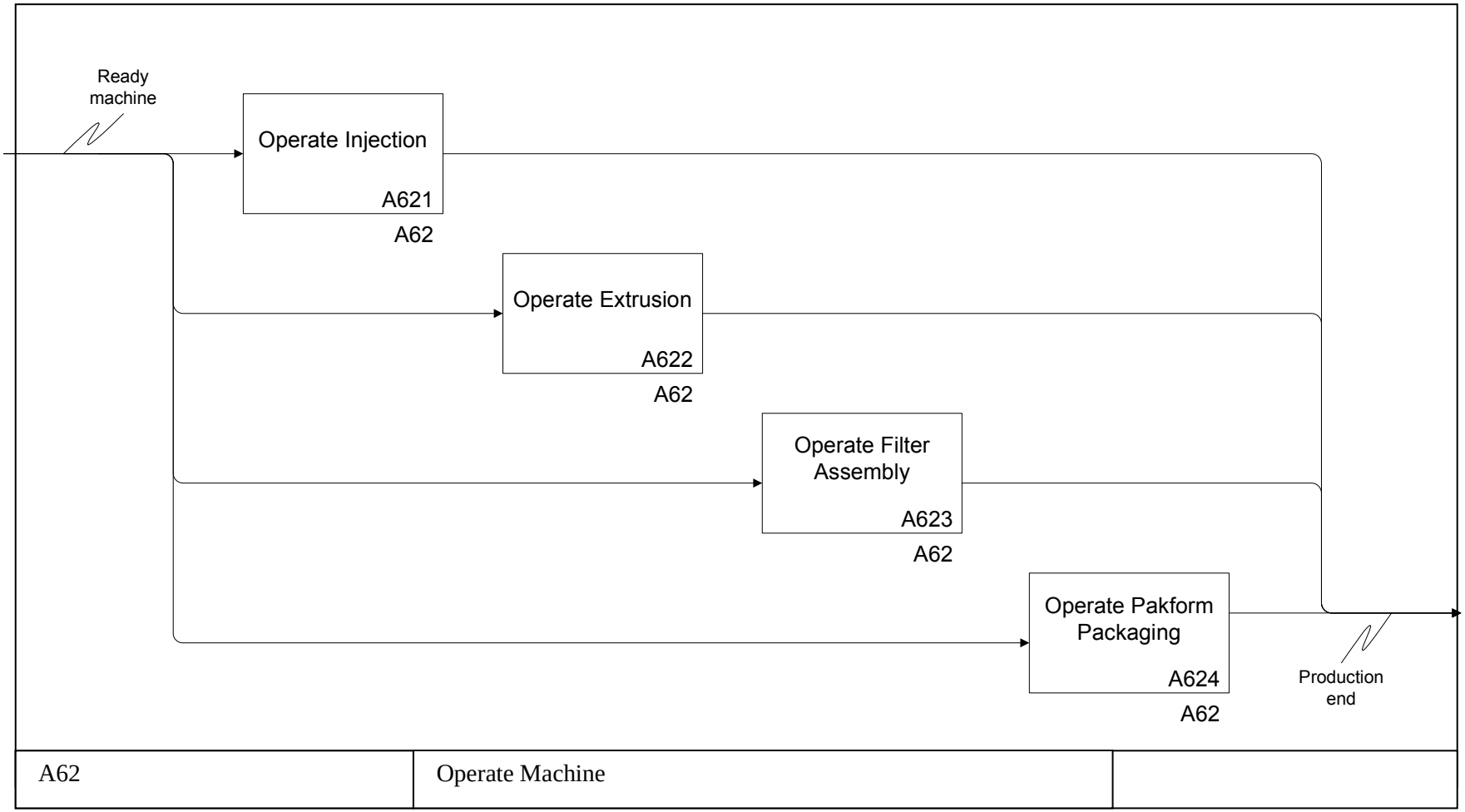

Figure A.11 Operate machine sub-activities (Node A62)

