INVITED PAPER

INTERMODAL FREIGHT TERMINALS: TERMINAL HANDLING COSTS

Bart W. WIEGMANS[1], Peter NIJKAMP[2] and Enno MASUREL[3]

[1] Economic and Social Institute, Vrije University Amsterdam, The Netherland
[2] Department of Spatial Economics, Vrije University Amsterdam, The Netherland
[3] Economic and Social Institute, Vrije University Amsterdam, The Netherland

SUMMARY

The main purpose of this paper is to identify the terminal handling cost structure. In particular, its aim is to investigate whether the Activity Based Costing (ABC) approach offers a better perspective for assessing and allocating the costs of freight terminals. In this framework, our objective is also to learn about the sales performance of mainly large container terminals. The specific problem addressed here is as follows: To what extent is the Activity Based Costing approach useful for terminal operators in order to be able to charge its customers a fair and cost-oriented price? The activities performed at an intermodal freight terminal –the topic of this paper- are focussed on handling (loading, discharging, and transhipping) and storage of containerised cargo. Supportive activities (e.g. administration, customs) are taken into account as well. The conclusion of this paper is that Activity Based Costing is a useful tool for both terminal operators and customers to provide more insight into terminal resource use: cost dividing and price charging can be executed more appropriately. Clearly, besides the terminal handling costs, other factors influence the price charged per container.

1. INTRODUCTION

It is often claimed that prices per handling imposed by freight terminals are high. The intermodal freight terminals do not provide cost figures to justify these high handling prices. Several general backgrounds suggest that terminal service charges are not exceptionally expensive:

1. Average financial results of terminal operators in general (in the Netherlands) are not extremely high (average 5,1% of terminal sales)
2. The terminal handling may be expensive, but the total cost figure of the combined transport channel as a whole is far more important. Therefore, it is more important to look at terminal service charges from a marketing channel perspective
3. The price/quality ratio is not well balanced. Terminals may provide their customers with much more quality and clear cost figures to justify their terminal handling prices.

Intermodal freight terminal operators may be very suitable to combine interfaces, transport carriers, shipping companies, producers, and intermediaries into well-organised and well-equipped marketing channels in order to realise scale economies in the combined transport market. The resulting quality of these networks is generally perceived to depend for a large part on the quality of the interfaces (intermodal freight terminals). Terminal service quality may be looked upon three perspectives (Hilferink, 1994); I) Customer-oriented; II) Network-oriented; III) Production-oriented. In this paper we concentrate on the customer.

Generally, the objectives of terminal operators are stated as cost minimisation/profit maximisation, capacity oriented, and realising political goals (e.g. environment, enhancement of status and role). As yet not much specialisation can be found in the freight terminal market (e.g. in the form of for instance segmentation by groups of goods or geographic regions) (Wiegmans, 1999). Usually terminal operators are not extensively informed about their customers, and therefore offer a broad package of functions for the sake of risk-spreading and widening the operating base (many potential customers). However, freight terminals must be positioned so that they can provide, or form part of, the desired level of service at the least total channel costs.

It is important to note here that the least-cost solution is unique for each organisation, because of differences in customer service standards, inventory costs, physical transport costs, and other logistic costs (Bowersox, 1986). There is no need to have the lowest transport cost or terminal cost, but central attention should be paid to lowest total marketing channel cost. Much of the

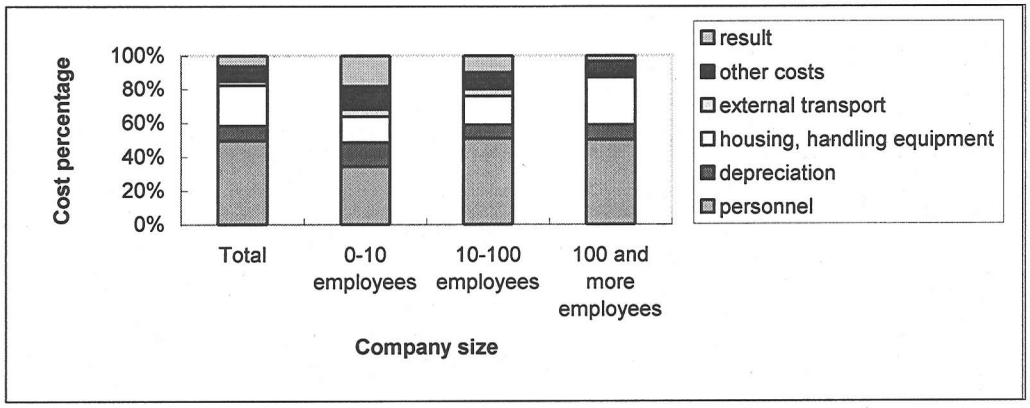

Figure 2.1. Cost structure according to terminal employee size for 1997.
Source: adapted from http://statline.cbs.nl, September 1998

current research on freight transport is based on a comparison between different transport modes and their related (dis)advantages. In this paper we will focus on combined transport solutions, including the use of freight terminals. The main purpose of this paper is to identify the terminal handling cost structure and to find out if the Activity Based Costing (abc) approach offers a better perspective on the costs of terminals.

Is the Activity Based Costing approach useful for terminal operators in order to be able to charge its customers a fair and cost-oriented price?

At an intermodal freight terminal the single most important activity is handling of containers, whereas the secondary function is storage. This primary function of a freight terminal can be divided into different parts: loading, discharging, and direct transhipment of containers. *Transhipment* is the discharging of a Transport Unit (TU) directly followed by the loading of the TU onto another transport mean. *Discharging* is the unloading of a TU followed by the temporary storage (usually the first seven days of storage are free of charge) of the TU at the terminal, which is followed by loading the TU on another transport mean for further transport. Finally, *loading* is loading the TU on a transport means for further transport. This is always preceded by discharging and temporary storage. In general, handling of containers can not be avoided but it should be minimised to the maximum extent possible. The activities performed at the intermodal freight terminal –we are taking account of in this paper- are focussed on handling (loading, discharging, and transhipping) and storage of containerised cargo. Supportive activities (e.g. administration, customs) are taken into account as well.

The remainder of this paper is divided into four sections. Section two will describe the current terminal handling cost structure based on general numbers about the freight terminal sector in the Netherlands and based on specific numbers about small container terminals. Section three then deals with costing theories and Activity Based Costing in particular. Next, the fourth section discusses the interaction between three intermodal freight terminals and Activity Based Costing. The final section contains the conclusion of this paper.

2. CURRENT TERMINAL HANDLING COST STRUCTURE

(1) Terminal Cost Structure

In this section we will take the Dutch case as a framework of reference. Research by the Dutch CBS (1998) shows some interesting results for the overall loading, discharging and transhipment industry in the Netherlands. Various kinds of terminals (e.g. coal, grain, containers, fruit, etc.) are included in this sector. In **Figure 2.1** the cost structure according to terminal employee size is depicted for three categories. It shows that if the terminal size increases, the financial result decreases. The importance of the categories "other costs" and "external transport costs" decreases, if the terminal size increases. Especially the housing and handling equipment shows a major increase if the terminal size grows. The developments for depreciation costs and personnel costs are somewhat mixed.

In **Figure 2.2** the key performances indicators per employee are depicted according to terminal size. Sales per employee increase if the terminal grows in size. The costs per employee increase relatively more with terminal size, which results in a decrease in profits per employee.

In **Figure 2.3** cost percentages and cost structure are depicted according to terminal size. The importance of other costs and external transport costs decreases also relative to growing terminal size. Costs for housing and handling equipment increase considerably with larger terminals. The personnel costs show a mixed development.

