3rd Logistics International Conference

Belgrade, Serbia, 25-27 May 2017

Editors

Milorad Vidović
Milorad Kilibarda
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Momčilo Miljuš
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Proceedings of the

3rd LOGISTICS INTERNATIONAL CONFERENCE

LOGIC 2017

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Preface

The idea of organizing a logistics conference was in correlation with the Logistics department alumni's meeting, that is held traditionally every last Saturday in November. During the 2012 alumni's meeting, our colleagues and friends, most of which are now distinguished professionals, scientists, managers or officials in logistics and related areas, have given us a decisive impulse and encouragement to run the conference in 2013.

Thanks to one of the youngest researchers at our department, the conference holds, I believe, an impressible and penetrative acronym "LOGIC", which is at the same time associative and deeply tied with the essence of logistics. This way, by organizing Logistics International conference we have made one step ahead in further popularization and spreading of the ideas from this emerging area, while at the same time reestablishing the practice of our department in organizing logistics conferences, which goes back to the '80s.

The conference has tried to materialize the idea of becoming a forum and a meeting place where participants from universities, institutes and companies from different logistics related fields may have the opportunity to collaborate and exchange ideas.

Preface to the 3rd LOGIC proceedings

With this 3rd meeting LOGIC slowly becomes tradition. Short, but still tradition. This year during the conference were presented 46 papers from 155 authors, while workshops "Innovations in logistics and supply chains" included 18 presentations. About 200 speakers and discussants from 11 countries, mostly from the region, were given to the conference strong regional profile, making the conference a real meeting place and forum for exchanging ideas, in this way following and validating LOGIC's objectives.

The third conference proceedings book is here, giving the opportunity to wider professional and academic community to have insight into the participants ideas and thoughts on logistics.

This volume brings together research papers presented at the conference. Topics covered range from the modeling and planning of processes, to innovative methods and the latest technologies describing new logistic challenges and practical experience able to adapt to constantly changing environment. Although the book primarily addresses the needs of researchers and practitioners from the field of logistics, we hope that will also be beneficial for students and professionals interested in logistics.

We do hope that the interested readers will evaluated the conference similarly to the participants and Program committee members, as very interesting and instructive.
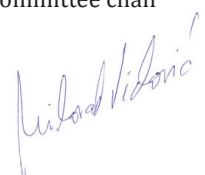
To make this conference, and keep it quality and continuity, besides the effort of participants, authors and organizers, we have received immense help from the Ministry of Education, science and technological development of the Government of Republic of Serbia, from our general sponsors, company Milšped, and Delhaize Serbia, together with special supporters: GEODIS, NTS, Cargo partner, Nelt and DTS. Also huge number of sponsors and the friends has also supported this event: Smart cargo, RALU logistika, Lodis logistika, Dunav osiguranje, Uniqa osiguranje, Logit, Standard logistics, Infora, Nestle, Rauch, CC Hellenic, Sarantis, Carlsberg and Nacionalna asocijacija špediterskih društava i agenata "Transport i logistika". More visibility provided our media supporters: RTS, RTV, Pluton logistics, and E-kapija.

To all of them we would like to express our sincere thanks and appreciation!

To continue the tradition, we warmly invite you to meet again and exchange ideas on the 4th LOGIC conference to be held in 2019.

Belgrade, June 2017   Program committee chair

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Part I

OPTIMIZATION AND MODELLING IN LOGISTICS AND TRANSPORTATION

LOGIC

NEW MATHEMATICAL FORMULATIONS OF THE DYNAMIC BERTH ALLOCATION PROBLEM

Miloš Nikolić [a,*], Dušan Teodorović [a]

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Abstract: *This paper considers Dynamic Berth Allocation Problem. The mathematical formulation of this problem was proposed by Imai et al. (2001). Trying to apply proposed mix-integer programming model we have noticed that the model has some weaknesses. In order to mitigate the observed drawbacks we proposed changes in the original mathematical formulation. We tested the models on the small size example.*

Keywords: *Dynamic Berth Allocation Problem, mathematical formulation, mix-integer programming.*

1. INTRODUCTION

The Berth Allocation Problem represents one of the most important port optimization problems. This problem is also known in the literature as the berth scheduling problem. The Berth Allocation Problem concerns the allocation of berth space for vessels. The dispatchers in terminals have to assign, as soon as possible, arriving vessels to berth to be loaded and/or unloaded. There are various types of the Berth Allocation Problem, depending on the berthing space (discrete or continuous), the portion of the vessels to be assigned that are already in the port (static or dynamic Berth Allocation Problem), the nature of vessel handling time (handling time is an input, or handling times are decision variables), existence of service priorities, etc.