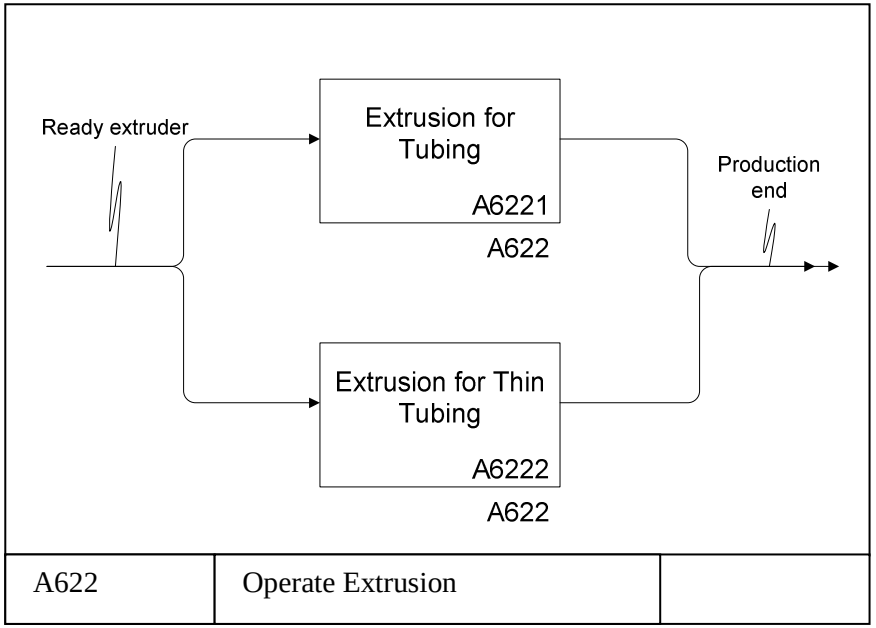

Figure A.12 Operate Extrusion sub-activities (Node A622)

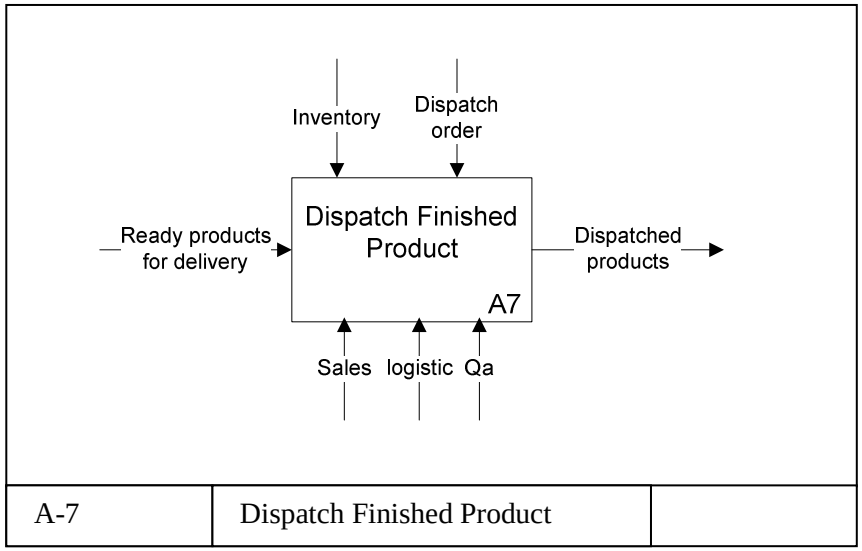

Figure A.13 Dispatch Finished Product activity centre (Node A-7)

