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DEVELOPMENT OF A PROCESS BASED GENERIC PRODUCT COSTING SYSTEM FOR SME'S AND AN APPLICATION TO A LOGISTIC COMPANY

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Development of a Process Based Generic Product Costing System for SME's and an Application to a Logistic Company

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Supervisor
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ABSTRACT

DEVELOPMENT OF A PROCESS BASED GENERIC PRODUCT COSTING SYSTEM FOR SME'S AND AN APPLICATION TO A LOGISTIC COMPANY

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The present age of competition leads all the companies to being effective and efficient in their operations. In order to be effective and efficient, they have to know their process information and their product costs. In the recent eras many costing approaches has emerged for the sake of this information. Although there are many studies in the literature which explain modern costing approaches including Activity Based Costing, Target Costing, Kaizen Costing and so on, the number of studies which present real life applications is very few. This is especially true for logistics and transportation applications. One of the main difficulties in land transportation companies is to determine and evaluate true cost of their operations and services, this is because the complexities of the processes and the variations of the transportation services that the company serve. If used and implemented properly ABC can be very helpful for transportation companies to determine cost of their operations with higher correctness. Business process reengineering and process improvements are also important for a competitive market structure of logistics. In this thesis a process based costing system is developed and an application of the model to a land transportation company which is located in Gaziantep is performed. SIMPROCESS process modeling and simulation software is used in order to apply the developed costing model. The cost estimations of ongoing costing system of the company are compared with the cost estimations of the proposed costing system. It is figured out that the proposed costing system can be used in order to achieve process improvements and cost reduction in logistics operations and services.

Key Words: Activity based costing, Process based costing, Logistics processes, Logistics costs, Business process modeling, Transportation costs.

ÖZET

KOBİ'LER İÇİN SÜRECE DAYALI GENEL BİR ÜRÜN MALİYETLEME SİSTEMİ GELİŞTİRİLMESİ VE BİR LOJİSTİK ŞİRKETİNE UYGULANMASI

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Günümüzün rekabetçi iş dünyası işletmeleri operasyonlarını yönetirken daha etkili ve etkin olmaya itmiştir. İşletmelerin etkili ve etkin olmak için iş süreç bilgilerini ve ürün maliyetlerini bilmeleri gerekmektedir. Bu faydalı bilgilere ulaşabilmek için geçtiğimiz on yıl içerisinde bir çok yöntemler geliştirilmiştir. Faaliyet Tabanlı Maliyetleme, Hedef Maliyetleme ve Kaizen Maliyetleme gibi literatürde birçok örnek bulmak mümkündür. Fakat bu çalışmaların gerçek örnekler üzerinden işlenmesi literatürde pek de sık karşılaşılan bir durum değildir. Hatta lojistik ve taşımacılık sektöründeki uygulamalar daha da azdır. Karayolu taşımacılığı yapan işletmelerde yapılan hizmetlerin gerçek maliyetlerinin bulunamaması lojistik faaliyetlerin karmaşıklığından ve sunulan hizmetlerin değişken yapısından kaynaklanmaktadır. Doğru ve etkin bir şekilde kullanıldığında Faaliyet Tabanlı Maliyetleme, taşımacılık yapan işletmelerin gerçek maliyetlerinin bulunmasında oldukça doğru sonuçlar veren bir yöntemdir. İş süreç yeniden yapılama ve süreç iyileştirme çalışmaları da rekabetçiliğin öne çıktığı lojistik alanında çok büyük bir öneme sahiptir. Bu tez çalışmasında, sürece dayalı bir maliyetleme sistemi geliştirilmiş ve geliştirilen model Gaziantep ilinde bulunan bir lojistik işletmesine uygulanmıştır. İşletmede kullanılan maliyet yönteminin sonuçları, geliştirilen maliyetleme sistemi sonuçları ile kıyaslanmıştır. Uygulamanın yapılabilmesi için SIMPROCESS isimli süreç modelleme ve simülasyon yazılımı kullanılmıştır. Süreç modelleme ve sürece dayalı maliyetleme politikası ile öne sürülen model söz konusu işletmenin süreç iyileştirme çalışmalarında da kullanılmıştır.

Anahtar Kelimeler: Faaliyet tabanlı maliyetleme, Sürece dayalı maliyetleme, Lojistik süreçleri, Lojistik maliyetleri, İş süreç modellemesi, Taşıma maliyetleri.

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LIST OF SYMBOLS/ABREVIATIONS

ABC	Activity Based Costing
TCA	Traditional Cost Accounting
DPP	Direct Product Profitability
CPA	Customer Profitability Analysis
AHP	Analytical Hierarchy Process
USD	United States Dollar
Km	Kilometers
BPR	Business Process Reengineering

CHAPTER 1

INTRODUCTION

1.1 Introduction

In this chapter, general information about process based costing will be given. The literature of process based costing subject and ABC is derived and evaluated in detail. Techniques for cost estimation are discussed. SIMPROCESS as a process based costing tool is introduced at the end of this chapter.

Present age of rigorous international competition and rapidly improving technologies and improving information systems has forced companies to use new business management techniques (Baykasoğlu and Kaplanoğlu, 2006c). Market structures of products and services enforced companies to manage their costs according to business competition. Under severe competition, companies need to become leaner, responsive and agile, with ever-increasing efficiency and effectiveness (Agrawal and Mehra, 1998). A company should be able to provide high quality services/products in a short period of time with lowest possible cost in order to retain the competitive status. In order to be able to provide lower costs, accurate cost information is critical for every aspect of business, and it affects the pricing policies and performance reviews (Gupta and Galloway, 2003). This is not a critical issue for only manufacturing companies, it is also vital for service sector companies including logistics and transportation companies. In a rigorous business environment manufacturing and supply services have become very hard to maintain satisfactory returns or profits. Therefore the role of cost estimation for products and services has become more critical.

Before the modern business management times, accounting was being just used to record the costs of products and/or services. However, the important role of cost

estimation and cost information appeared after the advent of modern business management techniques. This is because traditional cost accounting systems were not able to satisfy the needs of modern business management. As a result, a gap has emerged between the accounting information gathered and the modern business management. In this thesis, the methods used to estimate more detailed cost values are evaluated. Traditional Cost Accounting (TCA), Activity Based Costing (ABC) and SIMPROCESS simulation software are used as a tool to estimate the costs of a logistics company. In this thesis, a costing model is also developed and applied to a logistics company.

1.2 Literature Survey

Many business management concepts have been developed since the global competition had become serious. Organizations have started to practice their improvement of competitiveness. In order to achieve this goal they have started to use modern and advanced process and cost management techniques such as activity based costing, kaizen costing, total quality management, process improvement etc. All these kind of techniques are being used for the sake of process improvement and for increasing the competitiveness of the organizations. Competition for logistics and transportation companies is severe and they are under the pressure of demanding business conditions. Logistics are becoming more and more important because the cost of logistics has a considerable proportion in the total cost of products. Physical Distribution cost estimates range from 7.93 % to 30 % of sales (Davis, 1988). This is generally because of increasing product and/or service differentiations. Therefore the proportion of logistics costs attract interests of researchers because the improvement of logistics cost has a direct impact on the total cost of products.

Majority of costs occurred in logistics come from the indirect costs of the services provided (Baykasoğlu and Kaplanoğlu, 2006a-c). As the customer needs change drastically and delivery time of goods decrease, the complexity of the logistics processes increase and thereby the indirect cost proportion of the logistic operations increases, even for some organizations, the overheads amount may exceed the amount of direct costs. Therefore, overheads proportion of the total costs of logistics cannot be overlooked during the cost control. The studies performed by “Council of

Logistics Management" and "Institute of Management Accountants" presented that firms had increasingly asked logistic managers to plan and manage complex operations and networks while reducing cost and enhancing service (Pohlen and La Londe, 1994). This is a natural consequence of the importance of logistic operations within an organization.

Among all the costs (resources used), the true cost of transportation services provided must be determined accurately. On the other hand, the true costs of the transportation services are not so easy to determine at a first glance because many logistics costs remain buried in overheads and logistics managers do not have adequate visibility or control over their costs (Pohlen and La Londe, 1994) and the cost estimation of the transportation services have not been carried out by using sophisticated costing methods. The cost data recorded has been generally assigned to transportation services directly. However, for an adequate decision support more is needed than just cost assignment. There is a need for an instrument that is capable of linking logistical process information to financial information (Van Damme and Van Der Zon, 1999).

In practice, there are some alternative means to find the cost of logistics services provided. Traditional cost accounting method is widely used in order to find the cost of the logistics services provided. Direct product profitability (DPP) and customer profitability analysis (CPA) are some other mentioned means of logistics costing. The DPP methodology attempts to identify all of the costs associated with a product or an order as it moves through the distribution channel (Themido et al., 2000) and CPA tries to identify the true costs associated with servicing an individual customer (Christopher, 1992; Cooper and Kaplan, 1991). However strict market conditions of logistics necessitate a different cost approach which combines process conditions, the business costs and process performances. Although there are many studies in the literature which explain modern costing approaches including ABC, the number studies which present actual case studies are very few. This is especially true for logistics and transportation services. If used and implemented properly ABC can be very helpful for transportation companies to determine true cost of their operations and services.

According to Nachtmann and Al-Rifai (2004) ABC helped many manufacturing and service organizations to improve their competitiveness by enabling them to make better decisions based on an improved understanding of their product cost behavior. There are many applications of ABC in manufacturing organizations (Dhavale, 1993; Zhuang and Burns, 1992) and some applications in logistics organizations. Stapleton et al. (2004) discussed advantages, disadvantages and difficulties of ABC for logistics and marketing in general. Goldsby and Closs (2000) illustrated application of ABC to reverse logistics activities performed across supply chain organization without presenting details of implementation. Van Damme and Van Der Zon (1999) presented a logistics management accounting framework to support logistics management decisions without presenting an actual implementation. Liberatore and Miller (1998) proposed a framework for integrating ABC, Analytical Hierarchy Process (AHP) and balanced scorecard for logistic strategy development and monitoring. Pohlen and La Londe (1994) carried out a survey of leading-edge firms within USA in order to present trends for implementing ABC. They concluded that there is a trend towards implementing ABC in logistics and most firms expect the ABC applications in logistics to produce results similar to those experienced in manufacturing. However, we can not find many applications and implementations of ABC in transportation companies, especially in Turkey we can not come across with any real application. The work of Themido et al. (2000) is one of most detailed study on the application of ABC to logistics. They presented application of ABC for costing the service provided by a third part logistics operator in Portugal to one of its clients.

1.2.1 Traditional Cost Accounting

Traditional cost accounting (TCA) uses a simple but an effective method to allocate the indirect costs. The cost of materials and direct labor can be traced to the products easily but the complexity arises with the allocation of indirect costs. In traditional cost accounting the direct materials and direct labor act an important role to constitute a basis for the allocation of indirect costs. Indirect cost of the products is calculated by multiplying the direct cost by a constant (Andrade et al., 1999). This process is shown in Figure 1.1.

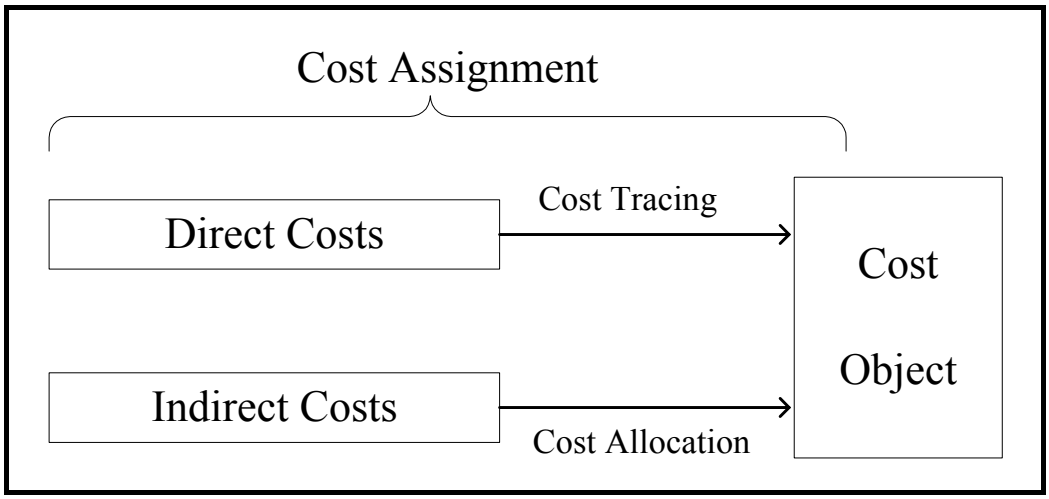

Figure 1.1. Cost relations (Horngren et al, 2001)

Another traditional cost system definition is exhibited in the Figure 1.2. "In the first stage, service department costs are assigned to production or operating departments. In addition, the costs directly arising in these production departments are directly traced to these departments. Thus, after the first stage, all organizational expenses are assigned, either directly or through assignment from service departments, to production departments. In the second stage, shown in the Figure 1.2., costs are assigned from production departments to the products processed through those departments. The first stage of an ABC system has the same structure as a traditional cost system, though instead of assigning service department resource costs to production centers, ABC systems assign resource expenses of both production and service departments to the activities performed by those resources." (Kaplan and Atkinson, 1998).

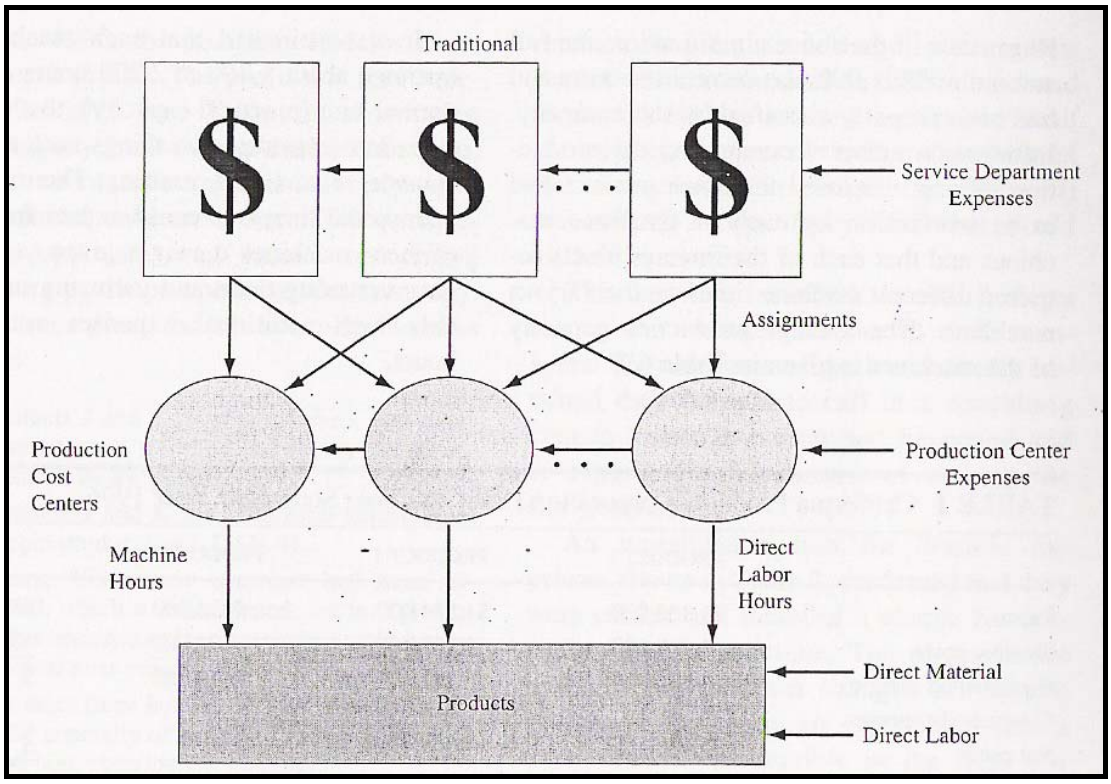

Figure 1.2. Traditional two stage cost system: Assign service department costs to production centers and products (Kaplan and Atkinson, 1998)

1.2.2 Activity Based Costing

Activity Based Costing (ABC) represents an alternative paradigm to traditional cost accounting system and has received extensive attention during the past decade. Rather than distorting the cost information by using traditional overheads allocation methods, it traces the cost via activities performed on the cost objects (production or service activities) giving more accurate and traceable cost information (Köker, 2003).

ABC has been revealed recently and used rarely by the service sectors especially by the logistics sector. ABC has appeared during the 1980s' with the studies of Cooper (1988a, 1988b), Cooper and Kaplan (1988) and Johnson and Kaplan (1987). There are some differences between TCA and ABC; Cost calculation of the products and/or services in traditional costing is based on the determination of direct costs and indirect costs by a single cost driver, however ABC uses more than one cost drivers to allocate the indirect costs.

In recent years activity based costing (ABC) evolved to be a well-known and widely used instrument of cost accounting (Shields and Ewen, 1996; Waeytens and Bruggeman, 1994). The popularity of ABC has grown at a fast pace in the 1980's due to the promotion of organizations such as computer-aided manufacturing-international (CAM-I) and the National Institute of Management Accountants (Ben-Arieh and Qian, 2003).

ABC has been applied to various industries (Tsai, 1996) such as electronics (Merz and Hardy, 1993), automotive (Miller, 1994), aerospace and defense (Soloway, 1993), airplane manufacturing (Haedicke and Feil, 1991), shipbuilding (Porter and Kehoe, 1994), telecommunication (Hodby et al., 1994), machine production (Turaç, 1998) and for general production systems (Özbayrak et al., 2004). ABC is also used for the production learning (Andrade et al. 1999). ABC is also integrated with many different management techniques. Gurses (1999) has integrated ABC with *theory of constraints* in order to use it for product-mix decisions.

In traditional costing, the overheads distribution to the products and/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. Direct labor or raw material usages are frequently considered as a cost driver in traditional costing and a single cost driver is generally used for the distribution of overheads. In addition to this, TCA may lead some cost distortions due to some lack of cost calculation. There is a consensus about distortion of product costs when the accounting is performed with TCA especially for the organizations where the proportion of overheads to total costs is fairly high (Baykasoğlu et al., 2003; Tsai and Kuo, 2004; Gunasekaran and Sarhadi, 1998). On the other hand, the main premise behind ABC is to classify overheads or indirect costs and to allocate them to end products or services based upon the activities required to produce these products (Raz and Elnathan, 1999). The allocation of the indirect costs to product and/or services differs from the TCA. ABC assumes that cost objects (products, product lines, processes, customers, channels, markets and so on) create the need for activities, and activities create the need for the resources (Tsai and Kuo, 2004). Resources include overheads of the organizations and they are allocated to the activity centers (see Figure 1.3). Resource drivers (first-stage cost drivers) are used during allocation of the resources to the activity centers

(Figure 1.3). Resource driver is an allocation rate of an individual resource and shows the resource consumption levels of the activities. This procedure comprises the first stage of ABC.

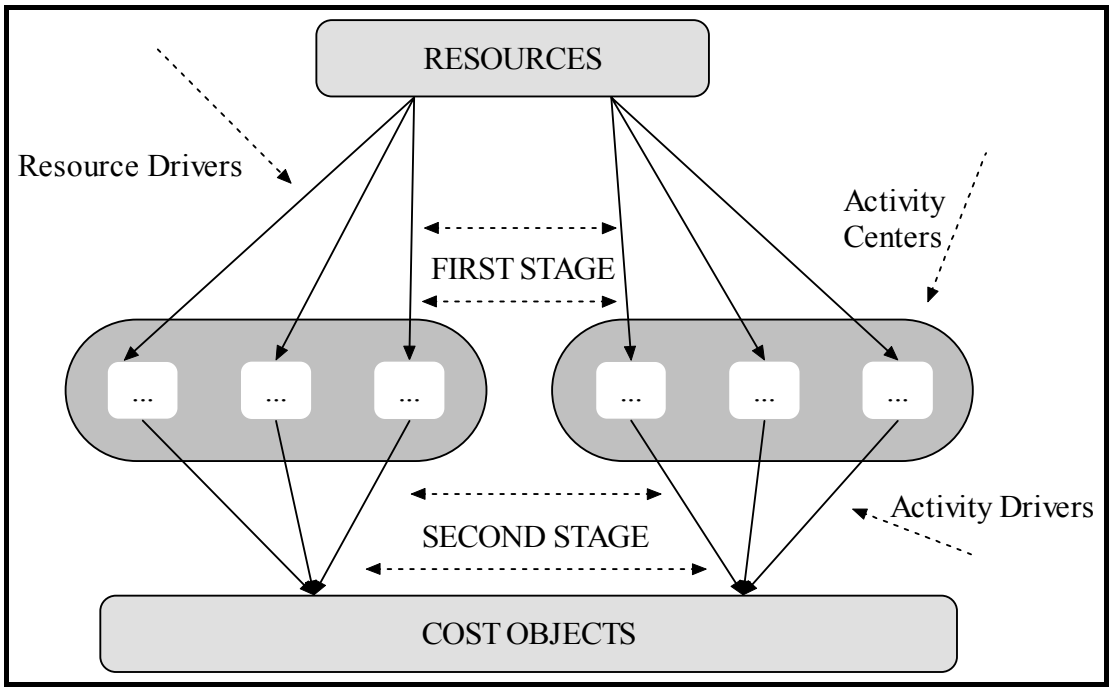

Figure 1.3. Detailed cost assignment of ABC (Tsai and Kuo, 2004).

After finding the costs of the activities (cost pools), ABC plans to distribute them to cost objects. Some drivers are used for the allocation of activity costs to the cost objects in a similar manner of first stage cost allocation. The meaning of "*driver*" in the second stage of ABC has the same meaning with the first stage cost driver of ABC. Cost objects are loaded by the activity cost pools by using the activity drivers (second-stage cost drivers). As a result of activity cost pool allocation to the cost objects, cost consumptions of each cost object are found. The unit cost of each cost object is then found by dividing the total allocated cost by the product amount.

Of those companies which had adopted ABC most had implemented it within one to two years after making their decision to adopt it and the majority of the companies believed that they had achieved five goals (Sohal and Chung, 1998), which are;

- More accurate product costing
- Better cost management
- Better cost control
- Better allocation of overheads
- More accurate cost information

Many business opportunities appeared after the development of ABC. Some of the numerous advantages of ABC over its traditional counterpart were mentioned in the literature as follows (Stapleton et al., 2004);

- ABC has helped firms across the world to become more efficient and more effective
- ABC provides a clear picture of where resources are being spent, customer value is being created, and money is being made or lost
- ABC offers a better alternative to labor-cost based product costing
- ABC identifies value-added activities
- ABC eliminates or reduces non-value added activities.

Although using ABC brings many advantages from the viewpoint of management, implementation of ABC to service organization especially to logistics pose several challenges which do not generally exist for ABC applications in manufacturing. There are several reasons of this challenge of ABC implementation to logistics which are (Rotch, 1990);

- Output is harder to define
- In many cases determining activities and cost drivers is not straightforward
- Data collection and measurements is more complicated than manufacturing
- Activity in response to service requests may be less predictable
- Joint capacity represents a high portion of total cost and is difficult to link output related activities.

In other words, the output of the processes of the logistics organizations can not be represented as easily as the outputs of manufacturing organizations. Activities performed in a manufacturing organization are generally known with certainty but they can not be easily defined in many service and logistics organizations. Another challenge of the application of ABC to logistic organizations is the complexity of logistic work processes (Baykasoğlu and Kaplanoğlu, 2006b). The complexity of the business processes increases the load of ABC calculations.

1.2.3 SIMPROCESS

SIMPROCESS is a hierarchical and integrated process simulation tool that radically improves the organization's productivity for process modeling and analysis. SIMPROCESS is designed for Business Process Reengineering (BPR) professionals of industrial and service enterprises that need to reduce the time and risk it takes to service customers, fulfill demand, and develop new products.

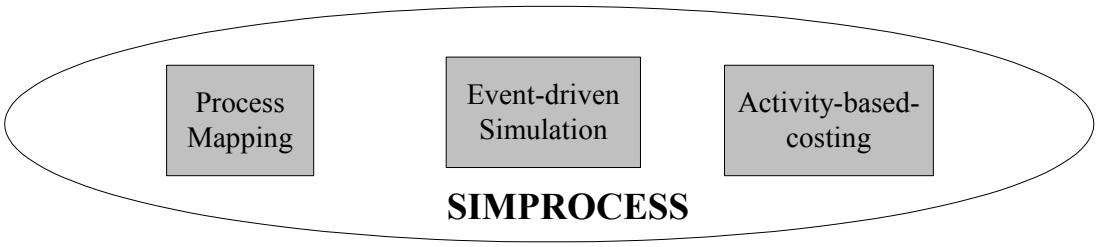

Figure 1.4. General framework of SIMPROCESS concept (SIMPROCESS User Manual, 2005)

SIMPROCESS integrates process mapping, hierarchical event-driven simulation, and ABC into a single tool. The architecture of SIMPROCESS provides an integrating framework for ABC. The building blocks of SIMPROCESS are processes, resources, entities (flow objects), activities, ABC, and dynamic process analysis. ABC embodies the concept that a business is a series of inter-related processes, and that these processes consist of activities that convert inputs to outputs. The modeling approach in SIMPROCESS manifests this concept and builds on it by organizing and analyzing cost information on an activity basis (Simprocess User Manual, 2005).

1.2.4 Analytic Hierarchy Process (AHP)

AHP is a technique for considering data or information about a decision in a systematic manner (Golden et al., 1989; Saaty, 1980; Saaty, 1988). Researchers have shown that AHP helps to bring consistency in selection problems whose decision criteria is expressed in subjective measures based on managerial experience (Bryson, 1996). There are many applications of AHP in the literature; however there are not many applications of AHP for ABC analysis. Partovi (1991)'s work is one of the rare applications of AHP to ABC.

1.3 Activity Based Costing and SIMPROCESS

Simprocess provides a framework which integrates ABC, process modeling and simulation. ABC embodies the concept that a business is a series of inter-related processes, and that these processes consist of activities that convert inputs to outputs. The modeling approach in SIMPROCESS manifests this concept and builds on it by organizing and analyzing cost information on an activity basis (Simprocess Manual, 2005). Resource allocation mechanism of SIMPROCESS has the principles of ABC. First of all the resources are distributed to the mapped activities and then, the costs of the resources used by the activities are allocated to the entities flowing in the model.

The most difficult point of implementation of ABC is finding the adequate level of business details. SIMPROCESS provides a tool to build a detailed process map. SIMPROCESS also provides a dynamic analysis platform to in order to evaluate different process scenario. SIMPROCESS can do this with its process modeling and mapping functions. Another important support of SIMPROCESS to ABC analysis is its randomness for some activities and some resource usages. Randomness of a process or any activity might be reflected directly to the model. The cost allocations are made according to the defined randomness. If activity durations changes with any distribution, SIMPROCESS can also reflect it to the activities and to the cost objects.

1.4 Methodology and Materials Used

In this thesis; ABC and AHP are used as a methodology and SIMPROCESS is used as a material in order to estimate the costs of transportation services of a logistics company. The reason of usage of these materials and methodologies is to estimate the costs of logistics services accurately. ABC methodology is used in order to have a general framework for the proposed costing model. ABC establishes the backbone of the proposed costing system. AHP is used in order to determine some resource allocation coefficients which will be discussed in the further chapters. SIMPROCESS is used as a tool for determining some activity cost pool allocation coefficients. SIMPROCESS is also used for the process modeling studies and process improvement analysis.

1.5 Scope and Objectives of the Thesis

The objective of this thesis is to propose an integrated costing model and implement it to a logistics company. To meet this objective the thesis addresses 2 separate goals;

- Develop a process based product/service costing system and discuss its details

- Estimate the transportation costs of a Logistics Company via using the proposed costing model

In order to reach these goals, chapter 2 gives a brief explanation about the logistics company and then introduces the developed costing model. Chapter 3 addresses the application of the proposed costing model to the Logistics Company. Chapter 4 summarizes the thesis.

As a whole, this thesis identifies the cost estimations of the logistics services which are provided by a Logistics Company located in Gaziantep by using the proposed ***process based generic product costing system***.

CHAPTER 2

STATEMENT OF THE PROBLEM AND GENERIC COSTING SYSTEM

2.1 Introduction

In this thesis, costs of the transportation services of a Logistics Company are estimated by using the ***process based generic product costing system***. In this chapter, firstly the Logistics Company and its cost data (recorded by the accounting department) will be introduced. Secondly, the proposed costing system will be introduced and the components and supporting materials of the proposed costing model will be analyzed in detail. Next, the necessity for such a costing model will be discussed by demonstrating the ongoing costing method and cost estimates of the company.

2.2 Logistics Company Profile

The main services of the Logistics Company where the cost estimations will be obtained consist of export services from Gaziantep to European countries and import from European countries to Turkey. The company is established at 1936. The company presented a sharp growth rate after year 2000. The company owns 100 vehicles presently. The company is presently one of the biggest logistics company (land transportation service provider) in the south east of Turkey. Company's main operations consist of planning (vehicle assignment and organization, route planning, load consolidation etc.), customer relations/marketing, land transportation (import and export), warehousing, accounting, maintenance, and support services. Some of the operations are conducted for the preparation of the loads for the transportation services. Vehicle assignment, route planning, load consolidation etc. are performed in order to make the loads (demands) ready for the transportation. Customer

relations/marketing, warehousing, accounting and maintenance are all performed in order to support the transportation services.

The company has many objectives to reach while performing its operations. In order to reach these objectives it has vision and mission statements. Vision and mission statements of the company are as follows; (Baykasoğlu and Kaplanoğlu, 2006d).

2.2.1 Vision and target statements of the company

Logistics is one of the most important sectors in modern business environment. It is becoming more important with the increase of production and requirements on transportation of products to desired areas. With increased production and work improvement of our customers, we aim to enlarge and develop our service capacity. We aim sustained customer satisfaction by supplying online vehicle control service. We know what our customers will demand from the logistics sector in the future. Therefore, we aim to develop our work and be able to make competition with European companies. We also aimed to be the leader in the logistics sector by supplying integrated logistic services (warehouse, distribution, customs clearance, insurance etc.) all over the world, giving better services than customer desires.

2.2.2 Mission statements of the company

- Providing sustained customer satisfaction by supplying safe, economic and fast services.
- Satisfying the changing needs of customers
- Providing new processes and optimizing the existing services
- Being leader at the logistics activities of international transportation in the region
- Increasing the variety of services provided to the customers

2.2.3 Cost Profile of the company

Cost of the transportation services is one of the most important elements of vision and mission statement of the company. In this thesis, the economy perspective of the company's objectives is focused. Providing economic transportation services is one of the most important missions of the company. Knowing the true costs of the transportation elements is the initial point of cost analysis and cost improvement studies.

In order to obtain an accurate cost analysis, cost records are necessitated. The interviews with the accounting staff of the company has resulted in obtaining a standard cost record. The cost records which are got from the accounting staff of the company can be divided into two types. *Direct costs* occurred (Type 1) and the *overheads* committed (Type 2). Direct costs of the transportation services are recorded with a day by day basis. Driver wages, vehicle fuel consumptions, direct costs occurred during transportation and etc. are recorded and classified as *direct costs*. The second type of records of the accounting department is the cost of resources which are used indirectly during the operations of the company. The indirect resources used in the company for the operations include the vehicles, operations personnel, operations building, computers, office utilities etc.

Cost record given by the accounting staffs of the company consist the cost data of last 9 months. *28* different transportation services including both exports and imports were conducted during this time period. The number of transportations, total amount of load carried (in terms of ton) and etc. are given in the Table 2.1. Transportation prices are also represented in Table 2.1. The unit prices of these transportation services are obtained by dividing the *Total Transportation Prices* to the *Total Number of Transportations*. *Total Transportation Direct Costs* represents Type 1 costs occurred. They are all recorded during the transportation processes. These costs include fuel consumptions of the vehicles, RO-RO tariffs paid, directly paid driver wages and etc. General characteristic of these costs is their occurrence when the transportation is performed. In other words they are direct costs occurred.
Type 2 costs emerge by the usage of some resources. Vehicles, operations personnel, operations building, computers, office utilities etc. are some examples of the

resources used. In the company, overheads are mostly related to resources used to perform transportation services. There are many different types of overheads in the company therefore overheads are grouped based on their similarity to each other. 19 overhead categories are identified and represented in Table 2.2. The overheads groups are obtained by grouping the individual overheads according to their similarity. Making the cost calculation easier and more understandable is the reason of overheads grouping.

