Solution for Modified Traveling Salesman Problem with Variable Cost Matrix Using Bacterial Evolutionary Algorithm

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Abstract: The aim of the Traveling Salesman Problem (TSP) is to find the cheapest way of visiting all elements in a given set of cities and returning to the starting point. In solutions presented in the literature costs of travel between nodes (cities) are based on Euclidian distances, the problem is symmetric and the costs are constant. In this paper a novel construction and formulation of the TSP is presented in which the requirements and features of practical application in road transportation and supply chains are taken into consideration. In the paper numerical examples are presented as well.

Keywords: Traveling Salesman Problem, time dependent costs, bacterial evolutionary algorithm

1. Introduction

The aim of the Traveling Salesman Problem (TSP) is to find the cheapest way of visiting all elements in a given set of cities where the cost of travel between each pair of them is given, including the return to the starting point. The TSP is a very good representative of a larger class of problems known as combinatorial optimization problems. Thus, if an efficient algorithm (i.e., an algorithm that will guarantee to find the optimal solution in polynomial number of steps) can be found for the traveling salesman problem, then efficient algorithms could be established for all other problems in the NP (nondeterministic polynomial time) class, that is why the TSP is probably the most studied of all NP-hard problems [5]. An algorithm can be considered as an effective (good) one if it has a polynomial function of the problem size *n*, that is, for large values of n, the algorithm runs in time at most Kn^c for some constant number *K* and *c*. The question whether or not there is a good algorithm for the TSP has not been settled. For its practical importance and wide range of application in practice [5] many approaches, heuristic searches and algorithms have been suggested [8, 10, 11, 12], while different extensions and variations of the original TSP have been investigated [6, 9, 13].

Solutions presented in the literature most frequently have the following features. Costs of travel between nodes (cities) are based on Euclidian distances, the problem is symmetric, meaning that the cost from $node_i$ to $node_j$ equals to the cost from $node_j$ to $node_i$, and the costs are constant. In this paper a novel construction and formulation of the TSP is presented in which the requirements and features of practical application in road transportation and supply chains are taken into consideration. Since the original formulation of the problem states: the aim is to find the "cheapest" tour, thus the cost matrix that represents the distances between each pair must be determined by calculating the actual costs of transportation processes. The costs of transportation consist of two main elements: costs proportional to transit distances (km) and costs proportional to transit times. Obviously the physical distances can be considered as constant values in a given relation, but transit times are subject to external factors, such as weather conditions, traffic circumstances, etc., so they should be treated as a time-dependent variable. On the other hand in real road networks the actual distance between two points often alter from the Euclidian distance, furthermore occasionally some extra costs (e.g., ferriage, tunnel fare) can modify the distance-related variable costs. Considering these characteristics the original TSP should be reconstructed, so that realistic solutions can be developed.

For solving the above-mentioned road-transport TSP (RTTSP) in this paper we suggest the bacterial evolutionary algorithm (BEA) since that algorithm is suitable for global optimization of even non-linear, high-dimensional, multi-modal, and discontinuous problems. As numerical example a modified TSP (RTTSP) instance is considered, in which the elements of cost matrix are dependent on the steps they are selected to carry on with.

2. Formulating and solutions for the classical TSP

In the case of the traveling salesman problem, the mathematical description can be a graph where each city is denoted by a point (or node) and lines are drawn connecting every two nodes (called arcs or edges). A distance (or cost) is associated with every line. When the salesman can get from every city to every other city directly, then the graph is said to be *complete*. A round-trip of the cities corresponds to a special subset of the lines when each city is visited exactly once, and it is called a tour or a Hamiltonian cycle in graph theory. The length of a tour is the sum of the lengths of the lines in the round-trip.

Asymmetric and symmetric TSPs can be distinguished depending on if any edge of the graph is directed or not. To formulate the symmetric case with n nodes $c_{ij} = c_{ji}$, so a graph can be considered where there is only one arc (undirected) between every two nodes. Let $x_{ij} = \{0,1\}$ be the decision variable ($i= 1,2,\ldots,n$ and $j=1,2,\ldots,n$), and $x_{ij} = 1$, means that the arc connecting $node_i$ to $node_j$ is an element of the tour.

Let
$$x_{ii} = 0 \; (i= 1,2,\ldots,n) , \tag{1}$$

meaning that no tour element is allowed from a node to itself. Furthermore

$$\sum_{i=1}^{n}\sum_{j=1}^{n} x_{ij} = n \tag{2}$$

that is the number of decision variables where $x_{ij} = 1$ is equal to n, and

$$\sum_{i=1}^{n} x_{ij} = 1 \qquad \forall j \in \{1,2,..., n\}, \tag{3}$$

$$\sum_{j=1}^{n} x_{ij} = 1 \qquad \forall i \in \{1,2,..., n\}, \tag{4}$$

meaning that each column and row of the decision matrix has a single element with a value 1 (i.e., each city is visited once). For assuring the close circuit, an additional constrain must be set. A permutation of nodes $(p_1,p_2,....p_n)$ has to be constructed so that the total cost $C(p)$ is minimal:

minimize $$C(p) = \left(\sum_{i=1}^{n-1} c_{p_i, p_{i+1}}\right) + c_{p_n, p_1}. \tag{5}$$

For a symmetrical network there are *1/2 (n-1)!* possible tours (because the degree of freedom is *(n-1)* and tours describing the same sequence but opposite directions are not considered as different tours) and for asymmetric networks where $c_{ij} \neq c_{ji}$ the number of possible tours is *(n-1)!*. Some reduction can be done [14], a guarantee that is proportional to $n^2 2^n$ can be given, however it is clear that an exhaustive search is not possible for large n in practice. Rather than enumerating all possibilities, successful algorithms for solving the TSP problem have been capable of eliminating most of the roundtrips without ever actually considering them. The main groups of engines are [5-12]:

- Mixed-integer programming
- Branch-and-bound method
- Heuristic searches (local search algorithms, simulated annealing, neural networks, genetic algorithms, particle swarm optimization, ant colony optimization, etc.)

In this paper a bacterial evolutionary algorithm is proposed as a novel heuristic search for TSP.

3. Variable costs and consequences of their nature

3.1. Costs in real road networks

Considering real road transport networks, especially in city logistics, the actual circumstances and condition of the transit process are subject to not only the topography of the given network but to timing as well. Referring to the phenomenon of cyclic peak-hours and also to the weekly (monthly, yearly) periodicity of traffic on road, it can be stated that the unit cost of traveling is also a variable, and it can be described as a time series rather than a constant value. The main reasons of that are the following:

- The actual cost of 1 km depends on the current fuel consumption, which is partly affected by the speed, but the speed is externally determined by the current traffic.

- A relatively large proportion of transportation cost is the cost of labor (i.e., wages of drivers), which is calculated on driving time. In Europe distance-based payment for commercial drivers are not allowed according to the European Agreement Concerning the Work of Crews of Vehicles Engaged in International Road Transport (AETR).
- The return on equity capital is a vital issue for haulage companies, since the transportation sector of the economy is a capital intensive one, meaning that utilization of vehicle in time is a crucial problem.

In addition, during long-distance shipments the drivers occasionally must stop for a rest (according to AETR) at a minimum 11 hour period (often overnight), and very often week-end traffic restrictions for heavy vehicles are introduced.

Concerning the above-mentioned facts, it can be seen that the circumstances and conditions are significantly changing in time that is the actual value of cost matrix element c_{ij} should be subject to timing of transit between $node_i$ and $node_j$. In this sense geographical optimization alone is not appropriate, and the road transport operation has to be scheduled in time as well.

3.2. The modified TSP, the Road Transport Traveling Salesman Problem (RTTSP)

For fulfilling the requirements of realistic road transport processes, we propose the following modification to the classical TSP.

Since the overall target is to achieve the cheapest tour (in monetary terms), the constraint that each node (city) is visited once is skipped. Calculating with time-dependent cost coefficients that are not necessarily proportional to distances, a longer route can be a cheaper one. In some cases, when graph mapping the real road network, there are some nodes that have only one connection to the rest, so when visiting that particular city one must return to a point that had been visited before. Thus in the RTTSP we eliminate restrictions (2), (3) and (4).

If a significant improvement in traffic conditions can be expected, that is a future value of a cost c_{ij} will be less then its present value, it is worth waiting (suspending the tour for a while) and continuing in the next step. In this case obviously the cost of staying at a point must be calculated. In this sense we eliminate restriction (1) as well. Very often in the solutions restriction (1) is fulfilled by selecting $c_{ij} = \infty$. In our case c_{ij} is the cost of staying at $node_i$ in a given step.

The permutation of nodes $(p_1,p_2,\ldots.p_n)$ is being modified as well. As a city may be visited several times, objective function (5) must be rewritten:

minimize
$$C(p)=\left(\sum_{i=1}^{mn-1} c_{p_i,p_{i+1}}\right)+c_{p_{mn},p_1}, \tag{6}$$

where $m=1,2,\ldots$ is the multiplier factor (see paragraph 5.1). Objective function (6) is a generalized form of TSP, the multiplier factor equals to 1 in the classical cases. However applying $m>1$ for classical TSP in a bacterial evolutionary algorithm (BEA) does not generate any problem, since BEA will eliminate that kind of bad bacteria efficiently.

4. Bacterial evolutionary algorithms

Nature inspired some evolutionary optimization algorithms suitable for global optimization of even non-linear, high-dimensional, multi-modal, and discontinuous problems. The original genetic algorithm was developed by Holland [1] and was based on the process of evolution of biological organisms. It uses three operators: reproduction, crossover and mutation. Later, new kind of evolutionary based techniques were proposed, which are imitating phenomena that can be found in nature.

Bacterial Evolutionary Algorithm (BEA) [2] is one of these techniques. BEA uses two operators; the bacterial mutation and the gene transfer operation. These new operators are based on the microbial evolution phenomenon. Bacteria share chunks of their genes rather than perform a neat crossover in chromosomes. The bacterial mutation operation optimizes the chromosome of one bacterium; the gene transfer operation allows the transfer of information between the bacteria in the population. Each bacterium represents a solution for the original problem. BEA has been applied for wide range of problems, for instance optimizing the fuzzy rule bases [2, 3] or feature selection [4].

The algorithm consists of three steps. First, an initial population has to be created randomly. Then, bacterial mutation and gene transfer are applied, until a stopping criterion is fulfilled. The evolution cycle is summarized as follows:

```
create initial population
do {
   apply bacterial mutation for each individual
   apply gene transfer in the population
} while stopping condition not fulfilled
return best bacterium
```

First, the initial (random) bacteria population is created. The population consists of N_{ind} bacteria (chromosomes). It is followed by the evolutionary cycle, which contains two operators. The bacterial mutation is applied to each chromosome one by one. First, N_{clones} copies (clones) of the bacterium are generated, then a certain segment of the chromosome is randomly selected and the parameters of this selected segment are randomly changed in each clone (mutation).

Next all the clones and the original bacterium are evaluated and the best individual is selected. This individual transfers the mutated segment into the other individuals. This process continues until all of the segments of the chromosome have been mutated and tested. At the end of this process the clones are eliminated.

In the next step the other operation, the gene transfer is applied, which allows the recombination of genetic information between two bacteria. First, the population must be divided into two halves. The better bacteria are called the superior half, the other bacteria are called the inferior half. One bacterium is randomly chosen from the superior half, this will be the source bacterium and another is randomly chosen from the inferior half, this will be the destination bacterium. A segment from the source bacterium is chosen randomly and this segment will overwrite a segment of the destination bacterium or it will be added to the destination bacterium. This process is repeated for N_{inf} times. The stopping condition is usually given by a predefined maximum generation number (N_{gen}). When N_{gen} is achieved then the algorithm ends otherwise it continues with the bacterial mutation step.

The basic algorithm has four parameters: the number of generations (N_{gen}), the number of bacteria in the population (N_{ind}), the number of clones in the bacterial mutation (N_{clones}), and the number of infections (N_{inf}) in the gene transfer operation.

5. BEA for the modified traveling salesman problem

When applying evolutionary type algorithms first of all the encoding method must be defined. The evaluation of the individuals has to be discussed, too. The operations of the algorithm have to be adapted to the given problem.

5.1. Encoding method and evaluation of the individuals

In the modified traveling salesman problem one city may be visited more than once. Because each city must be visited at least once, one solution of the problem does not need to be a permutation of the cities. The evident encoding of the problem into a bacterium is simply the enumeration of the cities in the order they should be visited. Therefore, a length of the bacterium may be greater than the number of cities (N_{cities}), but an upper bound for the bacterium length has to be defined too, we allow bacteria not longer than $m \cdot N_{cities}$, where m is the multiplier factor, which is a parameter of the algorithm. The initial city is not represented in the bacterium.

The length of the bacteria can be changeable. It can be changing during the evolutionary process and the individuals can have different lengths. In the initial population generation, the length of the bacteria is a random number greater than or equal to N_{cities} and less than or equal to $2 \cdot N_{cities}$. $(m=2)$.

The evaluation of a bacterium is based on the time dependent distance matrix. The distance between the first element of the bacterium and the initial city is taken from the distance matrix at the zeroth time step, the distance between the second element of the bacterium and the first element of the bacterium is taken from the distance matrix at the first time step, and so on, these distances are summed up, and the total distance is obtained in this way.

5.2. Bacterial mutation

In the bacterial mutation there is an additional parameter, the length of the segment to be mutated in the clones. First, the segments of the bacterium are determined, and a random segment order is created. In the clones, the mutation of the given segment is executed. For example in Figure 1, the length of the segment is 3, and there are 4 clones. The random segment order is e.g., {3rd segment, 1st segment, 4th segment, 2nd segment}. This means that in the first sub-cycle of bacterial mutation, the 3rd segment is mutated in the clones. After the mutation of the clones, the best one is being chosen, and this clone (or the un-mutated original bacterium) transfers the mutated segment to the other individuals.

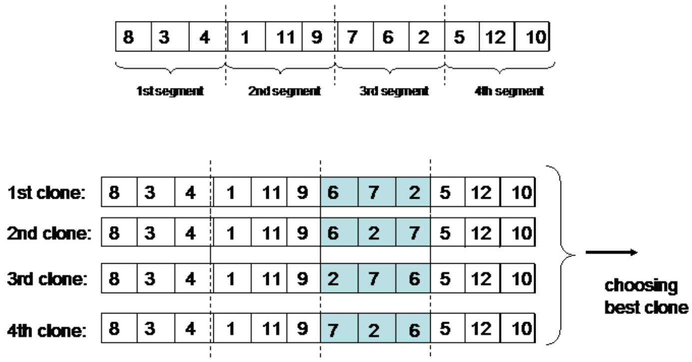


Figure 1. Bacterial mutation

The segments of the bacterium do not need to consist of consecutive elements. The elements of the segments can come from different parts of the bacterium as it can be seen in figure 2.

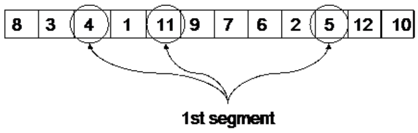


Figure 2. Segment in the bacterial mutation

Because in the modified TSP the number of visited cities is not predefined, bacteria with different length can occur in the population. Although in the initial population generation bacteria with different length can arise we would like to allow the changes in the length within the bacterial operations, too. Therefore before a clone is mutated a random value is used for determining that after the mutation the length of the clone will increase, decrease or remain the same. Increasing is allowed only in the case, when the maximum bacterium length ($2 \cdot N_{cities}$) is not exceeded, similarly, decreasing is allowed only in the case, when the minimum bacterium length (N_{cities}) is guaranteed. If the length will increase, then besides changing the positions of the cities in the selected segment of the clone, new cities are added to this clone randomly. If it will decrease, then some cities are deleted from the clone taking care that only those cities are allowed to be deleted, which have at least one other occurrence in the clone. If the length remains the same, then only the positions of the cities in the selected segment are changed.

5.3. Gene transfer

In the gene transfer operation there is also an additional parameter, the length of the segment to be transferred from the source bacterium to the destination bacterium. In contrast with the bacterial mutation, in the gene transfer, the segment can contain only consecutive elements within the bacterium. The reason for that is the segment containing consecutive elements representing sub-tours in the bacterium, and transferring good sub-tours is the main goal of the gene transfer operation.

Figure 3 shows the gene transfer in the case of time independent distance matrix. In the case of time dependent distance matrix, the position where the transferred segment goes to in the destination bacterium must be the same as the position of the segment in the source bacterium.

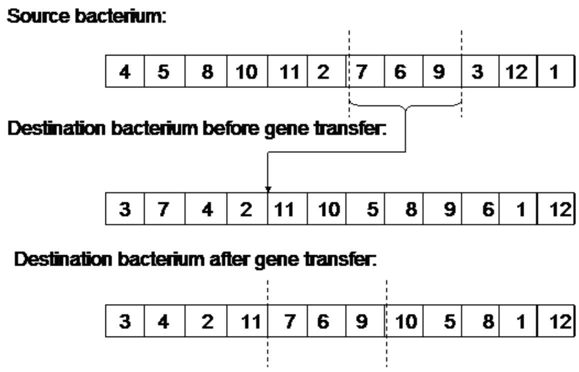


Figure 3. Gene transfer

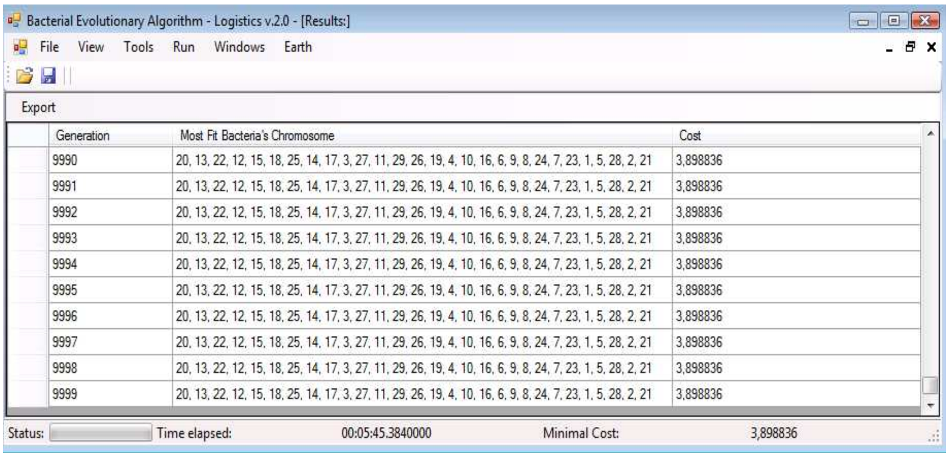
The different individual lengths are allowed also in the gene transfer operation. After the segment was transferred to the destination bacterium, the elements that occur in the transferred segment and are already in the destination bacterium can be deleted from the destination bacterium. If the same number of elements is deleted from the destination bacterium as the length of the segment, then the length of the destination bacterium remains the same. If less elements are deleted, then its length will be increasing. If more elements are deleted (taking care that each city must have at least one occurrence in the bacterium), then the length will be decreasing. We must also take care that the length of the destination bacterium must be at least N_{cities} and at most $2 \cdot N_{cities}$ (multiplier factor $m=2$).

6. Computational results

In the evaluation process a symmetric and an asymmetric, time dependent version of the same graph is compared. The topography of the graph is presented in Fig. 4.

Figure 4. The topography of the graph

Solution for the symmetric case is shown in Fig.5./a and 5./b.



Generation	Most Fit Bacteria's Chromosome	Cost
9990	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 4, 10, 16, 6, 9, 8, 24, 7, 23, 1, 5, 28, 2, 21	3,898836
9991	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 4, 10, 16, 6, 9, 8, 24, 7, 23, 1, 5, 28, 2, 21	3,898836
9992	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 4, 10, 16, 6, 9, 8, 24, 7, 23, 1, 5, 28, 2, 21	3,898836
9993	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 4, 10, 16, 6, 9, 8, 24, 7, 23, 1, 5, 28, 2, 21	3,898836
9994	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 4, 10, 16, 6, 9, 8, 24, 7, 23, 1, 5, 28, 2, 21	3,898836
9995	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 4, 10, 16, 6, 9, 8, 24, 7, 23, 1, 5, 28, 2, 21	3,898836
9996	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 4, 10, 16, 6, 9, 8, 24, 7, 23, 1, 5, 28, 2, 21	3,898836
9997	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 4, 10, 16, 6, 9, 8, 24, 7, 23, 1, 5, 28, 2, 21	3,898836
9998	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 4, 10, 16, 6, 9, 8, 24, 7, 23, 1, 5, 28, 2, 21	3,898836
9999	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 4, 10, 16, 6, 9, 8, 24, 7, 23, 1, 5, 28, 2, 21	3,898836

Figure 5./a The best tour

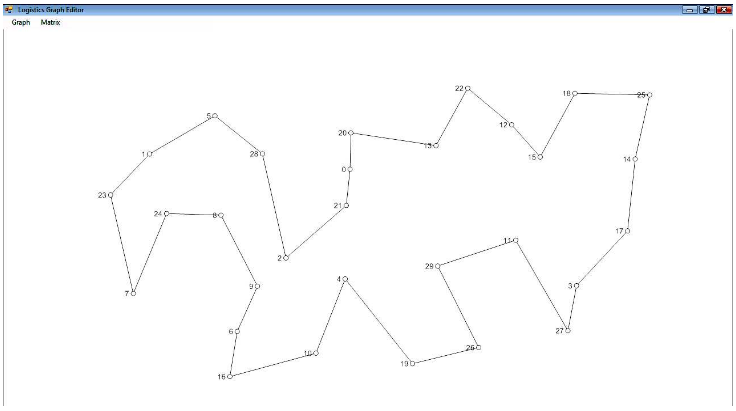


Figure 5./b Graphical representation of the best tour

The RTTSP version is modified in the following points.

$Node_{16}$ has only one connection to $node_6$.

$Node_6$ has two connections, to $node_{16}$ and to $node_9$.

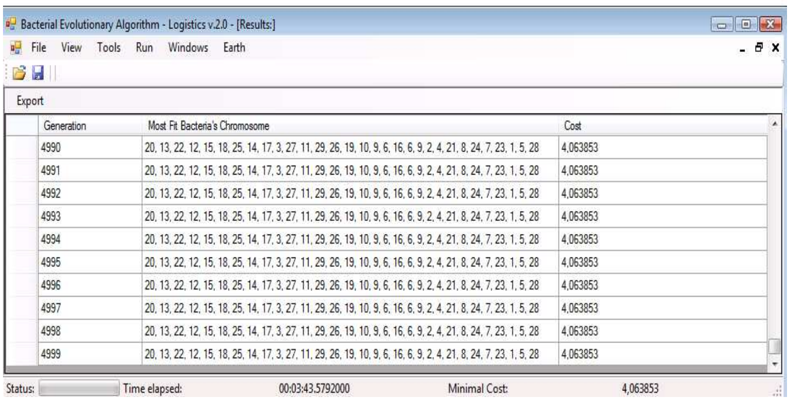
$$C_{10,23}(t) = C_{10,23} + 0.05t$$

$$C_{23,10}(t) = C_{23,10} + 0.05t$$

$$C_{20,0}(t) = C_{20,0} + 0.01t$$

$$C_{13,0}(t) = C_{13,0} + 0.02t$$

where *t* is the step in which the tour visits the node. This is a very simple representation of the time dependency of the graph. The results are shown in Fig.6/a and 6/b.



Generation	Most Fit Bacteria's Chromosome	Cost
4990	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 10, 9, 6, 16, 6, 9, 2, 4, 21, 8, 24, 7, 23, 1, 5, 28	4,063853
4991	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 10, 9, 6, 16, 6, 9, 2, 4, 21, 8, 24, 7, 23, 1, 5, 28	4,063853
4992	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 10, 9, 6, 16, 6, 9, 2, 4, 21, 8, 24, 7, 23, 1, 5, 28	4,063853
4993	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 10, 9, 6, 16, 6, 9, 2, 4, 21, 8, 24, 7, 23, 1, 5, 28	4,063853
4994	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 10, 9, 6, 16, 6, 9, 2, 4, 21, 8, 24, 7, 23, 1, 5, 28	4,063853
4995	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 10, 9, 6, 16, 6, 9, 2, 4, 21, 8, 24, 7, 23, 1, 5, 28	4,063853
4996	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 10, 9, 6, 16, 6, 9, 2, 4, 21, 8, 24, 7, 23, 1, 5, 28	4,063853
4997	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 10, 9, 6, 16, 6, 9, 2, 4, 21, 8, 24, 7, 23, 1, 5, 28	4,063853
4998	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 10, 9, 6, 16, 6, 9, 2, 4, 21, 8, 24, 7, 23, 1, 5, 28	4,063853
4999	20, 13, 22, 12, 15, 18, 25, 14, 17, 3, 27, 11, 29, 26, 19, 10, 9, 6, 16, 6, 9, 2, 4, 21, 8, 24, 7, 23, 1, 5, 28	4,063853

Figure 6./a The best tour for RTTSP

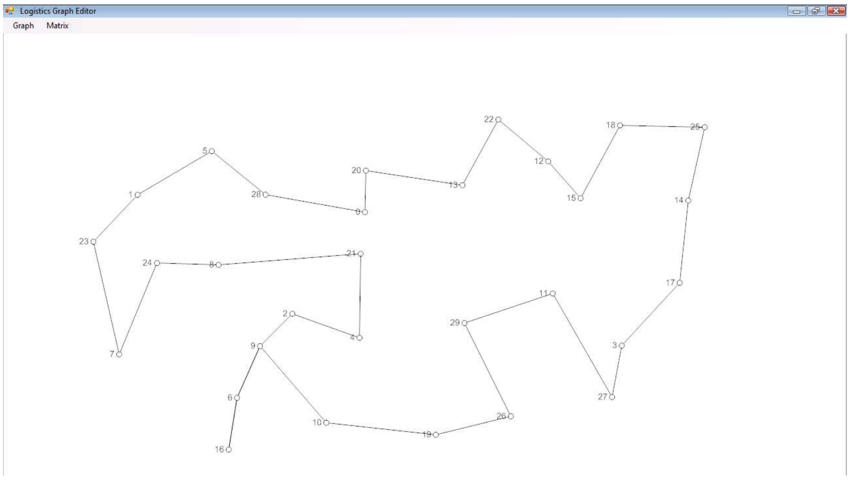


Figure 6./b Graphical representation of the best tour in RTTSP

The required number of generations can be different subject to the size and topology of the network. One of the reasons is that the number of possible tours in RTTSP increases because of the time dependency of cost matrix. Since the running time of BEA is about proportional to the number of generations it is a crucial task to select the most efficient parameters:

- number of bacteria in the population (N_{ind})
- number of clones in the bacterial mutation (N_{clones})
- number of infections (N_{inf}) in the gene transfer operation
- length of the segment to be mutated
- length of the segment to be transferred.

Furthermore the parameters of BEA solver of the classical TSP cannot be used without modification, since in RTTSP the length of a bacterium can be *m* times longer than in TSP (twice in our example).

7. Conclusions

The special features of road networks and road transportation processes encourage the modification of the classical TSP, eliminating most of the original constrains. Solutions in the literature are devoted to the classical problem, so after redefining the TSP and transforming it to RTTSP a novel approach is proposed. The bacterial evolutionary algorithm can efficiently handle the modified problem, which can be considered as a generalized version of TSP.

Scope of future research is twofold. First general rules must be set that can give instructions in order to find the most efficient parameters of BEA according to the size and other (e.g. topographical) features of a given RTTSP since running time is significantly affected by those parameters.

Another question is the interpretation of uncertainty concerning the variance of cost coefficients and the errors in prediction. In the RTTSP the cost coefficients are not considered as constants, because in the practice traffic conditions change in time. For forecasting the values time-series analysis could be used, however the random variables sometimes are not able to describe the real-life processes in road transportation. Thus consideration of fuzzy cost coefficients seems to be applicable [15].

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Outsourcing Distribution to a Third Party Logistics Provider Relying Upon Cost Savings Criteria

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Abstract: Outsourcing logistics areas is widely regarded for the last decades as a useful approach to reducing costs and gaining competitive advantage. Thus, the strategy of employing third-party logistics (3PL) providers' services has attracted growing interest. Many studies have been dealt with the advantages and disadvantages of outsourcing warehousing and transportation areas to 3PL providers, however, few of them make an attempt to quantify analytically the potential savings expected by handing over these logistics activities to 3PLs. This paper tries to reveal where the savings could be derived from. It will be demonstrated that savings occur almost evidently involving the 3PL provider into the development of distribution. It will be shown that these savings are a function of the number of the suppliers who outsource their distribution to the (same) 3PL provider and that this number has probably an optimum value.

Keywords: Outsourcing distribution, third party logistics

1. Introduction

Increasing competition and rapid changes in the business world in the last 30 years world have made organizations re-think their strengths and core competencies. They are increasingly focusing on their core business process and outsourcing non-core business processes to outside service providers. Companies can outsource any function from information technology to manufacturing.

Outsourcing is „a strategic use of outside parties to perform activities, traditionally handled by internal staff and resources" [6]. Organizations today have the option of outsourcing any activity or function they need. Service providers exist in almost every area of business that can provide the required services to companies. Companies today can outsource services like logistics, warehousing, information technology software and hardware, human resources, enterprise resource planning etc.

More and more companies view *logistics* as a key component of their core business strategy. Increasing numbers of shippers are realising the potential economic advantages of outsourcing their logistics activities. In fact, 74% of Fortune 500 companies report having at least one contract with a third party logistics provider [11,16]. In North America, according to Goddard [5] „it is clear that manufacturers and retailers consider 3PL services to be a viable option, a strong 79% are currently using 3PL services for their logistics operations".

Without any doubt, outsourcing is widely regarded as a useful approach to lowering costs and gaining competitive advantage. Logistics and transportation were among the most popular areas that used outsourcing from the 1980s. The strategy of employing the third-party logistics (3PL) providers' services has attracted growing interest. It means to involve external companies to perform logistics functions that have traditionally been performed within an organisation. The functions performed by the 3PL can encompass the entire logistics process or selected activities within that process [12]. There are more definitions about 3PL in [14,15].

Though there are many reasons for the companies to deploy their activities to a 3PL provider, according to many comprehensive research studies one of the main objectives is to reduce the logistics costs [5]: „73% of all companies1 expect to reduce their operating costs by taking advantage of economies of scale obtained by third party logistics companies". A review of the literature on the outsourcing of logistics services [12] suggests that cost and service related factors are the main concerns for firms when outsourcing: „Cost-related factors seemed to be the top priority among the customers, over service-related factors, in the decision to outsource. Just over half of the respondents perceived that reducing logistics costs (56.3%) and avoiding investments in a non-core activity (54.6%) were the main reasons for outsourcing. Improvement of service was a secondary priority for the customers."

Third party logistics that provide services like warehousing, transportation, packaging, labelling etc. are playing an increasing role in the management of supply chains. Classical distribution functions such as transportation and warehousing are most likely to be outsourced. The most „popular" areas that were outsourced by companies in the UK, according to Jaafar and Rafiq [12], are the following: basic transport (82.5%), storage (53%), order picking (43.7%), shipment consolidation/break bulk (40.4%) and cross-docking (33.3%)". Transport (61%) and warehousing (35%) are the leading activities outsourced in Slovakia, too [16].

If the aim of the outsourcing according to the majority of companies is the diminishing of costs (by employing 3PL's services particularly for transport and warehousing), how could these expected savings be achieved? It is widely accepted, that one of the main advantages is that the 3PL, working for many companies, can achieve the best economies of scale. „Logistics outsourcing offers many cost-related advantages such as the reduction in asset investment (turning fixed costs into variable), labour and equipment maintenance costs. Logistics service providers serve multiple customers and are able to utilize capacity better and spread logistics costs, thus achieving economies of scale and scope" [4].

The other factor is the freight consolidation. Consolidation is the process of grouping different shipments from suppliers into a large shipment at the consolidation point. The motive behind consolidation is to take advantage of lower transportation rates through better utilization of a vehicle's capacity [13]. As the 3PL „in general, operates the clients' warehouses and transportation services, through the use of these warehouses it is able to couple the inbound and outbound transportation, may consolidate the customers demand and due its expertise will probably use the cost savings logistics opportunities like cross-docking" [11].

Albeit the above-mentioned allegations are widely known, however, studies that elaborate the theoretical aspects of the cost savings opportunities by involving 3PL provider have received considerably less academic attention. This paper tries to prove that in most cases the outsourcing of core logistics tasks like warehousing and transportation very likely cut the distribution costs. A function between the size of the 3PL provider and the expected savings will be established. We shall demonstrate through the aid of a fictive example that there exists at the 3PL provider an upper limit for the economy-of-scope. Another objective of the paper is to propose a simple tool for companies to find the most promising 3PL partner from the point of view of obtainable cost savings (if there are no remarkable differences between the decision criteria for selecting a potential 3PL).

2. Costs-analysis in the distribution

It is given that a 3PL provider in P_P offers warehouse capacity and transport service for its clients. At the beginning it has got only one client. Let us suppose that the shape of the area where the distribution takes place is approximately a circle, which has its centre in P_0. The client company that outsourced its distribution activity to the 3PL had originally the finished goods in P_C from where the goods had been transported to the customers by the client itself. The distance from P_C to P_0 is L_V and from P_P to P_0 is L_D (fig. 1).

We shall try to determine the ΔL distance between the client and the 3PL at which the outsourcing leads to cost savings for the client. Since the examination considers only the outsourcing costs and it doesn't cover other criteria therefore only the expenses of transport, warehousing and material handling are scrutinized.

Originally the client itself delivered the finished goods to its customers. We can estimate the distribution costs for one day with the following formula [8,9,10]:

$$K_V = k_F^V \cdot 0{,}75 \cdot \sqrt{T} \cdot \left(\frac{qN}{g^V} + \sqrt{N}\right) + \frac{8}{9} \cdot L_V \cdot k_F^V \cdot \frac{qN}{g^V} \qquad (1)$$

Here:

k_F^V delivery costs per unit vehicle distance (Ft/km),

T territory of the area to be supplied (km^2),

q average quantity of goods demanded by a customer (ton),

N average number of customers visited in one day,

g^V capacity of the vehicles used for the delivery (ton),

L_V the distance between the client's warehouse and the centre of the area (km).

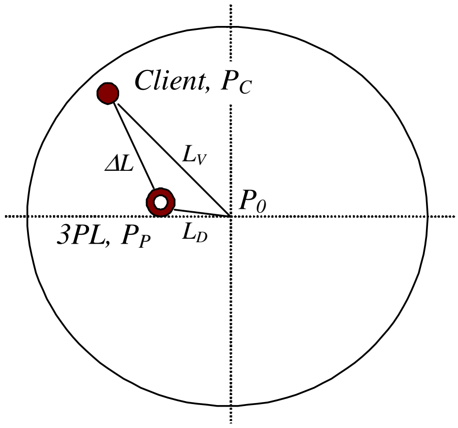

Figure 1. Positions of the client and the 3PL in the area to be supplied

In this we supposed that the company has used only one vehicle type and it could totally utilize its capacity in the given environment (working and driving time restrictions, time window limits at the customers, average speed on the roads etc.).

We can evaluate the expenses the following way, if the 3PL provider carries out the distribution:

$$K_D = k_F^D \cdot 0{,}75 \cdot \sqrt{T} \cdot \left(\frac{qN}{g^D} + \sqrt{N}\right) + \frac{8}{9} \cdot L_D \cdot k_F^D \cdot \frac{qN}{g^D} + 2\Delta L \cdot k_F^T \cdot \frac{qN}{G} + k_H \cdot qN \tag{2}$$

.

The following are the new symbols representations:

k_F^D delivery costs per unit vehicle distance (Ft/km),

g^V average capacity of the vehicles used for the delivery (ton),

G average capacity of the vehicles used for the transfer (ton),

L_D the distance between the 3PL's warehouse and the centre of the area (km),

ΔL distance between the client and the 3PL,

k_F^T transfer costs of the goods from the client plant to the 3PL warehouse per unit distance (Ft/km),

k_H handling costs of goods (loading, unloading) per unit weight at the 3PL's warehouse (Ft/ton).

We postulated above that the 3PL uses a different vehicle type for the delivery than the client, and its extra capacity can be utilized to the fullest. For the transfer of goods a cheaper transport solution must be used (big articulated lorries or even railway), therefore the unit costs per distance for the transfer are smaller than for the delivery. We did not take into account the *stock keeping costs* in the 3PL's warehouse, these are supposed to be approximately the same as they were at the client.

There are cost savings if $M = K_V - K_D > 0$. (3)

Should this cost difference cover the extra expenses for the transfer and handling expenses arising from the usage of the 3PL then it seems to be worth outsourcing the distribution task to a 3PL provider. Putting (1) and (2) into (3) and reducing the equation:

$$0{,}75 \cdot \sqrt{T} \cdot qN \cdot \left(\frac{k_F^V}{g^V} - \frac{k_F^D}{g^D} \right) + 0{,}75\sqrt{NT} \cdot \left(k_F^V - k_F^D \right) + \frac{8}{9} qN \cdot \left(\frac{L_V \cdot k_F^V}{g^V} - \frac{L_D \cdot k_F^D}{g^D} \right)$$
$$\geq 2\Delta L \cdot k_F^T \cdot \frac{qN}{G} + k_H \cdot qN \tag{4}$$

Though widely assumed that a 3PL works at a lower costs level, we may assume at the beginning that the capacities (and the unit costs) of the vehicles used by the client or by the 3PL are roughly the same. (E.g., the 3PL takes over the vehicle fleet of the client).

In this case $g^V \approx g^D \approx g$ and $k_F^V \approx k_F^D \approx k_F$:

$$\frac{8}{9} qN \cdot \frac{k_F}{g} (L_V - L_D) \geq 2\Delta L \cdot k_F^T \cdot \frac{qN}{G} + k_H \cdot qN \tag{5}$$

If the 3PL provider lies on or near the direct line leading from the client to the centre of area, then $\Delta L \approx L_V - L_D$, and we can write:

$$L_V - L_D \geq \frac{k_H}{\frac{8}{9} \frac{k_F}{g} - 2 \frac{k_F^T}{G}} \tag{6}$$

Should the left side of this equation be greater than the right, then it seems the distribution will be cheaper when outsourced to a 3PL provider, even if this provider works only for one client. According to the fact that companies are often situated quite far from the centre of their market territory, they may cut their distribution cost only by putting the distribution warehouse towards the centre of the market. For a new 3PL provider it means that it is advisable to seek a good location for its premises in the vicinity of the market centre.

3. Consolidation: the elementary source of savings

We have seen that a company may reduce its distribution costs even to reallocate the point from where the direct delivery starts. This phenomenon is well known in the practice but hardly mentioned in technical literature [13] though according to Wei Shi Lim [18] considerable costs savings could be realized under an optimized warehouse location.

As we pointed out at previously the bigger part of the cost savings could be derived from the possible consolidation of goods. A freight consolidation is a systematic attempt to decrease the total transportation cost between a given origin and many destinations. We can distinguish *shipment* consolidation (whereby several small orders are dispatched as a single, combined load) and *terminal* consolidation (whereby shipments of many different companies and products are "dispatched mixed" to delivery points) [2, 7].[1]

The shipment consolidation is actually the well-known „milk run”. According to (1) the total costs of the necessary delivery tours (milk-runs) by which the customers' demands will be met depend on the position of the warehouse. In the previous section we achieved the cost-savings only by shifting the origin of the delivery tours towards the centre of the region.

Without terminal consolidation and each company dispatches its delivery routes directly to the customers. The demand of the customers is small (to avoid unnecessary inventory) and the time windows for accepting the shipments are narrow. Since the working time of the vehicle drivers are limited, the number of customers to be supplied in one tour is curbed. For these reasons the vehicles used by the companies are usually small or middle-sized.

In the terminal consolidated case the suppliers transport their goods to the same warehouse (usually run by a 3PL provider). This transfer of goods will carried out probably with big lorries, the warehouse is presumably open the whole day therefore transport can be received even during the night. As a result the unit cost for this part of the transportation (primary distribution) is comparatively cheap.

From the consolidation terminal (3PL's warehouse) the shipments of the clients will be "dispatched mixed". With this solution the delivery routes will be „leaner” and they will visit customers close to each other. Sometimes customers receive goods from more than one supplier. In this case the number of visits to a customer subsides as well. Albeit this kind of transportation (secondary delivery) is more expensive than the previous one, it is still less expensive than the original solution.

[1] Some authors even distinguish a third type of consolidation, the so called *inventory* consolidation [13]

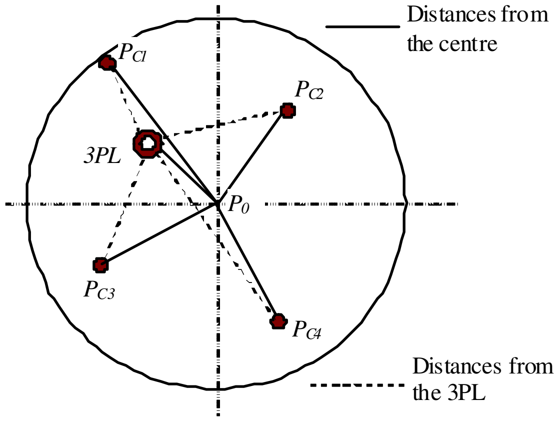

Figure 2. The 3PL has more clients

The effect of consolidation can be realised when the 3PL provider has more clients (fig. 2). Let us suppose that the number of clients the 3PL works with is *m*. Before these clients joined to the 3PL provider each of them delivered the goods directly to their own customers that are lying scattered approximately on the same area (*T*).

For making the analysis simpler we assume that the capacities of the delivery vehicles are approximately equal ($g_1^V \approx g_2^V \approx ... \approx g_1^V \approx g^V$). As the vehicles have the same size, their unit costs per km should not be very different, that is ($k_{Fi}^V \approx k_F^V \approx const.$). With these simplifications the estimated total cost for the deliveries referring to (1), if every company supplies the customers directly, then it could be calculated in the following way:

$$\Sigma K_V = 0,75 \cdot \sqrt{T} \cdot k_F^V \sum_{i=1}^{m} (\frac{q_i N_i}{g^V} + \sqrt{N_i}) + k_F^V \cdot \frac{8}{9} \sum_{i=1}^{m} (L_{V\,i} \cdot \frac{q_i N_i}{g^V}) \qquad (7)$$

It is easier to use this function if we introduce the weighted average value for the number of each customer group ($\overline{N}$), for the quantity to be transported to a customer by one supplier ($\overline{q}$), for the distance from the centre of area ($\overline{L_V}$) and from the 3PL provider ($\overline{\Delta L}$).

$$\overline{N} = \frac{\sum_{i=1}^{m} Q_i N_i}{\sum_{i=1}^{m} Q_i}, \quad \overline{L_V} = \frac{\sum_{i=1}^{m} Q_i L_{Vi}}{\sum_{i=1}^{m} Q_i}, \quad \overline{q} = \frac{\sum_{i=1}^{m} q_i N_i}{\sum_{i=1}^{m} N_i}, \text{ and } \quad \overline{\Delta L} = \frac{\sum_{i=1}^{m} Q_i \cdot \Delta L_i}{\sum_{i=1}^{m} Q_i}. \tag{8}$$

Putting these values in (7) the total delivery costs will be a linear function of *m,* supposing that with the increase of *m* the new clients will not influence significantly the above-determined averages:

$$\Sigma K_V = 0{,}75 \cdot \sqrt{T} \cdot m \cdot k_F^V \cdot (\frac{\overline{qN}}{g^V} + \sqrt{\overline{N}}) + m \cdot \frac{8}{9} \cdot \overline{L_V} \cdot k_F^V \cdot \frac{\overline{qN}}{g^V} \tag{9}$$

Now we calculate the summarized costs for supplying the customers with goods if every supplier will be a client of the same 3PL provider. Here we postulate that the products of the different clients may be transported together, that is, they can be consolidated. According to (2):

$$K_D = k_F^D \cdot 0{,}75 \cdot \sqrt{T} \cdot (\frac{\overline{q} \cdot \Sigma N}{g^D} + \sqrt{\Sigma N}) +$$
$$\frac{8}{9} \cdot L_D \cdot k_F^D \cdot \frac{\overline{q} \cdot \Sigma N}{g^D} + 2\overline{\Delta L} \cdot k_F^T \cdot \frac{\overline{q} \cdot \Sigma N}{G} + k_H \cdot \overline{q} \Sigma N \tag{10}$$

Temporarily we assume that the 3PL provider uses approximately the same delivery vehicles as it had used for their clients' distribution before they were given to the 3PL ($g^D \approx g^V \approx g$). With this we take for granted that the costs per unit distance are approximately the same, too ($k_F^V \approx k_F^D \approx k_F$).

With these, in the case where the 3PL carries out the distribution for the client, there will be a total cost saving (3), if the following inequality is true (11):

$$0{,}75 \cdot \sqrt{T} \cdot \overline{q} \frac{k_F}{g} \left(m \cdot \overline{N} - \Sigma N\right) + 0{,}75\sqrt{T} \cdot k_F \left(m \cdot \sqrt{\overline{N}} - \sqrt{\Sigma N}\right) +$$
$$+ \frac{8}{9} \overline{q} \cdot \frac{k_F}{g} \left(m \cdot \overline{L_V} \cdot \overline{N} - L_D \cdot \Sigma N\right) \geq 2\overline{\Delta L} \cdot k_F^T \frac{\overline{q} \cdot \Sigma N}{G} + k_H \cdot \overline{q} \cdot \Sigma N \tag{11}$$

The interdependences are easier to understand if we introduce other simplifications. Here we suppose that $N \approx N_1 \approx N_2 .... \approx N_i$, $q \approx q_1 \approx q_2 .... \approx q_i$. With these we get the total savings from (11):

$$M = 0{,}75\sqrt{T}\cdot k_F \cdot \left(m\sqrt{N} - \sqrt{mN}\right) + \frac{8}{9}\cdot\frac{qk_F}{g} mN\cdot\left(\overline{L_V} - L_D\right) - mNq\cdot\left(\frac{2\overline{\Delta L}\cdot k_F^T}{G} + k_H\right) \quad (12)$$

Projected (12) to one client:

$$M = 0{,}75\sqrt{T}\cdot k_F \cdot \left(\sqrt{N} - \sqrt{\frac{N}{m}}\right) + \frac{8}{9}\cdot\frac{qk_F N}{g}\cdot\left(\overline{L_V} - L_D\right) - mNq\cdot\left(\frac{2\overline{\Delta L}\cdot k_F^T}{G} + k_H\right) \quad (13)$$

It is easily understandable that $\overline{\Delta L} + L_D \geq \overline{L}_V$ (in a triangle the sum of two sides are always longer than the third side), namely $\overline{\Delta L} \geq \overline{L}_V - L_D$. We shall get the best solution (the greatest savings) if the 3PL provider's warehouse is situated in the centre of the area to be supplied. In this case $L_D = 0$, and $\overline{\Delta L} = \overline{L}_V = \overline{L}$:

$$M_{MAX} = 0{,}75\sqrt{T}\cdot k_F \cdot \left(\sqrt{N} - \sqrt{\frac{N}{m}}\right) + \frac{8}{9}\cdot\frac{qk_F N}{g}\cdot\overline{L} - mNq\cdot\left(\frac{2\overline{L}\cdot k_F^T}{G} + k_H\right) \quad (14)$$

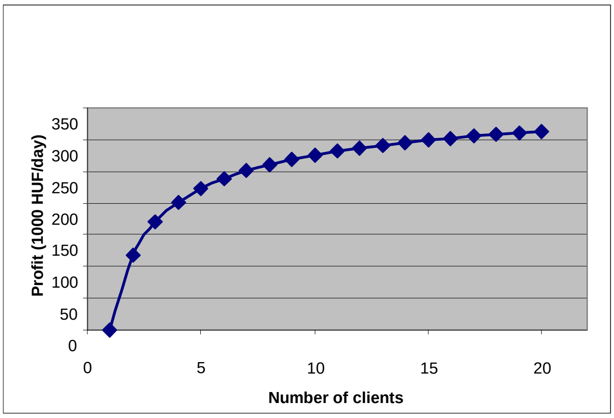

Figure 3. Expectable savings per client (3PL is in the centre)

It is shown in figure 3 the curve of the expectable savings if the 3PL provider increases the number of its clients. The initial data for this example is the following:

T 100000 km^2,

N 200,

g 3,5 (ton),

Q 0,5 (ton),

k_F 120 (HUF/km),

G 20 (ton),

k_F^T 250 (HUF/km),

ΔL 100 (km),

k_H 550 (HUF/ton).

With this data there is actually no savings when only one company gives over its distribution to a 3PL provider. It is also observable that with the growing number of the clients the probable savings per client increases definitely though the rate of this increase is continuously diminishing.

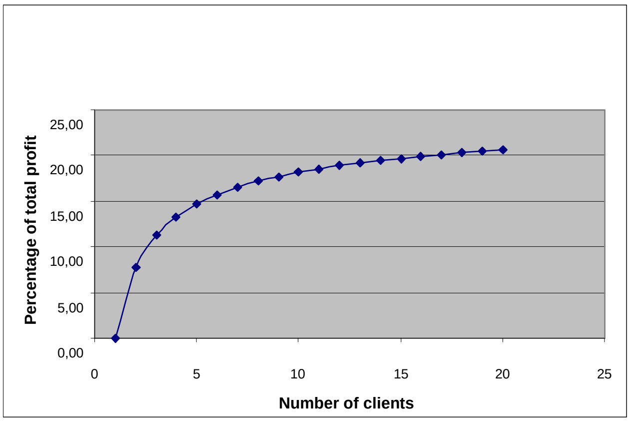

Figure 4. Percentage of total expectable profit as a function of the clients' number of 3PL providers

With only having 3 clients the 3PL provider may achieve a profit over 10% (if it is able to overtake the distribution activities of the clients at the original costs). On the other hand, the growth rate of the expectable savings is regressive and there is hardly any increment over 20 clients (fig. 4).

We can conclude that the total distribution expenses of many independent companies, if they outsource this profile to a suitable 3PL provider, most probably will diminish even if the 3PL provider *does not make any special effort* except living with the opportunity of terminal consolidation.

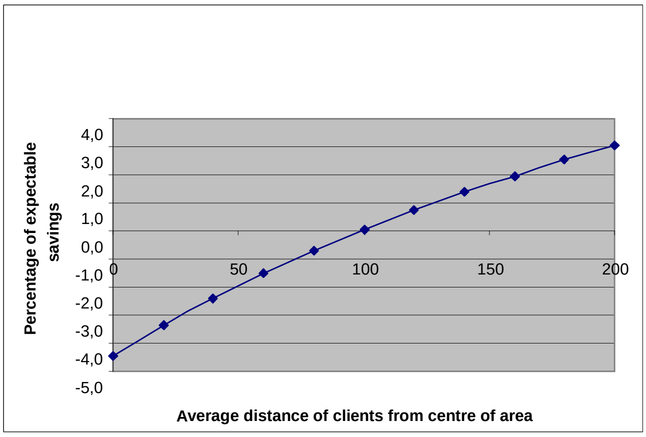

Figure 5. Percentage of total expectable profit as a function of the average distance of clients from the centre of area

The cost reduction is higher when the suppliers are further from the centre of the market (country). Figure 5 shows how the attainable savings change according to the average distance of the suppliers (clients) from the centre. In the example above the value of the parameters have been purposely but realistically chosen. As it can be seen from figure 3 and 4, there are no savings for one client at 100 km distance from the centre. When the 3PL provider does not consolidate the goods in the warehouse, then the relative savings do not depend on the number of clients but only on the average distance from the centre (in this case the other parameters remain the same). This is visible in figure 5.

Should the clients be in the centre (close to the 3PL provider) the total savings would have been 4,5% smaller, and at 200 km 3% higher. Note that the potential savings obtainable by the decentralized position of the clients is inferior compared with the values we can achieve by the consolidation process.

4. Using an adequate vehicle fleet: a possibility for obtaining more savings

We assumed previously that, except consolidating the shipments, the 3PL provider will not utilize any of its special skills and knowledge such as introducing computerised vehicle routing and scheduling (CVRS) system, extending working days putting 2 drivers to a lorry, shortening with better handling equipment the waiting times at the customers etc. Here we will only investigate that quite often occurring case when the 3PL provider adjusts its vehicle fleet to the modified transport conditions.

The customers to be supplied have usually a specified time window for taking over the commodities. The length of the working- and driving time for the drivers are regulated (limited). Municipals may prohibit the transport during the night. It may be supposed that according to these circumstances there is always an ideal lorry-size, which is the best for the deliveries from the warehouse.

We take into account for the estimation of this lorry capacity only the permitted working time of the drivers. It is assumed that only one driver works on each of the vehicles (with a maximum work time in line with the regulations), so the highest number of customers to be visited during one day by one vehicle is x, because:

$t_M \geq t_V + t_R \cdot x$, where the meaning of the symbols is:

t_M the limit of the working day,

t_V the permitted driving time during the day,

t_R the average waiting time at one customer (for loading, unloading, administration etc.).

According to Hirkó [9,10] the value of x could be determined by the following formula:

$$x \leq \frac{v \cdot t_M - 0{,}75 \cdot \sqrt{T} - \frac{8}{9}\Delta L}{0{,}75 \cdot \sqrt{\frac{T}{N}} + t_R \cdot v} \tag{15}$$

and with this the suitable average capacity for the vehicles is:

$$\overline{g} = \overline{q} \cdot x \tag{16}$$

(It is worth to mention here that for deliveries from one depot to many points the optimal solution in most cases is not using a homogeneous vehicle fleet but instead of vehicles with mixed capacity [11])

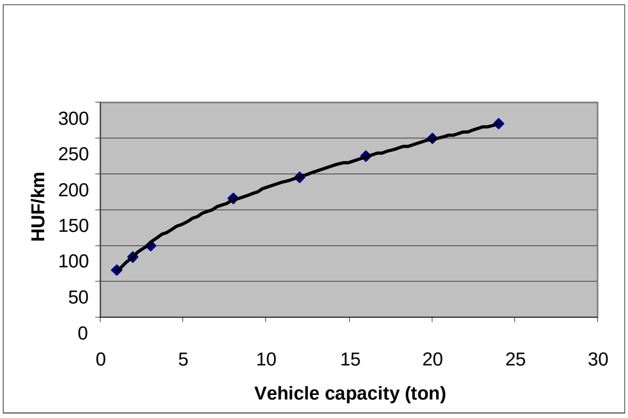

Figure 6. Costs per vehicle km as a function of the vehicle size (example)

For x depends on the number of the points to be supplied, the more clients the 3PL has the more points can be visited by one route. (The customers in the same route will be closer to each other; in consequence the driving time will lessen.) Since the curve of the vehicle costs per km is convex (see fig. 6), using a higher capacity vehicle for the delivery the potential amount of the total savings will be even greater than it has been calculated in section 3.

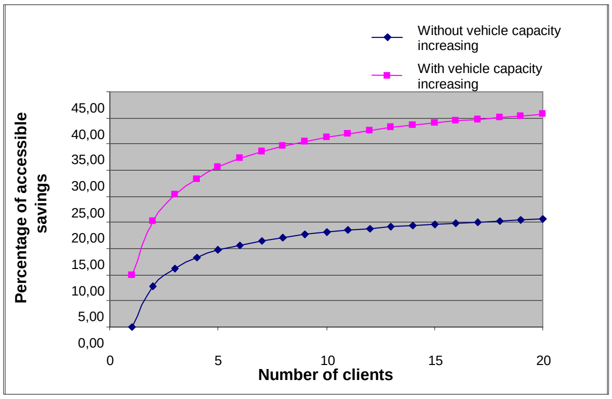

Figure 7. Percentage of total expectable profit as a function of the clients' number of a 3PL provider

In our case we supposed an average speed of 50 km/h for the vehicles, 0,3 h/point loading time per customer, and 11 h. highest possible working time for the drivers. Taking into account the 100 km distance of clients from the centre we get from (15) and

(16) a 3,5 ton capacity as a recommended value. After outsourcing, the delivery is organised by the 3PL provider from the centre and applying again the deduced formulas (15,16) we get a higher capacity value (4,9 ton), even if the 3PL has only one client. If the 3PL can add more clients to its initial one, the possible size of its vehicles can be enlarged (fig. 7).

It is immediately recognisable that the potential savings are actually doubled. This is often overlooked though the obtainable improvement is not to be neglected and it explains why 3PL providers use generally larger vehicles than suppliers performing their deliveries themselves.

(Naturally this saving-potential can not be entirely utilized in practice for many reasons, e.g., there are restricted areas for big lorries in town centres, the customer can accommodate only small vehicles or even a prosperous 3PL cannot replace its vehicles with bigger ones each time it gets a new client etc.)

5. Overlapping customer groups may increase the savings potential

Until now we have supposed that the customers of a supplier are entirely different from the customers of another supplier. In the practical world it is observable that among these groups of customers there is very often overlap. As a consequence the number of the points that are to be visited will decrease, the average volume carried to one point will get bigger, and even the time for one stop will diminish.

The waiting time at a customer can be divided into 2 parts: (a) for the effective loading or unloading time and (b) for the preparing and closing time of the loading process. The former depends (linearly) on the volume transported to a point, the latter is approximately constant:

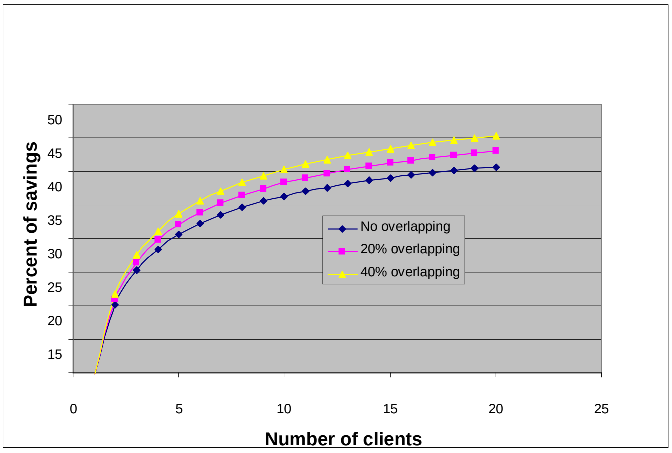

Figure 8. Percentage of potential savings of overlapping customer groups

$$t_R = t_v + q \cdot t_r \tag{17}$$

where the symbols mean the following:

t_v average waiting time at a stop

(parking time, preparations, administration etc.),

t_r actual loading, unloading time,

q average volume (quantity) carried to a customer.