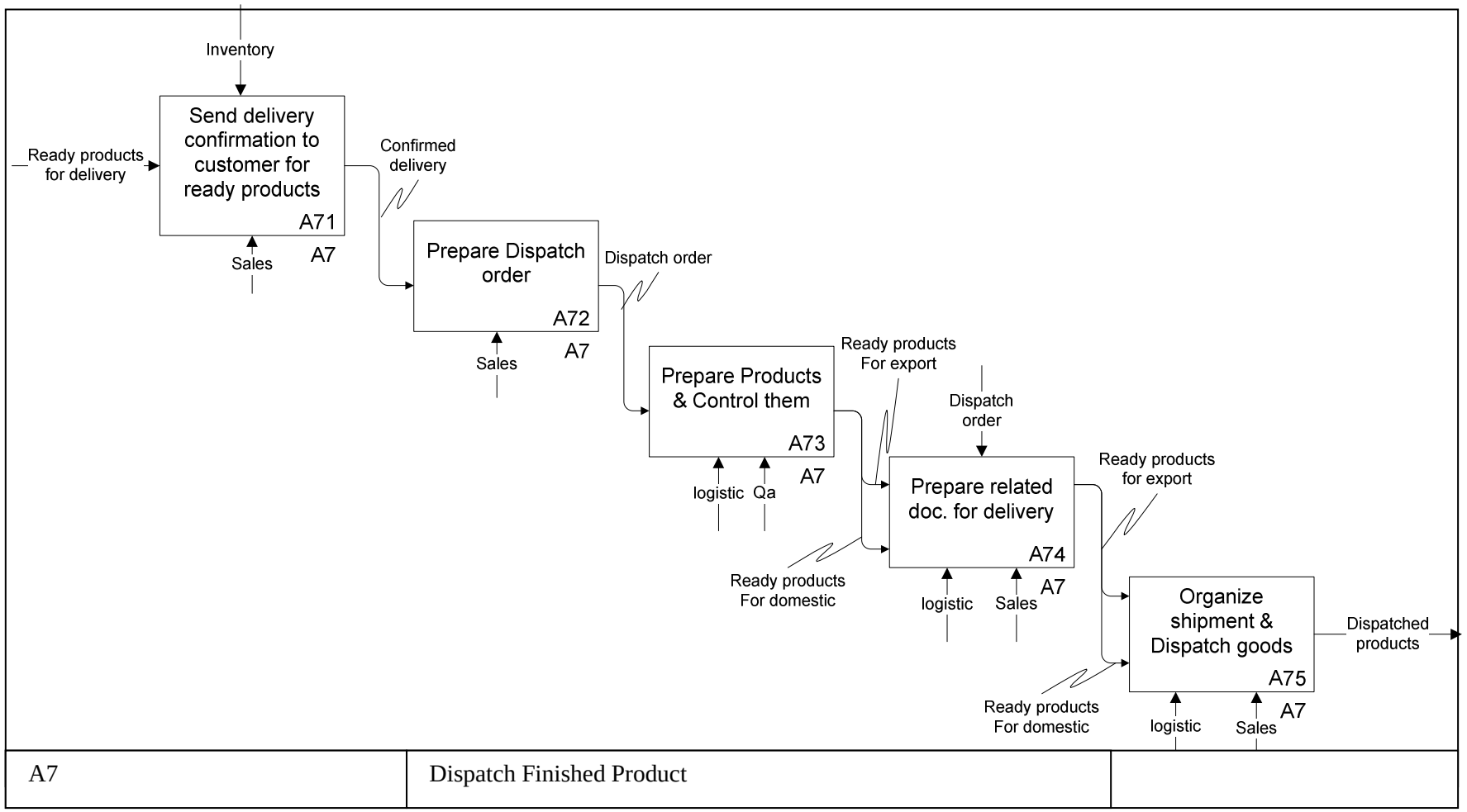

Figure A.14 Dispatch Finished Product sub-activities (Node A7)