Lai and Shih 1992 proposed three allocation policies and compared them with allocation current allocation policies in Hong Kong. To evaluate proposed allocation policies, the authors applied simulation model. The discrete static berth allocation problem is introduced by Imai et al. (1997). The authors presented mathematical formulations for the single objective and multi-objective cases. Imai et al. (2001) considered dynamic berth allocation problem. They gave mathematical formulation and proposed lagrangian relaxation heuristic for the considered problem. Since 2001 many different versions of berth allocation problems have been considered in the literature, for example: berth allocation with service priorities (Imai et al. 2003), berth allocation at indented berths for mega-containerships (Imai et al. 2007).

Continuous berth allocation problem (BAPC) has been considered, for the first time, by Lim (1998). Author described the problem, proposed heuristic algorithm, and proof of its efficiency by using historical data from Port of Singapore Authority. Guan et al. (2002) presented heuristic algorithm (Heuristic H) for the continuous berth allocation problem. Guan and Cheung (2004)

proposed two mathematical formulations and heuristic algorithm (Heuristic HB), improved version of Heuristic H. One heuristic algorithm for BAPC also has been developed in Imai et al. (2005b). Their heuristic is based on the solution of the dynamic berth allocation problem. Wang and Lim (2007) proposed a stochastic beam search algorithm and tested them on Singapore Port's test data. Two versions of Greedy Randomized Adaptive Search Procedure (GRASP) were developed in Lee et al. (2010). The results obtained by these approaches were compared with CPLEX and stochastic beam search.

Papers of Stahlbock and Voβ (2008) and Bierwirth and Meisel (2015) present broad reviews of the Berth Allocation Problem.

In this paper we consider Dynamic Berth Allocation Problem. The main research task in this problem is to find an assignment of ships to berths in the way to minimize the total time that all ships spend in the system (waiting time + service time). Word "Dynamic" assumes that when berths start to work it is not necessary that all ships are already in the port. Imai et al. (2001) proposed mix integer programming mathematical formulation for this problem. In this paper we start from their formulation and make, in the next step, improvements of their mathematical formulation.

The paper is organized in the following way. Imai et al. (2001) mathematical formulation is given in section 2. In section 3 we present improvements of the mathematical formulation. Numerical examples are also given in sections 2 and 3. Section 4 contains conclusions.

2. MATHEMATICAL FORMULATION OF THE DYNAMIC BERTH ALLOCATION PROBLEM

Imai et al. (2001) proposed the following mathematical formulation of the dynamic berth allocation problem:

$$Minimize \quad \sum_{i \in B} \sum_{j \in V} \sum_{k \in O} \left\{ (T-k+1)C_{ij} + S_i - A_j \right\} x_{ijk} + \sum_{i \in B} \sum_{j \in W_i} \sum_{k \in O} (T-k+1) y_{ijk} \tag{1}$$

subject to:

$$\sum_{i \in B} \sum_{k \in O} x_{ijk} = 1 \qquad \forall \, j \in V \tag{2}$$

$$\sum_{j \in V} x_{ijk} \leq 1 \qquad \forall \, i \in B, k \in O \tag{3}$$

$$\sum_{l \in V} \sum_{m \in P_k} \left(C_{il} \, x_{ilm} + y_{ilm} \right) + y_{ijk} - \left(A_j - S_i \right) x_{ijk} \geq 0 \qquad \forall \, i \in B, j \in W_i, \quad k \in O \tag{4}$$

$$x_{ijk} \in \{0,1\} \qquad \forall \, i \in B, j \in V, k \in O \tag{5}$$

$$y_{ijk} \geq 0 \qquad \forall \, i \in B, j \in V, k \in O \tag{6}$$

where are (Imai et al. (2001)):