Table 2.1. Logistics Company profile (for the last 9 months)

Transportation Services	Total number of Transportations	Total Amount of Load carried (ton)	Total Transportation Prices ($)	Unit Transportation Prices ($)	Total Transportation Direct Costs ($)
Belgium Export	49	825.5	225,000	4,591.84	125,649
Belgium Import	119	2,130.2	520,415	4,373.24	239,911
England Export	19	283.3	112,000	5,894.74	52,490
England Import	11	163.8	52,624	4,784.00	26,818
France Export	107	2,253.2	369,633	3,454.51	194,906
France Import	92	1,035.9	425,300	4,622.83	182,051
Germany Export	73	1,207.6	268,487	3,677.90	178,966
Germany Import	114	1,731.4	498,436	4,372.25	253,070
Greece Export	36	639.2	78,365	2,176.81	40,273
Greece Import	46	1,026.6	59,638	1,296.49	42,905
Holland Export	7	117.8	45,000	6,428.57	15,012
Holland Import	5	66.5	22,568	4,513.60	5,086
Iran Import	10	146.7	11,647	1,164.66	9,811
Ireland Export	2	28.0	15,600	7,800.00	2,646
Italy Export	12	256.1	39,466	3,288.80	21,137
Italy Import	11	177.1	60,828	5,529.80	11,392
Norway Export	12	23.8	52,078	4,339.81	34,790
Norway Import	35	690.0	343,158	9,804.51	101,593
Poland Export	107	2,195.9	364,031	3,402.16	249,292
Poland Import	23	381.6	57,931	2,518.75	48,078
Russia Export	66	1,258.1	385,652	5,843.21	78,677
Russia Import	31	627.7	52,638	1,698.00	35,345
Spain Export	2	49.0	8,207	4,103.46	2,965
Spain Import	1	17.4	4,224	4,224.15	1,473
Sweden Export	4	42.9	18,104	4,525.88	8,232
Sweden Import	38	581.9	356,523	9,382.18	95,017
Ukraine Export	13	252.2	68,000	5,230.77	26,174
Ukraine Import	3	56.2	4,816	1,605.21	2,953

Table 2.2. Overheads in USD (for the last 9 months)

Overheads	Amount ($)	Overheads	Amount ($)
Vehicle Depreciation Costs	1,144,008.02	Warehouse Costs	18,091.81
Employees Insurance Costs	107,525.60	Building Electricity Costs	
Indirect Labor		Building Water Consumption	
Staff Training	121,202.90	Building Cleaning Expenses	9,537.61
		Personnel Transportation	
Withholding Tax		Service Costs	
Return of Tax	50,523.20	Urban Transport of Staff Costs	
		Urban Transport Fuel	
Motor Vehicle Tax		Consumption	
Vehicle Insurance		Other Fuel Consumptions	30,053.05
Vehicle License Costs		Aero plane Ticket Expenses	
Vehicle Traffic Control Costs		Foreign Travel Expenses	5,901.45
Vehicle Maintenance	311,866.10	Conveyance Lawyer Costs	
Tax of Building		Consultancy Costs	
Insurance of Building	10,007.07	Other Counseling Costs	
Vehicle Driver License Costs	72,516.38	Banking Costs	191,676.43
Replacement Part of Vehicles			
Costs		Advertising	
Tire Costs	63,212.64	Documents Expenses	
Customs Costs		Stationery Costs	
Tickets bought during			
transportations	17,863.30	Newspaper Expenses	
Telephone Bills	24,504.28	Computer Maintenance Costs	32,370.42
Refectory Expenses	24,150.39	Donations	
Representation Expenses		Other Costs	
Car Park Expenses		Motoring Fine Costs	80,257.35
Mailing Expenses			
Photocopy Costs	5,620.46	Total	2,320,888.46

In total $ 2,320,888.46 has spent for the resources which are used indirectly. Main premise behind such kind of cost record is the aim to reach deliberate and accurate cost estimations.

2.3 The Proposed Costing Model

The proposed costing model is represented in Figure 2.1. The general framework of the proposed model is constituted by Activity Based Costing method. AHP technique and Simulation are used as a support for the ABC analysis. Step by step clarification of the proposed costing model will be given in this chapter.

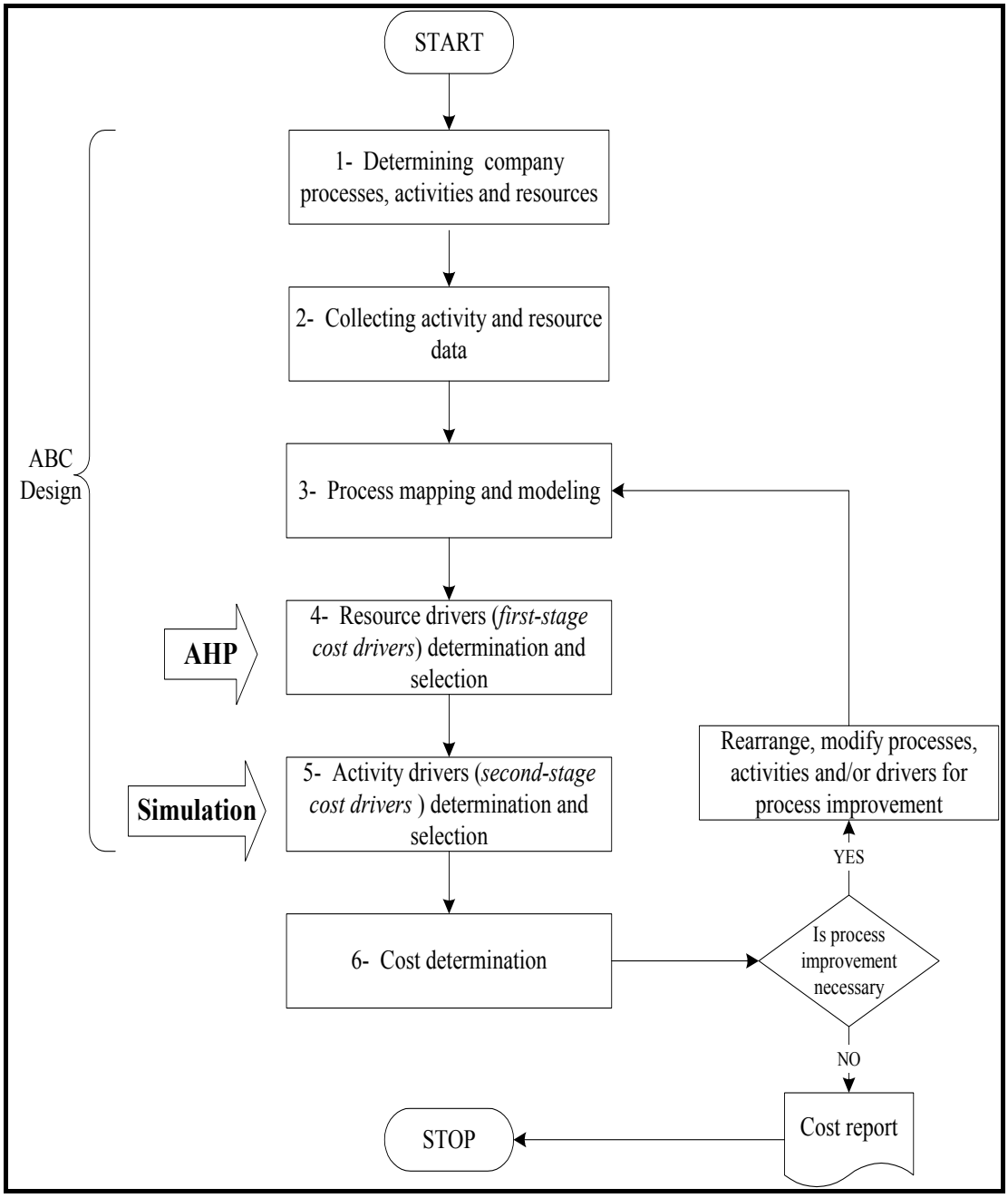

Figure 2.1. Developed generic product costing framework

2.3.1 Determining company processes, activities and resources

First step of the model (*Determining company processes, activities and resources*) is adapted from ABC analysis. This is one of the main steps of the proposed costing model. There are many different ways in order to do this step. Interviews with the company personnel and managers can be done. The processes of the company might be monitored. This step is also the most time consuming step of the proposed costing

model. The details of analysis of the processes and activities should be determined sensitively. This is because the details of the analyses might outweigh the purpose of the study. The cost of process analyses might outweigh the benefits which will be earned by the application of the proposed costing analysis. This is also the main concept behind the ABC cost analysis.

In this step of the proposed costing system, firstly the main processes are determined. *Export* and *import* processes are selected as main processes of the Logistics Company. The sub-processes and activities of them are determined later. The resources used during the logistics operations and their respective costs are determined in this step of the proposed costing system. The model given in Figure 2.1 is designed for the costing studies of past. In other words the model proposed in Figure 2.1 is used for the cost estimations of the recent records. In this model overheads constitute the most important part of the model.

2.3.2 Collecting activity and resource data

In this step of the proposed model, the data related with the determined processes and activities are collected by some interviews with the accounting staff and with the management of the companies. The personnel working for the activities which are determined in the first step of the model are interviewed also. Activity durations and their resource consumptions are obtained by making meetings with both personnel and with the managers. Data of activities include; activity durations and their respective distributions, resources used for the activities, and predecessor and successor of the activities. Activity distributions might be obtained by monitoring the activities or asking to the personnel working. Resources used for any activity are obtained by interviewing with the management. Predecessor and successor of each activity can be determined by monitoring the processes and activities.

2.3.3 Process mapping and modeling

Organizations always need differences in their processes and activities however changing the processes or activities might result in unpredictable results. Therefore business process mapping and modeling (BPM) is necessitated by many companies. BPM is a sub-component of *enterprise modeling*. The objective of enterprise modeling is to develop a repository regarding organizational elements and functions that maps information objectives with business functions. This is accomplished through an exhaustive process that analyses and models the business to a level of detail sufficient to enable selection of appropriate technologies and design of specific information systems (Moynihan, 1997).

The main goal of the BPM is to create a simplified but useful model of a business enterprise. The enterprise can be an entire company or a particular division of a company or a related set of departments. The purpose of BPM is generally to achieve the following (Baykasoğlu and Bartık, 2005);

- Determine the *bottlenecks*
- Determine *non-value adding* activities
- Devise *revisions* to the process to improve performance
- Generate *alternative* process designs and select the one, which gives best results
- Provide cost *justification* to planned alternatives
- Establish performance *targets* etc.

In addition the goals of BPM stated by Baykasoğlu and Bartık (2005), it can also be used for the cost estimation studies.

Third step of the proposed costing model is process mapping and modeling. In this step of the model, the processes, sub-processes and activities are mapped. There are numerous computer programs which can be used in order to map the processes. Process model can be mapped in two different ways; static process modeling and dynamic process modeling. Static process modeling can be used for the education

purposes. However, dynamic process modeling can be used for both education purposes and for cost analysis.

2.3.4 Resource drivers (*first-stage cost drivers*) determination and selection

The processes, sub-processes and activities consume resources during their operations. The most important concept embedded to ABC system is the idea of cost drivers. Resource driver determination is critical for the accuracy of the cost assignment of the products and/or services. Traditional Cost Accounting (TCA) uses single cost driver in order to allocate the overheads, however ABC uses more than one cost drivers. This increases the accuracy of cost estimation.

The determination of the resource drivers is not an easy task. This is because different people might select different cost drivers for the same resource. Therefore, costing system represented in the Figure 2.1 emphasizes the resource driver determination. AHP technique is used in order to determine the coefficients of the resource allocation matrix. In some studies in the literature, driver determination is also selected by using AHP but in the model given in the Figure 2.1 AHP is only used for coefficient determination.

2.3.5 Activity drivers (*second-stage cost drivers*) determination and selection

After completing the step 4 of the proposed costing model, the activity cost pools are obtained. The costs of every activity are obtained. Value added and non-value added activities can be seen easily after step 4.

Activity drivers (*second-stage cost drivers*) are used for the cost allocation from activity cost pools to the cost objects. Determination of the activity drivers is also important for a good cost estimation study. Some of the allocation coefficients used in this step of the model is obtained after the simulation of the mapped processes. The simulation software plays an important role here. This is because the output report of the software will be used as an allocation coefficient.

2.3.6 Cost determination

This is the last step of obtaining cost estimations. The cost determination is performed after the driver determinations. The selected cost drivers and their coefficients are used in order to allocate the cost pool to the cost objects. The coefficients determined by using simulation are used in order to allocate cost pools to cost objects. During the cost allocation matrix multiplication is used.

2.3.7 Process and/or cost improvement

The model proposed in the Figure 2.1 collects the process, activity and resource data and maps all of the data collected. The model proposed in the Figure 2.1 also uses Analytical Hierarchy Process and SIMPROCESS as an integrated tool. Analytical Hierarchy Process is used in order to obtain the first-stage cost drivers. The need of Analytical Hierarchy Process emerges from the difficulty of making decisions. SIMPROCESS is used in order to obtain second-stage cost drivers. The model mapped to the software in the step 3 of the model is simulated and the results are obtained.

When the processes of the companies are changed, their respective resource usages change. The change in resource usages of the activities directly affects the cost allocation coefficients. This is because; the costs of the activities which consume more resources must be higher.

After the cost determination step of the proposed cost model, the cost results of product and/or services are evaluated. If any improvement can be made, the process map is rearranged and the model continues from the step 3 and it loops until reaching a desired cost level. The improvement could be whether a reduction in overheads or a better driver rate.

In the next chapter, the application of the proposed costing model to a Logistics Company will be represented. The model given in the Figure 2.1 will be analyzed in a step by step manner.

2.4 The necessity of the proposed costing system

In order to show the necessity of the proposed costing system, Traditional Cost Accounting (TCA) will be evaluated and the TCA cost estimations of the Logistics Company are presented in this section.

TCA uses a simple method to allocate the indirect costs. The cost of materials and direct labor can be traced to the products easily but the complexity arises with the allocation of indirect costs. In traditional costing the direct materials and direct labor act an important role to constitute a basis for the allocation of indirect costs. Indirect cost of the products is calculated by multiplying the direct cost by a constant (Andrade et.al., 1999).

While using TCA, the cost estimation of the transportation services are obtained by adding the direct cost used to conduct them and the overheads used during the operations of the company. TCA cost estimation can be divided into two different steps. One of the steps is *direct cost determination* and the other one is *indirect cost determination*.

2.4.1 Direct cost determination

Direct costs of transportation services are found by dividing the total direct cost of services with the number of services given during the nine-month time period. For example, total direct cost used for Belgium exports is $125,649.4 (see Table 2.1). Unit based direct cost of this transportation services is found as; ($125,649.4) / (49 transportation) = $ 2,564.3 for each transportation. Direct costs of other services are found in the same manner.

2.4.2 Indirect cost determination

With the standard and traditional costing methods indirect cost of each cost object is derived by a singe volume cost driver (Nachtmann and Al-Rifai, 2004; Tsai, 1998; Helberg et al., 1994). As Gupta and Galloway (2003) stated, traditional cost

accounting uses single cost driver (direct labor or machine hours) as the basis for allocating overhead in manufacturing organizations but in service organizations like logistics, the traditional cost accounting drivers does not work properly. Logistic operations does not include a direct labor hours for its services or any type of raw materials. Therefore, cost driver for this study is determined by the accounting staff as the "*number of transportation"*. For the time interval of nine-months 1,048 transportation services are conducted in total for both export and import services (see Table 2.1). By using TCA, the indirect costs are allocated to each 28 different services via the total number of transportation. Unit based indirect costs are calculated by the following equation;

Indirect cost allocated to each unit of service = Total Indirect Costs / Selected Cost Driver

Indirect costs of the company are $ 2,320,888.5 for the predefined time period of 9 months. With the help of equation the overhead for each service can be determined as;
($2,320,888.5) / (1,048 transportations) = $2,214.6 / transportation.

After finding the direct and indirect costs of each service, total costs are found by summing up the allocated indirect cost and average direct cost of each cost object. Table 2.3 presents the costs of each cost object with its corresponding cost data.

Table 2.3. Traditional costing results of transportation services

No.	Transportation Services	Direct Costs ($)	Total Number of Transportation	Unit Direct Costs ($)	Unit Overheads ($)	Total Cost ($)
1	Belgium Exports	125,649.4	49	2,564.3	2,214.6	4,778.9
2	Belgium Imports	239,911.2	119	2,016.1	2,214.6	4,230.6
3	England Exports	52,489.5	19	2,762.6	2,214.6	4,977.2
4	England Imports	26,818.3	11	2,438.0	2,214.6	4,652.6
5	France Exports	194,905.8	107	1,821.5	2,214.6	4,036.1
6	France Imports	182,051.2	92	1,978.8	2,214.6	4,193.4
7	Germany Exports	178,965.5	73	2,451.6	2,214.6	4,666.2
8	Germany Imports	253,069.6	114	2,219.9	2,214.6	4,434.5
9	Greece Exports	40,272.9	36	1,118.7	2,214.6	3,333.3
10	Greece Imports	42,904.7	46	932.7	2,214.6	3,147.3
11	Holland Exports	15,012.1	7	2,144.6	2,214.6	4,359.2
12	Holland Imports	5,085.9	5	1,017.2	2,214.6	3,231.8
13	Iran Imports	9,810.8	10	981.1	2,214.6	3,195.7
14	Ireland Exports	2,646.2	2	1,323.1	2,214.6	3,537.7
15	Italy Exports	21,137.0	12	1,761.4	2,214.6	3,976.0
16	Italy Imports	11,391.8	11	1,035.6	2,214.6	3,250.2
17	Norway Exports	34,789.6	12	2,899.1	2,214.6	5,113.7
18	Norway Imports	101,592.7	35	2,902.6	2,214.6	5,117.2
19	Poland Exports	249,292.0	107	2,329.8	2,214.6	4,544.4
20	Poland Imports	48,078.1	23	2,090.4	2,214.6	4,304.9
21	Russia Exports	78,676.6	66	1,192.1	2,214.6	3,406.7
22	Russia Imports	35,344.7	31	1,140.2	2,214.6	3,354.7
23	Spain Exports	2,965.4	2	1,482.7	2,214.6	3,697.3
24	Spain Imports	1,472.8	1	1,472.8	2,214.6	3,687.4
25	Sweden Exports	8,232.0	4	2,058.0	2,214.6	4,272.6
26	Sweden Imports	95,016.7	38	2,500.4	2,214.6	4,715.0
27	Ukraine Exports	26,173.8	13	2,013.4	2,214.6	4,228.0
28	Ukraine Imports	2,952.9	3	984.3	2,214.6	3,198.9

Cost estimations obtained by using TCA are represented in this chapter in order to show the necessity of the proposed costing system. The cost estimated here might be distorted because only one cost driver is used as an allocation coefficient. The unit overheads given in Table 2.3 are same for all of the transportation services. However the transportation services do not consume same resources. The amount of overheads constitutes a big proportion of total costs occurred. Direct costs occurred during the time period of 9 month is $ 2,086,709 in total. However overheads committed for the same time period is $2,320,888.5. As a result the overheads committed are more than the direct costs occurred. Therefore the application of a process based costing system which has the main concept of ABC is necessary for an accurate costing.

CHAPTER 3

APPLICATION OF THE PROPOSED COSTING SYSTEM TO A LOGISTICS COMPANY

3.1 Introduction

In this chapter, costs of the transportation services of the Logistics Company are obtained by using ***process based generic product costing system*** which is introduced in chapter 2. The application will be performed in a step-by-step manner in this chapter. The processes, sub processes, activities and resources of the company are determined firstly. The data about the activities and resources are collected then. Thirdly, the processes, activities and resources are mapped to SIMPROCESS. Then, resource drivers (*first-stage cost drivers*) and activity drivers (*second-stage cost drivers*) are determined. As a final step, the cost determination of the transportation services are conducted and process/cost improvement is achieved.

3.2 Determining company processes, activities and resources (Step 1)

The processes and their sub processes are obtained by making interviews with the personnel of the Logistics Company. The company has two main processes. They are **Export Process** and **Import Process**. **Export Process** includes all the sub processes and activities which are performed in order to conduct export transportation services. **Import Process** includes all the sub processes and activities which are performed in order to conduct import transportation services

Main processes and their sub processes are represented in Table 3.1. The processes and sub processes given in the Table 3.1 are performed for each country. Export transportation services follow the **Export Process** of Table 3.1 and Import transportation services follow the **Import Process** of Table 3.1

Table 3.1. Main processes and their sub processes

	Main Processes	
	Export Process	**Import Process**
Sub Processes	1- Operations	1- Operations
	2- Bounded Warehouse	2- Transportation
	3- Transportation and Transportation Information	3- Customs Clearance Arrival and Unloading
	4- Customs Clearance Arrival and Unloading	4- Returning to Center

The *support* process which includes vehicle maintenance, driver accounts and etc. are comprised by the *Returning to Center* sub process of **Import Process**. Some sub processes given in the Table 3.1 have their own sub processes also. They will be discussed in detail in the step 3 (Process mapping and modeling) of the proposed model. Full list of the activities performed inside of the **Export Process** and **Import Process** is given in Table 3.2 and Table 3.3 respectively.

Table 3.2. Activities of **Export Process**

Operations	Bounded Warehouse	Transportation and Transportation Information	Customs Clearance Arrival and Unloading
Export Information Gathering	Seal Control 1	Transportation Activities for Each of the Export Transportation Services	Customs Clearance Arrival of Export Transportation
Demand Appraisal and Bidding for Export	Vehicle Bag Control	Collecting Transportation Information During Export Transportation	Unloading
Inform Customers	Bounded Warehouse Record 1	Informing Consignor About Vehicle and Freight During Export Transportation	
Consolidation and Getting Vehicle	Unloading		
Document Collection From Customer for Export	Customs Officer 1		
CMR, Result Affirmation, C2, and Vehicle Document Preparations	Seal Control 2		
Driver Visa and Passport Check	Vehicle Bag Control 2		
Delivery of Documents to Customs Clearance Personnel	Bounded Warehouse Record 2		
Vehicle Goes to Loading for Export	Customs Officer 2		
Loading for Export	Loading		
Informing the Consignee	Customs Officer 3		
Customs Clearance Activities			
Route Instructions			
Advance Payment			
Vehicle Maintenance Before Export Transportation			
Fuelling Before Export Transportation			

Table 3.3. Activities of **Import Process**

Operations	**Transportation**	**Customs Clearance Arrival and Unloading**	**Returning to Center**
Import Information Gathering	Transportation Activities for Each of the Import Transportation Services	Informing Consignor About Arrival of Import Freight	Wheel Maintenance
Demand Appraisal and Bidding for Import	Inform Customer About Loading of Import Freight	Customs Clearance Arrival for Import	Wheel Air Pressure
Inform Customer		Unloading	Changing Filter
Consolidation and Getting Vehicle			Changing Motor Oil
Preparations of Vehicle Bag			Axle Control
Loading Import Transportation Freight			Review of The Vehicle
Informing the Consignee			Driver Accounts
Customs Clearance for Import Load			

When the number of activities increases the complexity and load of ABC analysis also increases. The number of activities given in the Table 3.2 and Table 3.3 is so much for the application of the proposed costing model. Therefore the number of activities is reduced to a number which can be handled. In order to reduce the number of activities they are grouped. The number of the activities is reduced to 17. Table 3.4 shows the activities in groups. They include all the activities given in Table 3.2 and Table 3.3.

Table 3.4. Activities in groups

1-Taking Information of Demand
2-Transportation Rate Determination
3-Preparation of Freight Agreement
4-Vehicle Scheduling and Preparation
5-Departure of Vehicle to Customer
6-Preparation of Loading Notification
7-Customs Clearance
8-Other Transportation Documents Preparation
9-Submission of Documents and Advance Pays
10-Vehicle Refueling
11-Transportation
12-Collecting Transportation Information
13-Informing Customers About Vehicle and Freight
14-Preparing and Sending Arrival Notification to Customers
15-Customs Clearance-Arrival
16-Vehicle Maintenance
17-Driver Accounts Calculation

After determining the processes and their activities, the resources are determined in this step of the application. Overheads represented in Table 2.2 are the costs of resources used during the 9 month operation duration of the company. Vehicles, facilities and personnel are some of the resources used during the operations of the Logistics Company. There are 100 vehicles, one building and 17 personnel working for the company as a resource.

The letter of "P" is used in order to abbreviate "Personnel". P1, P2…, P10 represents the operations personnel of the company. They work for different activities. For example P1 works for the demand appraisal and load consolidation activities. P11 represents the accounting personnel of the company. P11 comprises 4 accounting personnel. Three personnel work for the vehicle maintenance department of the company.

3.3 Collecting activity and resource data (Step 2)

The activities represented in Table 3.2 and Table 3.3 covers all the activities performed to serve logistics operations. In this step of the application, the data about

the activities and resources are collected. This is because they will be used for the process modeling, driver determination and simulation steps of this application.

The activities have their own processing times. The data of the activities include both the processing times and resources used to perform them. The activities and their respective data are represented in Table 3.5 and Table 3.6. These data are given in order to show the activity and resource data collection step of the application. The data represented in Table 3.5 and Table 3.6 is of *Germany Export* process and *Germany Import* process respectively. The activities of other county transportation service processes are same but their activity durations and their resource usages are different. Activity durations and their resource usages of some other countries are given in the **APPENDIX D** in order to show the data collection step of the application. The activity and resource data are collected for all of the transportation services which are shown in the Table 2.1.

Table 3.5. Activity durations and resource usages of *Germany Export*

Activity	Activity Duration	Resource Used	Predecessor
Export Information Gathering	Uni(5.0,10.0,1) Min	P3, P7	
Demand Appraisal and Bidding for Export	Uni(15.0,20.0,1) Min	P1, P2, P3, P7	Export Information Gathering
Inform Customers	Nor(10.0,1.0,1) Min	P7	Demand Appraisal and Bidding for Export
Consolidation and Getting Vehicle	25 Min	P1, P2, P3	Inform Customers
Document Collection from Customer for Export	Uni(15.0,20.0,1) Min	P4	Consolidation and Getting Vehicle
CMR, Result Affirmation, C2, and Vehicle Document Preparations	Uni(20.0,40.0,1) Min	P8 or P10	Document Collection From Customer for Export
Driver Visa and Passport Check	Nor(10.0,1.0,1) Min	P2, P3	CMR, Result Affirmation, C2, and Vehicle Document Preparations
Delivery of Documents to Customs Clearance Personnel	Uni(2.0,3.0,1) Min	P8	Driver Visa and Passport Check
Vehicle Goes to Loading for Export	Uni(10.0,15.0,1) Min	Vehicle	Delivery of Documents to Customs Clearance Personnel
Loading for Export	Uni(10.0,50.0,1) Min	Vehicle	Vehicle Goes to Loading for Export
Informing the Consignee	5 Min	P4	Loading for Export
Customs Clearance Activities	Uni(40.0,100.0,1) Min	P4	Informing the Consignee
Route Instructions	Nor(8.0,1.0,1) Min	P6 or P7	Customs Clearance Activities
Advance Payment	Uni(5.0,10.0,1) Min	P11	Route Instructions
Vehicle Maintenance Before Export Transportation	Uni(15.0,30.0,1) Min	Vehicle Maintenance Personnel	Advance Payment
Fuelling Before Export Transportation	Uni(10.0,30.0,1) Min	Vehicle Maintenance Personnel	Vehicle Maintenance Before Export Transportation
Seal Control 1	Nor(10.0,1.0) Min	P4	Storage of loads
Vehicle Bag Control	Nor(10.0,1.0) Min	P4	Seal Control 1
Bounded Warehouse Record 1	Nor(15.0,1.0,1) Min	P4	Vehicle Bag Control
Unloading	Nor(50.0,10.0,1) Min	No resource	Bounded Warehouse Record 1
Customs Officer 1	Nor(10.0,1.0,1) Min	P4	Unloading
Seal Control 2	Nor(25.0,3.0,1) Min	P4	Customs Officer 1
Vehicle Bag Control 2	5 Min	P4	Seal Control 2
Bounded Warehouse Record 2	Uni(3.0,10.0,1) Min	P4	Vehicle Bag Control 2
Customs Officer 2	5 Min	P4	Bounded Warehouse Record 2

Table 3.5. Continued

Activity	Activity Duration	Resource Used	Predecessor
Loading	Uni(50.0,70.0,1) Min	No resource	Customs Officer 2
Customs Officer 3	15 Min	P4	Loading
Transportation Activities for Each of the Export	Uni(3500.0,3700.0,1) km / 60 km per hour	Vehicle	Customs Officer 3
Collecting Transportation Information During Export Transportation	Uni(20.0,30.0,1) Min	P7, P3	Transportation Activities for Each of the Export
Informing Consignor About Vehicle and Freight During Export Transportation	Uni(5.0,10.0,1) Min	P7, P3	Collecting Transportation Information During Export Transportation
Customs Clearance Arrival of Export Transportation	Uni(5.0,15.0,1) Min	No resource	Informing Consignor About Vehicle and Freight During Export Transportation
Unloading	Uni(18.0,22.0,1) Hours	No resource	Customs Clearance Arrival of Export Transportation

Table 3.6 Activity durations and resource usages of *Germany Import*

Activity	Activity Duration	Resource Used	Predecessor
Import Information Gathering	Uni(3.0,5.0,1) Min	P5, P9	
Demand Appraisal and Bidding for Import	Nor(3.0,1.0,1) Min	P1, P2	Import Information Gathering
Inform Customer	Uni(2.0,4.0,1) Min	P9	Demand Appraisal and Bidding for Import
Consolidation and Getting Vehicle	25 Min	P1, P2, P3	Inform Customer
Preparations of Vehicle Bag	Nor(10.0,1.0) Min	P9	Consolidation and Getting Vehicle
Loading Import Transportation Freight	Uni(10.0,18.0,1) Hours	No resource	Preparations of Vehicle Bag
Informing the Consignee	5 Min	P5	Loading Import Transportation Freight
Customs Clearance for Import Load	Uni(3.0,4.0,1) Hours	No resource	Informing the Consignee
Transportation Activities for Each of the Import Transportation Services	Uni(3500.0,3700.0,1) km / 60 km per hour	Vehicle	Customs Clearance for Import Load
Inform Customer About Loading of Import Freight	Uni(5.0,7.0,1) Min	P5	Transportation Activities for Each of the Import Transportation Services
Customs Clearance Arrival for Import	Uni(3.0,4.0,1) Hours	P4	Inform Customer About Loading of Import Freight
Unloading	Uni(2.0,3.0,1) Hours	No resource	Customs Clearance Arrival for Import
Return To Vehicle Garage	Uni(20.0,30.0,1) Min	Vehicle	Unloading
Wheel Maintenance	Uni(1.0,2.0,1) Hours	Vehicle Maintenance Personnel	Return To Vehicle Garage
Wheel Air Pressure	Uni(1.0,2.0,1) Hours	Vehicle Maintenance Personnel	Wheel Maintenance
Changing Filter	Nor(30.0,5.0,1) Minutes	Vehicle Maintenance Personnel	Wheel Air Pressure
Changing Motor Oil	Uni(30.0,40.0,1) Min	Vehicle Maintenance Personnel	Changing Filter
Axle Control	Uni(10.0,40.0,1) Min	Vehicle Maintenance Personnel	Changing Motor Oil
Review of The Vehicle	Uni(1.0,2.0,1) Min	Vehicle Maintenance Personnel	Axle Control
Driver Accounts	Uni(15.0,20.0,1) Min	P8, P10	Review of The Vehicle

3.4 Process mapping and modeling (Step 3)

In this step of the application, the processes, sub processes and their respective activities are mapped to SIMPROCESS. SIMPROCESS simulation software is selected for the business process modeling and cost analysis because it has a property that integrates business modeling-simulation with ABC analysis. SIMPROCESS is a good candidate for the business process modeling analysis because it is easy to map the processes by using it. Another benefit of the program is the animation property of it. It might be followed the flow of the entities during their operations.

The activities determined in step 1 and their respective data given in step 2 are used in order to map the processes, sub processes and activities. In order to make the processes more understandable Figure 3.1 is represented. Figure 3.1 is given for only represent the main processes of the Logistics Company.

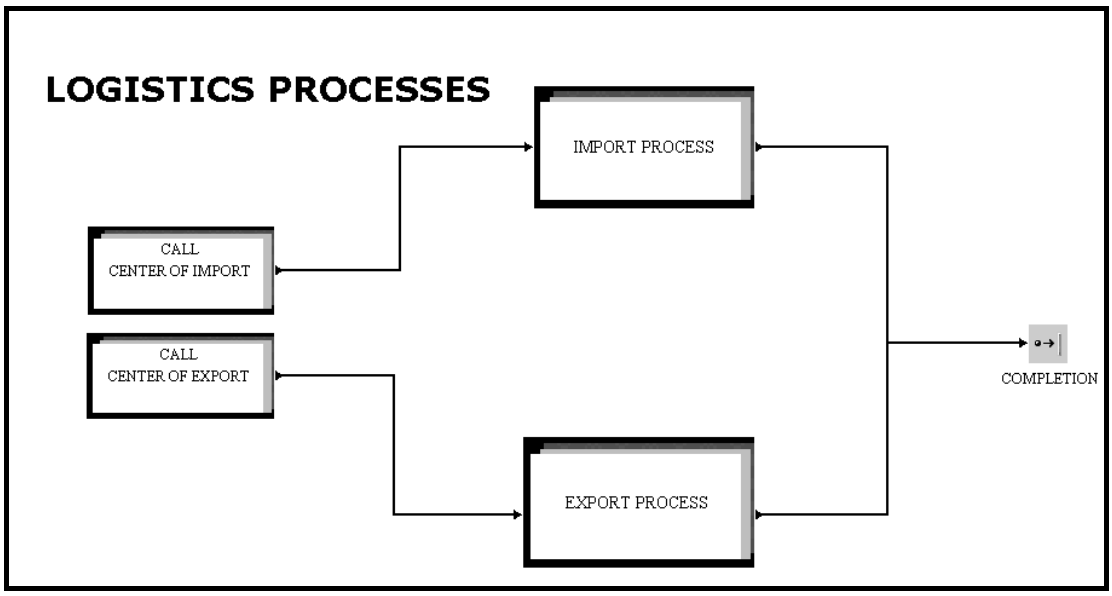

Figure 3.1. General view of the process model

The processes, sub processes and activities are mapped to the SIMPROCESS modeling and simulation software in this step of the application. A SIMPROCESS model contains the following components:

- Processes
- Activities
- Entities
- Resources
- Connectors
- Pads

3.4.1 Processes

Processes are mapped to the program by just dragging and dropping the objects of SIMPROCESS. It can be easily learned and implemented how to model a process. Figure 3.2 shows the objects of SIMPROCESS.