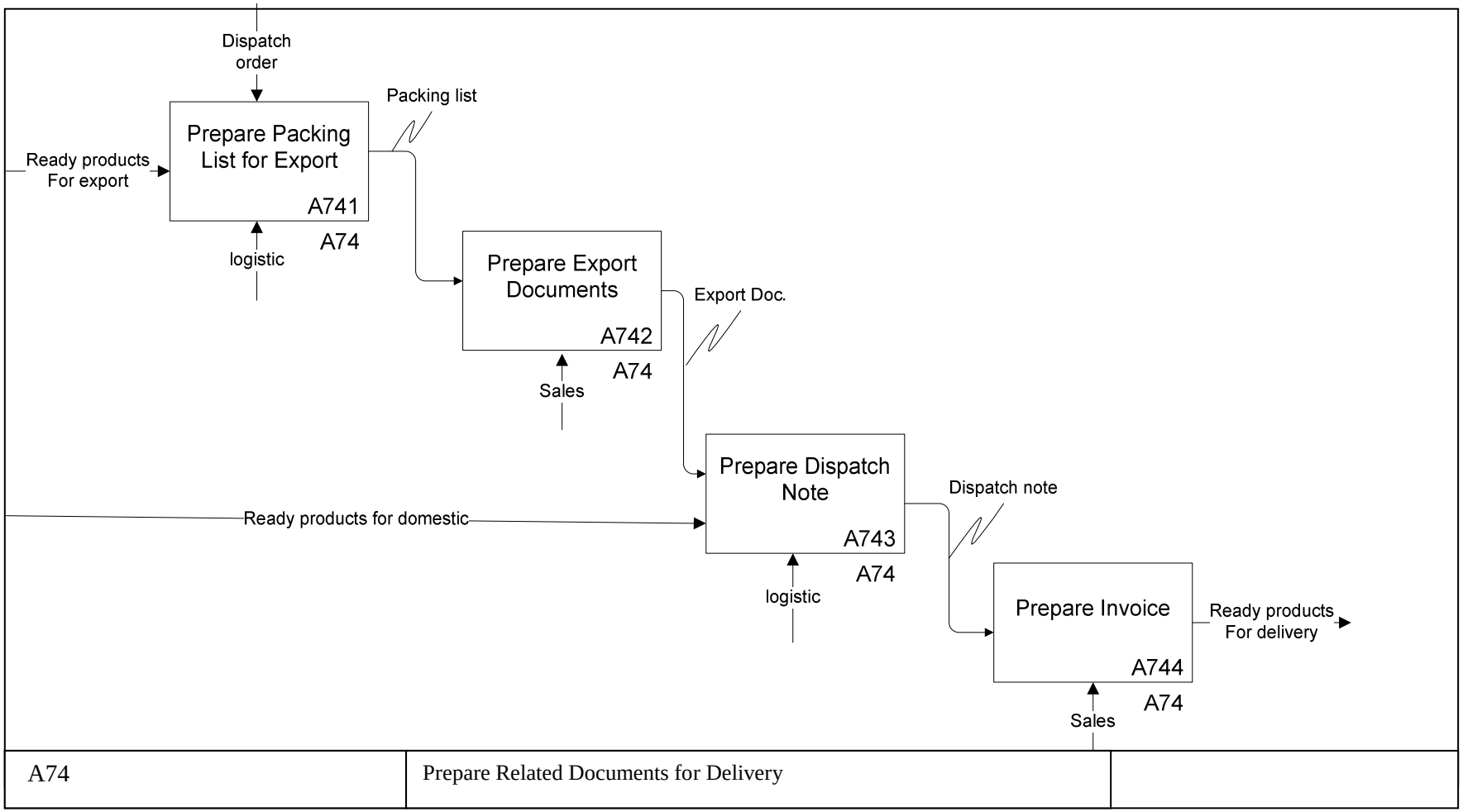

Figure A.15 Prepare Related Documents for Delivery sub-activities (Node A74)