$i \quad (=1,\dots,I) \in B$ set of berths
$j \quad (=1,\dots,T) \in V$ set of ships
$k \quad (=1,\dots,T) \in O$ set of service order
S_i time when berth i becomes idle for the berth allocation planning
A_j arrival time of ship j
C_{ij} handling time spent by ship j at the berth i
x_{ijk} 1 if ship j is serviced as the kth ship at berth i
         0 otherwise

P_k subset of O such that $P_k = \{p | p < k \in O\}$

W_i subset of ships with $A_j \geq S_i$

y_{ijk} idle time of berth i between the departure of the k-1th ship and arrival of the kth ship when ship j is serviced as the kth ship

Objective function (1), which represents the total time of all ships (waiting and service times), should be minimized. Constraint (2) guarantees that all ships will be served. Constraint (3) explains that only one ship can be served at the berth. Berth idle times are calculated according to Constraint (4). Constraints (5) and (6) define decision variables.

Corrigendum of the paper Imai et al. (2001) are made in the paper Imai et al. (2005a) where the authors made precise exploration about meaning of the decision variables x_{ijk} and y_{ijk}. They defined these decision variables in the following way (Imai et al., 2005a):

$x_{ijk} = 1$ if ship j is served as the $(T-k+1)$th last ship at berth, $x_{ijk} = 0$ otherwise

y_{ijk}: idle time of berth i between the departure of the $(T-k+2)$th last ship and the arrival of the $(T-k+1)$th last ship when ship j is served as the $(T-k+1)$th last ship.

Let us consider the following example (this example is based on instance 25x5-01 given in Cordeau et al. 2003). Suppose that we have 5 berths and 15 ships. Also, let us assume that the ship service times are given (Table 1), and:

- times when berths become idle for operations (S_i) are: 12, 12, 12, 12 and 12;
- ship arrival times (A_j) are: 71, 90, 39, 17, 12, 117, 94, 29, 43, 79, 2, 129, 123, 43 and 5.

Table 1. Ship service time at each berth

	Ship														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Berth 1	20	44	22	14	12	30	28	6	26	22	20	16	26	14	18
Berth 2	20	44	22	14	12	30	28	6	26	22	20	16	26	14	18
Berth 3	40	88	44	28	24	60	56	12	52	44	40	32	52	28	36
Berth 4	40	88	44	28	24	60	56	12	52	44	40	32	52	28	36
Berth 5	40	88	44	28	24	60	56	12	52	44	40	32	52	28	36

By solving the mix integer program, generated according to the presented data and the mathematical formulation (1)-(6), we obtained the following solution: $x_{1,3,14} = 1$, $x_{1,5,12} = 1$, $x_{1,6,15} = 1$, $x_{1,11,13} = 1$, $x_{2,1,13} = 1$, $x_{2,2,15} = 1$, $x_{2,7,14} = 1$, $x_{2,8,11} = 1$, $x_{2,15,12} = 1$, $x_{3,12,14} = 1$, $x_{3,13,15} = 1$, $x_{4,4,14} = 1$, $x_{4,9,15} = 1$, $x_{5,10,15} = 1$, $x_{5,14,14} = 1$, $y_{1,11,1} = 51$, $y_{2,11,1} = 38$, $y_{3,11,1} = 117$, $y_{4,11,1} = 5$, $y_{5,11,1} = 39$. All other variables have value zero. The objective function value of this solution is equal to 55. Taking into consideration x_{ijk} variables we can see that:

- at the berth one will be served ships: 5, 11, 3 and 6;
- at the berth two will be served ships: 8, 15, 1, 7 and 2;
- at the berth three will be served ships: 12 and 13;
- at the berth four will be served ships: 4 and 9;
- at the berth five will be served ships: 14 and 10.

But if we carefully take a look on variables y_{ijk} we can notice that all variables ($y_{1,11,1}$, $y_{2,11,1}$, $y_{3,11,1}$, $y_{4,11,1}$, and $y_{5,11,1}$) refer to ship 11. That means that ship 11 should wait service at all berths. Obviously, the obtained solution is problematic and should be carefully examined.