To estimate the effect of overlapping we introduce a coefficient δ (<1). It denotes the share of *common* customers in a customer group. For example if each of the two suppliers has 200 and 200 customers and δ = 0,4, then a 3LP having these two clients do not need to visit 400 customers but only 320 (=N*):

$$N^* = mN \cdot (1-\delta) + \delta N = 2 \cdot 200 \cdot (1-0{,}4) + 0{,}4 \cdot 200 = 320.$$

(We have assumed here that the number of customers in each group is equal.)

With the help of δ we reformulate (15):

$$x^* \le \frac{v \cdot t_M - 0{,}75 \cdot \sqrt{T}}{0{,}75 \cdot \sqrt{\dfrac{T}{mN(1-\delta) + \delta N}} + (t_v + q \cdot t_r) \cdot v} \tag{18}$$

Considering that the goods can be carried together the demands of the common customers can be treated together as well (further consolidation). The points to be visited during a day diminish further and as a result the average quantity carried to one point increases:

$$q^* = \frac{mN \cdot q}{mN(1-\delta) + \delta} = \frac{m}{m(1-\delta) + \delta} \cdot q = \frac{q}{1 - \delta + \dfrac{\delta}{m}} \tag{19}$$

Referring to (16) the suitable vehicle capacity (G* = x*·q*) will grow because both factors are higher than they were before not taking the common customers into account. (At this point we have to mention that this increase has a limit; the permitted gross weight of a lorry by the authorities or in regards to other conditions.) Figure 8. shows the potential savings at different overlapping.

6. Optimum number of clients

It is well known that the necessary handling times of shipments depend on the size of the warehouse [17]. The distances for carrying the goods into or out from the stocking area will be longer. The picking routes grow longer, too. For reasons of simplicity we conceive a long warehouse for the 3PL in that every customer has a separated space for its stock. (Actually it is quite usual.) If we suppose that the area occupied by the stock of one client here is about the same as it was at the supplier (before the distribution had been outsourced), we can understand that the picking cost does not need to change significantly, at least until the picking routes reach the end of the racks. (This explains why the picking costs have been left out of our investigation.)

As the main source of savings is the consolidation of shipments in the warehouse, all goods should be carried to a central (manipulation) area. The consolidated (unit) packages must be loaded to the very vehicle, which is assigned to the route containing the target consumers. This vehicle can be anywhere on the dispatching area (fig. 9). The average distances we need to bridge over will be longer with the expansion of the warehouse (along with the increase of the number of clients).

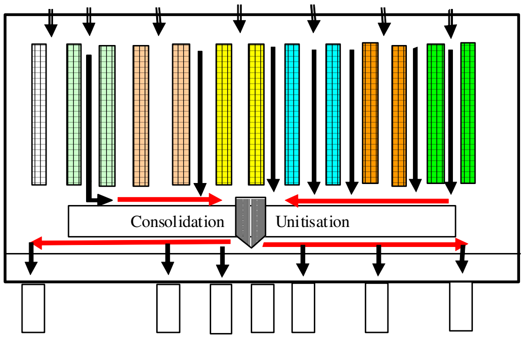

Figure 9. Possible layout of a 3PL warehouse

The growth of the material handling costs is approximately a linear function of the length of the warehouse that is the number of clients. Let us estimate this cost for 40 HUF/ton. As at the beginning the operating cost in the warehouse was 550 Ft, then after signing the contract with the 20th client these costs increased up to 1350 HUF/ton (= 550+20*40).

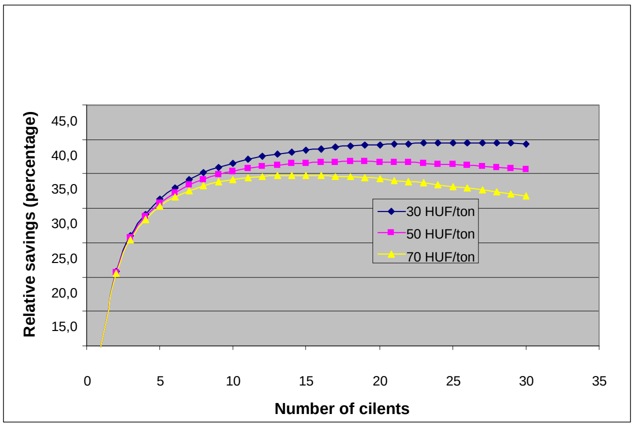

Figure 10. Percentage of potential savings (considering the costs of consolidation)

Figure 10 illustrates how the costs develop if we take into account the necessary extra work that is needed in the 3PL's warehouse to consolidate the shipments. The data for this figure is the same and has been used in this paper before; the overlapping rate between the customers groups is 20%.

We may realise that considering the unavoidable costs (resulting from the expanded material handling activities that are required for the consolidation of goods of various clients) the relative values of the savings potential will probably have an optimum. In other words: if the distribution tasks of many suppliers will be given to a 3PL provider, then it is to be expected that the obtainable possible total costs savings, which is a function of the number of clients contracted with the 3PL, will diminish if the number of these clients exceeds a certain value. It is observable that the best number of clients moves toward the smaller values with the rise of the consolidation costs.

As we pointed out previously, the data we used in this paper is fictive (though realistic) and therefore they are by no means suitable for drawing far-reaching conclusions. We should still point at the well observable fact that in spite of the worldwide globalisation very few 3PLs provide complete distribution (warehousing and transport) to more than 30-40 clients, at least not from one warehouse.

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Methodology of Optimising Complex Logistics Supply Networks

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Abstract: This article is aimed at introducing the technical-economic analysis of the efficiency of complex logistics networks and the methodology of their optimization by the means of experiences of practical examples.

Keywords: supply networks, supply chain, optimization, genetic algorithm, distribution system

1. Introduction

The analysis and optimization of the efficiency of supply and distribution networks operating in value production chains is a complex technical-economic problem, in which the realisation of the optimum calculation criterion and target-function system is quite a difficult task. Beside this, the discovery of the optimal solution complying with the criteria is also not a trivial question. Decisions aiming at an occurrent modification of the network structure are long-term in the lives of corporations and basically determine future costs related to the operation of the network [4], [8], [10]. Researches have been performed for a relatively long time with the aim to experiment such methods and policies by the means of which decision support can be realised in specific situations like this. Our article examines a procedure recently developed by us that we have already successfully applied, several times, in the case of restructuring the network structure of multinational corporations in Hungary.

2. Analysis methods of operational efficiency of an existing network

We find it essential to review those basic purposes that motivate such complex examinations in corporate practice based on our experience:

- Is the number of depots sufficient (too many or too few)?

- Is the spatial dimension of our warehouses appropriate? If not, where should we build new warehouse(s)?
- Is it ideal to operate the current system in a centralized or decentralized structure?
- Is the vertical and horizontal structure of the network appropriate?
- What procedures should we outsource or insource out of or in the range of the corporation (out- and insourcing questions)?
- What indicators do we measure with the fulfilment of service level agreements in regards to outsourced procedures?
- What logistic standards should we provide our customers with?
- What product transportation methods should we apply? What vehicle fleet should we fulfil transportation tasks with?
- Which customers and products are preferable or non-preferable?
- Do we apply appropriate inventory strategies?
- Other specially occurring questions not listed here (e.g., the localization of the production plant).

Considering the above list it can be stated, that the method of complex evaluation can be expedient to apply in addition to the strategic questions in the case of the regulation and refinement of operative procedures. Furthermore, it is important to note that our article primarily examines the problem of existing networks; similar problems might occur not only in the case of existing networks but in the case of networks to be created as well. The above questions should be seen from a different view, and from a different approach.

2.1. The specification of base data

In accordance with the questions listed above, a number of basic base data is required from a technical point of view to set up a decision model capable of handling the problem. Based on our experience, gathering the data groups related to the following seven topics is recommended:

1. Basic technical, technological characteristics of *production places*, plants as the sources of the supply network essential from a logistic perspective are …

   the spatial dimension of the plants, data related to its technical condition, the characteristics of transport connections, the characteristics of production capacity and output.

2. Basic technical, technological characteristics of warehouses essential from a logistic perspective operating in the current supply network (either their own or provided by the supplier), out of which emphasizing those essential are…

   the spatial dimension of *warehouses*, data related to its technical condition, the characteristics of transport connections, the technology of goods receipt, inventory, commissioning, goods release, the basic receipt and release characteristics, and expansion options of the area/buildings.

3. Basic technical, technological characteristics of *product transportation system* (either their own or provided by the supplier) essential from a logistic perspective that is…

   basic data, loading machinery, product transport technology and receipt characteristics related to transport vehicle, loadability, equipment, operation characteristics and other occurrent specialties.

4. *The basic characteristics related to network infrastructure, in the case of which the following have to be gathered…*

   different road network and geographic features related to applied (and currently applicable) product transport methods, in consideration of supplied areas.

5. Data groups related to moved, shipped *products*, in the respect to which are especially important…

   the so-called logistic characteristics of the products, i.e., primarily the physical parameters of those, in consideration of the data of the applied packaging system (package units, shipping units, standard cargo, currently the applied intermodal unit) and of the different product handling technicalities.

6. The basic characteristics related to the *supply claimants* as the swallowers of the supply network that is…

   the spatial dimension of the supply claimants, technical, technological terms of goods receipt, and occurrent specialties related to the supply procedure (e.g., is there a transport timeframe system).

7. the characteristics of *IT solutions* applied in the management of the supply network are…

   specialities of the applied ERP's, corporate IT systems, their connection methods, data exchange solutions, the operative management systems currently applied, and solutions (e.g., patch editor systems, SCM monitoring systems, warehouse management systems, etc.).

The characteristics related to the listed characteristics feature the applied solutions of the existing network structure in the form of quantitative or qualitative data and can be integrated into the procedure of network optimization directly or indirectly, but they are absolutely inevitable in respect to the qualification of the existing network. We can work with a number of data from the ones above during the qualification that cannot be or can hardly be integrated into an optimising decision model, but can definitely be considered by the means of a certain correction during the evaluation of the results provided by the optimum-seeking model. That is they can affect the optimal build-up of the planned network.

The input data of *economic examinations* can be very complex, similar to the technical optimum seeking tasks. The following economic-type base data are required for the exact modelling and for the evaluation based on it (referring to the examination period defined in the preparatory stage of the work):

1. Sales/ production / turnover data;
2. Economic data related to inventory;
3. Economic data related to transportation;
4. Other costs data.

Basic data can be obtained in the form of questionnaires, spreadsheets, personal interviews and specific questions during the preparatory work. Here is a possible specification of the above cost groups as an illustration in the following table.

Table 1. Main cost groups applied during the examination

Transportation costs	Site / store costs
Rolling costs	Hiring fee of real estate
Fuel costs	Compensation of site employees
Tyre costs	Costs of warehouse machines
Service, maintenance	Costs related to the operation of the site (overhead)
Other service costs	Communication (telephone) costs
Vehicle amortization	IT costs
Compensation of vehicle employees	Tax-like costs (industrial tax, communal charge, etc.)
Tax-like expenses	Advertisement costs
Weight tax, insurances	Cost of tied-up capital
Plant running costs	

Sales and stock data downloaded from the sales and stock registration system supply the input data of turnover and inventory analysis. It has to be noted that these databases have deficiencies in a number of cases (e.g., inconsistent data, lack of movement types, unnecessary redundancies, just to mention a few), so the composition of a head database that is applicable for further analysis is a single technical task.

This data is in a close relationship with the technical characteristics, they cannot be examined apart in certain cases. It is also important to emphasize that it is not expedient to work only with costs registered by an accounting (that is only quantitative) perspective in the case of such examinations in the calculation of logistic expenses, but it is worthy of applying a controlling-type approach, where the procedure approach that is the identification of certain costs by cost centre is determinative. It follows that the obtained values cannot be compared directly with the annual financial statements; they can only be used together by applying careful interpretation and correction factors.

2.2. The modelling and optimum searching procedure

After the specification and collection of the base data, what follows is the build-up of a model complying with the methodology of the examination, during which we build a supply network model of mapping the current situation. It depends on the depth of the examination, the givens of the network and the specialities of the procedures to be modelled of how complex if a model should be created, and what data can be neglected. Our experience shows that production companies participating in different global supply networks emphasize the question in the point of the networks operated by them and in what way do the manufactured products produced by them reach the end users. A typical example of this is the new FMCG sector, where the efficiency of the developed network is of basic importance, as the competition is very strong, and there is a huge number of wholesale and retail companies trading the products of competitors as well. Thus modelling can be a quite complex task, as the types of the different supply channels belonging to different sales methods can vary quite a bit. Based on our experience it can be said that due to the industrial peculiarities and differences it is hard to develop such system that can be applied to all cases, hence the modelling of the network is a single task in all cases, only principles, the process of modelling and optimum-seeking methods can be stated. The basic purpose in all cases, during the optimum-seeking process, is that both the qualification of the current situation and optimum-seeking should happen based on: combined technical-economical views, an opportunity to examine as many alternatives as possible, and the selection of the optimal solution. The process of the modelling is examined in figure 1.

It is quite essential during the modelling and optimum-seeking process that the qualification of both the current and planned network structures should be performed by the same technical-economic terms and applied methodology, as we can evaluate compared to what and how much better results can be achieved by the reconstruction of the network. This process is called qualification procedure. Below we demonstrate the network optimization procedure applied by us by the means of a food industrial example. A model of such a typical network is demonstrated by the figure (no. 2) on the next page. It can be seen in the figure that such a complex network has to be optimized, in which „$i = 1...n$" (usually with a position fixed in space - refer to the exemption below) production plant is given, and given are the examined elements of the supply channels, that are…

- key accounts (KA's for short, e.g., TESCO, METRO etc.) in the case of which central warehouses with fixed positions, and shopping centres with fixed positions are supplied from these,
- wholesalers in the case of which the given wholesale warehouses with fixed positions, and retail units area supplied by these, and

- HoReCa's (i.e., hotels, restaurants and café's) in the case of which sales points with fixed positions.

Practice shows that in most of the cases the *base questions* are the structure of the distribution warehouse network (how many warehouses should be built, where and of what capacity?) framed in a broken line in the figure with the number „ $j = 1...m$". And it should be decided whether it is optimal to have these operated by their own operation or by logistic supplier. However, according to our experience, this base question can be complemented with other additional decision problems too. This can be e.g., the dilemma in which the existing network elements of the supply channel should be used by the planned supply network to supply consumers.

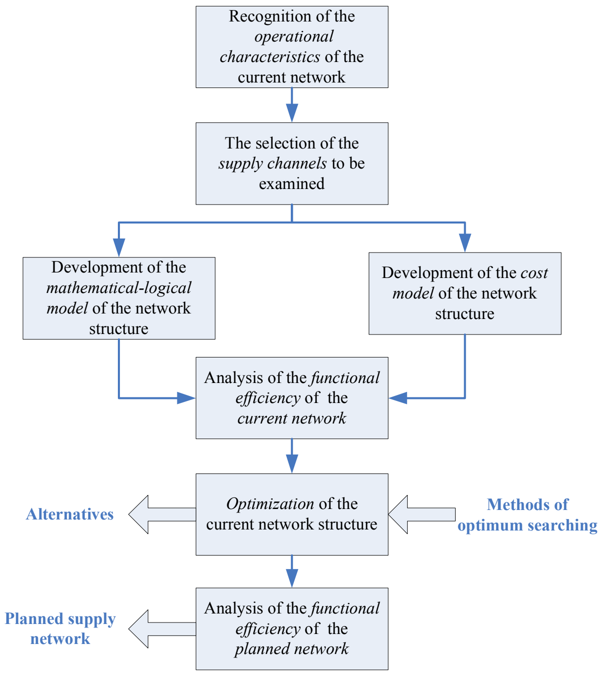

Figure 1. The process of the network structure's function and optimization.

The network modelled and to be optimized can be in fact imagined as a controlled graph in which the junctions are the elements of the network (e.g., plant, distribution centre), and the edges show the existing connections between the junctions (e.g., where from is each product shipped to). Each of the junctions and edges has their own special characteristics. The characteristics can be interpreted by the analysis and systematization of the above base data. These should be fully taken into consideration in order to achieve as precise results as possible during the optimum-seeking process.

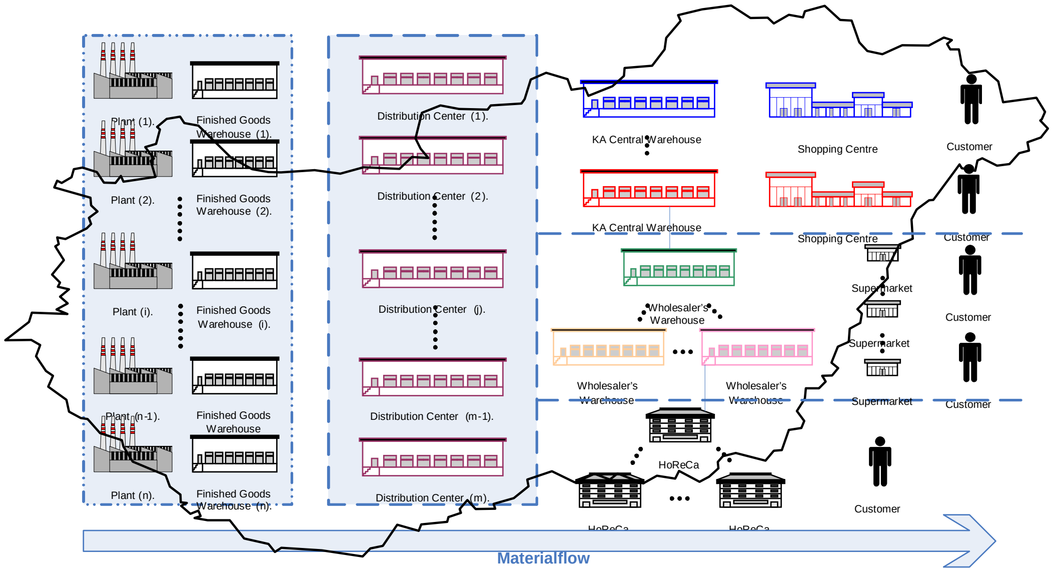

Figure 2. Diagram of the examined supply network.

3. Introduction of the optimization of a modern supply network

The complexity of the modelling and optimum-seeking task can be sensed from the above. It is considerably difficult to create an optimising model that takes into consideration all quantitative and qualitative parameters but in some regards quantitative factors from the base data listed above the mapping network characteristics in one level. Simplifications have to be applied during the development of the mathematical-logical and costs model, and the optimum-seeking process is expedient to be realised in several levels. For the sake of simplicity in our article we have only examined the case where the *base question* defined at the end of subsection 1.2 has to be answered. Even in this relatively simple issue the optimization of the network structure can be a quite complex question. One of the well-tried methods in the optimization network structures is the seeking of the minimum of storage and transport costs [4], [8], [10]. In the course of calculations it is expedient to proceed from those physical processes that realise logistic performance in the network. The target function of optimum seeking has to be mapped from the estimated value of these transport and storage performances reflected to the network and by the means of aggregated costs calculated from these after the calculation of specific costs.

$$C_{logistics} = C_{transport} + C_{storage} \Rightarrow MIN! \qquad (1)$$

3.1. The estimation of transport and storage performance, the optimization of network resources in several ways

To estimate the logistic performance related to the supply network such a function should be applied by the means of which logistic values related to transport and storage processes can be approximated as simple as possible. The bases of these calculations are provided by the base data already defined above (unfortunately incomplete in several cases). The outputs of calculations should be interpreted as the input parameters of the target function defined in (1.) that is the aggregated costs related to the network can be produced by the means of a relatively simple substitution. The base data to be applied (characteristically aggregated on a yearly basis) shall be aggregated to settlements as the preparation of the calculations in regards to the examined supply channels ($t = 1...x$), as the model does not handle the certain network elements separately, but as a simplification it aggregates the interests represented by them to geographic geo-codes. Hence an aggregated „I_t" interest can be calculated to e.g., each settlements (geo-codes). It is also an essential base data of how many alternatives we wish to examine during the optimization of the network and what basic characteristics these have. The most important of these is that how many sectors (m) do we wish to categorize the aggregated demand into. Further preparatory measures are as follows:

1. The development of the raster-network based on the geographic characteristics of the examined are (e.g., Hungary) the aim of which is the further territorial categorization of the settlements, their mapping of interests, and the further simplification of the examination. The number and the development of the rasters ($r = 1...y$) depend on the characteristics of the supplied area to a great extent. An example is demonstrated by figure 3, in which each settlement demand points are noted by a blue circle, a certain „t_r" number of demand points belong to a raster, and the demand aggregated to a raster is noted by „I_r" herein after.
2. The obvious assignment of centre areas (rasters) and the settlement of rasters determined by the location of production plants, the aim of which is to appoint „m" number of rasters including district- or distribution centre and „n" number of rasters including production plants incidentally.
3. The clusterization of settlements by the means of the developed raster-network by minimising the straight line distances (s_{jr}) between the centre of the base centre areas and the raster-centres, the aim of which is the categorisation of interest aggregated to rasters „I_r" into a number of districts depending on the examined alternatives.

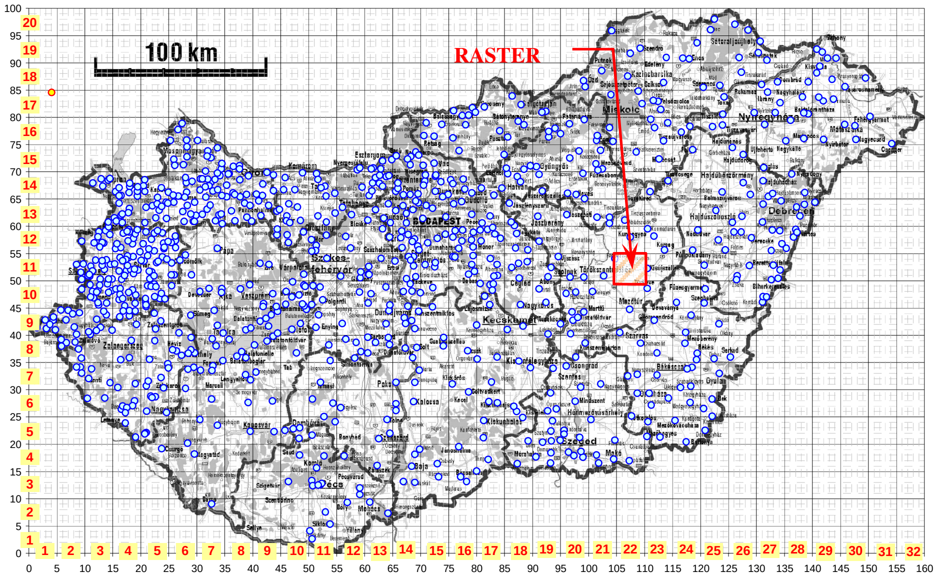

Figure 3. An optional solution to the raster

The optimization of the network occurs in *two steps* after the preparations. First a so-called *centre-seeking* [7] shall be performed by the means of an iteration process in regards to the „m" number districts that is we should decide starting from the accidentally adapted district categorisation which settlements will be supplied from which central warehouses and where these warehouses will be located. Iteration is performed by *a genetic algorithm combined with local search* [6] in which we have performed the local search with the *centre seeking* [5] of Jándy. The location of the centre area and the capacity of distribution centres realised in it changes continuously during iteration due to the „clusterization" of the demand. The stopping of this „movement" and the process of „realignment" means the end of iteration (this is the optimum). Special iterational standards (originating from the characteristics of the generic algorithm) provide the opportunity to measure this. The definition of the so-called *distribution transport performance* gives the target function of the optimum-seeking process. It is an essential boundary condition that the demand of any „t" demand point belonging to raster „r" can be fulfilled from a certain distribution centre in all cases that is any raster number „r_j" (and „t_j" number demand point) defined can belong to any j centres that is

$$\sum_{j=1}^{m} t_j = x \quad , \tag{2}$$

and

$$\sum_{j=1}^{m} r_j = y \quad , \tag{3}$$

is realised.

Furthermore, any centres to be realised should be of unlimited capacity (e.g., a greenfield site) that is any size of demand can be assigned to it. So that the target function can be put down in the following form:

$$P_{transport}^{distribution} = \sum_{j=1}^{m} \sum_{r=1}^{r_j} I_r \cdot s_{jr} \Rightarrow MIN! \quad , \tag{4}$$

where

$$I_r = \sum_{t=1}^{t_r} I_t \quad . \tag{5}$$

The outcome of the first optimization step is the position of the optimal centre areas (refer to figure 4 - the size of the „bubbles" is proportional with the demand aggregated to the raster), and the output intensity of the distribution centres to be placed on them, which can be put down in:

$$I_j = \sum_{r=1}^{r_j} I_r$$

(6) form.

Network resources shall be optimised by the solution of a so-called *assignment*, also known as *transportation* problem [1], [11] as a second step that is it has to be decided which distribution centres have to be supplied from which production plant by the location and the output intensity of the production plants (I_i) given, and the material demand of a certain distribution centre can be fulfilled from different production places at the same time. This process is called inventory and it is characterized by the so-called *inventory transport performance*. The optimisation of the resources means the solution of a simple linear programming task, which can be solved by any simple application that can perform optimum seeking (e.g., MS Excel Solver). The target function can be put down in:

$$P_{transport}^{replenishment} = \sum_{i=1}^{n} \sum_{j=1}^{m} I_{ij} \cdot s_{ij} \Rightarrow MIN!$$

(7) form, where

I_{ij}: the intensity of material flow between (i) production place and (j) distribution centre;

s_{ij}: the distance between (i) production place and (j) distribution centre.

The outcome of the second optimization step is the *aggregate transport performance* of the distribution and inventory performance related to the network, which can be calculate as follows:

$$P_{transport} = P_{transport}^{distribution} + P_{transport}^{replenishment} . \tag{8}$$

Figure 5 shows the development of aggregated transport performances in the case of certain alternatives (different area codes).

In the measurement of the *aggregated storage performances* the planned inventory, storage and release and/or commissioning performances necessary to operate the planned supply network shall be basically taken into consideration. These characteristics can be characterized as a result of a complex optimum-seeking task similarly to the above. The inputs of the calculations will be the results of the above optimum-seeking methodology (related to the transport system), the functional parameters (e.g., planned inventory turnover speed) demanded from the planned system (defined in advance) and the output results of the statistical examinations performed on the base data.

However, as these optimum calculations result from the solution of the fairly complex and complicated optimum seeking tasks (refer to [3]) only the most essential outcomes of these calculations are demonstrated due to the limitations of content being presented at this time:

- inventory and release performance:

$$P_{stockpiling} = \left[\frac{\text{stockpiling}}{\text{period}}\right],$$

$$P_{release} = \left[\frac{\text{release}}{\text{period}}\right],$$

- planned average inventory level:

$$Q_{average} = [\text{quantity unit}] ,$$

- order picking performance:

$$P_{order\,picking} = \left[\frac{\text{picking}}{\text{period}}\right].$$

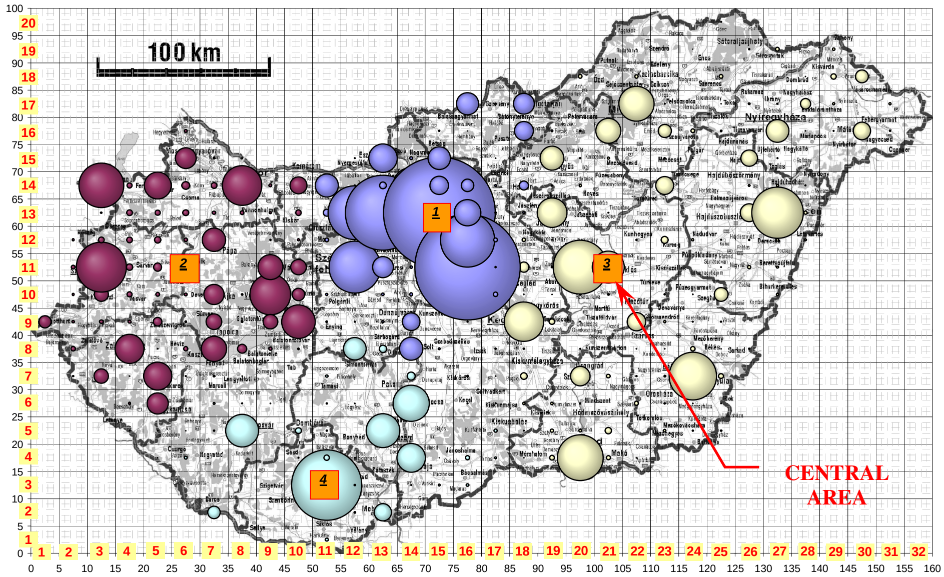

Figure 4. The optimal solution of a centre-seeking problem of four districts

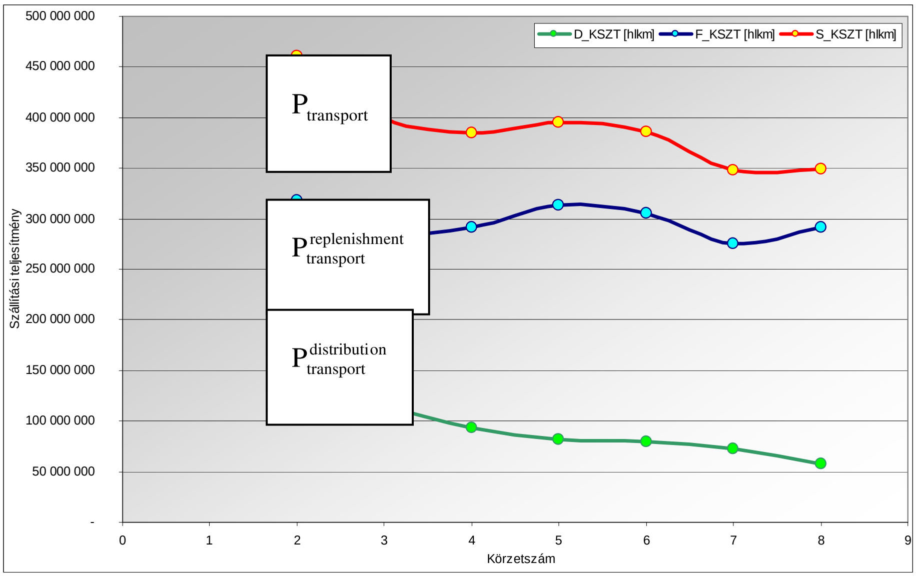

Figure 5. Transport performances belonging to certain alternatives

3.2. Costs related to solution alternatives

Performance has to be taken into consideration as defined in (8) at the calculation of complex transport performance. The dimension of quantity and period can be different (e.g., hl, pcs, and year, month, etc.), considering the specialization of the certain company. With the help of the methodology outlined in the previous section, the detailed logistic natural characteristics of a certain part process (e.g., hl-km/year dimension) are available and the specific costs (e.g., HUF/hl/km) can be created by the means of database analysis during financial examinations, by simple calculations, by the means of developing logistic and financial models of the historic performance and of cost data. The costs related to the certain process from either the costs side or the performance side and the filtering of characteristic activities is a challenge. In staying with our example, to determine the inventory, transport performance and costs in the past, e.g., the performance of cross-docking activity and the costs to be allocated to it have to be determined and have to be left out of consideration. The fraction-type specific indicators costs (counter) side can be generated by the means of the corporate costs-registration systems and supplementary expert estimations. The past transport performances in the denominator are unavailable in most of the cases, as e.g., in the case of transport to be performed by subcontractors, the companies don't register the exact running performances, so that e.g., hl-km type indicators cannot be generated. Hence the model outlined above is applicable to estimate past performances as well - indicating the versatile applicability of the model to these types of problems -; running with fixed centres adequate to the situation in the past (with distribution centres). The simplified draft of the above method is demonstrated by the following figure (no. 6).

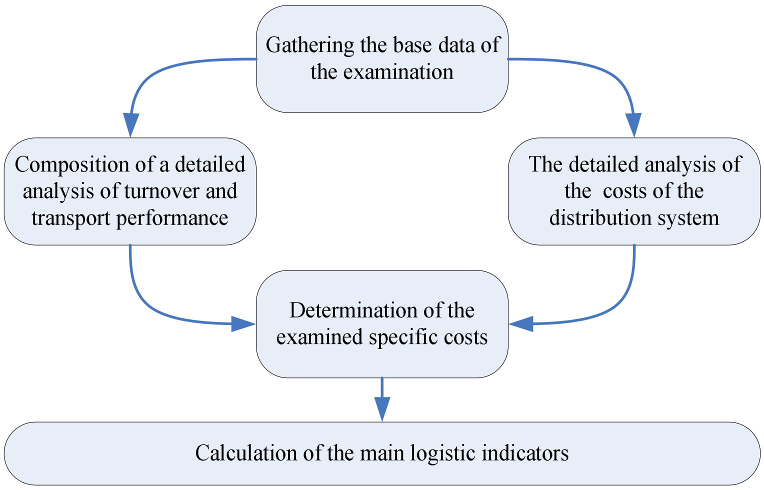

Figure 6. The relationship between the methodology used during the analysis and the calculations and the base data required for the calculation and the result indicators.

The estimated specific transport costs to be generated by the aggregated transport costs and natural terms [HUF/hl/km] indicator. The different accounting costs are divided into *fix* and *variable* costs at the definition of storage costs. The value of the alternative costs of the tied-up capital in the stock related to the examined period can be calculated by taking as a basis the average inventory values and the rate of interest of the alternative investment (characteristically around 10% in the recent years). Variable costs are

$c_{\text{stockpiling}} =$ [HUF/hl/year],

$c_{\text{store-in}} =$ [HUF/loading unit],

$c_{\text{store-out}} =$ [HUF/loading unit], and

$c_{\text{order picking}} =$ [HUF/picking].

These types indicators are the result, which are then multiplied by the natural values stated in the previous section and we get all the variable storage costs of the examined alternatives. In addition, due to the peculiarity of the storage system, the sites also have *fix costs* ($C_{\text{storage, fix}}$) that are independent from the realised turnover and grow almost linear with the number of sites. The transport and storage total costs of the certain alternatives can be determined by the means of the natural output of the network model and the specific costs mentioned above, and all of the logistic costs of the corporation produced as the total costs of these are:

$$C_{\text{logistics}} = (c_{\text{transport}} \cdot P_{\text{transport}}) + C_{\text{storage, fix}} + C_{\text{storage, variable}}, \tag{9}$$

where

$$C_{\text{storage, variable}} = c_{\text{store-in}} \cdot P_{\text{store-in}} + c_{\text{stockpiling}} \cdot Q^{\text{stock}}_{\text{average}} + c_{\text{store-out}} \cdot P_{\text{store-out}} + c_{\text{order picking}} \cdot P_{\text{order picking}} \tag{10}$$

You can analyse the effects of the change of certain input parameters by so-called sensibility-examinations. It is important to note that such type of elasticity examinations are valid in certain environments, consequently the bigger scale modification reduces the reliability.

Methodologically a number of *notes essential* to the practice need to be added to the above:

- It can be often useful to verify the outcome results by detailed on-site surveys besides data request, and to gather missing data, as we have noted before, the frequent deficiency of corporate information systems might cause serious problems

- It is also important to emphasize here that it is expedient to include activities of the broadly considered logistics into the processes of logistics, e.g., the elements of marketing activities related to general corporate management and distribution as well. According to our experience, the entire logistic costs of trade companies that calculate it this way is 0,5-2% higher in comparison with the total turnover, depending on what cost centre we allocate the certain cost elements to. This interpretation approach of logistic costs is justified by the fact that the activity of the certain participants and the related costs also form the inseparable part of the total value-production process within a given supply network
- The standard methodology approach is also justified by the fact that based on the results produced by the means of this, the logistic performance of the company becomes not only valuable, but commensurable as well with the similar indicators of other companies of the same profile (benchmarking)
- The following indicators have to be emphasized in the evaluation of the development of costs:
    - Economies of scale: as in the case of all economic processes, the principle of growth of returns to scale might affect the economic efficiency to a significant extent, to come up with a theoretical example, a regional or a country distribution can be characterized with different values from a scale economies perspective
    - Significant scale and variability of site costs:
        - Due to the settlement peculiarities of the classic accounting systems, the larger part of the costs is allocated to the sites. Hence site costs are usually more significant than transportation costs. On the other hand, while no significant differences can be experienced in transportation costs at a country level, costs related to real estate may vary (even to a ratio of 1:3)
        - The affect of the change of certain on-site cost elements to certain logistic costs aggregates (e.g., inventory costs) can be analyzed by the means of a flexibility examination due to the usual "overlap" of the trade/production and logistic function on a site (the costs of each activities cannot be exactly distinguished and divided)

3.3. The selection of the optimal decision alternative

Seeking the solution of the optimal network development means in fact the selection from the examined decision alternatives. It is quite essential to perform the qualification of the current network structure prior to the selection (by the method defined above) by the application of the developed mathematical-logical and costs model. The primary aim of this is that the efficiency of optimum seeking can be measured in comparison to the current situation that is there should be a base of reference. The qualification can be easily performed by substituting the performance parameters characterizing the current network, calculated from the base data into the (8), (9) and (10) functions above. The total logistic costs calculated by the method defined in (9) is the primarily examined characteristic during the selection process as the result of the above process, however the selection can be „burdened" (but at the same time disburdened too) by a number of other characteristics (e.g., infrastructural factors, workforce supply, growth factors related to the examined area, etc.) as well, that can be taken into consideration in either quantitative or qualitative forms. Characteristically the main view is to emphasize directly „cost-able" factors that are collaterally considerable in the first round, so that an aggregated cost can be calculated, which is closer to the cost of the examined alternative by superponating to the aggregated logistic costs in the form of aggregated „other costs" (C_{other}). Finally, other factors can be taken into consideration by the means of value analysis measures supporting the multi-factor decision-making [9], [11], by the means of which optimal decision alternatives (occurrent alternatives) can be appointed.

4. Conclusions

We have participated in a number of innovative researches (e.g., [2]) in which we had to develop such methods and procedures given by multinational corporations with a significant infrastructural background and long history where the application of which could answer the question how can the optimal structure of a supply network with pre-defined functional parameters and boundary conditions be planned or re-planned. It has been proved during the research that the handling of the complex modelling problem examinable from many perspectives is a quite complicated task, as the „beauty" of such problems given by its uniqueness that is in all cases its most serious „enemy" of the development of such modelling systems and tools, that can be applied successfully under all circumstances (e.g., in the case of two corporations with different logistic background). There obviously are such factors and processes that show significant similarity in the structure and operation of supply networks, however it can be said that the technical „fineness" and novelty of the models developed by us so far arose due to the differences in most of the cases. Based on our research and on the experiences from the concrete network optimization projects it can be said that the logic of modelling and the applied optimum-seeking logic and the applied procedures can be shaped quite well, but we are (contrary to many others) considerably sceptical in regards to the possibility of the development of a software by the means of which any network modelling, and optimum-seeking problem can be handled.

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Approximation of Quasi-Optimal Depot Numbers in Simple Two-Step Delivery Systems

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Abstract: The limitation of the drivers' working time diminishes the size of good transport vehicles. As a consequence the costs of distri-bution increase. A tool for dampening this tendency could be the introduction of indirect distribution systems, usually with cross-docking depots. Without suitable sophisticated computer soft-ware it is difficult to determine a near optimal distribution network. This paper tries to present a method to calculate the necessary number of depots, the boundaries of the areas served by them, and the adequate placements of depots within these areas.

Keywords: Depot number, two-step delivery, distribution network

1. Introduction

In spite of the soaring transport costs resulting from the short lead times and small delivery batches the share of logistics costs in the price of products decreases. What is needed is the introduction of new transportation solutions to achieve this development. To establish indirect distribution systems is a common means for reducing distribution costs. Characteristics for these distribution systems are the bridging of longer distances by a relative cheaper transportation method, and solving deliveries by using small capacity road transport vehicles [1].

The prevalence of these systems are supported by the very strict prescriptions throughout Europe referring to the working and driving limits even for smaller vehicles with over 3.5 total weight. One of the consequences of the shorter working days is that even in a territory the size of Hungary it is not economical any more to use the common big or middle-sized vehicles for collection or delivery tasks [2].

More and more companies try to solve the contradiction between the quick lead-time and the resulting cost-increase by introducing cross-docking (CD) depots. The goods will be transported during the night into these depots with large capacity vehicles; meanwhile the actual delivery to the customers is covered by small or medium sized vehicles that start from the depots early morning. If this is organised properly the distribution of goods can be cheaper than the indirect transport, even if the lead-time is below 24 hours.

Several well-known heuristic, simulations or optimizing algorithms have been developed for determining the suitable distribution structure. There are available some sophisticated computer software as well, based on the above mentioned algorithms that help work out the best solutions (Radical: Cast-dpm., Paragon: Fastnet, etc). The mathematical methods are rather complicated, the computer programs are usually expensive and their usage is tedious and time consuming. Companies tend to determine therefore their distribution network in practice on the basis of intuition. The number of depots to be established, the shape and size of areas served by them will be typically specified by „visual inspection" [3].

In this paper we try to prove with some limitations and simplifications that the area supplied by a depot is bordered by a hyperbola and by the boundary of the whole distribution territory. The size of an area depends partly on the location of one of the hyperbola's focus-points (actually from the distance of the central warehouse and the regional depot) and partly on the number of depots in the whole territory. We offer here also a simple method that can be used for determining the near optimum number and placement of the necessary CDs.

2. Shape of the area served by a regional depot

According to the common opinion the shape of the area served by a regional depot is approximately a circle with the depot in the centre. It will be shown here that this theory does not support this assumption. To prove this statement the costs of both the direct and indirect transports will be given.

Our starting-point is that for the actual delivery we shall use small or medium sized capacity vehicles, independent from the fact that the goods are either delivered from the central warehouse or a regional depot. (It is worth to mention that in the case where the customer to be supplied is far from the centre the capacity of the transport vehicle could be even smaller than that when starting from a CD, because of the strict working time limits of the drivers [2].).

At a first look (in Figure 1), we can see an area-division between the central warehouse (in Budapest) and a regional depot (Debrecen)[1]. We may observe that the goods often go from the CD „backward" that is in the direction of the central warehouse. Obviously it is not worth to transport the goods through a depot to the customer (that is a longer distance) if this is more expensive than direct delivery. Along the dividing border of the two areas the supply costs are equal.

In Figure 2 the point „P" receives the products either directly from the central warehouse (x) or indirectly, via a CD (L, y).

[1] Prepared by a computerized software package (Fastnet), product of Paragon Software Systems plc.

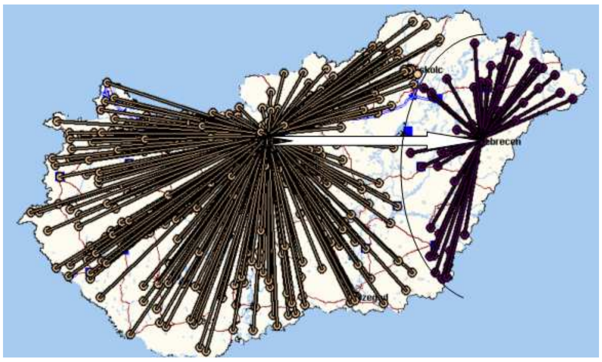

Figure 1. Supply area of a warehouse in Budapest and its regional depot in Debrecen (example)

Assuming that the demand in point P is equal with the capacity of the vehicle the number of customers on the route will be only one. Let us suppose that the location of point P between the centre and the depot is on the dividing curve that is the costs of the direct and indirect transports are the same. In this case:

$$2x \cdot k_F^T = 2L \cdot k_F^{Á} \cdot \frac{g}{G} + 2y \cdot k_F^T + k_R \cdot g \text{ ,where} \qquad (1)$$

G the capacity of the bulking (transferring) vehicle,

g the capacity of the delivering vehicle (g < G),

k_F^T costs per unit of the delivery vehicle [HUF/km],

$k_F^{Á}$ costs per unit of the bulking vehicle [HUF/km],

k_R costs per unit of reloading in the depot [HUF/ton].

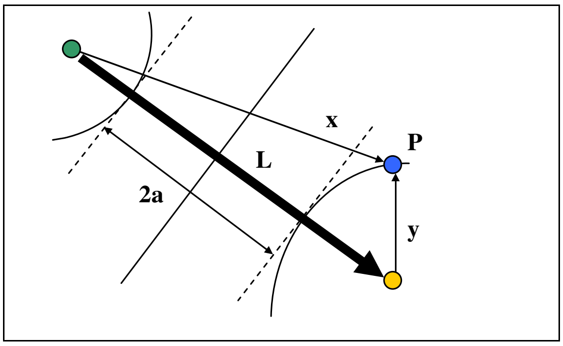

Figure 2. Determining the dividing border between the centre and the CD

By rearranging the equation (1) we get the following formula:

$$x - y = L \cdot \frac{g}{G} \cdot \frac{k_F^{Á}}{k_F^T} + g \cdot \frac{k_R}{2k_F^T} = 2a \tag{2}$$

Hence the right side of (2) is constant so we may rewrite it to “2a”. Applying this modification we see that the result is a hyperbola, which is clearly recognizable in figure 1, too.

In the equation (2) the distance (L) between the central warehouse and the regional depot is fixed. The shape of the hyperbola changes evidently if L is a variable. This is shown in figure 3. If the focal distance is short the hyperbola is “narrow”, at a longer focal length the form of hyperbola will become more linear. It can be seen that by increasing the distance between the centre and the depot the “height” of the intersections between the hyperbola and the territory’s boundary soars at the beginning but later it diminishes.

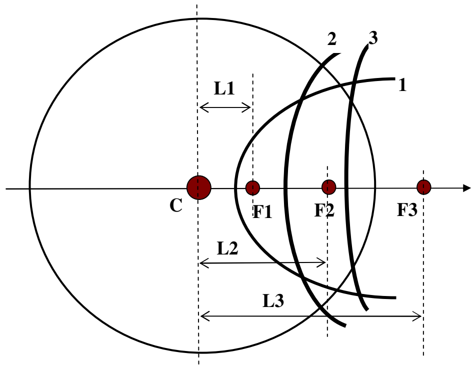

Figure 3. The shape of the hyperbola is a function of the distance between the centre and the depot

If we use only one CD, as is depicted in figure 1, the areas to be supplied is divided between the central warehouse and the CD. Delivery routes start from both of them. The total costs of transport will be equal with the sum of the delivery costs from the CD and from the central warehouse, and of the reloading fixed and variable costs in the depot and finally of the transferring costs of goods from the centre to the CD:

$$\sum K = K_{TER}^{CD} + K_{TER}^{KP} + K_{FIX}^{CD} + K_{R}^{CD} + K^{ÁT} . \tag{3}$$

The delivery (routing) costs could be estimated with the knowledge of the expected length of the routes. The approximate length of the routes has been determined by [4], [5] and [6], and this has been improved by [7]. Someone can find several practical solutions [8,..,11]. According to the above referred to points, on a roughly circle shaped area, where it is given N points randomly distributed, each with a demand of q_i ($i= 1,2,\dots N$), the average length of a delivery route can be estimated in the following way[2]:

$$\bar{j} = 0{,}75 \cdot \sqrt{T}(1 + \frac{G}{q} \cdot \frac{\sqrt{N}}{N}) \text{, where} \tag{4}$$

T size of the area to be supplied (for a circle: $T=R^2\pi$),

q average demand of the customers,

G capacity of the vehicle used in the route.

According to this the total vehicle km in area T (supposing that the vehicles utilisation is 100%):

$$F = 0{,}75 \cdot \sqrt{T}(1 + \frac{G}{q} \cdot \frac{\sqrt{N}}{N}) \cdot \frac{q \cdot N}{G} = 0{,}75 \cdot \sqrt{T} \cdot (\frac{q \cdot N}{G} + \sqrt{N}) \tag{5}$$

If the transport costs are proportional to the distance covered by the lorries and the starting point of the delivery routes is in the middle of the area the total distribution costs (3) can be formulated in more detailed:

$$\begin{aligned} \sum K = {} & k_F^S \cdot 0{,}75 \cdot \sqrt{T_{CD}} \cdot \left(\frac{N_{CD} \cdot q}{\alpha_{CD}^S \cdot G^S} + \sqrt{N_{CD}} \right) + 2 \cdot L \cdot k_F^P \cdot \frac{N_{CD} \cdot q}{\alpha^P \cdot G^P} + \\ & + k_F^S \cdot 0{,}75 \cdot \sqrt{T - T_{CD}} \cdot \left(\frac{(N - N_{CD}) \cdot q}{\alpha_C^S \cdot G^S} + \sqrt{N - N_{CD}} \right) + \\ & + K_{FIX}^D + q \cdot N_{CD} \cdot k_R^D \end{aligned} \tag{6}$$

In this formula P refers to the primary circle (transfer to the depots), and S to the secondary one (actual delivery to the customers).

k_F unit costs of the vehicles per km, [HUF/km],

$\propto$ utilisation of the vehicles ($\propto \leq 1$),

K_{FIX}^D fixed costs of the depots

k_R^D variable (unit) costs of the depots [HUF/ton].

In the case where the transfer-distance between the centre and the CD changes then the area served from the CD alters as well, in other words the total distribution cost is a continuous function of the centre-depot distance. As a consequence to seek the best place of the depot on the x-axis (where the total distribution costs are minimum) we have to describe the size of the delivery area of a depot as a function of L.

We assumed that the whole territory to be supplied with goods is approximately a circle. The centre of this circle that is the warehouse the goods come from, is in the first focus of the hyperbola (the depot is in the other focus). Putting the centre of this circle into the

[2] According to Daganzo [7] the actual length is longer.

first focus of the hyperbola means shifting the circle with its radius, therefore its equation will be the following polar-coordinates:

$$R^2 = (x+P)^2 + y^2 , \tag{7}$$

and the hyperbola:

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1 . \tag{8}$$

From the two equations the (x_0, y_0) coordinates of the intersection points of the curves can be derived (we show in figure 4 the coordinates only in the first quarter) by:

$$x_0 = \frac{a}{P}(R-a) , \quad y_0 = \sqrt{R^2 - \left[\frac{a}{P}(R-a)+P\right]^2} \tag{9}$$

The hyperbola that borders the area supplied by a depot intersects the circle of the total territory in the point $P_0(x_0, y_0)$. To estimate the size of the area in between a line has to be drawn from the origin to this P_0 point and the hyperbola [12] and this gives us a solution. To make use of this result we can determine the size of the area below the hyperbola by calculating the territory of the sector (containing the hyperbola), subtracting it from the territory of the $OPP(x_0, y_0)$ triangle (in figure 4 the grey area) and the area between the above mentioned linear starting from the origin to point $P_0(x_0, y_0)$ and the hyperbola (represented in dark grey).

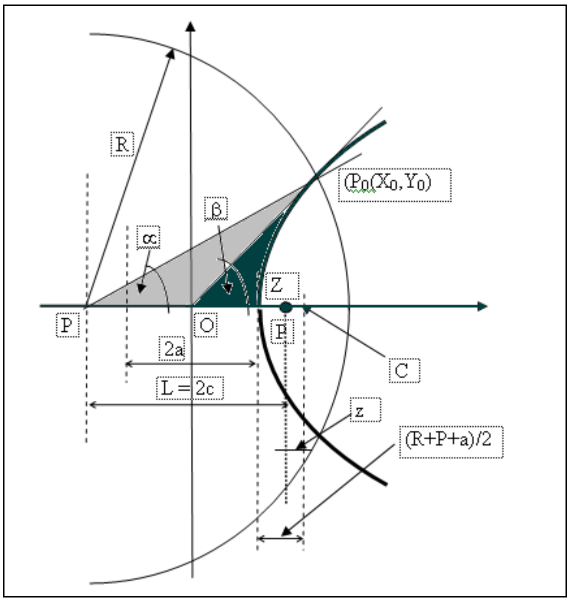

Figure 4. Estimation of the area of a depot

To calculate the area of the sector we establish the rise of the straight line from *P* to point $P_0(x_0, y_0)$:

$$\alpha = arctg\frac{y_0}{x_0 + P} \tag{10}$$

If L increases, the α angle grows at first, but later diminishes. The β angle (the angle of the linear curve drawn from the origin to $P_0(x_0, y_0)$ and the x-axis) changes, too:

$$\beta = arctg\frac{y_0}{x_0} \tag{11}$$

According to (10) the territory of the sector of the circle is:

$$T_{k\ddot{o}rcikk} = \frac{R^2 \cdot \alpha}{2} \tag{12}$$

Referring to Figure 4 the size of the $OPP(x_0, y_0)$ triangle will be the following:

$$T_{3sz\ddot{o}g} = \frac{P \cdot y_0}{2} \tag{13}$$

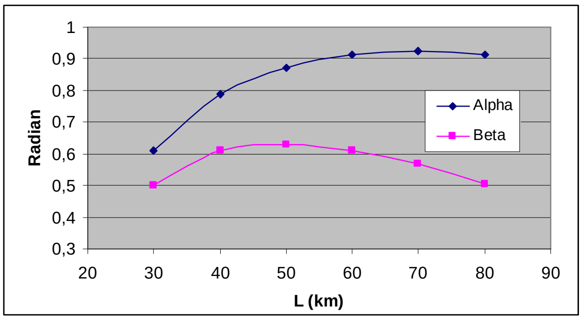

Figure 5. The central angles as the function of the centre-depot distance (example)

Now only the size of the $OZP_0(x_0, y_0)$ area (marked in figure 4 in dark grey) remains to be determined. This is the area between the straight line from the origin to point $P(x_0, y_0)$, the x-axis and the hyperbola that after [12] can be calculated with the following formula:

$$T_{idom} = \frac{1}{2} a \cdot b \cdot \log\left(\frac{x_0 + \sqrt{x_0^2 - a^2}}{a}\right) \tag{14}$$

hence, using (12), (13) and (14) the size of the area supplied by a depot can be established with the formula given below:

$$T_{depó} = 2 \cdot \left[\frac{R^2 \cdot \alpha}{2} - \frac{P \cdot y_0}{2} - \frac{1}{2} a \cdot b \cdot \log \left(\frac{x_0 + \sqrt{x_0^{\;2} - a^2}}{a} \right) \right] \tag{15}$$

Here both a, b, and point $P(x_0, y_0)$ are functions of the distance between the centre and the depot (L). If this distance increases the area of the depot will be at the beginning bigger (consequently the area served directly from the centre grows less), but later the direction of the process of changing turns and the territory diminishes (figure 6).

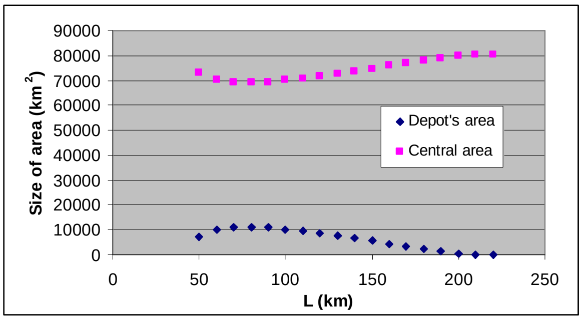

Figure 6. Alteration of the areas supplied by the centre or by the depot as a function of the centre-depot distance

We succeeded in determining the areas either supplied directly from the central warehouse or from a regional depot as a function of the distance L. There is nothing to prevent us any more from establishing the total distribution costs. Considering that in the area to be supplied the customers are spread evenly, the number of customers in a given area will be proportional to the size of this area. With this in (6) the number of points to be delivered (N_{CD}) is approximately $N \cdot T_{CD}/T$.

It has been mentioned before that equation (6) provides results close to the reality if the depot is in the centre of the area supplied by it. There have been many attempts to analyse the connection between the shape of the area (and the actual site of the depot inside it) and the expected transport demand. A simple formula is suggested by Vaughan [5] but it is suitable only for limited x values. Therefore we propose here a method [2] that gives acceptable results for all x distances. According to this the total distance of the delivery routes if the site of the depot is from the geometrical centre of the circle as far as z ($\leq R$):

$$F = 0{,}75 \cdot \sqrt{T} \cdot \left(\frac{q \cdot N}{G} + \sqrt{N}\right) + \frac{8}{9} \cdot \frac{z \cdot q \cdot N}{G}, \tag{16}$$

or, if $z > R$, then

$$F = 0{,}75 \cdot \sqrt{T} \cdot \left(\frac{q \cdot N}{G} + \sqrt{N}\right) + \left(2z - \frac{10}{9} R\right) \cdot \frac{q \cdot N}{G}. \tag{17}$$

The displacement of the depot from the centre of area according to figure 4:

$$z = \frac{R + P + a}{2} - 2P \tag{18}$$

Thus, as far as the necessary data (i.e., the radius of the territory, the number of the customers, the capacity and specific costs of the transport vehicles, etc.)[3] is given, we can estimate the distribution costs for the different L distances. This is shown in Figure 7.

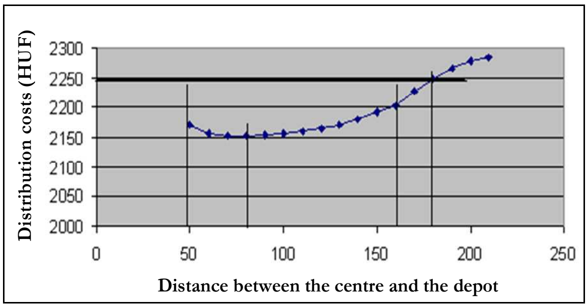

Figure 7. Alteration of the total distribution costs as the function of the centre-depot distance (R = 160 km)

It is noticeable that below 50 km distance there is actually no savings (the depot is too close to the centre). The optimal solution is about 80 km from the centre. Also mentionable is that there are savings even in those cases when the site of the CD is outside the area to be supplied (the distance from the centre is over 160 km). If the CD is further from the centre (over 170 km) then the total distribution costs of the indirect transport surpass the costs of the direct transport, which is indicated with a thick black line in Figure 7.

3. Evaluation of the optimal number of depots

Real distribution networks have more CDs in practice. If the number of depots are small than these CDs are arranged in a formation of a near regular polygon (i.e., triangle, quadrangle etc.). If the number of depots exceeds 4 then the hyperbolas of the areas of the depots may cross each other (especially in cases when the distances between the centre and the depots are short), in other words the actual size of the depots' territories get smaller. This is depicted in figure 8 where the two-dimensional diagram (determined by the points $P_0P_hP_k$) shows the overlapping of two neighbouring areas (more precisely half of it).