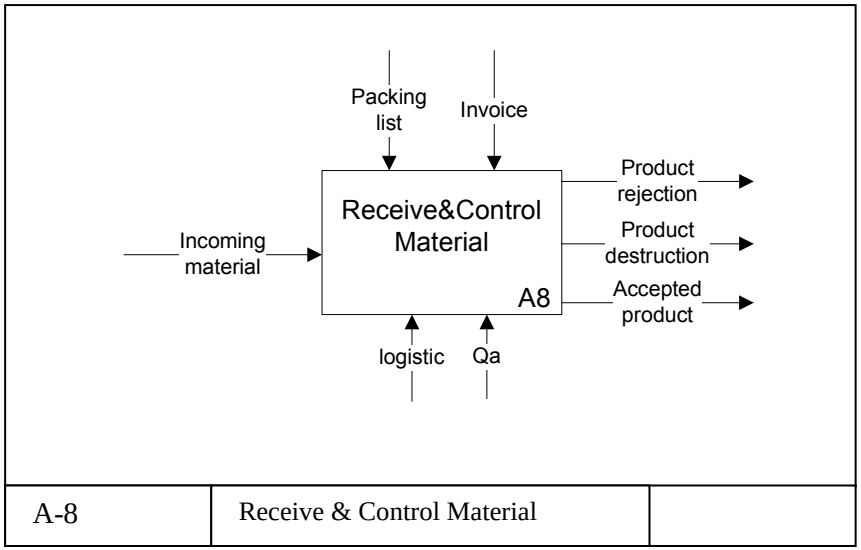

Figure A.16 Receive & Control Material activity centre (Node A-8)