Let us investigate the input data. We can notice that ship 11 arrives before time point when berths start to work. Also, we can notice that objective function value, 55, does not include the obtained values for y_{ijk}. Taking into consideration that ship 11 arrive before berths start to work, it is obvious that $11 \notin W_i, i = 1, 2, 3, 4, 5$. As a consequence, any y_{ijk} where $j = 11$ is not included into objective function. Because $l \in V$ (the set V contains all the ships, including ship 11) in the first part of (4), $\sum_{l \in V} \sum_{m \in P_k} (C_{il} \ x_{ilm} + y_{ilm})$, decision variables $y_{i,11,k}$ are included into these constraints.

Large enough values for $y_{i,11,k}$ caused that these constraints are not broken even though obtained solution is unfeasible.

We make in this paper the suggestions how to improve mathematical formulation. The suggestions are proposed in the next section. The proposed suggestions are closely related to the above observations.

2. MODIFICATION OF THE MATHEMATICAL FORMULATION

There are two possible modifications of the mathematical formulation proposed in (Imai et al. 2001). The mathematical formulation could be improved in the following two ways: (a) modification of the objective function; (b) modification of the constraints.

2.1 Modification of the objective function

As we already noticed, the decision variables y_{ijk}, for ships j that arrive before berths start to work ($j \notin W_i$), are not included in the objective function (1). In order to resolve the problem in the mathematical formulation (1)-(6) we modify the objective function. We use the set V instead of W_i in the last part of the objective function in, i.e.: $\sum_{i \in B} \sum_{j \in V} \sum_{k \in O} (T - k + 1) y_{ijk}$. The other parts of the mathematical formulation remain unchanged. The new mathematical formulation reads:

$$Minimize \quad \sum_{i \in B} \sum_{j \in V} \sum_{k \in O} \{(T - k + 1) C_{ij} + S_i - A_j\} x_{ijk} + \sum_{i \in B} \sum_{j \in V} \sum_{k \in O} (T - k + 1) y_{ijk} \tag{7}$$

subject to

$$\sum_{i \in B} \sum_{k \in O} x_{ijk} = 1 \qquad \forall j \in V \tag{8}$$

$$\sum_{j \in V} x_{ijk} \leq 1 \qquad \forall i \in B, k \in O \tag{9}$$

$$\sum_{l \in V} \sum_{m \in P_k} (C_{il} \ x_{ilm} + y_{ilm}) + y_{ijk} - (A_j - S_i) x_{ijk} \geq 0 \qquad \forall i \in B, j \in W_i, \quad k \in O \tag{10}$$

$$x_{ijk} \in \{0, 1\} \qquad \forall i \in B, j \in V, k \in O \tag{11}$$

$$y_{ijk} \geq 0 \qquad \forall i \in B, j \in V, k \in O \tag{12}$$

The meanings of the objective function and the constraints are the same as in formulation (1)-(6).

2.2 Modification of the constraints

The second idea for resolving problem in mathematical formulation (1)-(6) is to use variables y_{ijk} only for ships that arrive after the time point when berths start to work ($y_{ijk} \geq 0 \quad \forall i \in B, j \in W_i, k \in O$). (There is no reason to delay handling of any ship already in the port, scheduled to be served as the next one at the berth). We must rewrite the first part of the constraint (10). Instead of the $\sum_{l \in V} \sum_{m \in P_k} \left(C_{il} \, x_{ilm} + y_{ilm} \right)$, we write $\sum_{l \in V} \sum_{m \in P_k} C_{il} \, x_{ilm} + \sum_{l \in W_i} \sum_{m \in P_k} y_{ilm}$. In this way, the constraint takes into account service times of all ships, and the berth idle times for the ships that arrive after berths start to work. The new mathematical formulation reads:

$$Minimize \quad \sum_{i \in B} \sum_{j \in V} \sum_{k \in O} \left\{ (T - k + 1) C_{ij} + S_i - A_j \right\} x_{ijk} + \sum_{i \in B} \sum_{j \in W_i} \sum_{k \in O} (T - k + 1) \, y_{ijk} \tag{13}$$