From **Figure 2.3** it follows that almost all terminal costs consist of personnel and housing and handling equipment (including depreciation).

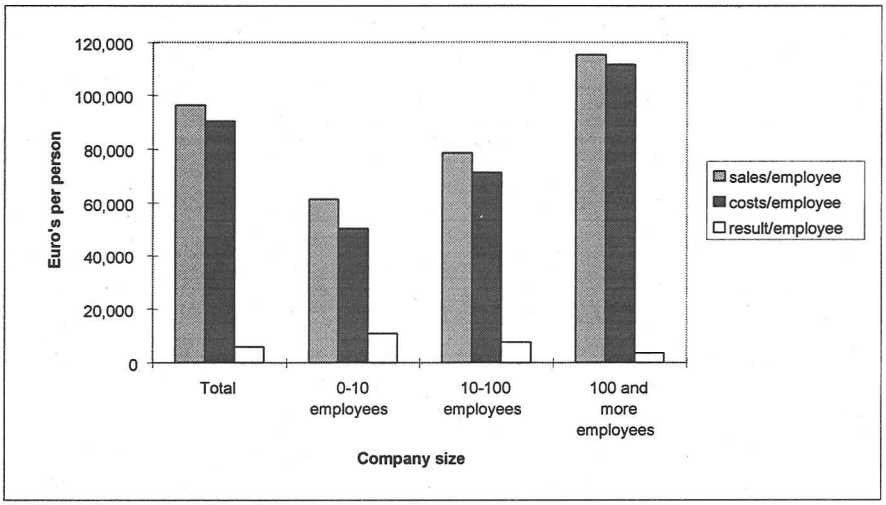

Figure 2.2. Key performance per employee according to terminal size in 1997.
Source: http://statline.cbs.nl, September 1998

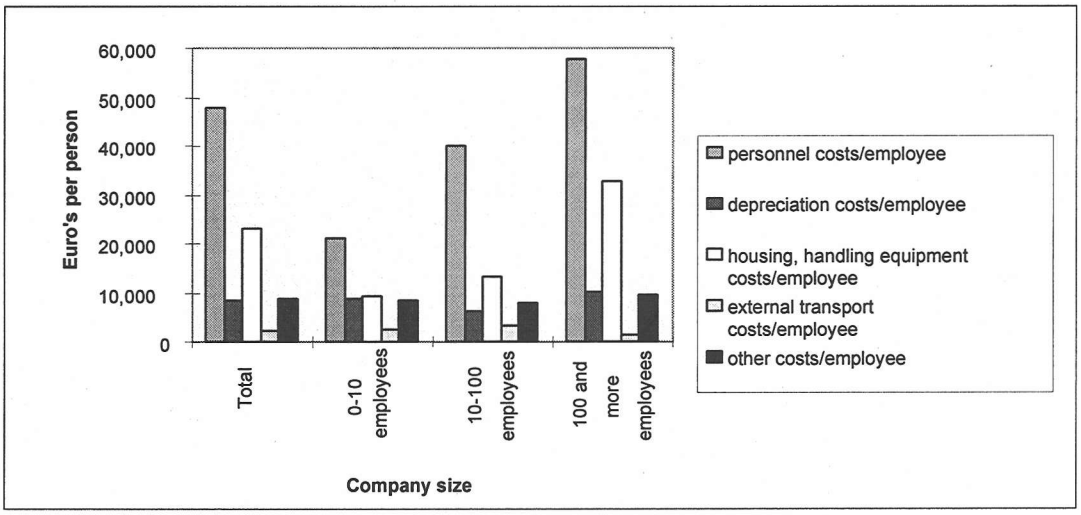

Figure 2.3. Performance per employee according to terminal size in 1997.
Source: http://statline.cbs.nl, September 1998

(2) Terminal handling costs of small terminals

In this subsection we will concentrate on relatively small container terminals. Research of small container terminals by the TU Delft (1995) is used to look in detail into the cost structure. In this context small is defined as handling 2,500 (and less) - 20,000 containers per year. Two small terminals are chosen out of eight cases to illustrate the small container terminal cost structure. The amounts are changed from guilders to Euro's (http://www.statistics.dnb.nl, 1998) and adapted to 1997 price-levels. **Table 2.1** shows a small terminal with 5,000 handlings and **Table 2.2** shows a small terminal with 20,000 handlings.

These two tables give useful insights into the costs structure of small container terminals. From these tables we may derive some conclusions. Firstly, the amounts are quite low. Secondly, Capital costs are missing. Thirdly, the management fee is missing. Fourthly, general costs are higher than presented here. Finally, taxation is not taken into account. If we then use the eight cases to build a general view on small container terminals, we are able to provide the following figures on costs per handling and the ratio variable/investment costs.

Table 2.1 Yearly cost (1997) of a terminal 5,000 handlings, 10,000 moves (adapted from TU delft, 1995)

Cost Category	*Amount (ε)*	*Percentage*
1. Investment cost		
a. heavy VHT, old	ε33,094	34%
b. fork lift truck	ε 0	0%
c. crane rails 100m	ε 0	0%
d. quay construction 100m	ε 49,248	50%
e. pavements 3,333m2	ε 11,818	12%
f. lightning 3,333 m2	ε 1,891	2%
g. office 25 m2	ε 1,773	2%
h. rest	ε 236	0%
Total	ε 98,061	100%
2. Variable costs		
a. wages (2 persons)	ε 70,917	39%
b. maintenance	ε 14,183	8%
c. energy	ε 4,728	3%
d. rent	ε 15,759	9%
e. communication	ε 7,092	4%
f. rent mobile crane	ε 70,917	39%
Total	ε 183,595	100%

Table 2.2 Yearly cost (1997) of a terminal 20,000 handlings, 40,000 moves (adapted from TU delft, 1995)

Cost Category	*Amount (ε)*	*Percentage*
1. Investment cost		
a. containercrane, new	ε 141,833	44%
b. heavy fork lift truck, new	ε 56,733	18%
c. crane rails 100m	ε 13,789	4%
d. quay construction 100m	ε 49,248	15%
e. pavements 13,333m2	ε 47,277	15%
f. lightning 13,333 m2	ε 7,564	2%
g. office 50 m2	ε 3,546	1%
h. rest	ε 236	1%
Total	ε 320,227	100%
2. Variable costs		
a. wages (4 persons)	ε 141,833	49%
b. maintenance	ε 37,822	13%
c. energy	ε 18,911	7%
d. rent	ε 63,037	22%
e. communication	ε 28,367	10%
f. rent mobile crane	ε 0	0%
g. rest	ε 0	0%
Total	ε 289,970	100%