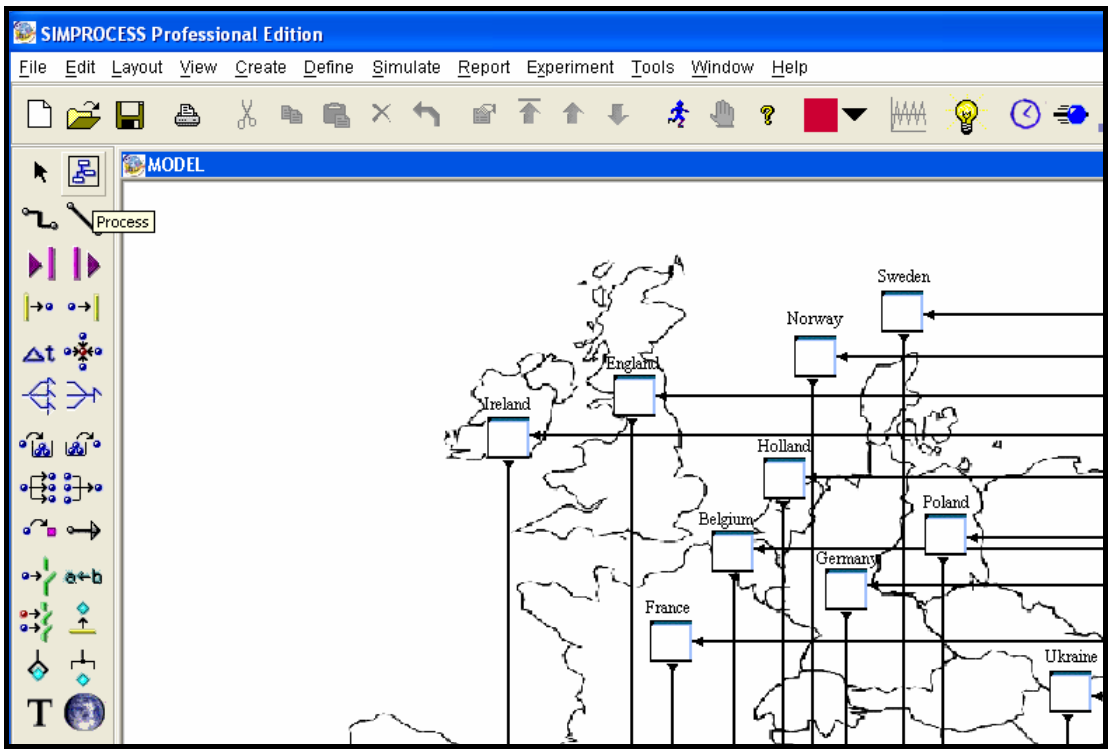

Figure 3.2. Building the processes on the SIMPROCESS.

The processes of the Logistics Company are analyzed in a detailed manner at the rest of this step of the application. The data required for the mapping of the processes are obtained in the previous step of the application. There are two main processes they are called as **Export** and **Import** processes. Figure 3.3 is the model of the Logistics Company which is mapped to SIMPROCESS. The **Export** processes are located in the "*Processes inside the Logistics Company*" process (see Figure 3.3). This is done in order to increase the model readability. The export preparations are done inside the Logistics Company's central building. All the processes and activities are mapped to SIMPROCESS according to their physical locations and their sequence.

3.4.1.1 Export processes

Export transportation organizations and transportation plans are conducted at the central building of the company. The warehousing, loadings of the loads, vehicle maintenance and some other support activities are conducted at the central facility of the company.

In Figure 3.3, the general framework of the transportation network of the company is represented. The links between Logistics Company facility and the destination countries are represented obviously. The connectors between each unit have its distance property. For example, when a vehicle follows a connector between the Logistics Company and Germany, it has to spend time on the road proportional to the distance of the connector it follows.

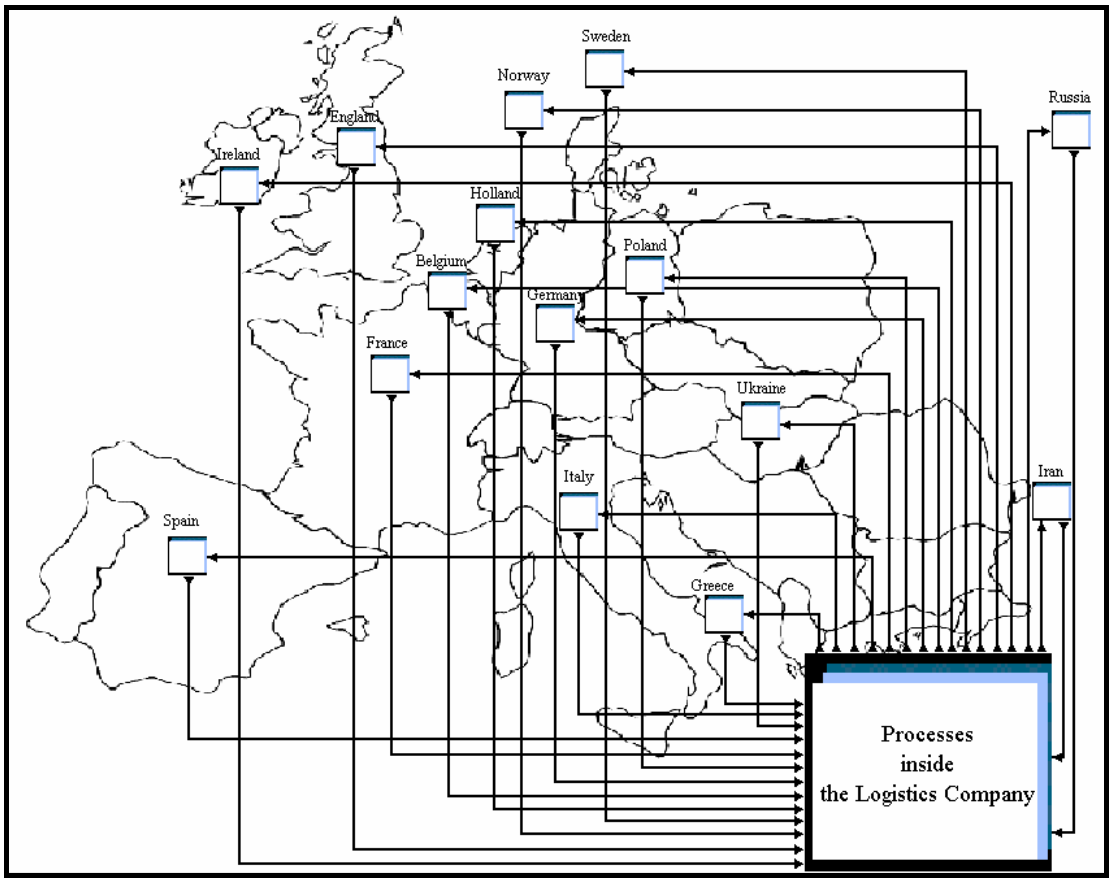

Figure 3.3. Snapshot from the overall process map of the company

Figure 3.4 represents the processes occurring inside the Logistics Company. There are 15 different icons representing each export transportation services (each icon represents each of the transportation services given in the Table 2.1). Each icon which is labeled with country name includes the export processes of respective country. There is also a call center icon which generates the transportation service demands (Figure 3.4). The support activities are also represented with a process named "*Customs Clearance Arrival, Unloading and Returning to Center*".

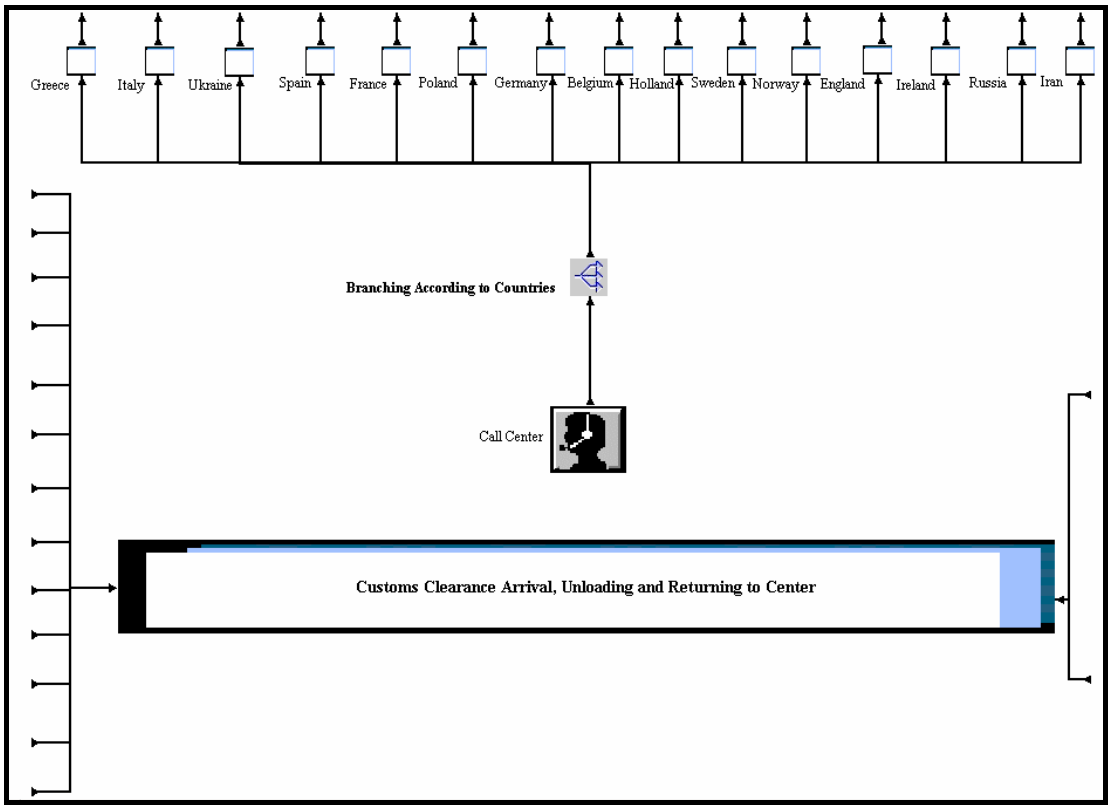

Figure 3.4. Processes inside the Logistics Company

The export activities start when an entity is generated (see Figure 3.4). Export transportation service demands are generated by the *Call Center* activity represented in the Figure 3.4. The demands are branched according to their types. The *branch* activity located between the *Call Center* and the *Country* icons do this task.

When any of the country icons is double-clicked, the processes it has can be seen. Figure 3.5 to 3.9 represents the export processes inside any country. Figure 3.5 represents two different sub processes. They are "*Operations*" and "*Bounded Warehouse*". The "*Operations*" sub process includes all the document preparations and other transportation preparation activities. "*Bounded Warehouse*" sub process includes all the activities performed for stocking the loads and load stocking procedures.

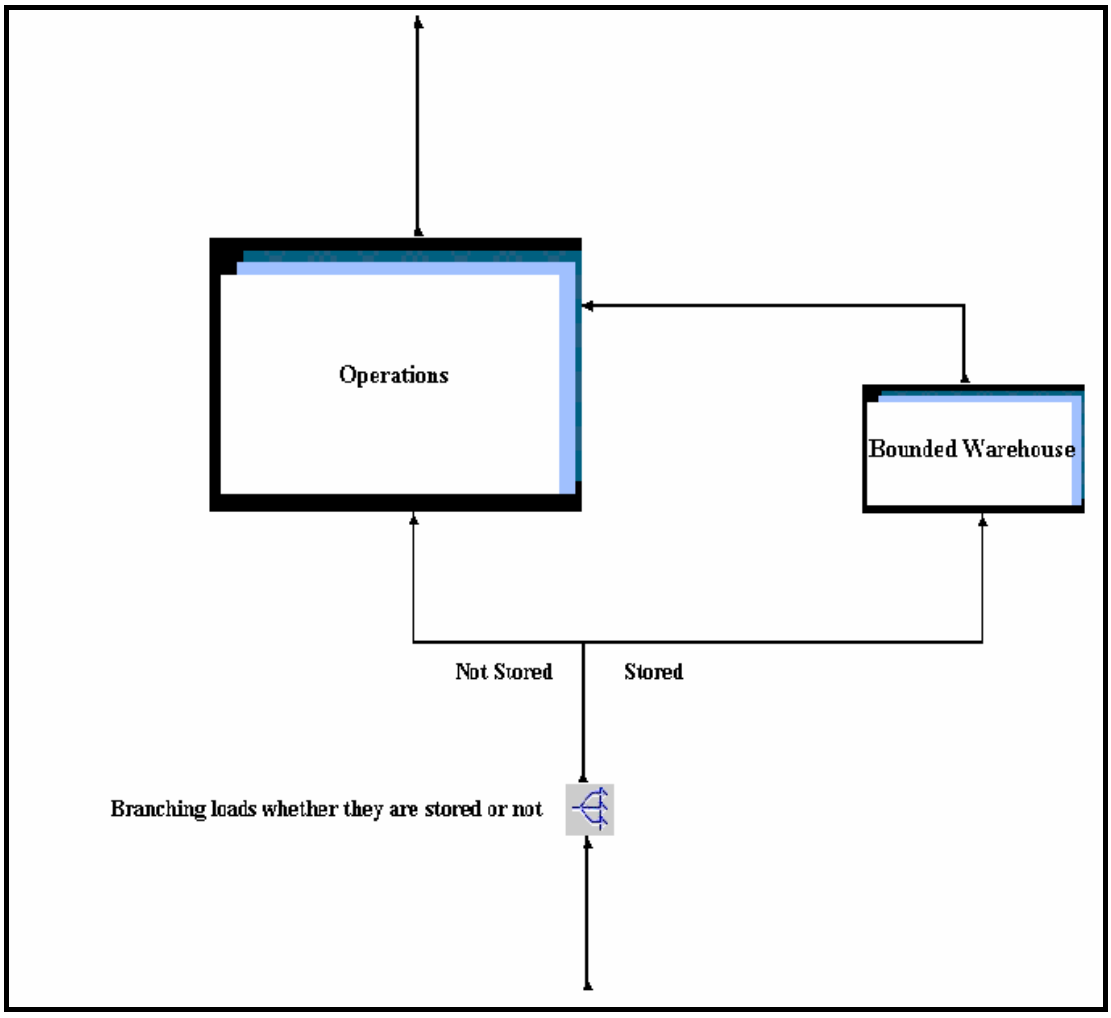

Figure 3.5. Country based sub processes

Full list of the main processes and their activities were given in step 1 of this application. When the "*Operations*" process of Figure 3.5 is double-clicked on, the sub processes shown in the Figure 3.6 are obtained. There are five different sub processes inside operations as seen in the Figure 3.6.

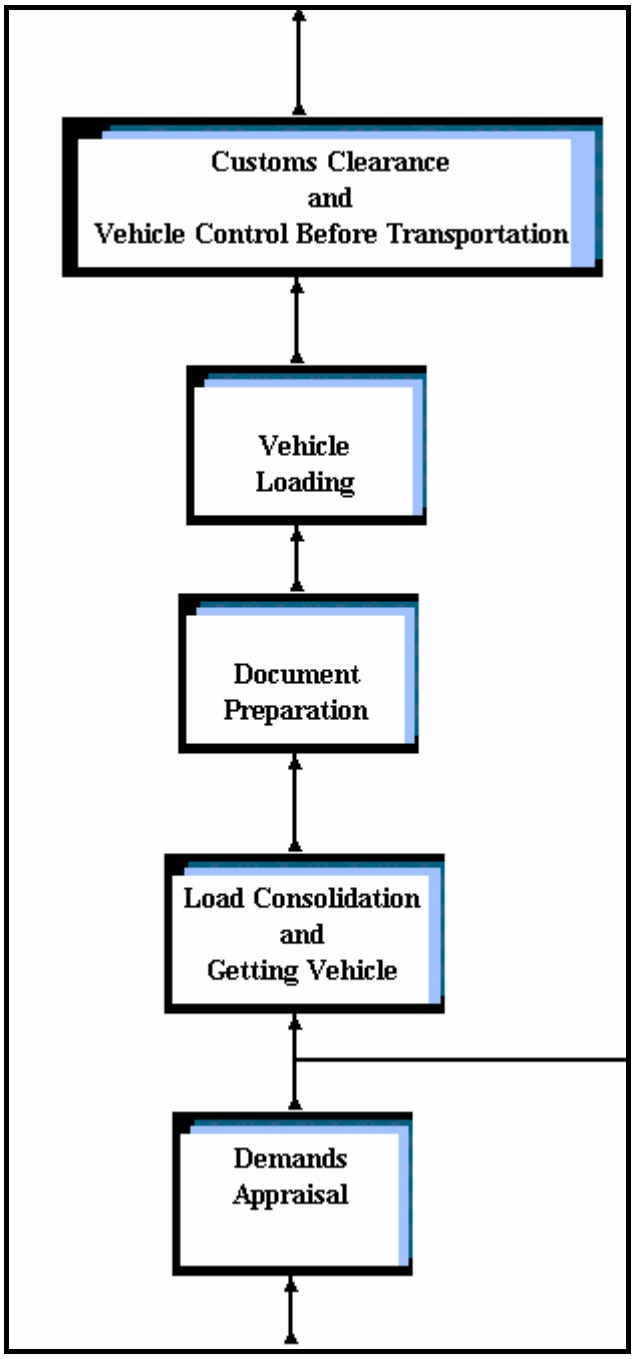

Figure 3.6. The sub processes under the *Operations* process

The operations process includes all the processes and activities which are performed in order to prepare any demand to be transported to desired country (see Figure 3.6). The activities of "*Demands Appraisal*" sub process are given in the **APENDIX A**, Figure A1. The activities of "*Load Consolidation and Getting Vehicle*" sub process are given in the **APPENDIX A,** Figure A2. The activities of "*Document Preparation*" sub process are given in the **APPENDIX A**, Figure A3. The activities

of "*Vehicle Bag Preparation*" sub process which is the sub process of "*Document Preparation*" sub process are given in the **APPENDIX A**, Figure A4. The activities of "*Vehicle Loading*" sub process are given in the **APPENDIX A**, Figure A5. The activities of "*Customs Clearance and Vehicle Control Before Transportation*" sub process are given in the **APPENDIX A**, Figure A6. The activities of "*Customs Clearance*" which is the sub process of "*Customs Clearance and Vehicle Control Before Transportation*" sub process are given also in **APPENDIX A,** Figure A7.

All the processes and activities given previously are the processes and activities of "*Operation*" process of **Export**. The "*Bounded Warehouse*" process is also included by export process (see Figure 3.5). The activities inside the "*Bounded Warehouse*" process are given in the **APPENDX A**, Figure A8. After the "*Operations"* process is completed the vehicles start to transport the loads to the destination countries. When the vehicles reaches to the destination countries "*Transportation Information*" "*Customs Clearance Arrival*" and "*Unloading*" processes are occurred. These processes are included by the destination countries. Figure 3.7 represent these processes.

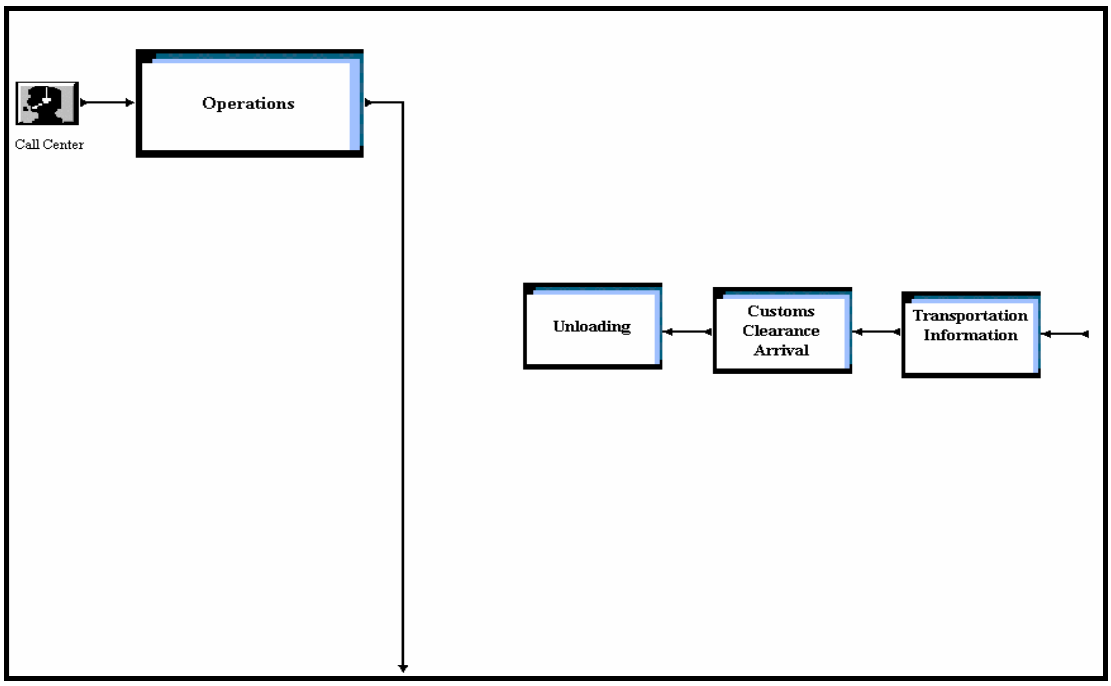

Figure 3.7 Processes inside destination countries

The activities inside the "*Transportation Information*" process are given in the **APPENDX A**, Figure A9. The activity inside the "*Customs Clearance Arrival*" sub process is given in the **APPENDX A,** Figure A10. The activity inside the "*Unloading*" sub process is given in the **APPENDX A,** Figure A11. **Export** processes finish after the "*Unloading*" sub process is completed.

3.4.1.2 Import processes

Import processes are occurred in the individual county-named processes which are depicted in the Figure 3.3. There are 15 different countries which are represented by small icons on the Figure 3.3. Import processes of the countries which are shown in Figure 3.3 are similar to each other. In Figure 3.7, the general framework of the import processes are shown. There is a "*Call Center*" activity which produces the import **Load** entities. The "*Operations*" process is similar to the "*Operation*" process of **Export**; it includes *"Demands Appraisal*", "*Consolidation and Getting Vehicle*" and "*Transportation Preparation, Loading and Customs Clearance*" sub processes which are shown in the Figure 3.8.

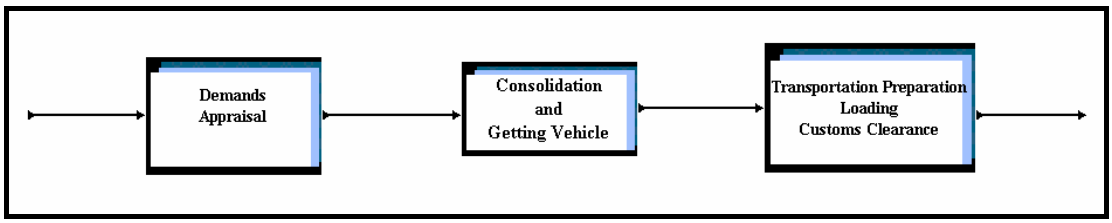

Figure 3.8. The processes inside **Import** "*Operations*" Process

The activities inside the "*Demands Appraisal*" sub process of **Import** are given in the **APPENDIX B**, Figure B1. The activities inside the "*Consolidation and Getting Vehicle*" sub process are given in the **APPENDIX B**, Figure B2. The activities inside the "*Transportation Preparation, Loading and Customs Clearance*" sub process are given in the **APPENDIX B**, Figure B3. After the operation process is finished, the vehicles start to transportation (see Figures 3.3 and Figure 3.7). At the end of the transportation, the vehicles reach to consignee. Figure 3.9 represents the processes when the vehicles reach to the consignee.

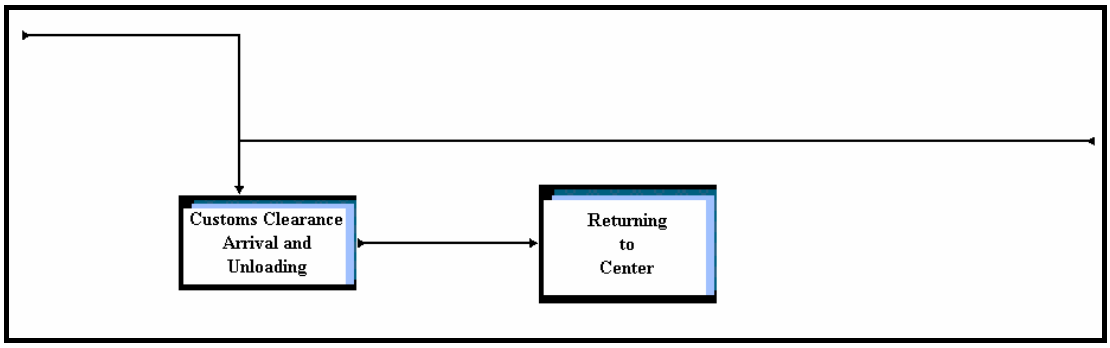

Figure 3.9. *"Customs Clearance Arrival and Unloading"* and *"Returning to Center"* sub processes

The activities inside the "*Customs Clearance Arrival and Unloading*" sub process are given in the **APPENDIX B**, Figure B4.

When the vehicles turn to central building of the company, there are two sub processes occurring inside the "*Returning to Center*" sub process. The sub processes are given in the Figure 3.10.

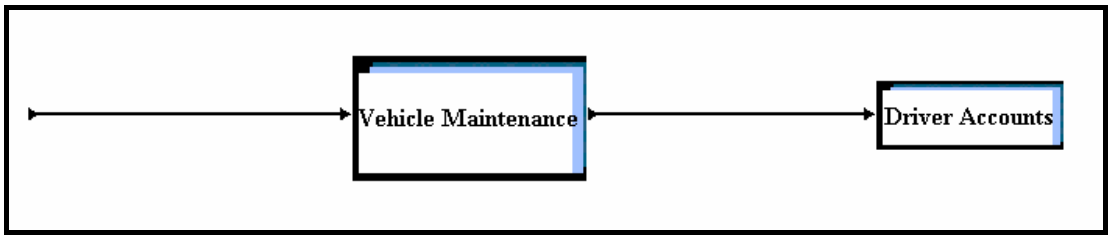

Figure 3.10. Sub processes of "*Returning to Center*" sub process

The activities inside the "*Vehicle Maintenance*" sub process are given in the **APPENDIX B**, Figure B5. The activities inside the "*Driver Accounts*" sub process are given in the **APPENDIX B**, Figure B6. The **Import** processes finish after "*Driver Accounts*" sub process is completed.

3.4.2 Activities

The activities performed for the logistics operations are determined in step 1. The information about these activities is collected in step 2 (see Table 3.5 and 3.6). Mapping and modeling of these activities are represented in step 3. Mapping of the activities are represented in the **APPENDIX A** for **Export** processes and in the **APPENDIX B** for **Import** processes.

The activity data which are mapped to SIMPROCESS were collected from the personnel of the company and they were given in the step 2. Many interviews with the company personnel were made in order to collect activity data.

In this step of the application, the activities occurring in the real processes are mimicked by the activities of SIMPROCESS. The activities of SIMPROCESS which represent the activities of the real system are defined to system. *Delay, Branch, Assign, Transform, Batch, Get Resource and Free Resource* activities are the system tools of SIMPROCESS which are used during the mapping and modeling of the real system. They are used in order to mimic the real system as much as possible.

3.4.2.1 Delay Activity

In the Figure 3.11 below, sample activity mapping is shown. The *Delay* activity of SIMPROCESS is used in order to map the *Germany Export Demand Appraisal* activity (see Table 3.5 for activity data used in this step of the application).

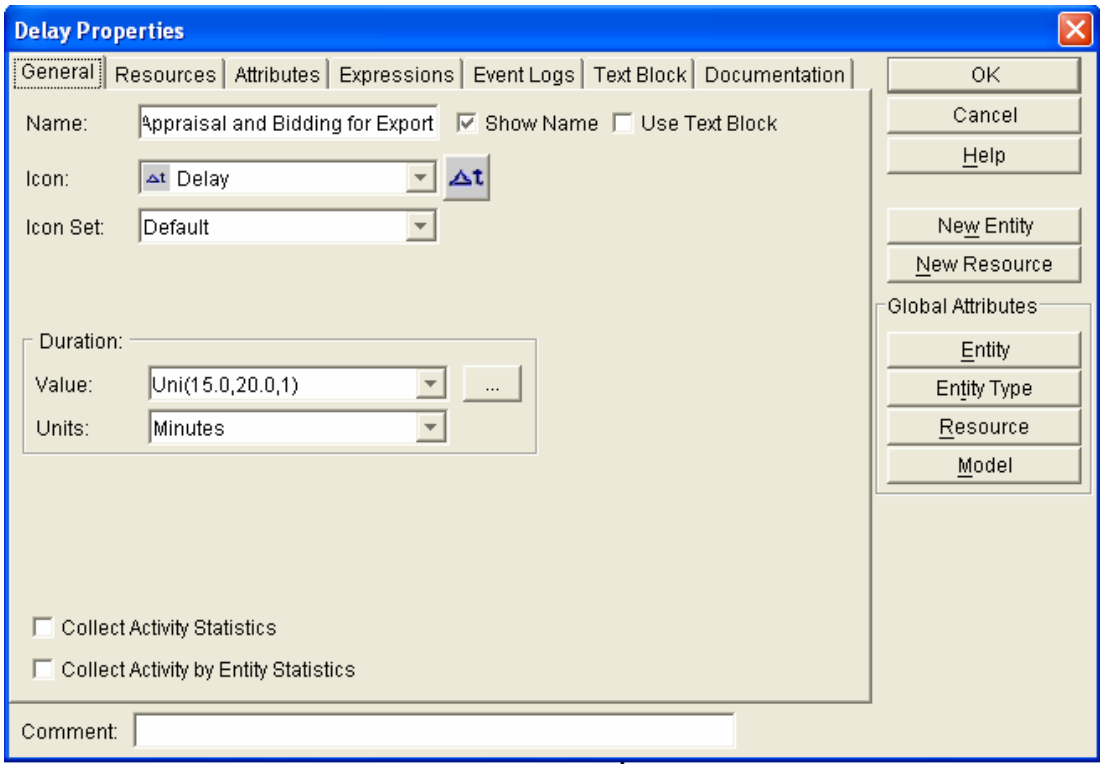

Figure 3.11. Activity duration mapping to SIMPROCESS

Duration tab of the activity properties window requires the value needed to perform this activity. The duration required is defined with a uniform distribution. It has a minimum value of 15 minutes and maximum value of 20 minutes. The distribution defined in this model is the result of the face to face interviews with the personnel performing this activity. He or she says that, the activity takes between 15 and 20 minutes. This point of the SIMPROCESS mapping contributes to ABC cost estimation.

3.4.2.2 Branch activity

There are many types of activities other than the delay activity. *Branch* activity also performs an important task for the modeling of the logistics processes. The entities arriving to the *Branch* activity chooses one way according the probability of acceptance defined to the connector which is located between *Branch* activity and other activities.