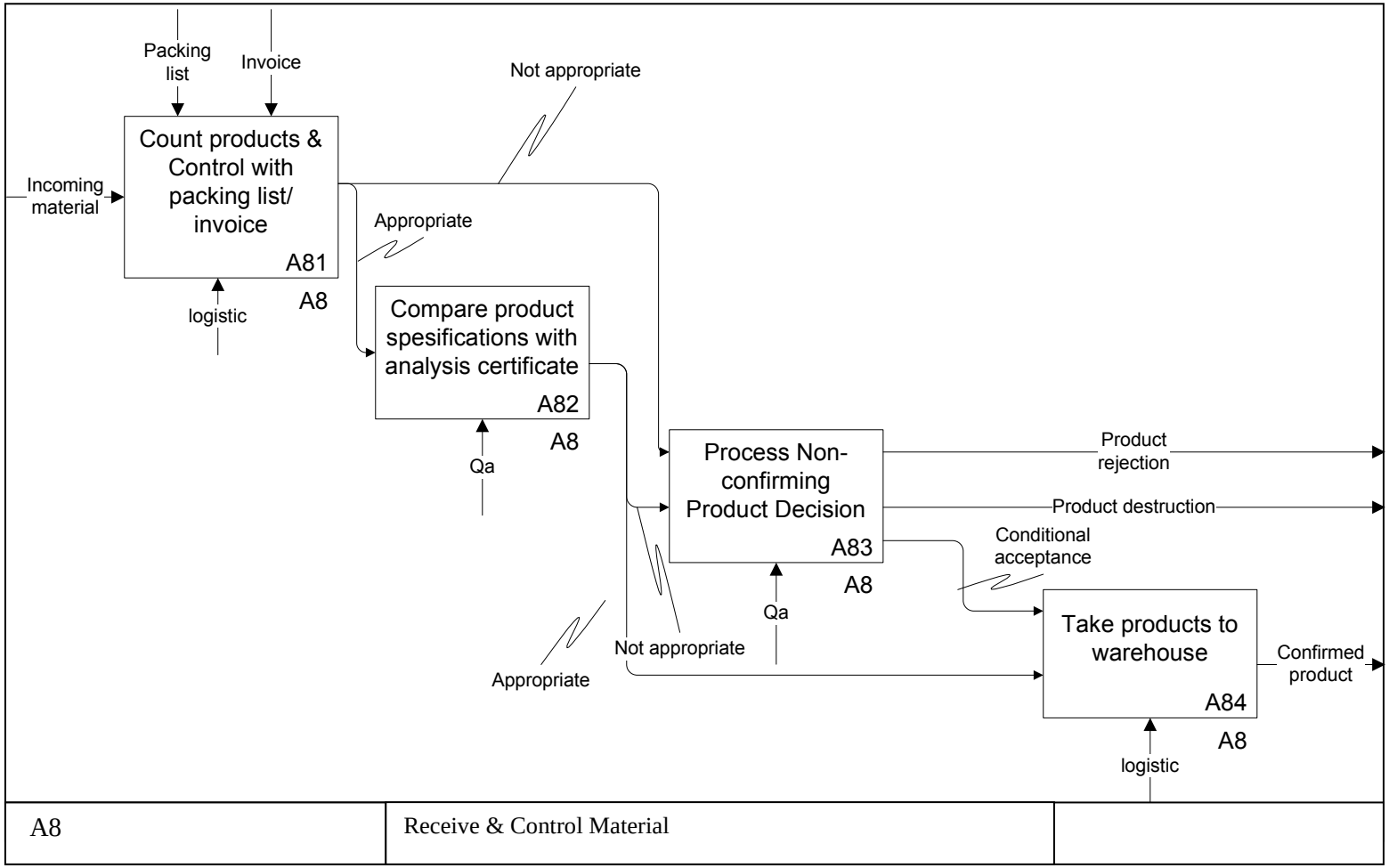

Figure A.17 Receive & Control Material sub-activities (Node A8)

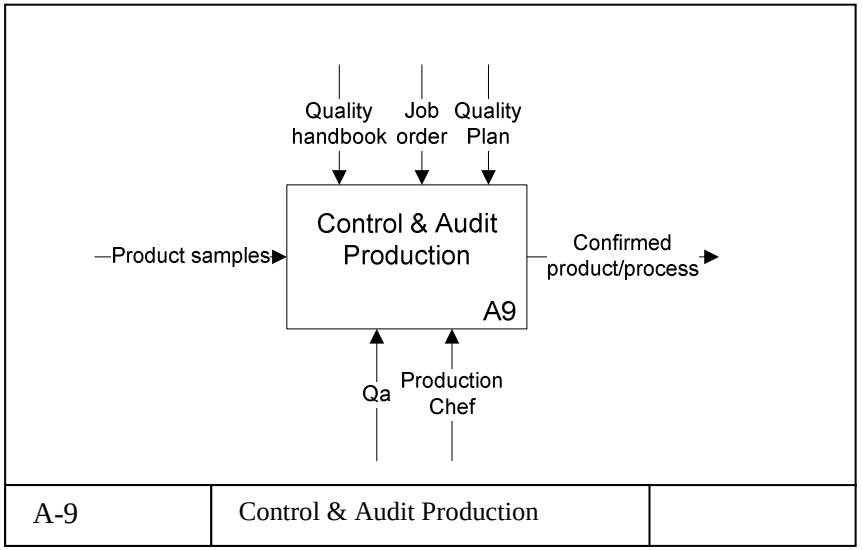

Figure A.18 Control & Audit Production activity centre (Node A-9)