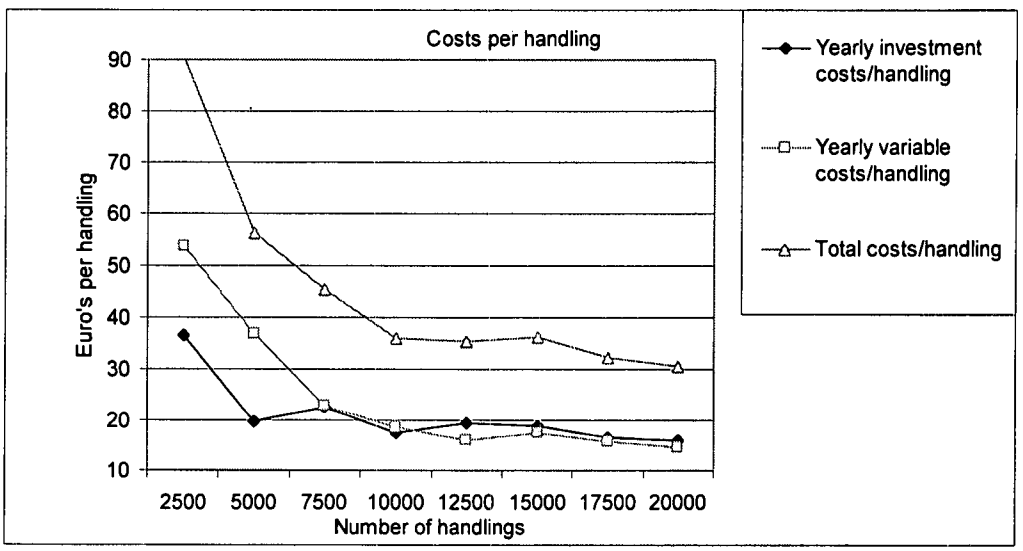

Figure 2.4 Costs per handling in Euro's (€)
Source: adapted from TU delft, 1995

We observe a decrease in costs per handling as the number of handlings increase from 2,500 per year to 20,000 per year. Average total costs per handling range from € 30-40.

The ratio variable/investment costs is around 50 per cent for all small terminals.

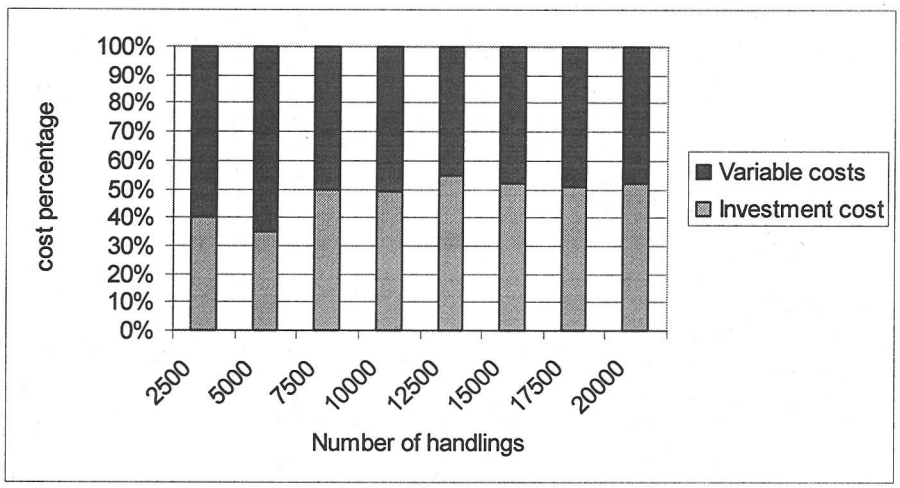

Figure 2.5 Variable and Investment cost percentages and number of handlings per year
Source: adapted from TU delft, 1995

(3) Conclusion

Research by the Dutch CBS (1998) shows some interesting results for the overall loading, discharging and transhipment sector in the Netherlands. From this research it follows that if the terminal size increases the financial result decreases. Especially the housing and handling equipment shows a major increase if the terminal size grows. If we take a closer look to key-performance indicators per employee according to terminal size, we observe that sales per employee increase if the terminal grows in size. The costs per employee increase relatively more with terminal size, which in the end results in lower profits per employee.

Next, we concentrated on the cost structure of relative small container terminals. Average total costs per handling range from € 30-40. We observe a decrease in costs per handling as the number of handlings increase from 2,500 per year to 20,000 per year. The ratio variable/investment costs is around 50 per cent for all small container terminals that were taken into account.

The review of these two studies concerned leads us to the following conclusions:

1. A number of cost categories is missing (capital, profits, general, management, and taxation);
2. There is no account of the use that each terminal customer makes of the terminal resources. According to the terminal operators each terminal handling carries —in principle— the same costs.

The current cost structure is apparently incomplete, so that cost allocations may support biased activities and users. Therefore, there is a need for a more solid cost accounting approach. In the next section we present an alternative approach to the costing of terminal activities.

3. TERMINAL HANDLING COSTS AND ABC

(1) Cost allocation criteria

Cost allocation in the area of transport has not been extensively studied, but some cost allocation theories focussing especially on indirect costs have been developed. First we need criteria to split the costs into different categories. Some important categorisations are among others:

1. Direct versus indirect costs
2. Investment (fixed) costs versus variable costs
3. Completely individualised en restrained individualised costs

Setting apart the direct costs usually is no problem, the real problem is concentrated on the indirect costs. First we need a quantifiable performance unit and secondly, there must be coherence between the number of performance units in a certain time period and the indirect costs in that period.

Investment costs are based on the normal, or optimal number of performance units in a certain period. Variable costs are based on a standard quantity per performance.

Completely individualised costs can be significantly directed to cost centres. Significant means that there are quantifiable, causal relations between costs and cost centres. Restrained individualised costs are costs that can not be adequately directed to cost centres.

A new perspective is offered by Activity Based Costing. Activity Based Costing (ABC) has originated from the United States. ABC has been widely accepted in recent years as a better system for measuring resource consumption (Shields and McEwen, 1996). ABC directs indirect costs to services (or products) according to the degree of usage of supportive activities. Furthermore, it provides insight into the cost structure and into the

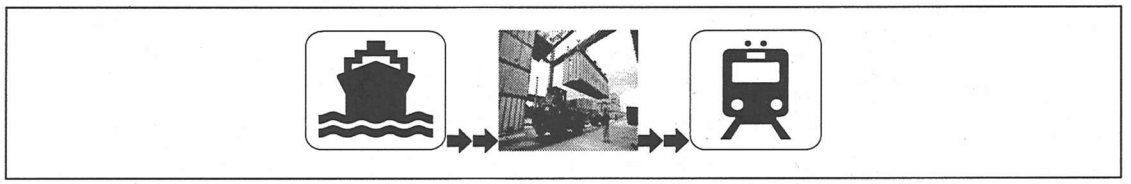

Figure 3.1. Direct transhipment from ship to train

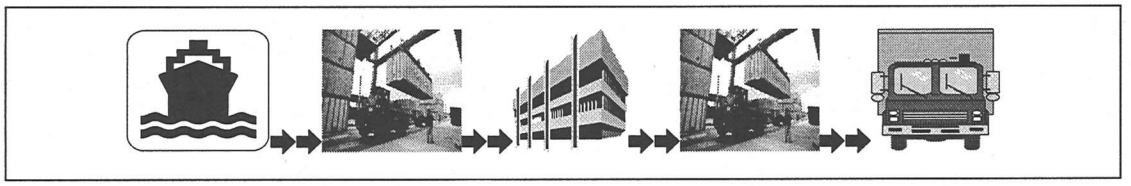

Figure 3.2. Discharging a ship, followed by storage and loading onto a truck

activities that cause (produce) the costs. This method looks for causality between activities and costs, which may result in effective improvement programs. ABC can help companies avoid dropping products erroneously because of misleading product costs. Companies are able to evaluate the true costs of products, thus ensuring that they make the right long-term decisions on whether to keep particular product lines. Radhakrishnan and Srinidhi (1997) find that: I) traditional costing systems tend to report low profits for large-volume products that consume more of the cost driver, these products are likely to be discontinued first; II) traditional costing systems report low profits for the remaining smaller-volume products that then consume more of the cost driver, thus leading to their likely discontinuance as well. For example, companies that use labour hours as the sole cost driver will remain in the market for products that use relatively more machine hours. This may be extended to the terminal operator. Generally, terminal operators use the number of containers (TEU) as the sole cost driver and thus they will remain focused on increasing the number of handled containers (capacity filling).