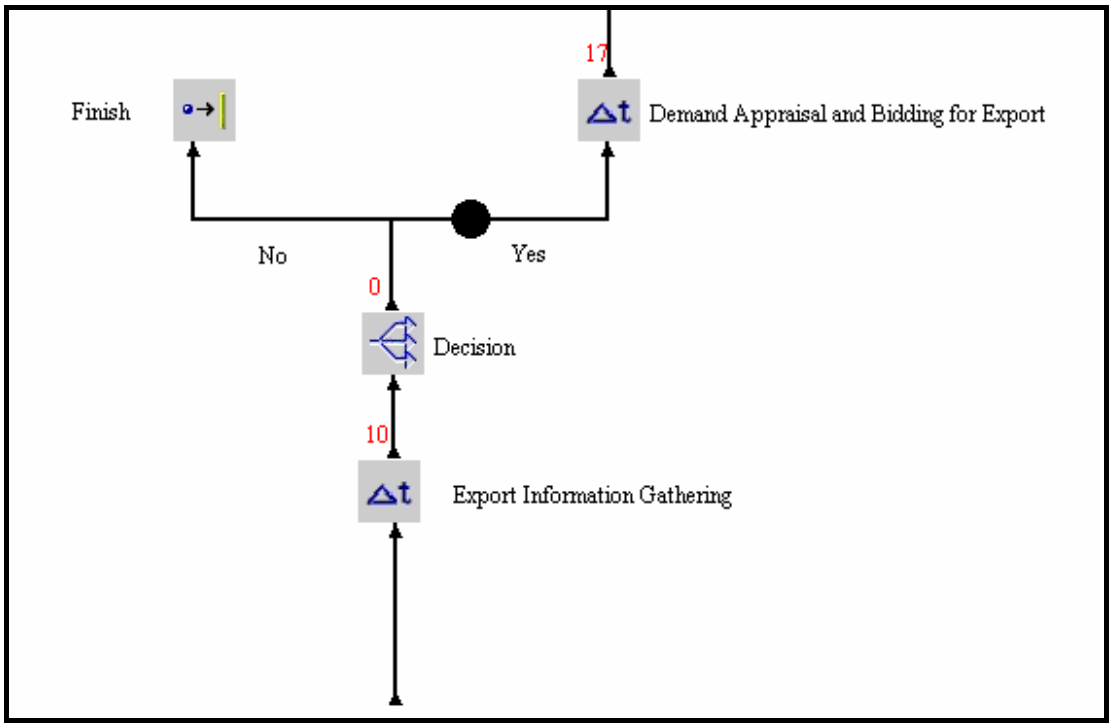

Figure 3.12. Sample branch activity

The black point seen in the Figure 3.12 represents the **Load** entity flowing over the "*Demands Appraisal*" process. The connector between branch activity and dispose activity which is seen as *Finish* in the Figure 3.12 has the property shown in the Figure 3.13. There is a 3 % probability to reject the load demand (**Load** entity) requested by the customer. 97 % of the demands are accepted and than they are let to continue to the model. The percentages are determined by the personnel working for the demand appraisal activity.

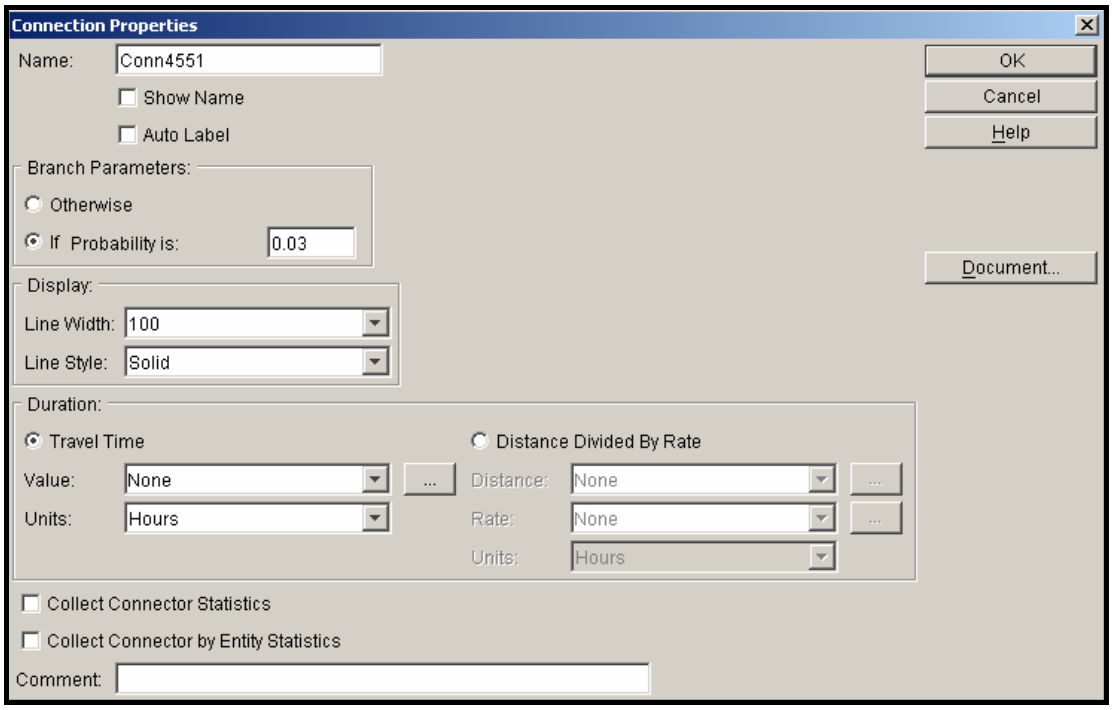

Figure 3.13. Property of the connector between *Branch* and *Dispose* activity.

3.4.2.3 Assign activity

Assign activity assigns numerical, string or boolean values to the attributes of the entities. The assign activity used for the processes of the Logistics Company can be seen in **APPENDIX A**, Figure A2. When the **Load** entity comes to the *Assign* activity, v*olume* and w*eight* attribute is assigned to it. Figure 3.14 represents the assignment window of the *Assign* activity.

The *weight* attribute of the entities are assigned with a distribution of Nor(6000.0,600.0,1). This means that, each entities passing through assign activity will have a weight according to normal distribution with a mean of 6,000 kg and with a standard deviation 600 kg. The attribute values assigned to the entities at this step of the model will carry the value until end of the simulation.

The *volume* attribute of the entities are assigned with a distribution of Nor(20,5). This means that, each entities passing through assign activity will have a volume according to normal distribution with a mean of 20 m^3 and with a standard deviation

5 m^3. The distributions of the assignment activity are obtained from the past experience of the load consolidation personnel.

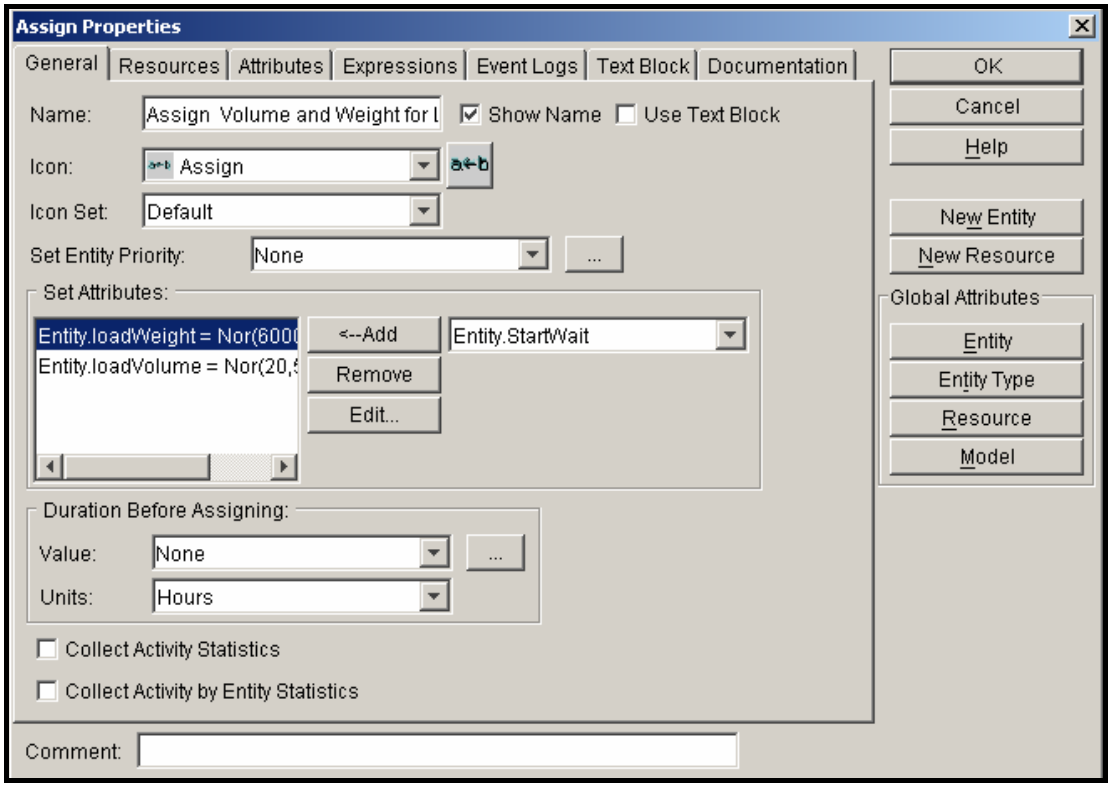

Figure 3.14. loadWeight and loadVolume assignment

3.4.2.4 Transform activity

The *transform* activity changes one type of entity into another type. When the load demands come to the Logistics Company *Generate* activity generates **Load** entity. After the generation of the **Load** entity, it is processed by some of the activities. After the **Load** entities are processed and evaluated they are consolidated with the *Batch* activity (see **APPENDIX A**, Figure A2). After the loads are consolidated, a new type of entity is needed. Transform activity is used for such conditions. Figure 3.15 below represents a sample transform activity property window. The **Load** entity is transformed to **Transportation** entity.

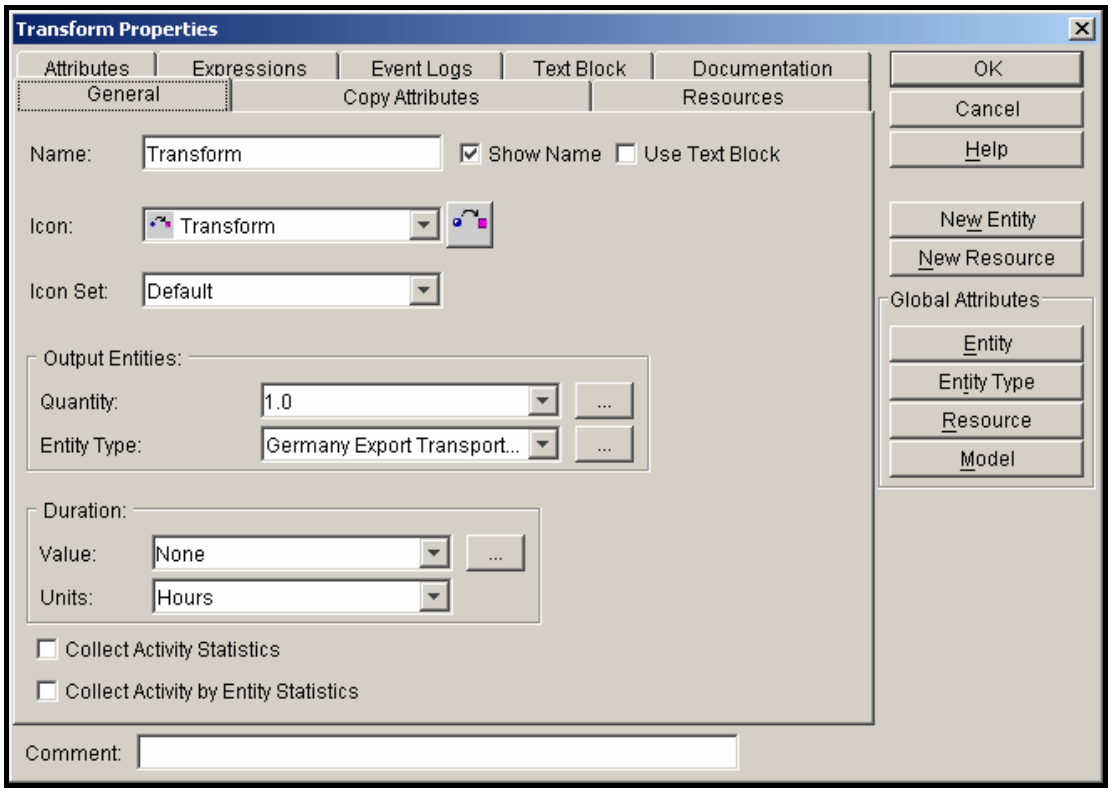

Figure 3.15. Sample *Transform* activity

3.4.2.5 Batch activity and load consolidation

The *Batch* activity combines several entities into one entity while retaining the identity of the original entities. The resultant entity travels throughout the process as a single entity. It can be disassembled into its constituent entities using an *Unbatch* activity. *Batch* activity is useful when combining several entities (e.g., merchandise ordered by various customers) into a parent entity for transportation. After the transportation activities, the parent entity can be broken down into the entities that comprised it. Statistics can be collected for the batched entity separately from its constituent members (SIMPROCESS Manual, 2005).

Batch activity of SIMPROCESS is used for consolidation of the loads which are desired to be transported. The attributes and expressions are used for this purpose. When we double click on the *Batch* activity in the Figure A2 of **APPENDIX A** and then select the expressions tab of the properties window, the list of expression locations can be seen (see Figure 3.16). The locations which have an asterisk on the right hand side have an expression script inside.

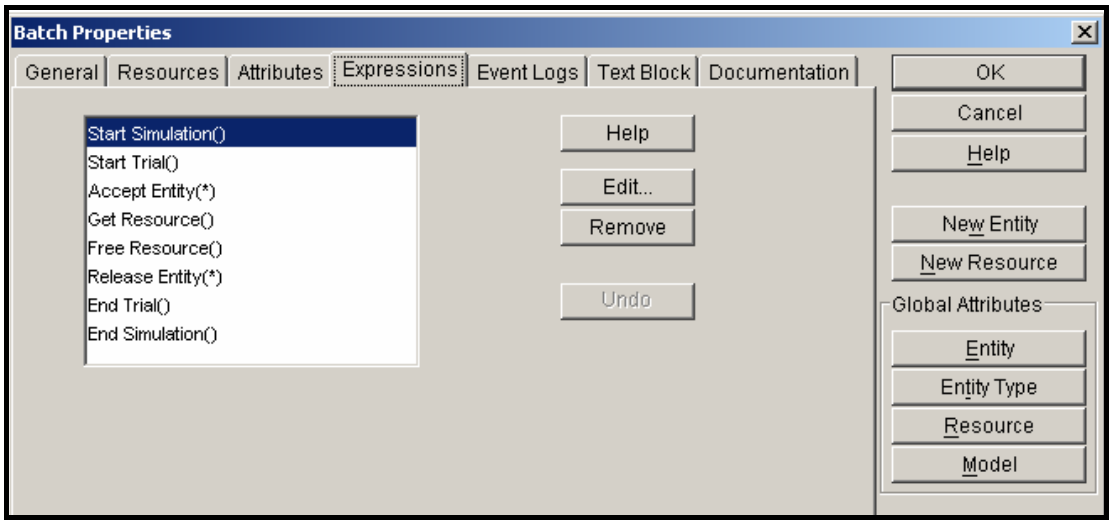

Figure 3.16. List of expression locations

The expressions for the consolidation are typed to the "*Accept Entity*" location because the loads are accepted to the batch if the batch volume or weight does not exceed the limit value. When the "*Accept Entity"* location is selected and Edit… button is clicked, the code embedded to the script can be seen (Figure 3.17).

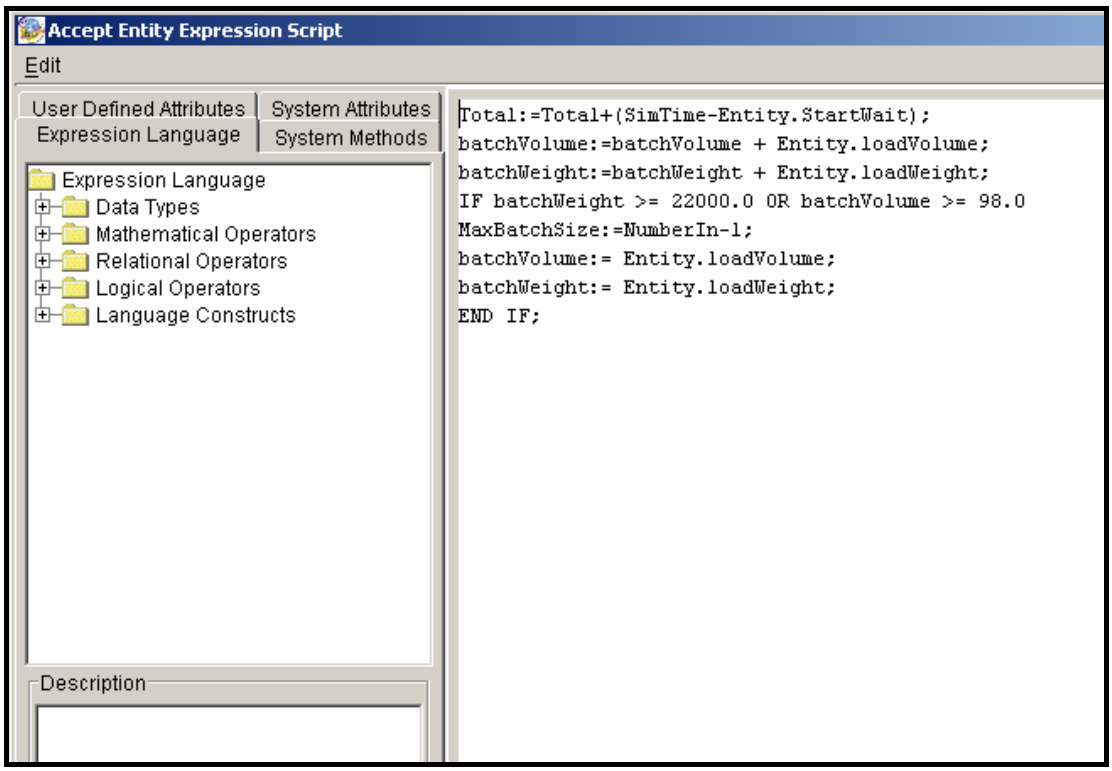

Figure 3.17. Expression script editor

This script provides *Batch* activity to batch the entities (loads) to a level that will not exceed the predetermined limit.

batchVolume and *batchWeight* used in the script (see Figure 3.17) is a locally defined attribute of the entities. *loadVolume* and *loadWeight* are globally defined attributes. *loadVolume* and *loadWeight* attributes get values when the entities are passing over the *Assign* activity. However, the *batchVolume* and *batchWeight* attributes are used only for the check of the limits. If the consolidated loads exceed 22 tons or 98 m^3 they are consolidated and released as a transportation entity. The code which provides this mechanism is,

IF batchWeight >= 22000.0 or batchVolume >= 98.0

Last load added to the consolidation makes the consolidation volume or consolidation weight more than the limit. Therefore the last entity (load) added to the consolidation should be restrained. The code "MaxBatchSize:=NumberIn-1" provides that the last entity is restrained (see Figure 3.17).

3.4.2.6 Get resource activity

The *Get resource* activity gets a resource and holds it during multiple processes and activities. In this application the *vehicle* resource is got after the consolidation is performed and it is hold throughout the transportation duration. *Get resource* activity can also be used by typing expressions. When we type "GetResource("Vehicle", "1", "anytag")" script to any delay activity, the resource stated in the code is got and hold until its release.

3.4.2.7 Free resource activity

Free resource activity performs the opposite of *Get resource* activity. When the resource which is got previously finishes its job, *Free resource* activity releases the resource for other usages. In this application, when the vehicles arrive to the destination points, they are unloaded and released. The script below also provides the release of a resource.

“FreeResource ("Vehicle", "Tag", TRUE)”;

3.4.3 Entities

Entities which are used for the simulation of the logistics processes are defined according to system requirement. There are 6 different entities which are defined for each of the countries. Therefore there are 90 different entities used for the simulation of the logistics processes. Full list of the entities used with the simulation model is given at the **APPENDIX C**. As an example, the entities defined for the Belgium Transportations are represented in the Table 3.7.

Table 3.7. Entities defined for Belgium transportations services

• Belgium Export Load
• Pre Belgium Export
• Belgium Export Transportation
• Belgium Import Load
• Pre Belgium Import
• Belgium Import Transportation

The entity types defined to the model might be generated by using the *Generate* activity or they might be obtained by using *Batch* and *Transform* activities.

Call Center activity which is mapped in “*Operations*” process of **Export** generates **Export Load** entities. **Export Load** entities flow over the processes without changing its type. When the **Export Load** entities reach to *Consolidation and Getting Vehicle* activity (see **APPENDIX A**, Figure A2) they turns into **Pre Export** entity after their consolidation. If the **Pre Export** entity waits more than tolerated it finishes. If the **Pre Export** entity waits less than tolerated, it continues to the process. When the **Pre Export** entity enters to *transform* activity it changes its type to **Export Transportation** entity (see **APPENDIX A**, Figure A2).Then, type of the entity does not change from transform activity to end of the export processes.

Figure 3.18 represents the entity definition window of SIMPROCESS. If a new entity is needed to be defined, the Add… button can be used. There are so many types of icons to represent the entities on the model. This makes the model more understandable.

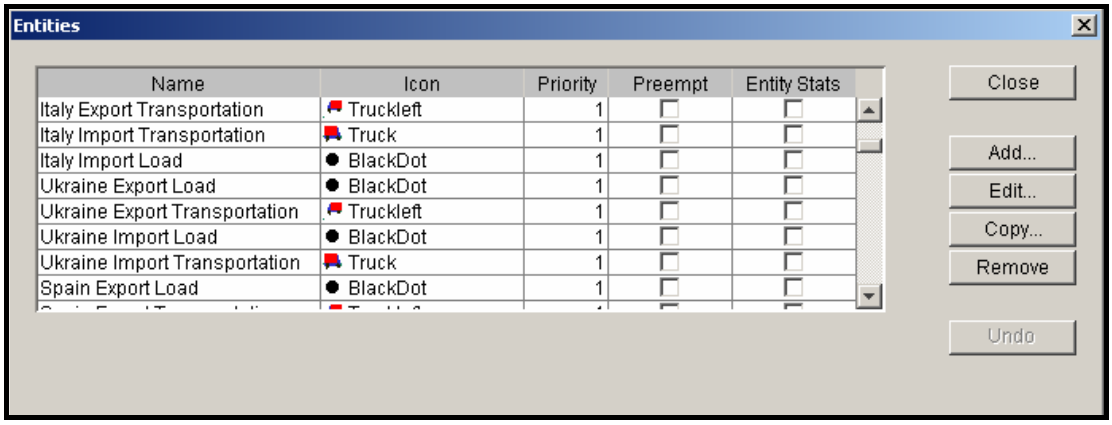

Figure 3.18. Entity definition window

3.4.4 Resources

The resources are defined in the step 1 of the application and their respective data are collected in step 2. There are 17 personnel working for the transportation services in the company and there are 100 vehicles for the transportation. The resources used by the activities are defined to the processes in this step of the application.

The personnel are defined to the system as P1, P2…, and P10 for each of the operation personnel and P11 (4) for the accounting personnel. The personnel working for the vehicle maintenance are defined to the system as "Vehicle Maintenance Personnel (3)". In total there are 17 personnel working for the transportation preparation activities. The representation of resources definition is given in Figure 3.19.

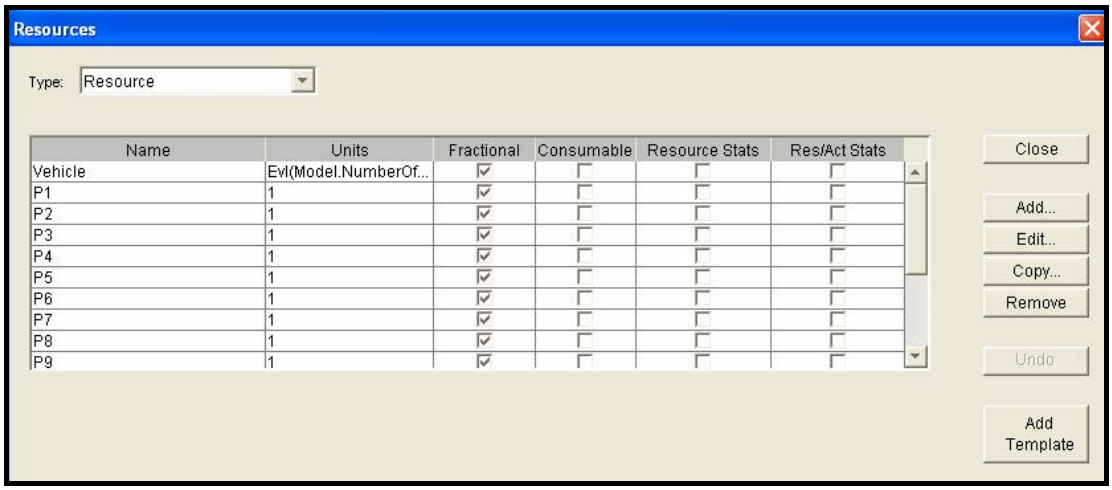

Figure 3.19. Resource definition to the SIMPROCESS

The definition of the Vehicle to the SIMPROCESS is represented in the Figure 3.20. The "**Units**" input box on the resource properties window requests the number of vehicles defined to the system. Evl(Model.NumberOfVehicle) statement shows that, the number of vehicles could be defined to system dynamically.

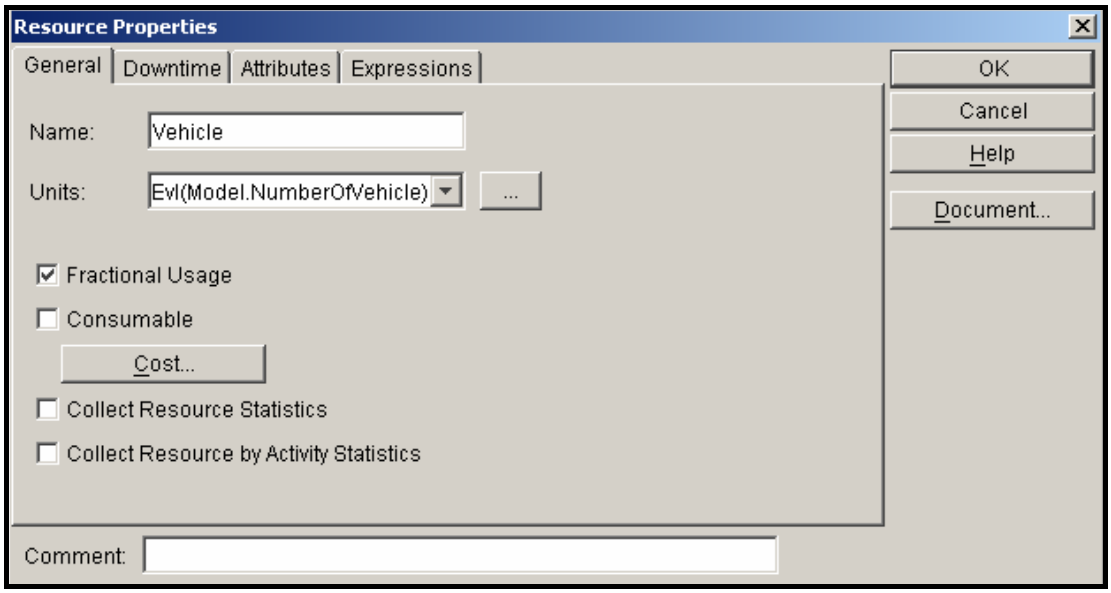

Figure 3.20. Vehicle definition to the model

3.4.5 Connectors

Connectors link activities and processes together and are the paths used by entities to flow through the model. Connectors can have delay times. A Connector defaults to

no duration. Duration can be specified by setting a travel time or by distance divided by rate (SIMPROCESS Manual, 2005).

All the connectors used in the processes and their sub processes are used in order to link the activities. The links between the activities seen in the **APPENDIX A** do not require any delay because the time passes to move any entity between these activities are assumed to be 0. However the connectors between the Logistics Company and the destination countries and the connectors between the destination countries and the Logistics Company have some properties (Figure 3.3). The vehicles follow these connectors whenever the simulation is run. The average distance between any two points are determined and defined to the model. In the Figure 3.21 below it can be seen obviously that, the connectors between any points have some effects on the costing of the transportation services. In the Figure 3.21, the connector between Logistics Company and Germany is represented. The average distance between Gaziantep and Germany is defined to the model as Uni(3500.0,3700.0,1) it means that the distance between Gaziantep and Germany might change with a uniform distribution (Table 3.5). It takes 3500 kilometers in minimum and 3700 kilometers in maximum according to route selection of the vehicles. This value is defined to the connector as can be seen in the Figure 3.21. "**Rate**" inbox of the window necessitates the hourly velocity of the vehicles which uses this connectors and "**Units**" inbox necessitates the *time unit* to calculate the time. The inbox of "**Rate**" necessitates the hourly velocity of the vehicles with the script of Evl(Model.AvgKmPerHour). The "**Rate**" is a model definition and it is used for all the connectors between the Logistics Company and the destination countries. The connectors between each countries and the Logistics Company might be defined individually. Average velocity of the vehicles is assumed standard for each vehicle.

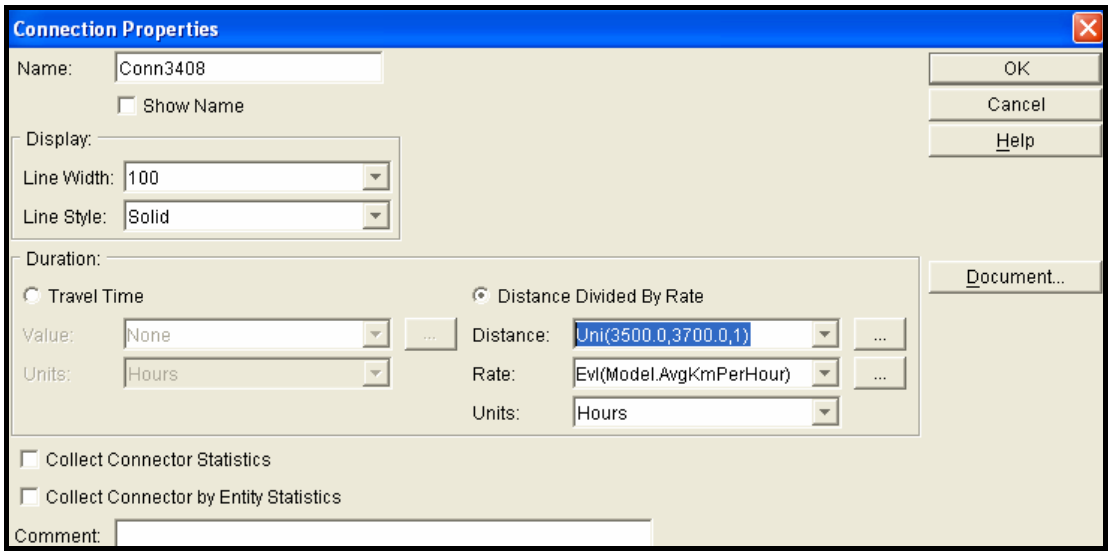

Figure 3.21. Distance definition

The model parameters are asked before the simulation is run. In Figure 3.22, the request of *Average Kilometers per Hour of the Vehicles* and *Number of Vehicles* parameters are represented.

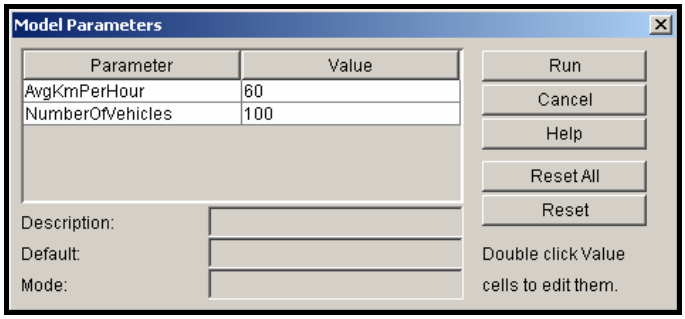

Figure 3.22. Model parameter definition before the run of simulation

3.4.6 Pads

Pads are small triangular objects attached to activities and processes which serve as attachment points for connectors. A single pad can connect one or (possibly) more connectors. Entities flow in one direction, entering nodes at input pads and exiting at output pads. Pads also connect one level of a process hierarchy to another. Pads can

be queuing areas for entities waiting for a resource or condition (SIMPROCESS Manual, 2005).

By default any process defined to the model have one input pad and one output pad. However some processes might require more than one pads therefore input and output pad method is used to add pad to the processes. In the model of the Logistics Company, the process of *Processes inside the Logistics Company* seen in the general framework of the model (Figure 3.3) have 15 input pads and 15 output pads, this is because the organization has 15 different transportation services for export and 15 different transportation services of import.

3.5 Resource drivers determination and selection (Step 4)

The consumption rates of the activities can be clearly stated with the question of; "The resources are consumed by the activities according to what?" The answer for this question is: "according to *first-stage cost drivers*". At the fourth step of the proposed costing model, first-stage cost drivers and their respective coefficients are determined. Resource driver and first-stage cost driver both have the same meaning. First-stage cost driver determination is a considerably difficult step of ABC (Goldsby and Closs, 2000). The careful selection of activity and cost drivers in ABC is the key to achieving the benefits of this cost system (Schniederjans and Garvin, 1997). There are many different ways of obtaining the cost drivers. In this step of the application, first-stage cost drivers are determined by brainstorming meetings with the departmental managers. A more systematic way of determining first-stage cost drivers might be to employ questionnaires similar to the applications of Tornberg et al. (2002). The first-stage cost drivers which are used during this study are shown in Table 3.8.