[3] See the data of the example in the Appendix.

Supposing that the placement of the depots is symmetrical around the centre, the intersections of depots from a different *L* distance from the centre will compose a linear curve. This starts from the origin and crosses the outer board of the total territory there, where it is determined by the number of the CDs. Let us postulate that the number of CDs in the total area is *D* and there is a distance *L* from the centre at which the intersections fall exactly on the bordering circle [e.g., in Figure 8 $P_k(x_k,y_k)$ is such a point]. This postulation is realisable in most cases[4]. The coordinates of point $P_k(x_k,y_k)$ can be established by crossing the linear curve that rises with γ and is set off from the origin with the border of the total area.

According to our interpretation the angle γ is:

$$\gamma = \frac{2\pi}{2D} = \frac{\pi}{D}. \qquad (19)$$

With this the equation of the linear curve is:

$$y = \lambda \cdot x. \qquad (20)$$

This intersects the bordering circle at the following points (7):

$$x_k = \frac{-P + \sqrt{R^2 + \alpha^2 \cdot (R^2 - P^2}}{1+\alpha^2}; \; y_k = \gamma \cdot x_k \qquad (21)$$

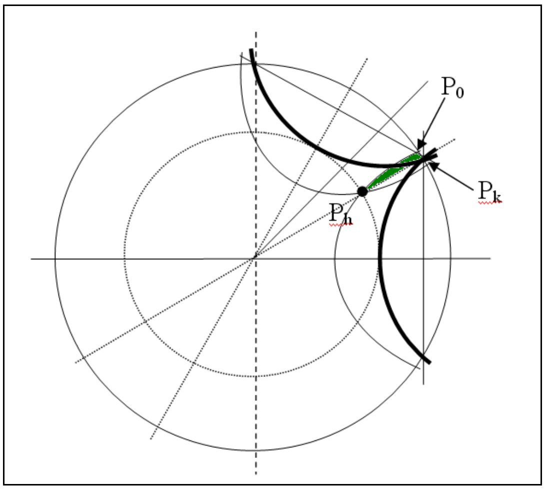

Figure 8. If there are many depots the area of a depot diminishes because of the overlapping

[4] Those cases, when this postulation is not true, are not dealt with in the paper.

The hyperbolas have intersections as well if they cross each other and these intersections are on the linear curve (20). The coordinates that belong to these intersections can be established by using the equation (8):

$$x_h = a \cdot P \cdot \sqrt{\frac{1}{P^2 - a^2 \cdot \alpha^2}} \; ; \; y_h = \gamma \cdot x_h \, . \qquad (22)$$

4. Demonstration of the method by an example

We determined half of the area for a depot by applying equation (15). This area has been diminished by the area stated by the points $P_hP_kP_0$ according to figure 8. The extension of this area can be approached by the triangle determined by the above-mentioned $P_hP_kP_0$ points. The base of this triangle is the section P_hP_k, and its altitude is the P_kP_0 section.

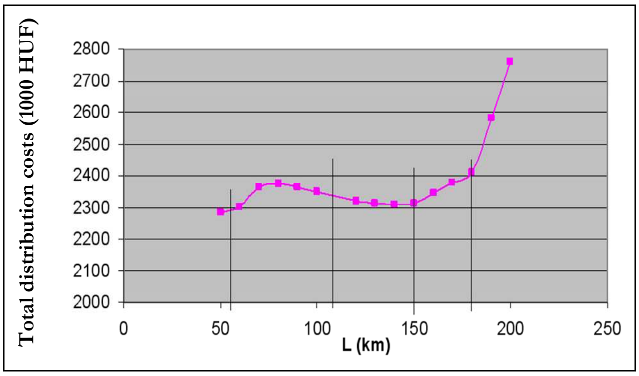

Figure 9. Characteristic points of the distribution costs (example)

Results of the example[5] are perceptible in figure 9. Up to 50 km transferring distance, the shapes of the regional depots' areas stretch themselves out and do not cross each other. Though the results seem to be favourable, the variants between 50 and 100 km are unsuitable, because the capacities of the semi-trailers or articulated vehicles that are needed for the transfer of goods from the central warehouse to the depots do not meet the demands of the latter. As a consequence the vehicles used for the primary distribution are underutilized. This contradicts our hypothesis that the vehicles are dispatched with a full load[6].

The acceptable section is between 100 and 150 km. If *L* is here, the daily demands of the depots (actually the demands of the customers attached to the depots) and the capacities of the trucks used for the transfer are approximately the same, namely, they

[5] Here also the fixed costs of the depots are taken into consideration.
[6] See the equations (1) and (5).

will be almost fully utilized (see table 1). The best result is at the distance of 130-150 km.

Table 1: Alteration of the total distribution cost as a function of the number of CDs in the system

Number of depots	*Focal length (km)*	*Utilization of trucks used for transfer*	*Total costs of distribution (1000 HUF)*
0	*Direct transport*		2528
1	160	0,89	2484
2	160	0,89	2448
3	160	0,89	2420
4	150	0,99	2374
5	140	0,96	2357
6	130	0,94	2359
7	120	0,93	2379
8	110	0,97	2418
10	90	0,89	2550
12	60	0,83	2601

At 150 km the focus of the hyperbola and the theoretical centre of the depot's area changes their position that is the focus (*P*) comes behind the point *C* (figure 4). At 180 km the focus reaches the border of the whole territory, and at about 190-200 km there will be no more savings, because direct distribution is cheaper than indirect transport (in this case).

By altering the number of depots the minimum of the distribution costs alter as well. In our example, if we decrease the number of depots the size of the area per depot increases, therefore we obtain good capacity-utilization results for the vehicles with a longer transferring distance (figure 10). The other way round, if we raise the number of depots their territories will diminish, for this reason they have to come closer to the centre to get sufficiently big enough areas (i.e., customer demand).

5. Conclusions

With the procedure introduced in this paper one can estimate the rough number of depots and their approximate distance from the central warehouse. For the determination of the actual number of depots and their exact sites in the territory naturally many other factors need to be taken into consideration. Anyhow, it is advisable that someone should seek the best suitable solution close to the results of the above-described analysis.

We may realise (and it has been stated by numerous cases) that the total distribution costs, if the number and sites of the depots are carefully chosen, do not react too sensitively to the alteration of the number of depots, at least not in a well defined section. In our example this section is between 4 and 7 (figure 10).

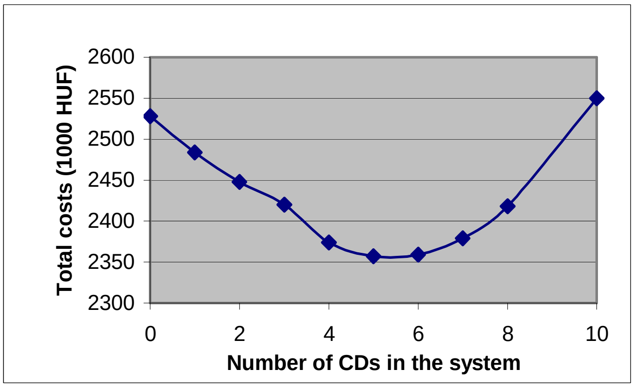

Figure 10. The effect of the number of depots to the costs of distribution (example)

The method yields more precise results if also the transformation (form-change) of the depots' areas is taken into consideration, because the expected transport demand depends not only on the size of the area and the detachability of the actual site of the depot from the theoretical centre of the territory supplied by it, but also on the shape of this area as well [2].

The suggested analytical method offers an opportunity to fit vehicle capacities to a given distribution system, too.

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Impacts of Road Transport Pricing Reform on Supply Chains

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Abstract: Transport pricing reform has effective impacts on providing transportation services. In this article we are examining the impacts on forwarding services in supply chains. Elements of the needed reform process are well known among scientists and researchers, but there is a permanent underreporting of results to shippers and politicians, thus the realisation of reform steps are facing serious barriers. Economic and environmental aspects always emphasise the importance of improving the existing pricing regimes towards a fair and efficient solution. Recognition of existing evidence always reveals dependencies between instruments and their impacts moreover support for the evaluation steps of the reform process and results gain a higher acceptance of reform among stakeholders.

Keywords: transport, logistics, road pricing, supply chain

1. Introduction

The logistics industry is facing crucial challenges of raising demand, narrowing margins and societal calls to reduce pollution and infrastructure congestion. In fact, the transportation flows between companies and performance support are dissociated from the functions of production. The almost exponential increase of shipped goods between companies thus requires nowadays a global evaluation of the performance and the management of supply chains.

Principles of sustainable transport and sustainable environment highlight serious problems of the current set of economic instruments, which are unable to solve these problems without any changes. Transport prices do not match full (internal and external) marginal costs, so we have too much congestion and environmental damage. A radical transformation is needed, where transport pricing reform will play a prominent role. Setting prices equal to marginal social costs would reduce the problems and finance the solutions.

Adaptation of new pricing principles can give signals to the users of logistics supply chains including all kinds of infrastructure and service providers to link sources to destinations of transported goods in the system based selection of „best” ways. Besides, the companies and service providers can no longer reject indefinitely the environmental costs on society and the new cost allocation principles have to be applied, which will, in all probability, lead to growing fiscal burdens in the following years. Nevertheless, higher costs are not definitely hindering market competition between the transport sectors; moreover they are supporting several social and economic objectives on a macro level.

2. European context of road pricing

The 1999/62/EC "Eurovignette" Directive amended by the 2006/38/EC Directive supports the pricing framework for heavy goods vehicles (HGVs) having a maximum permissible laden weight of not less than 12 tonnes by 2012, afterwards this will be extended to lower categories as well. It defines the method for calculating infrastructure costs on the Trans European Road Network and the principle for levying the tolls on such road network elements. The current revision of the Eurovignette Directive projects a forthcoming implementation of external cost charges in the road sector.

The European Common Transport Policy gradually and slowly moves towards interurban road pricing based on distance charges covering the social marginal cost, applying the "user pays" and "polluter pays" principles. In Europe four states have already implemented mileage based interurban road tolling for HGVs: Switzerland, Austria, Germany and Czech Republic. Many others (Belgium, Hungary, Netherlands, Poland, Slovakia, Slovenia, Sweden, UK, Finland and Ireland) are investigating the possibilities. Urban road pricing has been implemented most recently in London and Stockholm with success.

Overall objectives of road transport policy are parallel to the common principles, first of all in reaching a better efficiency in the whole transportation sector. These objectives are applying the "polluter pays" principle, shifting inefficient transport performances of the road sector to the rail network, and managing financial issues of road infrastructure development. The secondary objectives are slowing down the growth of road freight-traffic, making better logistic operations, reducing the empty trip ratio and making better use of loading capacities using alternative transport modes [3]. Effective use of revenues earned by infrastructure tolling is a reasonable measure of the achievement of these objectives.

When setting a national pricing policy in the road sector, the following criteria should be fulfilled [6]:

- Highly differentiated tariffs – taking into account the differences of vehicle, infrastructure and time characteristics
- Regulatory effects – in special cases where aspects of infrastructure operation or environment are significant, prices shall reflect these special circumstances to manage the traffic demand for such road elements
- Vehicle category scope – we shall distinguish the vehicle categories because they use transport infrastructure with differing aims, by setting appropriate schedule plans for extending the existing pricing systems for other vehicle categories and of course basing it on social, economic and environmental considerations

- Road network scope – the pricing principles lead us to implement road pricing systems to the entire infrastructure network to reach balanced pricing burdens in different surface transport sectors and to support the spread of "co-modal" thinking in logistics
- Common frames – the European integration process moves towards setting a common framework for network oriented sectors like transportation, i.e., interoperability and harmonisation of national infrastructure and road pricing systems for supporting the achievements of Acquis Communautaire

Social and environmental aspects have been increasing in importance in the last decade, where the latest research results are already supporting the gradual improvement of marginal social cost based pricing regimes, therefore a realisation of transport pricing reform is expected in the short term.

3. Existing evidence for effects and challenges of pricing reform on supply chains

Practical experience and prior expectations highlight the effects of different pricing instruments on efficiency for the operation of supply chains, among them the effects of road pricing on the operation of forwarding services. Although a longer time period is required in order to evaluate the effects of pricing reforms, experience and existing research results are already available to define tendencies. First of all, we shall make clear distinctions between the interurban and the urban contexts.

The European steps made towards mileage based *interurban* tolling system so far led to reasonable results on this issue. The responses of goods vehicle traffic to interurban pricing are likely to be slightly larger than at the urban level since transit traffic is much more typical in interurban transportation. Existing evidence shows that there is a direct interaction between choice of pricing instruments and realisation of principles on sustainability, although there is a longer term response available to the transport and distribution sector. For this reason the available model approaches [2] can improve the understanding of dependencies.

Generally implementation of differentiating pricing systems result in the increasing efficiency of operation: better utilisation of vehicle capacities, capacity demand, environmentally oriented fleet investments, better management of logistics services, and reducing the average length of haul by reconfiguring distribution systems to rely less on long haul movements [7]. From a financial point of view such pricing systems have only marginal effects on the economy: in the year of implementation in Germany the end prices increased by 0,15%, and transportation prices increased by 5-7% [6]. Swedish [1] and Hungarian [5] expectations are a 6-10% increase of the forwarding prices when implementing a mileage based pricing system and the expected inflation effects are very close to the German evidence.

Consequently – due to low price elasticity of demand for road transportation – shippers partly increase the service prices, but also provide more efficient services to compensate higher operation costs. This latter result is based on the tendency of the decreasing percentage of transportation costs in the overall operation cost of supply chains.

In an *urban context* the proportion of transit traffic is now quite small, particularly for larger HGVs, so that most of their movements within urban areas are either to pick up or to deliver goods in that area. Accordingly, the overall impact of urban road charging is likely to be smaller than in an interurban context. In many cases it would tend to require locational changes in economic activity patterns to lessen the volume of goods to be collected and delivered in the urban area. However, there will be a scope for some adjustments via mechanisms such as transit traffic rerouting to avoid the charged area, where a charging by area licence is used. Furthermore lightening the traffic burden in such areas can be supported by lessening the number of licences to be purchased. This allows for greater consolidation to enable larger loads and less empty running for those vehicles entering the charged area however this depends on the sector being serviced. There also may be a scope for reschedule movements to avoid the charged period [7].

The evidence from London shows that the first year for operation of cordon charges led to an 11% reduction for HGV or LGV entries of potentially chargeable movements. The statistics on vehicle kilometres driven within the charged area show that in the first year the HGV or LGV traffic reduced by 7% and 5% respectively (by the way passenger car performances reduced by 34%) in relation to the growing overall proportion of traffic to the vans. By 2006, when the charge had increased, all these percentages had reduced slightly further. These statistics illustrate the relatively limited scope for operators to reduce their level of goods vehicle activity within this charged area. [7]

The short impact analysis of the related aspects of road infrastructure pricing reform on supply chains separated to interurban and urban areas is a warning signal that moderated pricing rates generally have only marginal impacts on the economic production and employment, but it could have positive impacts on environmental issues. The implementation of road pricing instruments has to be accompanied by tax reforms as well. As far as the overall financial burden of domestic shippers will not change significantly, the wished for modal shift in freight transport will not be come true.

Transparency of changes has primary importance for making a clear framework for the long-term application of such instruments. Effects in peripheral countries can differ from these expectations, therefore specific analysis is needed in this case. Expected and so far experienced impacts on competition between land transport sectors are marginal: increasing road prices do not shift reasonably the transport performances to the rail service providers, because the pricing instrument is only one element in the set of quality services, other elements (e.g., providing door-to-door and JIT-based services) are dominant and needed in linking the demand and supply sides in the forwarding market. There is a comparative scope for the transfer some of the longer distance traffic on dense routes to rail or even to water shipping. Anyway, investigation of the state interventions for supporting intermodal transportation is due to the changes in the pricing regime and changes in the short term shall give positive answers to the problems of stakeholders at the micro-economic level [3].

All these investigations show the necessity of a system based composition, introduction and implementation of road transport pricing reform in the frame of consistent and properly scheduled application of hard and soft elements including policy packages.

4. Conclusions

Transport policy package is an important tool to reach the primary social and environmental goals. One important measure of this is the pricing policy: calculation and allocation of costs on infrastructure users by setting infrastructure prices. Existing set of policies cannot reflect the changing requirements of economy, therefore an overall pricing reform is needed.

Pricing reform aimed at reforming the whole pricing regime will create a more equal taxation towards the stakeholders of the domestic economic playing field, and better conditions in international competition. While reform steps mainly raise general expenses of service providers, experience shows there are several ways to enhance overall efficiency of forwarding services in supply chains. The marginal social cost based pricing method in itself does not influence the supply chains significantly for aiming at the "first best" solution from a social and economic point of view. To approach this we need to develop a consistent pricing reform policy package for Europe as well as for the globalised world.

The main criteria for a successful reform process are the social and political acceptability and transparent operation. For this we need to follow a step-by-step approach in implementation to leave reasonable time to identify the impacts of simple changes already done.

All developments financed by revenues from levying infrastructure prices must meet the criteria of efficiency, environmental impact and equity. These allocations shall be transparent, publicly reported, and subject to scrutiny, regulation and challenged by adequate political institutions.

The harmonised use of advanced technologies and upgraded price regulation will trigger a paradigm shift to the "intelligent cargo" to consider co-modality aspects dominantly and will support the step-by-step application of the social marginal cost based pricing concept. The right motivation will connect all the players of cargo movements to each other, users will communicate to logistic service providers, they will contact transport infrastructure managers and authorities to provide information services whenever required along the whole transport chain, enabling optimal and eco-friendly supply chain (virtual route) selection across transport modes.

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Activity Based Costing in Logistics

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Abstract: Activity based costing is a widely used method to reshape the traditional accounting systems into management information systems providing a reliable guidance for decision makers. The currently applied logistics costing procedures can also be further developed by using this methodology. Doing so calculation distortions preventing the exact cost-benefit evaluation of logistics or supply chains – and their components – can be reduced significantly. The paper aims to identify the related problems and propose a solution for logistics costing by adopting the activity based approach. The corresponding basic mathematical formulas are elaborated, too. As the recommendations are derived from a theoretical point of view, additional practical validations of the model are intended to be developed in the near future.

Keywords: logistics controlling, activity based costing

1. Problem identification

The efficient and effective controlling of logistics services or supply chains needs a sound information base supporting operative as well as strategic management decisions (e.g., resource allocation, outsourcing vs. insourcing, etc.). This information base can be created by using up-to-date cost and performance calculation methods being able to deliver reliable inputs to profitability assessments.

Current practices applied in the case of logistics cost calculations often prefer using average values of aggregated costs. Indirect cost items are allocated to the different product or service units on an arbitrary basis. Ignoring cause and effect relationships in cost allocation, however, can lead to distorted information: so profit or loss generators in the supply chain may not be identified properly [3].

The task is to find a methodology, which is able to overcome the problems mentioned. A possible solution can be the inclusion of technology principles into logistics cost calculation mechanisms. Thus cost allocation can be realised in a more exact way by taking into account cause and effect relations between activities within business processes.

The central elements of dedicated examinations will be the logistics or supply chains consisting of different kinds of logistics tasks. These tasks are performed by logistics activities. If we are able to measure the cost and performance efficiency even in activity levels the reliability of logistics cost and benefit analyses can be improved significantly. It will make it possible to prevent using generalised average values not taking into account the different characteristics of each service chain. Nevertheless, average values cannot be absolutely eliminated but they are used in lower aggregation levels (see later). It allows for a much smaller incorrectness than relying on no cause-effect cost allocations.

2. The principles of the proposed logistics cost calculation model

Activity based logistics costing (ABC) uses the principle of including technology process performances into cost calculations to make them more exact. The key elements of the methodology are logistics activities, which enables the support of not only operative resource allocation decisions but also business process reengineering (BPR) of supply chains [6]. Extending logistics functions to an entire supply chain requires a rather process oriented management point of view and ABC corresponds to its criteria in contrast with the traditional operative logistics controlling (adopted from the manufacturing industry).

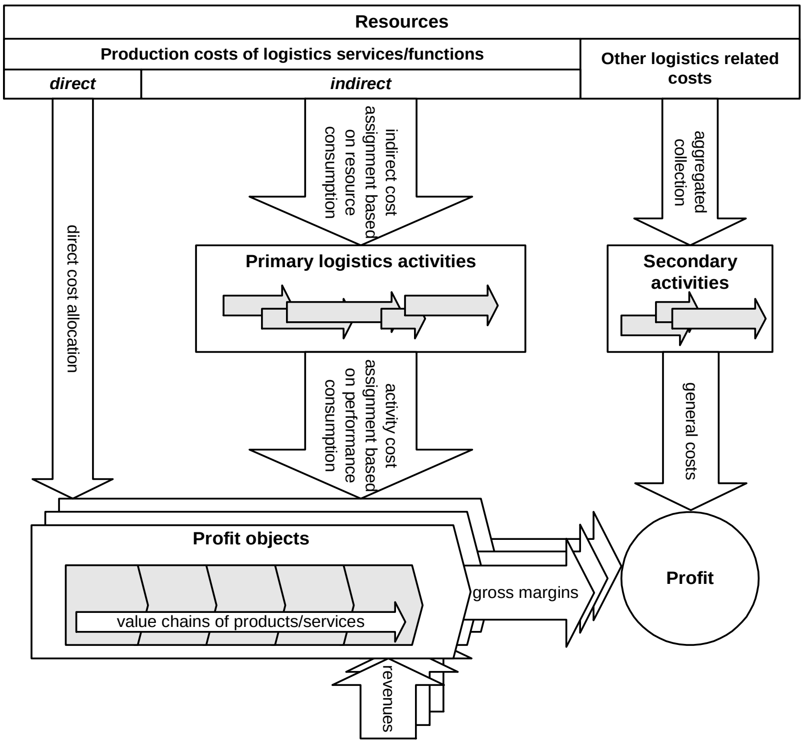

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Figure 1. The activity based costing model adapted to logistics

Most of the research articles dealing with activity based costing have their focus on manufacturing operations, although this approach can be applicable across the spectrum of other company functions – like logistics [7]. The adaptation of ABC had been carried out in Hungarian transport economics practice first in the case of the rail transport sector [2]. This model can be improved by taking into account the specifications of logistics service chains. Figure 1 illustrates the mechanism of ABC adapted to logistics. It is also inevitable to define the necessary mathematical or logical formulas so that the model can be implemented in practice, too.

The following summarises the essence and calculation procedures of logistics ABC based on the outcomes of a research work aiming to elaborate a consistent methodological framework [1].

3. The mathematical logic of activity based logistics costing

First the logistics related cost items need to be identified and collected (from the general ledger). Then they are to be differentiated as follows:

$$C = C_p + C_g \,, \tag{1}$$

where,

C_p – production cost of logistics services or functions,

C_g – general logistics cost.

$$C_p = C_d + C_{id} \,, \tag{2}$$

where,

C_d – direct logistics cost,

C_{id} – indirect logistics cost.

This cost differentiation needs to introduce the concept of profit objects. They are products or services gaining revenues and at the same time consuming different resources so they are bearing costs. Here one can distinguish between companies where logistics is the core activity (logistics service providers) and where logistics is a background function (e.g., in manufacturing industry or FMCG sector). In the former profit objects are complex logistics services or their chains. They are fully examined by logistics cost calculations. In the latter profit objects are different kinds of – not logistics – products or services. Here logistics controlling covers only a certain part of cost calculations so complete cost and benefit analyses can be realised in connection with other areas – e.g., manufacturing, sales, marketing, etc. – only.

Production costs can be related to profit objects in a direct (direct logistics costs) or indirect way (indirect logistics costs). The latter ones are the monetised values of resource consumption of so called primary activities producing logistics services or functions. The general costs reflect the resource consumption of so called secondary activities – e.g., PR, HR, finance, general management – which are in the background from the point of view of logistics performance generation. The dividing line between primary and secondary activities is company specific, and cannot be definitely generalised. The secondary activities and their costs are rarely analysed in details in the frame of ABC – they are generally the objects of dedicated examinations.

Direct logistics cost items can be allocated to profit objects in one step and no additional performance measurement is needed. Such cost elements could be e.g., the infrastructure user charges in the case of a transport task. Nevertheless, the resources causing indirect costs (e.g., of disposition, operative administration, maintenance) are consumed by multiple profit objects so the cost intensity of a single object cannot be investigated in a simple manner. ABC concentrates on these indirect cost items as it tries to allocate them to profit objects based on cause-effect relationships.

Indirect logistics costs are first assigned to primary activities and business-technology processes constituting of them (like transport, loading, warehousing, providing information, etc.) based on the resource consumption of each activity. It can be solved mainly by direct cost accounting to activities as the different input resources – like workforce, machinery, and infrastructure elements – are assigned to activities (if possible). However, even here estimation techniques may be necessary when the ratio of direct activity costs is low.

Thus indirect logistics costs are collected on primary activities. Another task is to find an appropriate performance indicator – e.g., number of handled pieces, operation time, number of orders, vehicle km, etc. – for each activity. The indicators will be measurable. Activity costs are then to be differentiated into variable and fix parts according to their relations to performance intensity:

$$C_a = C_v + C_f \quad , \tag{3}$$

where,

C_a – total cost of a primary logistics activity,

C_v – variable activity cost,

C_f – fix activity cost.

A fix cost item can be for example the simple time based depreciation while a variable one could be the piece wage rate. The integration of technology principles into cost calculation is realised here as the so-called “intern price” (average variable cost) of the activity and can be counted here:

$$c_a = \frac{C_v}{P_a} \quad , \tag{4}$$

where,

c_a – intern price (average variable cost) of the primary logistics activity,

P_a – performance of the primary logistics activity.

For example, if we measure the performance of a disposition activity by the number of directions the intern price is measured in EUR/direction. The intern prices concentrating on variable costs reflects cause and effect relations better as only performance dependent items are posted up into profit object calculation (see later). Fixed cost elements are not neglected but they are taken into account during the higher levels of margin calculation only (similar to general logistics cost items).

Each profit object uses different activities and their performances to produce added value. For example a logistics service chain of a certain piece of goods (as profit object) may make use of performances of different disposition as well as physical processes. If it is possible to elaborate the performance values consumed by profit objects driving over (variable) activity costs to profit objects can be carried out as follows (by using also intern prices):

$$C_{po} = \sum_x C_{d_x} + \sum_y c_{a_y} P_{a_y} i_{a_y} , \qquad (5)$$

where,

C_{po} – production cost of the profit object;

i_a – rate (intensity) of performance consumption of the profit object at a certain activity:

$$i_a = \frac{P_{po}}{P_a} , \qquad (6)$$

where:

P_{po} – performance consumed by the profit object at a certain activity.

Index x go through the direct cost items related to the profit object while index y goes through the activities taking part in its value chain.

Using the calculation method described before the prime cost of a complex logistics service (chain) or the logistics related part of the prime cost of a certain product/service can be elaborated in an exact way. Of course an important precondition of it is to realise and operate a comprehensive performance measurement regime being able to exploit technology knowledge, too.

In case of companies offering complex logistics services (so their key activity area is logistics = logistics service providers) the margins of profit objects can also be counted by including revenues. Margins show how revenues can cover production costs. The first level margin (or gross margin) is calculated as follows:

$$MI_{po} = R_{po} - C_{po} , \qquad (7)$$

where,

MI_{po} – gross margin of the profit object,

R_{po} – revenue of the profit object.

The second level – aggregated – margin constitutes of the summarised gross margins of cost objects debited with the summarised fix costs of primary activities:

$$MII_{po} = \sum_{w} MI_{po_w} - \sum_{z} C_{f_z} , \qquad (8)$$

where,

MII_{po} – the second level, aggregated margin of profit objects.

Index *w* goes through all profit objects while index *z* goes through all primary activities.

Finally, we will come to the logistics service company's/provider's profit if the second level margin is debited with the general logistics costs:

$$PR = MII_{po} - C_g , \qquad (9)$$

where,

PR – total profit of the logistics service company/provider.

4. Practical usefulness of the model

The costing model described contributes to (at least partly) eliminating the shortcomings of traditional logistics accounting systems by including additional technology information. Their inputs and outputs, however, are the same: detailed cost/revenue data and aggregated profit data. The real added value of the methodology can be identified if we look at the details: the use of performance data makes it possible to evaluate the effectiveness of elementary (not aggregated) logistics profit objects as well as that of elementary logistics performance generators (activities) in a more precise and transparent way. One can find out what logistics products/services realise profits or have negative margins. It will turn out what logistics performance generators (activities) have relatively high resource consumption in comparison to their actual performance levels: it may be reasonable to rationalise or even outsource them, etc.

According to business surveys the use of activity based costing applied to logistics is often explained by the need to enhance accuracy and reliability of cost or profitability information needed in short term executive decision making. Furthermore the exact preparation of strategic BPR decisions may induce developing effective logistics cost and performance management solutions, too. In the first phase of implementation generally a narrow scale pilot project concentrating on the main cost drivers and performance generators is launched. Decisions on the wider use are set after evaluating the first results: if the pilot project is successful the implementation towards a more sophisticated system will start. The necessary level of sophistication is determined through the ratio of indirect costs of logistics functions: if a considerable part of examined cost items can be regarded as indirect it will be worth investing in building up a more detailed logistics ABC [5].

Activity based costing can be used to support supply chain integration and management, too. Modelling tools can be provided for supply chains in different industries where a well-parameterised ABC model calculates the consequences of changing activities or integrating certain functions. Nevertheless it is often concluded that applying accounting measures are important but it may not be sufficient for the success of supply chain management [4].

The Hungarian practice of logistics cost and performance management is in the initial phase only. It means that the applications concentrate on monitoring and influencing technology performances rather than on also using this information for (detailed) cost calculations. Mainly inventory and warehousing are the logistics functions, which have IT supported management information systems. These systems have the tasks to make material flows more transparent and to rationalise inventory and ordering processes. The methods often used are the following: portfolio analysis of inventory, monitoring of material handling and optimisation of purchasing schemes [3].

5. Conclusions

As a summary of the study we can conclude that the inclusion of technology performance data into logistics cost calculation procedures expands the scope of traditional accounting approaches. The results will be more reliable (but not absolutely) so that managers responsible for operative resource allocation or strategic process development issues can make better, well informed decisions. Activity based costing has a good future outlook in the logistics sector, as it is a suitable tool to enhance the business visibility and controllability throughout the entire supply chain.

The elaborated model, however, needs further verification. The Hungarian logistics market offers an excellent environment for this as logistics controlling applications are still in its initial phases (see above). So the author intends to validate his theoretical research results for the case of concrete logistics service chains. Logistics service providers as well as companies coming from manufacturing or trading industries will be examined to test the relevance of the ABC model. After having a broad picture of the current practices and their problems it is expected that no a single solution applicable for all market actors exists but the basic principles and mathematical formulas can probably be widely used after the necessary customisations.

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Methodology and Managerial Lessons of Tendering Logistics Hardwares

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Abstract: The study begins by questioning the necessity of using tenders, then, continues detailing the implementation of tenders starting from the preparation of the call for offers up to making the final decision. Meanwhile, it elaborates the practical experiences of tenders for the acquisition of warehouse logistics systems. It emphasises the application of multi-criteria pre-decisional algorithms in the assessment of offers received for a tender. To this end, it demonstrates a self-developed multi-criteria pre-decisional system, and it presents the evaluation of an actual tender. Finally, it evaluates the effects of the applied tender algorithm in brief.

Keywords: infrastructure of logistic systems; tenders; multi-criteria pre-decisional algorithm.

1. Introduction

The preparation and support of the actual implementation of warehouse-logistics technologies is gaining in importance in today's practice of consulting and logistical system management. The reason for this is that consigners expect with good reason, from consultants, to see bigger and more complex projects through, from system mapping and system design, right to its implementation (often including installation). These exciting phases of consulting work - despite their numerous pitfalls - set a major challenge for consultants. This study demonstrates a complex methodology which had been used by us on many occasions with success, and which is efficient enough to help choose the optimal contractor(s) and supplier(s).

2. The implementation of tenders for the execution of the infrastructure of warehouse-logistics systems

2.1. General statements

In our experience, the key to the successful implementation of tenders is a customised tender procedure, which is based on hardware-independent expertise, constant communication, and control. Therefore, we believe it is important to present the underlying procedure, which - by its complex nature in allowing plenty of feedback at many stages - can help choose the optimal contractor/supplier. What does hardware-independence mean in this context? Hardware (i.e., tool) - independence is one of the chief (if not the principal) assets of an exigent consulting and professional logistics system manager. Among others, this is precisely the reason why the involvement of an independent expert in the tender process is beneficial for the consigner. The statement that to one problem there exist multiple solutions is almost a commonplace. This is particularly true for the planning and realisation of logistics systems. Should we wish to find an abstract model for this problem (either in the case of system design or system implementation), we could say that each good solution is some kind of a local optimum. In this pre-implementation phase, the task is to find the best solution i.e., the “global optimum”, out of a number of good solutions i.e., “local optimums”. The expertise of independent professionals in this matter could give a chance that relevant local optimums be more or less mapped; and from these, the global optimum is chosen with an appropriate selecting methodology.

Almost always, the *tender process* is based on a model which has been proved in many cases, and which has developed gradually out of experience (fig. 2). However, it must be noted that almost every tender has some distinguishing feature, which requires the basic structure of the process to be customised.

Figure 1 shows the *time demand* of the individual phase segments in relation to each other. (This is rather variable depending on the complexity of the logistics system.) The numbers correspond to the phase segment numbers shown in figure 1.

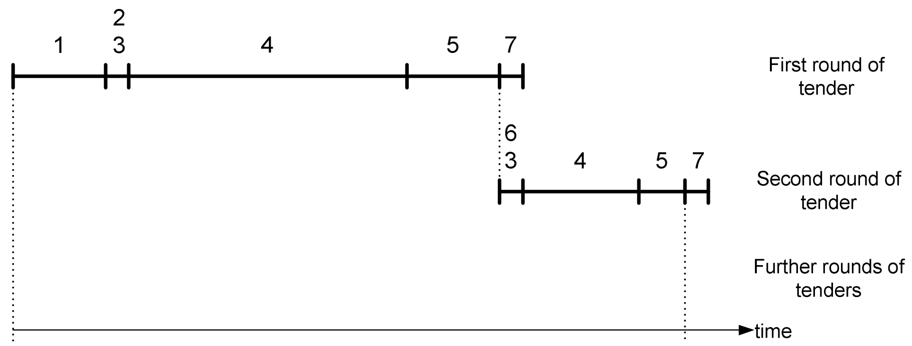

Figure 1. Defining suppliers to be invited to tender

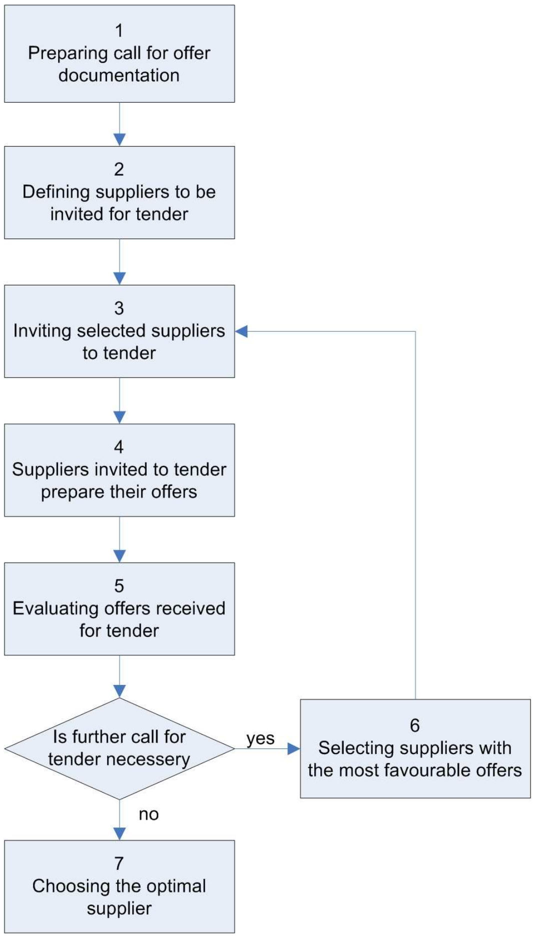

Figure 2. Basic structure of the tender process

2.2. Preparing call for offers documentation

Preparing the call for offers (RFQ or RFT) documentation is perhaps the most important part of the tender process. The thorough compilation of this is a basic criterion for the possible suppliers to make an offer, which is assessable both technically and economically. In other words, it enables a relevant system solution or system version to be realised. This documentation specifies the actual logistics and/or warehouse system, which is to be executed. It needs the gathering and systematization of all relevant input information, which the company, who prepares the offer, will need. Where does this data come from? As we had mentioned before, the establishment of such complex systems is a multi-stage process. The tender process must be preceded by the phases of logistics system design. Our experience shows that appropriate input information can only be gathered from a logistics system plan, which is properly done and validated many times by the consigners. In case of a complex tender, basic *input information* could be the following:

- Drafts specifying the logistics system to be realised: plotting, layouts, layout plans with necessary cutaway views, and different section plans (e.g., pallet racking). These contain storage-and logistic technologies, material routes, technological dimensions, and all drawing/image components, which are indispensable for preparing the technological offer.
- Basic features of stored/moved units: unit forms, weight, size (in case of variable weights and sizes: their minimum and maximum values), load equipment, type of packaging, aggregation factors, other significant parameters, and peculiarities.
- Exact features of storage-and material moving tasks: short description of tasks, clarifying task limits, specification of needed tools for storage/material moving, estimated number of machines, and other peculiarities.
- In the case of special material handling tasks: parameters of equipment or intermodal units to be used (e.g., swap-body containers), description of establishments, tools, and equipment used at the place of handling.
- Target function of the consigner with special relevance to its expectations and cost of operation.
- If possible, photos of some elements of the existing logistic system, about the loads to be stored/moved, storage aids (if there exist any), and machines used to handle/transport material.

A systematized and complete listing of the above data is primary to avoid misunderstandings, and to eliminate system solutions that cannot be assessed technologically. Sadly, in spite of this, unsatisfactory solutions are still made. One of the main reasons for this is that a possible supplier has to invest a lot of energy to prepare a proper offer, and this is a time-consuming and laborious task. Therefore, the timing of the tender process is extremely important, and likewise, that applicants are given a sufficiently long lead-time with regard to the individual phases.

Systematic input is guaranteed by a call for offer documentation with the appropriate format. In it, references have to be made regarding the requirements for format of the offer to be submitted. In order to support this, and to make the evaluation easier later, it is expedient to “trick” the applicants, as far as the obligatory parameters and information is concerned. It is thus usually recommended to pre-design some summarizing and *ordering charts* where one might as well search for data relating to the offer in an automatic way in the evaluation phase. Similarly, such data could be transferred into the evaluation system. As such, a properly prepared documentation includes:

- Related source data as specified above, internal references to information
- Optional, supplementary elements of the storage/material moving technology
- A list of required alternative solutions to the storage/material moving technology in question

- Compulsory and optional system factors, elements
- Information on implementation
- Rules for making offers
- Documents to be submitted
- Data charts to be filled in which refer to the technological/economical parameters of the offer
- Technology of handling offers (paper-based and electronic documents, information sharing)
- Timing of the tender process (deadlines etc.)
- Required guarantees and warranties in connection with technology and activities.
- Any information on the expectation and the priorities of the tender issuer orienting bidders about the relative importance of the criteria
- Way of liaising

From the above - whereby we do not intend to be exhaustive - we would like to highlight one point: the technology of handling offers; as this is a key element in tenders' data protection as well as in "excavating" the data of the offers which will be evaluated, and are necessary for multi-criteria analyses. The solution we use is the result of a long-term learning process. We have tried out a lot of methods. The Internet or the application of FTP based technologies has proven to be the most efficient, because it enables the handling of data quickly, systematically, professionally and in an adequately protected way. Communicational protocol (access, uploads and downloads) has pre-defined rules, along which these systems operate. Developers are currently making efforts to find out how to match the basic data needed for evaluation (and which are directly or indirectly within the offers that had been submitted) with the data charts of the multi-criteria analysing system, using automatic data exploring technologies. This could considerably shorten the time of the evaluation, since in all cases; one of the most time-consuming tasks is the gathering of such data as well as their "trimming" for the multi-criteria analysis system.

2.3. Defining possible suppliers, invitation to tender

According to experience, in the case of such complex assignments, it is difficult for consigners to define that potential scope of suppliers who would implement the planned logistics system. One of the most important reasons for this is that they are not aware of either the suppliers, or their competencies and skills. Hiring independent experts in such cases could thus be advantageous, since they are competent and skilled enough to cope with the problem. Experiences show that - depending on the type of the assignment - it is suggested to invite 10 - 15 companies for similar tenders; then, they need to be provided with the call for offer documentation, as described above. Naturally, invitations to tenders have set rules, too, which must be drawn up in accordance with the rules of the procurement team of the consigner.

Some advice on the process (not complete):

- In the invitation to tender, it is recommended to clearly define how to access the call for offer documentation
- It is suggested to briefly sketch the applied protocol, and handling instructions for the applied offer handling system
- One must specify the types of documents to be found on the server (plans, data charts, call for offer documentations, photos, etc.)
- It is important to draw attention to the deadlines, as well as restrictions on contents and format
- It is recommended to ask for an e-mail feedback once the offer has been uploaded onto the server (in certain cases state-of-the-art offer handling systems generate this automatically)

2.4. Preparation of the supplier's offer

The time span for the preparation of the supplier's tender may vary according to the complexity of the logistics system to be implemented. In our experience, this requires a minimum of two weeks, considering the whole tender process. Practical experience proves that despite an exact, precise and well-prepared invitation to tender, continuous communication with the possible suppliers in the offer preparation phase is vital. This requires the comprehensive and thorough knowledge of the logistics system plan and the tender, as a number of questions might come up in connection with the system or the supplier, which - lacking the necessary competence - could mislead the suppliers. Nevertheless, it had actually happened before that despite the careful preparation of the tender, the supplier pointed out problems, which had been overlooked in the phase of the tender preparation. It may also happen that some suppliers have unique system solutions, which bring up further questions. In such cases, quick decision-making is crucial so as not to endanger the implementation of the tender.

At the end of the offer preparation phase, suppliers invited to tender prepare their offer, which they then upload to the designated server using adequate protocol and technology. During this preparatory phase, suppliers are in constant contact with a competent expert who had been assigned to make the tender. Consequently, during this phase, one can get to learn some of the valuable information about the tricks of implementation, or other technological matters. Such information is profitable for upcoming tenders, and could benefit current and possible future consigners, too. Further, this incites the development of the implementation of tenders, and of the evaluation methodology.

2.5. Evaluating offers

It is crucial, and almost a commonplace that, when evaluating offers, one should apply more criteria. Often, we experience that this is not applied at all, or just in part. Reasons are hard to explore but based on a survey among consigners we can say that one of the most important problems is the acute lack of time (situations when decision-making is urgent or necessary). Likewise, the lack of adequate competency, of thinking in systems, or of the ability to make multi-criteria comparisons, is not rare. As practising analysers we can say that in cases when such complex issues are concerned, it is not easy to implement an exact evaluation system, which meets the requirements of system-based thinking. To establish a system like this, thorough mathematical and methodological help is needed. The mathematical apparatus supporting multi-criteria analyses is the *decision-preparation method* well-known in the field of operational research for years [4], [5]. It has served as the basis for us, too, while developing our evaluation system.

Choosing the *evaluation aspects* in this phase should not pose a problem anymore. Since already in the phase of tender invitation great care must be taken to define the parameters of the individual offers in a controlled way, and to ask them to be submitted in a structured form. Thus, the aspects defining the suitability of a logistics system are already laid down. The most important factors include (the list is not complete):

- Total Cost of Ownership (TCO):
    - Price parameters: price of each alternative, price of options that can be chosen
    - Delivery costs
    - Assembly/installation costs
    - Maintenance costs (e.g., 18000 working hours for fork-lifts)
- Maintenance, solutions to ensure continuous operation
- Delivery deadline parameters
- Required time for assembly/installation
- Warranty, post-delivery warranty
- Terms and way of payment
- Other technologically and economically specific tasks

Time-consuming is the gathering, structuring and trimming of the input data, which is necessary for the multi-criteria analysis, and which has been received from the offers and relate to the alternatives on offer. The automation of this process is in the focus of current developments of data management, and are hoped to be introduced in the near future.

One of the chief values of our system is the automatic application of multi-criteria evaluation methods that are well-known from textbooks, but may not be used enough in practice. We have developed a mathematical method called *multi-criteria decision-supporting algorithm (MDA)* [1], which we use for evaluating tenders [2], [3]. *MDA* enables us to determine the weights of evaluation aspects under examination in a mathematically correct way. To this, one must set the importance ratio of the evaluation aspects based on discussions and agreement with, and validation by the consigner. This is a vital step, as these settings create the internal, mathematical input, which generates the weights of evaluation aspects. In determining weights, consistency is underlined, because in the case of inconsistency (there is contradiction in the importance of evaluation aspects in relation to each other) the evaluation system could give a false picture of the alternatives. Therefore, consistency, as well as the permitted level of inconsistency is controlled by an inner checking routine. Offers received can be arranged in an order of "usefulness" (exactly calculated); based on the value they get from the pre-defined evaluation aspects, as well as the generated weights of the aspects. The arranged offers get a value between 0 and 1, where the most favourable offer has the biggest value (if an offer proves to be the most favourable in all aspects, it will get the performance value 1). Performance values can be interpreted in a percentage context, meaning how "good" they are in relation to the "optimal offer". It happens fairly frequently that the difference between two or more solutions is very small. In such cases, a sensibility analysis must be carried out, which examines what happens to the order of offers if weights are changed. There are four types of aspects (fig. 3):

- Changing the weight does not affect the best alternative (E-1)
- The weight has a minimum limit, below which the best offer changes (E-2)
- The weight has a maximum limit, above which the best offer changes (E-3)
- The weight has both maximum and minimum limits, this could mean a change in the best offer (E-4)

The *sensibility analysis* is to determine those weight limits of aspects, which prove the same offer to be the best and which had been the most favourable along the original weights, too. In our system, this examination can be done automatically, too. Based on this, it is recommended to choose the final order after several changes in weights. *MDA* is an MS Excel and Visual Basic Application (VBA)-based system. By its pre-decision making nature, it generates reports that help making well-founded decisions (*Table 1.*). However, one should not forget that even the interpretation of results is not trivial in many cases. Consulting an expert in this is highly recommended, as he/she can explain the content behind the numbers. A thorough tender evaluation procedure should –in all cases –finish with such a consultation.

Table 1. Example for MDA generated report

Main aspects			Sub-aspects				Offers and their values								
Ser. No.	Name	Weight	Ser. No.	Name	Weight	Interpretation	1	2	3	4	5	6	7	8	Ideal
1	Price	0,574	1	Price (euro)	1	K	114315	140880	102000	81030	150000	136780	126021	110490	81030
2	Delivery deadline	0,115	1	Delivery deadline (week	1	K	8	6	4	8	8	8	8	6	4
3	Assembly	0,115	1	Assembly (week)	1	K	9	14	9	30	22	23	30	14	9
4	Warranty	0,082	1	Warranty (year)	1	N	5	1	2	1	1	2	2	2	5
5	Payment	0,115	1	Deposit (%)	0,5	K	0,00	0,30	0,30	0,00	0,40	0,3	0,00	0,3	0,00
			2	Deadline (day)	0,5	N	30	30	30	30	8	8	15	15	30
1	Price	0,574					0,71	0,58	0,79	1,00	0,54	0,59	0,64	0,73	1
2	Delivery deadline	0,115					0,50	0,67	1,00	0,50	0,50	0,50	0,50	0,67	1
3	Assembly	0,115					1,00	0,64	1,00	0,30	0,41	0,39	0,30	0,64	1
4	Warranty	0,082					1,00	0,20	0,40	0,20	0,20	0,40	0,40	0,40	1
5	Payment	0,115					1,00	0,50	0,50	1,00	0,13	0,13	0,75	0,25	1
				Ser. No. of offers			1	2	3	4	5	6	7	8	
				Points			0,776	0,554	0,775	0,797	0,446	0,490	0,580	0,633	
	Final order of offers			Ser. No. of offers			4	1	3	8	7	2	6	5	
				Offer value			0,797	0,776	0,775	0,633	0,580	0,554	0,490	0,446	

Critical aspects and their critical weight, along which the current results (offer No 4 is the most favourable) is valid:

Main aspects	Lower limit	Upper Limit
Price	0,52	1
Delivery deadline	0	0,14
Assembly	0	0,13
Warranty	0	0,1
Payment	0,06	1

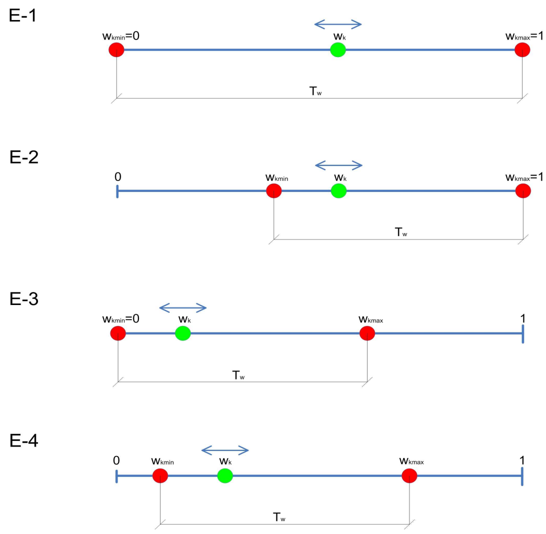

Figure 3. Types of the aspects, sensibility analysis

2.6. Further calling(s) for tenders, decision-making, choosing the supplier

Decision-making is often a challenge even with methodological and professional support. There is a tendency among consigners that they are incapable of coming to an agreement owing to problems in their organisational structure or some limitations on responsibilities or simply because of changing investment & development strategy. It often happens that the evaluation phase is ready for months, but the actual decision-making regarding "what next" will just not come about. We lose precious time, and the tender process may become irrationally long. That is to say, based on MDA results, it is suggested to invite the first two (or maximum three) potential suppliers to further tender(s), partly to further specify the offers technically, and partly to get more favourable terms. It may also be useful to make a reference visit at the potential suppliers; in a warehouse, which - in terms of equipment - resembles the technology specified in the tender. In this phase of the tender, the multi-stage installation of the storage/material moving system as the subject of the tender can be considered (especially in the case of big investments). This is also when negotiations about the purchase price begin, which - according to experience - have a high potential for savings. However, due to the time constraints mentioned above, further tenders are often left out of the tender process. Frequently, it turns out in mid-process that there is no time left for further calls whereby in many cases, consigners miss out on considerable savings, not to mention the problems it generates later during the implementation.

Somehow or other, the last step of the tender process is in all cases the final decision based on the multi-stage selection process, namely, choosing the supplier(s). It may well happen that two different contractors win the implementation of the storage and of the material moving system. In such cases, one must cater for the compatibility of the two systems, and this could mean further problems, as well as new challenges for experts and system developers.

3. Conclusions

The tender process described in the article is the result of an evolution or continuous research and development, whereby we made efforts to combine years of experiences in tender processes with the long-standing and existing methodologies. During our practical work and the testing of the developed process and algorithms, we have encountered numerous problems, from the acquisition of racks worth only a few million Forints, to the tendering of complex storage/material moving systems worth nearly half a billion Forints. We have invited tenders for diverse storage technologies: from painting the place of the takeover, setting up modular shelving, pallet racking or drive-in pallet racks, right through to the most peculiar storage systems (gallery-art storage with shelves, special deep racks, etc.). In respect to material moving systems, we have prepared the set-up of different systems by applying the above-specified tender process. Such systems include: systems with periodical operation (e.g., hand pallet trucks, electric counterbalance trucks, reach trucks, and order pickers), and systems with continuous operation (roller track for production). Experience shows that the system is working properly, and its efficiency is measurable. However, there is no doubt that the above-mentioned directions of development may leave some potential opportunities undiscovered, which could further enhance the efficiency. In the end, it is important to note that tenders could generate further assignments for those companies that had been chosen during the processes: if the consigner is satisfied with the end-result and the ensuring of constant operation, he/she may hire the same contractor to equip his other warehouses/parts of warehouses.

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The Significance of Logistic Package System Design

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Abstract: Implementation of packaging that provides protection for the transported goods is a significant cost factor in logistics. Remarkable savings can be achieved, if the packaging material used is reduced to a minimal level, meanwhile high capacity utilization of vehicles is achieved and through precision design of package transportation damages are avoided. In the first part of the article complex packaging systems and the external effects that emerge during transportation are demonstrated. The physical quantitative features of the external effects in specific cases have to be determined and tested through laboratory simulations. This will determine whether the chosen packaging system is adequate for these features, or does it have to be modified by an iterative procedure in order to allow the utilization of minimal packaging material, while only providing the necessary minimal product protection. The second part of the article deals with the features of different effects in specific cases, and how to build up laboratory simulations.

Keywords: Packaging, Cushioning, Environmental testing, Vibration test, Shock test, Packaging planning

1. Structure and steps of planning logistic packaging systems.

The structure of logistic packaging systems is demonstrated in figures 1-4.

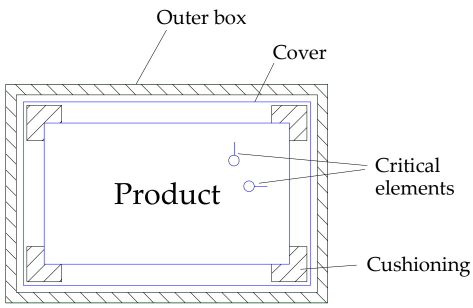

Figure 1. Structure of sales packaging (source: own compilation)

Figure 1 shows the selling package of the product. Certain parts of the product are critical from the aspects of effects caused by logistic processes [1]. These effects can be seen in the following (chart 1):

Table 1. effects caused by logistic processes(source: own compilation)

Air temperature	> low	
	> high	> unventilated
		> ventilated
	> change	> air/air
		> air/water
Humidity	> relative	> slow temperature change
		> rapid temperature change
	> absolute	> rapid temperature change
Air	> pressure	> low
		> change
	> speed	
Water	> rain	
	> other sources	
	> wetness	
Radiation	> solar	
	> heat	
Chemically active substances	> sulphur	
	> chlorine	
	> nitrogen	
	> hydrogen fluoride	
	> ozone	
Mechanically active substances	> dust - sedimentation	
	> sand - suspension	
Flora and fauna	> micro organisms	
	> rodents, insects	
Vibration	> sinusoidal	
	> random	
Shocks		
Fall	> free fall	
	> toppling around	
Acceleration		
Load	> static	
	> dynamic	
Miscellaneous	> rolling	
	> pitching	
Electrostatic charging		

The combination of the above factors affects the product. Cushioning protects from mechanical effects, while foil coverage provides resistance against dust, humidity, friction, electrostatic charging, etc. In many cases the design modification of critical elements can significantly reduce the requirements against packaging, and can also result in savings in the following aspects:

- Thinner cushion layer is needed, this way the volume of the package decreases, and more product can be transported in one shipment. The transportation cost per product decreases.
- Less packaging material is needed, the packaging material cost per product decreases.

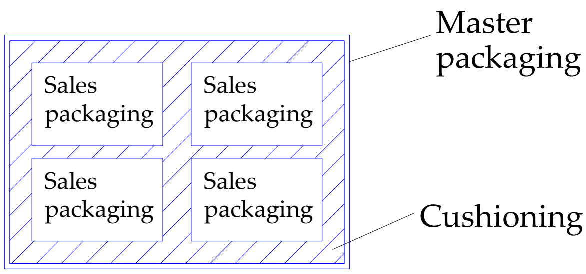

Figure 2. Structure of master packaging (source: own compilation)

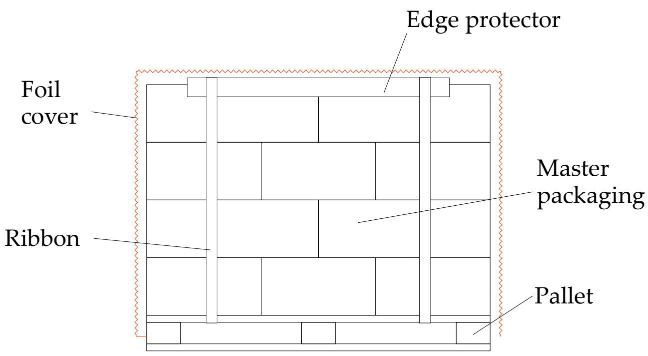

Figure 3. Structure of palletized unit (source: own compilation)

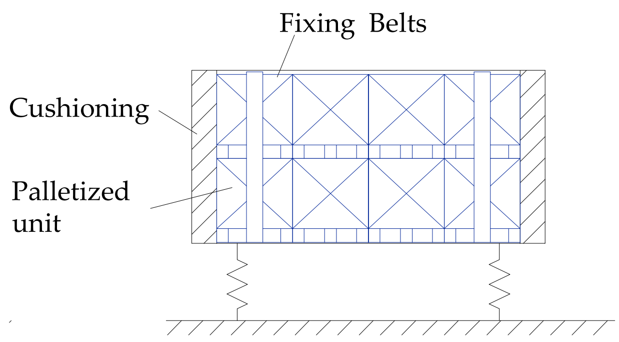

Figure 4. Alignment of palletized units in a shipping container (source: own compilation)

The geometric alignment of products in a complex system indicated in figures 1-4 has to be defined during the design phase of the packaging. If more alignment versions are capable, more than one version of optimal vehicle capacity utilization can be achieved [2].