The basic idea of ABC is that costs are not only caused in proportion with production volume, but also in proportion with supportive activities. The ABC-method consists of six steps (Horngren, Foster, and Datar, 1997):

1. Identify the job that is the chosen cost object
2. Identify the direct costs for the job
3. Identify the indirect-cost pools associated with the job
4. Select the cost-allocating base to use in allocating each indirect-cost pool to the job
5. Develop the rate per unit of each cost-allocation base used to allocate the indirect costs to the job
6. Assign the costs to the cost object by adding all direct costs and all indirect costs.

First, all the activities that a certain organisation is performing, are identified. Secondly, the direct costs are directed to the activities concerned. Thirdly, indirect costs associated with certain activities are identified. Fourth, cost-allocating bases are selected to allocate each indirect cost to a certain activity. Fifth, the rate per unit is developed to allocate the indirect costs to the activity. Finally, all direct costs and indirect costs are assigned to the concerned activity. ABC should be linked to a company's competitive strategy regarding organisational design, new product development, and technology (Shields and McEwen, 1996). This idea seems to have a meaningful usage in freight terminals.

(2) Terminal activities and Activity Based Costing

At an intermodal freight terminal three groups of services can be distinguished (Wiegmans et. al., 1998): central terminal services, terminal related services, and diverted terminal services. Central terminal services consist of discharging (unloading freight and containers), loading, direct transhipment, storage, and supportive activities (acquisition, ordering, planning, administration). Terminal related services are freight handling, collection/distribution of freight (locally), physical transport of freight, and freight monitoring (tracking and tracing of freight). Finally, diverted terminal services are manufacturing, renting, leasing, selling services, and other services (restaurant, hotel, supermarket). In this paper we only focus on the primary function of freight terminals. Two terminal services take centre stage in our paper: direct transhipment (see **Figure 3.1**) and discharging in combination with storage and followed by loading (see **Figure 3.2**).

In both services the transport mode may vary per terminal.

(3) The Activity Based Costing approach and terminal costs

In this section we use the Activity Based Costing approach to obtain insight in the cost structure of intermodal freight terminals and the performed activities. Almost all the cost numbers are based on the report "Intermodhaalbaar" (TU Delft, 1995). The cost figures are changed from guilders to Euro's (€) and the numbers are also changed to 1997 figures. In this publication eight different terminals are presented. We have chosen two terminal cost structures out of these eight different cases, to combine them with the ABC-approach. We use the six steps, presented below, as the general framework.

a) Identify the job that is the chosen cost object

A job at an intermodal freight terminal is an order of any size for one of the following *central terminal services*: loading, discharging, direct transhipment, storage and supportive activities. In this paper we concentrate on the central terminal services, but terminal related services and diverted terminal services may be taken into account as well. The same ABC-approach can be used for activities out of the last two groups as well.

b) Identify the direct costs for the job

In step one we have identified five different jobs at a freight terminal. In step two we use the different cost categories out of the eight different terminals. Then the five jobs are linked to the different direct cost categories based on the researchers' perception. An overview is presented in **Table 3.1.** Different cost categories are missing: capital costs, management fee, profits, general costs, and taxation.

c) Identify the indirect-costs pools associated with the job

In this step the five different indirect cost categories are linked to the terminal activities (jobs) based on the perception of the researchers. An overview is presented in **Table 3.2.** Pavements, lightning, and rent are chosen as indirect cost categories because, no direct relation exist between loading, discharging, and direct transhipment on the one hand and storage on the other hand. Quay is also chosen as an indirect cost category because, loading, discharging, and direct transhipment may have different forms. It depends on the pattern of the containers within the terminal if the quay is used or not (e.g. rail-rail transhipment does not use a quay).

d) Select the cost-allocation base to use in allocating each indirect cost pool to the job

We have started with identifying the most appropriate cost allocating base for each indirect cost pool. The results are shown in Table 3.3 Terminal activities, indirect cost categories, and cost allocation base. Forced by the available numbers, in the end we had to resort to container- and TEU-numbers only.

Table 3.1 Terminal activities and related direct cost categories

Activity	*Direct cost category*
1. loading	- heavy VHT
	- wages
	- maintenance
	- energy
	- rent mobile crane
	- containercrane
	- crane rails
	- fork lift truck
	- heavy fork lift truck
2. discharge	- heavy VHT
	- wages
	- maintenance
	- energy
	- rent mobile crane
	- containercrane
	- crane rails
	- fork lift truck
	- heavy fork lift truck
3. direct transhipment	- mobile crane
	- wages
	- maintenance
	- energy
	- containercrane
	- crane rails
4. storage	- pavements
	- lightning
	- energy
	- rent
	- maintenance
	- wages
5. supportive activities	- office
	- wages
	- maintenance
	- energy
	- communication

Table 3.2 Terminal activities and related indirect cost categories

Activity	*Indirect cost category*
1. loading	- quay
	- pavements
	- lightning
	- rent
2. discharge	- quay
	- pavements
	- lightning
	- rent
3. direct transhipment	- quay
	- pavements
	- lightning
	- rent
4. storage	- fork lift truck
	- heavy fork lift truck
5. supportive activities	

Tabe 3.3 Terminal activities, indirect cost categories, and cost allocation base

Activity	*Indirect cost category*	*Cost allocation base*
1. loading	- quay	ship length, time at the quay, depth of ship
	- pavements	m2
	- lightning	m2
	- rent	m2
2. discharge	- quay	ship length, time at the quay, depth of ship
	- pavements	m2
	- lightning	m2
	- rent	m2
3. direct transhipment	- quay	ship length, time at the quay, depth of ship
	- pavements	m2
	- lightning	m2
	- rent	m2
4. storage	- fork lift truck	labour hour
	- heavy fork lift truck	labour hour
5. supportive activities		

Table 3.4 Direct cost categories for 40-40-20 and 25-25-50 (5,000 containers)

Activity	*Direct cost category*	*40-40-20*	*Direct cost category*	*25-25-50*
1. loading	- heavy VHT [50]	€ 16,547	- heavy VHT [50]	€ 16,547
	- wages [20]	€ 14,183	- wages [20]	€ 14,183
	- maintenance [20]	€ 4,728	- maintenance [20]	€ 4,728
	- energy [20]	€ 1,418	- energy [20]	€ 1,418
	- rent mobile crane [40]	€ 28,367	**- rent mobile crane [25]**	€ 17,729
Costs/container		€ 16.31		€ 21.84
Costs/TEU		€ 10.87		€ 14.56
2. discharging	- heavy VHT [50]	€ 16,547	- heavy VHT [50]	€ 16,547
	- wages [20]	€ 14,183	- wages [20]	€ 14,183
	- maintenance [20]	€ 4,728	- maintenance [20]	€ 4,728
	- energy [20]	€ 1,418	- energy [20]	€ 1,418
	- rent mobile crane [40]	€ 28,367	**- rent mobile crane [25]**	€ 17,729
Costs/container		€ 16.31		€ 21.84
Costs/TEU		€ 10.87		€ 14.56
3. direct transhipment	- rent mobile crane [20]	€ 14,183	**- rent mobile crane [50]**	€ 35,459
	- wages [20]	€ 14,183	- wages [20]	€ 14,183
	- maintenance [20]	€ 4,728	- maintenance [20]	€ 4,728
	- energy [20]	€ 1,418	- energy [20]	€ 1,418
Costs/container		€ 34.51		€ 22.31
Costs/TEU		€ 23.00		€ 14.88
4. storage	- pavements [70]	€12,410	- pavements [70]	€12,410
	- lightning [70]	€ 1,986	- lightning [70]	€ 1,986
	- energy [20]	€ 1,418	- energy [20]	€ 1,418
	- rent [70]	€ 16,547	- rent [70]	€ 16,547
	- maintenance [20]	€ 4,728	- maintenance [20]	€ 4,728
	- wages [20]	€ 14,183	- wages [20]	€ 14,183
Costs/container		€ 12.82		€ 20.51
Costs/TEU		€ 8.55		€ 13.67
5. supportive activities	- office [100]	€ 1,773	- office [100]	€ 1,773
	- wages [20]	€ 14,183	- wages [20]	€ 14,183
	- maintenance [20]	€ 4,728	- maintenance [20]	€ 4,728
	- communication [100]	€ 10,637	- communication [100]	€ 10,637
	- energy [20]	€ 1,418	- energy [20]	€ 1,418
Costs/container		€ 6.55		€ 6.55
Costs/TEU		€ 4.37		€ 4.37