subject to

$$\sum_{i \in B} \sum_{k \in O} x_{ijk} = 1 \qquad \forall j \in V \tag{14}$$

$$\sum_{j \in V} x_{ijk} \leq 1 \qquad \forall i \in B, k \in O \tag{15}$$

$$\sum_{l \in V} \sum_{m \in P_k} C_{il} \, x_{ilm} + \sum_{l \in W_i} \sum_{m \in P_k} y_{ilm} + y_{ijk} - \left(A_j - S_i \right) x_{ijk} \geq 0 \qquad \forall i \in B, j \in W_i, \quad k \in O \tag{16}$$

$$x_{ijk} \in \{0, 1\} \qquad \forall i \in B, j \in V, k \in O \tag{17}$$

$$y_{ijk} \geq 0 \qquad \forall i \in B, j \in W_i, k \in O \tag{18}$$

The meanings of the objective function and the constraints are the same as in formulation (1)-(6).

We have solved the example given in the section 3 as the mix-integer program obtained according to the mathematical formulation (13)-(18). The obtained solution is the following: $x_{1,1,13} = x_{1,2,14} = x_{1,6,15} = x_{1,8,11} = x_{1,9,12} = x_{1,15,10} = x_{2,3,12} = x_{2,7,14} = x_{2,10,13} = x_{2,11,11} = x_{2,13,15} = x_{3,4,15} = x_{5,5,13} = x_{5,12,15} = x_{5,14,14} = 1$, $y_{1,1,13} = 2$, $y_{1,9,12} = 7$, $y_{2,3,12} = 7$, $y_{2,10,13} = 18$, $y_{3,4,15} = 5$, $y_{5,12,15} = 58$ and $y_{5,14,14} = 7$. The objective function value of this solution equals 424. The solution represents the following allocation ships to berths:

- berth 1 serves the ships: 15, 8, 9, 1, 2 and 6;
- berth 2 serves the ships: 11, 3, 10, 7 and 13;
- berth 3 serves the ship 4;
- berth 4 does not serve any ship;
- berth 5 serves the ships: 5, 14 and 12.

3. CONCLUSION

The Berth Allocation Problem has been extensively studied in the literature. We considered in this paper dynamic discrete berth allocation problem. The widely accepted mathematical formulation of this problem is proposed by Imai et al. (2001). We noticed some weaknesses in the formulation of Imai et al. (2001). In order to mitigate these weaknesses, we proposed two ways for mathematical formulation improvement. The first way represents the modification of the proposed objective function. Our second proposal is related to the modification of constraints. We showed that the new mathematical formulation of the discrete berth allocation

problem is based on the modification of constraints in the formulation proposed by Imai et al. (2001).

ACKNOWLEDGMENT

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LOGIC

OPTIMIZATION OF VEHICLE ROUTING DEPENDING ON VEHICLE LOAD

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Abstract: *Nowadays many subjects pay attention to reduction of environmental externalities of greenhouse gases emissions. Unsurprisingly the transport is one of the areas significantly contributing to the production of CO_2 emissions. One of important areas in the transport logistic is analyzing various routing problems simultaneously with using integrated optimization approaches where one of the source of emissions reduction are shorter routes, and better management of vehicle loads. Obviously, greenhouse emissions are directly reflected by fuel consumption. The paper is focused on modified vehicle routing problem that enables setting vehicle routes depending on vehicle load. The illustrative example presenting difference compared to classical vehicle routing problem is also given.*

Keywords: *capacitated vehicle routing problem*

INTRODUCTION

A variety of optimization models to support decision making of distribution companies are commonly known. Distribution companies often implement models aimed at minimizing the total traveled distance. However, when analyzing the fuel consumption, it is clearly observed that the traveled distance is not the only relevant factor. Undoubtedly also vehicle load has significant impact on the fuel consumption. The paper is aimed on model that minimizes the fuel consumption, depending on the length of the traveled route and also on the vehicle load. The paper is structured as follows: In the first section we present a classic model of distribution [(Čičková, Brezina, Pekár 2013), (Federgruen, Simchi-Levi 1995), (Golden, Raghavan, Wasil 2008), (Miller, Tucker, Zemlin 1960)] which serves as the basis for constructing a modified model involving the vehicle load. The modified model is given in the second part. The third part is devoted to an illustrative example, where we calculated optimum route based on classical model as well as on a modified model. The results illustrate the difference using different approaches, while we also report an achieved decrease in the fuel consumption.