Table 3.8. Overheads and first-stage cost drivers

Overheads	Amount ($)	Cost Drivers	Overheads	Amount ($)	Cost Driver
1- Vehicle Depreciation Costs	1,144,008.02	Distance (km)	**13-** Warehouse Costs	18,091.81	Amount of Freight (kg)
2- Employees Insurance Costs	107,525.60	Number of Personnel	**14-** Building Electricity Costs		
3- Indirect Labor			Building Water Consumption		
Staff Training	121,202.90	Number of Personnel	Building Cleaning Expenses	9,537.61	Area Used
			15- Personnel Transportation Service Costs		
4- Withholding Tax			Urban Transport of Staff Costs		
Return of Tax	50,523.20	Number of Transportation	Urban Transport Fuel Consumption		
5- Motor Vehicle Tax			Other Fuel Consumptions	30,053.05	Number of Personnel
Vehicle Insurance			**16-** Aero plane Ticket Expenses		
Vehicle License Costs			Foreign Travel Expenses	5,901.45	Number of Customer
Vehicle Traffic Control Costs			**17-** Conveyance Lawyer Costs		
Vehicle Maintenance	311,866.10	Number of Vehicles	Consultancy Costs		
6- Tax of Building			Other Counseling Costs		
Insurance of Building	10,007.07	Area Used	Banking Costs	191,676.43	Number of Customer
7- Vehicle Driver License Costs	72,516.38	Number of Vehicle	**18-** Advertising		
8- Replacement Part of Vehicles Costs			Documents Expenses		
Tire Costs	63,212.64	Distance (km)	Stationery Costs		
9- Customs Costs			Newspaper Expenses		
Tickets bought during transportations	17,863.30	Number of Transportation	Computer Maintenance Costs	32,370.42	Number of Transportation
10- Telephone Bills	24,504.28	Transaction Duration	**19-** Donations		
11- Refectory Expenses	24,150.39	Number of Personnel	Other Costs		
12- Representation Expenses			Motoring Fine Costs	80,257.35	Number of Personnel
Car Park Expenses					
Mailing Expenses					
Photocopy Costs	5,620.46	Transaction Duration	**Total:**	2,320,888.5	

In some studies in literature, some authors select the first-stage cost drivers by using AHP. In this model the first-stage cost drivers are determined intuitively. However, AHP is used while determining the distribution coefficients of first-stage cost drivers. As it can be seen from the model diagram in chapter 2, Figure 2.1, AHP technique is used as a support in order to get the allocation coefficients.

AHP is a technique for considering data or information about a decision in a systematic manner (Golden et al., 1989; Saaty, 1980; Saaty, 1988). Researchers have shown that AHP helps to bring consistency in selection problems whose decision criteria is expressed in subjective measures based on managerial experience (Bryson, 1996). There are many applications of AHP in the literature; however there are not many applications of AHP for ABC analysis. Partovi (1991)'s work is one of the rare applications of AHP to ABC.

In this step of the application, overheads given in Table 3.8 of "Building Electricity", "Building Water" and "Building Cleaning" are grouped. As it can be seen from Table 3.8 the driver for this group is "*Area Used*". Cost driver for the cost group of "Tax of Building" and "Insurance of Building" is also determined as "*Area Used*". However, the certain values of the distribution coefficients are not known exactly, therefore the total cost for this group is distributed to the related activities with the help of AHP. The activity-related personnel and managers of the company were interviewed to obtain a systematic and deliberate cost allocation via AHP. The rank of priorities derived from AHP is used as a driver coefficient for the allocation of the resources to the activities. Table 3.9 shows the activity groups which use the mentioned overheads. The activities which are given in the Table 3.9 are used for structuring pair-wise comparison matrix. After removing the names of the activities and converting fractions to decimals the pair-wise comparison matrix is presented in Table 3.10.

Table 3.9. Activities which use “Area Used” as a driver

1-Taking Information of Demand
2-Transportation Rate Determination
3-Preparation of Freight Agreement
4-Vehicle Scheduling and Preparation
5-Preparation of Loading Notification
6-Other Transportation Documents Preparation
7-Preparing and Sending Arrival Notification to Customers
8-Driver Accounts Calculation

Table 3.10. Pair-wise comparison matrix

Activities	1	2	3	4	5	6	7	8
1	1.00	1.00	2.00	0.50	2.00	1.00	5.00	3.00
2	1.00	1.00	1.00	0.50	2.00	1.00	3.00	2.00
3	0.50	1.00	1.00	4.00	1.00	1.00	2.00	2.00
4	2.00	2.00	0.25	1.00	3.00	2.00	2.00	4.00
5	0.50	0.50	1.00	0.33	1.00	0.33	2.00	2.00
6	1.00	1.00	1.00	0.50	3.00	1.00	5.00	2.00
7	0.20	0.33	0.50	0.50	0.50	0.20	1.00	0.33
8	0.33	0.50	0.50	0.25	0.50	0.50	3.00	1.00

In order to obtain ranking (resource consumption rates) of the activities, the well known AHP procedure is applied (Saaty, 1980). Overhead consumption coefficients are obtained by using the ***Expert Choice*** software. The resulting rank of the activities is obtained with an overall inconsistency of 0.09 (see Figure 3.23). An inconsistency ratio of 0.10 or less is considered acceptable therefore the coefficients given in the Figure 3.23 can be used as resource allocation coefficients.

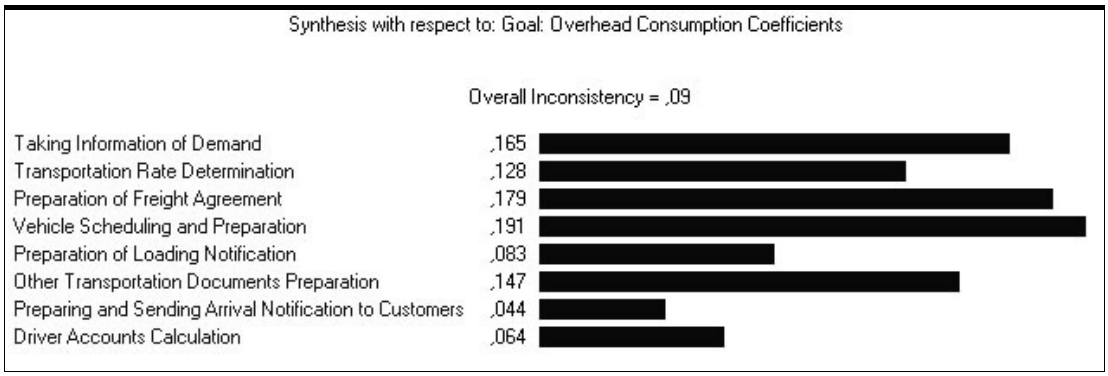

Figure 3.23. Overhead consumption coefficients of the activities

Another driver in Table 3.8 which is not known with certainty is "*Transaction Duration*". It is the driver of "Telephone Bills" and "Representation, Car Park, Mailing, Photocopy Expenses" overheads. The activities use this cost group and their consumption coefficients are given in Figure 3.24. The overall inconsistency is smaller then 0.10 therefore the coefficients given in Figure 3.24 can be used as resource allocation coefficients.

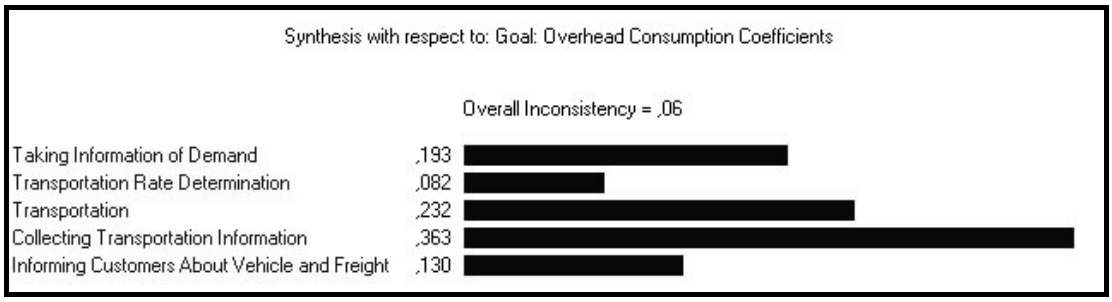

Figure 3.24. Overheads consumption coefficients of the activities

The AHP results are inserted to the Table 3.11.

Other coefficients of the overhead allocation could be found with linear methods. Two types of allocation columns are obtained by using AHP method and inserted to the allocation matrix as seen in the Table 3.11. The columns with the number of 6, 10, 12 and 14 are inserted after the AHP calculations. These four different columns have the driver of "*Area Used*" or "*Transaction Duration*". Other columns given in the Table 3.11 are calculated with the past data or some experience of the personnel.

The first column of the Table 3.11 is calculated as follows; the sum of distance taken by the vehicles from company to the customer warehouses and the total distances of the vehicles taken from Logistics Company to the destination countries was recorded 111,217 km and 3,596,032 km are the total kilometers taken for the loading of the vehicles and the total kilometers taken for the transportation services respectively. Total distance taken by the vehicles is 3,707,249 km. “Departure of Vehicle to Customer” activity is calculated 3 % of the total distance made by the vehicles. Therefore, the first group of the overheads (Table 3.8) is allocated to the “Departure of Vehicle to Customer” activity with a coefficient of 0.03 and 0.97 to the “Transportation” activity.

Second column of the Table 3.11 is calculated as follows; in total there are 17 personnel working at the logistics company. 10 % of the personnel are working for the activity of “Taking Information of Demand”. 5 % of the personnel are working for the activity of “Transportation Rate Determination”. 5 % of the personnel are working for the activity of “Preparation of Freight Agreement”. 15 % of the personnel are working for the activity of “Vehicle Scheduling and Preparation”. 5 % of the personnel are working for the activity of “Preparation of Loading Notification”. 10 % of the personnel are working for the activity of “Customs Clearance”. 5 % of the personnel are working for the activity of “Other Transportation Documents Preparation”. 5 % of the personnel are working for the activity of “Submission of Documents and Advance Pays”. 5 % of the personnel are working for the activity of “Vehicle Refueling”. 5 % of the personnel are working for the activity of “Collecting Transportation Information”. 5 % of the personnel are working for the activity of “Informing Customers about Vehicle and Freight”. 5 % of the personnel are working for the activity of “Preparing and Sending Arrival Notification to Customers”. 5 % of the personnel are working for the activity of “Customs Clearance-Arrival”. 10 % of the personnel are working for the activity of “Vehicle Maintenance”. 5 % of the personnel are working for the activity of “Driver Accounts Calculation”.

Third column of the Table 3.11 is same with the second one. Fourth column of Table 3.11 is calculated as follows; “Number of transportation” driver given in Table 3.8 is valid for only “Transportation” activity. Therefore the coefficient is “1” for

"Transportation" activity. Fifth column of Table 3.11 is calculated in the same manner with the fourth column. Sixth column is obtained with AHP. The column 7 have same coefficient with the column 4. Eighth column of Table 3.11 is same with the first column because they both uses same driver of "Distance". Column 9 is same with the column 4. Column 10 is obtained from AHP calculation, because of its indeterminate structure. Column 11 has the same coefficients with the column 2. Column 12 is also obtained from AHP calculations. Column 13 of table 3.11 is obtained in a similar manner of Column 4 and 5 because "Transportation" activity absorbs all the resources on it. Column 14 is also obtained from AHP calculations. Column 15 is same with the coefficients of column 2. The coefficients of Column 16 are obtained according to "Number of Customer" that the activities face. The interviews with the personnel of the logistics company have resulted that 50 % of the resources are used by the "Preparation of Freight Agreement" activity and 50 % of the resources are used by the "Other Transportation Documents Preparation" activity. The coefficients of column 17 are same with the coefficients of column 16. The coefficient of column 18 is same with the column 4 and coefficient of column 19 is same with column 2.

Table 3.11. Coefficients of the first-stage cost drivers

Activities	Consumption coefficients of the activities																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Taking Information of Demand		0.10	0.10			0.16				0.19	0.10	0.19		0.16	0.10				0.10
Transportation Rate Determination		0.05	0.05			0.13				0.08	0.05	0.08		0.13	0.05				0.05
Preparation of Freight Agreement		0.05	0.05			0.18					0.05			0.18	0.05	0.50	0.50		0.05
Vehicle Scheduling and Preparation		0.15	0.15			0.19					0.15			0.19	0.15				0.15
Departure of Vehicle to Customer	0.03							0.03											
Preparation of Loading Notification		0.05	0.05			0.08					0.05			0.08	0.05				0.05
Customs Clearance		0.10	0.10								0.10				0.10				0.10
Other Transportation Documents Preparation		0.05	0.05			0.15					0.05			0.15	0.05	0.50	0.50		0.05
Submission of Documents and Advance Pays		0.05	0.05								0.05				0.05				0.05
Vehicle Refueling		0.05	0.05								0.05				0.05				0.05
Transportation	0.97			1.00	1.00		1.00	0.97	1.00	0.23		0.23	1.00					1.00	
Collecting Transportation Information		0.05	0.05							0.36	0.05	0.36			0.05				0.05
Informing Customers About Vehicle and Freight		0.05	0.05							0.13	0.05	0.13			0.05				0.05
Preparing and Sending Arrival Notification to Customers		0.05	0.05			0.04					0.05			0.04	0.05				0.05
Customs Clearance-Arrival		0.05	0.05								0.05				0.05				0.05
Vehicle Maintenance		0.10	0.10								0.10				0.10				0.10
Driver Accounts Calculation		0.05	0.05			0.06					0.05			0.06	0.05				0.05

3.6 Activity driver determination and selection (Step 5)

Activity driver determination is conducted by using the company profile given in chapter 2 and the simulation of the mapped processes. The drivers of the activity cost pools are represented in the Table 3.12. Some of the drivers given in Table 3.12 are obtained by using the SIMPROCESS process simulation software. The descriptions of the selected drivers are as follows;

Average cycle time of **Load** entity: It is the average time passes in order to complete each of the activities before its consolidation. The explanation of this entity type is made in step 3, section 3.4.3 (**Entities**). When the transportation demand is generated by the *call center,* the **Load** entity is generated. It continues to have some processes and activities until its consolidation. The Average Cycle Time of **Load** entity is the average time passes from the *call center* activity to *consolidation* activity.

Average cycle time of *processing* of **Transportation** entity: It is the average time passes from the consolidation activity to the set off of the vehicles. The explanation of this entity type is made in step 3, section 3.4.3 (**Entities**).

Average cycle time of *traveling* of **Transportation** entity: It is the average time passes for the transportation of the vehicles. It starts from the Logistics Company and finishes at the destination country or it starts from the destination country and finishes at the Logistics Company. The detailed explanation of this entity type is made in step 3, section 3.4.3 (**Entities**).

Average total cycle time: It is the sum of "Average Cycle Time of **Load** entity", "Average Cycle Time of *processing* of **Transportation** entity" and "Average Cycle Time of *traveling* of **Transportation** entity"

Number of transportation: The number of transportation is recorded by the Logistics Company during their transportation activities and they are represented in the company profile in chapter 2, Table 2.1.

Weight of loads transported: The weights of the loads are recorded during the transportation processes and they are represented in the company profile in chapter 2, Table 2.1.

Table 3.12. Activity cost pools and their respective cost drivers

No.	Activities	Second-Stage Cost Drivers
1	Taking Information of Demand	Average cycle time of **Load** entity
2	Transportation Rate Determination	Average cycle time of **Load** entity
3	Preparation of Freight Agreement	Number of transportation
4	Vehicle Scheduling and Preparation	Average cycle time of *traveling* of **Transportation** entity
5	Departure of Vehicle to Customer	Number of transportation
6	Preparation of Loading Notification	Average cycle time of **Load** entity
7	Customs Clearance	Average cycle time of *processing* of **Transportation** entity
8	Other Transportation Documents Preparation	Average cycle time of **Load** entity
9	Submission of Documents and Advance Pays	Number of transportation
10	Vehicle Refueling	Average cycle time of *traveling* of **Transportation** entity
11	Transportation	Average cycle time of *traveling* of **Transportation** entity
12	Collecting Transportation Information	Average total cycle time
13	Informing Customers About Vehicle and Freight	Average total cycle time
14	Preparing and Sending Arrival Notification to Customers	Average total cycle time
15	Customs Clearance-Arrival	Weight of loads transported
16	Vehicle Maintenance	Average cycle time of *traveling* of **Transportation** entity
17	Driver Accounts Calculation	Number of transportation

After the second-stage cost drivers are determined, their allocation coefficients are needed to be determined. The coefficients of the drivers which are based on company profile are derived directly because they are recorded during the operations of the company. *The number of transportation* and *weight of loads transported* drivers are known with certainty. The coefficients which are used in order to allocate the activity cost pools by using *number of transportation* and *weight of loads transported* second-stage cost drivers are given in Table 3.13.

Table 3.13. The coefficients of *number of transportation* and *load weight transported* drivers

No.	Transportation Services	Total Number of Transportations	Total Amount of Load Carried (ton)	Number of Transportation Coefficient	Amount of Weight Coefficient
1	Belgium Export	49	825.5	0.0468	0.0452
2	Belgium Import	119	2130.2	0.1135	0.1166
3	England Export	19	283.3	0.0181	0.0155
4	England Import	11	163.8	0.0105	0.0090
5	France Export	107	2253.2	0.1021	0.1234
6	France Import	92	1035.9	0.0878	0.0567
7	Germany Export	73	1207.6	0.0697	0.0661
8	Germany Import	114	1731.4	0.1088	0.0948
9	Greece Export	36	639.2	0.0344	0.0350
10	Greece Import	46	1026.6	0.0439	0.0562
11	Holland Export	7	117.8	0.0067	0.0064
12	Holland Import	5	66.5	0.0048	0.0036
13	Iran Import	10	146.7	0.0095	0.0080
14	Ireland Export	2	28.0	0.0019	0.0015
15	Italy Export	12	256.1	0.0115	0.0140
16	Italy Import	11	177.1	0.0105	0.0097
17	Norway Export	12	23.8	0.0115	0.0013
18	Norway Import	35	690.0	0.0334	0.0378
19	Poland Export	107	2195.9	0.1021	0.1202
20	Poland Import	23	381.6	0.0219	0.0209
21	Russia Export	66	1258.1	0.0630	0.0689
22	Russia Import	31	627.7	0.0296	0.0344
23	Spain Export	2	49.0	0.0019	0.0027
24	Spain Import	1	17.4	0.0010	0.0010
25	Sweden Export	4	42.9	0.0038	0.0023
26	Sweden Import	38	581.9	0.0363	0.0319
27	Ukraine Export	13	252.2	0.0124	0.0138
28	Ukraine Import	3	56.2	0.0029	0.0031
	Totals	1048	18265.5	1	1

However the coefficients of the cycle time based drivers are obtained by simulating the Logistics Company's processes which are mapped in step 3 of this application.

The model requests two model parameters when the mapped logistics process is simulated. The requested model parameters are shown in Figure 3.22. In this application, the number of vehicles is fixed to 100.

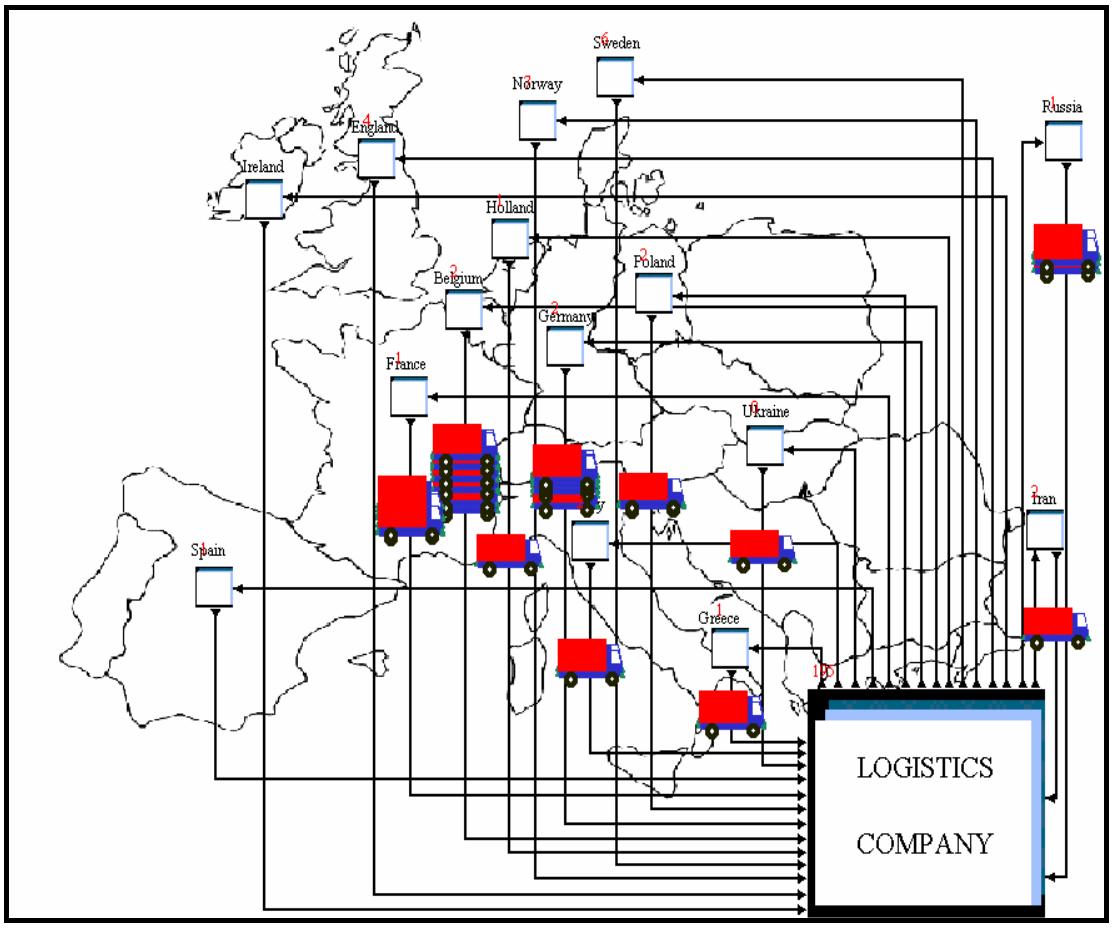

Figure 3.25. General view of the simulation

When the simulation is started the transportations of the vehicles can be followed with the support of animation property of SIMPROCESS (see Figure 3.25). The simulation is done for 10 times. It is assumed adequate to obtain effective and sufficient information about the cost allocation coefficients of the system elements (entities). The simulation is done for the time period of 9 months.

After the simulation is complete the report of the SIMPROCESS is obtained. The driver coefficients are obtained by getting the average of 10 replications of the simulation.

The average cycle times of **Load** entities are given in Table 3.14. The average cycle time of each **Load** entity is multiplied with the number of transportations which are given in the Table 2.1 and the total average time for each entity is obtained. Then, the distribution coefficients are obtained. The distribution coefficients are found by dividing each entity's total average time (column 4 of Table 3.14) by the grand sum of the total average times. Therefore, column 5 can be used as a second-stage cost driver.

Table 3.14. Average cycle times of **Load** entities and their coefficients

Entity Names	Average Processing Time (Months)	Total Number of Transportations	Average Processing Time X Total Number of Transportations	Coefficients
Belgium Export Load	0.001855	49	0.090902	0.054990
Belgium Import Load	0.000819	119	0.097478	0.058968
England Export Load	0.001571	19	0.029857	0.018062
England Import Load	0.001616	11	0.017771	0.010750
France Export Load	0.001978	107	0.211593	0.128001
France Import Load	0.003972	92	0.365442	0.221070
Germany Export Load	0.001409	73	0.102875	0.062233
Germany Import Load	0.000223	114	0.025441	0.015390
Greece Export Load	0.001144	36	0.041169	0.024905
Greece Import Load	0.000739	46	0.034008	0.020573
Holland Export Load	0.002357	7	0.016498	0.009980
Holland Import Load	0.001246	5	0.006228	0.003767
Iran Import Load	0.001291	10	0.012906	0.007807
Ireland Export Load	0.001367	2	0.002734	0.001654
Italy Export Load	0.001785	12	0.021415	0.012955
Italy Import Load	0.001095	11	0.012049	0.007289
Norway Export Load	0.002792	12	0.033507	0.020270
Norway Import Load	0.002018	35	0.070630	0.042727
Poland Export Load	0.001806	107	0.193276	0.116920
Poland Import Load	0.001470	23	0.033818	0.020458
Russia Export Load	0.001331	66	0.087822	0.053127
Russia Import Load	0.001122	31	0.034788	0.021045
Spain Export Load	0.001658	2	0.003316	0.002006
Spain Import Load	0.000720	1	0.000720	0.000435
Sweden Export Load	0.001815	4	0.007258	0.004391
Sweden Import Load	0.002056	38	0.078146	0.047274
Ukraine Export Load	0.001446	13	0.018802	0.011374
Ukraine Import Load	0.000871	3	0.002612	0.001580
Total:	0.043571	1048	1.653060	1

The average cycle times of processing of **Transportation** entities are given in Table 3.15. The average cycle time of processing of each **Transportation** entity is multiplied with the number of transportations which are given in the Table 2.1 and the total average processing time for each **Transportation** entity is obtained. Then, the distribution coefficients are obtained. The distribution coefficients are found by dividing each entity's total average processing time (column 4 of Table 3.15) by the grand sum of the total average processing times. Therefore, column 5 can be used for the allocation of activity cost pools to the cost objects.

Table 3.15 Average cycle time of processing of **Transportation** entities

Entity Names	Average Processing Time (In Months)	Total Number of Transportations	Average Processing Time X Total Number of Transportations	Coefficients
Belgium Export Transportation	0.035095	49	1.719678	0.039771
Belgium Import Transportation	0.037498	119	4.462308	0.103201
England Export Transportation	0.039129	19	0.743442	0.017194
England Import Transportation	0.038009	11	0.418101	0.009670
France Export Transportation	0.042438	107	4.540855	0.105017
France Import Transportation	0.043450	92	3.997444	0.092450
Germany Export Transportation	0.034314	73	2.504920	0.057932
Germany Import Transportation	0.041926	114	4.779600	0.110539
Greece Export Transportation	0.035613	36	1.282074	0.029651
Greece Import Transportation	0.050835	46	2.338417	0.054081
Holland Export Transportation	0.045853	7	0.320971	0.007423
Holland Import Transportation	0.035574	5	0.177872	0.004114
Iran Import Transportation	0.045750	10	0.457499	0.010581
Ireland Export Transportation	0.052702	2	0.105405	0.002438
Italy Export Transportation	0.038291	12	0.459496	0.010627
Italy Import Transportation	0.041972	11	0.461693	0.010678
Norway Export Transportation	0.054954	12	0.659446	0.015251
Norway Import Transportation	0.054495	35	1.907334	0.044111
Poland Export Transportation	0.035816	107	3.832329	0.088631
Poland Import Transportation	0.044713	23	1.028401	0.023784
Russia Export Transportation	0.036772	66	2.426970	0.056129
Russia Import Transportation	0.060269	31	1.868344	0.043209
Spain Export Transportation	0.044676	2	0.089352	0.002066
Spain Import Transportation	0.045394	1	0.045394	0.001050
Sweden Export Transportation	0.052397	4	0.209588	0.004847
Sweden Import Transportation	0.049674	38	1.887622	0.043655
Ukraine Export Transportation	0.032430	13	0.421587	0.009750
Ukraine Import Transportation	0.031018	3	0.093055	0.002152
Totals:	1.201060	1048	43.239197	1

Average cycle time of traveling of **Transportation** entity is given in the Table 3.16. The average cycle time of traveling of **Transportation** entity is multiplied with the number of transportations which are given in the Table 2.1 and the total average time for each entity is obtained. Then, the distribution coefficients are obtained. The distribution coefficients are found by dividing each entity's total average traveling time (column 4 of Table 3.16) by the grand sum of the total average traveling times

of entities. Therefore, column 5 can be used for the allocation of activity cost pools to the cost objects.

Table 3.16 Average cycle time of traveling of **Transportation** entities.

Entity Names	Average Processing Time (In Months)	Total Number of Transportations	Average Processing Time X Total Number of Transportations	Coefficients
Belgium Export Transportation	0.079816	49	3.910970	0.047521
Belgium Import Transportation	0.078698	119	9.365111	0.113793
England Export Transportation	0.085552	19	1.625490	0.019751
England Import Transportation	0.090939	11	1.000329	0.012155
France Export Transportation	0.075235	107	8.050193	0.097816
France Import Transportation	0.081656	92	7.512322	0.091281
Germany Export Transportation	0.083382	73	6.086860	0.073960
Germany Import Transportation	0.081343	114	9.273056	0.112675
Greece Export Transportation	0.043554	36	1.567942	0.019052
Greece Import Transportation	0.043398	46	1.996302	0.024257
Holland Export Transportation	0.078068	7	0.546479	0.006640
Holland Import Transportation	0.078011	5	0.390055	0.004739
Iran Import Transportation	0.075298	10	0.752983	0.009149
Ireland Export Transportation	0.092176	2	0.184353	0.002240
Italy Export Transportation	0.059874	12	0.718485	0.008730
Italy Import Transportation	0.057400	11	0.631398	0.007672
Norway Export Transportation	0.098305	12	1.179660	0.014334
Norway Import Transportation	0.107588	35	3.765594	0.045755
Poland Export Transportation	0.075456	107	8.073815	0.098103
Poland Import Transportation	0.082138	23	1.889167	0.022955
Russia Export Transportation	0.090259	66	5.957096	0.072383
Russia Import Transportation	0.070016	31	2.170491	0.026373
Spain Export Transportation	0.075845	2	0.151690	0.001843
Spain Import Transportation	0.076073	1	0.076073	0.000924
Sweden Export Transportation	0.100463	4	0.401851	0.004883
Sweden Import Transportation	0.104908	38	3.986493	0.048439
Ukraine Export Transportation	0.064124	13	0.833615	0.010129
Ukraine Import Transportation	0.067128	3	0.201384	0.002447
Total	2.196702	1048	82.29925	1

Table 3.17 represents the average total cycle time of each transportation services by summing the cycle times of previous three tables. The total average cycle time is multiplied with the number of transportations which are given in the Table 2.1 and the total average time for each entity is obtained. Then, the distribution coefficients

are obtained. The distribution coefficients are found by dividing each entity's average total cycle time (column 5 of Table 3.17) by the grand sum of the average total cycle times of the entities. Therefore, column 6 can be used as a second-stage cost driver.

Table 3.17 Average total cycle time of the transportation services

Entity Names	Entity Processing Average (in Months)	Transportation Processing Average (In Months)	Transportation Traveling Average (In Months)	Total Time X Number of Transportations	Coefficients
Belgium Export	0.001855	0.035095	0.079816	5.721551	0.044984
Belgium Import	0.000819	0.037498	0.078698	13.924897	0.109480
England Export	0.001571	0.039129	0.085552	2.398788	0.018860
England Import	0.001616	0.038009	0.090939	1.436202	0.011292
France Export	0.001978	0.042438	0.075235	12.802640	0.100656
France Import	0.003972	0.043450	0.081656	11.875208	0.093365
Germany Export	0.001409	0.034314	0.083382	8.694656	0.068359
Germany Import	0.000223	0.041926	0.081343	14.078096	0.110684
Greece Export	0.001144	0.035613	0.043554	2.891186	0.022731
Greece Import	0.000739	0.050835	0.043398	4.368726	0.034348
Holland Export	0.002357	0.045853	0.078068	0.883947	0.006950
Holland Import	0.001246	0.035574	0.078011	0.574154	0.004514
Iran Import	0.001291	0.045750	0.075298	1.223388	0.009618
Ireland Export	0.001367	0.052702	0.092176	0.292491	0.002300
Italy Export	0.001785	0.038291	0.059874	1.199396	0.009430
Italy Import	0.001095	0.041972	0.057400	1.105140	0.008689
Norway Export	0.002792	0.054954	0.098305	1.872614	0.014723
Norway Import	0.002018	0.054495	0.107588	5.743557	0.045157
Poland Export	0.001806	0.035816	0.075456	12.099421	0.095128
Poland Import	0.001470	0.044713	0.082138	2.951386	0.023204
Russia Export	0.001331	0.036772	0.090259	8.471888	0.066607
Russia Import	0.001122	0.060269	0.070016	4.073623	0.032027
Spain Export	0.001658	0.044676	0.075845	0.244358	0.001921
Spain Import	0.000720	0.045394	0.076073	0.122186	0.000961
Sweden Export	0.001815	0.052397	0.100463	0.618697	0.004864
Sweden Import	0.002056	0.049674	0.104908	5.952262	0.046798
Ukraine Export	0.001446	0.032430	0.064124	1.274005	0.010016
Ukraine Import	0.000871	0.031018	0.067128	0.297050	0.002335
Total:	0.043571	1.201060	2.196703	127.191512	1.000000

3.7 Cost determination (Step 6)

At the sixth and the final step of application of the proposed costing model, the cost determination is performed. Cost determination is conducted in two steps which are; allocating the overheads to the activity cost pools and allocating the activity cost pools to cost objects.

Table 3.18 represents the process of allocation the overheads to the activity cost pools. In this step of the application, matrix multiplication is performed. Each column in Table 3.11 is multiplied with the overheads given in Table 3.8. When a 17x1 matrix is multiplied with a 1x1 matrix, a matrix with a dimension of 17x1 is obtained. Each 17x1 matrix is deployed to the Table 3.18.