The planning process of the system shown in figures 1-4 should be executed with the help of an iterative procedure that can proceed in two directions. The two directions are [3]:

- Geometric dimensions and carrying capacity of vehicle/shipping container platform
- Geometric dimensions and weight of sales package

The steps of the iterative procedure are described in figure 5. The final plan of the selected version has to be worked out considering the effects of logistic processes. The data for the diagrams in figures 6 and 7 are retrieved from a measuring instrument fixed on a pallet of freight. This instrument registers the following data [4]:

- Temperature – time diagram
- Relative humidity – time diagram
- Acceleration in x,y,z dimensions – time diagram

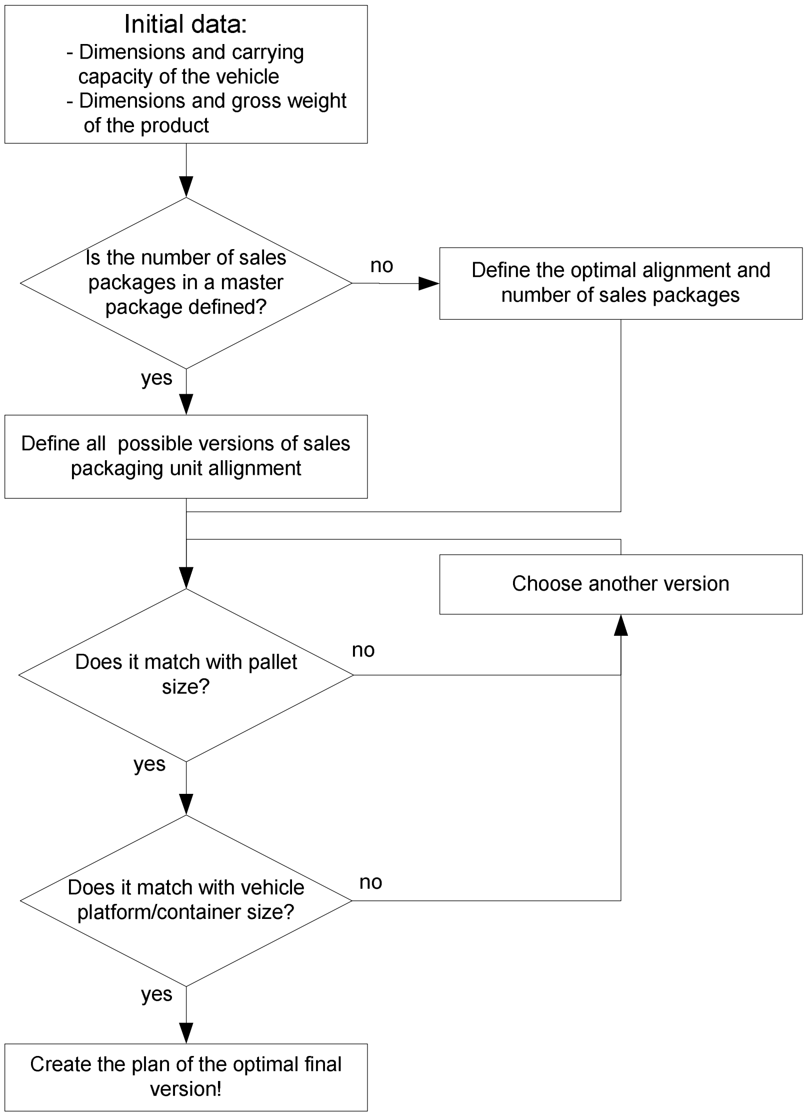

Figure 5. Process of package system planning (source: own compilation)

The acceleration sensors were installed on the part of the platform of the vehicle where the worst conditions can be measured. During the research the motion of the platform was simplified and was regarded as a linear dynamic system. The linear dynamic system can be associated with second rank linear inhomogeneous differential equation. The free coordinates of the examined dynamic system with concentrated parameters can be represented by the following ‘n’ dimensional vector:

$$x(t) = [x_1(t), x_2(t), \ldots x_n(t),]^{\tau} \in R^n \tag{1}$$

The coordinates of the impulsive effects affecting the system can be represented by the following 'n' dimensional vector:

$$g(t) = [g_1(t), g_2(t), \ldots g_n(t),]^{\tau} \in R^n \tag{2}$$

The finite amount of mass, moment of inertia, spring stiffness, damping factor, and geometric dimensions in the system appear in the:

- M: Mass matrix
- D: Damping matrix
- S: Stiffness matrix

This way the linear inhomogeneous differential equation describing the motion of an n dimensional system can be written in the following form:

$$M\ddot{x}(t) + D\dot{x}(t) + Sx(t) = g(t) \tag{3}$$

The initial value is the $x(t_0)=x_0$ location vector and $\dot{x}(t_0) = x_0$ velocity vector belonging to the t_0 initial time value.

By introducing the equation describing the motion stage:

$$y(t) = \left[\dot{x}(t), x(t)\right]^{\tau} \in R^{2n}, \tag{4}$$

and by the derivation of the motion equation the following formula can be written:

$$\dot{y}(t) = \begin{bmatrix} \ddot{x}(t) \\ \dot{x}(t) \end{bmatrix} = \begin{bmatrix} -M^{-1}D\dot{x}(t) - M^{-1}Sx(t) + M^{-1}g(t) \\ \dot{x}(t) \end{bmatrix} = \begin{bmatrix} -M^{-1}D & -M^{-1}S \\ E & 0 \end{bmatrix} \begin{bmatrix} \dot{x}(t) \\ x(t) \end{bmatrix} \begin{bmatrix} M^{-1}g(t) \\ 0 \end{bmatrix} \tag{5}$$

The elements of the system are shown in figure 6. The examination opportunities of the linear time invariant system [5], [6.] assures that reactions given to impulsive functions, which differ both in time and in frequency range can be approximately determined.

The previous statements also mean that the acceleration sensors have to be positioned at the farthest point (x, y, z direction) from the centre of gravity of the vehicle-shipment system.

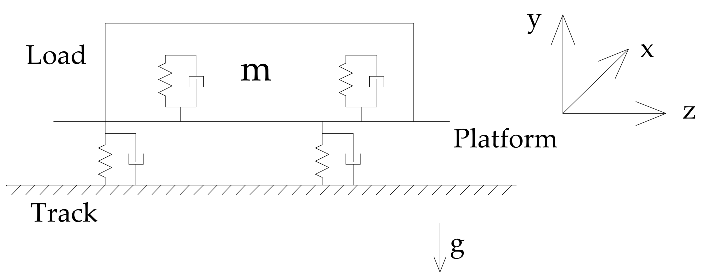

Figure 6. Track –vehicle – load system model (source: own compilation)

Figure 7 shows the features of the road-ship-road transportation chain of the entire freight of 40 shipping containers to the USA. Figure 8 shows the peculiar data of a road-air-road transportation to the USA of a separate palletized unit.

To avoid transportation damages it is recommended to simulate the transportation processes based on the registered data under laboratory circumstances and monitor the reaction of a trial pallet.

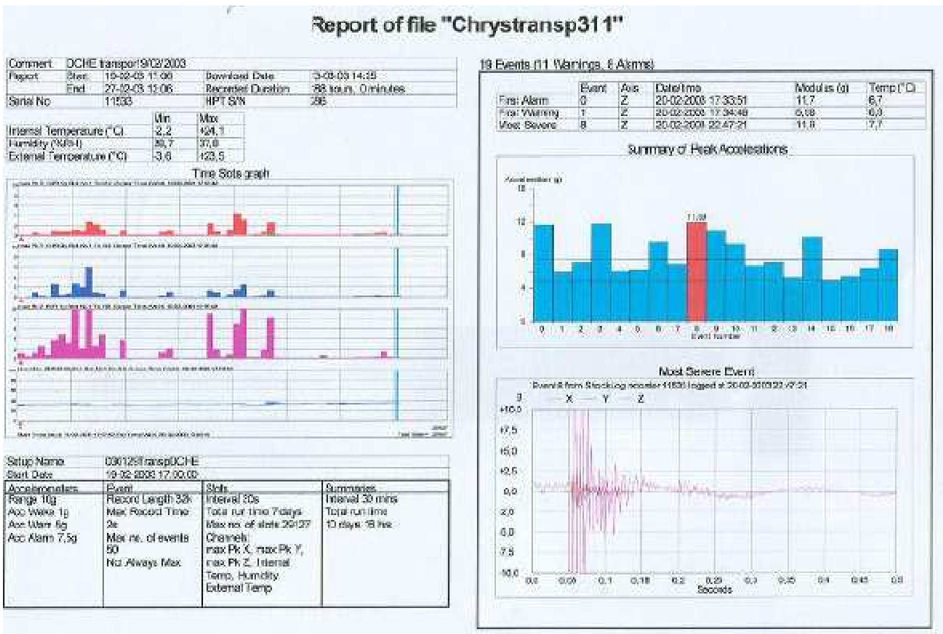

Figure 7. Road-ship-road transportation (source: own compilation)

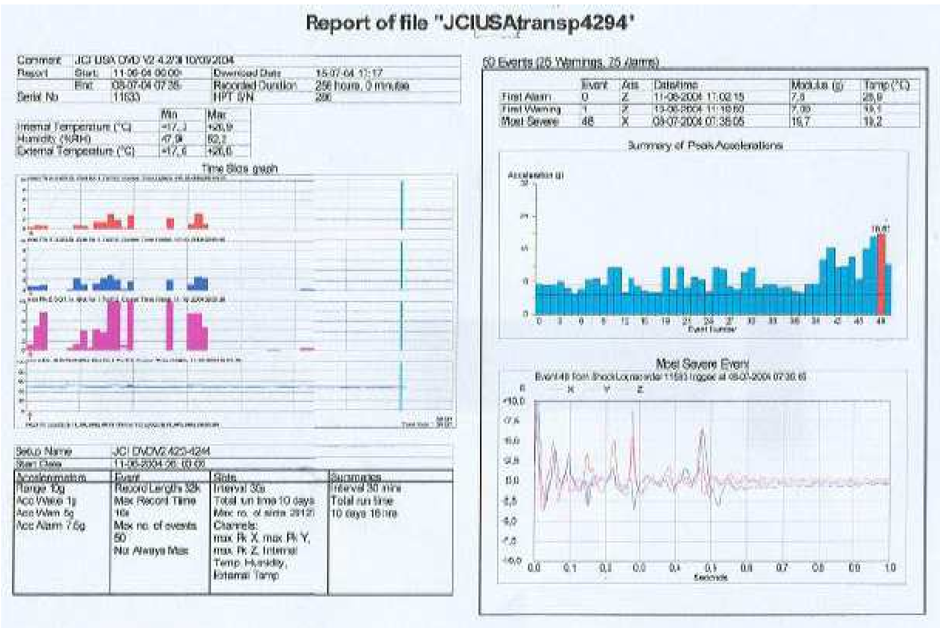

Figure 8. Road-air-road transportation (source: own compilation)

2. Laboratory simulations of logistic effects

In the followings the simulation of logistic effects is demonstrated in a specific case.

To check and to compare the newly designed m8 Module Package Versions with a used one a test program, including shock (drop) and vibration tests, was carried out in accordance to the test methods described earlier in accordance with *MSZ EN ISO 2248*, *MSZ EN ISO 2206*, *MSZ EN ISO 2247* and the Supplier Packaging Release Sheet WUT 173-15-0050 1998 of Philips GmbH for Automotive Playback Modules.

The Drop Test (according to MSZ EN ISO 2248, MSZ EN ISO 2206) was realized from a *height of 0,70m (2, 30 ft)* with an *accelerometer* of the *Type B12-500, the* PC based *measure system SPIDER8 and the software CATMAN.* The accelerometer used for measuring was fixed on a module placed in the middle of the package system in the Drop Test and also in the Vibration test (figure 9).

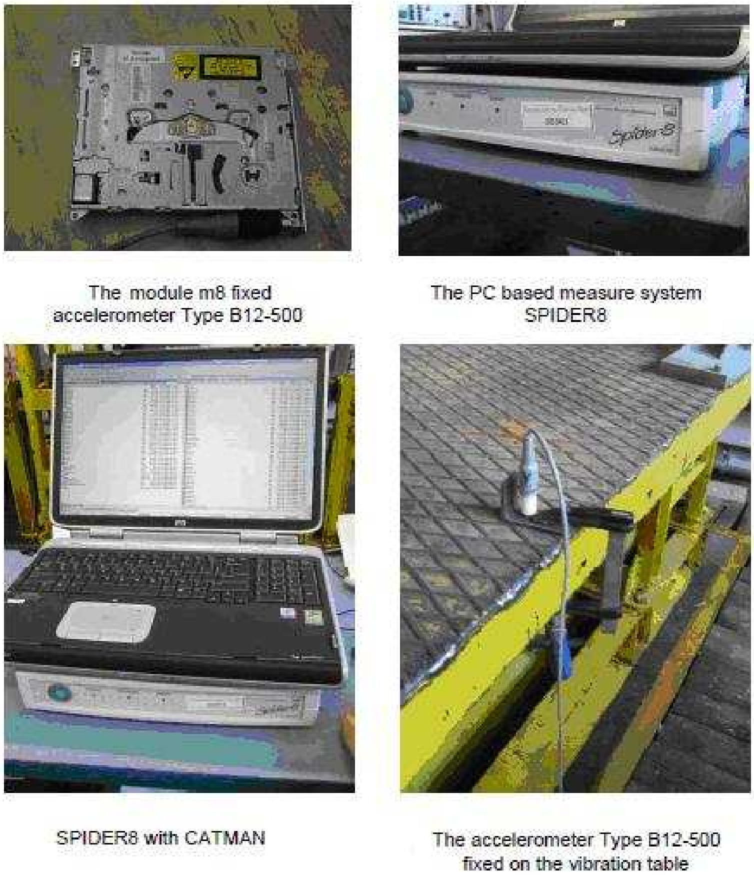

Figure 9. Vibration measuring system (source: own photo)

The test program was carried out systematically, that means the position of the sensor was approximately the same, and also the sequence of the drops. The first drop occurred from a height of 0,70m from the bottom, the second from the top, followed by the left side and right side drop, and the front and rear drop (if there wasn't any noticeable damage). The "g'" values calculated from the measured acceleration were recorded in *.exe files*, and also represented in the diagram form acceleration versus time, after the evaluation with the CATMAN software.

The Vibration Test (according to MSZ EN ISO 2247) was examined on the hydraulic Vibration Table RA-00 with a frequency range of 0-150 [Hz] in the Packaging Laboratory of Széchenyi István University, Győr. The measurement was carried out with the same sensor type and system as the drop test. Results were also recorded as data in *.exe files,* and evaluated in diagram form. The test program ran in normal climatic conditions, at 23 ±2°C and 50% relative humidity.

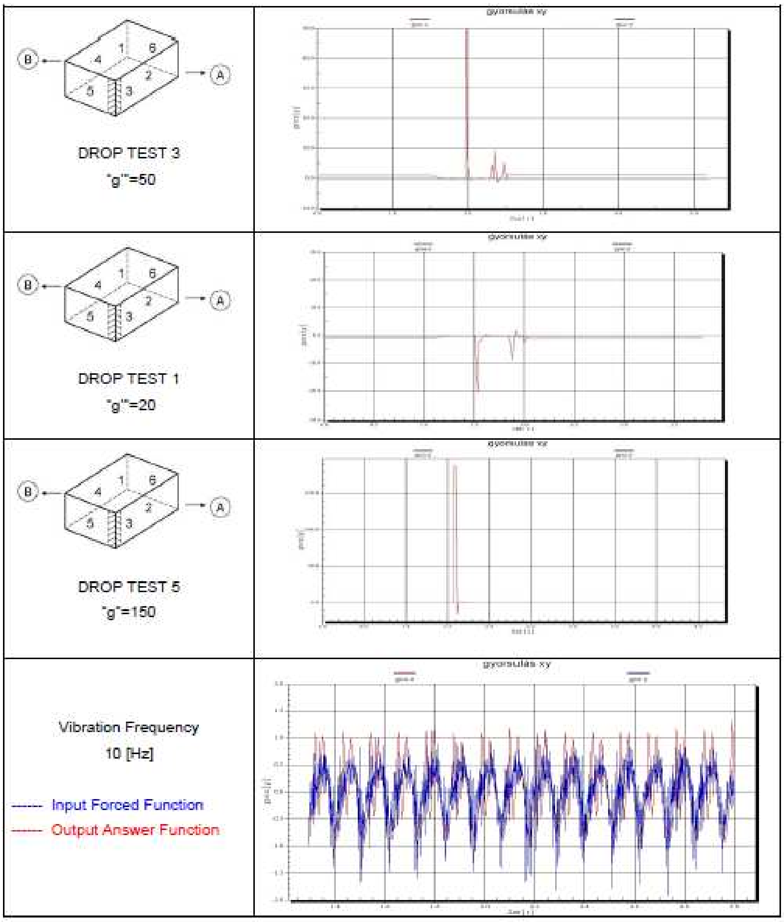

Figure 10. Results of drop and vibration test (source: own compilation)

The value "g'" was measured according to the specified standards of the bottom and of the top. The values "g'B"=50 and "g'T"=20 are smaller than the international recommended acceleration factor ("g'B"=65-85). The "g'L"=150 measured by the drop on the left side considerably exceeded the value "g'B"=65-85. Furthermore after the drop the package was damaged so the drop test could be not continued [7].

3. Conclusions

To summarize the facts, the used *SCA m8 Module Package Version* seems not to be enough strong. Although the cushioning of the package ensures good vibration isolation, the shock damping of the system is not suitable.

Figure 11. Condition of package after vibration and drop test (source: own photo)

The iterative planning continues with the modification of the cushioning until the test results show that the shock acceleration becomes less than 50 g, and the modules are not removed.

The author of this article wishes to thank the cooperation of the members of the test team of Philips APM, Wetzlar Germany and SCA Packaging Hungary.

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The Application of the Game Theory onto the Analysis of the Decision Theory of Logistic Packagings

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Abstract For the characters of a logistic system the common decision making is not an instictive action yet. Choosing a common strategy does not provide the theoretically best result for the individual or for the organization. But this strategy can create a balance state, which is worthy for nobody to differ from in a concrete case. This study is looking for the solution conditions, which are necessary to the development of a strategy that can lead to a a balance state in the final result in the course of planning of a logistic transport-packaging. In the study to create the model development we use a game theory method for the detailed analysis of the decision theory problem, and for identifying the possible outcomes of it.

Keywords: logistics, packaging, game theory

1. Introduction

To analyse modern logistic systems, and to evaluate them according to their expense, expected results, and its environmental influence and effects of exterior are only approximate even by using the most complicated decision theory models. In a lot of cases these endeavours can face difficulties at operative decision levels already in the early phase of the analyses, not reaching the upper management's level. The game theory in this study wishes to examine the system’s inclination between the elements (supplier-customer) in order to promote the common profit of the system (its result), meanwhile not allowing to hurt the parties' own usefulness.

In the model the decision alternatives presuppose decisions between systems of returnable and one-way (disposeable) transport-packaging systems. The decision makers are the producer company (supplier) and the company that gets the products (customer). The idea is not a new new one. The decision problem on reuseable and disposable bottles can be analysed according to similar principles [1].

Moreover, it is interesting to see that both the European Union and Hungary do not really motivate the usage of returnable devices. There is no applied regulation in the EU on the preference of the returnable packaging [2]. The council directive (2004/12/EC) on the packagings and the packaging waste regulation does not prefer the usage of returnable packaging to the recycling of material substance [3].

It is necessary to note that there are essential differences between the application of consumer reuse, and collecting packagings of use of recycling in company-producion logistics. According to the effective environment protection regulations there is no sufficient incentive system available for the returnable packaging, but this system is only introduced by an individual (corporate) decision for personal savings. Reuseable pallets, metal and plastic containers were generally used instead of disposable barrels, trays and pallets. This trend seems to prevail reversed.

In spite of having tangible benefits of the returnable packaging device, the application of disposable packagings is of ever growing importance in the industrial practice [4]. The possible reason for this is that the packaging damages are extremely considerable. Furthermore, the customers can handle the one-way devices much more easily after a single usage, since these are not necessary to store, direct or prepare and additional costly actions are just rarely required.

The extrtemely detailed calculations preceding the single corporate decisions yield savings merely for the individuals. At the same time the decision between the packaging systems, that is, which one-way or returnable devices to select in the actual logistic system, does not definitely yield the results calculated.

2. The game theory as a possible solution

The aim of the application of the game theory is to offer a suitable framework for the introduction of an optimal strategy in the planning process of a life cycle for packaging. It defines, how the decision between returnable and one-way device can achieve the best financial and environmental performance, what conditions the participants (supplier, customer) must meet regarding by keeping their strategy [5]. It needs consideration which conditions can lead to a balance, where reactions of one party are a combination of strategies to the other party's actions. We are looking for a balance state, where it is not worth deviating from the combination of strategies [6] [7].

We assume that the packaging applicable several times means higher expenses to the customers, nevertheless, they can decide to send it back to the supplier, so that this sum can be refundable as a deposit. Thus, the game depends mostly on the customer's willingness to send back and pay more for expensive packaging, or the supplier persuades customers to return and reuse the device.

3. Life cycle analysis and the outcomes of the game

A general life cycle analysis requires some simplification in order to be able to identify the elements, and their interactions at the single levels of the life cycle [8]. We have to analyse a packaging life cycle (figure 1) to assess the quality of the outcomes in the single phases. That is, how the packaging is wandering and what underlying information we should look for, that we can assign values to.

Our aim is to identify the points of the cycle where some parties are of strategic importance while others are not. In the present case, for example, the governmental interventions as bounding force are essential in terms of the sustainable development, but they are not affected by the strategy of the examined two characters. The governmental acts from the parties' aspect are considered as external force on making decisions and forming the strategy [9] [10]. Orders and regulations affect all events of the game. We have to mention here characters like product compilers and recyclers as well, who have and important role, but they do not play a strategic role and do not have a direct effect on the price of the packing implements (or on the expense of the full life cycle).

The supplier's and a customer's strategies and their results depend on the transactions which can be interpreted in the above chain [11]. Should the supplier collect and reuse the used packaging or rather buy a new one-way packaging from his supplier? Does the customer have to throw away the used packaging or rather send it back to his supplier? Naturally, the decisions always depend on the possible expense factors primarily, which can theoretically provide plenty of possible ways for balance.

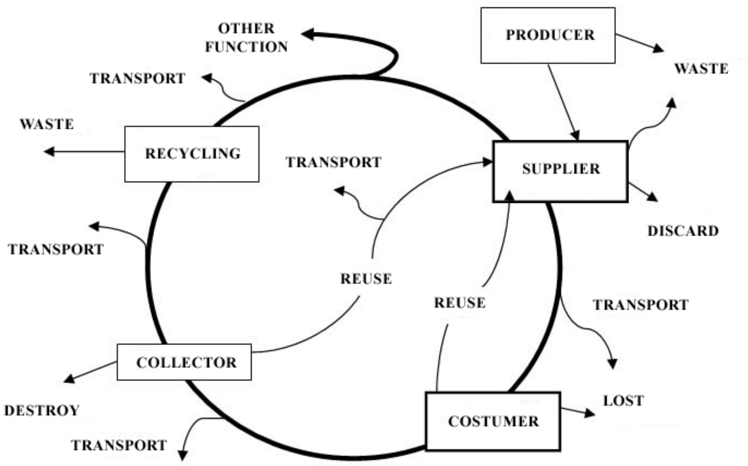


Figure 1. The life cycle diagram of the packaging (source: Authors)

It is mportant to note that sometimes it is the participants' personal results that determine the best balance solution. In this case everybody selects his own best strategy. This is a very frequent example in the industrial sphere, since mutual relation is regulated according to some kind of contract, in which the own best efficiency controls the parties concerned.

4. The analysis of the return of packaging

The outcome of the game depends on a lot of decision functions variables, which are strongly related to and depend on the return of the packaging. The determination of the final expenses are primarily effected by the expense of returnable devices, the ratio of return, the expense of the return and the probability of return. Then, only the comparison of these results in the forming of the definitive strategy.

As a consequence the supplier's and the customer's options can be modeled as a serial game where the supplier selects the type of the packaging device first, then the customer decides if he sends it back or throws it away after the usage (should it be a one-way or a returnable device).

To illustrate this with a plain example, it means that the supplier wants to minimize the packaging expense of a single package item (*C*). In this study we do not examine the effect of the other placement expenses (E_e). This way the expense of a one-way packaging item equals the expense of purchase (P_e):

$$C_e = P_e + (e_e) \quad (1)$$

We assume that P_e is of lower value than the expense of a returnable packaging (P_t) (which is stronger, and more durable). By using returnable packaging there are some additional expenses such as the return freight and storage expenses, below indicated with (t_c). If (t_c) is lower than the expense of a new one-way packaging item, the introduction of a new strategy on the usage of returnable packaging is highly motivated.

The theoretical expense of an returnable packaging device can be estimated by the number of the reusing, that is P_T divided by the number of the usages (*u*). In addition, here we must take (t_c) into account as a derivable expense from every return, just like the umpteenth expense (*i*) of return.

$$C_T = \frac{P_T}{u} + (u-1) \cdot t_c + (e_T) \quad (2)$$

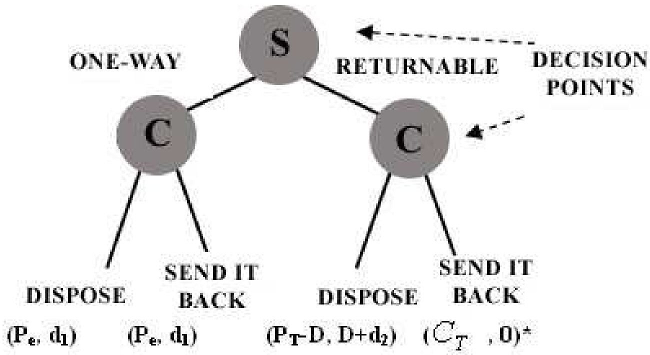
Obviously a packaging extra price (deposit price, D) can be lower or higher than and equal to that of pruchasing a new returnable packaging again. However, if the device returns in a condition unsuitable for re-usage or does not return at all, the packaging extra deposit remains with the supplier.

This market process can be defined as a strategic game, which can be interpreted with a tree depicting a cost function value belonging to each single branch in all of its endpoints (Figure 2). According to this, each participant can decide only once, one after the other and the supplier can decide at first.

In the second turn the customer is already aware of the the first turn (supplier's) decision, but is not dependent of on it. Because of this the supplier makes the best decision, selects the best type of packaging system, knowing how the customer reacts to the usage of a returnable or a one-way packaging system.

The customer can choose from m^N strategies where *N* stands for the number of the decision junctions, and *m* for the possible number of decisions in the single junctions.

Obviously, the customer has to play the game where his exenses are the least, and his expense originating from the disposal (d_1, d_2) together with the deposit of the device (D) is less. The disposal expense of the returnable device can be given simply with a formula, $d_2 = d_1/u$, where, reasonably, a single usage expense should be far below that of using a one-way device.



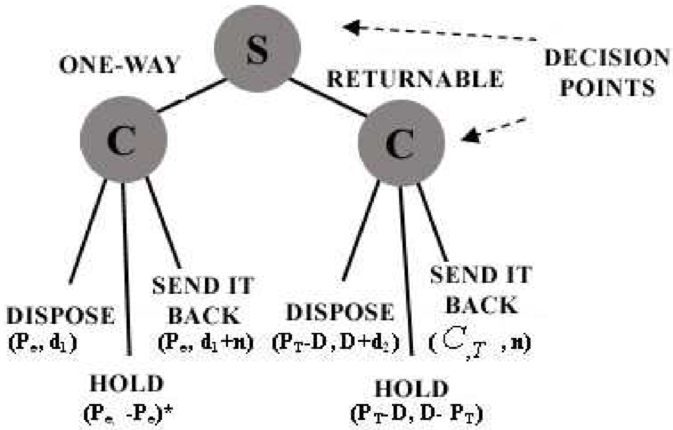
* We can find Nash balance, where D, d_1, P_T and P_e > 0 and $P_T \geq P_e \geq C_T$

Figure 2. Game tree on the return and disposal (source: Authors)

The above tree allows the customer to send back the returnable device, however, it is not deemed by the supplier. So, the customer has to pay the deposit independently of sending back the device or not. Partically the game has four possible outcomes according to the decision tree. The outcomes (results) of the single strategic steps are in the endpoints of the extensive form game. At the same time we can realise that the customers tend to use a dominant strategy. It is indifferent for them whether they send back the device or not, because payments for both cases will be of the same size. That is why the supplier must suppose that the customer plays the dominant strategy. Induction gives this plain game a backward solution, namely, regarding the decision points in subordination, selecting the cheapest expense, heading bottom up. The solution is a Nash balance, in which the supplier selects the returnable device and the customer decides on returning, where none of the players can reduce their expenses by using a new strategy.

5. The effect of value changing of the device

As mentioned before the decision tree applied is an exceptionally simplistic example, since there can occur various and complicated ways of behavior by the parites involved, resulting in a higher number of possible outcomes and effects (Figure 3).



* We can find Nash balance, where $P_T > D$ and

$$P_e > P_T - D$$
$$n > P_T - D$$
$$n > D + d$$

Figure 3. Game tree on changing-value device (source: Authors)

Take the above example when the price of the packaging device is higher than the inbuilt (deposit) price. In this case it is worth for the customer to consider keeping the pacaging device, as this gives the most convenient result for him. However, if he keeps the returnable packaging device, this costs (*D*) for him, which is possible at each place of P_i. Namely, sending back the device can be interpreted that the customer has some loss (of income) of (*n*). If he sends it back it means lack of income of +*n* to him because by keeping the device the surplus value could have stayed with him. The expense for the customer is D-P_T if he keeps the device, and D+d_2 if he throws it away. Obviously, the customer will never send back while (*n*) is higher, than D-P_T, and higher than D+d_2.

In the above case the supplier can decide on using the one-way packaging, which excludes the expense of replacement of the returnable device that would not be sent back by the customer. The supplier will strive for making the price of the returnable device higher than its theoretical price ($D>P_T$), which can motivate the customer to return it, or the supplier can cover his own expense of buying the device again. But it is necessary to notice that too high prices will move us away from the balance, because if the supplier preferred this measurement (which is nevertheless the best outcome for him), no common strategy or interest will be possible with the customer.

6. The returning ratio of device

Determining the packaging price for resale and its deposit is up to the supplier, which has to be calculated according to the willingness of the customer to send back the device by the given price. That is, it shows the sensitivity of the customer, where the high price can prevent the costumer from misusing the device, and the device could not be sold. The supplier has to consider several options simultaneously. The above mentioned consumer sensitivity will be the primary determining factor of the return ratio of the returnable packaging device, which can expand from 0 to 100%. So the outcome of the game depends on the price of the device and the ratio of return (the high return ratio results in the preference of returnable devices, while the low ratio return supports the usage of one-way devices). The total logistic costs of supplier (SC_e) for one-way packaging, containing all the further placement cost (E_e) and variable expenses as well (such as the purchase expense, P_e), and taking the whole amount of devices to be used into account, can be determined as follows:

$$C_e(Q) = P_e \cdot Q + E_e \tag{3}$$

In case of application of returnable packaging the supplier's total cost will decrease according to the ratio of (*RV*) devices returned. For the present case the usage-ratio is proportional with return ratio, that is RH~RV. This is the turning ratio of a device detailed above. That is, for example, if 100% of the devices are getting back, the supplier tends to have long-term profit, while his purchase expense will be minimal. In case the returns are under 100%, the growing expenses can be depicted with the number of the average returns. By usage returnable packaging the full logistic expense of supplier (C_T) can be calculated as follows:

$$\sum C_T = P_T(Q) \cdot Q + P_T(Q) \cdot Q \cdot (1 - RV) + t_e(u-1) \cdot RV \cdot Q + e_t \cdot (Q) \cdot Q \cdot RV' \tag{4}$$

But we have to consider in this case that after the last transport the devices will stay at the depot of customer. In this case there is no return, and theoretically we can find all devices at the customer, which means further expenses like the placement expenses of that quantity. So, we cannot use the RV, but we add RV' into the equation. Obviously RV ≤ RV' ≤ 1, because we probably cannot find all of the devices at his depot, but we can find more as if the consumer would had send them back.

Moreover if the devices get back to the supplier than we have to calculate with (+*u*) as the last transport cost, and there is no RV'. We have to use RV, and the full logistic expense of supplier can be calculated as follows.

$$\sum C_T = P_T(Q) \cdot Q + P_T \cdot (Q) \cdot Q \cdot (1 - RV) + t_e \cdot u \cdot RV \cdot Q + RV \cdot e_t \cdot (Q) \cdot Q \tag{5}$$

7. Changing the deposit value and the returning ratio

The additional expenses like deposit price will reduce willingness for usage, nevertheless, the usage increases the number of returns. Having high deposit prices the customer tends to send back the device, not to lose the deposit. So, the supplier has to determine a deposit price, which reduces the real selling price of the product and also his expense of used packaging, moreover, he imposes this burden on the customer.

Based on this, the ratio of sending back returnable packaging can be estimated as returning can reduce the customer's expenses or probable losses. If the supplier is not able to foresee the customer's final decision (his returning ratio at a given deposit level), then the customer is considered as an independent variable in the equation.

These expenses can be examined by comparing the supplier's total costs with the income from the deposit prices. In this way we can simply define the packaging expenses and actual total expense of operating the packaging system. This can be determined by concerning the difference emerging from the incoming sums (deposits) and the usage of the system (total costs of purchase and operation). We can calculate on income (I_T) from the deposit price staying with us. The expenses are the cost of new purchasing and the return-transportation, etc. The supplier has to find the lowest full cost. We call it modified cost (MC_T) (7).

$$I_T = \frac{(u-1)\cdot Q\cdot(1-RV)\cdot D}{u} + \frac{Q\cdot D\cdot(1-RV')}{u} \tag{6}$$

In this calculation the first part of right side is the all deposits coming from till the last return, and the second is the deposits from the last return, if the costumer does not send the devices back.

So, we can calculate the modified cost of supplier as follows:

$$\begin{aligned} MC_T &= \sum C_T - I_T \\ MC_T &\to \min \end{aligned} \tag{7}$$

When minimizing MC_T we have to find that variable which has effect on the logistic process (on the returning). This parameter is the deposit (D). The RV will depend on the ratio of deposit and the packaging price (P_T).

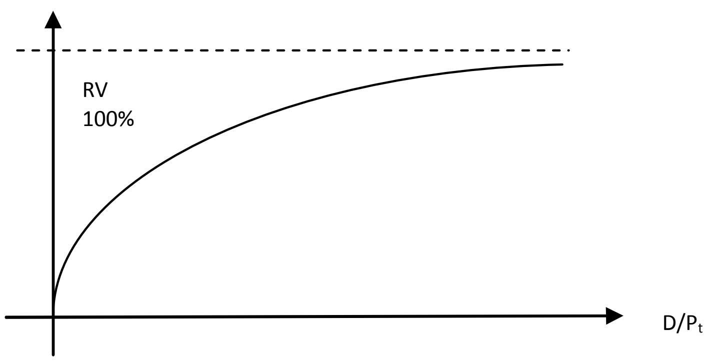


Figure 4. The curve of return ratio in D/P_T

We assume that RV never reaches the 100%. It is possible because the experience shows that there is no case when all of the devices are totally coming back. If we choose a suitable function then we can give the following formula for the RV.

$$RV = \left(\frac{D}{P_T}\right)^{\varepsilon} \tag{8}$$

where (ε) is an elasticity modulus.

We assume that:

$$0 < \varepsilon < 1$$
$$P_T = const.$$
$$\left(\frac{D}{P_T}\right)^{\varepsilon} = \frac{D^{\varepsilon}}{P_T^{\ \varepsilon}} \leq 1$$

So we are looking for the minimum value of the equations (7). Here we examine further the case when the devices are not sent back with the last transport. The equations (4), (6) and (8) can be substituted in (7):

$$MC_T = P_t \cdot Q + P_t \cdot Q \cdot \left(1 - \frac{D^{\varepsilon}}{P_T^{\ \varepsilon}}\right) + t_e \cdot (u-1) \cdot Q \cdot \frac{D^{\varepsilon}}{P_T^{\ \varepsilon}} + e_t \cdot Q - \frac{(u-1) \cdot Q \cdot \left(1 - \frac{D^{\varepsilon}}{P_T^{\ \varepsilon}}\right) \cdot D}{u} - \frac{Q \cdot D \cdot (1 - RV')}{u} \tag{9}$$

$$\frac{dMC_T}{dD} = 0$$

$$MC_T' = -\left(\varepsilon \cdot \frac{P_T}{P_T^{\ \varepsilon}} \cdot Q \cdot D^{\varepsilon-1}\right) + \frac{\varepsilon \cdot t_c \cdot (u-1) \cdot Q \cdot D^{\varepsilon-1}}{P_T^{\ \varepsilon}} - \frac{(u-1) \cdot Q}{u} + (\varepsilon+1)\frac{(u-1) \cdot Q}{P_T^{\ \varepsilon} \cdot u} * D^{\varepsilon} = 0$$

$$MC_T' = D^{\varepsilon-1}\left(\cdot \frac{\varepsilon \cdot (t_c \cdot (u-1) \cdot Q - P_T Q)}{P_T^{\varepsilon}}\right) + D^{\varepsilon}(\varepsilon+1) \cdot \frac{(u-1) \cdot Q}{u \cdot P_T^{\varepsilon}} - \frac{(u-1) \cdot Q}{u} = 0 \tag{10}$$

Using the presenred analytical way we could find a D_{opt} point. But we must not forget that in this case the level (value) of deposit is the supplier's choice.

Here we have to mention another case, when the level of deposit is determined by legislation or a governmental regulation (D_c: compulsory minimum deposit). In this case there is a minimum deposit level. So we could define three possible way as follows.

i. if the $D_c < D_{opt}$, than supplier choose the D_{opt}.

ii. if $D_c = D_{opt}$, than the supplier get automatically into his minimum modified cost.

iii. if $D_c > D_{opt}$, than supplier cannot get to the optimum point.

In the first case (i), the equation mentioned above (10) is suitable to solve this minimum problem. In the second case (ii), the supplier has not to do anything. Concluding from (iii), the supplier will choose another way to find his minimum cost. This leads far away, for instance the supplier will break the rules or switch over to use a one-way packaging system.

8. Conclusion

We can find numerous process series in the industrial practice and consumer market where the presented model is applicable (e.g. metal waste and battery industry). It is true that the balance is difficult to achieve if the customers or the suppliers are not motivated enough to return devices. Mainly, if throwing away the device makes lower expenses in some individual aspects. This process is even more complicated by the latest reinforcement of regulations on environmental protection, which can be one of the most important factors of development of mutual strategies in the future.

This situation is in constant moving and changing because of new characters appearing in the chain, as, for example, companies for developing returnable packaging or recycling and handling for waste enter the market. These new characters mean an additional decision problem by creation of the mutual balance strategy.

Our next aim should be to improve how the D_c has to be determined. We have to find a way which is the best to achieve a balance between the participants in logistic chain and the state or society. A test calculation series can provide a realistic picture about the adaptability of the presented model.

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Performance and Competition of Logistics Service Providers in Hungary

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Abstract: The bankruptcy of a fast-growing logistics provider claiming to have a remarkable market share can seriously shock the customers and the business community. On choosing the next provider, they will pay more attention to company size, growth and corporate performance indicators. Do they affect one another and, if yes, to what extent? Is there a direct or an inverse effect? What is the 'measure of competition' in the logistics service providing sector?

It is widely discussed whether time-based competition and through it the enhancement of market concentration has favourable or adverse effects on the profitability, productivity and efficiency of companies. Several researchers have found a positive relationship between market concentration and profitability as well as efficiency. However, both theoretical and empirical research confirms that, on markets with moderate technological development and innovation (e.g. logistics), where lots of players are involved in the activities and competition works efficiently, the margin approaches zero. In such cases, the price–cost margin can indicate the strength of competition relatively well.

The statement that can be found in international literature and that can be observed in the Hungarian practice as well – that is, along with the increase of competition, the price–cost margin decreases – is backed up by the analyses carried out in database. The connection between the concentration of the class, the price–cost margin and profitability can be proved. The correlation between price–cost margin and profitability indicators in highly concentrated classes is even stronger. Based on the calculations with the 2001–2006 figures of companies belonging to the economic sector and having double-entry book-keeping, we could rather say that productivity can be increased by enhancing market share, and not that market share can be enhanced by increasing productivity.

Keywords: competitiveness, logistics regression analysis, profitability, productivity

1. Introduction

Outsourcing logistics functions is an important issue in Hungary; even these daysit has become easier to find a suitable service company over the past 10 years, as there has been considerable growth in the service market. Meanwhile, competition among service providers has strengthened. More and more multinational service providers have appeared and, during this period, several small enterprises have 'grown up' to become medium-sized enterprises. (In the meantime, independently of the global financial competition, some companies have filed for bankruptcy.)

Is there a reason why customers give preference to bigger service providers? What is their reason based on? This study examines the effects of market competition and the concentration growth caused corporate performance indicators. In addition, it tries to answer the hen or egg question of whether efficiency increases with the growth of the company size and the market share, or just the opposite: a company starts to grow through the increase in efficiency.

Our research was based on own data collection and the data to be found at the Registry Court and KSH (the Hungarian Central Statistical Office) of companies with double-entry book-keeping in the logistics sector.

2. Competition and its measurability

Researchers dealing with economics have been interested in the role of competition and its influence on economic efficiency for a long time. Most of them emphasize the 'beneficial' role of competition, although competition is not omnipotent, which is proved by the financial world crisis at the end of 2008, for example. Competition can be linked to certain markets (e.g. the market of logistics services).

A market can be described on the basis of its structure, form, size and the number of players. These factors determine the possibilities of the players and the strength of the competition. The forms of the market can be judged by *the number* of sellers and buyers, whether it is easy or difficult for *new players* to enter the market and whether a player is able *to influence the market price alone*. The two extreme forms of market competition are perfect competition and pure monopoly. In one of the most well-known transitional market situations, some companies knowing one another and being able to adapt to one another compete on the given market. This is called a multi-participant *oligopolistic* market.

A basic issue of the literature dealing with the relationship between competition and the performance of companies is defining the intensity of competition numerically. Competition is hard to measure directly. For the lack of exact index numbers, empirical studies attempt to demonstrate the intensity of competition based on an observable factor relating to competition indirectly. On the literature studied, we can declare that there are no universal index numbers that could give a really reliable picture of the extent of competition on a given market.

2.1. Index numbers of competition intensity

Of the indicators used for measuring competition, we can distinguish between *static* and *dynamic* index numbers. Static indexes provide information on the *state* of a given market at the time of the investigation, whereas dynamic indexes are applied to show the *changes* taking place on the market. The indicators based on the demography (establishment and closing down) and the market share changes of companies can provide further useful information on the intensity of competition.

In addition to and completing static and dynamic index numbers, several other approaches to assessing the extent and trends of competition can be found while studying the literature. Among others are index numbers demonstrating the existence of certain institutional conditions, the *regulation* level of the market or *freedom of international trade* and *innovation*.

We focus on the following indicators used for measuring market structure: a) concentration rate (CR), b) Hirschman–Herfindahl index (HHI) and c) Lerner index (L) or price–cost margin (PCM).

2.1.1. Concentration rate

The *concentration rate* shows what percentage the largest companies have of the total production or total turnover of a market. The concentration rate can be calculated on the 2, 4, 8, 16, etc. largest companies relating to the division and class concerned. The CR4 and CR8 indexes of the logistics division are in columns 3 and 4 of Table 1.

2.1.2. The Hirschman-Herfindahl index

The *Hirschman-Herfindahl index* is the index number of market concentration in the industrial sector, which is calculated by squaring and summing the market share of each firm. The maximal value of the index is 10 000 (100^2).[1] The HHI index is shown in the last column of Table 1.

There is a strong correlation between the concentration rates calculated with Hungarian corporate data on class level. The strongest relationship ($r = 0.984$) is between CR4 and CR8, but there is a close connection between CR4 and the HHI index ($r = 0.796$), as well as CR8 and the HHI index ($r = 0.722$). Correlations are significant at level $p<0.001$.

[1] In compliance with the Merger Guide, we speak about moderate concentration if the index is between 1000 and 1800, and concentration if it is over 1800.

http://www.usdoj.gov/atr/public/guidelines/horiz_book/15.html

Table 1. The nine most highly concentrated classes in the section Transportation, warehousing, post, and telecommunications in Hungary in 2006[2]

Class	Company	CR4	CR8	HHI
Scheduled air transportation	12	99,09	99,97	8 273
Rail transportation	17	97,95	99,49	4 309
Support activities for air transportation	32	96,79	98,27	4 337
Non-scheduled air transportation	55	87,18	94,93	3 695
Telecommunications	650	71,58	82,88	2 027
Courier mail activities	371	69,86	75,21	1 891
Inland water transportation	71	67,46	81,54	1 300
Support activities for water transportation	39	61,68	80	1 201
Support activities for ground transportation	190	59,38	71,08	980

2.1.3. Lerner index

The *Lerner index* is an indicator determining the market power of the company as the difference between price and marginal cost. The higher the Lerner index, the more market power the company has, as the company needs more and more power to be able to deviate from the price equal to the marginal cost.

[2] The table includes the classes, which had more than eight companies operating in 2006. For the sake of completeness, all the classes of the section are listed in the table of Appendix 1.

2.1.4. International empirical studies on the above indicators

In empirical studies, both the concentration rate and the Lerner index are frequently applied (to measure competition). See for example: [COLLINS, N. R. – PRESTON, L. E. 1966, 1969; SAVING, T. R. 1970; ORNSTEIN, S. I. 1975; ROSENTHAL, R. W. 1980; DOMOWITZ, I. et al. 1986, 1988; AMIR, R. – LAMBSON, V. E. 2000; NEVO, A. 2001], etc.

However, not all the publications we have studied led to an unambiguous result. ORNSTEIN's investigations [1975], for instance, justified COLLINS and PRESTON's [1966, 1969] conclusions, stating that, in the industrial sector manufacturing of consumer goods,[3] the Lerner index shows statistically significant results with market concentration trends, but in sectors producing durable consumer goods, the results did not prove to be significant. Similarly, no significant relations could be detected in more capital-intensive divisions.

DOMOWITZ [1986] and his co-authors came to the conclusion that, in the 1970s, there was a dramatic narrowing of the spread between the average price–cost margins of concentrated and non-concentrated divisions in the USA. The change in the spread between the margins of concentrated and non-concentrated sectors can be largely attributed to the different changes of adaptation and demand, which suggests that, in the explanation of price–cost margin fluctuation, the aggregate impact of demand is of greater importance than the effects of local demand [DOMOWITZ, I. et al. 1986].

Nevertheless, both theoretical and empirical research supports the hypothesis that, on markets characterized by moderate technological development and innovation, with lots of players, where competition functions efficiently, the margin approaches zero. In such cases, the price–cost margin can indicate the strength of competition well. A value close to zero indicates strong competition, whereas higher values point to the weakness of competition. The higher the index value, the weaker the competition. (We proved this thesis through utilizing the – independent – international research results of the 1990s. For this purpose, we could not find more recent publications.)

The vast majority of the empirical studies found on the effect of market share on profitability published in the last decades confirmed a positive correlation. The increase of productivity showed different extents taken as a function of the features of the samples, the methodology and the model applied, but according to the conclusions drawn from the studies, the increase in market share is equal to the rise in profitability [SZYMANSKI, D. M. et al. 1993].[4]

- Shepherd [1972] also found a positive and significant link between market share and profitability, but the relationship among companies in the service sector appeared to be stronger than among those in the production sphere. He pointed out

[3] For more about 'nondurable goods', see for example: http://www.census.gov/epcd/naics02/def/NDEF424.HTM.

[4] The authors examined 28 other studies on the relationship between market share and profitability, but they did not include the extent of the effect [SZYMANSKI, D. M. et al. 1993].

the variability of the connection between market share and profitability, dividing the period under survey into parts. More profitable companies lost some of their market share later [Shepherd, W. G. 1972].

- Nickell et al. [1992] believe that productivity growth is usually stronger in the case of companies with a large market share [Nickell, S. J. et al. 1992]. Nickell later [1996] adds that this growth effect is a cross-sectional result; therefore, it is not free from the problem that, in the long run, companies producing a relatively high rise in productivity usually grow faster and gain a larger market share. Thus, it cannot be regarded as an original competition effect [Nickell, S. J. 1996].
- HAY and LIU [1997] say that the shifts of market shares are connected with the levels of efficiency, the price flexibility of demand and the company management, as well as with the number of companies on the market. If the competitor uses similar prices, the equation applied by the authors suggests that the market share of a company is in direct proportion to its relative costs; furthermore, the share of the players on the market decreases if the number of companies goes up. The shifts of market shares, or in other words, the reallocation effect, is less marked if the number of companies was originally high. It can also be concluded from the equation that, if the price flexibility increases or competitors' reaction regresses, efficient companies gain market share at the expense of the less efficient ones [HAY, D. A. – LIU, G. S. 1997].
- HALPERN and KŐRÖSI [2001] examined the relationship between efficiency and market share in the Hungarian corporate sector over the period 1990–1998. In their study, in order to measure concentration, they used the reciprocal of the number of companies operating in the classes [HALPERN, L. – KŐRÖSI, G. 2001]. In the period we examined, the concentration rate derived from the number of companies can mainly be connected with the HHI index. If we make the calculations concerning groups and classes (less aggregate data), the relationships between the indicators slightly weaken.

We would like to add to the above facts that – as supply chain management is emerging – it is not only the 'market share' that is interesting for a logistics service provider. Being embedded in the chain, the degree of dominance or the offer of supplementary value added services (postponement, vendor managed inventory (VMI), etc.) might have the same importance. Measuring supply-chain-wide efficiency will definitely be the great challenge of the next five to ten years.

2.2. The basic model of our calculations

Besides the concentration rate, the price–cost margin is one of the most frequently used index numbers for measuring the intensity of competition. In the model of economic theory describing a perfectly competing market, none of the players depart from the market price, which will be equal to the marginal cost in the long run. In a monopoly, it is only the demand that can limit the trend of prices; therefore, the less elastic the demand for a product, the bigger the market power and the price–cost margin of the company in a monopolistic position.

COLLINS and PRESTON [1966] explain the differences in the price–cost margins (PCM) of industries with the following model:

$$Y_{tu} = \alpha + \beta_1 \, CR4_{tu} + \beta_2 \, CR4_{tu}^2 + \beta_3 \, IGEOD_{tu} + \beta_4 \, K\_S\_R_{t0} + \beta_5 \, G_{tu/t0}$$

Y_{tu} = price–cost margin (PCM) in the last year of the examined period.

$CR4_{tu}$ = concentration rate calculated on the four largest companies of the class in the last year of the examined period.

$IGEOD_{tu}$ = index of geographical dispersion.

$K\_S\_R_{t0}$ = value of total assets output in the first year of the examined period.

$G_{tu/t0}$ = percentage change in the output of classes over the examined period.

The price–cost margin (PCM) was defined in two different ways. When calculating the numerator of PCM1, staff costs and material costs are deducted from the periodic output corrected with the variation in stocks; in the case of PCM2, besides material costs, material-type expenditures are also deducted. In both cases, the denominator is the periodic output corrected with the variation in stocks.

The index of geographical dispersion was calculated concerning the last year of the examined period as the sectoral sum of the absolute differences between the aggregated percentage of industry output on a regional level and the percentage of population in that region. The higher the geographical dispersion, the smaller the index[5].

In the value of total assets output ($K\_S\_R_{t0}$), the difference between the asset intensiveness of class output is taken into consideration. The quantity of assets (particularly the ratio of current assets and tangible assets, and intangible assets) can influence the trend of the price–cost margin differently.

3. The database examined

We worked with the data of 2001–2006, aggregated on class level, of companies having double-entry book-keeping, with respect to the classes operating in the Transportation, warehousing, post, telecommunications sector. We measured corporate performance using the average values, calculated in the class, of profitability indexes widely applied in foreign literature (ROE, ROA, ROS)[6] and the gross value added per capita[7] index.

[5] **ROE** = EBIT / [(Equity $_t$ + Equity $_{t-1}$) / 2], **EBIT** = Company's usual profit + Interests to be paid and other interest-type expenditures – Other interests received and interest-type revenues; **ROA** = EBIT / [(Total assets $_t$ + Total assets $_{t-1}$) / 2]; **ROS** = EBIT / Net sales revenues.

[6]

[7] With the balance of taxes on products and subsidies on products, the **gross value added** index shows the company's contribution to GDP.

In the *I Transportation, warehousing, post, telecommunications* economic sector[8] examined in our study, there were 13 746 companies having double-entry book-keeping, which is less than four (3.79) % of all the companies having double-entry book-keeping that filed a tax return in 2006. The companies in this sector employed more than two hundred and twenty thousand people (which is 9.89% of the people employed by companies having double-entry book-keeping that filed a tax return in 2006), and produced nearly seven per cent of net sales revenues (6.60%), while they generated almost twelve per cent (11.52%) of the gross value added.

From Table 2, we can establish that, following the Post, telecommunications division, the companies having double-entry book-keeping in the *Road cargo transportation* class belonging to the Ground pipeline transportation division produced nearly fifteen per cent of the sector's contribution to GDP, while almost twenty per cent of the people working in the sector were employed here. In 2006, this class included the majority of micro and small enterprises[9] as well, as much as nearly ninety-seven per cent (96.5%) of such companies in all classes.

Table 2 Characteristic data of divisions in 2006

Division	Company	Assets (M HUF)	Full time employees	Gross value added (M HUF)
60 Ground pipeline transportation	8 126	2 176 412	131891	476 343
61 Water transportation	95	21 039	1193	4 193
62 Air transportation	89	91 708	2439	8 987
63 Supplementary activities for transportation, travel organizing	4 115	1 370 028	29744	202 657
64 Post, telecommunications	1 321	1 892 590	59376	632 111
Total:	**13 746**	**5 551 776**	**224643**	**1 324 291**

While, regarding the economic sector, according to the database available, the annual average growth in the number of companies was over thirteen per cent (13.34%), the gross value added only increased by 8.44% a year on average in the examined period.

[8] The study was made based on the classification of TEÁOR'03 (name of the previous classification system). From 2008, the European Union prescribes for all Member States the compulsory adoption of the new activity classification in statistical data collection and registrations. The documents of the Hungarian equivalent of NACE Rev 2, TEÁOR'08, are accessible on the homepage of KSH (Hungarian Central Statistical Office): http:///www.ksh.hu/ under Services/Classifications.

[9] In compliance with the specifications in Act XXXIV of 2004 on small and medium-sized enterprises and supporting their development.

In the Road cargo transportation class, the annual average growth in the number of companies of nearly fourteen per cent (13.96%) also appears in the rise in the gross value added (13.01%). It can also be pointed out that, while the number of employees fell by more than one per cent (1.31%) in the sector, in the Road cargo transportation class, it rose by nearly forty-four per cent (43.94%) between 2001 and 2006, which means an annual average increase of 7.56% in the examined period.

4. Empirical results of the investigation

In the course of the literature review, we explored the ways of demonstrating corporate competition. Based on the databases available, using the SPSS 15.0 for Windows program package, we carried out descriptive statistical calculations, comparing analyses of divisions and classes and comparing ratio analyses, as well as regression and variance analysis (ANOVA), in accordance with the mathematical methods used in the literature. Following the development of the basic model to be described, in addition to the compliance conditions of the regression analysis, the validity of the model in use was checked, too.

Similarly to the sample of COLLINS and PRESTON [1966], the values of the parameters received indicate a negative relation among concentration, the value of total assets output and the price–cost margin; moreover, the release growth of the classes shows a significant relation with the price–cost margin.

The parameters received on the basis of the model run on the 2001–2006 class data of companies in the **I** *Transportation, warehousing, post, telecommunications sector*, if $R^2 = 66.8\%$,[10] are as follows (see Table 3).

Table 3. Testing the initial model with Hungarian data

Coefficients [a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	,338	,047		7,156	,000
	CR4t6	-,009	,002	-1,350	-4,597	,000
	NNCR4t6	5,09E-005	,000	,916	3,159	,002
	IGEODtu	,006	,000	,834	13,600	,000
	K_S_Rt0	-,013	,008	-,125	-1,549	,124
	Gtut0	,000	,000	,542	6,509	,000

a. Dependent Variable: PCM106

In this form, the model with explanatory power of about 70% does not meet the requirements of regression analysis perfectly. The concentration rate ($CR4_{t6}$) and its

[10] The unbiased estimator of the explained proportion of the statistical population.

square indicate a rather strong correlation (r = 0.977) and, looking at Table 3, we find that the value of total assets output ($K\_S\_R_{t0}$) is not significant.

During the further development of the model, considering the models of COLLINS and PRESTON [1969], ORNSTEIN [1975] and DOMOWITZ et al. [1986], by omitting the square of the concentration rate ($NNCR4_{t6}$) from the basic model and replacing the dependent variable with the price–cost margins of the specific business years, we obtained the following regression equation:

$$Y_{ti} = \alpha + \beta_1 CR4_{t6} + \beta_2 IGEOD_{tu} + \beta_3 K\_S\_R_{t0} + \beta_4 G_{tu/t0}$$

Y_{ti} = price–cost margin (PCM1) in class *i* in year *t*.

$CR4_{t6}$ = concentration rate calculated on the four largest companies of the class in the last year of the examined period.

$IGEOD_{tu}$ = index of geographical dispersion.

$K\_S\_R_{t0}$ = the value of total assets output in the first year of the examined period.

$G_{tu/t0}$ = percentage change in output of classes over the examined period.

The explanatory power of the model slightly fell (R^2 = 62.6%), but its reliability improved remarkably. The standard error of the estimation is rather low, which indicates that the model can estimate quite well. The significance of the F-test also verifies the existence of the relation, and in the t-test, on the basis of the significance of the variables determining the slope, the explanatory variables really influence the value of the dependent variable (see Table 4).

Table 4. Parameters of the developed model

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	,337	,043		7,924	,000
	CR4t6	-,003	,000	-,517	-7,945	,000
	IGEODtu	,005	,000	,702	11,651	,000
	K_S_Rt0	-,022	,008	-,218	-2,610	,010
	Gtut0	,000	,000	,683	8,062	,000

a. Dependent Variable: PCM1

According to the beta values, the price–cost margin is the most strongly influenced by geographical dispersion ($IGEOD_{tu}$) and the percentage change in class output ($G_{tu/t0}$). Similarly to the model of COLLINS and PRESTON [1966], concentration ($CR4_{t6}$)

shows a negative relation to price–cost margin and to the value of total assets output ($K\_S\_R_{t0}$) as well.

Applying the concentration rate of the eight largest companies instead of the concentration rate calculated on the four largest companies ($CR4_{t6}$) as an explanatory variable, the explanatory power (R^2) of the model is 62.1%.