1. CAPACITATED VEHICLE ROUTING PROBLEM

This section is devoted to the capacitated vehicle routing problem (CVRP). The idea of this model is further refined in part 2. The formulation CVRP is based on the graph representation. Consider a graph with n + 1 nodes. Let $N_0 = \{0,1,...,n\}$ be the set of nodes representing the location of customers as well as the depot (origin). The standard CVRP consists in designing the optimal set of routes for a vehicle (vehicles) in order to serve a given set of customers located in a certain

nodes of the net representing by subset $N = \{1, 2, ..., n\}$. Each customer has a certain demand (g_i, $i \in N$). The demand need to be met from origin ($\{0\}$). Further on there exists a matrix $\mathbf{D}_{(n+1)\times(n+1)}$ that represents the minimum distances between all the pairs of nodes (customers and the depot). The optimal vehicle routes must be designed in such a way that each customer is visited only once by exactly one vehicle, all routes start and end at the origin, and the total demands of all customers on one particular route must not exceed the capacity of the vehicle (g). Consider that demands of customers are met in full and also consider the individual demands do not exceed the capacity of the vehicle, otherwise a quantity equal to the vehicle capacity is realized in self-route and the model includes only the remaining demand.

Based on this assumption, the model can be stated as follows:

$$\min f(\mathbf{X}, \mathbf{u}) = \sum_{i \in N_0} \sum_{\substack{j \in N_0 \\ i \neq j}} d_{ij} x_{ij} + k \sum_{i \in N} u_i \tag{1}$$

$$\sum_{i \in N_0} x_{ij} = 1 , \; j \in N , \; i \neq j \tag{2}$$

$$\sum_{j \in N_0} x_{ij} = 1 , \; i \in N , \; i \neq j \tag{3}$$

$$u_i + q_j - g(1 - x_{ij}) \leq u_j , \; i \in N_0 , \; j \in N , \; i \neq j \tag{4}$$

$$q_i \leq u_i \leq g , \; i \in N \tag{5}$$

$$u_0 = 0 \tag{6}$$

$$x_{ij} \in \{0, 1\} , \; i, j \in N_0 , \; i \neq j \tag{7}$$

Mathematical programming formulation of CVRP requires two types of variables: the binary variables x_{ij}, $i, j \in N_0$ where $x_{ij} = 1$ if the edge between node i and node j is used, otherwise $x_{ij} = 0$ (7). Further on the free variables u_i, $i \in N$ based on well-known Miller-Tucker-Zemlin's formulation of the traveling salesman problem (Miller, Tucker and Zemlin, 1960) are used. These variables enable to calculate the load of vehicle.

Objective function (1) models the total traveled distance. Adding the expression $k \sum_{i \in N} u_i$ (k is small positive number) enables setting the exact vehicle load to i-th, $i \in N$ node (including). To obtain the real value of traveled distance, if necessary, we can subtract the value of before mentioned expression. Equations (2) and (3) ensure that each customer (except the origin) is visited exactly ones. Equations (4) are anti-cyclical conditions that prevent the formation of such sub-cycles which do not contain an origin. The set of variables u_i, $i \in N$ also ensures the calculation of current load of vehicles in its route to i-th customer (including) and together with equations (5) they ensure that the current load does not exceed the capacity of vehicle, which is set to zero (6) in the origin.

2. CAPACITATED VEHICLE ROUTING PROBLEM DEPENDING ON VEHICLE LOAD

Consider the same preconditions as in part 1, but besides to existing known parameters (inputs to CVRP) also consider new known parameters associated with the fuel consumption. Let parameter c_0 be the vehicle consumption per unit distance and let c_1 be parameter representing the increase in consumption per unit distance for 1 unit of vehicle load. The goal of capacitated vehicle routing problem depending on vehicle load (CVRPVL) is to establish such distribution, which minimizes whole vehicle's fuel consumption (not minimizing the distance) under the

same conditions as in CVRP (2) – (7). The objective function (1) is replaced by function (8), Its meaning is as follows: minimizing the expression $\sum_{i \in N_0} \sum_{\substack{j \in N_0 \\ i \neq j}} c_0 d_{ij} x_{ij}$ enables modeling of the fuel consumption depending on the traveled route. While variables u_i, $i \in N$ and $u_0 = 0$ in model (1)-(7) enable setting the vehicle load, increased consumption depending on the load can be modeled by expression $\sum_{i \in N_0} \sum_{\substack{j \in N_0 \\ i \neq j}} c_1 \cdot u_i d_{ij} x_{ij}$.