Table 3.18. Overheads usages of the activities

	Overheads Groups $																		
ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Taking Information of Demand	0	10,753	12,120	0	0	1,649	0	0	0	4,731	2,415	1,085	0	1,572	3,005	0	0	0	8,026
Transportation Rate Determination	0	5,376	6,060	0	0	1,277	0	0	0	2,008	1,208	461	0	1,217	1,503	0	0	0	4,013
Preparation of Freight Agreement	0	5,376	6,060	0	0	1,792	0	0	0	0	1,208	0	0	1,708	1,503	2,951	95,838	0	4,013
Vehicle Scheduling and Preparation	0	16,129	18,180	0	0	1,912	0	0	0	0	3,623	0	0	1,822	4,508	0	0	0	12,039
Departure of Vehicle to Customer	34,320	0	0	0	0	0	0	1,896	0	0	0	0	0	0	0	0	0	0	0
Preparation of Loading Notification	0	5,376	6,060	0	0	826	0	0	0	0	1,208	0	0	787	1,503	0	0	0	4,013
Customs Clearance	0	10,753	12,120	0	0	0	0	0	0	0	2,415	0	0	0	3,005	0	0	0	8,026
Other Transportation Documents Preparation	0	5,376	6,060	0	0	1,470	0	0	0	0	1,208	0	0	1,401	1,503	2,951	95,838	0	4,013
Submission of Documents and Advance Pays	0	5,376	6,060	0	0	0	0	0	0	0	1,208	0	0	0	1,503	0	0	0	4,013
Vehicle Refueling	0	5,376	6,060	0	0	0	0	0	0	0	1,208	0	0	0	1,503	0	0	0	4,013
Transportation	1,109,688	0	0	50,523	311,866	0	72,516	61,316	17,863	5,686	0	1,304	18,092	0	0	0	0	32,370	0
Collecting Transportation Information	0	5,376	6,060	0	0	0	0	0	0	8,883	1,208	2,037	0	0	1,503	0	0	0	4,013
Informing Customers About Vehicle and Freight	0	5,376	6,060	0	0	0	0	0	0	3,196	1,208	733	0	0	1,503	0	0	0	4,013
Preparing and Sending Arrival Notification to Customers	0	5,376	6,060	0	0	445	0	0	0	0	1,208	0	0	424	1,503	0	0	0	4,013
Customs Clearance-Arrival	0	5,376	6,060	0	0	0	0	0	0	0	1,208	0	0	0	1,503	0	0	0	4,013
Vehicle Maintenance	0	10,753	12,120	0	0	0	0	0	0	0	2,415	0	0	0	3,005	0	0	0	8,026
Driver Accounts Calculation	0	5,376	6,060	0	0	636	0	0	0	0	1,208	0	0	607	1,503	0	0	0	4,013

When rows of Table 3.18 are summed up, total resource utilization of the activities can be determined. In the Table 3.19, the total resource utilization of the activities are obtained and represented.

Table 3.19. Total cost consumptions of the activities and their second-stage cost drivers

No.	Activities	Overheads ($)	Second-Stage Cost Drivers
1	Taking Information of Demand	45,356.1	Average cycle time of **Load** entity
2	Transportation Rate Determination	23,122.8	Average cycle time of **Load** entity
3	Preparation of Freight Agreement	120,448.7	Number of transportation
4	Vehicle Scheduling and Preparation	58,211.9	Average cycle time of *traveling* of **Transportation** entity
5	Departure of Vehicle to Customer	36,216.6	Number of transportation
6	Preparation of Loading Notification	19,772.2	Average cycle time of **Load** entity
7	Customs Clearance	36,318.9	Average cycle time of *processing* of **Transportation** entity
8	Other Transportation Documents Preparation	119,818.7	Average cycle time of **Load** entity
9	Submission of Documents and Advance Pays	18,159.5	Number of transportation
10	Vehicle Refueling	18,159.5	Average cycle time of *traveling* of **Transportation** entity
11	Transportation	1,681,225.5	Average cycle time of *traveling* of **Transportation** entity
12	Collecting Transportation Information	29,080.1	Average total cycle time
13	Informing Customers About Vehicle and Freight	22,088.8	Average total cycle time
14	Preparing and Sending Arrival Notification to Customers	19,028.4	Average total cycle time
15	Customs Clearance-Arrival	18,159.5	Weight of loads transported
16	Vehicle Maintenance	36,318.9	Average cycle time of *traveling* of **Transportation** entity
17	Driver Accounts Calculation	19,402.5	Number of transportation
	Total:	2,320,888.5	

At this point of the study, advantages of using this costing system come to scene because, resource distribution to the activity cost pools helps to the managers to

evaluate resource consumptions of value added and non-value added activities. If a non-value added activity consumes too much resource in comparison to value added activities then this activity is a candidate for improvement, replacement or elimination.

After obtaining the activity cost pools, their costs are allocated to the cost objects with the help of drivers and their respective coefficients found in the step 5 of this application.

The activity cost pools are 1x1 matrices and second-stage vectors have a dimension of 28x1 (see the coefficient columns of Table 13 to Table 17). When we multiply the second-stage allocation vector with the activity cost pool matrix we obtain a 28x1 matrix which is given in Table 3.20.

For example, second-stage cost driver of the first activity cost pool which is given in the Table 3.19 is "Average cycle time of **Load** entity". The allocation coefficients of "Average cycle time of **Load** entity" were obtained in the Table 3.14. When the allocation vector given in the Table 3.14 is multiplied with the activity cost pool of first activity, a vector which has a dimension of 28x1 is obtained. This vector is located in the first column of the Table 3.20. All of the activity cost pools are allocated in the same way.

Table 3.20. Allocation of the activity cost pools to the cost objects

Transportation Services	Activity Cost Pools ($)																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Belgium Exports	2,494.1	1,271.5	5,631.7	2,766.3	1,693.3	1,087.3	1,444.5	6,588.9	849.1	863.0	79,894.1	1,308.1	993.6	856.0	820.7	1,725.9	907.2
Belgium Imports	2,674.6	1,363.5	13,676.9	6,624.1	4,112.4	1,165.9	3,748.1	7,065.5	2,062.0	2,066.4	191,312.3	3,183.7	2,418.3	2,083.2	2,117.9	4,132.9	2,203.1
England Exports	819.2	417.6	2,183.7	1,149.7	656.6	357.1	624.5	2,164.1	329.2	358.7	33,205.8	548.4	416.6	358.9	281.7	717.3	351.8
England Imports	487.6	248.6	1,264.3	707.6	380.1	212.6	351.2	1,288.1	190.6	220.7	20,434.9	328.4	249.4	214.9	162.9	441.4	203.7
France Exports	5,805.6	2,959.7	12,297.7	5,694.1	3,697.7	2,530.9	3,814.1	15,336.9	1,854.1	1,776.3	164,450.9	2,927.1	2,223.4	1,915.3	2,240.1	3,552.6	1,981.0
France Imports	10,026.9	5,111.8	10,573.7	5,313.6	3,179.3	4,371.0	3,357.7	26,488.3	1,594.2	1,657.6	153,463.2	2,715.1	2,062.3	1,776.6	1,029.9	3,315.2	1,703.3
Germany Exports	2,822.7	1,439.0	8,390.0	4,305.4	2,522.7	1,230.5	2,104.0	7,456.7	1,264.9	1,343.1	124,343.6	1,987.9	1,510.0	1,300.8	1,200.6	2,686.2	1,351.5
Germany Imports	698.0	355.9	13,102.2	6,559.0	3,939.6	304.3	4,014.6	1,8”44.0	1,975.4	2,046.1	189,431.8	3,218.7	2,444.9	2,106.1	1,721.3	4,092.2	2,110.6
Greece Exports	1,129.6	575.9	4,137.6	1,109.0	1,244.1	492.4	1,076.9	2,984.1	623.8	346.0	32,030.2	661.0	502.1	432.5	635.5	691.9	666.5
Greece Imports	933.1	475.7	5,286.9	1,412.0	1,589.7	406.8	1,964.2	2,465.0	797.1	440.5	40,780.8	998.8	758.7	653.6	1,020.6	881.0	851.6
Holland Exports	452.7	230.8	804.5	386.5	241.9	197.3	269.6	1,195.8	121.3	120.6	11,163.6	202.1	153.5	132.2	117.1	241.2	129.6
Holland Imports	170.9	87.1	574.7	275.9	172.8	74.5	149.4	451.4	86.6	86.1	7,968.1	131.3	99.7	85.9	66.1	172.1	92.6
Iran Imports	354.1	180.5	1,149.3	532.6	345.6	154.4	384.3	935.4	173.3	166.1	15,382.1	279.7	212.5	183.0	145.8	332.3	185.1
Ireland Exports	75.0	38.2	229.9	130.4	69.1	32.7	88.5	198.2	34.7	40.7	3,766.0	66.9	50.8	43.8	27.8	81.4	37.0
Italy Exports	587.6	299.6	1,379.2	508.2	414.7	256.1	386.0	1,552.2	207.9	158.5	14,677.4	274.2	208.3	179.4	254.6	317.1	222.2
Italy Imports	330.6	168.5	1,264.3	446.6	380.1	144.1	387.8	873.3	190.6	139.3	12,898.3	252.7	191.9	165.3	176.0	278.6	203.7
Norway Exports	919.4	468.7	1,379.2	834.4	414.7	400.8	553.9	2,428.7	207.9	260.3	24,098.3	428.1	325.2	280.2	23.7	520.6	222.2
Norway Imports	1,937.9	988.0	4,022.6	2,663.5	1,209.5	844.8	1,602.1	5,119.4	606.5	830.9	76,924.3	1,313.2	997.5	859.3	686.0	1,661.8	648.0
Poland Exports	5,303.1	2,703.5	12,297.7	5,710.8	3,697.7	2,311.8	3,219.0	14,009.2	1,854.1	1,781.5	164,933.5	2,766.3	2,101.3	1,810.1	2,183.2	3,563.0	1,981.0
Poland Imports	927.9	473.0	2,643.4	1,336.2	794.8	404.5	863.8	2,451.2	398.5	416.8	38,592.3	674.8	512.6	441.5	379.4	833.7	425.8
Russia Exports	2,409.6	1,228.4	7,585.5	4,213.6	2,280.8	1,050.4	2,038.5	6,365.6	1,143.6	1,314.4	121,692.7	1,936.9	1,471.3	1,267.4	1,250.8	2,628.9	1,221.9
Russia Imports	954.5	486.6	3,562.9	1,535.2	1,071.3	416.1	1,569.3	2,521.5	537.2	478.9	44,339.2	931.4	707.4	609.4	624.1	957.8	573.9
Spain Exports	91.0	46.4	229.9	107.3	69.1	39.7	75.1	240.3	34.7	33.5	3,098.7	55.9	42.4	36.6	48.7	66.9	37.0
Spain Imports	19.7	10.1	114.9	53.8	34.6	8.6	38.1	52.2	17.3	16.8	1,554.0	27.9	21.2	18.3	17.3	33.6	18.5
Sweden Exports	199.1	101.5	459.7	284.2	138.2	86.8	176.0	526.1	69.3	88.7	8,209.1	141.5	107.4	92.6	42.6	177.3	74.1
Sweden Imports	2,144.2	1,093.1	4,367.4	2,819.7	1,313.2	934.7	1,585.5	5,664.3	658.5	879.6	81,436.9	1,360.9	1,033.7	890.5	578.5	1,759.3	703.5
Ukraine Exports	515.9	263.0	1,494.1	589.6	449.3	224.9	354.1	1,362.8	225.3	183.9	17,029.3	291.3	221.3	190.6	250.7	367.9	240.7
Ukraine Imports	71.7	36.5	344.8	142.4	103.7	31.2	78.2	189.3	52.0	44.4	4,113.9	67.9	51.6	44.4	55.9	88.9	55.5

After the cost pools are allocated to the cost objects the total costs of each transportation services can be obtained by summing their respective rows in Table 3.20. After the summation of each row, the unit costs of each transportation services are obtained.

Table 3.21 Costs of the transportation services

No.	Transportation Services	Total Number of Transportation	Total Overheads ($)	Total Direct Costs ($)	Unit Overhead ($)	Unit Direct Cost ($)	Total Costs ($)
1	Belgium Exports	49	111,195.2	125,649.4	2,269.3	2,564.3	4,833.6
2	Belgium Imports	119	252,010.9	239,911.2	2,117.7	2,016.1	4,133.8
3	England Exports	19	44,941.0	52,489.5	2,365.3	2,762.6	5,127.9
4	England Imports	11	27,386.8	26,818.3	2,489.7	2,438.0	4,927.7
5	France Exports	107	235,057.4	194,905.8	2,196.8	1,821.5	4,018.3
6	France Imports	92	237,739.5	182,051.2	2,584.1	1,978.8	4,562.9
7	Germany Exports	73	167,259.4	178,965.5	2,291.2	2,451.6	4,742.8
8	Germany Imports	114	239,964.9	253,069.6	2,105.0	2,219.9	4,324.9
9	Greece Exports	36	49,339.1	40,272.9	1,370.5	1,118.7	2,489.2
10	Greece Imports	46	61,716.0	42,904.7	1,341.7	932.7	2,274.4
11	Holland Exports	7	16,160.2	15,012.1	2,308.6	2,144.6	4,453.2
12	Holland Imports	5	10,745.2	5,085.9	2,149.0	1,017.2	3,166.2
13	Iran Imports	10	21,096.1	9,810.8	2,109.6	981.1	3,090.7
14	Ireland Exports	2	5,011.0	2,646.2	2,505.5	1,323.1	3,828.6
15	Italy Exports	12	21,883.1	21,137.0	1,823.6	1,761.4	3,585.0
16	Italy Imports	11	18,491.8	11,391.8	1,681.1	1,035.6	2,716.7
17	Norway Exports	12	33,766.2	34,789.6	2,813.9	2,899.1	5,713.0
18	Norway Imports	35	102,915.1	101,592.7	2,940.4	2,902.6	5,843.1
19	Poland Exports	107	232,226.6	249,292.0	2,170.3	2,329.8	4,500.2
20	Poland Imports	23	52,570.4	48,078.1	2,285.7	2,090.4	4,376.0
21	Russia Exports	66	161,100.6	78,676.6	2,440.9	1,192.1	3,633.0
22	Russia Imports	31	61,876.9	35,344.7	1,996.0	1,140.2	3,136.2
23	Spain Exports	2	4,353.1	2,965.4	2,176.6	1,482.7	3,659.2
24	Spain Imports	1	2,057.0	1,472.8	2,057.0	1,472.8	3,529.7
25	Sweden Exports	4	10,974.4	8,232.0	2,743.6	2,058.0	4,801.6
26	Sweden Imports	38	109,223.4	95,016.7	2,874.3	2,500.4	5,374.7
27	Ukraine Exports	13	24,254.6	26,173.8	1,865.7	2,013.4	3,879.1
28	Ukraine Imports	3	5,572.4	2,952.9	1,857.5	984.3	2,841.8

Process / Cost Improvement

The proposed costing model asks if any improvement necessary or not after the costs of transportation services are determined (Figure 2.1).

When the vehicle drivers who drive the vehicles to Russia are educated in order to reduce the waste way covered the second-stage cost drivers change. When any change in the process is occurred, the model proposed in Figure 2.1 indicates the step 3.

Step 3 of the model proposes the mapping and modeling the processes. The improvement is reflected to the processes. The connector between the Logistics Company and Russia is improved by changing the distance of it. Because the vehicle drivers are now educated on the way of Russia.

The distance between Russia and the Logistics Company is reduced to Uni(3150.0,3250.0,1) kilometers from Uni(3850.0,3950.0,1).

Model given in Figure 2.1, indicates obtaining first-stage cost drivers; however the first-stage cost drivers are not affected from the process change. Therefore, fourth step is skipped.

On the other hand, second-stage cost drivers which are required in the step 5 of the proposed costing system change slightly. In order to learn the change of second-stage cost driver coefficients the process is re-simulated. After the simulation the resulting report is obtained.

Average cycle time of traveling of **Transportation** entity is re-obtained and represented in the Table 3.22. The average cycle time of traveling of **Transportation** entity is multiplied with the number of transportations which are given in the Table 2.1 and then the total average time for each entity is obtained. Then, the distribution coefficients are obtained. The distribution coefficients are found by dividing each entity's total average traveling time (column 4 of Table 3.22) by the grand sum of the

total average traveling times. Therefore, column 5 can be used for the allocation of activity cost pools to the cost objects.

Table 3.22 Average cycle time of traveling of **Transportation** entities.

Entity Names	Average Processing Time (In Months)	Total Number of Transportations	Average Processing Time X Total Number of Transportations	Coefficients
Belgium Export Transportation	0.079591	49	3.899944	0.048018
Belgium Import Transportation	0.078559	119	9.348477	0.115104
England Export Transportation	0.085680	19	1.627918	0.020044
England Import Transportation	0.090561	11	0.996167	0.012265
France Export Transportation	0.075384	107	8.066075	0.099314
France Import Transportation	0.081727	92	7.518871	0.092576
Germany Export Transportation	0.083284	73	6.079713	0.074857
Germany Import Transportation	0.081343	114	9.273056	0.114175
Greece Export Transportation	0.043793	36	1.576545	0.019411
Greece Import Transportation	0.043938	46	2.021147	0.024885
Holland Export Transportation	0.077118	7	0.539829	0.006647
Holland Import Transportation	0.076357	5	0.381784	0.004701
Iran Import Transportation	0.073983	10	0.739835	0.009109
Ireland Export Transportation	0.091763	2	0.183526	0.002260
Italy Export Transportation	0.061238	12	0.734850	0.009048
Italy Import Transportation	0.057396	11	0.631360	0.007774
Norway Export Transportation	0.099028	12	1.188336	0.014631
Norway Import Transportation	0.107687	35	3.769037	0.046406
Poland Export Transportation	0.075366	107	8.064158	0.099290
Poland Import Transportation	0.082275	23	1.892315	0.023299
Russia Export Transportation	0.073993	66	4.883556	0.060129
Russia Import Transportation	0.069033	31	2.140022	0.026349
Spain Export Transportation	0.077322	2	0.154643	0.001904
Spain Import Transportation	0.077268	1	0.077268	0.000951
Sweden Export Transportation	0.095505	4	0.382019	0.004704
Sweden Import Transportation	0.105569	38	4.011634	0.049393
Ukraine Export Transportation	0.064525	13	0.838831	0.010328
Ukraine Import Transportation	0.065676	3	0.197028	0.002426
Total	2.17496	1048	81.21794	1

By using the new allocation coefficient in the model, the cost results below is obtained.

Table 3.23. Cost results after the improvement of the processes

Transportation Services	Total Number of Transportations	Total Overheads ($)	Total Direct Costs ($)	Unit Overhead ($)	Unit Direct Cost ($)	Total Costs ($)
Belgium Exports	49	111,251.2	125,649.4	2,270.4	2,564.3	4,834.7
Belgium Imports	119	252,158.5	239,911.2	2,119.0	2,016.1	4,135.0
England Exports	19	44,974.0	52,489.5	2,367.1	2,762.6	5,129.7
England Imports	11	27,399.3	26,818.3	2,490.8	2,438.0	4,928.9
France Exports	107	235,226.2	194,905.8	2,198.4	1,821.5	4,019.9
France Imports	92	237,885.6	182,051.2	2,585.7	1,978.8	4,564.5
Germany Exports	73	167,360.5	178,965.5	2,292.6	2,451.6	4,744.2
Germany Imports	114	240,133.9	253,069.6	2,106.4	2,219.9	4,326.3
Greece Exports	36	49,379.6	40,272.9	1,371.7	1,118.7	2,490.3
Greece Imports	46	61,786.9	42,904.7	1,343.2	932.7	2,275.9
Holland Exports	7	16,161.0	15,012.1	2,308.7	2,144.6	4,453.3
Holland Imports	5	10,740.8	5,085.9	2,148.2	1,017.2	3,165.3
Iran Imports	10	21,091.6	9,810.8	2,109.2	981.1	3,090.2
Ireland Exports	2	5,013.2	2,646.2	2,506.6	1,323.1	3,829.7
Italy Exports	12	21,918.9	21,137.0	1,826.6	1,761.4	3,588.0
Italy Imports	11	18,503.3	11,391.8	1,682.1	1,035.6	2,717.7
Norway Exports	12	33,799.8	34,789.6	2,816.6	2,899.1	5,715.8
Norway Imports	35	102,988.5	101,592.7	2,942.5	2,902.6	5,845.2
Poland Exports	107	232,360.4	249,292.0	2,171.6	2,329.8	4,501.4
Poland Imports	23	52,609.2	48,078.1	2,287.4	2,090.4	4,377.7
Russia Exports	66	159,719.7	78,676.6	2,420.0	1,192.1	3,612.1
Russia Imports	31	61,874.2	35,344.7	1,995.9	1,140.2	3,136.1
Spain Exports	2	4,360.0	2,965.4	2,180.0	1,482.7	3,662.7
Spain Imports	1	2,060.0	1,472.8	2,060.0	1,472.8	3,532.8
Sweden Exports	4	10,954.2	8,232.0	2,738.5	2,058.0	4,796.6
Sweden Imports	38	109,331.0	95,016.7	2,877.1	2,500.4	5,377.6
Ukraine Exports	13	24,277.1	26,173.8	1,867.5	2,013.4	3,880.8
Ukraine Imports	3	5,570.0	2,952.9	1,856.7	984.3	2,841.0

The Russia Export cost was $3,633.0 before the process improvement and it is $3,612.1 after the improvement. This improvement is obtained by reducing the time wasted on the way of Russia Export Transportations.

3.8 Results and discussion

In this chapter, costs of the transportation services of the Logistics Company are obtained by using ***process based generic product costing system*** which is introduced in chapter 2 in a step-by-step manner. The costs of the transportation services given at the end of this application are so detailed because approximately every activity is determined and mapped to the model. The cost results found in this chapter are accurate, because the cost drivers are selected in an accurate way. In addition to this, the coefficients which are used to allocate activity cost pools to cost objects are derived from the simulation of the processes of the Logistics Company.

The results of the ongoing costing system can be seen at the end of chapter 2. The cost results of ongoing traditional costing system results and the cost results of the proposed costing system are represented in Table 3.24 in order to compare the cost differences of two costing system.

Table 3.24. Cost estimations comparison

No.	Transportation Services	Cost Results of the Proposed Model ($)	TCA results ($)	Difference %	Company Prices ($)	Profit/Loss According to Model ($)	Profit/Loss According to TCA ($)
1	Belgium Exports	4834.7	4778.9	-1.2	4591.8	-242.9	-187.0
2	Belgium Imports	4135.0	4230.6	2.3	4373.2	238.2	142.6
3	England Exports	5129.7	4977.2	-3.1	5894.7	765.1	917.5
4	England Imports	4928.9	4652.6	-5.9	4784.0	-144.9	131.4
5	France Exports	4019.9	4036.1	0.4	3454.5	-565.4	-581.6
6	France Imports	4564.5	4193.4	-8.9	4622.8	58.3	429.4
7	Germany Exports	4744.2	4666.2	-1.7	3677.9	-1066.3	-988.3
8	Germany Imports	4326.3	4434.5	2.4	4372.2	45.9	-62.2
9	Greece Exports	2490.3	3333.3	25.3	2176.8	-313.5	-1156.5
10	Greece Imports	2275.9	3147.3	27.7	1296.5	-979.4	-1850.8
11	Holland Exports	4453.3	4359.2	-2.2	6428.6	1975.3	2069.4
12	Holland Imports	3165.3	3231.8	2.1	4513.6	1348.3	1281.8
13	Iran Imports	3090.2	3195.7	3.3	1164.7	-1925.6	-2031.0
14	Ireland Exports	3829.7	3537.7	-8.3	7800.0	3970.3	4262.3
15	Italy Exports	3588.0	3976.0	9.8	3288.8	-299.2	-687.2
16	Italy Imports	2717.7	3250.2	16.4	5529.8	2812.1	2279.6
17	Norway Exports	5715.8	5113.7	-11.8	4339.8	-1376.0	-773.9
18	Norway Imports	5845.2	5117.2	-14.2	9804.5	3959.3	4687.3
19	Poland Exports	4501.4	4544.4	0.9	3402.2	-1099.3	-1142.3
20	Poland Imports	4377.7	4304.9	-1.7	2518.7	-1859.0	-1786.2
21	Russia Exports	3612.1	3406.7	-6.0	5843.2	2231.1	2436.6
22	Russia Imports	3136.1	3354.7	6.5	1698.0	-1438.1	-1656.7
23	Spain Exports	3662.7	3697.3	0.9	4103.5	440.8	406.2
24	Spain Imports	3532.8	3687.4	4.2	4224.2	691.4	536.8
25	Sweden Exports	4796.6	4272.6	-12.3	4525.9	-270.7	253.3
26	Sweden Imports	5377.6	4715.0	-14.1	9382.2	4004.6	4667.2
27	Ukraine Exports	3880.8	4228.0	8.2	5230.8	1349.9	1002.8
28	Ukraine Imports	2841.0	3198.9	11.2	1605.2	-1235.8	-1593.7

The column with the heading of "**Difference %"** in Table 3.24 represents the difference of two cost results in percentage. Some of the differences are positive and some of the differences are negative. The positive differences show that, cost estimation results of TCA are bigger than the cost estimation result of ABC. The negative differences show that, cost estimation results of ABC are bigger than the TCA cost estimation results.

"**Company Prices**" column given in Table 3.24 shows the average unit prices of the transportation services provided. This data is gathered from the company profile which is given in chapter 2. "**Profit/Loss According to Model**" column of Table 3.24 shows whether any loss or profit is occurred according to cost estimation results of the proposed costing model. "**Profit/Loss According to TCA**" column of Table 3.24 shows whether any loss or profit is occurred according to cost estimation results of the Traditional Cost Accounting.

The cost estimation results of the proposed costing system and Traditional Cost Accounting differs drastically for some transportation services. For example there is 27.7 % difference between the cost estimation results of two different systems for "Greece Imports". There is 25.3 % difference between two system cost estimations for "Greece Exports". However, not all of the cost estimation results of transportation services differ drastically. For example, there is only 0.9 % difference between these two different cost estimation systems for the "Poland Exports".

The managers of the Logistics Company might think they are making a profitable job while giving services to "England Imports" according to their Traditional Cost Accounting estimates. On the other hand, "England Imports" transportation service is not a profitable service. According the proposed cost system, the Logistics Company loses $144.9 for each of "England Imports" transportation services.

Opposite condition is occurred for the "Germany Imports" transportation services. The cost estimation results of TCA indicate that there is a $ 62.2 loss, however the cost estimation result of the proposed costing system says vice versa. The costing result of the proposed costing system indicates that there is a $ 45.9 profit.

The cost results of both traditional costing system of the Logistics Company and the results of the proposed costing system are summarized in the Figure 3.26.

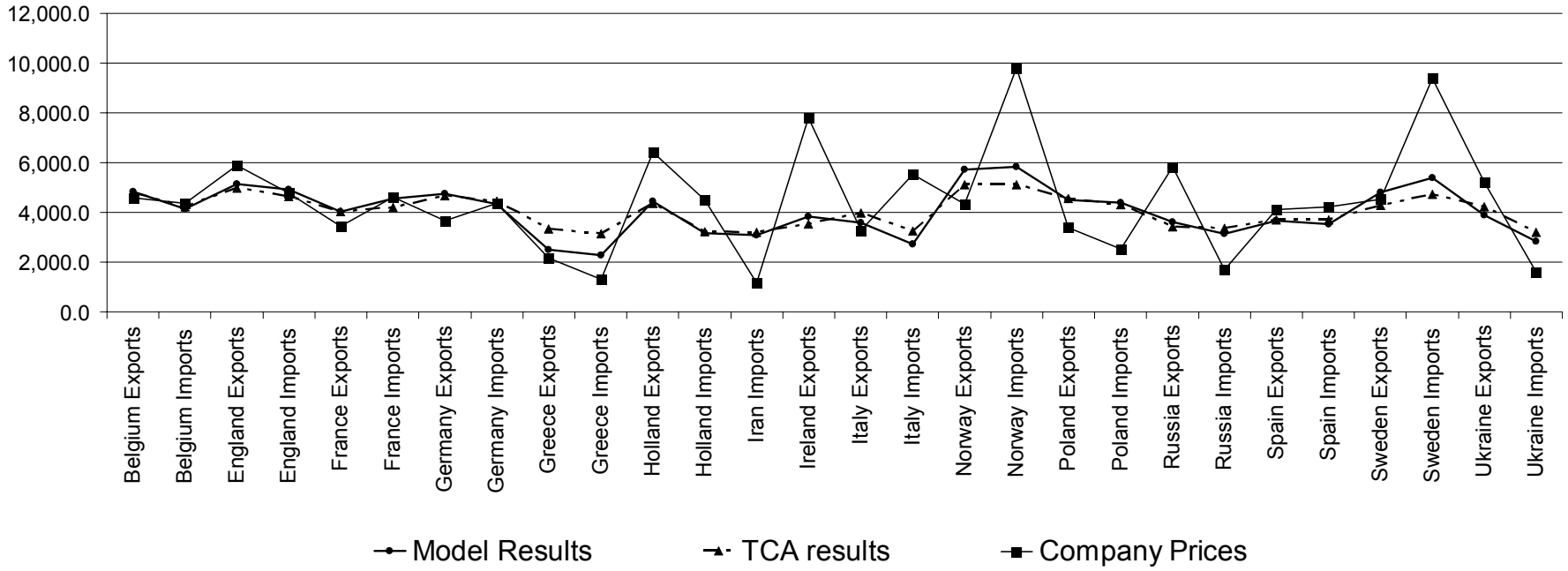

Figure 3.26. Cost results of TCA and proposed costing system and company price

CHAPTER 4

CONCLUSION

Present age of global competition forces companies and organizations being more cost efficient. They have to decrease their cost of products and/or services while maintaining a high level of product and/or service quality. In order to have a sustainable cost level, first of all the companies should know their true costs. True cost information is becoming more and more important in today's competitive businesses. The process improvement studies also require true costs of the products and/or services. Accurate cost estimation is not only critical for the manufacturing organizations. It is also vital for the service sector companies. Logistics sector is one of the service sectors of which cost estimations are very important. The operations of the logistics sector are very complex therefore estimating accurate costs is not an easy task.

The research presented in this thesis addresses the cost allocation problem and proposes a costing model which includes AHP, process modeling and simulation. This thesis handles the cost allocation differences of TCA and the proposed costing system.

The ongoing costing system of the company is derived by using Traditional Cost Accounting in chapter 2. The cost of the transportation services of the company is obtained by using TCA in order to show the necessity of the proposed costing system.

The proposed costing system is also introduced and represented in chapter 2. In order to make the model clear it is divided into 6 steps. The steps of the proposed costing system are similar to steps of ABC. However, the proposed costing system integrates

process modeling, simulation and AHP technique. The application of the proposed costing system is conducted in the chapter 3.

The difference between Traditional Cost Accounting and the proposed costing system emerges from the usages of the first-stage and second-stage cost drivers. TCA uses a simple method to allocate the overheads to the cost objects. In traditional cost accounting the direct materials and direct labor act an important role to constitute a basis for the allocation of overheads. However, in the proposed costing system the cost allocation is made in a more detailed and accurate way.

In the literature, there are many application of Activity Based Costing. ABC has been applied to various industries such as electronics, automotive, aerospace and defense, airplane manufacturing, shipbuilding, telecommunication, machine production and for general production systems. In most of the application the selection of the drivers are generally performed intuitively. However, some decision making tools and methods can be used in order to determine the cost drivers and their respective coefficients. The model proposed in this thesis uses AHP and simulation in order to obtain accurate cost drivers. In the proposed model AHP is used in order to obtain the first-stage cost driver allocation coefficients and simulation is used in order to obtain second-stage cost driver coefficients. The model proposed in this thesis has many advantages and some disadvantages.

4.1 Advantages of the proposed costing system

- It finds more accurate cost drivers and their respective allocation coefficients.
- It helps to find the value-added and non value-added activities of the organizations.
- Help managers to see where the costs incur.
- Help managers to see the result of process changes.
- Provides more accurate products and/or service cost estimations.

4.2 Disadvantages of the proposed costing system

- Mapping the processes, sub processes and activities are time consuming.
- It is difficult to obtain drivers and their respective coefficients.
- Simulation knowledge and experience is needed to apply the model.
- Decision making techniques are needed.