In the course of regression analysis, the compliance of the model can only be declared after checking the fulfilment of numerous conditions: a) there are no correlation coefficients of high value among the explanatory variables and the 'tolerance' indexes are also favourable, so there is no multicollinearity either; b) residual variance seems constant, too, and the residuals have a normal distribution according to the histogram, which is confirmed by the Kolmogorov–Smirnov (K–S) one-sample test.[11]

In his model, ORNSTEIN [1975] used the price–cost margin to measure profitability, supposing that the ratio of the assets output has a bigger influence on the price–cost margins of industry sectors than concentration. In the 'logistics' economic sector we examined, according to the Hungarian company database, this statement is not verifiable because, in our model, the beta value of assets output ($K\_S\_R_{t0}$) is smaller than the concentration rate ($CR4_{t6}$).

The explanatory power of the model can be further increased if the labour productivity of classes is also involved in the independent variables (R^2 = 65.9%) (see Table 5).

Table 5. Summarising table of the model supplemented with productivity index

Model Summary

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	,821[a]	,674	,659	,11525	,674	44,299	5	107	,000

a. Predictors: (Constant), VTK_M1, CR4t6, IGEODtu, K_S_Rt0, Gtut0

In classes where the intensity of competition rose in the first half of the examined period (PCM1 fell), the profitability indexes and labour productivity are *significantly* lower than in classes where the intensity of competition lessened.[12] In the second half of the examined period (2004–2006), we obtained similar results, but the differences are not significant any more.

If we investigate the performance of companies as a function of concentration, we obtain *significantly* higher values of both average profitability and labour productivity of companies in classes with higher concentration (CR4>70%).

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[11] The calculations were made by the SPSS 15.0 program package.

[12] For lack of normality of the analysed variables, besides variance analysis and a t-test, we made the calculations with non-parametric tests, too.

We can also state that, in classes showing a decreasing price–cost margin, both profitability indicators and labour productivity are lower than in classes with an increasing margin. Dividing the examined period into two parts, years 2001–2003 and 2004–2006, in classes showing *increasing competition*, the average profitability (ROA, ROE) is significantly lower than in less competing ones in the first half of the examined period. In classes with higher concentration (over 70%), *bigger values* of profitability can be detected than in less concentrated ones.

In the second half of the examined period (2004–2006), however, in classes with lower concentration and increasing competition, the average profitability (ROA, ROS) is higher, whereas in classes with higher concentration (over 70%) and decreasing competition, these values are higher. Consequently, in the whole period examined, in *highly concentrated classes, the relation between price–cost margin and profitability indicators* is much stronger.[13]

There is a positive, significant relationship between labour productivity, profitability indicators and the price–cost margin of company data, too, within the examined period. Dividing the price–cost margin into quartiles, based on ROA and ROE indicators, the profitability of companies in the lower quartile is smaller than in the upper quartile (see Figure 1).

[13] In which classes did competition increase or decrease between **2001** and **2003**?:
Increasing competition (decreasing price–cost margin) *On class level*
60.10 Railway transportation, 60.22 Taxi passenger transportation, 62.20 Non-scheduled air transportation, 63.12 Storage, warehousing, 63.30 Travel organizing
Decreasing competition (increasing price–cost margin) *On class level*
60.23 Other ground passenger transportation, 61.20 Inland water transportation, 62.10 Scheduled air transportation, 63.21 Other support activities for ground transportation, 63.22 Other support activities for water transportation, 64.11 National postal activities, 64.12 Courier mail activities, 64.20 Telecommunications
In which classes did competition increase or decrease between **2004** and **2006**?:
Increasing competition (decreasing price–cost margin) *On class level*
61.20 Inland water transportation, 63.12 Storage, warehousing, 63.40 Forwarding, 64.11 National postal activities, 64.12 Courier mail activities
Decreasing competition (increasing price–cost margin) *On class level*
60.10 Railway transportation, 63.22 Other support activities for water transportation

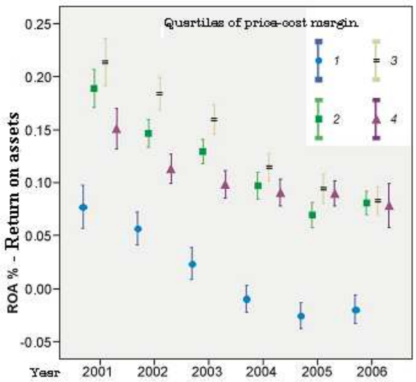

Figure 1. Profitability indicators in the quartiles of price-cost margin

While the profitability indicators (ROA, ROE) decline in the quartiles of the price–cost margin, labour productivity rises. In higher price–cost margin (PCM) quartiles, the average value of labour productivity is higher. A *significant difference* can be seen between the values of individual quartiles. In the examined period, indicators increase in every quartile year by year, which, with some exceptions, indicate a *significant difference* even between individual years and quartiles.

Looking at the tendency of labour productivity and profitability, we can state that the profitability of companies able to enhance labour productivity in each year of the examined period also increased, whereas the profitability of companies with decreasing labour productivity decreased. A *significant difference* can be observed between return on sales and return on equity (ROS, ROE) as well.

We can point out increasing labour productivity among companies showing rising profitability (ROA, ROE, ROS); the labour productivity of companies showing decreasing profitability, however, decreases in a strictly monotone manner. Between the two categories of companies, a *significant difference* can be noticed in the trend of labour productivity.

As far as the market share of companies is concerned, it can be laid down as a fact that *an increase in market share resulted in profitability growth* in the examined period. While the profitability of market-losing companies decreased steadily, the profitability of market-gaining ones rose dynamically. A *significant difference* can be calculated between the profitability of the companies classified into the two categories.

5. Conclusions

Companies increasing their market share were able to raise their labour productivity, whereas the indicators of 'market losers' began to fall. While this drop was not significant for the 'losers' in the years of 2001–2003, the tests showed a *significant difference* in the case of market gainers. We can also conclude from the results of the calculations that the average labour productivity of companies increasing their market share exceed the labour productivity of market share losers by the end of both the first and the second halves of the examined period. This rather refers to the fact that *an increase in market share leads to the enhancement of productivity. (Market share, however, can be increased much less by enhancing productivity!)*

This statement is also reinforced by the results obtained from the investigation into labour productivity and corporate market share. The market share of companies showing decreasing labour productivity in the examined period decreased, too, but companies able to enhance their productivity could not increase their market share significantly, either. The results of the separate analysis of the first and second parts of the examined period *provide further support to the above.*

The calculations in connection with profitability have similar results. The market share of companies with decreasing profitability fell significantly, while not even a slight increase in the market share of companies with growing profitability can be detected in the case of every indicator.

Looking at the above results, we can imagine that these will be somewhat surprising for company strategy makers. Nevertheless, these are only Hungarian data. We are aware of the need for international comparison, which we intend to execute in the following period.

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Appendix 1

Supplement to table 1

I Transportation, warehousing, post, telecommunications section includes 5 divisions and 20 classes.

Divisions TEÁOR'03 (two digits):

60 GROUND, PIPELINE TRANSPORTATION

61 WATER TRANSPORTATION

62 AIR TRANSPORTATION

63 SUPPLEMENTARY ACTIVITIES FOR TRANSPORTATION, TRAVEL ORGANIZING

64 POST, TELECOMMUNICATIONS

Classes TEÁOR'03 (four digits):

60.10 Rail transportation

60.21 Other scheduled ground passenger transportation

60.22 Taxi passenger transportation

60.23 Other ground passenger transportation

60.24 Road cargo transportation

60.30 Pipeline transportation

61.10 Sea transportation

61.20 Inland water transportation

62.10 Scheduled air transportation

62.20 Non-scheduled air transportation

63.11 Cargo handling

63.12 Storage, warehousing

63.21 Other support activities for ground transportation

63.22 Other support activities for water transportation

63.23 Other support activities for air transportation

63.30 Travel organizing

63.40 Forwarding

64.11 National postal activities

64.12 Courier mail activities

64.20 Telecommunications

Taking all divisions into consideration table 1 is modified as follows (in decreasing order of CR4):

	Class	A	B	CR4 (%)	CR8 (%)	MCR 8 (%)	HHIT4	C
6030	Pipeline transportation	1.83%	4	100	100	.	9 998	0.25000
6411	National postal activities	4.30%	1	100	100	.	10 000	1
6210	Scheduled air transportation	3.35%	12	99.09	99.97	0.88	8 273	0.08333
6010	Rail transportation	8.55%	17	97.95	99.49	1.55	4 309	0.05882
6323	Other support activities for air transportation	1.59%	32	96.79	98.27	1.49	4 337	0.03125
6110	Sea transportation	0.02%	8	93.86	100	6.14	2 869	0.12500
6220	Non-scheduled air transportation	0.69%	55	87.18	94.93	7.74	3 695	0.01818
6420	Telecommunications	29.32%	650	71.58	82.88	11.3	2 027	0.00154
6412	Courier mail activities	1.07%	371	69.86	75.21	5.35	1 891	0.00270
6120	Inland water transportation	0.38%	71	67.46	81.54	14.08	1 300	0.01408
6322	Other support activities for water transportation	0.05%	39	61.68	80	18.32	1 201	0.02564
6321	Other support activities for ground transportation	0.91%	190	59.38	71.08	11.69	980	0.00526
6312	Storage, warehousing	2.97%	329	48.01	58.54	10.53	1 168	0.00304
6021	Other scheduled ground passenger transportation	5.52%	97	46.48	61.8	15.33	1 073	0.01031
6022	Taxi passenger transportation	0.12%	288	44.61	62.28	17.66	733	0.00347
6311	Cargo handling	0.50%	115	29.34	46.65	17.32	393	0.00870
6330	Travel organizing	5.56%	1076	20.25	31.38	11.13	180	0.00093
6023	Other ground passenger transportation	0.75%	595	17.32	24.96	7.64	176	0.00168
6340	Forwarding	14.19%	1436	14.07	23.33	9.26	116	0.00070
6024	Road cargo transportation	18.33%	5885	11.87	16.14	4.26	68	0.00017

A - Breakdown of turnover

B - Number of companies

C - Hconc* (1/number of companies)

Cooperation between Economically Independent Companies that form a Business Concern

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Abstract: During the examination of a Hungarian manufacturing company operational defects had been detected, which mainly originated from the incorrect structure of the corporation. This article deals with the analysis of the relations between divisions; its aim is to define the benefits and the drawbacks of structural features to achieve an optimal cooperation model. A special sub-type of division cooperation, problem and solution is demonstrated through the waste material handling processes of a Hungarian manufacturing company. In the article a cooperation regulation is also described, which is how the process protocol should operate between divisions. The formation of a business cooperation between independent companies belonging to a business concern is the result of the fact that not all of these separate companies can fulfil customer orders 100%, because of the lack of resources, technology or know-how. In such cases these companies have to work in cooperation to provide such circumstances that their production can run with full capacity. Constant production with maximum capacity is the essential interest of each company. If these elementary principles are not present the company divisions obstruct each other. To detect the exact problems, and the solutions first the features of the basic structure types are demonstrated.

Keywords: Cooperation companies, business concern

1. Structure of business concerns

Business concerns can have a standard and holding structure. The former means that the divisions of the business concern don't make independent economic decisions (functional organizational structure). In the case of the latter divisions are connected only by the owner, they function as independent legal entities, making independent economic decisions (divisional organizational structure). (Table 1.)

Table 1. Types of Organizations – legal structure

Type of Organization – legal structure	***Explanation***
Functional organizational structure	*Divisions of the business concern are not economically independent; decisions are exclusively made by an economic company.*
Divisional organizational structure	*Divisions have independent business, legal and economic separateness, while they have the same owner*

The centralized structure supports the ambitions of the business concern to achieve economical optimum. This type of structure needs a lot of organizational work and cooperative activity between divisions. The divisions don't produce goods independently; they don't have any final products that enter the market.

Table 2: Features and terms of application of the organizational models

	Model of the organizational structure	
	Functional	**Divisional**
Terms of application	- Homogeneous basic activity - Stable, not complex environment	- Diverse activity - Dynamic, complex environment.
Features of organizational model	- The basic activity is done by functional sub-systems - Strategic and operative decisions are made by the central management - The operation (tasks and competences) of the organization is regulated also at the lower levels - The structure of the specialized sub-systems can differ from each other.	- The basic activity is specified by product, customer or regional principles. - The central management makes the strategic decisions, the leaders of the divisions make the operative decisions. - The operation of the divisions is regulated. - The inner structure of the divisions can differ from each other, they are functionally specialized.

In the case where the business concern forms a holding structure, where low organizational work and cooperative activity is needed, and the divisions manufacture their own final products, the problem is that the members of the business concern aim to optimize their own operation, which probably doesn't result in a global optimum.

The features of the types of organizations are illustrated in table 2.

2. Examination of the organizational structure of a Specific Business Concern

During the research the manufacturing activity of a business concern was examined in detail. This company was built up in a holding-like, mixed structure (figure 1). In a mixed structure the divisions operate independently from each other, trying to reach a local optimum, but there are still some functions of the business concern, that are provided by one division, such as finance, controlling, logistics or informatics.

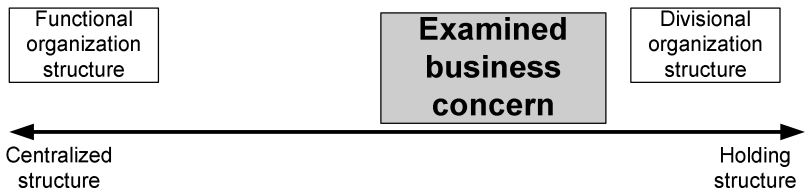

Figure 1. Position of the mixed structure

In the case of this business concern the cooperation procedures between divisions are strictly regulated, which conflicts with the holding-like organizational structure, since these regulations obstruct the separateness of certain divisions.

Research has been made at this company to find out how to change the regulated cooperation obligations to be advantageous. To achieve this, two possibilities exist; either we change the company structure and abolish profit centres or we can modify cooperation regulations, so that it would fit to outer market mechanisms.

2.1. Problems with present cooperation protocol

The cooperative regulations effect the divisions unequally, since the regulations are not based on the principles of the market, so in many cases only one of the parties get the advantage. The demands of the other party can only be fulfilled if all cooperation parameters are present.

The two parameters of the cooperation are quality and cost; within quality product and service quality can be distinguished. Product quality depends on the place of origin, specifically which division produced it. Service quality ensures the delivery deadlines and the terms of delivery. These parameters are determined by the availability of the human resources and machinery capacity.

The machine hour of manufacturing equipment is not as flexible as the labour hour since only human resources can be transferred between divisions – this is true in the case of this specific examined company, where resources mean heavy and extensive machinery, not hand tools.

If capacity is not available at one particular division, the cooperative skill is low. If there isn't any available machinery, the division has an opportunity to rent machinery from the other division and have its own operators use it. This flexibility can be achieved only with internal cooperation. In the examined company the lack of machinery capacity is the result of technical failure, or the aftermath of the fact that manufacturing equipment has been sold in the outer market.

When one division is obliged to cooperate under such circumstances, this compulsory cooperation may conflict with the business strategy of the partner division.

2.2. Optimal cooperative structure

During the research a new cooperative regulation for the examined company was determined. Since the holding structure seems to operate sufficiently, only the cooperative regulation should be modified, so that the outer competitive effects could influence decisions, besides the inner cooperation would have the priority. The protocol of the suggested cooperation process modification is illustrated in figure 3.

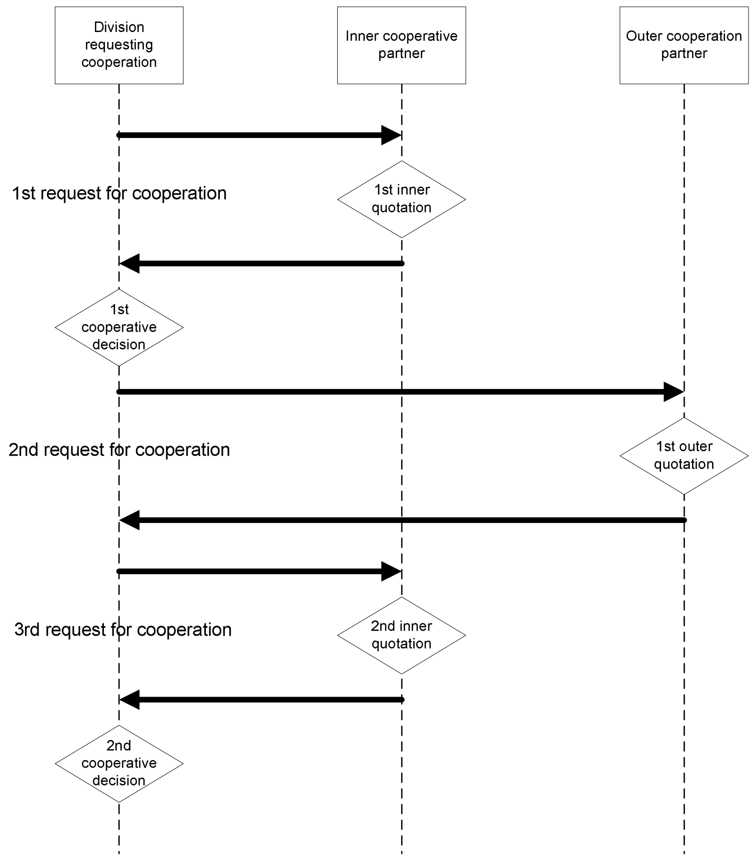

Figure 2. Cooperative protocol

The new cooperation regulation provides a priority for inner cooperation under competitive circumstances. The regulation consists of three steps:

1. Compulsory quotation request from the partner division, if capacity cannot fulfil customer needs.
2. If any point of the inner cooperation quotation is not adequate, the division has to request for an outer quotation.
3. The division has to inform the partner division about the received outer quotation, so that it can modify its previous quotation. The division chooses from the outer and the modified inner quotation.

The cooperative process is described in figure 3.

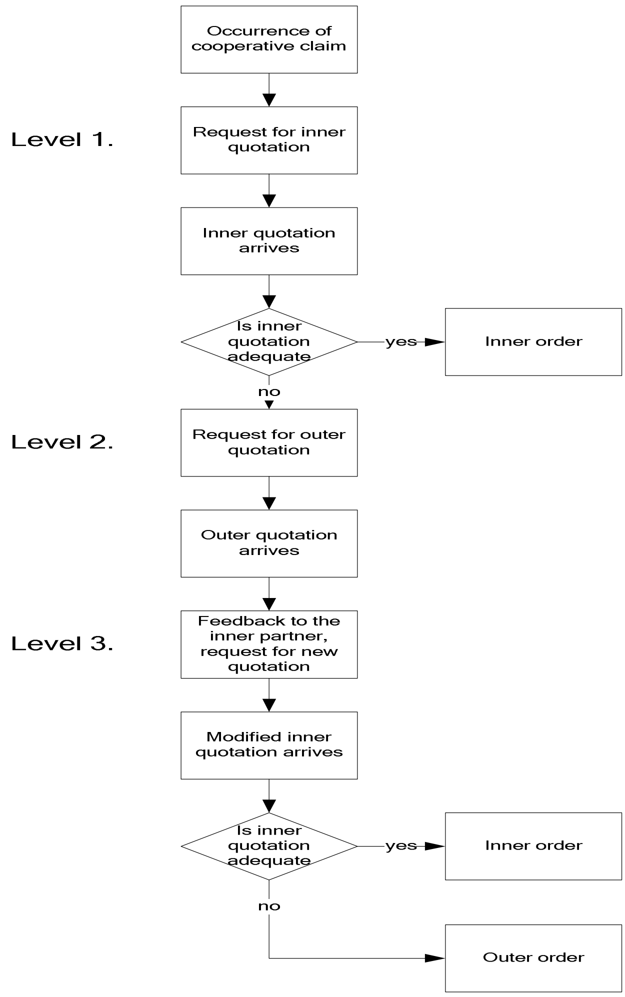

Figure 3. Modified cooperative procedure

With the modified cooperative regulation, the business processes become more traceable, they follow the principles of the outer market, and the benchmarking function appears. The regulation provides advantages for the inner partner, as the cooperation is not obligatory, the partner division does not have to allocate usable resources for less profitable inner cooperation.

3. Waste material handling

During the course of the examination of cooperative problems in this specific industrial corporation, a special element of the cooperation protocol emerged, the problem of waste material. In this case waste material has the same quality as raw material, but it is smaller than standard size raw material - it is produced during the cutting of raw material plates. Because of the features of this technology the production time of waste material reuse process is longer.

At many industrial corporations waste material may be used up during latter phases of production. The examined company applied strict regulations on how to handle waste material in cooperation, as indicated in figure 4.

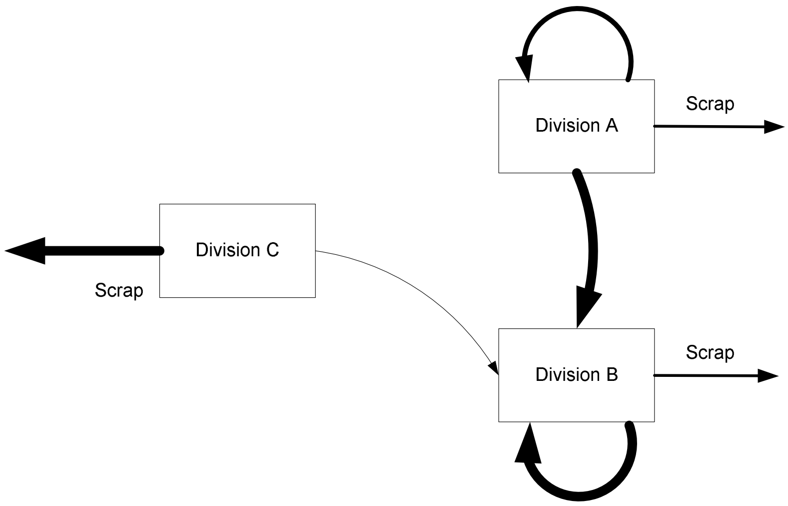

Figure 4. Waste material flow between divisions

Division C is a commercial division, which is suppose to keep contact with the outer market. Division A and Division B are manufacturing divisions, but Division A produces only with automatic machinery. The width of arrows symbolizes the intensity of the waste material flow.

The problem of waste material is a remarkably adequate example to examine the effects of company structure. The waste material flow in this holding like company structure is relatively low, because in the case of this company the divisions are not interested in the reuse of waste material. That is because of the technical features, namely reuse needs more labour hours than normal production, since automatic machines are calibrated to handle standard-size raw material. Regulation has to be applied to make the company's global interests prevail. The benefits of reuse would be global because waste material doesn’t mean extra cost for the company, since its cost price has been calculated as a loss during production, and has been added to the purchase price of the final goods.

At the company the waste material is registered at a defined price, which is in proportional size to the raw material, and not at a discount price. This way the partner divisions, and also the outer market are not interested in the reuse of waste material, unless it’s registered less than the raw material cost price and reduced by an extra production/handling cost.

To solve the conflict, the company should introduce a strict regulation of cooperation between the divisions, so that the waste material would be available for partner divisions at a reduced price. Besides financial regulation, the priority of markets was determined, so that the waste material is reused in the most cost effective way. The priority of waste material markets is shown in figure 5.

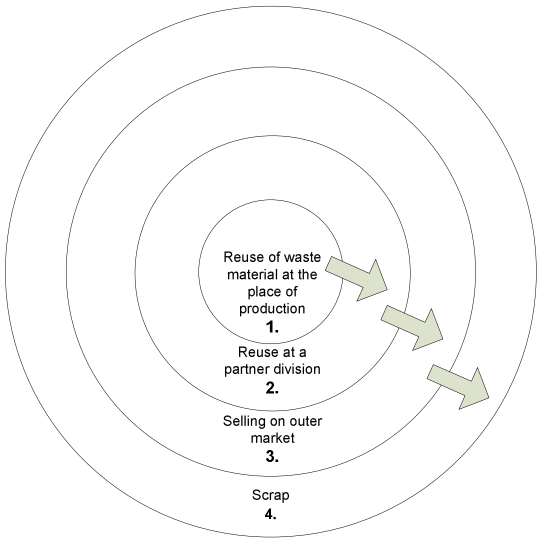

Figure 5. Priority of waste material markets

The waste material flow between divisions would change if the company ensured the priority principles described above. The connection between divisions would be tighter and only one market would need to sell to the outer market (figure 6.).

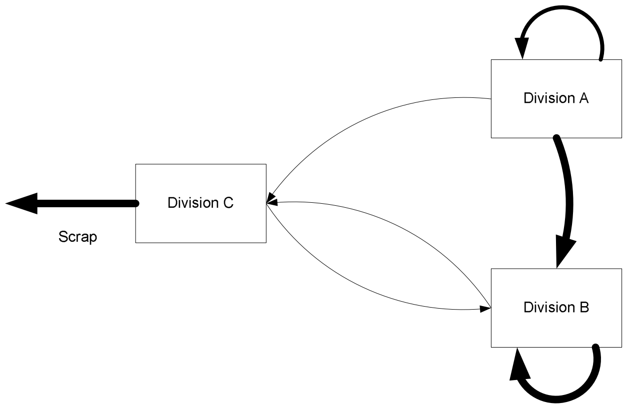

Figure 6. Optimal material flow between divisions

The divisions should be categorized into two categories: commercial and production divisions. The commercial divisions have to purchase the waste material that is not reusable for the production divisions, and sell it on the outer market, so that the business strategy of the concern is not disturbed. If the waste material is not marketable, it should be depreciated. The handling protocol of the waste material is described in figure 7.

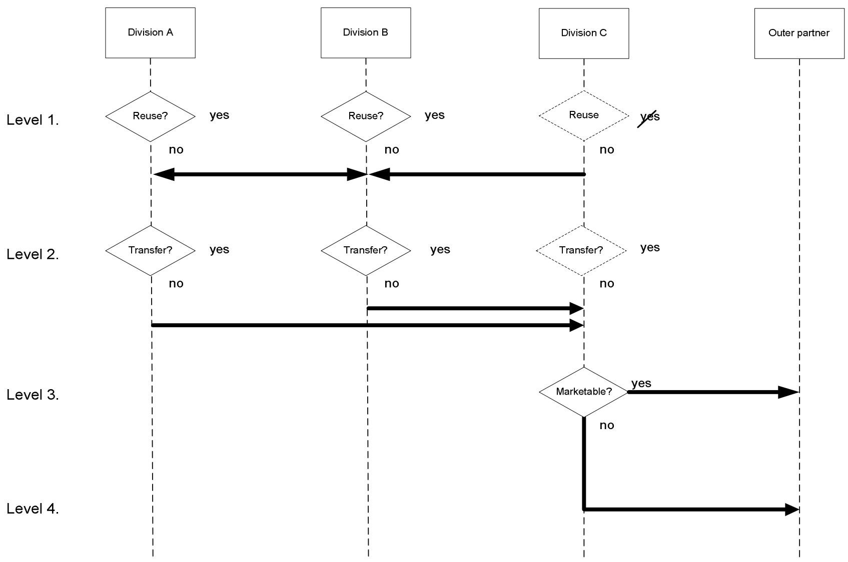

Figure 7. Handling protocol of waste material

Level 1: Waste material is reused in the division, which is significant in the production divisions. If reuse is not beneficial, the division has to offer it to the other production divisions.

Level 2: Waste material is transferred between production divisions. Those that are not reused by production divisions are transferred to the commercial divisions.

Level 3: Waste material is sold by the commercial division on the outer market.

Level 4: Waste material is depreciated as scrap; if this level is reached there is no profit for the corporation.

The upper protocol would provide maximum profit from waste material.

4. Steps of implementation of cooperation regulation

The modified cooperative regulation can only be competitive if it handles incoming customer claims within a reasonable time. To provide short processing time the IT system has to be improved. A web page should be created, where a division can register its cooperative claim for the partner division online. The partner division would have to answer the quotation request in a predefined response time. The request for the quotation should be forwarded to the outer partners using suitable telematics equipment. It also would be easy to get the overall picture of the current market situation, by using the reporting tools of the system.

The structure of the system is indicated in figure 8.

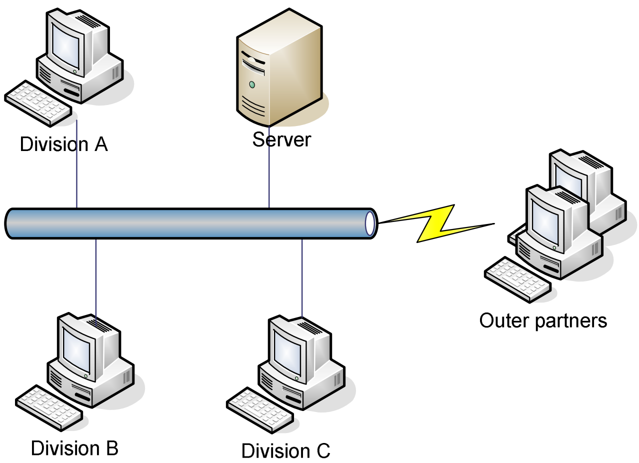

Figure 8. Telematics support of the cooperative process

Because of the structure of the examined company the information contact with the outer market should be the task of one specific commercial division. To provide the dynamism of the system, the waste material flow has to be transported between levels at an adequate pace. In this case the logistics costs can be minimized since the waste material is transported from its place of origin, just before it can be reused at the next level.

During the planning and the development of the structure of the business concerns, the future basic processes are influenced. Waste material handling and flow is only one process, which is basically determined by the cooperative structure of the company. Each structure has its own benefit, but in many cases- as in the example above- a hybrid solution is needed to achieve optimal operation and maximum profit.

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The Rolling-Mill Rolls Manufacturing Between the Logistics Processes and the Quality Assurance

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Abstract: Quality assurance is the activity of providing evidence needed to establish quality in work, and that activities that require good quality are being performed effectively. All those planned or systematic actions are necessary to provide enough confidence that a product or service will satisfy the given requirements of quality. Quality assurance covers all activities from design, development, production, installation, servicing and documentation. It includes the regulation of the quality of raw materials; assemblies; products and components; services related to production, and management; production; and inspection processes. Our proposal approaches the issue of quality assurance of the rolling mills rolls, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation. The experimented durability research, as well as the optimization of the manufacturing technology, allows for the conclusion of direct results on the rolls. The beneficiaries of these results are the unit in which the rolls are manufactured, as well as the unit that exploits them. The technological manufacturing process of the rolling mills rolls, as well as the quality of material used in manufacturing them, can have a different influence upon the quality and the safety in the exploitation.

Keywords: quality assurance, cast-iron rolls, manufacturing, laboratory research, mathematical modelling

1. Introduction

Engineering Management is a term that is used to describe a specialized form of management that is required to successfully lead engineering personnel and projects. The term can be used to describe either functional management or project management-leading technical professionals who are working in the fields of product development, manufacturing, construction, design engineering, industrial engineering, technology, production, or any other field that employs personnel who perform an engineering function.

Statistical Process Control is an effective method of monitoring a process through the use of control charts. This enables the use of objective criteria for distinguishing background variation from significant events based on statistical techniques. Much of its power lies in the ability to monitor both the process centre and its variation on that centre. By collecting data from samples at various points within the process, variations in the process that may affect the quality of the end product can be detected and corrected, thus reducing waste, as well as, the likelihood that problems will be passed on to the customer. With its emphasis on early detection and prevention of problems, the Statistical Process Control has a distinct advantage over quality methods, such as inspection, that apply resources to detecting and correcting problems in the end product or service.

In engineering and manufacturing, quality control and quality engineering are involved in developing systems to ensure products or services are designed and produced to meet or exceed customer requirements. These systems are often developed in conjunction with other business and engineering disciplines using a cross-functional approach.

Quality assurance covers all activities from design, development, production, installation, servicing and documentation. It includes the regulation of the quality of raw materials, assemblies, products and components, services related to production (see figure 1) and inspection processes (see figure 2).

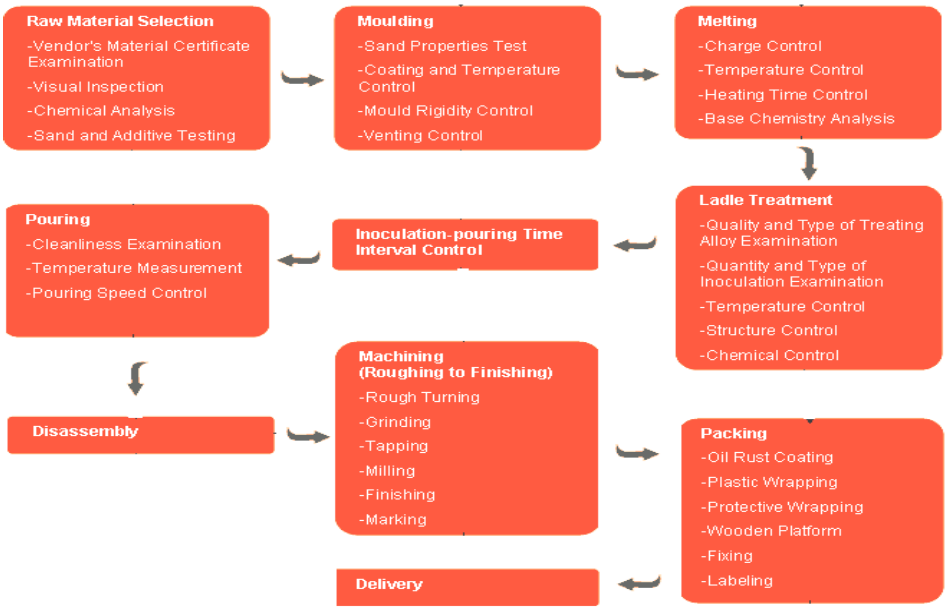

Figure 1. The production processes

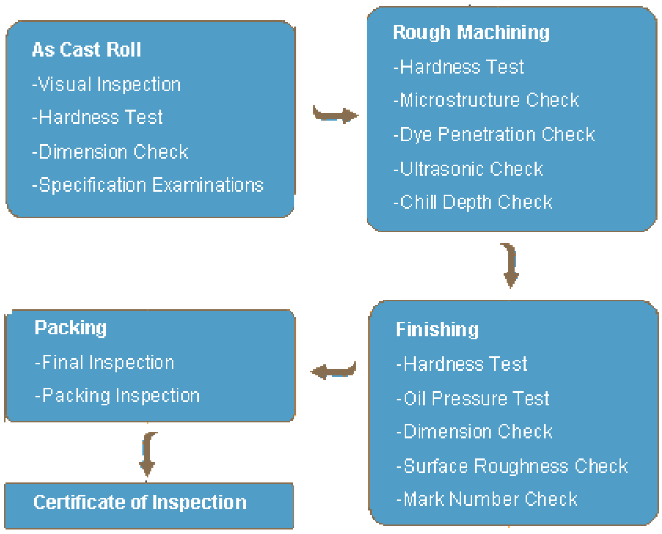

Figure 2. The inspection processes

Engineering Management is a term that is used to describe a specialized form of management that is required to successfully lead engineering personnel and projects. The term can be used to describe either functional management or project management - leading technical professionals who are working in the fields of product development, manufacturing, construction, design engineering, industrial engineering, technology, production, or any other field that employs personnel who perform an engineering function.

Production logistics is the term used for describing logistic processes within an industry. Also, the purpose of production logistics is to ensure that each equipment and technologies is being fed with the right product in the right quantity and quality at the right point in time.

What materials, products, or information come into the activity? What materials, products, or information flow out of the activity? Quality engineers use the DMAIC model (define, measure, analyze, improve, and control) to document processes before beginning process improvement. If processes are documented, another series of logical questions apply: Are the processes being followed? Are they within acceptable control and performance parameters? Are they outdated? Can they be improved? Those are the questions, which determine the correlations between the logistics process and the quality assurance.

2. Logistics concepts and quality assurance in the roll industry

The manufacture of rolls is continuously being perfected, the requirements for superior quality rolls are not yet completely satisfied, in many cases, the absence of quality rolls preventing the realization of quality laminates or the realization of productivities of which rolling mills are capable.

The application of logistics concepts in terms of procurement is called procurement logistics (see figure 3). It covers all activities that provide a manufacturer with raw materials, tools and operational supplies, as well as with purchase and replacement parts. In the past, the necessary materials were primarily obtained from local sources. Today, the companies can readily obtain them around the world thanks to global networks and the Internet. This has an impact on logistics as well.

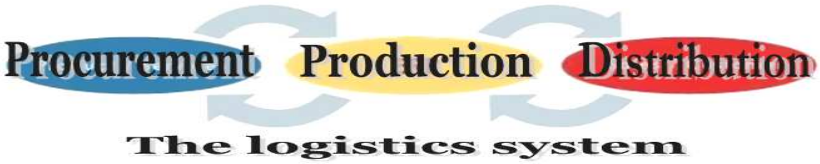

Figure 3. The logistics system of industrial companies

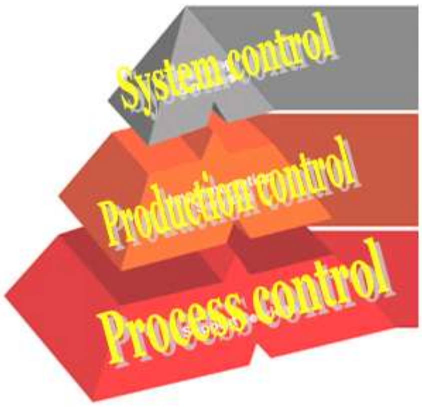

Figure 4. Logistic processes

Production logistics is an important component of logistics systems in production companies (see figure 4). This form of logistics covers planning, management and monitoring of the material flow – from raw-material warehouses and various production stages to warehouses for finished goods. In the complete value cycle, production logistics follows procurement logistics and precedes distribution and reverse logistics. The technological manufacturing process of the rolling mills rolls, as well as the quality of material used in manufacturing them, can have a different influence upon the quality and the safety in the exploitation. Our proposal approaches the issue of quality assurance of the rolling mills rolls, from the viewpoint of the quality of materials, which feature can cause duration and safety in exploitation.

Figure 5. Quality assurance research fields

The quality assurance research fields can be defined through the general research area, by the different experiments effectuated in the laboratories, and also, with the modern calculation programs, optimization technologies and the better utilization of the manufacturing data (see figure 5).

Figure 6. Quality assurance in rolling industry

In the rolling industry, the quality of the product (of the rolls, in this case) is directly in accordance with the quality of technologies (defined by the casting equipments, materials, applied procedures, etc), and also, with the quality of the manufacturing process (charging, melting, ladle treatment, casting, cleaning, etc), which are presented in figure 6.

3. Quality of rolls assured by the modelling of manufacturing data

Industrial engineering is also operations management, systems engineering, production engineering, manufacturing engineering or manufacturing systems engineering. Whereas most engineering disciplines apply skills to very specific areas, industrial engineering is applied in virtually every industry. Industrial engineers typically use computer simulation, especially discrete event simulation, for system analysis and evaluation.

Operational Research is an interdisciplinary branch of applied mathematics and formal science that uses methods such as mathematical modelling, statistics, and algorithms to arrive at optimal or near optimal solutions to complex problems. It is typically concerned with optimizing the maxima (profit, assembly line performance, crop yield, bandwidth, etc) or minima (loss, risk, etc.) of some objective function. Operations research helps management achieve its goals using scientific methods. Systems simulation is a set of techniques for using computers to imitate, or simulate, the operations of various kinds of real-world facilities or processes. The computer is used to generate a numerical model of reality for the purposes of describing complex interaction among components of a system.

Starting from the principle of the modelling process used, as a necessary basic instrument, both in the phase of conception, as well as in the industrial technologies analysis, it is determined by the optimum regimes of the cast rolls, from the view from chemical composition, as one as the most important parameters of disturbance of the manufacturing process. The enunciation of some mathematically modelling results, described through a number of multi-component equations determined for spaces with 3 and 4 dimensions, as well as the generation of some regression surfaces, of some curves of levels, of the volumes of variation, of the lines of outlines of the volumes of variation of surfaces and the areas of variation of these, can be represented and interpreted by technologists and can be considered diagrams of correlation between the analyzed variables. From this point of view the project is inscribed in the context of scientific capitalization of the process and the industrial technologies optimizations. The quality assurance through the modelling phenomenon is presented in figure 7.

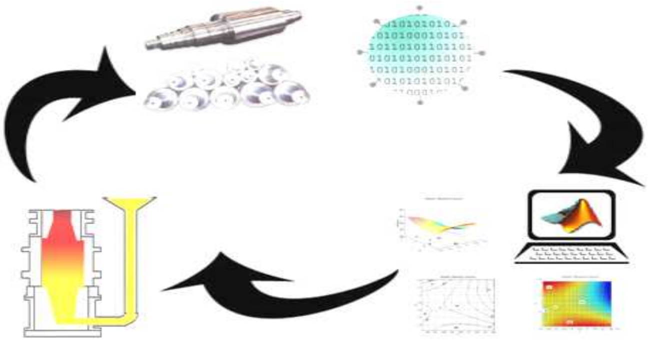

Figure 7. Quality assurance through the modelling phenomenon

The character of the metallurgical processes optimization is influenced by the complex peculiarities of these, which take place in a great number of variables (parameters) that operate independently or cumulatively.

For this reason, it is important to analyze the metallurgical processes used, mainly, the statistical fundamental methods that permit drawing conclusions, from the observed values, about the repartition of the frequencies of various parameters, about their interaction, about verification validity of certain premises, and about the research of the dependencies among different parameters. However, the statistical methods of the metallurgical process analyses do not solve a series of aspects regarding the mode of establishing decisions for the management of the process. Thereof, parallel with the statistical methods optimization methods were developed.

The optimization of any technological process has, as a base, a mathematical model. In order to find the best solution, which is the truth we need to find the relative truth, which is the definitive truth that includes implications and errors.

4. Quality of rolls assured by the laboratory experiments

The research of durability in the exploitation of cast from cast-iron rolls, constitute a scientific novelty, and experimentally define an important chapter from the thermal fatigue of the organs of machines in the movement of rotation, in variable temperature mediums. Hot rolling mills rolls work in the variable compound solicitations, due to the lamination process and which is repeated in regular intervals of time.

All these phenomena, which are more or less emphases depending on the type of rolling mills, are not taking into consideration in the classic calculus of rolls. If the study of the rolls resistance is extended to their durability, we must consider the whole complexity of tensions with mechano-thermic influences. The research on durability in the exploitation of hot rolling mills rolls assures relevant conditions for the appropriation of the research methods of the thermal regimes that submit the rolls or other organs of machines, that work in constant (symmetrical) or variable (asymmetrical) thermal solicitation conditions.

The recommendations for the increase of the duration of exploitation and removal of the damages through the accidental rupture of rolls from the stands of lamination, the attenuation of the rolls thermal fatigue, the avoiding of thermal shock and their rational exploitation are actual issues that must be continuously researched. In this trend is situated the research of the thermal fatigue phenomena, materialized in technical reports, whose beneficiary is the unit in which the rolls are exploited, as well as through scientific papers, that can develop the framework of scientific research. These researches results lead to direct conclusions about the cast-iron rolls, and permitted their comparison using the date of the steel rolls; an area studied thoroughly researched of specialists. The quality assurance through the laboratory experiment is presented in Figure 8.

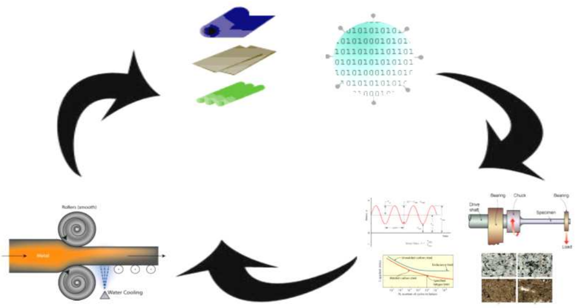

Figure 8. Quality assurance through the laboratory experiment

The work is of practical immediate utility, inscribing itself in the context of technical capitalization of the manufacturing technologies and of exploitation of cast-iron rolling mill rolls, for which exists an attentive preoccupation both from foundry sectors, as well as from lamination sectors. Thus having a determinate aim in the quality assurance and the increase in durability in exploitation.

5. Conclusion

The aim of the proposed research is to answer as many questions as possible regarding the quality of rolls. In this sense, durability in exploitation is extremely current, both for immediate practice, and for the scientific research attributed to cast-iron. Also, the realization of optimum chemical compositions of the cast-iron can constitute a technical efficient way to assure the exploitation properties, of the material from which the rolling mills rolls are manufactured.

In this sense, our research proposes, on one hand, to analyze the durability in industrial exploitation of rolling mills rolls – analysis materialized from the prism of the laboratory experiment (figure 8), and on another hand, the optimization of manufacturing technology of the cast rolls, especially those from cast-iron – using the electronic calculus technique as the modelling phenomenon (figure 7) and mathematical interpretation of the technological processes.

The research on durability in exploitation of hot rolling mills rolls assures relevant conditions for the appropriation of the research methods of the thermal regimes that submit the rolls or other organs of machines, that work in constant (symmetrical) or variable (asymmetrical) thermal solicitation conditions. Also, it can emphasize the thermal shock, a phenomenon that constitutes a permanent danger, which leads to rupture, specific to rolling mills rolls.

On another hand, the realization of an optimal chemical composition can constitute a technical efficient mode to assure the exploitation properties, of the material from which the rolling mills rolls are manufactured. From this point of view is applied the mathematical modelling, which is achieved starting from the differentiation on rolls component parts, taking into consideration the industrial data obtained from the hardness mensuration on rolls, as well as the national standards regulations, which recommends the hardness, for different chemical compositions.

Through the original aimed elements mentioned above, the suggested research allows for the enunciation of new approaches in the area internal to the theme.

Logistics activities are searching constantly for ways to improve process capabilities, shorten throughput times, improve quality, and cut costs. Many manufacturing and quality engineering books describe the specifics of defining process capabilities or optimally designing logistics systems. In many cases, the need for improvements may be obvious. In fact, to many private or public sector organizations, these improvements may be necessities.

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Multi-Agent based Algorithmization of Organizing Logistics

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Abstract: Traffic logistic systems have a structure often globally networked on several hierarchical levels. Their function is transporting materials and/or information within an area. From the cybernetic view the organization can be regarded both as the control of complex systems and as a communication process the nature of which is the transmission of information. Due to the spatially distributed structure of stationary and mobile traffic systems, multi-agent systems can be used for their organization. The organization algorithms are performed using the Petri net-based language BRIC. For this purpose target functions for the individual service systems are derived from the process reliability and further partial reliabilities are derived from it for modelling both the arriving and operating processes and the failure and repairing processes.

Keywords: Organization, Multi-agent systems, Reliability

1. Introduction

According to Baumann [1] traffic organization is defined as the science of

- organizing complex material flow systems and information systems in a geographical area;
- organizing networked operating systems for transporting both material objects and transmitting communications objects;
- organizing passenger/goods traffic as well as communication services, seen in the sense of service.

The task of traffic organization is the systematic design of an operating system at optimal costs for the material and information traffic products. For this purpose structures are required which permit a complex organization, i.e., there has to be a consideration of components, machines/devices, equipment (operational department) and sites (goods traffic centres) within the regional, country and global nets up to the orbital net in their appropriate layouts and hierarchies. In the following you will find an analytic procedure for modelling the organization of these complex structures.

2. Organization of logistic processes

2.1. System structure

For describing complex logistic systems the respective system is structured as a network. This network consists of a lot of elements - nodes and edges - that are interconnected. Within these elements a certain quantity of operations (processes, subprocesses) are implemented and via their links traffic flows (flows of similar traffic objects such as goods or letters) are carried at a certain current intensity. The elements of a network can be described as a cybernetic model. The basis is the technological system. In transportation this system implements one or more processes of treatment or transport of material or information, i.e., it transforms material, information and energy inputs into material or information outputs. A technological system is built up by coupling service and information systems. On the first level of the technological systems, the service systems Sy_L and control systems Sy_S are interconnected.

Figure 1 shows the block diagram for this purpose. The control system Sy_S integrates a program P for implementing the target function ZF. It performs the technological process concerned and is shown as the algorithm for the implementation of the target function P (ZF) → A (ZF). The target function ZF means that the input vector $\vec{x} = X$ (e.g., a random traffic object quantity X) is treated within a time Δt and with a reliability Z ≥ z. This reliability Z will be quantified later in more detail.

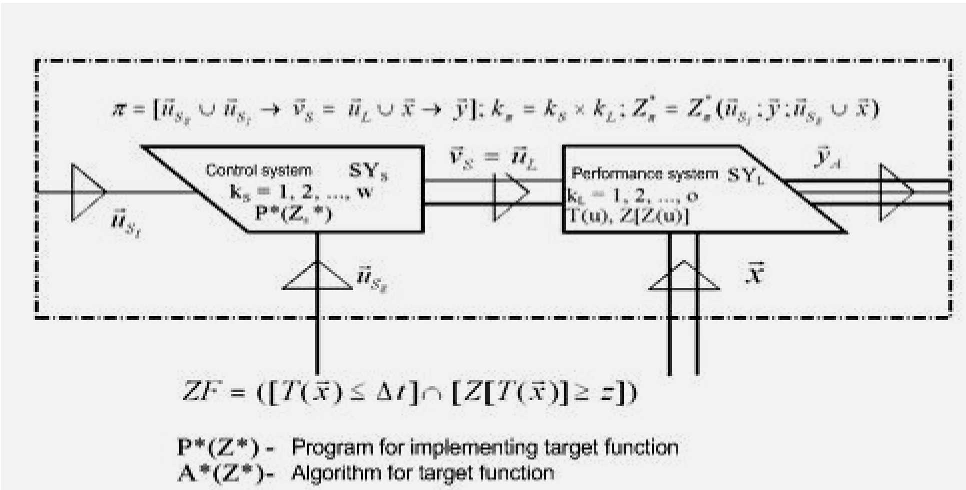

Figure 1. Technological system [3]

With the integration of guiding systems Sy_{Leit} as information systems of higher levels, hierarchical structures can be created, e.g., according to figure 2. Auxiliary processes such as maintenance can also be shown here.

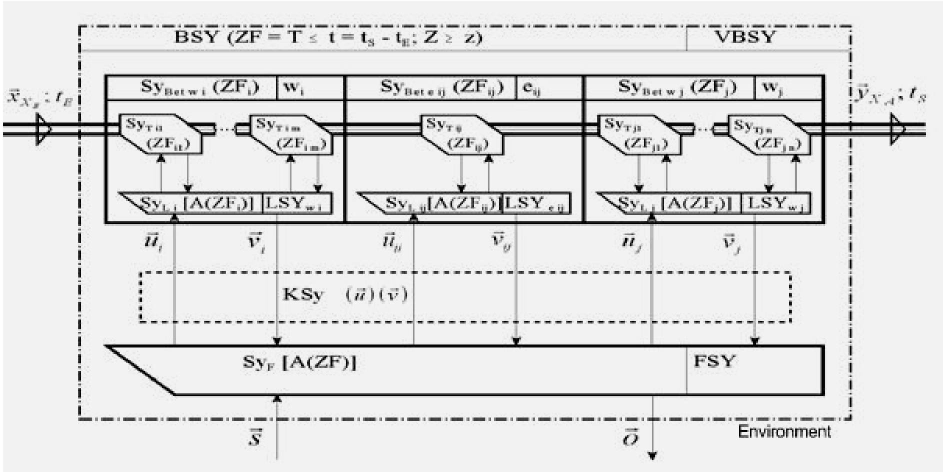

Figure 2. Block diagram of an organization system

In these distributed operating systems the distance between the individual organization systems is getting more and more important. Usually the management system Sy_F is integrated centrally in a node. The individual service systems, such as means of transport, but also elements of individual organization systems, such as measuring systems, can be mobile. For transmitting messages of the organization system a communication system KSy is therefore required.

2.1.1. Process analysis

The process analysis enables the derivation of the target functions and process parameters for the operating systems as a requirement for the analytic modelling of the organization of the traffic processes. Main issues are:

- The characteristic processes and the operational modes
- Transport processes
- Transport operational processes
- Process evaluation and process targets

A traffic process can be described - in the sense of the organization of material and information processes - by the following fundamental processes running simultaneously and relatively independently [1]:

- Traffic object input and output process → *traffic process* with the characteristic random parameter of traffic object quantity of X (XE, XA) and destination factors

- Technological process (including measuring/controlling), which depending upon the traffic object (goods or messages) and the location in the traffic logistic network (node or edge) is referred to as treatment or transport process → *operational process* with the random variable generally referred to as technological period TQ (Q – flow/treatment rate) or specifically referred to as treatment or transport period with consideration of the *arrival process*,
- Operational breakdown process → *failure process* with the random variable of $T\lambda$ operational period (λ - failure rate),
- Maintenance process → *repair process* with the random variable of repair period $T\mu$ (μ - repair rate),
- In addition the *organization processes* in the control and management systems also have to be considered.

The quality of the individual technological processes is different and therefore the resulting operational modes are different as well (see figure 3). The following definitions are applied:

Nominal (regular) mode: The process parameters are within the permitted limits defined by the planning body.

Optimum mode: The process parameters are within the optimum range.

Failure mode: One or more process parameters are beyond the permitted limits for the regular mode without causing the process to collapse. There are usually reductions in performance and/or quality.

Operation: Quantity of all operational modes

Collapse: One or more process parameters drift far enough that it causes the process to collapse.

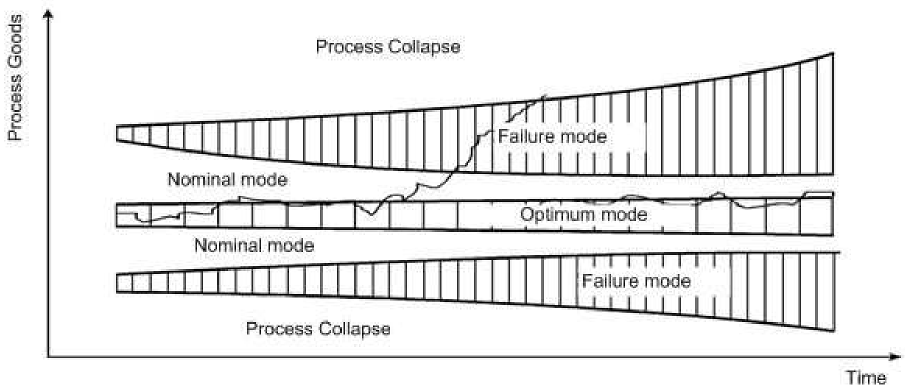

Figure 3. Operation modes (qualitative) [3]

The traffic processes cover traffic organization and the behaviour of the traffic objects. Contents and nature of traffic organization are the tasks to transport or transmit a certain quantity of traffic objects from a certain source to a certain destination within a certain period.

Based on the consideration of systems, strategies for process management have to be developed. For this purpose the operational strategies and the appropriate basic functions are given to the respective system structures [1]. Figure 4 shows the operational strategy for a traffic-logistic network with linking redundancy.

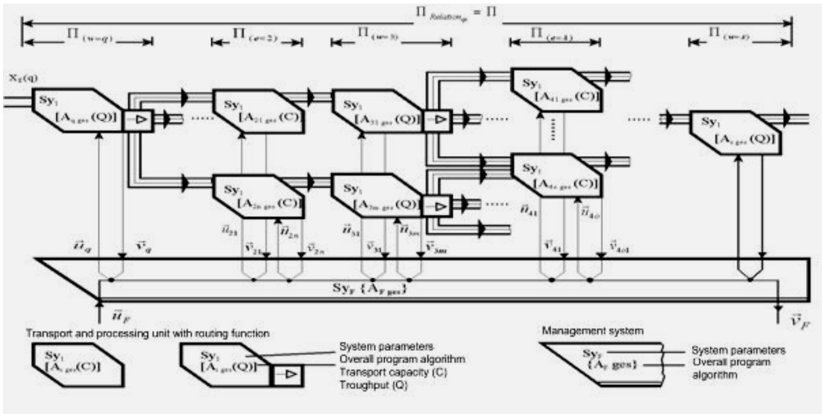

Figure 4. Operational strategy of a traffic-logistic network with linking redundancy

The respective basic functions are as follows:

1. The nodes $\hat{w}_{qs}$ and edges $\hat{e}_{qs}$ of the relation Rel_{qs} are serially laid out bipartite, beginning with the node (traffic source) w_q and ending with the node w_s (traffic destination).
2. Reserve systems are implemented by node and edge disjoint ways from w_q to w_s. The reserves in the nodes and edges are not considered.
3. Principally the nodes and edges can also be used for treating and/or transporting traffic objects from other relations without performance reductions. However, the respective treatment capacity Q or transport capacity C has to be considered.
4. The management system Sy_F works as a control system. It controls the optimal management particularly in the case of a failure mode. It is responsible for the total system only and allocates the managing parameters for the management systems in the nodes $\vec{u}_{F_w}$ and edges $\vec{u}_{F_e}$.

5. The guiding system program Prog(Sy_{Leit}) requires the following strategy of process management:

    - In the case of failure mode in a node or on an edge the process switches to failure mode.
    - In the case of a management system failure the process collapses.
    - In the case of failure mode the guiding control system organizes the process in such a way that under consideration of possible alternatives from the failed network element the performance reduction (extension of treatment or transport period and/or residues of traffic objects) is minimized.

6.1. The process collapse occurs

- if at least one node w or one edge e is no longer operational. The collapse affects all relations Relqs, which contain the node and/or the collapsed edge;
- following the failure of the management/guiding system.

6.2. If the collapse occurs before the traffic objects in the current cycle reach the collapsed network element, the management system organizes the process in such a way that those traffic objects are transported on one or more alternative routes to the destination w_s so that the reduction in performance (extension of treatment or transport period and/or residues of traffic objects) is minimized.

6.3. If the collapse occurs during the treatment in the node, the guiding system Sy_{Leit} organizes the following process steps for the completely treated objects and those which have not or have been partially treated in a way that the reduction in performance (extension of treatment or transport period and/or residues of traffic objects) is minimized.

6.4. If the collapse occurs during the transport on the edge, the guiding system Sy_{Leit} organizes the following process steps in a way that the reduction in performance (extension of treatment or transport period and/or residues of traffic objects) is minimized.

7. The guiding system has been designed as a technical system. With respect to failure, reserve and repair it behaves like an automatic system.