e) Develop the rate per unit of each cost-allocation base used to allocate indirect costs to the job

As we do not have the necessary numbers (FTE, number of contracts, labour hour, number of customers, duration and volume of contracts), this step could not be executed as precisely as we aimed. We had to use the alternative –more general– container- and TEU-numbers.

Table 3.5 Indirect cost categories for 40-40-20 and 25-25-50 (5,000 containers)

Activity	*Indirect cost category*	*40-40-20*	*Indirect cost category*	*25-25-50*
1. loading	- quay [40] - pavements [10] - lightning [10] - rent [10]	€ 19,699 € 1,773 € 284 € 2,364	**- quay [25]** - pavements [10] - lightning [10] - rent [10]	€ 12,312 € 1,773 € 284 € 2,364
Costs/container **Costs/TEU**		€ 6.03 € 4.02		€ 6.69 € 4.46
2. discharging	- quay [40] - pavements [10] - lightning [10] - rent [10]	€ 19,699 € 1,773 € 284 € 2,364	**- quay [25]** - pavements [10] - lightning [10] - rent [10]	€ 12,312 € 1,773 € 284 € 2,364
Costs/container **Costs/TEU**		€ 6.03 € 4.02		€ 6.69 € 4.46
3. direct transhipment	- quay [20] - pavements [10] - lightning [10] - rent [10]	€ 9,850 € 1,773 € 284 € 2,364	**- quay [50]** - pavements [10] - lightning [10] - rent [10]	€ 24,624 € 1,773 € 284 € 2,364
Costs/container **Costs/TEU**		€ 14.27 € 9.51		€ 11.62 € 7.75
4. storage				
5. supportive activities				

f) Assign the costs to the cost object by adding all direct costs and all indirect costs

We divide the costs of **Table 2.1** and **Table 2.2** according to the ABC-method. We will assume two cases for each terminal. We have one case with 40% of the containers loading, 40% of the containers discharging, and 20% of the containers direct transhipment (*40-40-20*). The second case is 25% loading, 25% discharge and 50% direct transhipment (*25-25-50*). Of course in practice these numbers may be different. The cases are used to illustrate the effects of allocating costs differently. We assume that 5,000 handlings are equal to 5,000 containers, and furthermore we assume that 1 container is equal to 1.5 TEU. The sub-case *40-40-20* means 40% loading (2,000 containers), 40% discharging (2,000 containers), and 20% direct transhipment (1,000 containers). The sub-case *25-25-50* means 25% loading (1,250 containers), 25% discharging (1,250 containers), and 50% direct transhipment (2,500 containers).

In the second case we assume that 20,000 handlings are equal to 20,000 containers, and furthermore we assume that 1 container is equal to 1.5 TEU. For this second case we developed two sub-cases. The sub-case *40-40-20* means 40% loading (8,000 containers), 40% discharging (8,000 containers), and 20% direct transhipment (4,000 containers). The sub-case *25-25-50* means 25% loading (4,000 containers), 25% discharging (4,000 containers), and 50% direct transhipment (8,000 containers).

The numbers in **Table 3.4.** are based on **Table 2.1.** At the terminal we have distinguished five services: loading, discharging, direct transhipment, storage, and supportive activities (see also first column). In the second column the corresponding direct cost categories are listed. In brackets the cost percentage that is directed to this direct cost category is given. For example, 50% of the cost for a heavy VHT is directed to the activity loading. Of course, the cost categories and the cost percentages are arbitrary. However, due to a lack of data, we developed a number of cases in order to be able to show differences in costs. The third column contains the amounts in Euro's (€) for the 40-40-20 case (5,000 containers). We observe the following direct cost levels per container: loading € 16.31, discharging € 16.31, direct transhipment € 34.51, storage € 12.82, and supportive activities € 6.55.

The fourth column contains the direct cost categories for the case 25-25-50. In bold the direct cost categories that change in percentage are depicted. The fifth column lists the corresponding amounts in Euro's for the 25-25-50 case (5,000 containers). We observe the following direct cost levels per container: loading € 21.84, discharging € 21.84, direct transhipment € 22.31, storage € 20.51, and supportive activities € 6.55.

The numbers in **Table 3.5.** are based on **Table 2.1.** In the first column the terminal services can be found. In the second column the corresponding indirect cost categories are listed. In [] the cost percentage that is directed to this indirect cost category is listed again. For example, 40% of the cost of the quay is directed to the activity loading. The third column shows the amounts concerning the indirect cost categories in Euro's (€) for the 40-40-20 case (5,000 containers). We observe the following indirect cost levels per container: loading € 6.03, discharging € 6.03, direct transhipment € 14.27, storage € 0, and supportive activities € 0.

In the fourth column the indirect cost categories for the case 25-25-50 are given. In bold the indirect cost categories that change in percentage are shown. The fifth column lists the corresponding amounts in Euro's for the 25-25-50 case (5,000 containers). We observe

Table 3.6 Direct cost categories for 40-40-20 and 25-25-50 (20,000 containers)