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APPENDICES

APPENDIX A

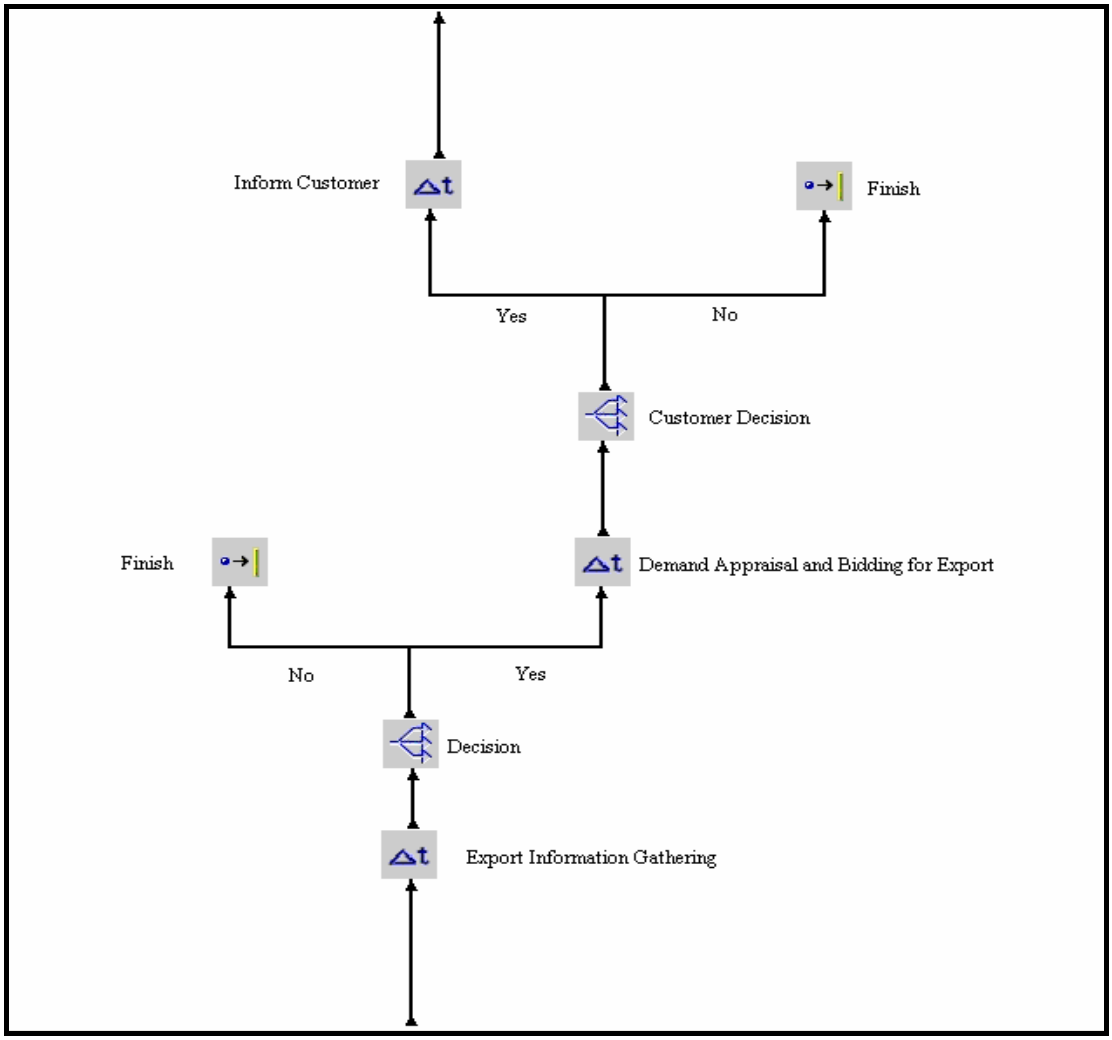

Figure A1. Activities of "*Demand Appraisal"* sub process

These activities include all the tasks performed in order to evaluate the load demands. The entities which are branched according to their type enter to this process. Export Information Gathering activity collects the information about the loads. After the Export Information Gathering activity, the entities are branched according to the decision of the Logistics Company. If the decision of the company is "yes" the loads are accepted. After the acceptance of loads they are appraised. Then the customer is contacted and their response is obtained. If the customer decision is also positive an agreement is accomplished and the customer is informed.

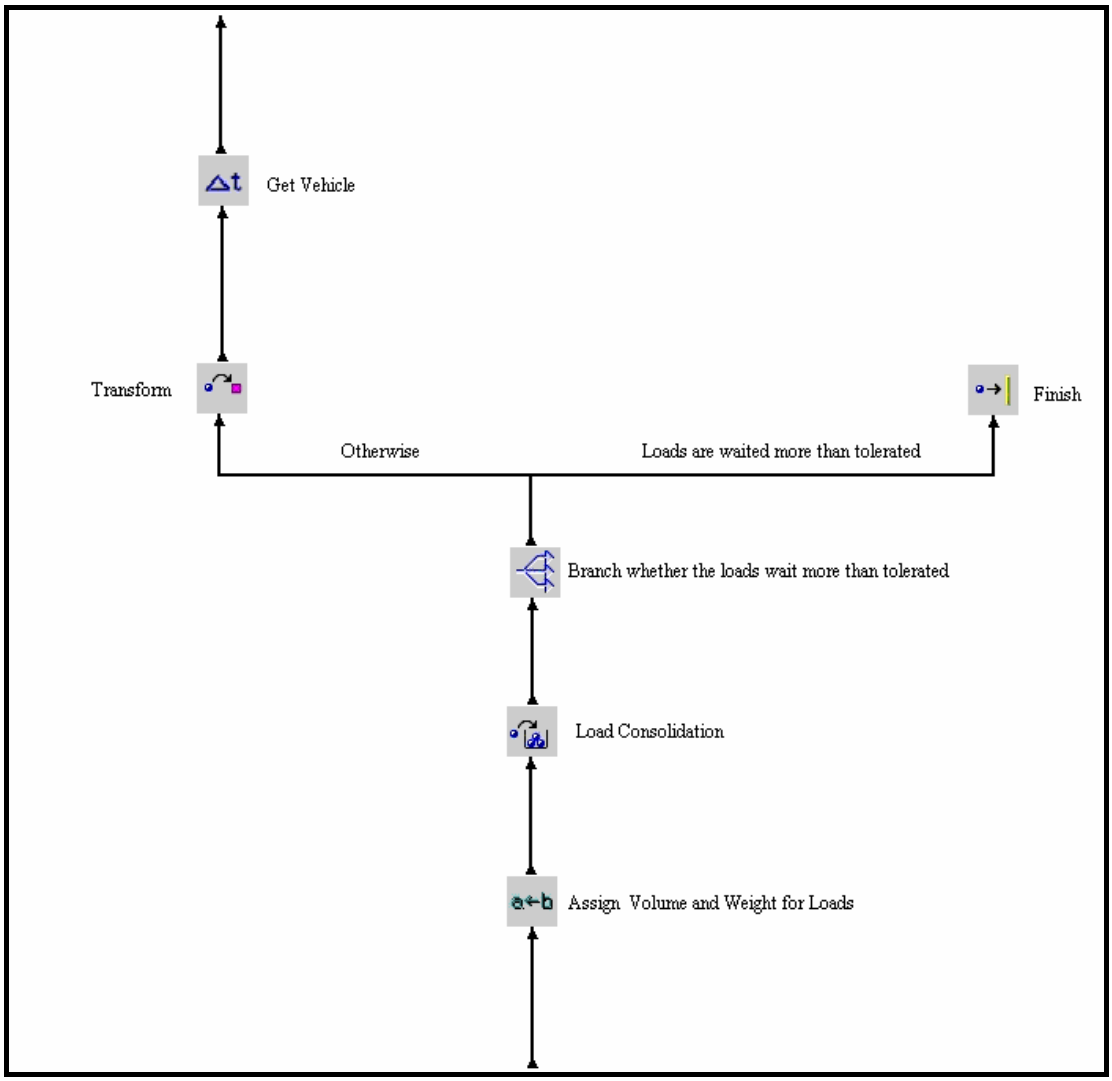

Figure A2. Activities of "*Load Consolidation and Getting Vehicle"* sub process

First of all the load information is assigned to the entities in this part of the model after the agreement is accomplished between the Logistics Company and the customer. Volumes and weights are assigned to the entities in this process of the model. Volume and weight values are assigned to the attributes of the entities. The loads are consolidated after the attribute definition is performed. Load Consolidation activity is performed according to the attributes of the entities reaching to the *Batch* activity of SIMPROCESS. After the *Batch* activity the entities are branched according to their waiting times in the system. If a load waits more than 1 week it finishes. If the loads are consolidated, the entity type changes by using *Transform* activity. After this point the entity is a vehicle with full of loads.

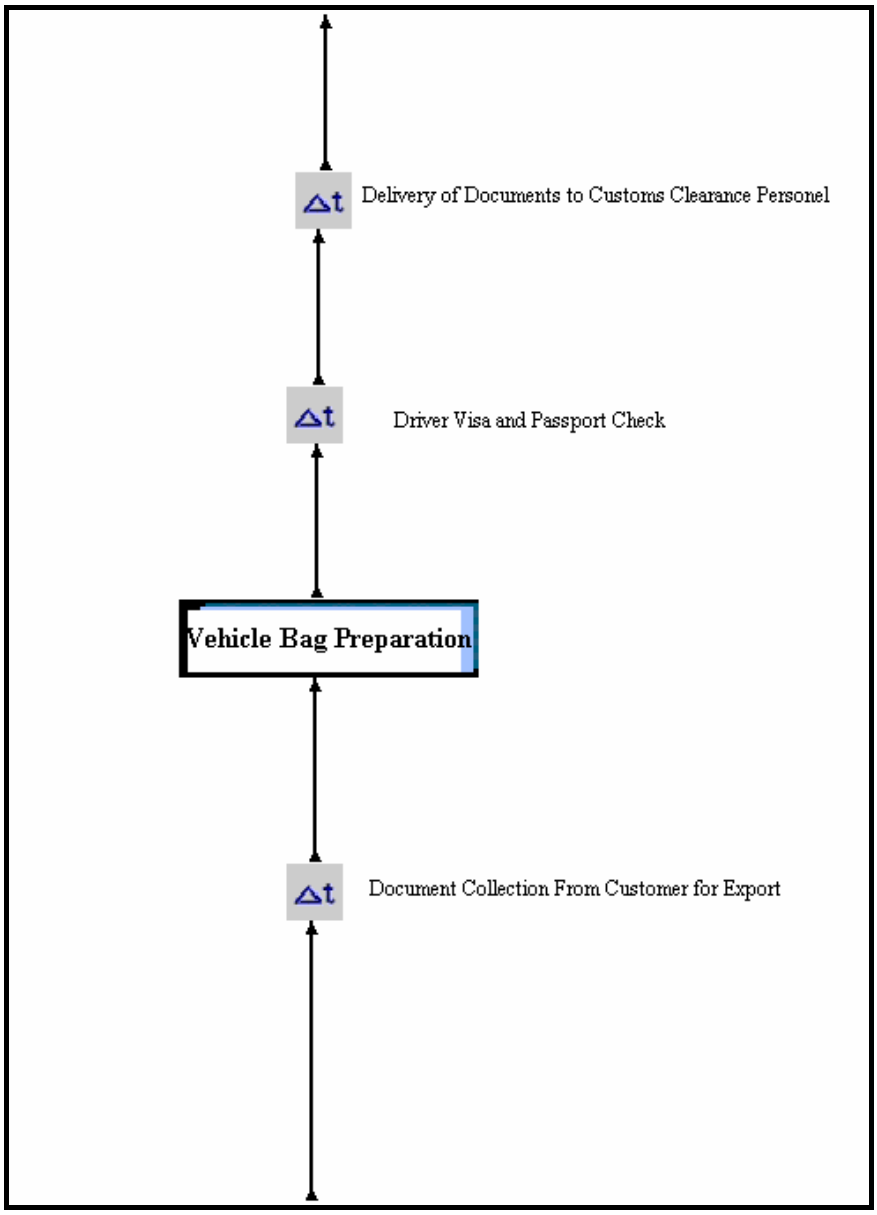

Figure A3. The activities of "*Document Preparation*" sub process

This sub process includes the activities of documents preparations. Fist of all, the information and documents are gathered form customers. After the information gathering the vehicle bag is prepared. "Vehicle Bag Preparation" is also a sub process. After the vehicle bag preparation the documents of vehicle driver are checked and all the documents are given to the Customs Clearance Personnel.

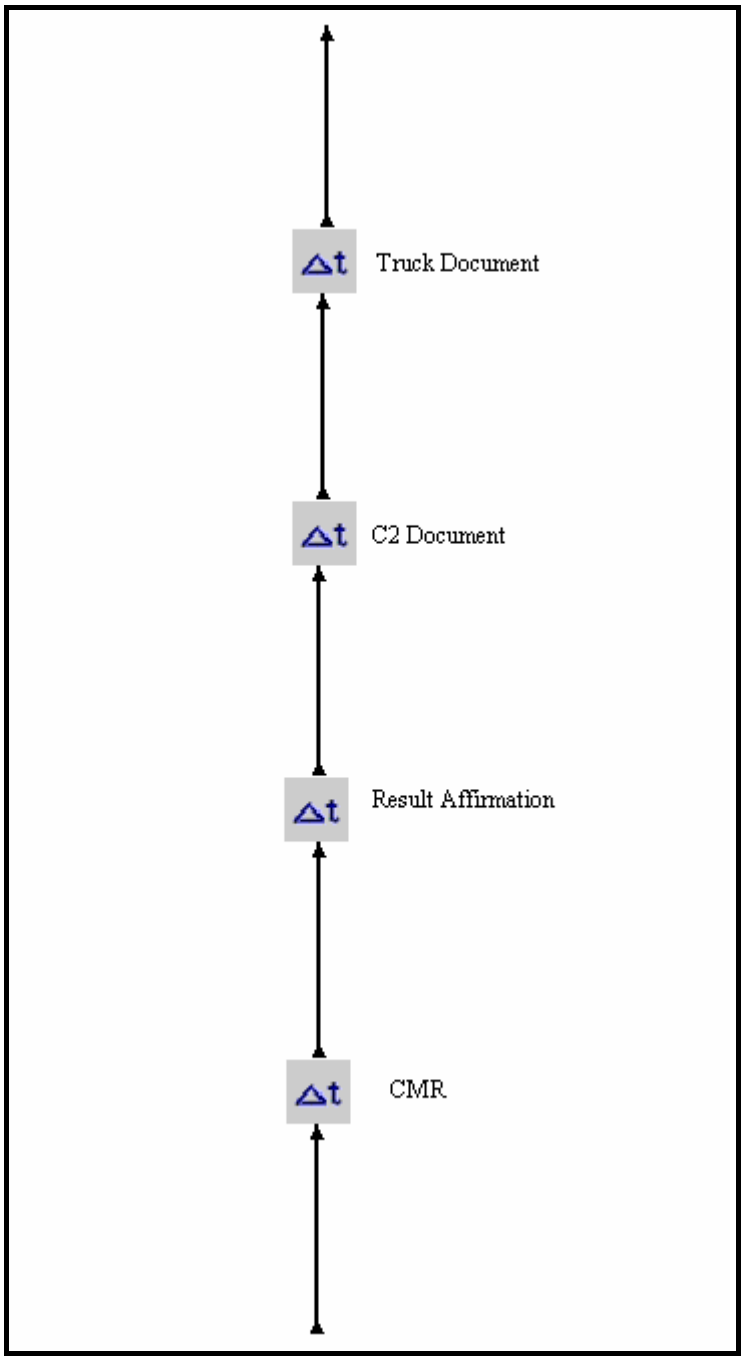

Figure A4. Activities of "*Vehicle Bag Preparation"* sub process

CMR, Result Affirmation, C2, and Vehicle Documents are prepared in this process of the model.

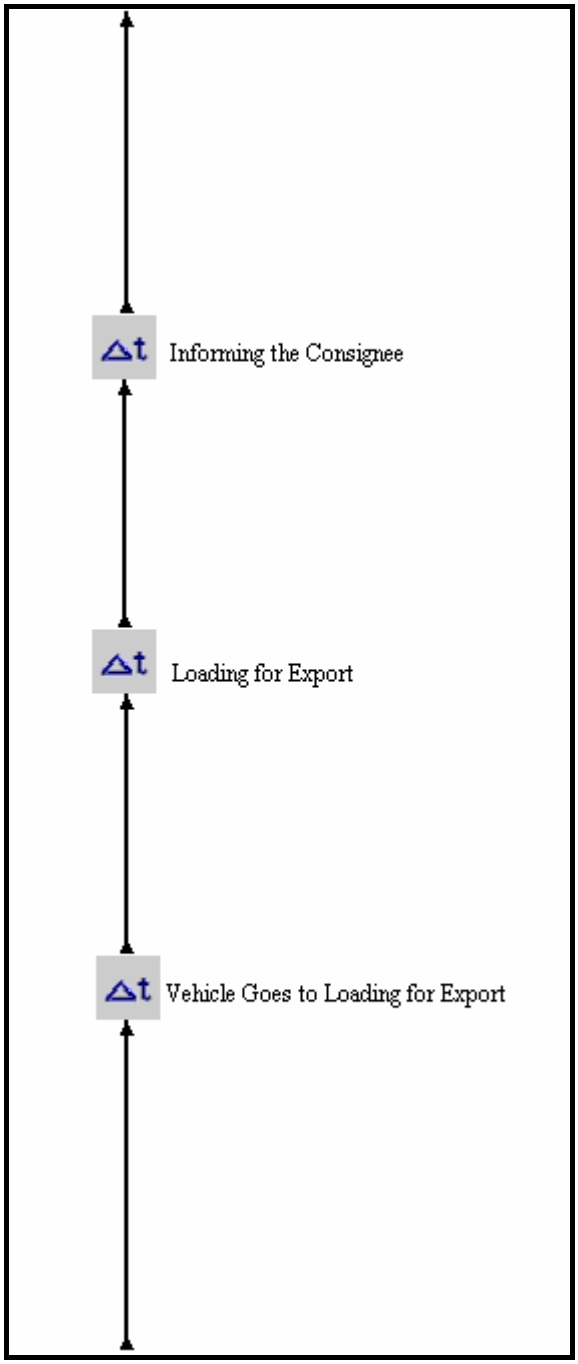

Figure A5. Activities of "*Vehicle Loading"* process

After the documents are prepared the loading of the loads are conducted in this process. Vehicles go to the customer in order to load the loads. After loading is completed the consignee is informed about the load.

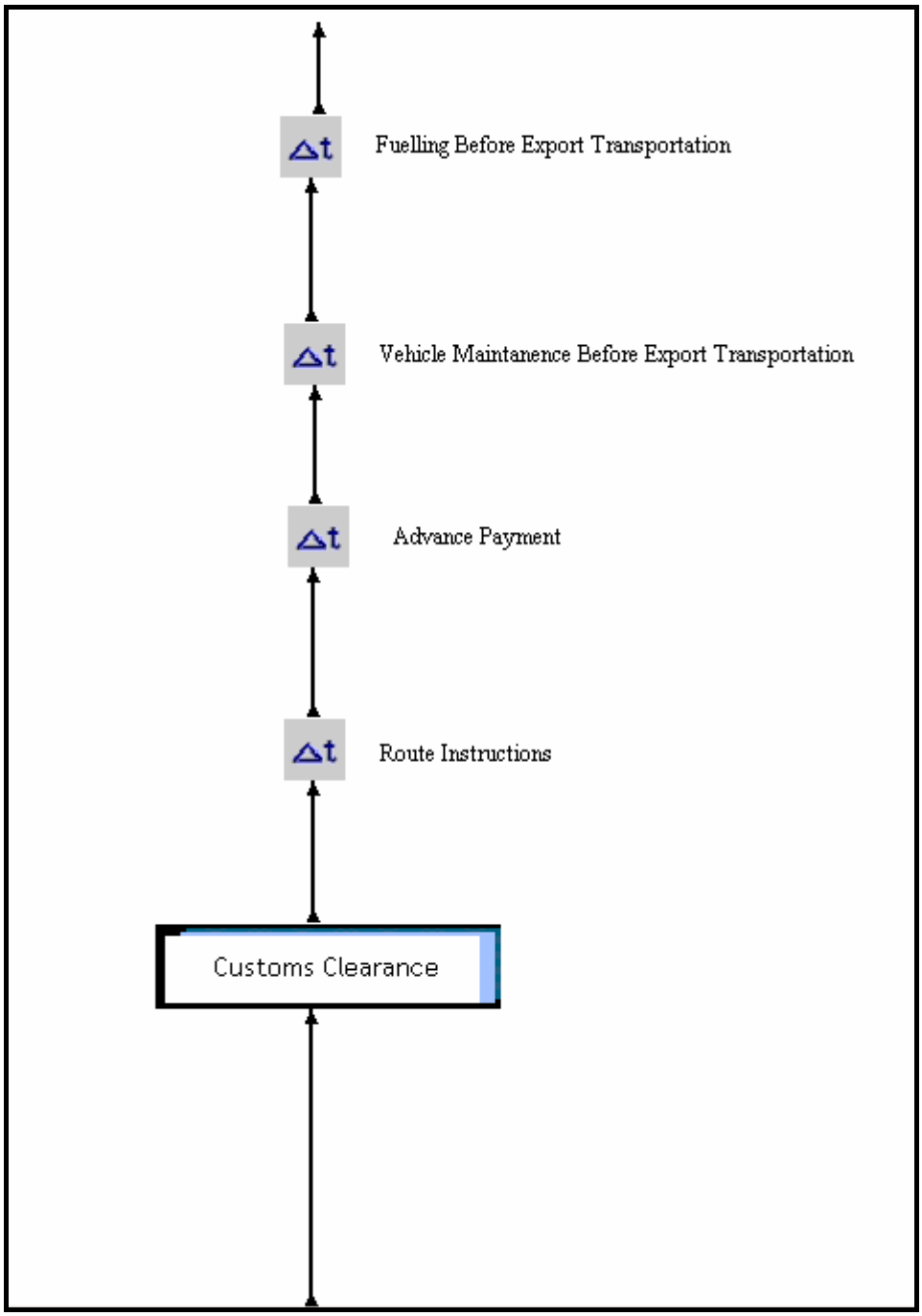

Figure A6. Activities of "*Customs Clearance and Vehicle Control Before Transportation"* sub process

The Customs Clearance process is conducted after the loading process. After the customs clearance activity the route instructions are given to the vehicle driver with his advance payment. The vehicles are checked one more time before the transportation and they are fuelled.

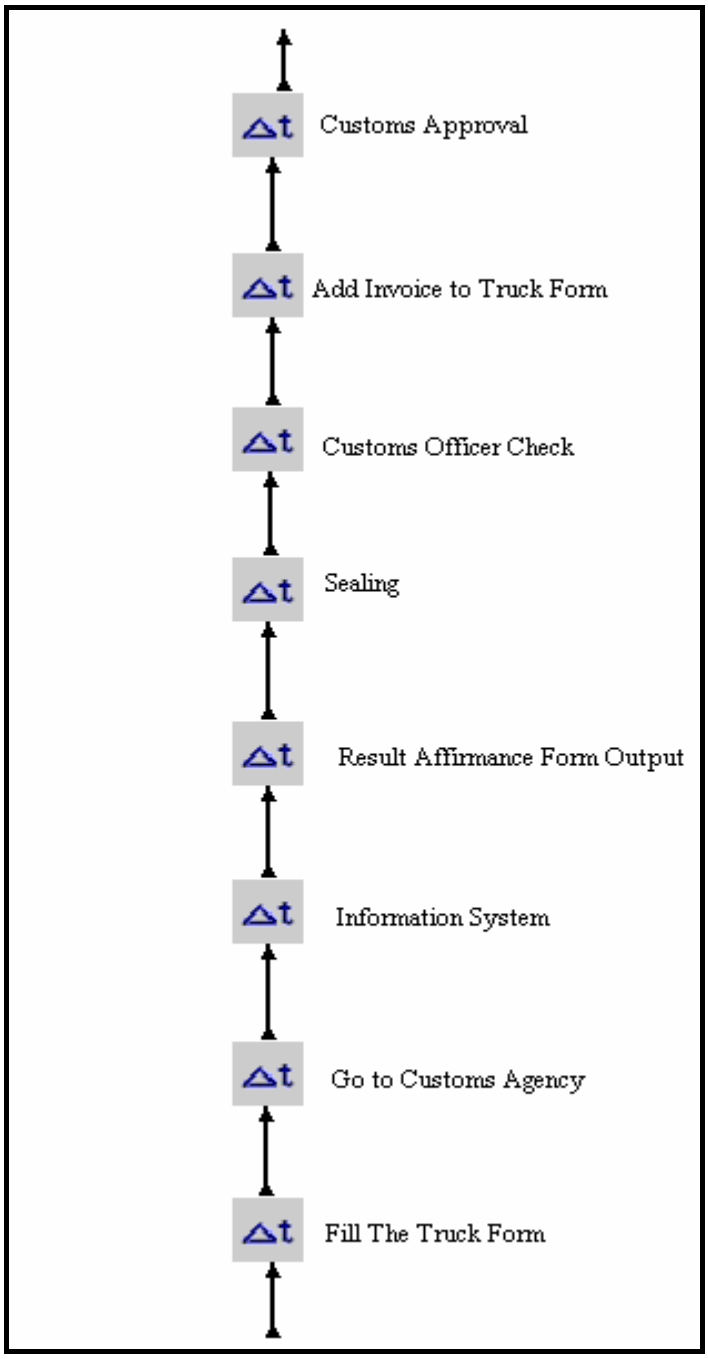

Figure A7. Activities of "*Customs Clearance"* sub process

In this process, the Customs Clearance requirements are accomplished. The sequence of the activities is given in the figure.

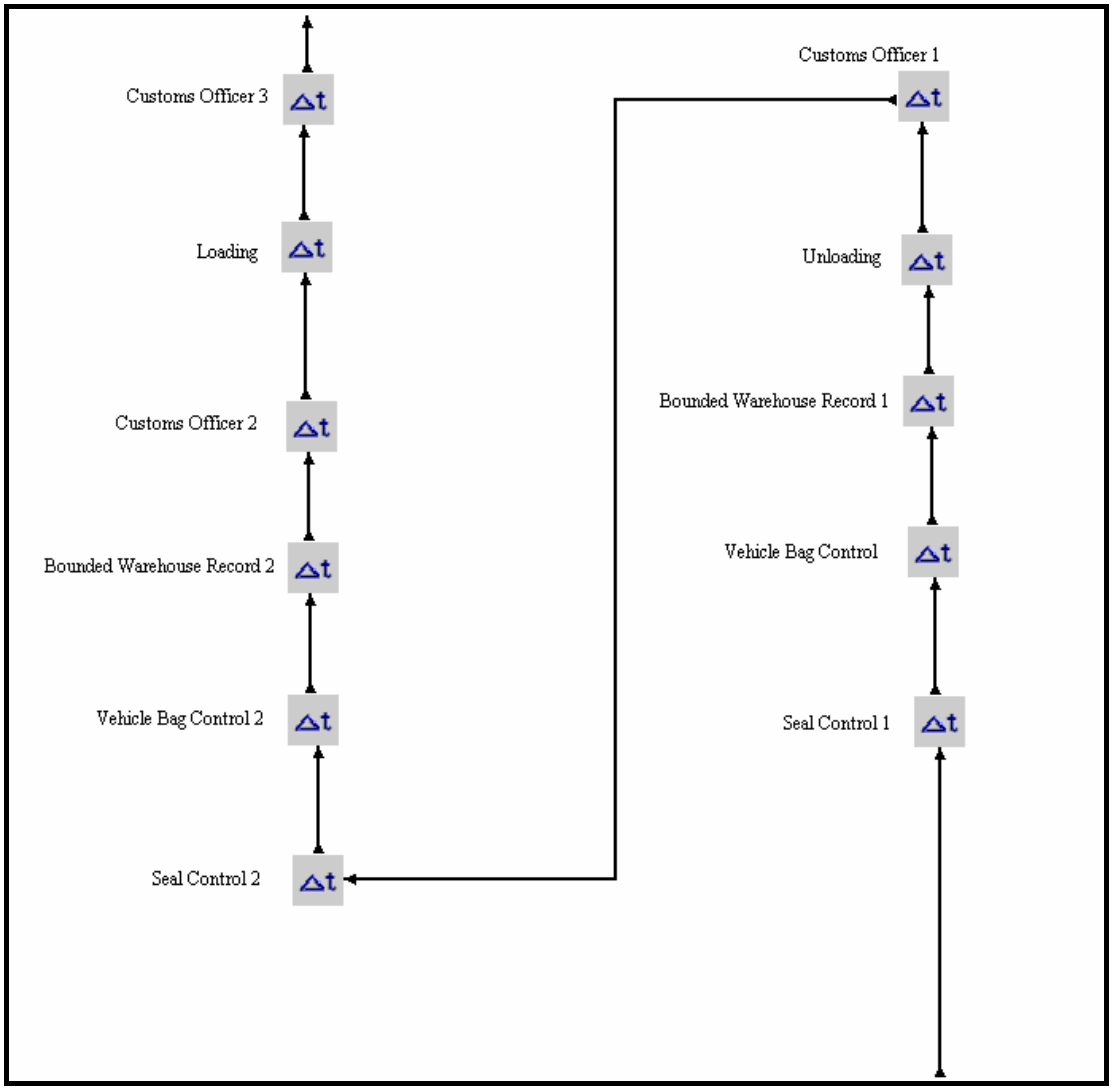

Figure A8. Activities of "*Bounded Warehouse"* sub process

In this process, the Bounded Warehouse requirements are accomplished. The sequence of the activities is given in the figure.

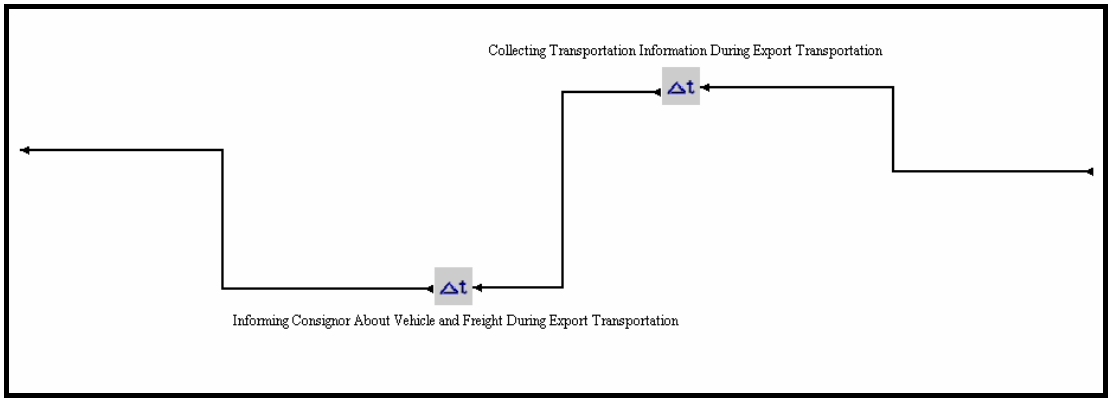

Figure A9. Activities of "*Transportation Information*" sub process

These activities are performed during the transportation and at the end of the transportation activities. The transportation information is gathered by the personnel located in the building of the company and the consignor is informed during the transportation.

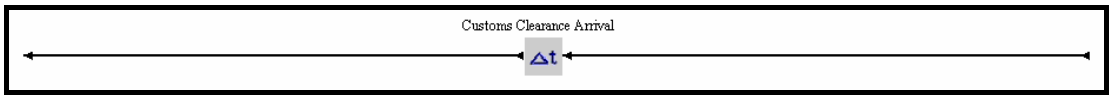

Figure A10. Activity of "*Customs Clearance Arrival*" sub process

This process includes only one activity. After the vehicles arrive to the destination country, the customs clearance activity is performed.

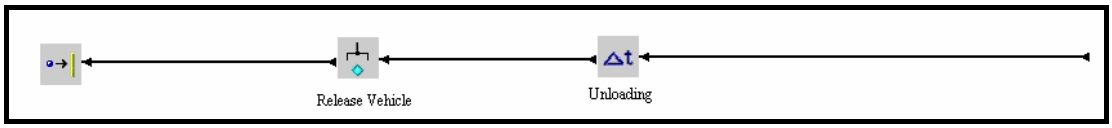

Figure A11. Activity of "*Unloading*" sub process

After the customs clearance is performed the vehicles are unloaded and the vehicles are released for any other transportation. The icon at the end of the process is used in order to finish the Export process

APPENDIX B

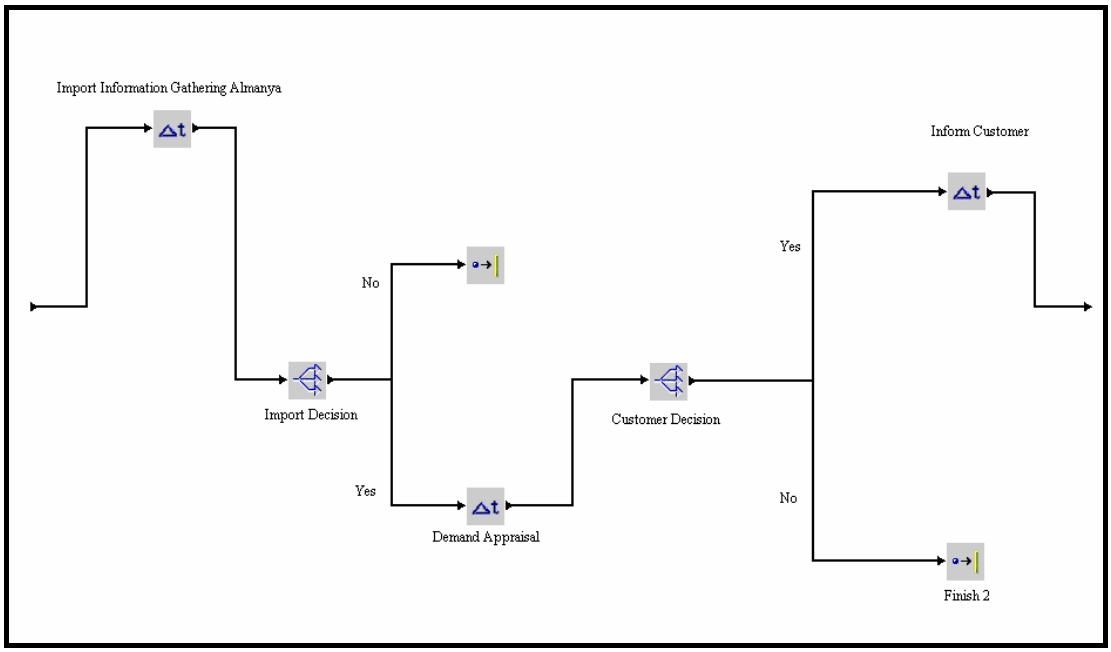

Figure B1. Activities of the "*Demands Appraisal"* sub process

These activities include all the tasks performed in order to evaluate the load demands. Import Information Gathering activity collects the information about the loads. After the Import Information Gathering activity, the entities are branched according to the decision of the Logistics Company. If the decision of the company is "yes" the loads are accepted. After the acceptance of loads they are appraised. Then the customer is contacted and their response is obtained. If the customer decision is also positive an agreement is accomplished and the customer is informed.