8. In the case of a collapse, the traffic objects remain in the collapsed system. After repairs the traffic objects are supplied to the current cycle.

9.1. Repaired nodes or edges are put into operation again by the management system in accordance with the optimal operation management.

9.2. Repaired management/guiding systems are put into operation again using the optimal system networking for the current process mode.

The behaviour of traffic operating systems is described by their operational processes. Such an operational process is the result of the basic processes of the arrival process, service process (treatment or transportation process), failure process and repair process running simultaneously.

For analytic considerations, the above-mentioned basic processes have to be described by mathematical models, which can be used for the operating regimes and strategies analyzed so far and are mutually compatible [4].

2.1.2. Description of process

The description of the process is made through the duality of the time function and stability. The process period T_Π is a stochastic parameter. It describes the dwelling period of the traffic objects, which is required for the operational process in a defined operating system, i.e., the treatment process period T_{Π_B} or the switching process period $T_{\Pi_{Tr}}$ in the node and the transport process period or the transmission process period on the edge. The process period is a random parameter. It corresponds to the time interval during which a traffic object quantity X is treated by a treatment system of the configuration SY in a certain organization regime OR and it is dependent on the operating, the failure and the repair processes:

$$T_\Pi = f\left(T_Q, T_\lambda, T_\mu\right) \tag{1}$$

The term process reliability Z_Π (t) is derived from the stability. For the complex traffic systems, the regular mode, the failure mode and the collapse are described.

The process reliability Z_Π (t) is defined as the probability that a system configuration SY treats the traffic object quantity X arriving at the time T_E completely (without any residues) using a maintenance method IM within a priod t.

The time behaviour pattern of traffic processes can be described through operating models analytically. But for the complex systems and organization types in transportation, the standard models are only partly suited. Therefore more complex models have to be derived from the standard models (e.g., Keil [4]).

The failure and the repair behaviour patterns for the technical systems, the infrastructure, but also the personnel are described via reliability models with or without renewal, e.g. according to Beichelt and Franken [5] or Fischer [6]. For systems with renewal the data availability V_{Sy} is used and for systems without renewal the lifetime function is R_{Sy} (Δt).

2.1.3. Multi-agent system

For organizing complex traffic systems control and information systems have to be used meeting the requirements and the appropriate algorithms. Agent systems are a relatively new and revolutionary access to the development and design of information-processing systems. A special aspect in systems having several agents („multi-agent system ") is the interaction of the agents [2]. Multi-agent systems are therefore applicable for these tasks. An additional aspect is that traffic systems are distributed due to their nature. Typically there are distributed problems arising in analysing, identifying, error tracing and controlling of physically distributed systems for which a centralized overview is difficult. In this case supervising and controlling should be distributed as far as possible among the individual nodes of the network. For the purpose of modelling, multi-agent systems are used in a blackboard architecture according to figure 5 [8].

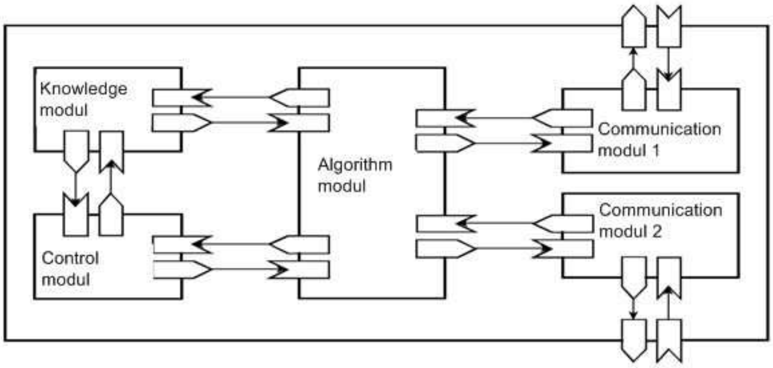

Figure 5. Structure of an agent

The knowledge module is the universal data memory of the agent. It administers all data objects, which are required for the agents, e.g., mode variables as well as a conforming object model of the service systems to be controlled. The fundamental tasks of an agent are to initialize and supervise the technological processes in the service systems of the transportation network. These tasks cover data-processing functions. For implementing and supervising the control actions, the agent communicates with other agents or with the required service systems to which it sends control instructions. The actions of an agent can be described by completed basic functions. These basic functions are described by algorithms for reaching the target function and are administered and called by the algorithm module.

For implementing their tasks the agents communicate with other agents (inter-agent communication) and with the subordinated control systems. The agent is equipped with two separate modules for communication. The communication module is responsible for sending and receiving messages to and from other agents. Communication interfaces are input and output boxes for the administration of incoming and outgoing messages. Communication with the control systems takes place via a separate interface in the same structure, since this is also the usual design.

The link between the modules is the control module. Its substantial task is to analyse the current mode, make control decisions and implement the decisions made by initiating the required actions. The current mode is found out via the information stored in the data module and the messages collected in the communication module. Decisions are regularly made by interpretation on a given regular basis and this will be referred to as control logic in the following. The control logic assigns actions to certain system modes. Each action covers the execution of one or several algorithms, which are supplied by the algorithm module.

For modelling multi-agent systems the BRIC formalism (Basic Representation of Interactive Components) is used according to Ferber [2]. It has been developed from two languages to describe the behaviour of agent and environment. A graphic language describes the modular structure of the BRIC components on an abstract level. The agents, the environment and the internal components of an agent are described as components, which are interconnected. Each component is defined by its interfaces and its own components. These components are interconnected by communication channels. The behaviour of the elementary components is described with Petri nets in terms of the extended predicate/transition networks according to [7].

3. Example

An example is the BRIC module for the selection of programs and functional components shown in figure 6.

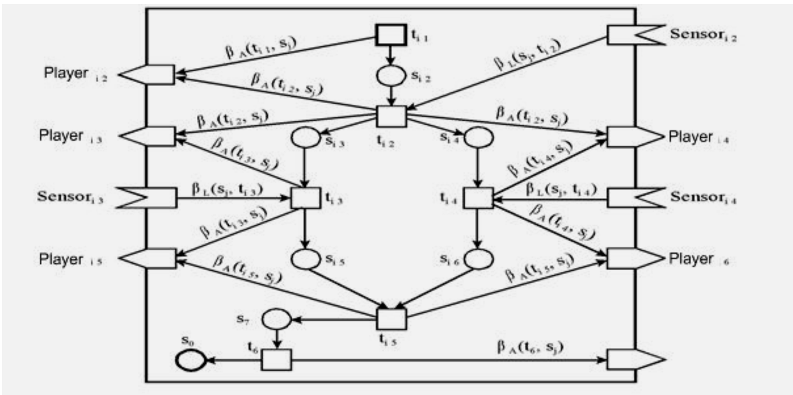

Figure 6. BRIC module for processing the control logic

Place $s_{i\ 2}$ is the start of the program P_i. Via the transition $t_{i\ 2}$ the branching starts into individual functional modules, which are processed in parallel in the program P_i. In the places $s_{i\ 3}$ to $s_{i\ 6}$ the individual output parameters are supplied for the actuators, which have been produced by arithmetic operators β_A ($t_{i\ k}$, V ($t_{i\ k}$) in the respective preceding transitions V ($t_{i\ k}$). The required input conditions are transferred by the sensors to these preceding transitions. The transition $t_{i\ 5}$ terminates the program P_i (final condition). All parallel functional modules are united. This transition also terminates the synchronisation graph. The place s_7 is the common interface for the individual programs. The starting configuration is recovered via t_6. The token for the selection of the required program $P_{i,}$ given via $s_{1,}$ first remains unchanged as a token in the synchronisation graph, but is duplicated in the individual functional modules. In the last transition $t_{i\,5}$ an arithmetic operation $\beta_A(t_6, s_j)$ is possible for determining the following conditions.

The hierarchical structure of individual synchronisation graphs in a modal machine, as shown in figure 6, is designed for all technical systems and all operators. It represents the algorithm module. The arithmetic operators β_A contain e.g., binary functions for control, but also complicated mathematical algorithms for the determination of the process reliability Z_Π.

4. Conclusions

Using the procedure presented here both logistic processes and any production processes, in particular with distributed components, can be modelled using multi-agent systems. The stochastic methods traditionally used in transportation, in particular methods of the operation and reliability theory and the graph theory, can be integrated without any problems into BRIC language using Petri nets.

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Agility in Supply Chains

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Abstract: "Agility means using market knowledge and a virtual corporation to exploit profitable opportunities in a *volatile* marketplace." Agility is a business-wide capability that embraces organizational structures, information systems, logistics processes, and, in particular, mindsets. In today's more challenging business environment, where volatility and unpredictable demand have become the norm, it is essential that the importance of agility be recognized.

Keywords: Supply Chain Management, Agile

1. Introduction

The importance of time as a competitive weapon has been recognized for some time. [2] The ability to be able to meet the demands of customers for ever-shorter delivery times, and to ensure that supply can be synchronized to meet the peaks and troughs of demand, is clearly of critical importance in this era of time-based competition. [3]

To become more responsive to the needs of the market requires more than speed. It also requires a high level of maneuverability that today has come to be termed agility.

2. Definition of agility

"Agility means using market knowledge and a virtual corporation to exploit profitable opportunities in a *volatile* marketplace." [1]

2.1. What is agility

Agility is a business-wide capability that embraces organizational structures, information systems, logistics processes, and, in particular, mindsets. A key characteristic of an agile organization is flexibility. Indeed, the origins of agility as a business concept lies in flexible manufacturing systems (FMS).

Initially, it was thought that the route to manufacturing flexibility was through automation to enable rapid change (i.e., reduced set-up times) and, thus, a greater responsiveness to changes in product mix or volume. Later, this idea of manufacturing flexibility was extended into the wider business context [3] and the concept of agility as an organizational orientation was born.

Agility should not be confused with leanness. Lean is about doing more with less. The term is often used in connection with lean manufacturing [4] to imply a "zero inventory" just-in-time approach. Paradoxically, many companies that have adopted lean manufacturing as a business practice are anything but agile in their supply chain. The car industry, in many ways, illustrates this conundrum. The origins of lean manufacturing can be traced to the Toyota Production System (TPS) [5], with its focus on the reduction and elimination of waste.

While the lessons learned from the TPS principles have had a profound impact on manufacturing practices in a wide range of industries around the world, it seems that the tendency has been for the benefits of lean thinking to be restricted to the factory. Thus, we encounter the paradoxical situation where vehicle manufacturing is extremely efficient with throughput time in the factory, typically down to 12 hours or less, yet inventory of finished vehicles can be as high as 2 months of sales—and still the customer has to wait for weeks or even months to get the car of his or her choice!

While leanness may be an element of agility in certain circumstances, by itself it will not enable the organization to meet the precise needs of the customer more rapidly. Webster's Dictionary makes the distinction clearly when it defines lean as "containing little fat," whereas agile is defined as "nimble."

There are certain conditions where a lean approach makes sense, in particular where demand is predictable and the requirement for variety is low and volume is high–the very conditions in which Toyota developed the lean philosophy. The problems arise when we attempt to implant that philosophy into situations where demand is less predictable: The requirement for variety is high and, consequently, volume at the individual stock keeping unit (SKU) level is low–a set of characteristics which is more typical of the Western automobile industry. In other words, it could be argued that many firms have been misguided in their attempts to adopt a lean model in conditions to which is not suited.

Figure 1 suggests that the three critical dimensions of variety, variability (or predictability) and volume determine which approach–agile or lean–make greatest sense.

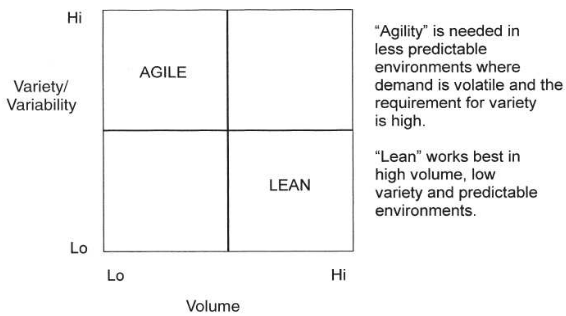

Figure 1. Agile or Lean

Agility might, therefore, be defined as the ability of an organization to respond rapidly to changes in demand, both in terms of volume and variety. The market conditions in which many companies find themselves are characterized by volatile and unpredictable demand; hence, the increased urgency of the search for agility.

2.2. The nature of agile supply chain

Until recent times, supply chains have been understood mainly in terms of long-term upstream collaboration with suppliers. An equal amount of emphasis is now paid to downstream collaboration with customers and lateral collaboration with competitors as a means of integrating the total value creation process. A supply chain, therefore, describes the series of linked activities amongst companies that contribute to the process of design, manufacture and delivery of products and services. The agility of a supply chain is a measure of how well the relationships involved in the processes mentioned above enhance four pivotal objectives of agile manufacturing. These objectives are customer enrichment ahead of competitors, achieving mass customization at the cost of mass production, mastering change and uncertainty through routinely adaptable structures, and leveraging the impact of people across enterprises through information technology.

The preceding list shows that enhanced responsiveness is a major capability of an agile supply chain. Enhanced responsiveness is important as an addition to the high level of efficiency in cost, quality and smooth operations flow, which have been associated with lean supply chains. These primary objectives of a lean supply chain can be realized by using the most basic forms of data communication on inventories, capacities, and delivery plans and fluctuations, within the framework of just-in-time (JIT) principles. The aim of integration is to ensure commitment to cost and quality, as well as achieving minimum distortion to plans, schedules and regular delivery of small volumes of orders.

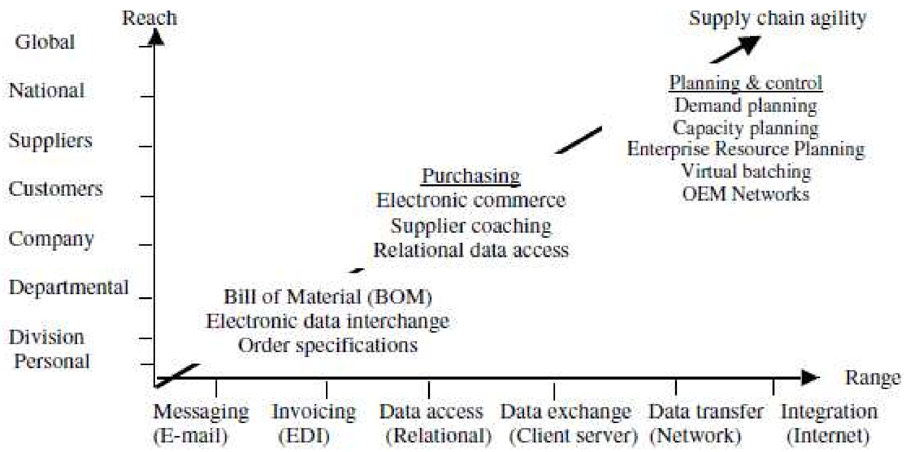

Figure 2. Reach and range analysis of supply chains

Supply chain agility can be discussed in terms of two dimensions of reach and range of activities covered by networking amongst companies. Figure 2 illustrates the two-dimensional framework. On the vertical axis, information reach extends from person to person to global. On the horizontal axis, the range of activities widens from electronic messaging to Internet-based integration. Accordingly, the degree of freedom in supply chain integration widens from bill of material controls through purchasing efficiency to planning and control of supply chain operations.

An agile supply chain should extend to the highest levels on both dimensions of reach and range. At the highest levels of attainment of two dimensions, the conduct of internal operations will be transparent to suppliers and customers. Also, local teams of employees can think globally and take virtual initiatives with teams in other companies within the supply chain. To this extent, responsiveness to changing competitive requirement becomes easier to master as a matter of routine, and with little penalties in time, cost and quality.

2.3. Stages of supply chain maturity

In addition to the reach and range approach, agility and capability of a supply chain can be assessed in terms of the stage attained on three inter-dependent dimensions of supply chain maturity. The three dimensions are shown in Figure 3 (column 1) as customer interaction, asset configuration and knowledge leverage.

The challenge of an agile supply chain will be to improve and ensure balance across the three dimensions. Figure 3 also shows three stages that can be used to evaluate progress on each of the three dimensions of supply chain maturity.

On customer interaction, the first stage of remote experience of products includes efforts to reach out to customers through sales catalogues, television demonstrations and, most recently, web-based advertisements, demonstrations and shopping. By remotely reaching out to spatially distributed customers through virtual means, a company can identify clusters of unique preferences for dynamic customization (Stage 2). Eventually, dynamic customization can be targeted at communities of customers (Stage 3), who have strong commitment to customer-specified product upgrades rather than variety as an end in itself.

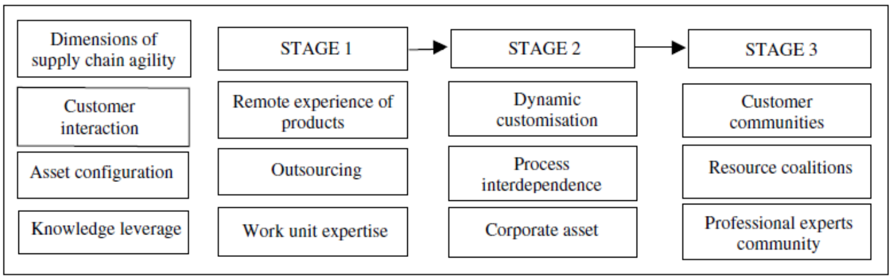

Figure 3. Three dimensions and stages of supply chain maturity

When a company attains the stage of customer communities, leading edge technology products can be introduction more rapidly due to the advantage of customer-input into their evolution as well as the benefit of market concentration.

As for customer interaction, the asset configuration dimension matures from emphasis on commercial outsourcing of materials and components, to business process inter-dependence. This means delegating critical business processes to members of a chain rather than outsourcing. Eventually, spatially distributed and inter-dependent business processes mature into resource coalitions. At this stage, companies will contribute and share knowledge and competence within global networks of resources, and focus on limited areas of the value creation processes where comparative advantage is higher. On the third dimension of knowledge leverage, supply chain agility requires advance from emphasis on individual job competencies and structures, to teaming and free flow of tacit knowledge across work units. Ultimately, the principles of free flow of knowledge across work units should extend to entire value chains as joint stakeholders in the process of conceiving, creating and delivering value. At this stage, a company aims to leverage competencies not only internally amongst its own employees and teams, but also within a globally linked but spatially distributed professional community of experts.

Across the three stages of maturity towards virtual organizing, the target locus of action would extend from task units to organization units and to inter-organizational units. Across the three stages as well, performance objectives would mature from operating efficiency through economic value added, to enhanced survival prospects.

The preceding discussion shows that an agile supply chain should strive to meet the three requirements specified in column 4 of Figure 2. The requirements are ownership of customer communities or niche markets, membership of manufacturing resource coalitions, and possession of a workforce that operates within a community of professional experts. Inter-organizational leverages should drive competitive strategies, plans and innovation. Most importantly, the supply chain should enhance growth and long-term survival.

2.4. Elements of an agile supply chain

Closely related to the three elements of virtual organizing as a means of assessing the agile capabilities of a supply chain, four dimensions of agile supply chain practices have been identified. They are:

- Customer sensitivity through continuous enrichment as against focusing on waste elimination.
- Virtual integration, with emphasis on instantaneous response in addition to stable production flows.
- Process integration through self-managing teams as against work standardization and conformance.

- Network integration through ''fluid'' clusters of associates who venture into temporal opportunities.

Figure 4 models the four elements. Market sensitivity means that collaborative initiatives should be driven by quick response to customer requirements. In this respect, manufacturing processes require integration and specialization based on relative areas of excellence in core competencies. Network integration requires that companies in the chain have a common identity, which can range from commitment to agile practices, compatibility of structure, information architecture and tradable competencies. The third element is process integration and inter-dependence so that core modules of products can be delegated within networks of agile competitors. Lastly, virtual integration envisages access to information, knowledge and competencies of companies through the Internet.

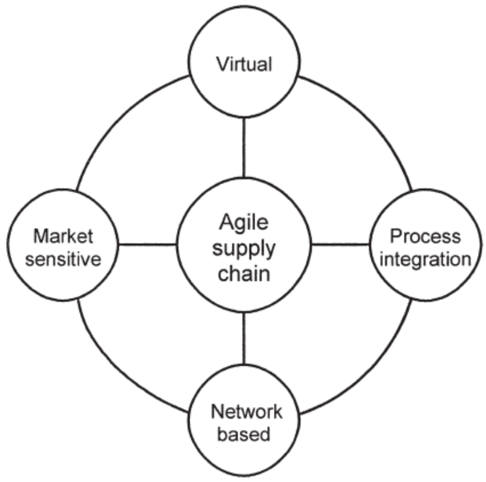

Figure 4. Elements of an agile supply chain

3. A conceptual model for assessing an agile supply chain

In Figure 5 is a conceptual model for assessing the capability of an agile supply chain. The model consists of four dimensions: (i) value chain practice, (ii) competitive objectives, (iii) impact of change drivers and (iv) business performance. The arrows indicate the direction of impact. The essential differences are the ease of formation and dissolution, relative status and commitment of members, the degree of data integration through the Internet, and goals, which can range from advancement of manufacturing knowledge, outsourcing or marketing. These differences are proposed to determine the attainment of competitive and business objectives as well as the impact of change drivers on operations.

It is expected that patterns of supply chain integration will differ across companies. Conceptually, supply chain practices should range from conditional alliances, to master–servant long-term relationships with suppliers and customer, and to the Internet-based collaboration. Across these range of supply chain practices, access to data and knowledge, as well as the ease of responding real time to changing market conditions differ. Such differences are expected to impact differently on competitive and performance outcomes.

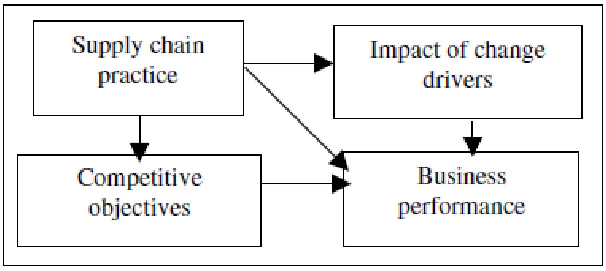

Figure 5. Elements of an agile supply chain

Three supply chain patterns are dominant in the literature. The first is the traditional alliance, which is the dominant practice among companies seeking global spread, as a strategy of penetrating new markets. It is renowned for difficult conditions on contribution, responsibilities and sharing. Data exchange is limited to sales reports and final accounts, which are essential for assessing compliance with terms and conditions as well as for tracking resources, profits and losses. Such alliances focus on outsourcing rather than sharing of knowledge and competencies. In the new competitive game plan, the traditional pattern of alliance practice has become increasingly irrelevant.

A concept referred to as the lean supply chain is the second dominant form of alliance practice. It is renowned for long-term collaboration with preferred suppliers and customers. The goal is to secure cost and quality advantage as well as ensure smooth flow of operations, within the framework of just-in-time deliveries of small volumes of output. In support of the goal, collaborative initiatives include electronic linkages, part ownership, coaching and long-term contractual obligations with suppliers and distributors. Data generation and exchange are largely electronic. These forms of data exchange would just have been adequate for monitoring stock, sales, demand and capacity levels. There seems to be no concerted effort to leverage manufacturing competencies amongst companies as equals. As such, the lean model of integration also has limited impact on competitiveness in a turbulent market.

Quite unlike the traditional and lean supply chains, the agile supply chain is underpinned by global exchange of manufacturing competencies. The agile chain has a stronger impact on competitiveness because it enables mobilisation of global resources to track evolving changes in technology and material development as well as market and customer expectations. Inter-dependent factories can focus and rapidly replicate narrow aspects of the value creation process where competitive advantage is greatest. Focusing and co-operation within the virtual enterprise has the potential to enhance capability for low cost, quality, speed, flexibility and product innovation. These in turn will lead to higher revenues, profits, market-share, customer loyalty and better survival prospects.

4. Enabling the agile supply chain

Supply chain "product champions" (usually, but not always Original Equipment Manufacturers (OEMS), or their equivalents) work with their suppliers simultaneously on the following three fronts[2]:

1. They work to provide each company in the chain with better and more timely information about orders, new products and special needs.
2. They help members of the chain, including themselves, to shorten work cycles by removing the obstacles to time compression that one company often unwittingly imposes on another.
3. They synchronise lead times and capacities among the levels or among tiers of the supply chain so that more work can flow in a coordinated fashion up and down the chain. In establishing a suitable route map to enable agility we suggest the addition of the following six cognate actions to the product champions portfolio:
4. They select good Decision Support Systems (if process lead times are reliable and operations information of high quality, then good, robust control systems can also be simple).
5. They engineer the slashing of material flow and information flow lead times (reduction of these is within the technological and organisational remit of individual echelons).
6. They ensure the widespread provision and integrity of operations information (however, the quality and quantity of data available throughout the supply chain are a political issue).
7. They eliminate redundant echelons (this removes distortion and delay but can give rise to ownership/political problems) needing skilful resolution.
8. They ensure capacity is flexible enough to meet the true customer demand.
9. They act to reserve capacity not buy materials.

By implementing such a route map towards agility, it may then be possible in the retail fashion trade to achieve net margins three times higher than the present 5% [29]. To do this requires the lead time between the retailer buying decision and product availability on the store shelf to be slashed. Hence the best selling lines can be maximised and failures minimised, with option availability increasing from an average of 65% to the market leader benchmark of 90%. According to other opinions such an agile supply chain has only four basic parts: create; make; move; and sell. The agile supply chain must remain simple; transparent information flow, synchronisation, and short lead times are the proven answer, and are an integral part of the recommended route map.

5. Conclusions

Marketing management has not traditionally recognized the importance of logistics and SCM as a key element in gaining advantage in the marketplace. However, in today's more challenging business environment, where volatility and unpredictable demand have become the norm, it is essential that the importance of agility be recognized.

Leading companies are already implementing marketing strategies that are underpinned by a supply chain strategy designed with agility in mind. These are the organizations that will be best equipped for survival in the uncertain markets of the twenty-first century.

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The Time Factor on Logistics

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Abstract: The study deals with the investigation of the critical factor of the supply chain, with regards to time. The literature review can give a background to understand and handle the reasons and consequences of the growing importance of time. It analyses the time- and place-value of products and it tries to value time by showing theoretical functions as well. By using utility functions to represent the value of various delivery-times for the different participants in the supply chain, including the final customers, it proves through the Kano-model, that the choices, behaviour and willingness of payment of time-sensitive and non time-sensitive consumers are different for varying lead times.

Keywords: logistics, time-sensitivity, time-compression, Kano-model

1. Introduction

The 21st century is referred to as the age of the fast paced society, in which several things work in different ways than we have gotten used to over a longer period [48]. The mainstream is the cause of the changes and this includes the attitude towards time [3] [25] [13]; the signs of can to be perceived in the fields of culture, lifestyle, customer needs, consumption, and customer behaviour [24]. The way of life is changing, time has limits, therefore consumers have become time-sensitive and choose the contents of their basket of commodities not only according to available money, but also to available time. The time necessary to obtain a product/service (access time) is involved in product utility to an increasing extent, the assurance of which is the task of logistics. There are more reasons for the shortening of this access time, one of the most important is the change in customer expectations, which can be related to new trends emerging in the most diverse areas with the time factor playing the main role [1]. The change in the attitude towards time can also be seen in the economy, where competition has been placed into a new field. Increasing rapidity is also encouraged by the sellers in the competition against each other based on time, because of the pressure to reduce costs and inventory, and to increase the efficiency and customer satisfaction [5] [23] [15]. After identifying the character of time as a resource it can be seen that there is a spread of new management technologies aimed at time compression and faster service. In addition to the actors are expected to achieve the traditional requirements such as cost reduction, capacity utilization, increase in efficiency, quality improvement, and customer satisfaction [21].

By reviewing the literature the present study first presents some thoughts on the nature of time, in addition its perception and measurement, then takes a closer look at the social fields where changes in the time attitude can be traced, and explores the multiple ways in which people experience time-space compression in varying historical and geographical circumstances. Next it identifies trends prevailing in social and economical behaviour in the long term. After that it intends to deal with effects of the time-based competition (TBC) [21] [22] and, with the different responses given to the increasing need for being fast, while also trying to find out the reasons behind this. The final part is concerned with the time-sensitive and non time-sensitive customers' behaviour by using utility functions, and it tries to find optimal time-parameters for different time-demands by using logistical performance measures based on time.

2. Accelerating time

The first part of this study deals with diachronic time that is how time was conceived, measured, and changed throughout history. Time brings an exceptionally wide variety of topics, from calendars and clocks to trade and telecommunications. The goal of this chapter is to briefly demonstrate how time awareness has changed in various societies depending on the varying historical and geographic impacts. Every society develops a different way of dealing with and perceiving time. Different social formations gave time widely variable meanings and every set of understandings proved to be temporary.

There is an acceleration of the rhythm of life. This aspect refers to the temporal compression of our daily actions. The quantity of actions contained in a lapse of time tends to increase. While the range of possibilities of action grows and expands its horizons, the temporal pressure weakens its quality. In more general terms the tension between interior rhythms and social rhythms is the distinctive sign of this form of acceleration [18]. Therefore, the time-sensitive segment of population continuously increases. The pace of progress has become faster with the coming of new generations. An example of this is provided by the duplication of scientific activity that occurs in every ten years; as a result, 90 % of all the scientists that have ever lived and worked are alive and working now in the world. For another example, if we wanted to depict the 4-5 million years of human history as a period of 1000 years then human civilisation would be crammed into the last 3-4 minutes. Life cycles shorten [4] [2] [13] and at present the Moore-law is often cited, indicating the time necessary for computer performance to duplicate is 18 months.

2.1. Changing time-awareness

Defining time is a rather complicated and difficult thing. The problems in connection with time have already been discussed by St Augustine more than 1500 years ago. Since the time of St Augustine we have not been able to get much closer to the notion of time, we do not know if it has a beginning or end, however several other aspects have become known. In the field of physics, great progress has been made concerning the nature of time and its measurement. The laws of time-based physics by Max Planck and Einstein have changed our worldview. Accordingly, there is no time without space. This thesis was published and interpreted in an understandable way by Hawking.

Time is a *relative* thing; its perception depends on the relative situation of the observer in space: hence time can be faster or slower. However in the age of Newton time was conceived as *absolute* phenomena. Time is a social symbol to manage our life according to philosophers.

The subjective experience of the objective flow of time can be possible only if something happens. In other words, experiencing time can be done only by experiencing events. There is no time without space. The subjective experience of time depends on our activity. This means, that there is an objective time that is perceived in a subjective way. So time is *objective* and *subjective*, that is it exists as an abstract entity that seems to take on a life of its own, and simultaneously as a living experience that is highly meaningful to the people who create and change it. The study of time is therefore much more than an abstract academic exercise but how societies are structured, change and how people live within it [25].

In practice, time units can be used properly without knowing etalons (etalon is a measurement instrument that embodies the measurement unit of a certain amount in a reproductive way) for most phenomena. Usually events or processes are connected to points or periods of time (their results can be categorized by time-state sequences or time-period sequences).

Measurement units of time and clocks give the opportunity to measure time. For measuring, the sequence of events can be used. With the development of astronomy and calendar-making, shorter and longer units than a day appeared along with separate number systems and as a consequence of the 365-day-long year (number-systems of 12 and 60). The first scientifically established unit of time has been the second (now SI unit), which was defined in 1820 as one over eighty-six thousand four hundred (1/86400) of the average Solar day (Solar day is the time passed by between the two successive culminations of the Sun). With the development of atomic physics, in 1967 a more exact definition was given for the length of a second. The atom-clocks – the most punctual constructions at present – still operate according to it. The actual definition is as follows: the time period of 9 192 631 770 periods of the radiation between two hyper energy levels of the basic-state caesium-133 atom.

The change in the attitude towards time is not a novelty and cannot be related to the formation of the pace society [3] [18]. The recognition of time as a value is related to the industrial societies where time passes not without purpose and not in a natural cycle but becomes the resource of material values. The events in nature have a regular system, a forced period with more or less permanent characteristics. The *cyclic time-sense* was decided by these events in a pre-modern age, while in the post-modern age it can be defined by *linear time-sense.* People in societies before Christ did not have time-awareness [13]. The attitude to time is not only determined by history but by space as well, there are huge differences between cultures also today [10]. Hofstede and Trompenaars, two significant scholars of intercultural research have also studied the differences between temporal dimensions within individual nations. In addition there is Levine who conducted research on the relationship between the attitude towards time and the pace of life in different countries [14]. He came to the interesting conclusion that the more effective of a country's economy is, the faster the pace of life is; the more industrialised a country is, the less leisure time people have; and the more urbanised a country is (there are more cities) the faster people move. Our age is not by accident referred to as the digital age, namely the possibility to handle information is covering more and more fields, enabling the so-called real-time mode[1], which is basically the idea that there is no break or pause between reacting or responding to activities [15]. We can say that information technologies (IT) create a new kind of spatial- and temporal structures by reshaping their use. Bridging the spatial gap can be achieved only through time sacrifices but the amount of this is declining with the increase in speed. Spatial and temporal boundaries are becoming relative, acceleration is diminishing economical space, however, the 'radius of action' is extending. These are the two different sides of the same phenomenon, so considerably less time (diminishing) is necessary to complete things and more things can be completed within the same amount of time (extension), respectively. In the context of time and space it means that the same distance can be covered in a shorter period of time and you can get further within the same time. This relationship can be depicted and it will be shown in the next subchapter.

2.2. Tools for represent different using of time

2.2.1. Time maps

Since aspects of movement other than optimisation based on time have emerged (optimisation based on time and cost) solutions are highlighted which concentrate on how to cover spatial distances in the shortest possible time with the lowest possible costs instead of getting somewhere in the shortest possible way. Thus between two geographical points not only a geographical space can be depicted but a time-distance as well, based on the time necessary to cover the distance between the two points and perhaps a cost space can also be depicted, based on the costs necessary to cover the distance [6]. The time space of the real-time telecommunication is concentrated on one point. The cost space of this, however, cannot be regarded one point.

There are two basic solutions for depicting time spaces (here we will not deal with introducing space informatics solutions in which optimisation based on time is also included). The first one is the group of isochron maps keeping the traditional geographical distances and depicts the points, which can be reached – from a determined place – within the same time with help of isolines. In the other group the distances depicted are proportional not to geographical distances but to the time necessary to reach them. The two points will be closely connected if it takes a short time to connect them and the points, which can be reached in a longer period of time, will get farther from each other.

On the isochron maps it can easily be seen that spaces expand where transport infrastructure is developing (motorways) and shrinking can be experienced where the transport conditions are poor (overcrowded roads and sparse transport network, etc.).

[1] The definition is included in the FOLDOC (Free Online Dictionary of Computing)

From the maps showing time distances you can see the consequences of the changes in transport conditions. On these maps the same effects are quite the opposite.

2.2.2. Time scales

Besides managing material goods (money) and energy (health), the third factor one may and has to manage is time. At present it is common to refer to a universal trend prevailing in Europe and in Hungary as well that the time spent working is continuously decreasing. If we look at the statistics taking into account the different time consumptions - time scales[2] – the decrease proves to be true regarding the whole society, however, our time management is shaped depending on demographic, employment and cultural characteristics, and it is also affected by the trend of the economy beyond the actual development of it.

Today an analysing framework also exists being able to connect time scales to spatial dimension, thus social activities can be analysed within the framework of temporal-spatial scales. This framework is time geography based on Hagerstrand's research. The starting point of which is the survey of the individual’s movement in time and space. The latest statistics on the time spent working (in minutes), within the segments of the ones working the least and the ones working the most, is based on the data collected in Hungary in 2000 (www.ksh.hu). From this we can see that the a fifth of the society spends half of the day of 24 hours/1440 minutes working, as a result, it is typical that very little time is left for other activities. It can be seen that leisure time (19 %) exceeds working hours (15%) – however we need to keep emphasizing that it is true only regarding the society as a whole.

2.3. Consequences of the lack of time

In this part I deal with not only the changes of time awareness, but its impacts on everyday life and the reasons of changeable consumption and behaviour as well. There are more explanations for the changes that can be seen in the structure of consumption. One is the appearance of the time-barrier.

This barrier influences the decisions of buyers because the changing way of life [18] effects time orientation [24], which is typical in western culture, and we can see the positive time-preferences and appearance of time-sensitivity.

The pressure of time may lead to a conflict in the case where the time needed is longer than the time at our disposal. People try to optimize their behaviour on a time basis. While doing so, we have to face conflicts with ourselves and also with our financial possibilities because we have are forced to change our consumption habits. Our consciousness insists on having permanence. It protects itself against the more and more frequent and too fast changes coming from the western way of life. A certain part of mental illnesses is due to the fact that we are not able to make our consciousness accept

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[2] In statistics and sociology the data collection and the data gained from this is called time scales, which explores the time management of the society; its changes and differences.

the environmental forces around us. Our financial resources can also prevent us from changing our consumption habits on a time basis. When the modification of the basket of commodity cannot be financed, a consumption trade-off occurs, i.e., we have to give goods up that are affordable to others. This causes frustration and can spoil one's chances to reproduce. Under this pressure, there will be changes in the needs of societies and their traditions and culture [12] [24] [13] [3]. Technical development is changing according to the tendency, which always requires something new and much more in consumption. The use of time varies disproportionally in the case of those working a lot and those not working, with consequences arising in life style and in consumption structure as well. Those working a lot have an increasing need for products and services with which they can save time. They can be regarded as *'new' consumers* having different features compared to the 'old' ones. The time-sensitive segment, which depends on time, expects shopping facilities without limitations; non-stop continuous opening hours (24/7, 24 hours a day every day of the week) [3] or availability due to their special schedule. This is the *trend of continuity*; its appearance can be noticed already today. The increasing time-preference allows us to enjoy life "here and now", instead of saving money for a future purchase. The intertemporal decision is present-asymmetric. This hedonistic attitude is becoming more and more popular, wasteful consumption is unlikely to scandalise people any longer (emphatic marketing). Lots of work is coupled with higher income [2] [26] so time becomes scarcer than money. Having time and money categorises the members of the society into different groups, as shown by figure 1.

lots of time and little money (life-long students, poorer pensioners, bohemians)	**lots of time and lots of money** (wealthy pensioners, rich married, lottery winners, free loaders of the new wealth)
little time and lots of money (managers, entrepreneurs, well-paid families and families with two wage-earners)	**little time and little money** (poor workers, low-income families)

Figure 1. The consumer segments increasing the fastest [3]

The above facts have consequences in relation to logistics as well, as customers lacking time take advantage of timesaving shopping possibilities (e.g., catalogue, internet), which transform the significance of the channels of distribution and creates new ones. Another effect is that logistics has to prepare for the end consumer as well to solve the so-called last-mile problem (with home delivery) extensively. A '*cocooning effect*' is very typical, accompanied by the home as a spot for arranging more and more things (shopping, e-banking). Consequently, the task of logistics is not completed by forwarding the goods to the distributors and intermediaries, where the product was picked up by the consumer. It is becoming more and more widespread that the product goes to the consumer. The so-called CEP (Courier-Express-Parcel) is specialized in meeting such demands and is able to expand at a greater pace compared to the traditional carriers.

3. Time-compression approach

Logistics has to find delivery solutions adjusted to the consumption behaviour of products, which generates *many kinds of logistical needs* to be seen already today. However, the *deliveries of higher frequency and less volume* resulting from this trigger higher costs and higher damage to the environment. These trends make greater cooperation and tighter connections necessary within the supply chains, and they have to create logistical service providers being able to provide complex logistical services, for the changeable needs. In fact not the needs, but the demand preferences are changed. The importance of time is different according to production and consumption points of view, but it is different due to customer segments and groups of product as well. Relevant literature deals with consequences of time-based competition and those methods, which can respond to this challenge.

More research [16] has found that there is a close relationship between the entire lead time (defined as the period between a purchase order placement and its receipt by the client), the customer's demands, the willingness of payment and the customer loyalty. The decreasing delivery time classifies the product to a higher quality-category so that for it can be sold at a higher price. Increasing demands and higher price cause an increasing market share. Karmarkar [11] pointed out that shorter delivery times are most probably inversely related to market shares or price premiums or both. Customers highly appreciate short and punctual delivery time; therefore they will not turn to competitors.

The stability of customer market brought on by customer loyalty can decrease the searching cost of new customers (it can cost four times as much to replace a lost customer with a new one than it does to keep that customer) – not to mention the time required to attract a new one [21].

Customers may be willing to pay a price premium for shorter delivery times. We can find several methods and practices in operations management, which cause visible results in manufacturing. These time-based performances include sales growth, return of investment, market share gain, and over-all competitive position [16] [17] [19] [22]. Companies use three main strategies to utilize speed to attract customers:

- To serve customers as fast as possible
- To encourage potential customers to get a delivery time quote prior to ordering
- To guarantee a uniform delivery lead time for all potential customers

The customer's need for fast service follows in the same direction as the company's ambition to decrease lead time. Time management is rooted back to the Taylor-times when during the work organisation the working time need of each process was compiled from elements divided into movements. An analogous way of thinking may be required on the time-management of the supply chain. The application of management methods and philosophies during the production had already started, which influenced time consumption and time management as well. By now it has turned out that time itself also behaves like a resource that has to be managed. Therefore within the supply chain not only the interior solutions are aimed at time-saving within the company but the spatial and temporal expansion of remote processes arranged by different actors and with different time-consumption is also of high importance. Literature on the competition strategies based on time is also aimed at the temporal integration of the different levels of the supply chain. Among these we can find the methods being popular nowadays such as just-in-time (JIT), agile production, lean production, Quick Response (QR), Efficient Customer Response (ECR), cross-docking, etc. [5] [16] [19] [22] [4] [23] [26]. Based on these we can distinguish the internal – measurable only by the company - and the external – perceived also by the customers - forms of time performances [5]. Figure 2 depicts the internal and external appearance of time performance.

Time Performance / Phase	Internal	External
Product development	Time to market	Freguency of introducing new product existing product improvements
Procurement Production Distribution	**Lead time** procurement production distribution	**Delivery time** speed punctuality

Figure 2. Internal and external time performance [5]

Time-based manufacturing, mass customization or just-in time philosophy are the strategies of a firm to emphasize a quick response to changing customer needs, to reduce end-to-end time, to eliminate unnecessary elements and additionally, their purpose is cost reduction. Planning of delivery time can be a part of the improved customization process development.

Mass customization is an ability of a firm to produce customized products on a large scale quickly at a cost comparable to non-customized (mass production) products. Mass customization can be defined as a low-cost, high-quality, large-volume delivery of individually customized goods and services. Customer responsiveness is an ability to reduce the time required to deliver products and to reorganize production processes quickly in response to requests. Speed is an indispensable criterion for evaluating an organization's activity.

A pull production system refers to production based on the demand of the final customer. Pull systems can greatly reduce the time that parts spend in the "system" (throughput time), especially the non-value-added waiting time and it can accelerate parts to customers. Manufacturing and delivering a product takes far less time than the actual time the service or product spends in the system [5] [19]. It highlights the poor time productivity of most organizations. A focus on time helps a company to reveal its quality problems [23] [21]. Most process quality problems appear in lost time – parts that cannot be used: information that does not arrive, work that must be done again and a customer service visit that does not solve the problem.

Improved customer responsiveness can be achieved through available inventory, which is close to buyers or faster delivery with shorter lead time and good connection to shipment logistics [21]. A flexible and faster response benefits the customers in a number of ways:

- They need less inventory
- Their cash flow cycle is speeded up
- They receive more special services and customized products
- They can make purchase decisions closer to the time of need
- Their customers are less likely to cancel or change their orders

To achieve these benefits, the firms need to differentiate their customers according to the basis of time sensitivity, while they need to know how time and their products along with their services are related to one another. This investigation cannot be separated from products value characteristics, using characteristics and competitive environment, which have to be clarified. It results in a basis of a strategy that will neither surpass nor underachieve the customer's time expectation (external time performance). In the meanwhile, lead time can be planned as well, according to the characteristics of the supply chain, the product and the market (internal time performance). Customer segments which are separated according to time expectation are different due to time sensibility, but for separation it is not enough to know the customers' desires about delivery time, it is also essential to know the payment willingness.

Time sensitivity dominates price sensitivity. This is underlined by personal research made in 2004 in which the variables of quality (speed and punctuality in service time) precede the service price. This empirical research has been studied amongst others the quality expectation of CEP services on a representative sample of Hungarian firms. Other Hungarian research has revealed that rapidity, punctuality and reliability are the first three demand-elements of quality, according to customers and potential customers as well. Customers increasingly need reliable, short delivery time services and they are willing to pay more for it. Customers know exactly how fast is the service they buy. The faster the service is, the more expensive it is. It can be seen by increasing market volume and increasing price level (in contrast to the traditional shipment services).

4. Value factors of goods

The possession-, consumer-, place- and time-value of products is different but it is the result of correlative processes. *Consumer-value* is created through production, which is basically determined by the quality of the product but it can be also influenced by the time and place of its access. These two latter values are value-categories created by logistics. Place- and time-value can be interpreted only in relation to consumer-value because we can decide the optimal time and place of consumption only by obtaining consumer-value and only in accordance with it.

Time-value becomes more important as it is determined by the lead time between the appearance and the satisfaction of demand [4] [27]. It is maximal when the search-production-obtaining of the product does not have any time-requirements, that is to say the demand can be fulfilled immediately at the moment of its appearance.

Time sensitivity is different with each consumer and product. We can speak about time sensitive consumer segments and also such kinds of products, which are very sensitive to any waiting or delay. The willingness of waiting is in relation to the importance of the product and its substitution. With the first one, the waiting-willingness is in direct proportion while with the latter one it is in the inverse ratio. Its formation determines the amount of the opportunity cost of waiting of a product for the consumer. Waiting means opportunity cost, the cost of which comes from wasted-time and wasted possibilities. Time – in a resource environment – behaves as a capacity, which we have to use efficiently. The consumer is always willing to wait as long as the advantage of sacrificed possibilities is lower than the benefit coming from the product, or the cost of waiting does not exceed it (for example unutilized capacities).

It is rather frequent in production-consumption that there are no possibilities for replacement (rare raw-materials, spare-parts waiting to be built-in, semi-finished goods, etc.). In this situation the consumer's willingness does not decrease with the progress of time, the time-value is constant. If the product is too distant, the time-value becomes zero. It can prevent consumption or the opposite situation, when time can be accelerated and when the product is worth everything (e.g., life-saving instruments, the prevention causes of disasters).

The main elements of consumption are the "then" and "there". So far we have discussed the topic of "then" but we cannot separate it from the problem of "there" either (the place of consumption). It is also the so-called *place-value* of products. The farther the product is from the consumer, the less valuable it is for the buyer. The decrease of place-value is in proportion with the distance, which is measured by the transportation cost. The extent of the willingness of payment depends on consumer value, more precisely how important it is considered to be by the consumer. Its importance can be separated from the real-product-utility.

4.1. The value of time

Customers tend to make decisions based on acceptability, affordability and accessibility. In the literature these are the 3As framework in assessing potential benefits. Perceived benefits are determined by more elements in connection with product, provider and circumstances, against the perceived sacrifices; factors like cost, risk/uncertainty and time. Time appears like a hidden cost [27].

How we value time depends on several factors. First of all it depends on the customer type. We distinguish between the end user and the industrial customer. The final buyer gets more and more time-sensitive, so in his case the choice based on time can describe a utility function, which measures product usefulness depending on the quantity/lengths of time it takes to obtain it. Diagram 1 shows a possible form of such a function. The derivative function can also give information about how the marginal utility of time behaves. If we can compare it with the marginal cost function of service, we can see whether it is worth making efforts to have faster service in a certain segment.

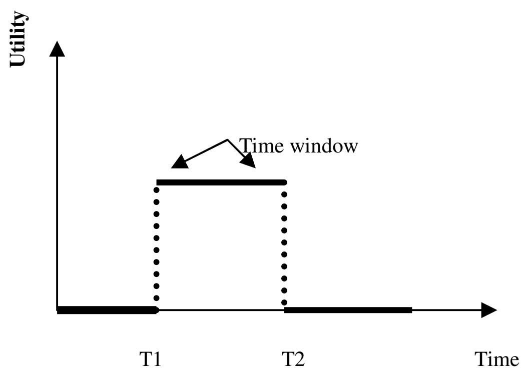

Diagram 1. Utility of time for the final buyers

For the buyers at higher levels of the supply chain, those who buy for further processing (producers), or for reselling (mediators/dealers), there is another kind of utility function to draw. This is shown in diagram 2. The limited time-utility is due to the larger time consciousness, because time costs money for companies. Like the aim to satisfy the consumer at a high level, the aim to operate efficiently as well leads to optimizing on a time basis.

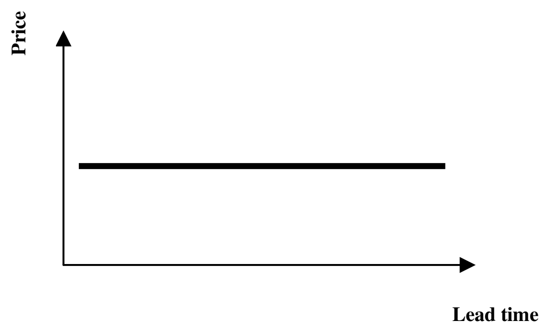

Diagram 2. Utility of time for the industrial buyer

4.2. Elasticity of time

There are consumers who are not sensitive to time, who do not want to or are not able to afford rapidity. There are products (services) as well, where urgency is not necessary, just the opposite, quality is brought by time (e.g., process-centred services, or 12 years old Chivas Regal). The behaviour of these consumers is shown in diagram 3, where price is not increasing parallel to faster service (opposite direction on the lead time axis) price is constant, independent of time. The buyer does not pay more, even for a quicker service. His relation to time is totally inflexible.

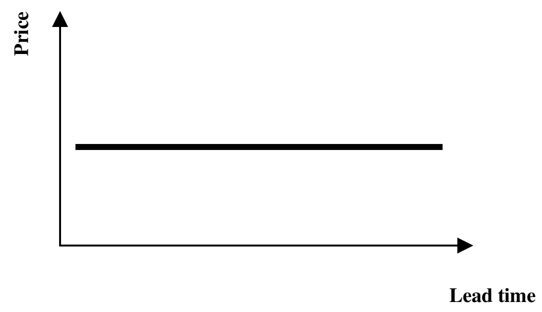

Diagram 3. Absolute time-insensitive consumer

Diagram 4 shows the opposite side, where, to get something at a certain time is worth everything; it means there is an endless time-elasticity.

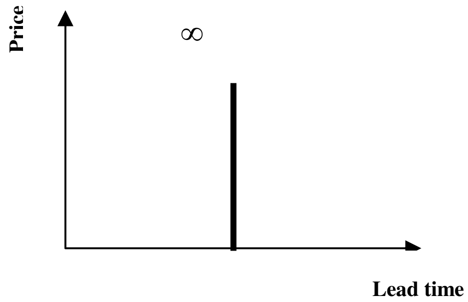

Diagram 4. Endless time-elastic consumers

Time-elasticity shows how much value there is for a buyer to get 1 % faster service. Diagram 5 shows the behaviour of a consumer who is not willing to appreciate the acceleration of delivery time in the same degree. Cutting the lead time from T1 to T2 he/she is only willing to pay the price P2 instead of the price P1, that means the relative decrease of T results only in a relative price increment (P2-P1)/P1.

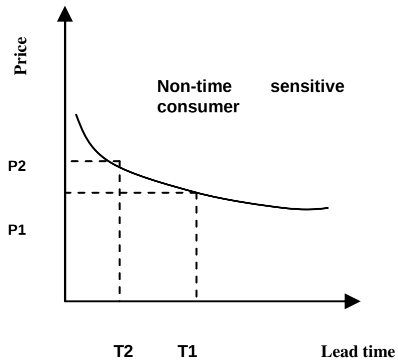

Diagram 5. Non-time sensitive consumers

Time-elasticity appears in a flexible behaviour, which means a 1 % relative decrease in lead time can realize a relative higher price-increment. Even a consumer surplus can arise if the reservation price (the maximum price the buyer is willing to pay for a certain time) is higher than the price fixed by the provider. Diagram 6 shows the behaviour of a time sensitive consumer.

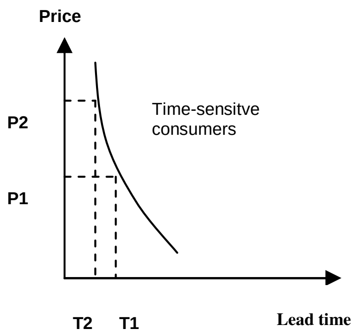

Diagram 6. Time sensitive consumers

Economics and marketing oriented research recognizes that longer lead times might have a negative impact on customer demand. There is a well-known model where demand is a function of actual delivery time and price [12]. The firm's objective is to maximize profit by optimal selection of price and delivery time.

5. Customer differentiation using the Kano model

The need to operate in a real-time manner is filtering through to other areas far away from technology as well. Getting used to immediacy we become impatient in other situations if we have to wait. However, our impatience is built not only by the information speed but other progresses taking place in other walks of life also influencing our changing time conscience. The roots of *immediacy* or rather the *real-time trend* have been discussed earlier, but we have to add that the fast-services developing in more and more fields have an accelerating effect on these needs. The dynamic character of the model by Kano explains the nature of the change in the expectations of time. Figure 3 shows the level of satisfaction accompanying each time performance. The grade of satisfaction is changing depending not only on quickness but also on getting used to it as well. It means that as time passes an inspiring level of performance – quickness, punctuality – is becoming expected and another inspiration can be reached only by achieving higher grades. Thus those providing services also themselves generate the need for faster and faster solutions.

The advantages of which are taken by the customers as well. However, through the Kano-model we can trace the phenomena of the customer evaluation of the obtained services - which shows a decreasing tendency as time goes by - and that of the sellers' pressure to assure higher and higher quality – externally influencing the customer to expect higher and higher quality. This way time utility can be traced back to endogenous and exogenous variables, which are rooted in the most important expectations for logistics along the temporal dimension.

Noriaki Kano (Japanese professor of quality management) has created the theory of quality elements classification [10] [20]. The service elements fall into three different categories that have different effects on customer satisfaction or dissatisfaction (see figure 3).

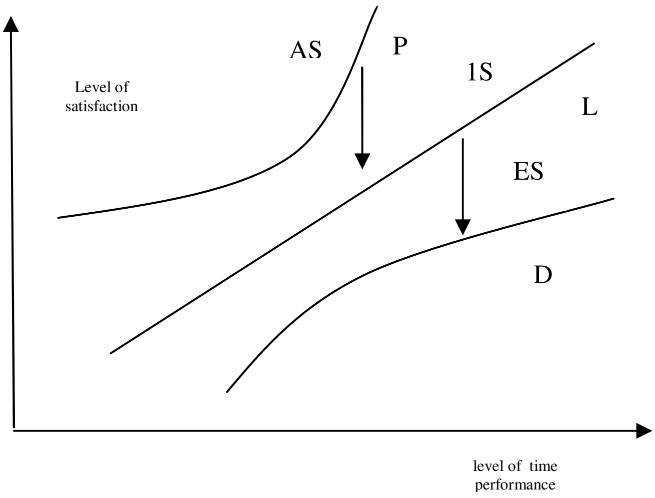

Figure 3. Kano model of the relationship between the parameters of customer satisfaction and obtaining products (services) [10]

Kano categories:

AS: Attractive service elements

1S: One-dimensional service elements

ES: Expected service elements

The relationship between the parameters of customer satisfaction and obtaining products (services) has three types (figure 3):

- Degressive relationship, expected performance: the improvement of parameters increases satisfaction in a decreasing way, their non-performance triggers high dissatisfaction (negative satisfaction) (Curve D). The fact of obtaining products (services) can be regarded as an expected parameter in itself, which cannot be connected – or can be only in the long term – to temporal dimension, but the parameter of punctuality (the divergence between promised and performed dates) works in the same way (in judging this there are huge differences between different cultures).
- Linear relationship, quality of performance/one-dimensional service elements: the improvement of the parameters results in an increasing improvement in the satisfaction directly proportional to it
- (line L). Among the parameters regarded as performance we can mention rapidity. The shorter time it takes to obtain a product or a service (access time) the more satisfied we are.

- Progressive, inspiring quality/attractive service elements: an improvement in a unit results in an improvement in satisfaction by more than a unit (Curve P). The promise and performance evoking the sense of immediacy can be categorized here with other factors the customers have not thought of but when offered he/she finds it very useful (the judgement of the grade of usefulness differs within the different customer segments and product groups).

There is free access between the grades and by getting used to rapidity they change into the direction of the degressive relationship. The actual judgement of the temporal performances depends on the time culture of the external environment, the time attitude of the consumer and on the nature and role of the product/service.

6. Conclusions

There are changes taking place both in the economy, and in society, which result in an accelerating production process (product, circulation), in an accelerating pace of life. Both the buyers and the sellers are making efforts to shorten the access- and service-time of products. This effort has produced solutions in different fields of the economy, in forms of separate, independent branches (e.g., fast-service branches), or reformed variations of traditional service methods. This tendency can be traced back to the revaluation of the role of time, which is true in the case of the final consumers and the companies serving them. Logistics has new tasks as well because of the need to accelerate product-access. Logistics is the field, which is known to represent the largest portion of the time necessary to become an end-product. This time consumption is partly filled by the waiting period between each working process; the other part is filled by movement among different locations. It is important what kinds of efforts are made to ensure time- and place-value. It must be known what kind of rapidity and precision is expected by certain segments. Several studies have proved that there is a connection between rapidity, buyers' needs, buyers' loyalty and the willingness to pay. Both the levels of the supply chain and the service companies/messengers have to have a common strategy for time-compression. Changes in the individual consumers' needs are in accordance with an intensified increase of supply from the economy and a new demand-structure, where time is playing the main role. The technological development, global operation and the shortening product-life-cycles generate new methods, which are able to satisfy the demands. In our study based on the changes in the attitude to time we have reviewed the trends triggered by the network economy emerging in consumption and service. The increasing importance of time has originated from technological development, mobility and the change in use of time. We have introduced empirical devices (time scales, time-space scales, time maps), and theoretic utility and elasticity functions that are capable of studying the changing attitude, the use of time and to depict and visualize their consequences. We have also highlighted those methods, which are useful in connection with planning the time-based strategies.