Activity	*Direct cost category*	*40-40-20*	*Direct cost category*	*25-25-50*
1. loading	- containercrane [40]	€ 56,733	**- containercrane [25]**	€ 35,458
	- heavy fork lift truck [50]	€ 28,367	- heavy fork lift truck [50]	€ 28,367
	- crane rails [40]	€ 5,516	**- crane rails [25]**	€ 3,447
	- wages [20]	€ 28,367	- wages [20]	€ 28,367
	- maintenance [20]	€ 7,564	- maintenance [20]	€ 7,564
	- energy [20]	€ 3,782	- energy [20]	€ 3,782
Costs/container		€ 8.15		€ 10.70
Costs/TEU		€ 5.44		€ 7.13
2. discharging	- containercrane [40]	€ 56,733	**- containercrane [25]**	€ 35,458
	- heavy fork lift truck [50]	€ 28,367	- heavy fork lift truck [50]	€ 28,367
	- crane rails [40]	€ 5,516	**- crane rails [25]**	€ 3,447
	- wages [20]	€ 28,367	- wages [20]	€ 28,367
	- maintenance [20]	€ 7,564	- maintenance [20]	€ 7,564
	- energy [20]	€ 3,782	- energy [20]	€ 3,782
Costs/container		€ 8.15		€ 10.70
Costs/TEU		€ 5.44		€ 7.13
3. direct transhipment	- container crane [20]	€ 28,367	**- container crane [50]**	€ 70,917
	- crane rails [20]	€ 2,758	**- crane rails [50]**	€ 6,895
	- wages [20]	€ 28,367	- wages [20]	€ 28,367
	- maintenance [20]	€ 7,564	- maintenance [20]	€ 7,564
	- energy [20]	€ 3,782	- energy [20]	€ 3,782
Costs/container		€ 17.71		€ 11.75
Costs/TEU		€ 11.81		€ 7.84
4. storage	- pavements [70]	€ 33,094	- pavements [70]	€ 33,094
	- lightning [70]	€ 5,295	- lightning [70]	€ 5,295
	- energy [20]	€ 3,782	- energy [20]	€ 3,782
	- rent [70]	€ 44,126	- rent [70]	€ 44,126
	- maintenance [20]	€ 7,564	- maintenance [20]	€ 7,564
	- wages [20]	€ 28,367	- wages [20]	€ 28,367
Costs/container		€ 7.64		€ 12.22
Costs/TEU		€ 5.09		€ 8.15
5. supportive activities	- office [100]	€ 3,546	- office [100]	€ 3,546
	- wages [20]	€ 28,367	- wages [20]	€ 28,367
	- maintenance [20]	€ 7,564	- maintenance [20]	€ 7,564
	- communication [100]	€ 28,367	- communication [100]	€ 28,367
	- energy [20]	€ 3,782	- energy [20]	€ 3,782
Costs/container		€ 3.58		€ 3.58
Costs/TEU		€ 2.39		€ 2.39

the following indirect cost levels per container: loading € 6.69, discharging € 6.69, direct transhipment € 11.62, storage € 0, and supportive activities € 0.

The numbers in **Table 3.6.** are based on **Table 2.2.** At the terminal we distinguished five services: loading, discharge, direct transhipment, storage, and supportive activities (See also first column). In the second column the corresponding direct cost categories are listed. In [] the cost percentage that is directed to this direct cost category is given. For example, 40% of the cost for a containercrane is directed to the activity loading. Of course, the cost categories and the cost percentages are arbitrary. However, due to a lack of data, we developed a number of cases in order to be able to show differences in costs. The third column contains the amounts in Euro's (€) for the 40-40-20 case (20,000 containers). We observe the following direct cost levels per container: loading € 8.15, discharging € 8.15, direct transhipment € 17.71, storage € 7.64, and supportive activities € 3.58.

The fourth column contains the direct cost categories for the case 25-25-50. In bold the direct cost categories that change in percentage are depicted. The fifth column lists the corresponding amounts in Euro's for the 25-25-50 case (20,000 containers). We observe the following direct cost levels per container: loading € 10.70, discharging € 10.70, direct transhipment € 11.75, storage € 12.22, and supportive activities € 3.58.

The numbers in **Table 3.7.** are based on **Table 2.2.** In the first column the terminal services can be found. In the second column the corresponding indirect cost categories are listed. In [] the cost percentage that is directed to this indirect cost category is listed again. For example, 40% of the cost of the quay is directed to the activity loading. The third column shows the amounts concerning the indirect cost categories in Euro's (€) for

Table 3.7 Indirect cost categories for 40-40-20 and 25-25-50 (20,000 containers)

Activity	*Indirect cost category*	*40-40-20*	*Indirect cost category*	*25-25-50*
1. loading	- quay [40]	€ 19,699	**- quay [25]**	€ 12,312
	- pavements [10]	€ 4,728	- pavements [10]	€ 4,728
	- lightning [10]	€ 756	- lightning [10]	€ 756
	- rent [10]	€ 6,304	- rent [10]	€ 6,304
Costs/container		€ 1.97		€ 2.41
Costs/TEU		€ 1.31		€ 1.61
2. discharging	- quay [40]	€ 19,699	**- quay [25]**	€ 12,312
	- pavements [10]	€ 4,728	- pavements [10]	€ 4,728
	- lightning [10]	€ 756	- lightning [10]	€ 756
	- rent [10]	€ 6,304	- rent [10]	€ 6,304
Costs/container		€ 1.97		€ 2.41
Costs/TEU		€ 1.31		€ 1.61
3. direct transhipment	- quay [20]	€ 9,850	**- quay [50]**	€ 24,624
	- pavements [10]	€ 4,728	- pavements [10]	€ 4,728
	- lightning [10]	€ 756	- lightning [10]	€ 756
	- rent [10]	€ 6,304	- rent [10]	€ 6,304
Costs/container		€ 5.41		€ 3.64
Costs/TEU		€ 3.61		€ 2.43
4. storage				
5. supportive activities				

Table 3.8 Direct cost per activity for 40-40-20 and 25-25-50 (5,000/20,000 containers)

Activity	*40-40-20 (5,000)*	*25-25-50 (5,000)*	*40-40-20 (20,000)*	*25-25-50 (20,000)*
1. loading				
Costs/container	€ 16.31	€ 21.84	€ 8.15	€ 10.70
Costs/TEU	€ 10.87	€ 14.56	€ 5.44	€ 7.13
2. discharging				
Costs/container	€ 16.31	€ 21.84	€ 8.15	€ 10.70
Costs/TEU	€ 10.87	€ 14.56	€ 5.44	€ 7.13
3. direct transhipment				
Costs/container	€ 34.51	€ 22.31	€ 17.71	€ 11.75
Costs/TEU	€ 23.00	€ 14.88	€ 11.81	€ 7.84
4. storage				
Costs/container	€ 12.82	€ 20.51	€ 7.64	€ 12.22
Costs/TEU	€ 8.55	€ 13.67	€ 5.09	€ 8.15
5. supportive activities				
Costs/container	€ 6.55	€ 6.55	€ 3.58	€ 3.58
Costs/TEU	€ 4.37	€ 4.37	€ 2.39	€ 2.39

the 40-40-20 case (20,000 containers). We observe the following indirect cost levels per container: loading € 1.97, discharging € 1.97, direct transhipment € 5.41, storage € 0, and supportive activities € 0.

In the fourth column the indirect cost categories for the case 25-25-50 are given. In bold the indirect cost categories that change in percentage are shown. The fifth column lists the corresponding amounts in Euro's for the 25-25-50 case (20,000 containers). We observe the following indirect cost levels per container: loading € 2.41, discharging € 2.41, direct transhipment € 3.64, storage € 0, and supportive activities € 0.

(4) Conclusion

The basic idea of the proposed ABC-approach is that costs are not only caused in proportion with production volume, but also in proportion with supportive activities. The use of the six steps — (i) identify the job that is the chosen cost object; (ii) identify the direct costs for the job; (iii) identify the indirect-cost pools associated with the job; (iv) select the cost-allocating base to use in allocating each indirect-cost pool to the job; (v) develop the rate per unit of each cost-allocation base used to allocate the indirect costs to the job; and (vi) assign the costs to the cost object by adding all direct costs and all indirect costs— enables a better measurement of the resource use of each terminal customer.

We focussed on the central terminal services but the approach can be applied to all other terminal services as well. In order to better structure the conclusions, we summarised the direct costs for a terminal with 5,000 handlings and for a terminal with 20,000 handlings. Each terminal has two sub-cases concerning the characteristics of the freight flows.