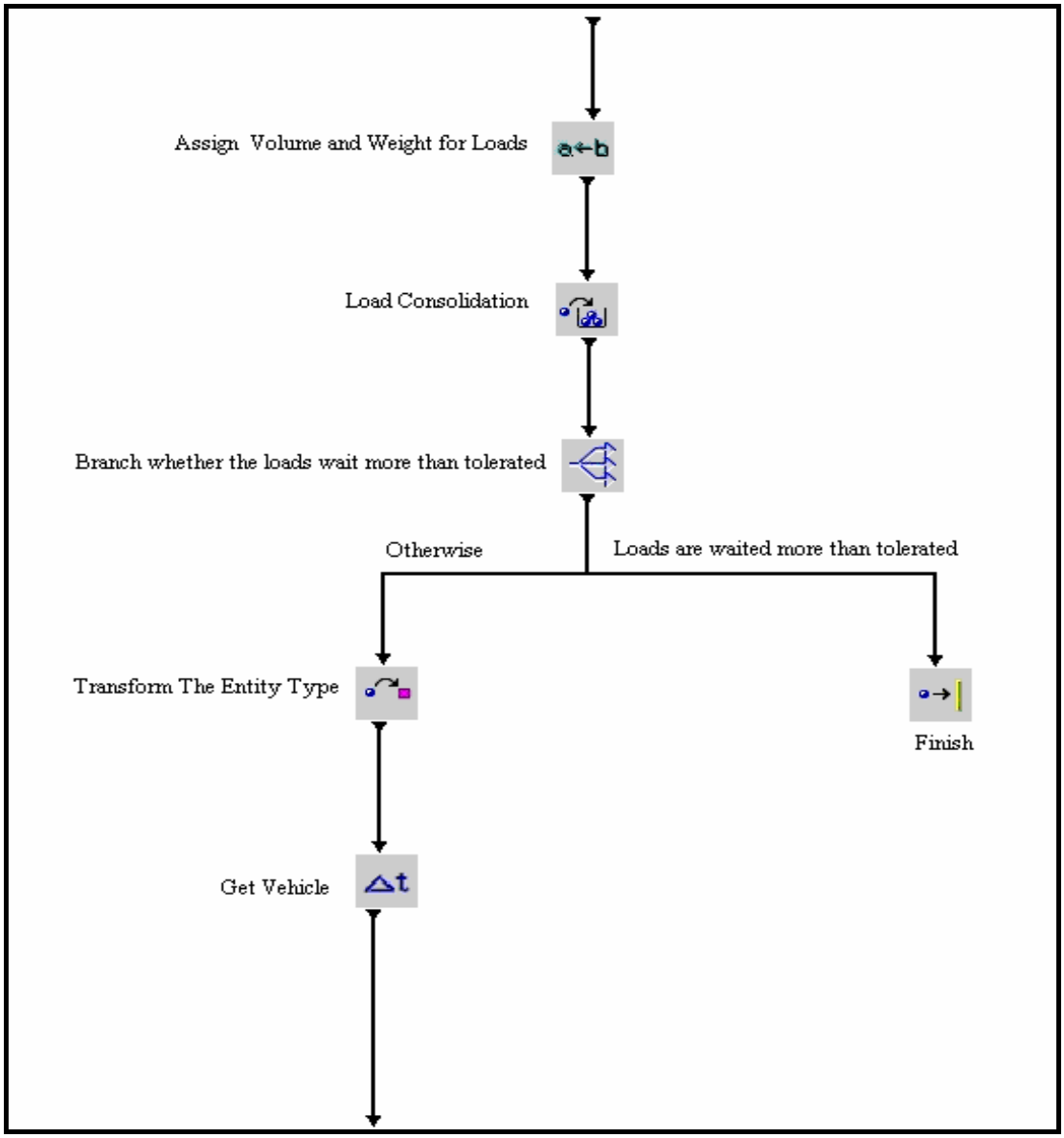

Figure B2. Activities of the "*Consolidation and Getting Vehicle"* sub process

First of all the load information is assigned to the entities in this part of the model after the agreement is accomplished between the Logistics Company and the customers. Volumes and weights are assigned to the entities in this process of the model. Volume and weight values are assigned to the attributes of the entities. The loads are consolidated after the attribute definition is performed. Load Consolidation activity is performed according to the attributes of the entities reaching to the Batch activity of SIMPROCESS. After the Batch activity, the entities are branched according to their waiting times in the system. If a load waits more than 1 week it is cancelled. If the loads are consolidated the entity type changes by using Transform activity. After this point the entity is a vehicle with full of loads.

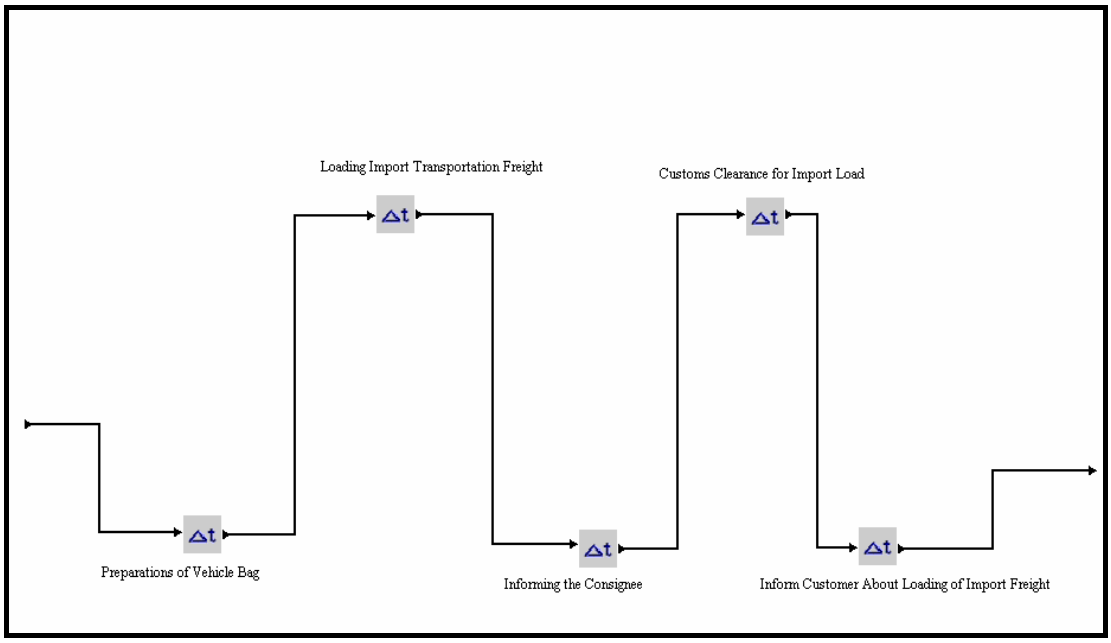

Figure B3. Activities of the "*Transportation Preparation, Loading and Customs Clearance"* sub process

After the loads are consolidated and the vehicle is got, the Vehicle Bag is prepared in this process. After the documents of the vehicle prepared the loading is conducted. After the loads are loaded to the vehicle the consignee is informed. At the end of this process the customs clearance is conducted and the vehicle start to transport.

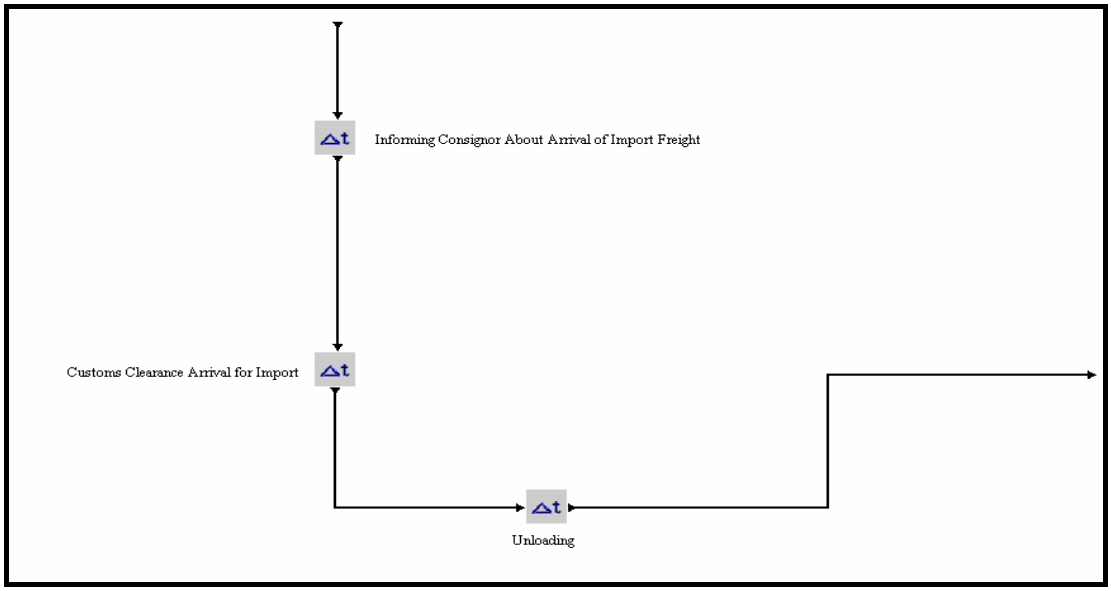

Figure B4. Activities inside the "*Customs Clearance Arrival and Unloading"* sub process

In this process, firstly consignor is informed about the load. Then, Customs Clearance Arrival activity is performed. After the customs clearance the loads are unloaded.

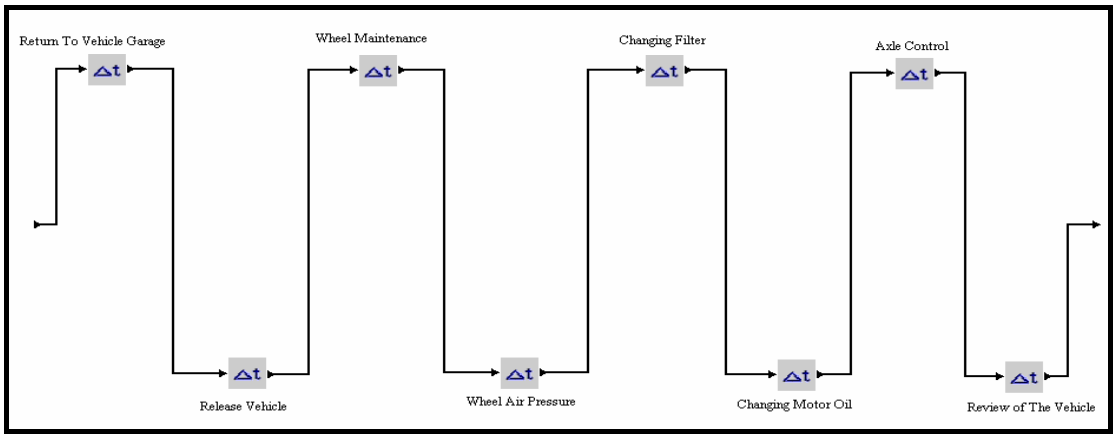

Figure B5. Activities inside the "*Vehicle Maintenance"* sub process

This process starts with the returning activity of the vehicles to the central building of the Logistics Company. When the vehicle returns to the central building garage the import entity and vehicle is released. After the release of the vehicle, maintenance is started. Wheel maintenance, Wheel Air Pressure, Filter Changing, Motor Oil Change, Axle Control and a general review of the vehicle is conducted. After the general review of the vehicle the driver accounts are calculated.

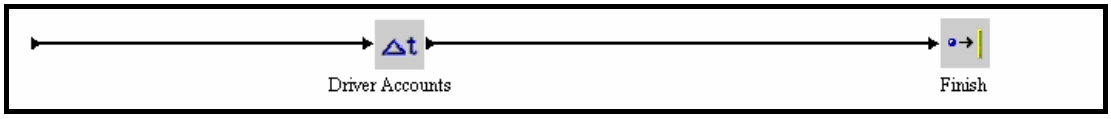

Figure B6. Activities inside the "*Driver Accounts"* sub process

This process starts with the Driver Accounts activity. This process is the end of import processes. It is also the end of export and import loop of the vehicles.

APPENDIX C

Table C1. Full list of the entities used in the simulation model

Belgium Export Load	Ireland Import Load	Pre Italy Export
Belgium Export Transportation	Ireland Import Transportation	Pre Italy Import
Belgium Import Load	Italy Export Load	Pre Norway Export
Belgium Import Transportation	Italy Export Transportation	Pre Norway Import
England Export Load	Italy Import Load	Pre Poland Export
England Export Transportation	Italy Import Transportation	Pre Poland Import
England Import Load	Norway Export Load	Pre Russia Export
England Import Transportation	Norway Export Transportation	Pre Russia Import
France Export Load	Norway Import Load	Pre Spain Export
France Export Transportation	Norway Import Transportation	Pre Spain Import
France Import Load	Poland Export Load	Pre Sweden Export
France Import Transportation	Poland Export Transportation	Pre Sweden Import
Greece Import Load	Poland Import Load	Pre Ukraine Export
Germany Export Load	Poland Import Transportation	Pre Ukraine Import
Germany Export Transportation	Pre Belgium Export	Russia Export Load
Germany Import Load	Pre Belgium Import	Russia Export Transportation
Germany Import Transportation	Pre England Export	Russia Import Load
Greece Export Load	Pre England Import	Russia Import Transportation
Greece Export Transportation	Pre France Export	Spain Export Load
Greece Import Transportation	Pre France Import	Spain Export Transportation
Holland Export Load	Pre Germany Export	Spain Import Load
Holland Export Transportation	Pre Germany Import	Spain Import Transportation
Holland Import Load	Pre Greece Export	Sweden Export Load
Holland Import Transportation	Pre Greece Import	Sweden Export Transportation
Iran Export Load	Pre Holland Export	Sweden Import Load
Iran Export Transportation	Pre Holland Import	Sweden Import Transportation
Iran Import Load	Pre Iran Export	Ukraine Export Load
Iran Import Transportation	Pre Iran Import	Ukraine Export Transportation
Ireland Export Load	Pre Ireland Export	Ukraine Import Load
Ireland Export Transportation	Pre Ireland Import	Ukraine Import Transportation

APPENDIX D

Table D1. Greece Export

Activity	Activity Duration	Resource Used	Predecessor
Export Information Gathering	Uni(10.0,15.0,1) Min	P7, P3	
Demand Appraisal and Bidding for Export	Uni(10.0,12.0,1) Min	P7, P3, P1, P2	Export Information Gathering
Inform Customers	Nor(15.0,1.0,1)Min	P7	Demand Appraisal and Bidding for Export
Consolidation and Getting Vehicle	Uni(10.0,15.0,1 Min	P1, P2, P3	Inform Customers
Document Collection from Customer for Export	Uni(5.0,10.0,1)Min	P4	Consolidation and Getting Vehicle
CMR, Result Affirmation, C2, and Vehicle Document Preparations	Uni(25.0,40.0,1) Min	P8 or P10	Document Collection From Customer for Export
Driver Visa and Passport Check	Nor(20.0,1.0,1) Min	P2, P3	CMR, Result Affirmation, C2, and Vehicle Document Preparations
Delivery of Documents to Customs Clearance Personnel	Uni(5.0,7.0,1) Min	P8	Driver Visa and Passport Check
Vehicle Goes to Loading for Export	15 Min	Vehicle	Delivery of Documents to Customs Clearance Personnel
Loading for Export	Uni(10.0,50.0,1) Min	Vehicle	Vehicle Goes to Loading for Export
Informing the Consignee	5 Min	P4	Loading for Export
Customs Clearance Activities	Uni(42.0,105.0,1) Min	P4	Informing the Consignee
Route Instructions	Nor(15.0,1.0,1) Min	P6 or P7	Customs Clearance Activities
Advance Payment	Uni(5.0,10.0,1) Min	P11	Route Instructions
Vehicle Maintenance Before Export Transportation	Uni(15.0,30.0,1) Min	Vehicle Maintenance Personnel	Advance Payment
Fuelling Before Export Transportation	Uni(10.0,30.0,1) Min	Vehicle Maintenance Personnel	Vehicle Maintenance Before Export Transportation
Transportation Activities for Each of the Export	Uni(1750.0,2000.0,1) / 60 km per hour	Vehicle	Fuelling Before Export Transportation
Collecting Transportation Information During Export Transportation	Uni(20.0,30.0,1) Min	P7, P3	Transportation Activities for Each of the Export
Informing Consignor About	Uni(15.0,20.0,1) Min	P7, P3	Collecting Transportation Information During Export

Vehicle and Freight During Export Transportation			Transportation
Customs Clearance Arrival of Export Transportation	Uni(5.0,15.0,1) Min	No resource	Informing Consignor About Vehicle and Freight During Export Transportation
Unloading	Uni(18.0,22.0,1) Hours	No resource	Customs Clearance Arrival of Export Transportation
Seal Control 1	Nor(10.0,1.0) Min	P4	Storage of loads
Vehicle Bag Control	Nor(10.0,1.0) Min	P4	Seal Control 1
Bounded Warehouse Record 1	Nor(15.0,1.0,1) Min	P4	Vehicle Bag Control
Unloading	Nor(50.0,10.0,1) Min	No resource	Bounded Warehouse Record 1
Customs Officer 1	Nor(10.0,1.0,1) Min	P4	Unloading
Seal Control 2	Nor(25.0,3.0,1) Min	P4	Customs Officer 1
Vehicle Bag Control 2	5 Min	P4	Seal Control 2
Bounded Warehouse Record 2	Uni(3.0,10.0,1) Min	P4	Vehicle Bag Control 2
Customs Officer 2	5 Min	P4	Bounded Warehouse Record 2
Loading	Uni(50.0,70.0,1) Min	No resource	Customs Officer 2
Customs Officer 3	15	P4	Loading

Table D2. Greece Import

Activity	Activity Duration	Resource Used	Predecessor
Import Information Gathering	Uni(10.0,20.0,1) Min	P5, P9	
Demand Appraisal and Bidding for Import	Nor(2.0,1.0,1) Min	P1, P2	Import Information Gathering
Inform Customer	Uni(1.0,2.0,1) Min	P9	Demand Appraisal and Bidding for Import
Consolidation and Getting Vehicle	15 Min	P1, P2, P3	Inform Customer
Preparations of Vehicle Bag	Nor(10.0,1.0) Min	P9	Consolidation and Getting Vehicle
Loading Import Transportation Freight	Uni(15.0,35.0,1) Hours	No resource	Preparations of Vehicle Bag
Informing the Consignee	10 Min	P5	Loading Import Transportation Freight
Customs Clearance for Import Load	Uni(30.0,40.0,1) Min	No resource	Informing the Consignee
Transportation Activities for Each of the Import Transportation Services	Uni(1750.0,2000.0,1) km / 60 km per hour	Vehicle	Customs Clearance for Import Load
Inform Customer About Loading of Import Freight	Nor(10.0,1.0,1) Min	P9	Transportation Activities for Each of the Import Transportation Services
Customs Clearance Arrival for Import	Uni(30.0,40.0,1) Min	No resource	Inform Customer About Loading of Import Freight
Unloading	Uni(2.0,3.0,1) Hours	No resource	Customs Clearance Arrival for Import
Return To Vehicle Garage	Uni(20.0,30.0,1) Min	Vehicle	Unloading
Wheel Maintenance	Uni(1.0,2.0,1) Hours	Vehicle Maintenance Personnel	Return To Vehicle Garage
Wheel Air Pressure	Uni(1.0,2.0,1) Hours	Vehicle Maintenance Personnel	Wheel Maintenance
Changing Filter	Nor(30.0,5.0,1) Minutes	Vehicle Maintenance Personnel	Wheel Air Pressure
Changing Motor Oil	Uni(30.0,40.0,1) Min	Vehicle Maintenance Personnel	Changing Filter
Axle Control	Uni(10.0,40.0,1) Min	Vehicle Maintenance Personnel	Changing Motor Oil
Review of The Vehicle	Uni(1.0,2.0,1) Hours	Vehicle Maintenance Personnel	Axle Control
Driver Accounts	Uni(15.0,20.0,1) Min	P8 or P10	Review of The Vehicle

Table D3. Italy Export

Activity	Activity Duration	Resource Used	Predecessor
Export Information Gathering	Uni(10.0,15.0,1) Min	P7, P3	
Demand Appraisal and Bidding for Export	Uni(30.0,40.0,1) Min	P7, P3, P1, P2	Export Information Gathering
Inform Customers	Nor(10.0,1.0,1)Min	P7	Demand Appraisal and Bidding for Export
Consolidation and Getting Vehicle	Uni(20.0,30.0,1 Min	P1 or P2	Inform Customers
Document Collection from Customer for Export	Uni(15.0,20.0,1)Min	P4	Consolidation and Getting Vehicle
CMR, Result Affirmation, C2, and Vehicle Document Preparations	Uni(20.0,40.0,1) Min	P8 or P10	Document Collection From Customer for Export
Driver Visa and Passport Check	Nor(50.0,5.0,1) Min	P2 or P3	CMR, Result Affirmation, C2, and Vehicle Document Preparations
Delivery of Documents to Customs Clearance Personnel	Uni(8.0,12.0,1) Min	P8	Driver Visa and Passport Check
Vehicle Goes to Loading for Export	15 Min	Vehicle	Delivery of Documents to Customs Clearance Personnel
Loading for Export	Uni(40.0,80.0,1) Min	Vehicle	Vehicle Goes to Loading for Export
Informing the Consignee	5 Min	P4	Loading for Export
Customs Clearance Activities	Uni(50.0,115.0,1) Min	P4	Informing the Consignee
Route Instructions	Nor(25.0,1.0,1) Min	P6 or P7	Customs Clearance Activities
Advance Payment	Uni(5.0,10.0,1) Min	P11	Route Instructions
Vehicle Maintenance Before Export Transportation	Uni(15.0,30.0,1) Min	Vehicle Maintenance Personnel	Advance Payment
Fuelling Before Export Transportation	Uni(10.0,30.0,1) Min	Vehicle Maintenance Personnel	Vehicle Maintenance Before Export Transportation
Transportation Activities for Each of the Export	Uni(2400.0,2800.0,1) km / 60 km per hour	Vehicle	Fuelling Before Export Transportation
Collecting Transportation Information During Export Transportation	Uni(20.0,30.0,1) Min	P7, P3	Transportation Activities for Each of the Export
Informing Consignor About Vehicle and Freight During Export Transportation	Uni(15.0,20.0,1) Min	P7, P3	Collecting Transportation Information During Export Transportation
Customs Clearance Arrival of Export Transportation	Uni(50.0,70.0,1) Min	No resource	Informing Consignor About Vehicle and Freight During Export Transportation

Unloading	Uni(15.0,25.0,1) Hours	No resource	Customs Clearance Arrival of Export Transportation
Seal Control 1	Nor(10.0,1.0) Min	P4	Storage of loads
Vehicle Bag Control	Nor(10.0,1.0) Min	P4	Seal Control 1
Bounded Warehouse Record 1	Nor(15.0,1.0,1) Min	P4	Vehicle Bag Control
Unloading	Nor(50.0,10.0,1) Min	No resource	Bounded Warehouse Record 1
Customs Officer 1	Nor(10.0,1.0,1) Min	P4	Unloading
Seal Control 2	Nor(25.0,3.0,1) Min	P4	Customs Officer 1
Vehicle Bag Control 2	5 Min	P4	Seal Control 2
Bounded Warehouse Record 2	Uni(3.0,10.0,1) Min	P4	Vehicle Bag Control 2
Customs Officer 2	5 Min	P4	Bounded Warehouse Record 2
Loading	Uni(50.0,70.0,1) Min	No resource	Customs Officer 2
Customs Officer 3	15	P4	Loading

Table D4. Italy Import

Activity	Activity Duration	Resource Used	Predecessor
Import Information Gathering	Uni(5.0,10.0,1) Min	P5, P9	
Demand Appraisal and Bidding for Import	Nor(15.0,20.0,1) Min	P5 or P9	Import Information Gathering
Inform Customer	Uni(1.0,2.0,1) Min	P9	Demand Appraisal and Bidding for Import
Consolidation and Getting Vehicle	15 Min	P1, P2, P3	Inform Customer
Preparations of Vehicle Bag	Nor(10.0,1.0) Min	P9	Consolidation and Getting Vehicle
Loading Import Transportation Freight	Uni(12.0,20.0,1) Hours	No resource	Preparations of Vehicle Bag
Informing the Consignee	5 Min	P5	Loading Import Transportation Freight
Customs Clearance for Import Load	20 Min	No resource	Informing the Consignee
Transportation Activities for Each of the Import Transportation Services	Uni(2400.0,2550.0,1) / 60 km per hour	Vehicle	Customs Clearance for Import Load
Inform Customer About Loading of Import Freight	Nor(10.0,1.0,1) Min	P9	Transportation Activities for Each of the Import Transportation Services
Customs Clearance Arrival for Import	Uni(30.0,40.0,1) Min	No resource	Inform Customer About Loading of Import Freight
Unloading	Uni(2.0,3.0,1) Hours	No resource	Customs Clearance Arrival for Import
Return To Vehicle Garage	Uni(20.0,30.0,1) Min	Vehicle	Unloading
Wheel Maintenance	Uni(1.0,2.0,1) Hours	Vehicle Maintenance Personnel	Return To Vehicle Garage
Wheel Air Pressure	Uni(1.0,2.0,1) Hours	Vehicle Maintenance Personnel	Wheel Maintenance
Changing Filter	Nor(30.0,5.0,1) Minutes	Vehicle Maintenance Personnel	Wheel Air Pressure
Changing Motor Oil	Uni(30.0,40.0,1) Min	Vehicle Maintenance Personnel	Changing Filter
Axle Control	Uni(10.0,40.0,1) Min	Vehicle Maintenance Personnel	Changing Motor Oil
Review of The Vehicle	Uni(1.0,2.0,1) Hours	Vehicle Maintenance Personnel	Axle Control
Driver Accounts	Uni(15.0,20.0,1) Min	P8 or P10	Review of The Vehicle

Table D5. Ukraine Export

Activity	Activity Duration	Resource Used	Predecessor
Export Information Gathering	Uni(5.0,10.0,1) Min	P7 or P3	
Demand Appraisal and Bidding for Export	Uni(15.0,20.0,1) Min	P1 or P2	Export Information Gathering
Inform Customers	Nor(20.0,1.0,1)Min	P7	Demand Appraisal and Bidding for Export
Consolidation and Getting Vehicle	Uni(20.0,30.0,1) Min	P1 or P2	Inform Customers
Document Collection from Customer for Export	Uni(40.0,50.0,1)Min	P4	Consolidation and Getting Vehicle
CMR, Result Affirmation, C2, and Vehicle Document Preparations	Uni(20.0,40.0,1) Min	P8 or P10	Document Collection From Customer for Export
Driver Visa and Passport Check	Nor(20.0,5.0,1) Min	P2 or P3	CMR, Result Affirmation, C2, and Vehicle Document Preparations
Delivery of Documents to Customs Clearance Personnel	Uni(2.0,3.0,1) Min	P8	Driver Visa and Passport Check
Vehicle Goes to Loading for Export	Uni(10.0,15.0,1) Min	Vehicle	Delivery of Documents to Customs Clearance Personnel
Loading for Export	Uni(40.0,50.0,1) Min	Vehicle	Vehicle Goes to Loading for Export
Informing the Consignee	15 Min	P4	Loading for Export
Customs Clearance Activities	Uni(37.0,90.0,1) Min	P4	Informing the Consignee
Route Instructions	Nor(8.0,1.0,1) Min	P6 or P7	Customs Clearance Activities
Advance Payment	Uni(5.0,10.0,1) Min	P11	Route Instructions
Vehicle Maintenance Before Export Transportation	Uni(15.0,30.0,1) Min	Vehicle Maintenance Personnel	Advance Payment
Fuelling Before Export Transportation	Uni(10.0,30.0,1) Min	Vehicle Maintenance Personnel	Vehicle Maintenance Before Export Transportation
Transportation Activities for Each of the Export	Uni(2600.0,2900.0,1) km / 60 km per hour	Vehicle	Fuelling Before Export Transportation
Collecting Transportation Information During Export Transportation	Uni(20.0,30.0,1) Min	P7, P3	Transportation Activities for Each of the Export
Informing Consignor About Vehicle and Freight During Export Transportation	Uni(5.0,10.0,1) Min	P7, P3	Collecting Transportation Information During Export Transportation
Customs Clearance Arrival of Export Transportation	Uni(5.0,15.0,1) Min	No resource	Informing Consignor About Vehicle and Freight During Export

			Transportation
Unloading	Uni(16.0,20.0,1) Hours	No resource	Customs Clearance Arrival of Export Transportation
Seal Control 1	Nor(10.0,1.0) Min	P4	Storage of loads
Vehicle Bag Control	Nor(10.0,1.0) Min	P4	Seal Control 1
Bounded Warehouse Record 1	Nor(15.0,1.0,1) Min	P4	Vehicle Bag Control
Unloading	Nor(50.0,10.0,1) Min	No resource	Bounded Warehouse Record 1
Customs Officer 1	Nor(10.0,1.0,1) Min	P4	Unloading
Seal Control 2	Nor(25.0,3.0,1) Min	P4	Customs Officer 1
Vehicle Bag Control 2	5 Min	P4	Seal Control 2
Bounded Warehouse Record 2	Uni(3.0,10.0,1) Min	P4	Vehicle Bag Control 2
Customs Officer 2	5 Min	P4	Bounded Warehouse Record 2
Loading	Uni(50.0,70.0,1) Min	No resource	Customs Officer 2
Customs Officer 3	15	P4	Loading

Table D6. Ukraine Import

Activity	Activity Duration	Resource Used	Predecessor
Import Information Gathering	Uni(2.0,3.0,1) Min	P5, P9	
Demand Appraisal and Bidding for Import	Uni(1.0,2.0,1) Min	P9	Import Information Gathering
Inform Customer	Uni(5.0,15.0,1) Min	P9	Demand Appraisal and Bidding for Import
Consolidation and Getting Vehicle	Nor(25.0,3.0,1) Min	P1or P2	Inform Customer
Preparations of Vehicle Bag	Nor(10.0,1.0) Min	P9	Consolidation and Getting Vehicle
Loading Import Transportation Freight	Uni(7.0,12.0,1) Hours	No resource	Preparations of Vehicle Bag
Informing the Consignee	5 Min	P5	Loading Import Transportation Freight
Customs Clearance for Import Load	Nor(10.0,1.0)	No resource	Informing the Consignee
Transportation Activities for Each of the Import Transportation Services	Uni(2750.0,2950.0,1) km / 60 km per hour	Vehicle	Customs Clearance for Import Load
Inform Customer About Loading of Import Freight	Nor(10.0,1.0,1) Min	P9	Transportation Activities for Each of the Import Transportation Services
Customs Clearance Arrival for Import	Uni(30.0,40.0,1) Min	No resource	Inform Customer About Loading of Import Freight
Unloading	Uni(2.0,3.0,1) Hours	No resource	Customs Clearance Arrival for Import
Return To Vehicle Garage	Uni(20.0,30.0,1) Min	Vehicle	Unloading
Wheel Maintenance	Uni(1.0,2.0,1) Hours	Vehicle Maintenance Personnel	Return To Vehicle Garage
Wheel Air Pressure	Uni(1.0,2.0,1) Hours	Vehicle Maintenance Personnel	Wheel Maintenance
Changing Filter	Nor(30.0,5.0,1) Minutes	Vehicle Maintenance Personnel	Wheel Air Pressure
Changing Motor Oil	Uni(30.0,40.0,1) Min	Vehicle Maintenance Personnel	Changing Filter
Axle Control	Uni(10.0,40.0,1) Min	Vehicle Maintenance Personnel	Changing Motor Oil
Review of The Vehicle	Uni(1.0,2.0,1) Hours	Vehicle Maintenance Personnel	Axle Control
Driver Accounts	Uni(15.0,20.0,1) Min	P8 or P10	Review of The Vehicle