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Finding the Logistics Organization that Fits Using Fuzzy Logic

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Abstract: In this article we outline a method that helps companies to find the appropriate logistics organization and to set the appropriate requirements for their logistics function. The method uses organizational growth models to determine in what state of development the companies are, which makes easier to find an organizational solution that fits. Determining the growth stage can be difficult, since growth models use soft factors and do not give objective diagnostic tools. These problems can be eliminated by using fuzzy methods.

Keywords: organizational growth models, fuzzy logic, logistics organization

1. Introduction

Logistics is one of the vital supporting functions in manufacturing and commercial companies. Conscious management of this function has a significant contribution to the success of the company. Especially small and medium sized companies tend to undervalue the importance of logistics and do not apply appropriate logistics solutions. In this article we aim to outline the correspondence between company development stage and ideal logistics organizational solutions and to present a tool for determining the actual state of development using fuzzy logic.

2. Company Growth Models

The best-known business growth model is L.E. Greiner's five-stage model, first published in a 1972 Harvard Business Review article. The main problem with Greiner's model from an entrepreneur's viewpoint is that it is designed for large organizations. Entrepreneurial stage-watchers prefer to use a model developed in 1983 by N.C. Churchill and V.L. Lewis, also published in the Harvard Business Review. [1] For the reason that the Greiner and the Churchill & Lewis models are the most popular among large and small companies respectively, we use these two models in our study.

2.1. Larry E. Greiner's Growth Model (1972)

Greiner defines two phases of companies' lifecycle: evolution, which is the period of growth, and revolution, which is a shorter period of crisis and change. As enterprises grow, these phases follow each other. Greiner describes 5 such cycles including 9 defined phases – 5 evolutionary and 4 revolutionary periods – during the growth of a company, these are shown graphically in Figure 1.

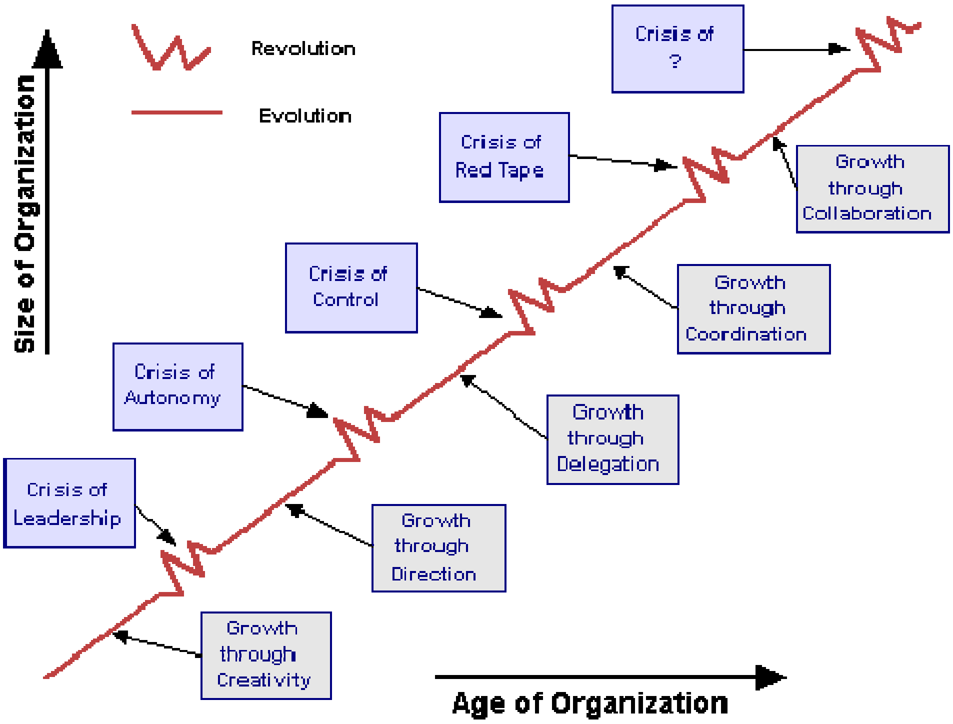

Figure 1. Diagram of the Greiner model (source: Greiner, L. E. (1972): Evolution and revolution as organizations grow. Harvard Business Review 1972 July-August)

In Grenier's view the following dimensions characterize the development stage of an enterprise: 1. age of the company, 2. size of the company, 3. stage of evolution, 4. stage of revolutiuon, 5. growth rate of the industry. Each evolutionary or revolutionary period has typical organizational and management characterictics and problems to solve. [2]

Criticism of the model

The main advantage of the Greiner model is its main disadvantage in the same time. It is a general model, applicable to nearly all organizations, regardless their industrial, geographical, cultoral or other specialities.

The most problematic point in real life application is that Greiner mentions only a few symptoms regarding the phases of the model, from which the real problems can be assumed, but these characteristics cannot be measured objectively. This makes it difficult to find the place of a certain company in the model. Another weakness is that it excludes negative effects coming form „outside" the company (industrial, political or economical factors), that the management cannot influence. Management can only react on these factors, but it is not necessarily enough to survive.

In practice there are usually no clear situations and sharply separated growth phases, only slower or faster changes in organizations. When observing a company, we get only a „snapshot" about the actual situation, and no complete information over a period of lifeycyle. Therefore, the ideal survey method should provide not necessarily precise data but enough information to build an overall picture of the organization. Fuzzy methods are typically applicable for such surveys.

2.2. Churchill & Lewis Small Business Growth Model (1983)

While Greiner defines the growth stage of a company, and then gives the typical management problems to each stage, Churchill and Lewis define the growth stage based on „softer" characteristics and management problems. In their model each stage is characterized by an index of size, diversity and complexity, and described by five management factors: managerial style, organizational structure, extent of formal systems, strategic goals and owner's involvement in the business. These factors are more tangible, and growth phase can be found more precisely, which is a great advantage of the model. [3] The five growth stages are shown on Figure 2.

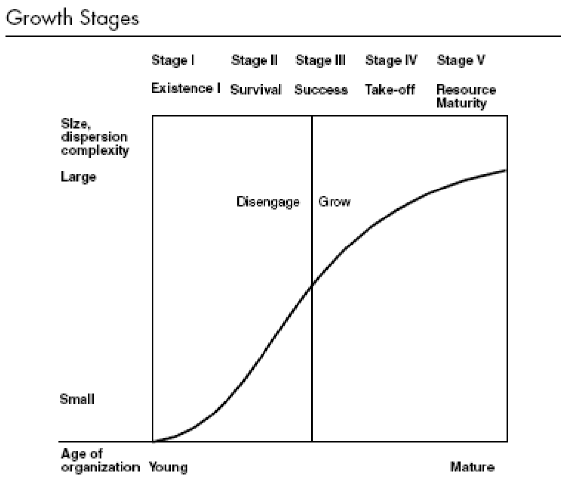

Figure 2. Diagram of the Churchill&Lewis Growth Model (source: Churchill, N. C. – Lewis, V. L. (1983): The five stages of small business growth. Harvard Business Review 1983 May-June)

In the C&L model not all companies go through all development phases. If a company is able to solve the problems of the actual stage, it can step forward to the next one, else it falls back to a previous stage or goes bankrupt. Figure 3 illustrates the possible walks of life and exit points where a business owner can leave the business.

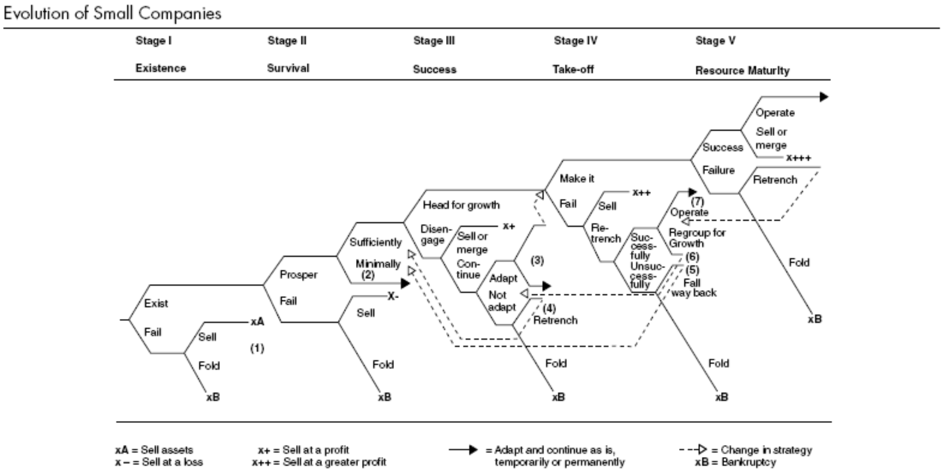

Figure 3. Evolution of companies and exit points (source: Churchill, N. C. – Lewis, V. L. (1983): The five stages of small business growth. Harvard Business Review 1983 May-June)

Criticism of the model

The C&L model does not involve well-defined events that would separate the evolution phases like the revolutionary periods in the Greiner model. This makes it difficult to categorize companies in practice.

Another weakness is that the model does not specify objective values to each parameter that characterize the development stages. Identification through management problems is also problematic because certain symptoms (like financial problems) associated with a certain stage can emerge in other stages as well. This means that a company that shows some symptoms of a stage can be in another stage in the real life.

In our opinion Griener's model is more realistic because the growth stages are more detailed, they include shorter periods and it distinguishes between dynamic and problematic periods of life. However, the model assumes that companies go through the phases sequentially as they grow in size and age, which is not necessary as some companies leave out certain phases and some companies never grow beyond a certain level of development. The graph of evolution with exit points and stepbacks in the C&L model solves this weakness, so the combination of the two models give a more realistic approach.

3. Fuzzy logic and its application in studying company growth models

The fuzzy approach was first published by professor Lotfi Zadeh. Fuzzy logic helps to build more sophisticated, „down-to-earth" models than categorizing only by 0/1 or yes/no. Therefore fuzzy models give a more realistic picture about complex practical issues, where the human factor is present. Fuzzy concepts were already applied in the fields of medical diagnosis, political and social sciences, stock-market analysis and engineering. [8] The advantage of fuzzy systems is that they take into account that human participation ends up in imprecise results, although the intention is clear.

Since business organizations are created and managed by humans, giving up yes/no categories gives us a more realistic view. This applies also to company growth models, where entering into a stage of development is not a rapid change but a longer process of taking new characteristics and leaving old ones. Moreover, these changes are not sequential but can happen paralelly. This is represented in the Greiner model through the presence of crises, which are transitional periods between two phases.

The Greiner model assigns some characteristics to each phase but these are not enough to constitute a tool for diagnosing companies. Since according to the fuzzy logic there are no clear situations, we consider this approach applicable to diagnose the development state of a company. Instead of telling in which stage is a company, we try to tell to what extent is the company in a given stage.

According to the logic of fuzzy sets, instead of stating that w is member of set H we determine the degree of membership in a $x[0;1]$ interval. Non-fuzzy logic uses only x=0 and x=1 values. In fuzzy logic x=0.2 also makes sense as the grade of the membership of w in H. [9, 11]

Since the changes in companies are continuous, using fuzzy logic the transition between two phases can be modelled. When a company shows the characteristics of both Delegation phase and Control crisis, we can interpret it as the membership of C company is for example 0.5 in set „Delegation" and 0.5 in the set „Control".

In the following pharagraphs we give an example on determinig the state of a company in the Greiner lifecycle based on a questionnaire survey.

At first a questionnaire is formed using characteristics and management problems corresponding with the phases of the model. In the correspondence matrix below we give for each question the membership factors defined to every phase. Table 2 shows some example questions from our questionnaire.

Table 1. Example questions for determining the development state of companies (source: own table based on an ongoing research

How much do the following statements apply to your company? (1 = not at all, 2 = a little, 3 = reasonably, 4 = fully)					
	Statement	1	2	3	4
1.	The executive is the operative maneger of the core activity.				
2.	The executive knows every employee personally.				
3.	The executive has to make too much decisions in one time, which leads to delays.				
4.	There is at least one middle line manager whose work the executive is not able to do professionally.				
5.	Controlling is a separate function.				
6.	The separate organizational parts (functions or divisions) are too egoists, and do not work for company goals.				

The values in correspondence matrices show the membership rate of the company in each phase in case of each answer[1]. Table 2 is an example of a correspondence matrix in case of answer 4 („fully”).

Table 2. Example of a correspondence matrix (source: own table)

Question	**Phase1**	**Crisis1**	**Ph2**	**Cr2**	**Ph3**	**Cr3**	**Ph4**	**Cr4**	**Ph5**
1	3	3	2	1	1	0	0	0	0
2	3	2	2	1	0	0	0	0	0
3	1	2	3	2	1	0	0	0	0
4	0	0	0	1	2	3	3	3	3
5	0	0	0	0	1	1	2	3	3
6	0	0	0	0	0	1	1	2	3
..	..	..	..	..	..	..	..	..	..
n	..	..	..	..	..	..	..	..	..
$\mathbf{W_{(Q,P)}}$	**15**	**17**	**12**	**13**	**14**	**15**	**10**	**11**	**8**

There are three other correspondence matrices referring to the answer values 2, 1 and 0 for each question. $W_{(Q,P)}$ values show the overall representation of each phase. To balance over- and underrepersentation of phases we use an adjusted matrix for each answer where the matix values are divided by $W_{(Q,P)}$.

[1] Meaning of the values: 3: member of the set; 2: probably member; 1: probably not member; 0: not member.

Table 3. Example of an adjusted correspondence matrix (source: own table)

Question	**Phase1**	**Crisis1**	**Ph2**	**Cr2**	**Ph3**	**Cr3**	**Ph4**	**Cr4**	**Ph5**
1	3/15	3/17	2/12	1/13	1/14	0	0	0	0
2	3/15	2/17	2/12	1/13	0	0	0	0	0
3	1/15	2/17	3/12	2/13	1/14	0	0	0	0
4	0	0	0	1/13	2/14	3/15	3/10	3/11	3/8
5	0	0	0	0	1/14	1/15	2/10	3/11	3/8
6	0	0	0	0	0	1/15	1/10	2/11	3/8
..	..	..	..	..	..	..	..	..	..
n	..	..	..	..	..	..	..	..	..

We use the following variables for calculating a fuzzy grade of membership to each Phase:

- Questions, Q = {1 .. n} (an integer value)
- Answers for a Question, AQ={1 ..4}
- Correspondence between Answers and a Phase, C(AQ;P) ={0 ..3}
- Overall representation of a phase in a Correspondence matrix, W(Q,P)
- Adjusted Correspondence between Answer and Phase, AC(AQ;P) = { 0 .. 3/W(Q,P)}

Membership factor of a company in a Phase in case of a given answer for a question:

$$MF_P = \sum_{Q=1 \to n} AC(A_Q; P) \tag{1}$$

The sum of all MF_P values is used to normalize the phase membership factors:

$$W = \sum_{P=1 \to 9} MF_P \tag{2}$$

The grade of membership in a phase:

$$MG_P = \frac{MF_P}{W} \tag{3}$$

Having the result on which growth phase is the company in, the next step is mapping the company's logistics organization and finding the most suitable organizational solution.

4. Logistics Organization and Organizational Development

Logistics organization is an important issue of international logistics literature. All authors agree in that logistics organization should suit to the internal and external environment of the company. Internally it means harmony with the company organizational structure and strategy, externally it means exploiting possibilities and meeting market expectations. Logistics operations should be effective and efficient in the same time. This means that growing companies need different logistics organizations as they go through their lifecycle.

Organizational growth models give detailed descriptions on company characteristics in each stage of their lifecycle, but do not give details on the different company functions – like logistics. In our opinion each stage of development require different contribution from the logistics function and different logistics organizational structure as well. Defining ideal logistics organization to each stage may be useful for developing companies to form their logistics function.

Table 4. Logistics organizational structure types in logistics literature – summary table (source: own table)

Bowersox-Closs-Cooper (2002)	Frazelle (2002)	Lambert-Stock-Ellram (1998)	Rushton-Croucher-Baker (2006)
Phase 0. Fragmented functional structures	-	-	Traditional organizational structure
Phase 1. Functional aggregation 1	-	-	-
Phase 2. Functional aggregation 2	Functional organization	-	-
Phase 3. Functional aggregation 3	Integrated logistics organization	Logistics as a function	Functional structure
	Global logistics organization		
Phase 4. Process integration	Process organization	Logistics as a program	Process-driven organizational structure
	Matrix organization	Logistics as a matrix organization	Matrix organizational structure
Phase 5. Virtuality and organizational transparency	Distributed logistics organization	-	-
	Business unit logistics organization		

Logistics organizational structures are discussed from different points of view in literature but basic models appear in most works. Table 4 shows the structures discussed by the authors we refer to in our article.

For the purposes of this study the Bowersox-Closs-Cooper approach is the most suitable as it is an evolutionary approach in contrast with Frazelle's approach, and it is more detailed than the other evolutionary approaches. Dividing the functional integration into three steps makes it more suitable for finding correspondence between the growth phases and the logistics organization structures as integration can go on through more phases. Therefore we use the Bowersox-Closs-Cooper approach as a basis and complete it with the ideas of the other three authors.

Phase 0. Fragmented functional structures

These structures are typical for traditional or young organizations. Logistics activities are dispersed to Marketing, Manufacturing and Finance functions. This fragmentation means the lack of cross-functional coordination which results in distortion or delay of information, duplication and waste. [5] Lines of communication are unclear so it is often impossible to optimize the different logistics sub-functions for effectiveness and efficiency. [7]

Phase 1. Functional aggregation 1

The first step towards integration is grouping the logistical activities within the original function. The overall organizational structure and hierarchy do not change significantly. Typical aggregations in this phase are for example:

- marketing: aggregation of customer service activities
- manufacturing: aggregation of materials management activities.

This organization still does not provide integrated inventory management and does not handle trade-offs between inventory and transportation costs. [5]

Phase 2. Functional aggregation 2

Logistics as a separated function appears in the organizational chart with own authority and responsibility. The logistics department usually involves physical distribution and material management at this stage. It still does not include some important logistical activities such as procurement or order processing, these tasks are performed by other functions. Limited communication and coordination between functions result in the lack of efficiency. [5] Another weakness is that since the logistics department performs only transportation and warehousing activities, it aims to minimize only these costs. This can lead to growing overall logistics costs and service level problems due to trade-offs. [4]

Phase 3. Functional aggregation 3

In this phase of aggregation the aim is to integrate all possible logistical activities within the boundaries of a single functional unit and exploit synergies. The logistics function includes planning and operations as well, so logistics get into strategic level. [5]

Advantage of the integration is that it can handle trade-offs, and overall logistics cost, service level and efficiency can be optimized. Responsibility is delegated to a Chief Logistics Officer (CLO). [4]

Global logistics organization is an extended version of integrated logistics organization, which is responsible for all logistical activities of a company operating in more than one regions. [4]

Despite the integration, there are still problems, generated by the characteristics of funtional organizations:

- overall company performance is still not optimal, considering there is no full cooperation between the functions. [6]
- it focuses on internal operations, the customers' expectations get less emphasis than needed. [7]

Phase 4. Process integration

Process-oriented organizations are able to reach a higher level of service and productivity than functional organizations. Process management appears in the following two types of organization.

- In process organization or process-driven organization the core business process defines its requirements for logistical activities, which are performed by the logistics function. All activities are driven by the key performance objectives of the core process, the other processes only service them. [4,7]
- Matrix organization is a combination of functional and process organization. Usually planning is the responsibility of the process manager, while operations are the responsibility of the functional manager. This provides high level customer service through process management and cost efficiency through functional optimization. [4,6,7]

Process-oriented organizations also have to face problems and dilemmas:

- How can an organization be structured so that it can manage a process as complex as global logistics without becoming overly bureaucratic? [5]
- It is impossible to meet perfectly the demands of service quality and efficient operation at the same time. Depending on the abilities of the functional and process management one of the goals will not be reached. [4]
- Coordination gets complicated due to functional egoism, so running such an organization requires constant support of top-level management. [6,7]

Phase 5. Virtuality and organizational transparency

These are the organizations of the future, but some companies (for example Dell) already apply this structure. Logistics operations are dispersed to different functions or processes under the coordination of a CLO. Advanced IT systems provide coordination through common database and information sharing, making optimization possible not only in company level but across companies in the supply chain. Performing operations locally provides the best competences and flexibility. [4,5]

5. Company lifecycle and the logistics organization

All authors except for Frazelle defined the different organizational structures as stages of historical development. They assigned each structure to the era they had appeared and had been applied by big US companies. The way of development was the following:

Phase 0.	Up to the 1950s
Phase 1.	Late 1950s – early 1960s
Phase 2.	Late 1960s – early 1970s
Phase 3.	1980s
Phase 4.	2000s
Phase 5.	Presently and in the future

Interpreting organizational solutions as historical development is only one point of view, that applies only to the most developed companies of one of the most developed economies of the world. This approach excludes companies that stopped growing at small or medium size or companies that are in the beginning of their lifecycle.

In our opinion the stages of historical development corresponds with the stages of company development. In new, small and not logistics-intensive companies (as the ones in the Creativity or Leadership phase) logistical activities are dispersed in the organization, often performed together with other tasks by the same employee. As the company grows, logistical activities are more consciously organized, and there is a growing need for efficient and transparent operations. This forces companies to step into the phases of functional aggregation 1 and 2, typically when the company is in the phase of Direction.

Full functional integration (Stage 3) is reached by large or very consciously managed middle-sized companies, where the logistics function is fully developed and tasks are cleared. This is usually in the Delegation phase or later.

Process integration is the solution when companies aim to rationalize their operations and focus on supply chain partnerships typically in the phase of Coordination. There is large emphasis on interorganizational management at this stage. Logistics function is often expanded and is referred to as SCM function. [13, 14]

Virtual organizations are applied by few companies so far, but it can be a good solution for the challenges of the Collaboration phase[15]. The solution lies in advanced IT systems that provide coordination within and between companies. The presence of logistics experts are beneficial in the fields of supplier relationship management, CRM, customer service management, demand management, order fulfillment, manufacturing flow management and product development. [10] However, this phase of development, like virtual organizations is a subject of recent researches.

6. Conclusion

One of the largest weaknesses of organizational growth models lies in their practical applicability. [12] Lack of objective scales and values for the given characteristics makes it difficult to tell in which stage of development a company is. The presence of human factor and the domination of soft factors are also aggravating circumstances. These problems can be handled by using fuzzy methods when modelling the companies' state of development.

The other weakness of growth models is that they do not pay attention to the development of supporting functions like logistics. The way logistical activities are organized is especially important in manufacturing and commercial enterprises, since their customer service quality and cost efficiency highly depend on logistics performance. Finding the appropriate logistics organization and setting the appropriate goals for the logistics function is an important condition of success. Determining the actual development state of the company and finding the corresponding logistics organizational structure can help to fulfill this condition.

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The Role and Adaptability of Product Traceability in Logistic

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Abstract: Széchenyi István University an R&D project started on product tracking. At that time we began a deeper research into this topic. In our article we will highlight why companies really need product tracking, how we can realize a tracking system and what kind of benefits a company can attain from product tracking and tracing.

Keywords: product tracking, identification

1. Introduction

According to researches on corporate competitiveness more and more recognize that the improvement of logistic processes can bring potential advantages. The companies perceived their market condition could be strengthened if they insist on the importance of getting information from their customers and utilize their IT system's facilities. The growing competition requires increasingly cost-effective production and services.

The companies do their best to keep their competitiveness and make bigger and bigger profits. To reach their targets they have several devices. One of them is product tracking.

According to the literature product tracking gives us the ability to identify a product and its origin. To be more precise we can say that product tracking assures exact information about a product, what happened to it during its life or how it was used, and we can locate its temporary location.

2. Importance of product tracking

To pre-plan the production and the transparency of production processes it is important to be able to identify the lots at any point of the production process. It is important to be able to trace the products or their components and to track any activities in the production process which use resources. Earlier product tracking and tracing were manual activities. It was even typical when stock control was supported by computers. Data originating from the production was handled manually and stored on scraps or documents and was put into the IT system posterior. Obviously, the manual data input can lead to making errors. When users input or only modify data in the database there is a risk of overwriting, missing or duplicating data. And of course it is also possible to fill in the original documentation in an incorrect way, and in this case it is sure we store false information in the database. We have to mention that this kind of data input process does not assure recent information, because between the production time and the time of data input a long period of time can elapse, furthermore, it can even take some days. This is one of the basic problems of logistic informatics, particularly how to decrease the time between the “birth” and the use of information.

By applying automatic identification we can solve the above mentioned problem. There are a lot of technical solutions to transfer the production data to the IT system without any human interference and moreover we can eliminate paper documentation or most of it from the production processes.

Product tracking is essential in terms of quality production and well directed processes. There can occur cases when manual product tracking may be cost effective, but it is not to be questioned that the automatic solution provides the most exact pieces of data. Furthermore, we suppose it is the most effective and most efficient technology.

3. Realization of product tracking

Product tracking is a kind of application which affects the operation of the whole company. If we analyze only the inner processes of a company we can say tasks connected to product tracking are present everywhere, from design through production to delivery. But if we examine the whole supply chain it turns out that almost each element of the supply chain takes part in the tracking chain which increases the system complexity. Namely, it is the complexity of the system that requires to audit

- what kind of requirements system has to fulfil
- what kind of industry characteristics we have to observe
- what kind of standards we have to keep in view
- what kind of national or international laws we have to comply

The product tracking system consists of several components. Firstly, we need an identifier which facilitates unique identification. Evidently, a device that marks the item or the one that makes the identifier, and a reader adapted to read the identifier form part of the system. We have to transfer the pieces of data originated from production to the IT system in order to gather the required information. Therefore the devices of the tracking system have to be connected to the IT system so that the data can be transferred to the database automatically.

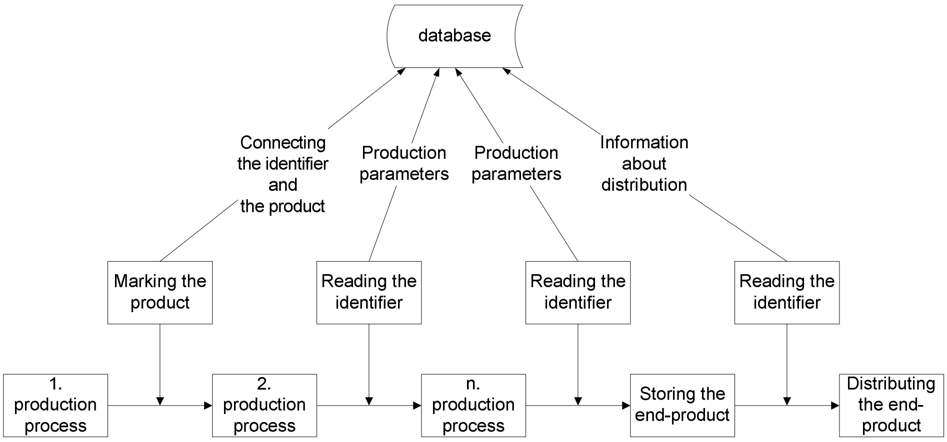

Figure 1. Structure of the inner product tracking system

It is not possible to give an exact description of the parameters of the above mentioned devices because product tracking can be used in many industries and companies. To have a clear insight we feature the main technological solutions of the components. These different solutions were not only created to displace the others, they also fulfil different functions. That is why we could not state a certain technology would be outdated and it is no worth taking it into consideration.

The literature sorts the identification techniques to 4 groups:

- mechanical (e.g. punched card)
- magnetic (e.g. magnetic stripe)
- optical (e.g. bar code)
- electronic (e.g. RFId)

We examine only the optical and electronic identification techniques in our present research, so we outline the joint technologies.

3.1. Bar code

The bar code system has been used for more than 30 years and we can say that today it is essential for industrial applications. Down to recent times more than 50 types of bar codes have been developed. The popularity of the original, linear bar is owing to the facts that

- its manufacturing is cheap
- it can be read relatively quickly and easily
- it can be printed on most of the packages
- it can be differentiated from the other information on the wrap

We can arrange the bar codes in 2 groups:

- 1-dimensional bar codes
- 2-dimensional bar codes

3.1.1. 1-dimensional bar code

1-dimensional bar code consists of black and white parallel lines following each other in a determined order, and can be read optically. Information is carried by the width of lines and spaces that change by every item. The height of a bar code helps only to read the stored information, does not have any other special function. The most popular 1-dimensional bar codes are:

- EAN/UPC
- Codebar
- Code-39
- Code-93
- Code-128

Figure 2. shows the EAN 13 bar code.

Figure 2. EAN 13 bar code

Each bar code reader can read the 1-dimensional bar codes. The readers work on CCD or laser principle. The CCD reader can read the code from relatively short distance and scan only codes on flat surface. It is used mostly by office applications. The laser scanner can read the code from longer distance and the ragged or curved surface does not barrier reading. To read the codes we can use different devices:

- pen scanner
- handheld scanner
- stationary scanner
- fixed position scanner

3.1.2. 2-dimensional bar code

2-dimensional codes contain information along the plane, along both axes. These can store much more data than 1-dimensional codes, because in a small place the information density is high. Most frequently used types are:

- PDF417
- MaxiCode
- Datamatrix
- QR Code

By product tracking solutions datamatrix code is the mostly used. Figure 3 shows a datamatrix.

Figure 3. Datamatrix code

2-dimensional codes can be read only with special scanners: laser scanner or imager. The imager reads the code as it was a picture, and with the help of an embedded software. Its great benefit is the ability to read damaged codes.

3.1.3. RFID

Radio Frequency Identification (RFId) is an automatic identification method. The basic idea behind RFId applications is extremely simple: a reading device queries a tag, generally attached to an object, and receives the information stored on it. The real power of RFId applications lies in the information stored on the tag and the ability to read those data automatically. Its functioning is equally simple. When powered the reader emits an electromagnetic field at a certain frequency that is detected by tags; power is induced in them and allows the answer to be sent. In terms of functional blocks, an RFId system is composed by three main elements: the transponder that stores the information, the antenna that emits the electromagnetic field and receives the answer from the tag, and the reader that decodes the answer and reads the information from the tag. Readers are generally connected to a host computer in order to star processing the retrieved data.

3.1.3.1. Transporder (tag)

Typical transponders consist of a microchip capable of storing data and a coupling element, such as a coiled antenna, used to transmit radio signals. The use of silicon-based microchips enables a wide range of functionality to be integrated into the transponder like read/write memories or sensors. Depending on the integrated device different information could be stored inside the tag, ranging from static identification numbers or a simple bit (just to signal the presence or absence of a tag in a lane, like in Electronic Article Surveillance equipment) to complex sensory data (for example the temperature reading from a tag applied to items that require temperature monitoring).

3.1.3.2. Antenna

The antenna is the part of the system that directly realizes the radio frequency communication with the tag. They both produce an electromagnetic field (of which intensity depends on the dimension of the antenna) and pick up the signal emitted by the tag in its range. Reader antennas are often the technically trickiest part of an RFId project due to the necessary matching between the operating frequency of the whole system (that determines the type of the antenna) and the application. For example, High Frequency (HF) applications with low power proximity range (typically at 13,56Mhz and at a distance of less than 10cm) such as access control, antennas, are generally integrated within the reader. Longer range HF, (10cm < 1m) or Ultra High Frequency (UHF) application (in the range of 860-915Mhz and a distance of less than 3m), on the contrary, have an external antenna connected to the reader through a shielded coaxial cable.

3.1.3.3. Reader

The reader is the device used to read/write data carried by/to the tag and to interact across interface with the external world. RFId readers, consist of a radio frequency module, a control unit, and a coupling element to interrogate electronic tags via radio frequency communication. In addition, many transceivers are integrated with an interface that enables them to communicate their received data to a data processing subsystem, like a database running on a personal computer. The Tags readers can be mobile devices (for site survey) or transportable devices (to be installed on truck or fixed position) or stationary devices (for access control to specific areas).

If many tags are present they will all reply at the same time. This behavior can cause a signal collision and a consequent wrong reading. The reader manages this problem by using an anti-collision algorithm designed to allow tags to be sorted and individually selected. There are many different types of algorithms which usually are defined as part of the protocol standards. The number of tags that can be identified depends on the frequency and protocol used, and can generally range from 50 tags for HF and up to 200 tags for UHF. When a tag enters the electromagnetic field, the reader is able to perform several operations such as read the tag identification number, or in the case of a read/write tag write data to it. After finishing the dialogue with the tag, the reader can either remove it from its virtual list, or put it on standby until a later time. This process continues under control of the anti-collision algorithm until all tags have been selected. The modern readers can also operate with tags that work at different frequency, so, using these multi-frequency readers, it is possible to choose the right tag for the right application, independently of the reader technology.

4. The usage of product tracking data

After we reviewed the technical devices applicable in product tracking we will put the question, on which area we can apply product tracking and tracing.

4.1. Product recall

Product recall can be ordered by a company's own decision, as a result of picking up mistakes in a certain product, or it can be ordered by an official institute or the government because a product does not meet some quality requirements. Any of these alternates is the basis of the recall. The recall process charges extra costs to the manufacturer. If a company can track its products in some way, huge amounts can be saved during the recall process. The cost of a product recall involves some components:

- work and material costs of the recall process
- resources of vital importance have to be taken away from production because of handling the recalled products
- the company may lose its good reputation and the trust of its consumers that decreases its market share

Product tracking helps to cut down the above mentioned costs, as we have exact information about the given products, and we can locate them easily.

4.2. Improvement of product quality

In many cases it is a big challenge for companies to decide how they should improve their products to capture a bigger market. The product development engineers need some pieces of data which reflect the consumers' demands and satisfaction. Product tracking is a useful device in developers' hands, because a database containing information about product tracking provides the opportunity to check the consumer's reactions to improvement, or stores data about defect of quality emerged previously. The analysis of the database shows us how we could make the production more efficient and what we should change in the processes to have better results.

4.3. Assurance of quality and origin

Of late years market participants in more and more industries expect to get information from the manufacturer about the purchased products' quality and origin. Naturally it is not surprising, because one can hear about newer scandals almost every week, mainly in food industry. But it is true of every industry that traceability of data is a guarantee for the manufacturer to certify that every process of the production was executed to specification and they built in or used materials of good quality during production. If a manufacturer cannot certify this, the company has to face the situation that it can sell its products only at lower price, and perhaps it cannot export to some countries.

4.4. Logistic application

Product tracing assures transparent supply chain. The co-partners in the supply chain can establish closer and efficient connections, and they can be responsive to market changes. In case accurate data about sales are available, they can plan production, buying and maybe distribution easier.

Product tracking helps to check the products' shelf-life. The tracking system can warn automatically how long we can forward a product, or the guarantee time of the product expires.

Product tracing can be a great help in freight transport, especially by not accompanied transportation. Considering rail transport we know only an approximate time of the arrival of the freight. Probably, the absence of these pieces of information contributes to the fact that the combined traffic is not too popular among conveyors. But if we install readers along the tracks, it is possible to read the identifier of the trains, and we can calculate by the gathered information when the carriage arrives at the destination.

Product or lot tracking in the process of production gives us measurable pieces of data, such as changeover time or delay time. If the tracking system is fully automated and complex enough, we surely get the real data.

4.5. Security

If all of the tracking data are recorded on each nodal point of the supply chain, we get a well-useable "checking route", which helps us to find out where the weak points of the chain are, in terms of security (e.g. where the most products are conveyed). Additionally, we cannot disregard that product tracking participates in prevention of different misuses. According to experts the counterfeiters use only few serial numbers over fabrication, thus the fake products can be picked out quickly.

4.6. Guarantee

A manufacturer is responsible for its products after sale that is why we cannot eliminate this issue. Furthermore, the product can be more attractive to consumers, if they resort extra guarantee services, even by personal constructions. Product tracking helps to handle these services. Since all information about the product's life is available it is easy to decide if the guarantee is still valid, or a main component was replaced, which causes the problem. To store the data of servicing is important not only because of the guarantee cases, but it is also used for the above mentioned product development.

4.7. Cost calculation

Product tracking can be used to support cost calculation. As we can identify a product at the beginning of the production process we can figure out easier what kind of resources we used during the production. Data on product tracking can also support the inventory management, so we can save great amount by the optimization of stock levels.

5. Conclusions

If we analyze the literature and investigate where product tracking and tracing is used, we can conclude that almost every area of a company can profit from a tracking system. Its material flow system becomes fully transparent and they always have exact information which is available in the database.

Naturally it would be worth analyzing the product tracking system from other aspects, as well. One of the approaches can be to examine which products can be involved in a tracking system. After all it is not sure that every product must or can be tracked by items, or rather we do not undertake to estimate without examinations which are those products that have to be tracked during their whole life, and which are those where it is enough to track a product during the production time. We have to mention the problem of waste recovery which causes really serious difficulties in the world. A uniform product tracking system would support us to control the manufacturers and we could oblige them to take back their products free of charge and reverse them.

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The Effect of Waste Logistics on the Environmental Impact of Road Transport

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Abstract: Nowadays we should consider waste in a much wider sense as an expedient raw material source. From a logistics point of view the fact that the flow of the secondary raw materials are not constant in waste logistics systems is a challenge. The quantity of the wastes of production, consumption and recycling are varying in time and space. The arising municipal wastes usually can be found in smaller items than previously, having relatively more utilization opportunity when they appear separated at the refuse dumps. Optimal cargos should be organized by the environmental aspect of road transport services. Recently road transport is one of the main polluters. With the internalisation of external costs of road transportation the price of waste as a basis of secondary raw materials will increase. The article describes these problems and the methods of which can be used for the solution.

Keywords: waste logistics, environmental protection, internalization of external costs

1. Introduction

In our days a number of studies have already dealt with waste management (activities that spotlight the usage of secondary raw materials), however we do not know much about its effect on traffic. Most research is on the raw material shortage controlled by waste recovery and waste logistics. Nowadays inverse logistics plays an increasingly more dominant role among the logistic trends, which are dealing with treatment, returning and management of unnecessary goods, and wastes [1].

The restraints of the exploitation are known and the demand for raw material is greater than the available primary raw materials (supply). That is the economic source of the increase in price of energy sources and raw materials. A bigger emphasis is put on waste management and waste logistics, mainly because of the lack of raw material in the EU. In the developed countries the additional utilisation of the wastes as secondary raw material (urban mining) becomes a more and more important economic factor.

Waste is partly exploitable through regained substances, partly with the burning for heat generation. What hinders the increase of this utilisation rate is that several primary raw materials are cheaper, but probably on a longer timescale there will be growing demand for secondary, recycled materials as the exploitation and the expenses of primary raw materials will increase.

2. Relationship between waste logistics and road transport

Today it's already a well-known fact, that all over the world and here in the European Union personal and freight traffic volumes are continually growing year to year, among them the volumes of the waste transportation. A correlation can be experienced between economic efficiency and waste production. The logistic provider network has many participants; these are connected to each other dynamically. In this network the route of the stock, semi-finished product, the product, the workforce, and the waste can be distinguished and the logistic tasks in connection to them. Nowadays yield process' deliveries are much more organised, than those, which generate and deliver raw materials from waste. The available modern (but slightly widespread) techniques are given to increase the number other secondary raw material's utilization potential. If the market conditions would be adequate, then waste production nowadays should have a much wider use than raw materials. The waste logistic systems are logistical challenges, because raw materials' flows are not constant. The quantity and quality of the wastes of production, consumption and recycling are varying in time and space. Municipal waste can only be raw material in the case where its quality is constant, not pendulate, and if its quality fulfils the requirements of raw material treatment manufacturers' regarding primary raw materials. So waste logistic chains can only be acceptable if raw materials produced from waste can be delivered in time with constant quality. The environmental political targets from a professional point of view give new logistics tasks: the emergent municipal wastes appear selectively apart, in smaller items than before, already selected by relatively plenty of utilizing aims, at the senders location or collections points („waste collection island"), and it would be imperative to assign logistically optimum loads. Because of this the complexity of network control is going to increase, and this demands more resources to manage the dynamic transport demands of the total network. The claims of the raw materials treatment industry will finance the system, because the primary raw materials are getting more and more expensive and the primary raw materials' replacement will be more economical. Within the above-explained process as an individual problem, the municipal solid trash collecting and its treatment must be optimised from an environmental point of view. Applying characteristics of collection modes can be seen at Table 1.

Table 1. Characteristics of collection modes of solid waste from settlements

Table 1.

Characteristics of collection modes of solid waste from settlements

[2]

Type of settlement		City		Town
Type of residency		Blocks of flats	Houses	Houses
Trash bin		*1100 litre container per staircase*	*110 litre trash bin per House*	*110 litre trash bin per House*
Collection of organic material		*“Waste collection island”*	*110 litre trash bin per House*	*110 litre trash bin per House*
Selective, Light Packing material	*“Yellow bag” method*	*Not available*	*Available (plastic, metal, paper)*	*Available (plastic, metal, paper)*
	“Waste collection island” (plastic, metal, paper, glass, organic min. 1500 person)	*Max. distance of 250 metres from staircase*	*Min. 1500 persons, Supermarkets*	*Min. 1500 persons, Town centre*
Waste yard (min. 15.000 persons)		*Hazardous waste (battery, etc.),*		-

Nationwide the miscellaneously collected wastes are removed by waste collecting vehicles from residential estates and if the settlement has a certain distance (approx. 30 km) away from the nearest refuse dump, than a two-step transportation is going to be used with the usage of a shifting place. The selectively collected waste is being transported from waste collection islands and waste yards by special transport wagons, which transport the waste to special places, where further cleaning of waste will take place. According to the report of ÖKO-Pack Kht. there are 4500 selective waste collection islands, where in 2007 the residential population collected more than 50 thousand metric tons of waste. This is a considerable rise from 2003, when 15 thousand metric tons were collected. And a future further dynamical rise can be predicted. The environmental friendly waste collection is slowed by the too few collection places, but this number probably will increase within a short period. Several surveys have demonstrated that an average citizen would walk 200-300 metres to a selective waste collection island. Waste logistics has an emphasized focus on plastic waste treatment. Before 2006, 90 percent of the collected and selected PET bottles, as well as the other plastic wastes, received pre-treatment, were milled and transported to Chinese manufacturers, where mostly textile products were made. Since 2008, the situation has changed, 70-80 percent of plastic - as a secondary raw material – is transported to Romania, Slovakia, Germany and Czech Republic, where it’s been used in textile industries. The remaining percentage is transported to China, and this will probably not change, as there will be no demand for the poorest quality of milled plastic elsewhere. In the future the European and Chinese plastic-trash-export will equalize. In 2006, 38 thousand metric tons, and in 2007, 43 thousand metric tons of Hungarian plastic waste was recycled and within the next 2 or 3 years further shifts are awaiting at the market, because of the fact that nowadays several industrial investments are being planned. The development of new manufacturers can be also related to the development of new technologies that can provide a better quality of secondary raw material. The multistage collection task of waste requires complex logistics planning and operative control, where efficient results can only be achieved if informatics and computer techniques are already applied (simulation models, optimal route planning, etc). Because of this, the following mentioned constraints have to be considered:

- The quantity of waste and their dispersion in space and time
- The available vehicles
- The data sets of the collection area

3. Road transportation and Waste management

In the last few thousand years nature has given humanity a stable base of living and an almost infinite supply of resources. In the early ages humanity made changes to the environment with limited technology, but the rate was infinitesimal compared to the size of the natural environment. Global changes were not detected. In the last two or three hundred years there was an explosion in the development of the industrial and technical sector, which gave people a multiplied set of tools to encroach nature. Motorization has been developed so dynamically that air, soil, and water pollution are considerable to the amounts of air, soil, and water on the Earth.

Sustainable development is a more controlled development, where the pace of technical development, the satiation of increasing supply and the raw materials and resources of the Earth are poised so that the rate of living and opportunities of the next generations need not be worse. Transport systems perform vital societal functions, but in their present state cannot be considered ‘‘sustainable’’. Particular concerns in this respect include climate change, local air emissions, noise, congestion, and accidents.

Transportation cannot be replaced because it is a part of the production chain. Societies are horizontally and vertically differential. People live in different places and do different things for living. The manpower, the stock, the semi-finished and finished products must be transported. The importance of the transportation sector is indicated by the sector production which is about 10% of the GDP of the European Union and more than 10 million people are working in this sector. One of the most emphasized goals of the transport policy of the European Union is sustainable mobility. For this reason transportation systems must be developed and standardized, the effectiveness of transportation service must be increased, while the environmental pollution must be decreased or prevented. This is a task for engineers and operators as well. The vehicles used nowadays are polluting. Most of them are converting fossils to mechanical energy and during this conversion at least 40% of the fossil energy is converted to heat energy that is useless, thereby heating our environment. [3]. The majority of the energy we use in the transport sector is mostly based on non–renewable fossil fuel. Nowadays with the great human impact, that is considerable to the size of atmosphere, the relation can be changed. More than the quarter of the total emission of CO_2 caused by the humanity is produced by road transportation (Figure). Within the transport sector, road transport's market share is the largest and it is increasing due to its superior service, in terms of greater flexibility, reliability, speed and lower probability of damage.

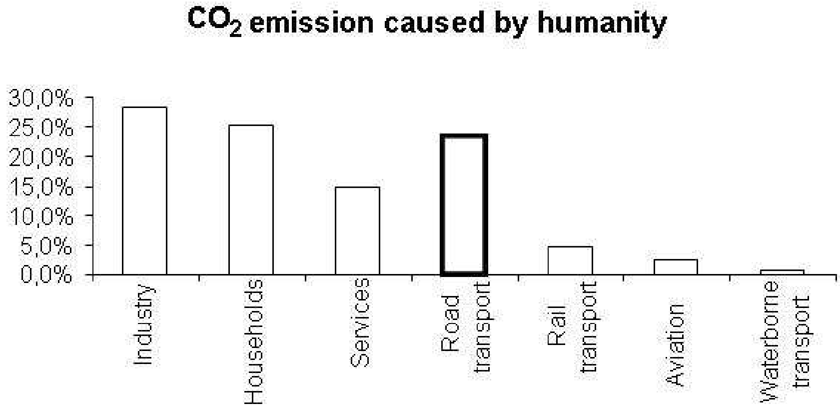

Figure 1. The road transportation contributes to climate change (source: EUROSTAT 2005)

Until now we have had only one solution to satisfy our mobility demands, to burn fossil fuels in internal combustion engines. Mostly these types of engines drive our vehicles nowadays. Road transportation has negative external effects on society. These are cumulative problems of our society, which ruin our standard of living in towns. The garbage and waste nowadays is mostly transported on road. In the past years, consumers, companies and governments have increased their attention towards the environment. In fact, our entire society is more aware of environmental damage caused by human actions due to increased exposure in the media, e.g., global warming and the depletion of natural resources. Companies invest more in the assessment and reduction of the environmental impact of their products and services [4]. Household waste collection is expensive to operate, and designing efficient collection strategies is vital not only to reduce operating costs and vehicle emissions, but also to maximise the amount of recycling generated, whilst minimizing any traffic congestion associated with refuse collection vehicle (RCV) operations [5]. If we take into consideration that the externalities should be expressed in monetary terms and internalised, that means the demand price curve for waste transportation is going to be raised, then the demand for waste transportation is going to be lowered. That means that the secondary raw materials mainly based on garbage are going to be more expensive, and could lose market share with the internalization of externalities of road transport compared to primary raw materials. Conceptions of modern city logistics can treat the above revealed problems. The implementation of such a conception can be done only with the cooperation of all those requiring organisational instruments [6].

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Flexibility in Supply Chain Management

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Abstract: For organizations, flexibility is becoming more important. All executives would like their organizations to perform better, and most seek ways to make that happen. This publication focuses on flexibility, as a key dimension of competitive strategy. Important issue concerning flexibility is for organisations to be able to understand and manage it strategically. We outline the definition and dimensions of flexibility, including a literature review.

Keywords: *supply chain, flexibility, performance*

1. Introduction

A supply chain is a system of people, activities, information, and resources involved in creating a product and then moving it to the customer. Many organizations attempt to integrate and closely coordinate the various elements of their supply chains in order to enhance efficiency. Indeed, minimizing cycle time – the time it takes to fulfill a customer's needs – has been a central goal of executives in recent decades.

2. The three A's

Nowadays supply chains, not companies, compete for market dominance. But companies often have diverging incentives and interests from their supply chain partners, so when they independently strive to optimize their individual objectives, the expected result can be compromised. The best efforts of one company could be wasted if its supply chain partners do not synchronize their efforts accordingly.

To respond to the high degree of uncertainty associated with product variety proliferation and disruptions due to unexpected crises, supply chains need to be agile and flexible to match demand with supply. And companies need to develop supply chains that are adaptable, that respond to the systematic changes of the market and the customer.

In addition, companies must be ready to adjust their supply chain structures and strategies when change occurs. Given the potentially diverse interests of the many players in the value chain, companies need to align their incentives so each acts in the best interests of the whole and the total supply chain is optimized.

2.1. Agility

Agility is the supply chain's relative capacity to act rapidly in response to dramatic changes in supply and demand. Agility can be achieved through the use of buffers. Excess capacity, inventory, and management information systems all provide buffers that allow a best value supply chain to provide better service and be more responsive to its customers. Rapid improvements and decreased costs in deploying information systems have enabled supply chains in recent years to reduce inventory as a buffer. Much popular thinking depicts inventory reduction as a goal in and of itself. However, this cannot occur without corresponding increases in buffer capacity elsewhere in the chain, or performance will suffer. A best value supply chain seeks to optimize the total costs of all buffers used. The costs of deploying each buffer will differ across industries; therefore no solution that works for one company can be applied directly to another in a different industry without adaptation. Agility in a supply chain can also be achieved or improved by co-locating with the customer. This arrangement creates an information flow that cannot be duplicated through other methods. Daily face-to-face contact for supply chain personnel enables quicker response times to customer demands due to the speed at which information can travel back and forth between the parties. Again, this buffer of increased and improved information flows comes at an expense, so executives seeking to build a best value supply chain need to investigate the opportunity and determine if this action optimizes total costs.

2.2. Adaptability

Adaptability refers to a willingness and capacity to reshape supply chains when necessary. Generally, creating a single supply chain for a customer is desired because this helps minimize costs. However, adaptable firms realize that this is not always a best value solution. For example a customer requires one type of products to be repaired in less than eight hours, while another type of products can be repaired and returned within one month. In order to service these varying requirements efficiently and effectively, the company (whose supply chains maintain the equipment) must devise adaptable supply chains. In this case, spare parts inventory is positioned at close proximity to the type of products requiring quick turnaround, while the less time sensitive products are sent to a centralized repair facility. This supply chain configuration allows the company to satisfy customer demands while avoiding the excess costs that would be involved in localizing all repair activities. In situations where the interests of one of the firms in the chain and the chain as a whole conflict, most decision makers will choose an option that benefits their firm. This creates a need for alignment among chain members.

2.3. Alignment

Alignment refers to creating consistency in the interests of all participants in a supply chain. In many situations, this can be accomplished by carefully written incentives into contracts. Collaborative forecasting with suppliers and customers can also help build alignment. Taking the time to sit together with participants in the supply chain to agree on anticipated business levels permits shared understanding and rapid information transfers between parties. This is particularly valuable when customer demand is uncertain, such as in the retail industry.

3. Literature review on flexibility

Flexibility can be often viewed as an adaptive response to environmental uncertainty. In the entrepreneurial literature flexibility is also viewed as being adaptive. ''The high levels of uncertainty and very rapid rates of change that characterize new ventures require fluid and highly adaptive forms of organization. An organization that can respond quickly and effectively is a must. Successful entrepreneurs are adaptive and resilient''[8]. Similarly, in the supply chain literature, flexibility is seen as a reaction to environmental uncertainty. Flexibility is a key dimension of competitive strategy. Japanese manufacturers are turning their attention to flexibility, having achieved mastery in quality. As companies place more and more strategic emphasis on flexibility, enhanced performance seems likely to tend to follow. Customization is another form of flexibility that is becoming increasingly important. There are five major types of supply chain flexibility; 1) product, 2) volume, 3) launch, 4) access, and 5) responsiveness [9]. Product flexibility is defined as the ability to handle difficult, nonstandard orders, to meet special customer specifications, and to produce products characterized by numerous features, options, sizes, and colors. Product flexibility is a value-adding attribute that is immediately visible to the customer. Volume flexibility is the ability to effectively increase or decrease aggregate production in response to customer demand. Launch flexibility is the ability to rapidly introduce many new products and product varieties that requires the integration of numerous value activities across the entire supply chain. Flexibility in production of type of cars for example can led to consumer perceptions of technology superiority for the given company based on their introduction of several varieties of the new product. Access flexibility is the ability to provide widespread or intensive distribution coverage and responsiveness flexibility captures the overall ability of the firm to respond to the needs of its target markets. Much of the literature on flexibility is limited to operational issues in the supply chain and does not specifically address purchasing. Since the purchasing function is a vital part of the supply chain it must provide support to enhance these flexibility strategies. Secondly, the current literature does not address the specific skills necessary to attain these levels of flexibility.

Flexibility is not a new concept; it has been researched in business by economists for over 60 years. The early focus of research is on the ability of a production facility to produce something other than originally intended. The acceptance by management of the importance of flexibility is demonstrated as early as 1975. At that time it became clear that flexibility was the evaluation criterion most used to assess organisational effectiveness. The long established recognition of the importance of flexibility is further supported by another authors who argues that capitalist industry has always combined flexibility with inflexibility, and what are possibly emerging now are new permutations of each rather than a simple trend towards greater flexibility. The literature shows that flexibility is seen as a `good thing'. However it is not a `free good'. Specifically, it has been shown that production plants that wish to have the ability to produce more than one good will have a higher unit cost curve than a plant specialising in the production of a single good. More recently, it has been outlined that there can be disadvantages to strategic flexibility in the form of increased costs, increased stress on employees and a lack of organisational focus. While flexibility may have associated costs, organisations continue to seek it in order to increase competetiveness. Flexibility, especially in the guise of adaptive manufacturing technologies, has become as important a determinant of competitiveness as costs. However, there is evidence that greater flexibility is needed in the strategic process now compared with the 1970s: flexibility has become so important to organisations that it may have a role as a critical success factor in its own right. There is no doubt about the importance of flexibility and believe that today's world demands more flexibility. The real issue concerning flexibility is for organisations to be able to understand and manage it strategically.

4. Definition of flexibility

While use of the term `flexibility' is ubiquitous, its meaning is not always clear. One reason why flexibility is so difficult to define is that definitions are often coloured by particular managerial situations or problems. Definitions available propose that flexibility is an ability or capability which an organisation possesses to change or react. Flexibility is multi- dimensional in that an organisation can be very flexible in some ways and less flexible in others. Consequently, they argue, it is not entirely appropriate to talk simply of a `flexible system'. Moreover, flexibility is polymorphous, having different meanings in various contexts. In order to progress research on flexibility, identification of the multiple types of flexibility is required so that they can be split into component parts which can be prioritised, measured and improved. Here, flexibility is defined as `the capacity to adapt'. Capacity is chosen in preference to capability because it better characterises the multi-dimensional element of flexibility.

5. Dimensions of flexibility

Flexibility can be defined as consisting of two dimensions, temporal and intentional. In expanding the framework we identify four dominant dimensions of flexibility in the literature. The first is temporal; how long it takes an organisation to adapt. The second is range; the number of options that an organisation has open to it for change that was foreseen and the number of options it has available to react to unforeseen change. The third is intention; whether the organisation is being proactive or reactive. The final dimension of flexibility is focus; specifically whether the flexibility is gained internally to the organisation or by managing external relationships with trading partners.

5.1. Temporal

The first dimension of flexibility, that is temporal, can be described in terms of the length of time that it takes an organisation to respond to environmental changes. There exists a typology of environmental change: operational, competitive, strategic. This typology can be mapped onto flexibility to conceive three types: operational, competitive and strategic. It is essential to identify `the critical time perspective or perspectives'. Flexibility can be divided on a time basis into three categories, operational, tactical and strategic. Operational problems are short-term, e.g. replanning due to breakdown of a machine or unexpected shortage of a raw material. Tactical problems are medium-term e.g. changes in design or rate of production. Strategic problems are long-term, e.g. investments in machinery or business expansion. There are three degrees of temporal flexibility. Operational flexibility is the ability to change day-to-day, or within a day, as a matter of course. Tactical flexibility is the ability to occasionally change or adapt, say every quarter, and to make changes which demand some effort and commitment. Strategic flexibility is the ability to make one-way, long-term changes which involve significant change, commitment or capital and which occur infrequently, say every few years or so. In the new hyper-competitive markets the length of time, for which a given flexibility will give a competitive advantage, will be significantly reduced. The temporal dimension of flexibility is the ability of an organisation to adapt within a given time frame.

5.2. Range

The second dimension of flexibility is the degree to which an organisation can adapt to foreseeable and unforeseeable changes. On one side, flexibility is a strategic response to the unforeseen. There is an other, which incorporates both foreseen and unforeseen environmental changes. `A flexible firm' possesses the ability to adapt to ensure its continued viability. One way to achieve this is by planning for developments in the environment which are likely to occur (foreseeable events). A second way is by adapting to circumstances; events taking place in the environment, which were by no means predictable or foreseeable. Two types of flexibility exist: Type I and Type II. Type I flexibility relates to the concept of risk and involves planning for foreseeable events. Type II flexibility relates to uncertainty and how to make good use of new disclosed opportunities and to rapidly respond to uninsurable (unforeseen) changes in the market. The second dimension of flexibility measures the range of options available in responding to environ- mental change. This dimension comprises two areas, the range which has been planned for and the range which is possible for events that were not planned for. Foreseen to unforeseen represent the two ends of the continuum for this dimension of flexibility.

5.3. Intention

The third dimension of flexibility acknowledges that, while change in the environment is inevitable, organisations are not helpless. This dimension of flexibility is the degree to which organisations take an offensive or defensive stance towards flexibility. Those who take an offensive role attempt to control change in the environment in such a way that they can gain competitive advantage. On the other hand, defensive organisations react to changes after they have occurred and try to minimise the impacts. This attempt to manage flexibility has also been described as active or passive.

5.4. Focus

The fourth dimension of flexibility is the area in which the flexibility is created. There can be two types of strategic flexibility, internal and external. In doing so the earliest reference to this dimension of flexibility is provided. The significant internal areas which can create internal flexibility are manufacturing, employee flexibility and organisational structure. The main avenues for obtaining external flexibility include suppliers, alliances, and multinational operations. The next section discusses the three internal areas, the subsequent section discusses external flexibility.