Table 3.9 Indirect cost categories for 40-40-20 and 25-25-50 (5,000/20,000 containers)

Activity	*40-40-20 (5,000)*	*25-25-50 (5,000)*	*40-40-20 (20,000)*	*25-25-50 (20,000)*
1. loading				
Costs/container	€ 6.03	€ 6.69	€ 1.97	€ 2.41
Costs/TEU	€ 4.02	€ 4.46	€ 1.31	€ 1.61
2. discharging				
Costs/container	€ 6.03	€ 6.69	€ 1.97	€ 2.41
Costs/TEU	€ 4.02	€ 4.46	€ 1.31	€ 1.61
3. direct transhipment				
Costs/container	€ 14.27	€ 11.62	€ 5.41	€ 3.64
Costs/TEU	€ 9.51	€ 7.75	€ 3.61	€ 2.43
4. storage				
5. supportive activities				

Table 3.10 Total costs per container

Activity	*40-40-20 (5,000)*	*25-25-50 (5,000)*	*40-40-20 (20,000)*	*25-25-50 (20,000)*
Transhipment	€ 55.33	€ 42.75	€ 26.70	€ 18.97
Discharging/storage/loading	€ 64.05	€ 84.12	€ 31.46	€ 42.02

The direct cost per container and TEU decreases if the terminal volume grows from 5,000 containers per year to 20,000 containers per year.

The direct costs associated with the direct transshipment service are less than half the costs associated with the discharging-storage-loading service. The direct cost of a direct transhipment in the case of a terminal that handles 5,000 containers per year and 40-40-20 (€ 34.51) is low compared to a service that requires discharging (€ 16.31), storage (€ 12.82) and loading (€ 16.31), leading to total direct costs of € 45.44 excluding the supportive activities. Supportive activities should be charged according to the number of customers or contracts because this number better reflects the terminal resource use. However, the lack of data caused us to use the container and TEU numbers instead. Furthermore, it is obviously clear that direct transhipment requires less supportive activities than discharging-storage-loading.

If a terminal performs relatively many discharging and loading services (40-40-20), this leads to relatively moderate cost differences with the direct transshipment service. In this case direct transshipment costs are less than half the costs for discharging-storage-loading. If a terminal concentrates on direct transshipment (25-25-50), the direct cost difference with the discharging-storage-loading service increases considerably. In this case the discharging-storage-loading service costs five times as much as the direct transshipment service.

The indirect cost differences are less striking. The indirect costs per container for the selected cases are about the same order. Total costs per direct transhipment are then € 55.33 (€ 34.51 + € 6.55 + € 14.27) in the case of 5, 000 containers and *40-40-20*, and € 42.75 (€ 22.31 + € 6.55 + € 11.62) in the case of 5,000 containers and *25-25-50*. Total costs per direct transhipment are € 26.70 (€ 17.71 + € 3.58 + € 5.41) in the case of 20,000 containers and *40-40-20*, and € 18.97 (€ 11.75 + € 3.58 + € 3.64) in the case of 20,000 containers and *25-25-50*.

Total costs for the service discharging-storage-loading are then € 64.05 (€ 16.31+ € 16.31+ € 12.82 + € 6.55 + € 6.03 + € 6.03) in the case of 5,000 containers and *40-40-20*, and € 84.12 (€ 21.84 + € 21.84 + € 20.51 + € 6.55 + € 6.69 + € 6.69) in the case of 5,000 containers and *25-25-50*. Total costs for the service discharging-storage-loading are € 31.46 (€ 8.15 + € 8.15 + € 7.64 + € 3.58 + € 1.97 + € 1.97) in the case of 20,000 containers and *40-40-20*, and € 42.02 (€ 10.70 + € 10.70 + € 12.22 + € 3.58 + € 2.41 + € 2.41) in the case of 20,000 containers and *25-25-50*.

The costs per container are lower in larger freight terminals. Furthermore, direct transhipment costs less than discharging/storage/loading and the difference increases when the importance of direct transhipment increases for the terminal operator.

4. INTERACTION BETWEEN ABC AND TERMINAL SALES

(1) Terminal sales structure

At an intermodal freight terminal three groups of services can be distinguished: central terminal services, terminal related services, and diverted terminal services. In this paper the main emphasis is on the central terminal service; handling containers. The central terminal services consist of: discharging, loading, direct transhipment, storage, and supportive activities. At each terminal there may be more or less services offered. The importance of different service activities may and will

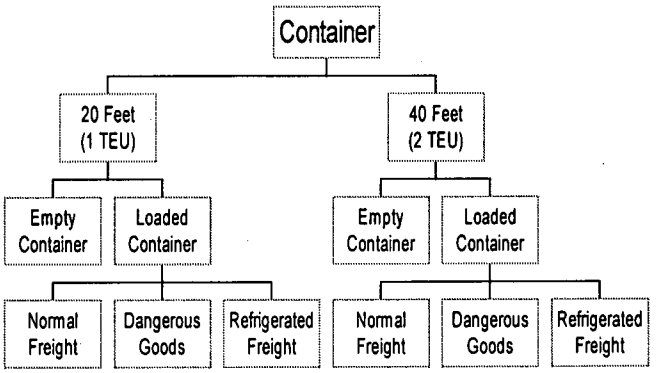

Figure 4.1. Terminal sales; different container types

Table 4.1. Financial performance of the Rotterdam ECT-terminal in 1996, 1997, and 1998

ECT	*1998*	*1997*	*1996*
Sales (million ε)	332,4	288,6	278,8
net profits (million ε)	19,6	17,9	18,4
Personnel	2220	2,083	2,054
Containers	2,827,000	2,518,000	2,358,000
TEU	4,461,000	3,950,000	3,537,000
Costs (million ε)	303,6	264,0	252,7
Personnel costs (million ε)	164,2	142,2	141,3
Sales/container	€ 117,6	ε 114,6	ε 118,2
Sales/TEU	€ 74,5	ε 73,1	ε 78,8
Sales/person	€ 149,730	ε 138,550	ε 135,735
net profits/container	€ 6,93	ε 7,12	ε 7,80
net profits/TEU	€ 4,39	ε 4,53	ε 5,20
net profits/person	€ 8,829	ε 8,593	ε 8,958
Costs/container	€ 107,4	ε 104,8	ε 107,2
Costs/TEU	€ 68,1	ε 66,8	ε 71,4
costs/person	€ 136,757	ε 126,740	ε 123,028
personnel costs/container	€ 58,08	ε 56,47	ε 59,92
personnel costs/TEU	€ 36,81	ε 36,00	ε 39,95
personnel costs/person	€ 73,964	ε 68,267	ε 68,792
TEU/container	1,58	1,57	1,50
containers/person	1,273	1,209	1,148

Source: Wiegmans et al., 1999, ECT Annual Report 1998

vary according to the terminal characteristics. Furthermore, the terminal sales structure will be influenced by the possibility to use more than one crane at the same time, waiting periods in the port and off-roads before operations may start, and the distance between berthing places and open sea.

Other factors influencing the terminal sales structure are (Drewry, 1998):

- Transport mode (rail, road, barge, coastal shipping, deep-sea shipping)
- Volume (number of containers)
- Container type (see **Figure 4.1**)

Other services that may induce sales are (Inamura, 1997 and Societa per Azioni, 1991):

- Opening/closing hatches (opening in a ship's deck through which containers are handled)
- Cargo plan preparation
- Overtime
- Stand-by on vessel's account (state of readiness because of the arrival of a vessel)
- Lashing/unlashing (fasten tightly together)
- Additional movements
- Weighing
- Lay-days at terminal
- Other (e.g. container- and seal checking)

The terminal service portfolio varies per terminal and cost structures also depend on the number of services included in the final price per container.