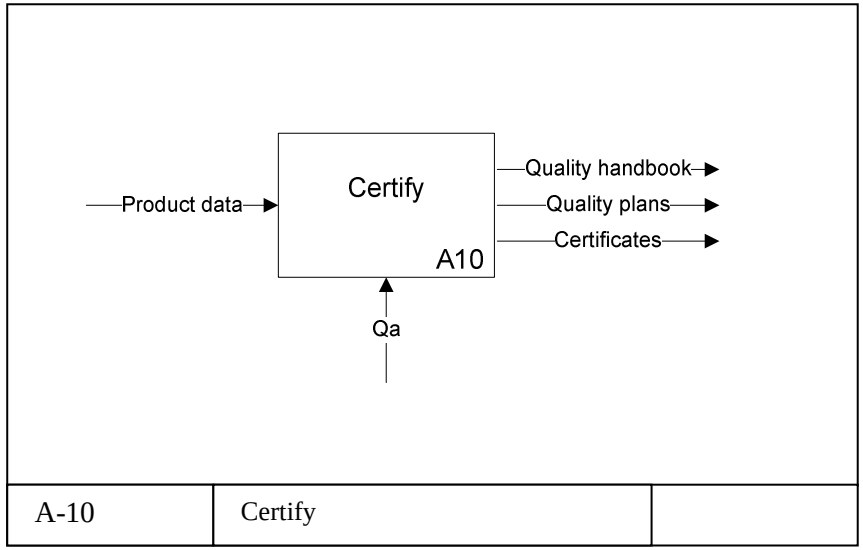

Figure A.19 Certify activity centre (Node A-10)

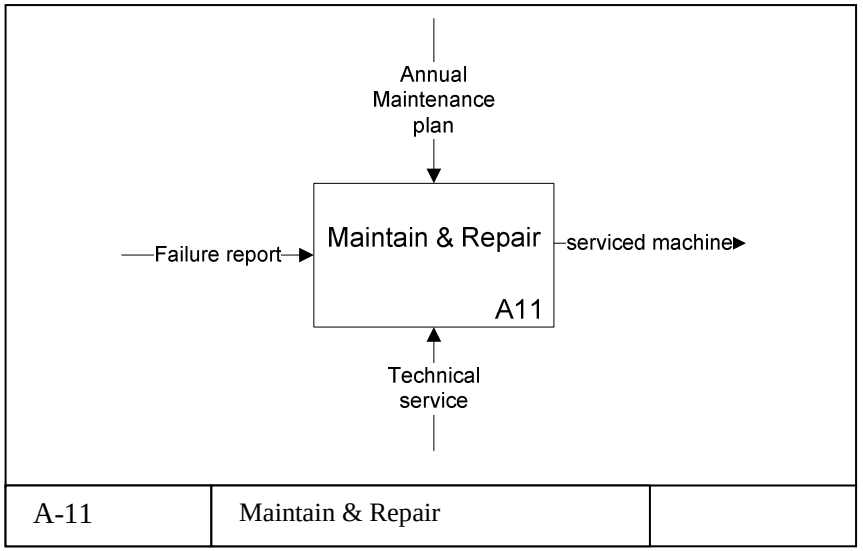

Figure A.20 Maintain & Repair activity centre (Node A-11)

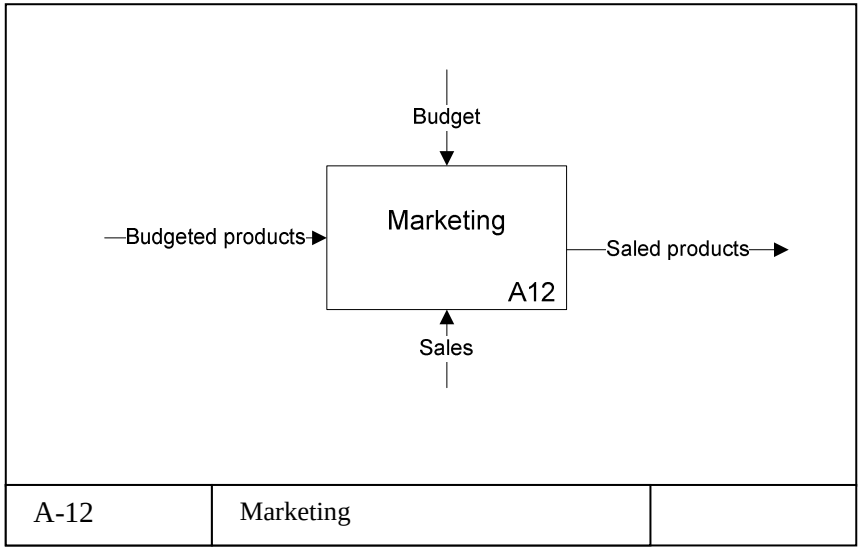

Figure A.21 Marketing activity centre (Node A-12)