5.4.1. Internal

One area in organisations, where it is proposed that the attainment of flexibility is possible, is in the manufacturing process. It is argued that flexibility in manufacturing is a critical source of competitive advantage. This can be brought about by creating the `flexible factory'. Some believe that new flexible manufacturing technologies will bring revolutionary change by eliminating the manufacturing flexibility advantages historically held by small firms and manufacturing efficiency advantages historically available to large firms. Human resource management is a second area through which organisations can create flexibility. Specific avenues are by permitting teleworking and by substituting part-time, contract, and other 'contingent' workers for more expensive full-time employees. High worker involvement and flexible wage schemes provide manufacturers with more flexibility than the flexible IT they use. Operational flexibility is determined primarily by a plant's operators and the extent to which managers cultivate, measure, and communicate with staff. Equipment and computer integration are secondary. A third route to organisational flexibility is provided through organisational structures. Organisations can obtain the desired flexibility by altering their structure to suit their competitive situation. An appropriate organisational design is based upon the creation of fast feedback loops, enabling processes to react quickly to changes, while retaining reliability.

5.4.2. External

One way to obtain external flexibility is to diversify into different products and markets. Subsequently external flexibility is associated with subcontracting production to provide the flexibility to step up or step down production. The trend towards outsourcing coincided with the trend to focus on `core competences'. In this way flexibility is achieved through `diverse specialisation'. This occurs where each firm focuses on what it does best and leverages the capabilities of other entities for complementary activities. An organisation obtains flexibility by increasing the levels of external flexibility available to it by increasing its ability to switch, at short notice, between the products its suppliers produce and also the ability to switch suppliers if necessary. The networked organisation is used to describe situations where individual organisations concentrate on their core competences and use other firms where required to enable a complete product to be made. Organisations working together as a network achieve `flexible integration'. That is, the network provides greater flexibility than that achievable through vertical integration by a single organisation. One main reason for this is that individual firms in the network can be added or dropped rapidly as required. The network implies a narrower range of output at the level of the individual firm, but a great degree of flexibility at the level of the network. Thus, an individual organisation in a network obtains lower internal flexibility while simultaneously obtaining increased external flexibility. Network forms of organisations may, in fact, be in the process of becoming the signature institutional form of this era – precisely because they offer managers the best working solution to the challenges posed by the increasing need for flexibility. Network form is especially appropriate for attaining flexibility. Fast, flexible and co-operative supply chains are a key issue for the survival of organisations. The idea of the network form and the external flexibility it creates is central to new concepts emerging such as `adaptive channels' and `quick response'. Adaptive channels are situations where organisations have worked with their distribution channels to make them more flexible and responsive. Quick response is a strategy for linking retailing and manufacturing to provide the flexibility to respond quickly to shifting markets. The fourth dimension of flexibility, focus, demonstrates that the attainment of flexibility is no longer confined within the boundaries of an organisation. Flexibility can also be obtained externally and one way of achieving this is through external links with other organisations, such as suppliers, customers and distributors. The fourth dimension of flexibility shows that external trading partners and links with them can be a source of flexibility.

6. The need for flexibility

The previous section addressed that changes in the purchasing skill mix are expected to require a more entrepreneurial approach due to the increased competition in today's business arena. It is becoming increasingly difficult to compete on price, quality, and product differentiation. Companies have to compete on service, which means developing a flexible supply chain that is customer focused. Specific purchasing techniques will also permit flexibility. Many purchasing professionals are involved with sophisticated hedging techniques that allow flexibility and risk management in pricing. This flexibility is quite evident in airline tactics for the purchases of oil in the current period of rising prices. Those that hedged more of their purchases such as Southwest Airlines are profitable while competitors are suffering from higher fuel prices that cannot be passed along to consumers. Strategic sourcing enhances the capacity of a plant to be more flexible. The ability of the supply base to respond to the demands made by changes in the buyer's plant contributed to improved change effectiveness in the buyer's plant. The careful selection, development, and integration of suppliers with the necessary capabilities contribute to manufacturing's ability to make changes rapidly and remain flexible. Thus, supplier assessment tools can no longer focus only on price, quality, and delivery but also must focus on flexibility in responding to suppliers as well as customers. The literature described entrepreneurs by their ability to adapt to the changing demands of their customers and their businesses. In this rapidly changing economy, rigidity often leads to failure. As our society, its people, and their tastes change, entrepreneurs also must be willing to adapt their businesses to meet those changes. Entrepreneurs have a high tolerance for ambiguity and changing situations in the environment in which they most often operate. This ability to handle uncertainty is critical because they are constantly making decisions using new, sometimes conflicting information obtained from numerous unfamiliar sources. One trait of the entrepreneur is being ''flexible minded''. This involves being sensitive to the changing marketplace and responding by implementation of new market strategies that address changing customer preferences through innovative products and services. Attaining this operational flexibility requires skills that support the need to be flexible.

7. Conclusions

The definition of flexibility is fraught with difficulties since it has many dimensions. Specifically, here, flexibility is seen as having four dimensions; temporal, range, intention and focus. The temporal dimension is the time which it takes an organisation to react to change. The range dimension is the potential responses that the organisation possesses, first, to changes which were foreseen and, second, to those not foreseen. The intention dimension acknowledges that organizations can either be offensive or defensive in their approach to flexibility. In other words, while change is inevitable, certain organisations manage it to their advantage and others do not. The final dimension of flexibility is focus, which can be both internal and external. The flexibility available is not confined to within organisational boundaries.

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Control Model of Road Transportation

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Abstract: Transportation of goods is a complex system, which is only possible to control by coordination of human and material elements involved. Controlling the road transportation company is a series of complex tasks and activities. Preserving competitiveness requires effective utilization of available devices and resources, high quality performance and satisfaction of the consigner party. In consequence, it has practical reasons why we do have the extremely lot of information. Thus, it is highly deemed to improve theory to keep up with or come before the speedy development of technology. Our research work aims to find a solution for this problem.

Keywords: Information system, transportation controlling, effectiveness off transportation, complex controlling system

1. Introduction

Road transportation of goods is a process spread in space. After starting the actual transportation process central control is hard to realize, as no effective interference is possible. However, transportation needs control where some feedback is given depending on available communication channels.

Transportation companies strive for improving utilization of transportation implementations, though, which is difficult to carry out by applying traditional methods.

Info-communication technology enables realization of controlling the transportation process. Being reinforced in everyday practice, some of its elements are working but still there is no detailed, systematic model available, which can be applied on the specific field of transportation.

The aim of the present research is to establish a general controlling model, which gives a unique systematic analysis of road transportation processes, complicating factors of these, interference possibilities, places and methods. The model is also used for effective controlling of transportation processes by applying up-to-date information technology and methods.

The article focuses on the conditions of and approaches to modeling. The study presents practical and theoretical solutions used on the transportation market for forwarding goods to their proper destination.

Although there is a quite clearly set system of terms concerning transportation, it is necessary to define some terms to have a unique basis of approach. The study specifies the tasks, implementation and processes of transportation, which contributes to making issues described in the present study transparent. After describing road transportation processes the article moves on to revealing the issue „Why does the transportation process require control?” from various aspects.

2. Defining road transportation

Transportation can be examined on the whole and in details. Transportation is mostly considered as part of a commercial process, where it is not important if the carrier forwards its own or another company’s products. However, in the present article transportation of goods is considered ’only’ as part of transportation.

The carrier does not consider economic processes required to the actual transportation task, as transportation is just an activity to realize by using specific technology. Thus, transportation is an uncomplicated activity with three actors involved, and with the *carrier* in the centre of activity.

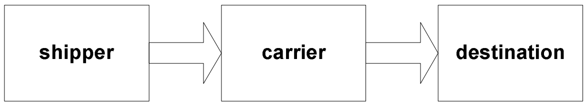

Figure 1. Raft model of transportation

From the aspect of the carrier transportation is a production task. Transportation, that is the *company objective* is regarded as the *primary company process*. Other processes like management, additional activities are subordinated to and responsible for realization of the primary company process.

The aim of the carrier is to have constant and effective economic achievement. Its realization is only possible by keeping time, quality and not exceeding costs.

This requires appropriate planning and its realization. So, transportation is a control task (see Figure 2) where drivers carry out tasks by regarding the set plans. Realization of transportation is strongly affected by complicating factors, which often results in deviating from the plans.

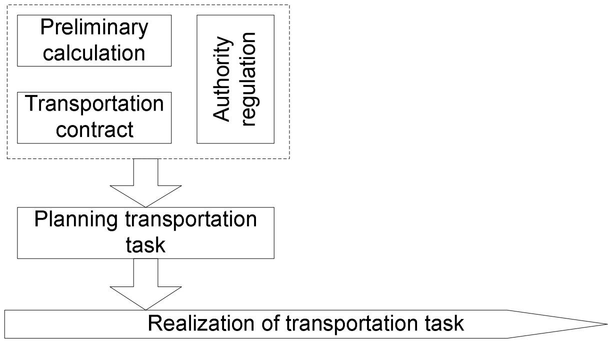

Figure 2. Transportation as a control task

3. Demand for controlling transportation processes

The way of realization of a transportation task can be planned. Effective planning today is aided with information technology involving local implementation, network based services, GPS, information data bases. There are, however, plenty of factors affecting and complicating transportation process from the sender to the destination:

- traffic jam, blocks, diversion due to accident
- decreasing ability of driver's concentration (e.g. due to extremely heavy traffic)
- unexpected change of weather conditions
- technical problems
- damage on the goods
- driver's illness
- missing the connection by combined transportation
- waiting (e.g customs)
- other problems

Deviating from the plan results in financial and/or moral losses for the carrier, therefore the carrier obviously makes efforts to solve the problems emerging during the transportation.

In the planning phase one must consider factors affecting transportation, and that is why some reserves have to be calculated. To solve the problems the driver takes own decisions based on previous experience, which is effective in most cases. The driver may ask for instruction (on the phone) if the problems are beyond the driver's competence.

Effectiveness of transportation is shown in the function

$$E_T=f(I, T, Q)$$

where

I – income from realizing transportation task, $I=P_A - C$, aim: I_{max}

P_A – agreed price (for transportation),

C – total cost of transportation,

T – time difference compared to agreed time, $T=T_A - T_R$, aim: $T \geq 0$

T_A– time of realization agreed on, set in contract

T_R– time of realization

Q – quality, no damage

The above approach is applicable for one concrete transportation task. At company level several tasks are carried out in a specific period of time. It is impossible to reach maximum effectiveness in realization of all tasks, and there are also cases when business policy requires tasks calculated with losses. The consequence is:

$$E_c^n = \sum_{i=1}^{n} E_t$$

where: E_c^n – company effectiveness in a specified period of time (n)

The bigger the company is and the more transportation tasks are carried out simultaneously, the less effective solution is to take private decisions on solving problems restricting transportation. The best way is to prevent complicating factors or at least minimize their affects.

For proper transportation there are three conditions to fulfill:

1. The dispatcher must be provided with all necessary information concerning all transportation tasks.
2. It is necessary to elaborate an evaluation and decision algorithm which makes information processing and decision making possible.
3. The driver must be informed on the decision in time.

Information on task management is sent continuously to the dispatcher who can evaluate and check phases of task management and intervene when necessary. Due to continuous feedback control comes from a higher organization level.

The aim is to establish a complex control system model, which, by using info-communication technology, cumulates information with the dispatcher on all complicating factors occurring during the transportation. The dispatcher is enabled to make fairly optimum decisions after evaluating the incoming information.

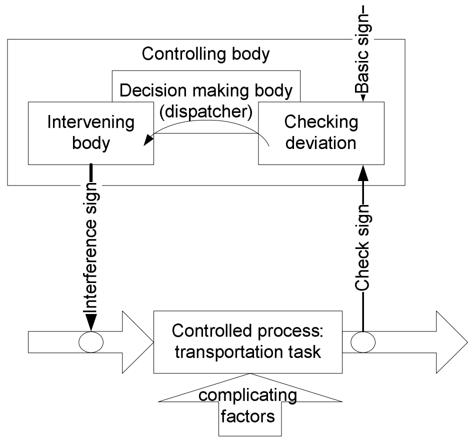

Figure 3 Controlling model of transportation

4. Information basis of the controlling process

Some pieces of information concern different units involved in transportation (vehicle, goods, driver), nevertheless, most pieces of information are independent of these. Basic information types concerning control task are:

- geographical position and condition of units involved in transportation
- complicating factors and restrictions occurring during transportation

There are several technical solutions (e.g. GPS) for managing problems of the first type as they are able to provide all required information. There is no satisfactory amount and definition of information available on the latter type of problems, or rather real time information transfer to the dispatcher is not possible by the present technology.

Due to the latest IT technology applications there is an enormous information flow in the present transportation system. This huge amount of information is not systematic, which contradictorily increases uncertainty about transportation processes instead of minimizing or stopping it.

The primary aims of the planned research are revealing and systemizing the information types which occur during transportation and affect it, and those which emerge in infrastructural setting and affect transportation processes, and furthermore establishing a control model applicable for utilizing information.

Time is an extremely important factor by information utilization. Control is only effective if information on problems occurring during the transportation process is forwarded well in time so that measures for problem management can be taken.

5. Conclusions

Transportation of goods is a complex system, which is only possible to control by co-ordination of human and material elements involved. Controlling the road transportation company is a series of complex tasks and activities. Preserving competitiveness requires effective utilization of available devices and resources, high quality performance and satisfaction of the consigner party. Speed, reliability, realistic prices are dominant when selecting a carrier. All these factors are strongly related and complex controlling systems depend on each other. There occur several complicating factors during the transportation activity, which, combined or one by one, barrier task realization. It is obvious that it is not possible to prevent or foresee all these difficulties (e.g. bad weather conditions, blocks, diversion) but their affects can be minimized.

Service quality of transportation companies is mostly determined by utilization of info-communication technology. The market offers various implementations and technology which aid transportation task management. It needs, however, further examination, to what extent these are applicable for the actual purposes. At the same time, the system of necessary information also needs consideration both in terms of information technology and transportation, since due to the multiplicity of up-to-date technology the amount of information is continuously increasing. The ever increasing amount of information does not definitely mean higher effectiveness. It has practical reasons why we do have the extremely lot of information. Thus, it is highly deemed to improve theory to keep up with or come before the speedy development of technology. Our research work aims to find a solution for this problem.

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Lean/agile Supply in Wire Logistics

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Abstract: The stability of competing modern supply systems (which are rather networks than chains) is becoming crucial. Lean thinking led to waste elimination and inventory reduction alongside the chain, but in extended intercontinental supply networks there are uncertainties in production and distribution processes, and also in commercial activities. The growing need to accommodate variety and demand uncertainty has resulted in the emergence of the concept of agility, closely associated with quick response. Lean/agile type logistics systems have analogues in the water- and electricity supply. These systems were traditionally developed to follow the demand fluctuation with oversizing the infrastructure: water supply works with protective inventories at different levels (reservoirs, water towers) while electricity supply applies protective capacities in power generation (fleet of power stations with different characteristics and costs) in providing the security of supply on marginal parameters. The characteristics of different wire-supply systems request different types of hybridization (which will be technically possible in the near future) to prevent system failures. The investigation confirms the strong need for developing better demand-management tools (according to the real nature of consumption) and the importance of decoupling points in order to achieve an appropriate design of a given supply system.

Keywords: lean/agile supply, oversize infrastructure, wire logistics

1. Introduction

The competition is shifting from firm versus firm to supply chain versus supply chain, and supply chain management is the approach for designing, organizing, and executing these activities. Supply chain management integrates suppliers, manufacturers, distributors, and customers through the use of information technology to meet customer expectations - in product variety, low cost, high quality, and fast response - efficiently and effectively.

As agile paradigm is relatively new, there are different approaches in the literature, considering lean and agile features in cooperation (summative viewpoint) [1], in competition (competing strategies) [2], in contradiction (separation tools) [1], and in symbiosis (decoupling in system design) [3].

There are general methods in the stability analysis of a supply system: the top-down or the bottom-up approach, the analysis of system structure and counteractions with the environment, the history of development, and finally failure analysis – which could be fruitful when analysing the reasons of oversizing in wire supply systems. The analysis of wire-logistics systems could be profitable for conventional logistics because these systems provide marginally different stabilization strategies based on pure technical conditions, although the daily and seasonal load curves are similar. What is also important that general operational parameters and data of water and electricity supply are published and free for analysis (these type of commodities form technical monopolies – there are no technically competing companies in the water supply of Győr and the in the Hungarian National Electricity Supply VER).

2. Theoretic approaches of lean/agile paradigm in modern logistics

2.1. The summative approach and a criticism of being lean and also being agile

Outsourcing manufacture to low cost overseas suppliers is an attractive lure in our global economy, but often undertaken without adequate regard for the market needs and the corresponding demands on the associated delivery systems. Offshore supply offers attractive cost benefits, but there is a strong need for higher levels of inventory to support a slower response capability. When these higher levels of inventory are combined with volatile demand the trade-off is more significant, with resulting obsolescence and shortages. However, what is commonly assumed is that one solution fits all and the consequence of the mismatch is not appreciated until it is too late.

Lean manufacturing and lean thinking have demonstrated the broad potential of the elimination of waste in improving business performance. The emphasis on waste elimination is closely associated with reduced inventory and one of the key concepts is enforced problem solving. The JIT management system was found to simultaneously improve customer service and efficiency by focusing on eliminating variation in the system and enabling flow. Through set-up time reduction, statistical process control, supplier development, total productive maintenance, etc., sources of variation internal to the supply chain were progressively reduced, thus reducing the need for the inventory previously used to protect the flow. For this design of delivery system to work well it is also necessary to stabilize the overall output rate and so decouple the effect of market demand variation.

Agility has less clearly defined industrial origins, but has emerged as a generic term with distinctly aspirational tendencies. Whereas with lean the focus is on eliminating waste and achieving low cost delivery of a standard and stable product, the agile paradigm focuses on the need to deliver a variety of products with uncertain demand. In reality, however, there is always variation in the system due to various factors, such as machine failure, process adjustment, quality problems, set-up delays, etc. If we now acknowledge the existence of these fluctuations, not only will the disruption directly affect the event concerned, but more importantly, there will also be a knock-on effect down the line of dependency. The traditional means of overcoming this is to place inventory between each process, so effectively decoupling the impact of the fluctuations. The functions of inventory, such as cycle, decoupling, buffer, etc. can be directly traced back to such system fluctuations and, in combination, to the supply chain amplification effects. An alternative to investing in inventory to protect the flow under these conditions is investing in additional capacity. This option has traditionally been avoided in efficiency focused volume manufacture, but excess capacity on most resources is an implicit feature of functional batch and cellular manufacture.

2.2. The viewpoint of competing strategies (match LSC-SP, ASC-IP, HSC-HP)

The lean supply chain (LSC) is supported by efforts to achieve internal manufacturing efficiencies and setup time reduction, which enable the economic production of small quantities and enhance cost reduction, profitability, and manufacturing flexibility to some degree. The short setup times provide internal flexibility, but a lean supply chain may lack external responsiveness to customer demands, which can require flexibility in product design, planning and scheduling, and distribution in addition to manufacturing. Organizations recognize that along with the added variety and responsiveness squeeze, they must remain adaptable to future changes. Customer requirements are continuously evolving and product life cycles are growing shorter, therefore, along with being lean, supply chains must respond to the market. Standard products (SP), which tend to be simple products with limited amounts of differentiation, should be produced by lean supply chains, which focus on simplicity, cost reduction, quality and limited amounts of flexibility. In this environment, the partners employ manufacturing practices that enable the economic production of small quantities. Small batch production allows manufacturers to keep inventory costs low, achieve manufacturing cost reductions, and meet customer demands for a variety of products.

The agile supply chain (ASC) paradigm relates to the interface between companies and markets, an external perspective on flexibility. Successful implementation involves responding to rapidly changing and continually fragmenting global markets by being dynamic, context-specific, growth-oriented, flexible across the organization, and driven by customer. An agile supply chain focuses on responding to unpredictable market changes and capitalizing on them through fast delivery and lead-time flexibility. It deploys new technologies, methods, tools, and techniques to solve unexpected problems. It utilizes information systems and technologies as well as electronic data interchange capabilities to move information faster and make better decisions. It places more emphasis on organizational issues and people (knowledge systems and empowered employees), so decision making can be pushed down the organization. It is a systematic approach that integrates the business, enhances innovations across the company, and forms virtual organizations and production entities based on customer needs. Early in their product life cycle, innovative products (IP), which may employ new and complex technology, require an agile supply chain.

An intermediate chain known as the hybrid supply chain (HSC) generally involves "assemble to order" products whose demand can be forecast with relative accuracy. The chain helps to achieve mass customization by postponing product differentiation until final assembly. The lean or agile supply chain techniques are utilized for component production with different characteristics. The agility is needed to establish a company–market interface to understand and satisfy customer requirements by being responsive, adaptable, and innovative. As the market and customer expectations shifts, the supply chain should make a transition from lean to agile. Hybrid products (HP), which are complex, have many components and participating companies in the supply chain. Some components may be commodities while others may be new and innovative.

2.3. Separation tools: eliminate the contradictions (TRIZ)

The theoretic base of investigation could be the analysis of lean and agile paradigms in terms of dependency, variation, inventory, and capacity.

The focal points of the TRIZ (Theory of Inventive Problem Solving) method are trade-offs, and several tools have been developed for solving the contradictions (identifying a parameter that is subject to opposite requirements, in this case being lean and agile) - if we could define a trade-off explicitly, there would be four generic separation principles which could be summarized as:

- Separation of opposite requirements in space.
- Separation within a whole and its parts.
- Separation of opposite requirements in time.
- Separation upon condition.

2.4. Decoupling the competing expectations in system design

As the lean and agile paradigms have been developed there has been a tendency to view them in progression and in isolation. There is a view that first there was a need to adopt the lean manufacturing paradigm and now manufacturers should strive to become agile. This is too simplistic a view - the lean and agile paradigms are distinctly different, and should have been combined within successfully designed total supply chains. The need for agility and leanness depend upon the total supply chain strategy, particularly by considering market knowledge and positioning of the decoupling point. The agile manufacturing paradigm is best suited to satisfying a fluctuating demand (in terms of volume and variety) and lean manufacturing requires, and promotes, a level schedule. These key differences between the two paradigms relate them to the positioning of the decoupling point. Agility means using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile market place. Leanness means developing a value stream to eliminate all waste, including time, and to ensure a level schedule.

Neither paradigm is better nor worse than the other, indeed they are complementary within the correct supply chain strategy. Once the need for agility and the position of the decoupling point has been identified there are further decisions to be made. The way in which an agile manufacturer differentiates its products from the lean manufacturer is through concentrating on the service levels at the expense of reducing costs.

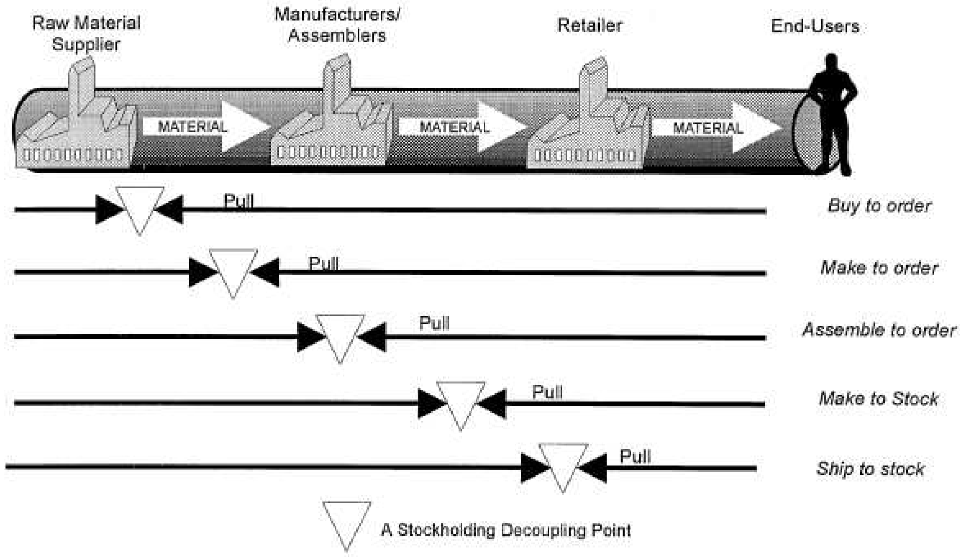


Figure 1. Decoupling of lean and agile strategy

3. The logistics nature of wire-supply systems

3.1. Overview of water and electricity supply

We could not imagine our everyday life without the absolute availability of drinking water and electrical energy [5], [6], [7].

The case of water supply gives an illustrative example of a supply chain where the demand fluctuation could be eliminated by constructing protective inventories (low and high reservoirs – basins and water towers) on different levels in the system. The wells (1st level) need continuous and stable pump operation to provide a balanced service. In the drinking-water supply system of Győr the pumps from wells (more than 30) are able to transmit 66 000 m3/day quantity at maximum. There are 10 900 m3 volume of basins (2nd level) in the system. The main pumps get the water from basins, and transmit it to water towers and high reservoirs (3rd level), which have 18 700 m3 volume in Győr. The consumers could get the requested water from the 3rd level, with standard pressure. The role of water towers in the system design is rather to secure the standard pressure than the volume; the high reservoirs are responsible for quantities.

In summary, the aggregated volume of daily available sources is nearly 100 000 m3, while the maximum daily consumption is about 10 000 m3 (decades ago the consumption was higher, today is about100 l/person/day, which will grow to 150 l/person/day in the next 20 years). Water supply could provide the needs with oversizing at the production and the distribution side (water towers, high reservoirs, and pipes also). The system load is automated by level switches, the physical flows could provide the system stability.

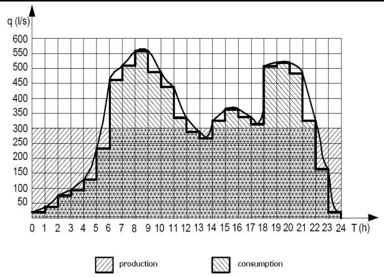
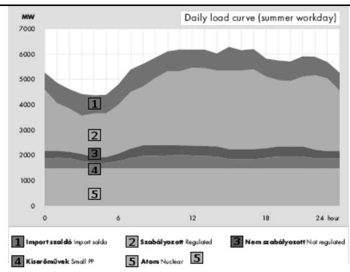
Fluctuating demand	Water supply - Győr	Electricity supply - Hungary
Daily profile		
Security of supply	Protective inventory	Protective capacity
Quality of supply	Robust distribution system (bar, m3/h)	Agile distribution system (V, Hz)
Thriftiness	Lean production	Portfolio optimalization
Stability, Control	Oversizing in inventory and in distribution system	Oversizing in capacity and in distribution system

Figure 2. The nature of water and electricity supply

The case of electricity supply - which is continually growing in European countries - brightly illustrates that a supply chain based on protective capacity for being agile could fulfill the expectations with enormous oversize in the installed generation capacity and also in the constructed distribution network. The electricity supply could be stable and balanced just with a hierarchical decision making structure and with the efforts of the national system operator/dispatcher centre.

At first sight it seems that the product of a power station is the alternating current power, but the real product is not simply the electrical energy, but the availability of electrical energy, whenever the consumers need it. The main function of the electricity supply is to serve the consumer demand with solidly available (security of supply) and satisfactory (quality of supply) electrical energy (with adequate frequency and voltage), as low full cost as possible (thriftiness) – or recently, in accordance with the contracts obtained amongst the partners.

These conditions and contradictions form the central problem of the system operator: integrate the portfolio of sources (the base-load, the regulated and the non-regulated power stations, the fluctuating renewable wind and solar energy) and switch to the optimal network topology, in accordance with changing demands.

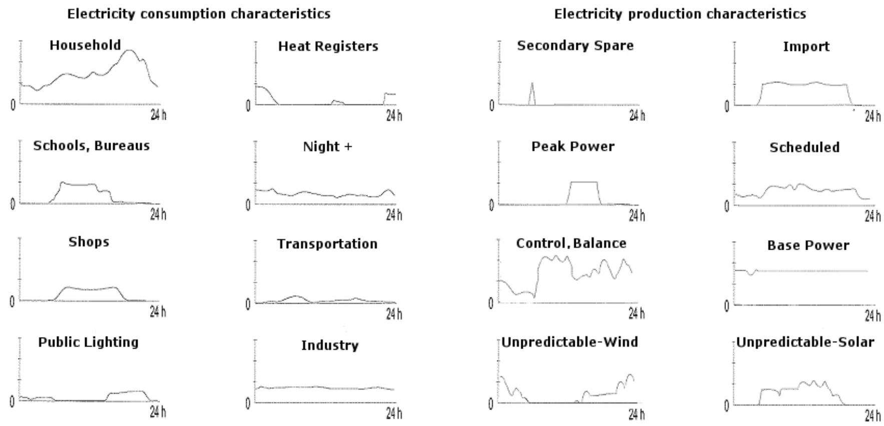


Figure 3. Consumption and production characteristics in electricity supply

From the viewpoint of conventional logistics electricity supply is a typical „pull" system, without significant storage possibilities at the final product (AC: alternating current) level. We should produce the required electrical energy from moment to moment, otherwise the system loses its balance, and the service breaks off – with the high cost of balancing energy, and enormous efforts (and cost) of restarting.

The consumers switch on and off their devices, so the energy demand fluctuates. The daily load curve shows the production, lifestyle and meteorological conditions of a country. In normal mode the switch-on and -off operations counterbalance each other, and the total consumption alternates relatively slowly and at forecastable rate. The daily peak demand and deep valley period are relatively short – but these are the critical points of control range. The in-built capacity of turbines (9014MW) is significantly higher (136%) than the required daily maximum consumption (6602MWh). The standby units are the rotary (hot) and stationary (cold) turbines, the import possibilities, and at least the limitation of energy supply for customers (automatic frequency-dependent limitation, dispatcher operation, voltage decrease, switch off with tone-frequency and others). The inertia of a monumental inter-connected system is an advantage, the physical laws automatically solve the balancing problems – but in case of a failure a harmful effect could penetrate to neighbouring countries without restraint.

There are several methods for the manipulation of demands – if we know the consumers, their behaviour and the whole supply chain in the function of energy and time. We could identify the different types of consumers: household, industry (1-2-3 shift), trade, school, bureau, shop, lighting, heat-register unit, and others. The tariff-system could be similar to that in telecommunication – different packages for different type of users (pay for availability and for usage, extra bonus for accurate behaviour, penalty for deviation). There are also technical applications for the manipulation of demands, like sound-frequency control, voltage-control (soft limitation techniques), automated frequency-power control (system-saving) and dispatcher switch-off (hard techniques).

3.2. Failure analysis in wire supply

The failure analysis could be based on consumers' sensitivity in case of a failure, which could be predictable (maintenance, network development activities, etc.) or unpredictable (broken pipes, short circuit, etc.)

Water supply could be damaged on the production side because of environmental reasons (disasters), water-level limitations or infections – there are reservoirs in the system for managing the demands if the production lead-time is longer. There could be a failure in the network – the network structure could provide multi-way supply for a given district continuously or temporarily. The consumers could shift the needs for later, but the personal hygienic needs are more important than laundry. There are also substitute products, for example bottled water for drinking or for cooking.

The electricity consumption is more sensitive in the function of the frequency and the extension of the fault (in space and in time). The needs for availability are marginally different for a household (candles are applicable for sufficient lighting, housework could wait for a minute, and the fridge can hold the appropriate temperature for food for a day) or for a factory (production processes need the energy, there is no substitute product for energy, restoration requires special efforts and additional cost, etc.) The growing need for ventilation and cooling for air-conditioning in non-industrial sectors led to serious failure events, in spite of the additional oversizing in development driven by these new expectations. Solving the problem with alternative production technology (absorption chillers instead of compressors, for using heating energy instead of electrical energy) and with half-complete production technology (ice-production, storage, extraction and use) is technically and technologically possible.

3.3. The role of variable speed pumps in water supply

Frequency-controlled pumps could operate with the application of inexpensive power electronics technology, and are able to transmit water with variable speed (without the fluctuation of pressure). Installing a pump (in an existing main pipe) which provides the needs of consumer demand fluctuation with agile characteristics could be comparable with installing a new water tower. This new flexible design of the distribution system has reserves, and the installation of expensive water tower infrastructure could happen according to real needs, which is another great advantage

3.4. The role of centralized and decentralized storage in electricity supply

The centralized production of electricity has led to the development of a complex system of energy production and transmission, making little use of storage (today, the storage capacity worldwide is the equivalent of about 90GW of a total production of 3400 GW, or roughly 2.6%). In the pre-1980 energy context, conversion methods for the „storage of alternate current" were extremely costly, unreliable, or simply were not being used. This, along with the fact that electricity is mass-produced, transmitted, and used in AC, has led to the belief that electricity cannot be stored. However, high-performance, inexpensive power electronics able to handle very high power levels have changed all that. It can now be asserted that electricity can be stored - even if it is indirect storage - but this requires that investment and operating costs be kept to an acceptable level, and that the environmental issues be considered. Delocalized electricity production and the introduction of variable, fluctuating sources (renewable energy: solar, wind turbines, etc.) increase the difficulty of stabilizing the power network, mainly due to a supply-demand imbalance. It is therefore convenient to generate the energy, transmit it, convert it, and then store it if need be. More than ever then, the storage of electrical energy has become a necessity. But electricity is difficult to store, as this requires bulky, costly equipment.

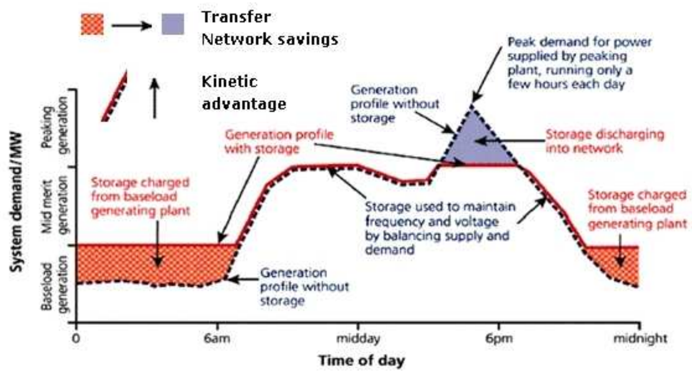


Figure 4. The role of storage in electricity supply

The main functions of storage are:

- Resource transfer: The intermediary energy obtained from electricity, through the transformation of a very-low-cost primary energy source utilized in regular power plants or an unpredictable renewable source, will be stored and utilized at an appropriate time as a substitute for the expensive primary power used in peak-load power stations, or for the „virtual energy" represented by fines that can be levied as a result of a breakdown in supply.
- Network savings: Schematically, power networks are comprised of many generating units, various levels of transmission and distribution lines and associated stations and substations, and a great many consumers with wide-ranging power requirements. The fluctuation in demand leads to the over-dimensioning of production and transmission equipment, which are designed as a function of peaks in demand rather than average daily consumption. Storage would make it possible to use the existing transmission and distribution facilities for many years to come. The levelling of consumption at the final distribution level would help both to reduce the power installed and to get the most out of the existing network.

- Kinetic advantage: The flexibility of future storage and retrieval systems can help provide instant response to demand and, as a consequence, add flexibility to the network in terms of load levelling. Network imbalance can be caused by a temporary production deficit, which could possibly be predicted. The need could also be the result of production failures.

The technical possibility of storing electrical energy exists, whenever and wherever they are needed, and in any quantity, but the storage is, and for years will be the weakest link of the energy domain.

We should consider electricity and hydrogen (generated mostly with the electrolysis of water, from renewable power sources) as a transportation fuel in the near future.

This could lead to oversizing electricity storing inventories (in the liberalized market environment), which could be a danger, because of the gambling factor (seasonal price fluctuation) and the missing information about different stock levels – the bullwhip effect is a costly phenomenon again, and a new challenge for the system operator.

4. Identifying the harmful effects of oversizing the infrastructure

Oversizing the infrastructure has two typical aspects, in according to the applied lean/agile logistics strategy.

- Bullwhip: in the case of lean supply, where we could follow the changing customer demand by the use of protective inventories (like in water supply), the bullwhip-effect can lead to stock-outs, large and expensive capacity utilization swings, lower quality products, and considerable production/transport on-costs as deliveries are ramped up and down along the supply chain.
- Puli: The oversizing situation is similar in the case of agile supply, where we could follow the fluctuation by protective capacities (like in electricity supply), and we have no significant storage opportunities, so we have to oversize the infrastructure on the production (and on the storage-less distribution network) side.

The main causes of oversizing	Lean supply - Protective inventory (bullwhip effect)	Agile supply - Protective capacity (“puli” effect)
Forecast	Error of the forecasted demand	Wide gap between the forecasted min and max demand
Lead time	Non-zero lead-time	Negligible lead-time
Batch (unit size)	Order batching	The size of protective capacity units
Necessity, shortage	Shortage of spare production capacity	Shortage of inventory, warehouse
Price	Price fluctuation	Price of shortage and restoration (or just the fear of)

Figure 5. The nature of oversizing

5. Conclusion

The role of decoupling points are critical in a modern supply system to separate the lean and the agile areas for stable and controllable operation. There are absolute needs for protective inventories and for protective capacities also to overcome the expectations in extended supply systems near changing technical and financial environment. (There are efforts in modern "pure agile" logistics towards 0-inventory – which is rather a constraint than a feasible solution.)

The identification of lean/agile points in space and in time is crucial, and need to be re-engineered according to market changing and the amplification of the supply failures costs.

While the inefficient use of protective inventories in a supply system could lead to the well-known bullwhip effect, a similar (opposite?) phenomenon appeared during the analysis of a system (electricity supply) operating with protective capacities. This new phenomenon was called "puli" effect.

The analysis of wire-logistics systems presents the enormous efforts in oversizing protective inventories and capacities which – in the absence of such technical limitations and contradictions - should be avoided on conventional fields of logistics. Otherwise according to recent development of variable speed frequency-driven pumps (water supply) and decentralized storage possibilities (electricity supply) wire supply systems should be also re-engineered.

Strategic, tactical and operational decision making have different time horizons and infrastructure investment costs in a supply system we should consider these before constructing a supply network for non-existing, latent or forecast (never incoming) future consumer demands.

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Theories and Methods to Develop the Systematic Approach for Package Design Technologies

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Abstract Nowadays, logistics, as a multidisciplinary science, is confronted with new problems and challenges. So the systematic approach for package design, which methodology needs both engineering and economic knowledge, demands continuous modifications by the consumers and more and more strict environmental requirements.

To pass the requirements of the sustainable development, we have to try to integrate the well-known product development methods, such as QFD, DfE, fuzzy, etc., to the systematic approach for package design development.

Allowing to take the synergic advantages of these development methods, e.g., Design for the Environment (DfE) strategy and Quality Function Deployment (QFD) process, systematic approach for package design would be able to give a wider perspective in the continuously developing and ever-changing divergent fields.

Keywords: DfE, QFD, systematic approach for package design,

1. Introduction

In a logistic system, when we have to design a “suitable” packaging system, we always meet a many-degree-of-freedom system, where the assistance of common engineering and economic knowledge are not certain to solve or expose the actual development problem [1]. In this paper, I will investigate the integrity of the well-known product development process –like QFD– to the packaging design process method, with the also well-known environmental strategy –the DfE guidelines. I will also write about the possibilities of using fuzzy in packaging development.

2. Actual and problematic questions about package design technologies

Nowadays, there is more emphasis on environmental protection, it is an ineluctable challenge to minimize and decrease the packaging waste, which mostly arises from the manufacturing and logistic processes. To solve this big volume and all-comprehensive problem, we have to approach it from two different angles. These are the following:

- The a widespread tendencies of the manufacturing and logistic methods
- The current applied packaging design methods

To solve the above-mentioned problem, we have to examine these methods. In the followings, I give a bold outline of these problems.

Arguments for the increase of packaging material demand:

We can sort the arguments as follows:

- Demographic and life-style changes which will see an increase in an ageing population, single households, and smaller families that will have an influence on the types of packaging used for products
- Technological changes where there is an expected increase in the growth of electronic and home shopping via the internet, this will introduce new demands on the packaging system
- Environmental issues will remain a major driving force, including litter and landfill
- Consumer demands will force market segmentation allowing products to be packaged depending on the demands of a particular group (such as, microwaveable products, salad kits, modified atmosphere packaging, pre-cut, pre-portioned, and smaller ready to consume products)
- Supply chain management will require a quicker more flexible response throughout the entire supply chain with a willingness to share information and develop long-term relationships. So the supply chain will become much longer in time than in distance
- Manufacturing changes have caused the manufacturing systems to become divided. The factories of one product can cover continents, so we have to package semi-finished goods and interim products, which has caused the increase in packaging material demand and logistics costs.

Problems with package design methods:

Problems with the package design techniques because of the full re-arrangement of the logistic fields have not been solved, because most of the companies use design and development methods only for the products.

What are the problems?

- The product engineers count only the “household” stresses during the development, and don't count the stresses during transportation and handling. These facts increase the demands against the future packaging system.
- These packaging systems are designed empirically with the information arising from one's own or a colleague’s experience
- The unknown logistic stresses solved by “over-packing”, which cause extra costs, decrease the logistical indices and additionally will not solve the product damages [2], [3].

3. Systematic approach for package design, as the solution of sustainable development?

3.1. The challenges of package design

The production companies, which have focused on the developments, are not allowed to forget problems and questions of the packaging, because the packaging development is as important as the product development.

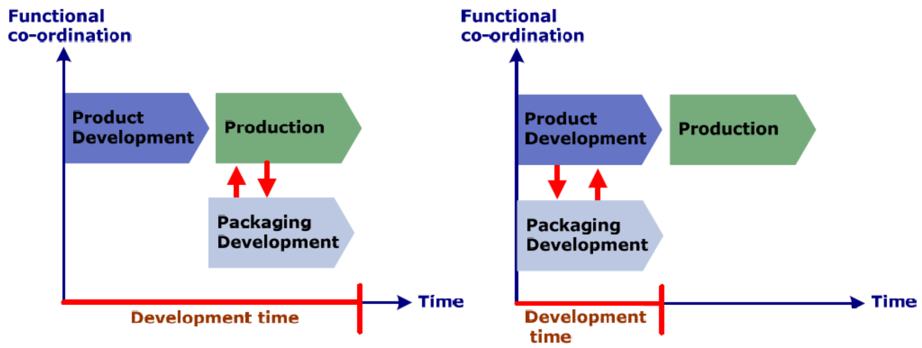

Figure 1. Context of the Product- and Packaging development time (source: Barmklev 2007)

In the figure of Barmklev (figure 1.) we are able to see the importance of the context of the product- and packaging development time. To reduce the development time these have to be connected and as much as possible be integrated [4].

From the complexity of package design, we can ascertain that these systematic design methods need overall and detailed information about the product. The packaging system is mostly set-up based on four components: Product → consumer packaging → collecting package → transportation (figure 2.) [5].

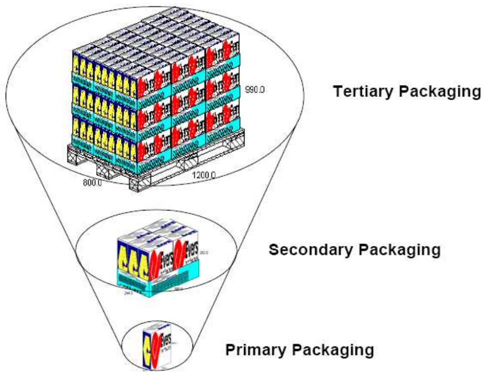

Figure 2. Product-packaging system (source: Hellström and Saghir, 2006)

Of course the development time is important. In addition, we have to know the connection points of when and where the components of our product and packaging system are interacting with divergent logistic processes (in different places and times)

Saghir's and Hellström's figure shows these interactions between the packaging and the logistic processes (figure 3.).

Only from the figures above, can we state that the packaging development is as important as the product development and manufacturing. So we have to accurately defend the product from "logistic stresses", and of course the product-packaging system has to be economical along the logistic chain. In short, this is the challenge of package design

Supply chain members	Manufacturer			Distribution centre					Retail outlet		
Logistics Processes	Filling process	Warehousing process	Transport	Receiving process	Storing process	Picking process	Shipping process	Transport	Receiving and shipping	Replenishing process	Re-use and recycle
Packaging system											
Primary (consumer)	✓									✓	✓
Secondary (collecting)	✓					✓			✓	✓	✓
Tertiary (transportation)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Figure 3. The interaction between the packaging system and the logistics processes (Source: Hellström and Saghir 2006)

When developing a new product we have to take account the following facts, information and requirements associating with packaging [2].

- Parameters of the characteristics and the sensitivity of the product (geometrical sizes of the product, centre of the mass, sensitivity against environmental and mechanical stresses, possible positions, etc.)
- Merchandizing relations, as questions about distribution practise (distances between departure and arrival locations, climate zones of departure and arrival locations, etc.)
- Information on transportation and material handling equipment (bearing capacity of the equipments, loading and unloading parameters, loading surface and space, etc.)
- Questions about the potential useable and suitable packaging materials (standardized, combined, laminated and special packaging materials, etc.)
- Standardized transportation packaging devices (standard packaging devices, pallets, etc.)
- Regulations and rules of packaging and transportation (international agreements, national decrees, international standards, EU directives, etc.)

4. Methods and theories and the possibility to apply them to develop the current packaging development processes

4.1. Design methods and methodologies in the field of products

The term *design methods* describes any procedures, techniques, aids or tools that contribute to the design process. They represent a number of distinct kinds of activities that the designer might use and combine towards the solution of design tasks.

Originally product design was the responsibility of a few people, whose function was to develop the concept, the prototype, the manufacturing methods, etc. Within this "over – the –wall" structure, the development blocks had been individually separated, so none of them had been responsible for the complete product design. Of course, from time to time new methods were born and evolved.

Here are some examples of design methods applicable to both product and industrial design [13]:

- Design-by-drawing
- Computer Aided Design (CAD)
- Brainstorming
- Concurrent engineering
- Value analysis

- Quality Function Deployment
- Design for X
- Fuzzy method

These methods have been developed in the fullest details, but all of them have missing parts or items, which have been disregarded. The most neglected field has been packaging and its development.

There have been many DFX methods in design, such as, design for manufacture and assembly, design for recycling, design for cost, design for environment and so on. These methods focus on a certain stage of the product life cycle and the integration that is needed [15]. Quality function deployment is able to do this integration, but we have to consider the special packaging problems that arise.

In the following sections, I will write about the last three mentioned methods, the basis of these theories and about their integration to packaging.

4.2. The QFD Theory

Quality function deployment (QFD) has been widely used as a multi-functional design tool to translate customer requirements to a product's technical attributes. QFD originated in the late 1960s and early 1970s in Japan from the work of Akao. In the beginning of QFD (also known as the method of the House of Qualities) development the primary functions of QFD are product development, quality management, and customer needs analysis [6]. So, by the QFD we can clearly divide the parts of the manufacturing processes and product developments.

4.3. Possibility of integrating QFD process to the package design methods

As I wrote in section 3 and 4, and as we can see the connection points of the product and packaging development, they have to be functionally and inherently united. Connecting the well-known processes and sub- functions of product design with the packaging requirements, mentioned chapter 3, QFD may be a suitable process in the field of systematic approach for package design.

As we compare the processes and the attached tasks from the product developments, with the packaging design requirements from section 2, we can find a lot of similarities between the developments.

In the following table (table 1.) we can see some samples regarding the similarities.

In the table, the parts of the sequence – connected by arrows- shows one House of Quality (HoQ) (figure 4.).

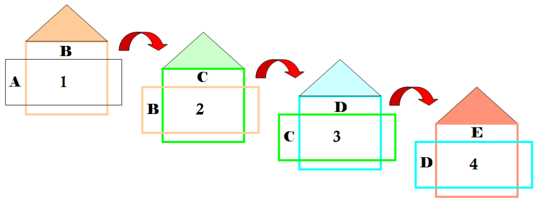

Figure 4. HoQ – the build-up of the House of Quality (source: own compilation)

Table 1. Parts of the QFD (source: own compilation)

CONSUMER DEMANDS	Product defense, marketing aspect, references, environment aspect, etc.
ENGINEERING PARAMETERS	Choosing: packaging material, transportation packaging device, stack ability, merchandizing relations, etc.
DETAILED TASKS	Geometrical sizes of the product and packaging system, choosing transportation method, etc.
TECHNOLOGY CHARACTERS	Adaptation to the manufacturing system, production planning, storing and handling plans, etc.
QUALITY ASSURANCE PLAN	Quality assurance tests of the packaging system components, suitability test of the completely filled transport packaging,

Many times, only the first two HoQs have been applied, but if we want to fill every requirement we have to run the method, fully. If we want to pass the continuously changing requirements and demands of the product and packaging design, we have to do these things.

The big advantage of applying QFD is that we could make the most of the *Concurrent Engineering (CE)* advantages, so the communication and group work would be able to settle between the marketing research, the development, the quality assurance, the suppliers and the production departments.

Besides the most important results of quality improvement and the higher consumer satisfaction, another important factor for using this method is that we could reduce the development time.

4.4. Context of the DfE strategy and the package design methods

Like the QFD process the *Design for Environment (DfE)* strategy was also born from the problems of product design and development. There are several Design for X methods, but the continuously increasing strictness of environment rules, parameters and customer demands have contributed to this strategy.

The principles of DfE are the following:

- Secure an environmental friendly life cycle in the design phase
- Sorting of the least impairing of environment solutions, in the fields of:
    - Applied materials
    - Applied technologies
    - Use
    - Reuse/recycle of waste

Developing product-packaging systems to optimize their life cycle, there are a lot of important points such as, when and where we have to take into consideration the environmental factors. These important segments are illustrated in the next circle diagram (figure 5.) [7].

The mentioned principles are well-known; we have to know the motivational factors and driving forces, which are important and can effect the methods, when the product-packaging systems are built up.

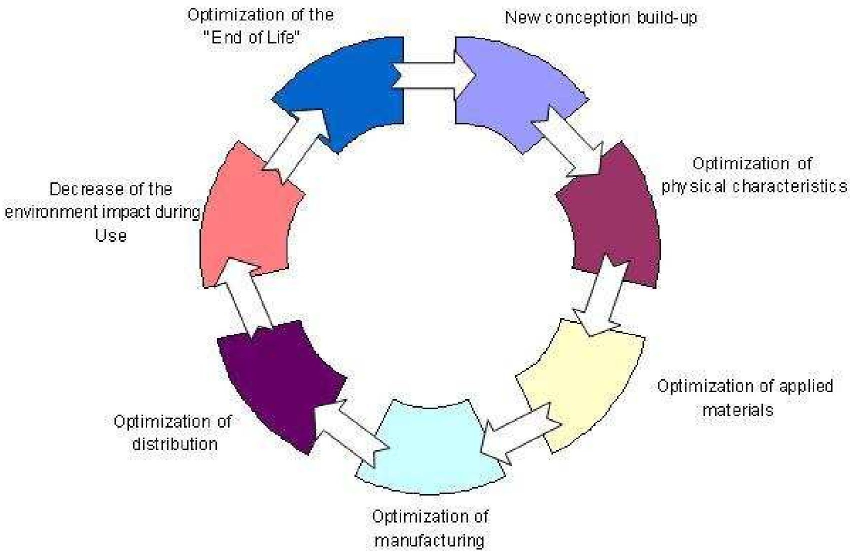

Figure 5. Important segments during the life cycle of the product – packaging system (source: own compilation)

Internal motivating forces:

- Demand for product quality improvement
- Improvement of the appearance of the manufacturing company
- Necessary reduction in costs of the product-packaging system

From the above-mentioned points, it is clear that if the manufacturing companies apply the DfE principles it has to be in continuous innovation and development, which may result in the radical modification of the product, the technology, and the packaging system.

External motivating forces:

- Factors of the authorities, the governments and officials
- Market challenge/competition
- Recommendation of professional organizations

4.5. The DfE helps the QFD to be "green"

The exclusive consumer demand orientation has to be divided, during product development, as Mackenzie [8] and Wong [9] mentioned in their papers. As I have mentioned, the environmental factors during purchasing strengthen, which is enhanced by the severe changes in consumer habits and the continuously changing requirements. From these facts, it is avoidless, not to count with DfE principles, during product and the attachable package developments and processes. Rahimi and Weidner [11], Wong and Juniper [10] completely analyzed the integration possibilities of DfE into QFD, but their papers extended only to product developments.

The *Green Quality Function Deployment* (GQFD) as Wong and Juniper mentioned in the integrated process has been integrated with the most important parts of the DfE. The created matrix is called *House of Ecology* (HoE), emphasizing the importance of environmental factors.

There are other studies that also can use QFD for environmental conscious design. Masui et al. [16] have focused on developing a decision-making support tool for the environmental aspects by using QFD, which is available in the early stages of the product design process. The modified and extended matrix is called Quality Function Deployment for Environment (QFDE).

In integrated product and packaging system research, Barmlkev [4] has not mentioned the environmental parameters, but in Bucci's [12] model, these parameters have already appeared.

In this systematic approach for packaging model, the possibility of integrating DfE strategy to QFD process is just mentioned as an example.

Recently, publications (Barmklev, Hung, Hellström) in this field, investigated only the context of product and packaging developments and their parameters.

The exact research and investigations regarding packaging development methods will have a greater importance in the near future, as the requirements became more and more strict. Of course, there are some theoretical solutions to make a longer life cycle for the packaging, as a waste formative, but these methods do not reflect the optimal solution, as of yet.

In figure 6, a quasi-optimal and simplified packaging life cycle can be seen, which may have been created with the assistance of QFD and DfE. From the figure it can also be seen that the members and locations where the packaging and its design takes place possibly needs modification.

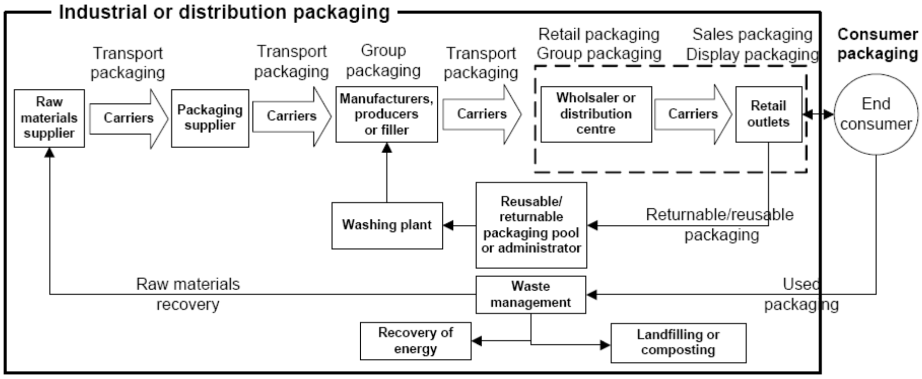

Figure 6. Simplified packaging life cycle (source: Saghir 2004)

4.6. Fuzzy Theory

Zadeh proposed fuzzy theory, a science to examine the realization of the fuzzy situation in the world with the help of mathematics. It allows "belong completely", the "belong partially" and "not belong at all" in the same field, which is the concept of belonging relatively and quantifies "belong concept". In fuzzy set, the level of belonging is a random value between 0 and 1 and the fuzzy set can have many membership functions. By using the advantages of fuzzy, it can have more promotional ability, endurance ability and it can be more suitable for the non-linear system in the real world [14].

4.7. Fuzzy application for package design?

In practice, different customers have different attitudes toward the same product and the same packaging. Their rating cannot be the same as each other. What is needed is a suitable tool to capture this information. Fuzzy mathematics is possibly a good tool to capture this highly uncertain information. Many papers have introduced fuzzy math into QFD; in the last decade e.g., Zhou (1998); Wang (1999); Shen, Tan, and Xie (2001); Karsak (2004); and Chen and Weng (2006). These papers have emphasized mostly product development and haven't found a healthy balance between the product and packaging [6]. To present the true rating information, it is possible to use for example the fuzzy performance-rating matrix (figure 7.) or the linguistic method of the rating (figure 8.). From the evaluating descriptions, we can integrate the differences among experts to provide the fuzzy description transfer in the matrix. So we can connect the linguistic variances to their relative fuzzy value.

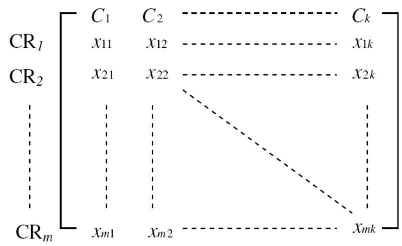

Figure 7. Performance-rating matrixes (source: own compilation)

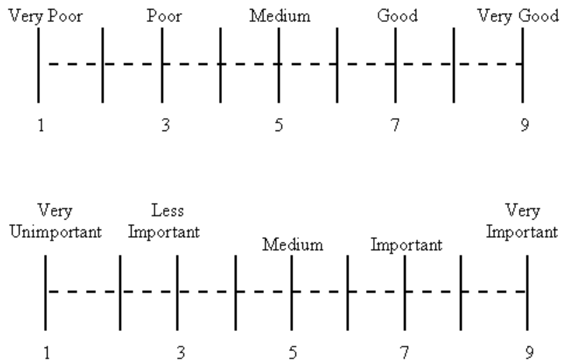

Figure 8. Fuzzy linguistic variables

Continuing with this process we can get the package design requirements, package design attributes and product design attributes. So we have to evaluate the package requirements and package design attributes. This part of the process is the most critical. In the following we can fill out and complete first two HoQ matrixes and next we are able to calculate the total value of product design attributed to the fuzzy relationship and then standardize the total value so that all values are between 0 and 1 [14].

As we can see from above, the fuzzy method is applicable but if we want to develop a product and packaging system suitable for more requirement groups (customers, environment, logistics, etc.) we have to prepare for problems and conflicts that may arise.

5. Conclusions

To summarize, we have ascertained that the packaging and product developments, nowadays, are inseparable and stand together. Although, we face a lot of new problems during product-packaging system design, which can be seen in many well-known product design methods, these product design methods are only useful if we modify them, according to the special fields of packaging. As we know packaging is one of the biggest waste producers, so the environmental requirements put packaging and its methods more and more into the spotlight. I have tried to investigate the approved product development methods and how we can use and integrate them into the systematic approach for package design method.

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