(2) Comparative analysis of terminal cost structures: an illustration

Three terminals in Europe are used as an illustration for a general cost analysis of terminals. The annual reports of the ECT-terminal in Rotterdam, the HHLA-terminal in Hamburg and the CERES-terminal in Amsterdam are used as input here.

Table 4.2. Financial performance of the HHLA-terminal in 1996 and 1997

HHLA-Hamburg	*1997*	*1996*	*Ceres Terminal (Amsterdam)*	*1997*	*1996*
sales* (million ε)	215.6	227.6	**sales* (million ε)**	9.82	15.91
net profits (million ε)	1.6	0.6	**net profits (million ε)**	-/- 0.32	1.31
personnel	1,593	1,724	**Personnel**	88	89
containers**	1,449,636	1,111,798	**Containers**	35,000	70,000
TEU	2,275,928	1,667,697	**TEU***	52,500	105,000
costs (million ε)	212.7	234.8	**costs (million ε)**	9.96	13.79
personnel costs (million ε)	111.4	118.1	**personnel costs (million ε)**	5.64	7.99
sales/container (ε)	148.7	204.7	**sales/container (ε)**	280.5	227.3
sales/TEU (ε)	94.7	136.5	**sales/TEU (ε)**	187.0	151.5
sales/person (ε)	135,342	132,019	**sales/person (ε)**	111,591	178,764
net profits/container (ε)	1.10	0.54	**net profits/container (ε)**	-/- 9.14	18.71
net profits/TEU (ε)	0.70	0.36	**net profits/TEU (ε)**	-/- 6.10	12.48
net profits/person (ε)	1,004	348	**net profits/person (ε)**	-/- 3,636	14,719
costs/container (ε)	146.7	211.2	**costs/container (ε)**	284.6	197.0
costs/TEU (ε)	93.5	140.8	**costs/TEU (ε)**	189.7	131.3
costs/person (ε)	133,522	136,195	**costs/person (ε)**	113,182	154,944
personnel costs/container (ε)	76.85	106.22	**personnel costs/container (ε)**	161.1	114.1
personnel costs/TEU (ε)	48.95	70.82	**personnel costs/TEU (ε)**	107.4	76.1
personnel costs/person (ε)	69,931	68,503	**personnel costs/person (ε)**	64,091	89,775
TEU/container***	1.57	1.50	**TEU/container#**	1.5	1.5
containers/person	910	645	**containers/person**	398	787

* Sales include also around 10% non-containerised freight
** These numbers are calculated with the TEU/container numbers at the end of this table
*** These numbers are taken from Wiegmans et al., 1999
Source: HHLA, 1998
These TEU numbers are based on Wiegmans et al., 1999
Source: Ceres Annual Report, 1997, Haven Amsterdam, 1997

In **Table 4.1** we observe a marked increase in sales, personnel, containers, costs, and personnel costs for the years 1997 and 1998. Per container we see a decrease in sales in 1997 and an increase in 1998. The profits per container show a decrease in both 1997 and 1998. The costs and the personnel costs per container show the same development as the sales per container; a decrease in 1997 and an increase in 1998.

In sales per person we observe an increase in both 1997 and 1998. The profits per person show a decrease in 1997 and an increase in 1998. The total costs per person increased considerably in both 1997 and in 1998.The personnel costs per person decreased moderately in 1997 and increased again in 1998. Finally, the number of handled containers per person improved again in 1998 to 1273 containers per person.

In **Table 4.2** we observe a decrease in sales, personnel, costs, and personnel costs for the year 1997. The number of handled containers in 1997 increased. Per container we see a decrease in sales in 1997. The profits per container, however, more than doubled in 1997. The costs and the personnel costs per container decreased considerably in 1997.

In sales per person we observe an increase in 1997. The profits per person almost tripled in 1997. The total costs per person decreased moderately in 1997. The personnel costs per person increased only moderately in 1997. Finally, the number of handled containers per person improved from 645 to 910 containers per person.

In 1997 two main customers (Hapag-Lloyd and Nedlloyd) of the CERES-terminal moved their operations to other container terminals. This caused a decrease of the volume of containers of around 60,000 containers. In the numbers above also the handling of auto's and other goods at the CERES-terminal could be included. This does not show clearly from the numbers. In **Table 4.2** we thus observe a large decrease in sales, costs, sales, profits and personnel costs for the year 1997. The number of personnel in 1997 stayed about the same. Per container we see a considerable increase in sales in 1997. The profits per container, however, sunk into the red numbers in 1997. The costs and the personnel costs per container increased considerably in 1997.

In sales per person we observe an enormous decrease in 1997. The profits per person changed from almost € 15,000 to -/- € 3,600. The total costs per person decreased considerably in 1997. The personnel costs per person decreased in 1997. Finally, the number of handled containers per person changed from 787 to 398 containers per person.

Cost levels per container are around € 105 at the ECT-terminal, and around € 145 at the HHLA-terminal. Sales per container are around € 115 at the ECT-terminal, and around € 150 at the HHLA-terminal. This results in profits of almost € 7 per container at the ECT-terminal and of just € 1 at the HHLA-terminal in

Hamburg. The CERES-terminal is used to illustrate the importance of capacity filling. The costs of terminals are not extensively documented, leading to the inability to use the ABC-approach on real terminal-cases. However, it is possible to dram conclusions, based on research and the practical cases.

5. CONCLUSION

The main purpose of this paper was to identify the terminal handling cost structure and to find out if the Activity Based Costing (ABC) approach offers a better perspective on the costs of intermodal freight terminals. The problem description was as follows:

To what extent is the Activity Based Costing approach useful for terminal operators in order to be able to charge its customers a fair and cost-oriented price?

Activity Based Costing is a useful tool for both terminal operators and terminal customers to provide more insight into terminal resource use. Terminal cost dividing and price charging can be executed more appropriate.

The alternative approach to costing terminal activities presented in this paper is the Activity Based Costing approach. The basic idea of the proposed approach is that costs are not only caused in proportion with production volume, but also in proportion with supportive activities. Currently, each container is charged the same average price and large volume terminal customers are given discounts. This suggests that a better measurement of the resource use of each terminal customer is needed. When using the ABC-approach in measuring resource use of terminal customers, we come to the following conclusions:

1. One cost-level for different types of terminal container handling (transhipment or discharging-storage-loading) and other services used, does not appropriately incorporate the different terminal resource use of each terminal customer
2. The current cost structure is incomplete and costs are improperly directed to activities and users. A number of cost categories are missing (capital, profits, general, management, and taxation) and there is not taken account of the use that each terminal customer made of the terminal resources
3. The different container handling types should carry different cost- and price levels in order to better reflect the terminal resource use per customer
4. Large terminal customers use relatively less terminal resources, thus incurring lower costs to the terminal operator
5. The direct transhipment handling service requires less supportive activities than the service discharging-storage-loading service
6. Supportive activities should be charged according to the number of customers or contracts because this number better reflects the terminal resource use
7. Performance indicators per employee improve if the terminal grows in size
8. The direct costs per container (and TEU) decrease if the total terminal handling volume grows (from 5,000 containers per year to 20,000 containers per year)
9. If a terminal concentrates on direct transshipment, the direct cost difference with the discharging-storage-loading service increases considerably.

Besides costs, many other factors influence the resulting price per container charged to the terminal customers. These factors include transport mode, type of container, contents of container, volume (number of containers) per customer, and the total terminal service package included in the price per container. Thus, costing terminal services is important, but not the only element that influences the finally resulting price per container.

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