Model CVRPVL can be stated as follows:

$$\min f(\mathbf{X}, \mathbf{u}) = \sum_{i \in N_0} \sum_{\substack{j \in N_0 \\ i \neq j}} (c_0 + c_1 \cdot u_i) d_{ij} x_{ij} \tag{8}$$

$$\sum_{i \in N_0} x_{ij} = 1, \ j \in N, \ i \neq j \tag{9}$$

$$\sum_{j \in N_0} x_{ij} = 1, \ i \in N, \ i \neq j \tag{10}$$

$$u_i + q_j - g(1 - x_{ij}) \leq u_j, \ i \in N_0, \ j \in N, \ i \neq j \tag{11}$$

$$q_i \leq u_i \leq g, \ i \in N \tag{12}$$

$$u_0 = 0 \tag{13}$$

$$x_{ij} \in \{0, 1\}, \ i, j \in N_0, \ i \neq j \tag{14}$$

It should be noted that the resulting routes depend on the type of the problem. When goods are collected than the optimum route represented by variables $x_{ij} = 1$, $i, j \in N_0$ is the route from i-th node to j-th node. In the case of distribution those variables represent the route from j-th to i-th node. In the next section we present an illustrative example of distribution of goods.

3. ILLUSTRATIVE EXAMPLE

Let us introduce the problem dealing with a distribution scheduling. The problem can be described by network consisting of origin from where 7 nodes need to be served, so that $N = \{1,2,...,7\}$, $N_0 = \{0\} \cup N$. Known customers' demands are elements of 7-dimensional vectors $\mathbf{q}$, $\mathbf{q} = (5, 2, 10, 10, 6, 8, 9)^\mathrm{T}$. Further on suppose the vehicle consumption per unit distance (c_0) is set to 1 and also suppose there is 3 percent increase in consumption per distance unit and per unit of load ($c_0 = 0.03$).

Table 1. Matrix of Minimal Distances between all the Pairs of Nodes

	0	1	2	3	4	5	6	7
0	0	200	400	100	390	100	50	170
1	200	0	200	120	200	150	170	100
2	400	200	0	300	40	300	350	230
3	100	120	300	0	300	90	50	140
4	390	200	40	300	0	290	350	220
5	100	150	300	90	290	0	80	70
6	50	170	350	50	350	80	0	150
7	170	100	230	140	220	70	150	0

The daily distribution need to be provided by vehicles with the same capacity (g = 24). The number of vehicles can be adapted as required; therefore it is not necessary to consider limits on the initial number of vehicles. The known matrix of shortest distances **D** between all nodes is given in Table 1.

Model CVRP (1) – (7) and model (8) – (14) were implemented in software GAMS (solver Cplex (CVRP), Couenne (CVRPVL)).

Firstly, model (1) – (7) was implemented. Results are given in Table 2.

Table 2 **CVRP Route**

Route	Sequence	Distance	Fuel consumption depending on load
Route	0-1-2-4-5-0-6-0-7-3-0	1340	1764.20
Route 1	0-1-2-4-5-0	830	1147.40
Route 2	0-6-0	100	112.00
Route 3	0-7-3-0	410	504.80

Source: Own compilation.

Then, model (8) – (14) was implemented. Results are given in Table 3.

Table 3 **CVRPVL Route**

Route	Sequence	Distance	Fuel consumption depending on load
Route	0-1-2-4-0-6-3-0-5-7-0	1370	1661.90
Route 1	0-1-2-4-0	830	1016.00
Route 2	0-6-3-0	200	242.00
Route 3	0-5-7-0	340	403.90

Source: Own compilation.

The change in resulting route is observed, when we provide two different objectives (1) and (8). In the case of implementing model (1) - (7) we obtain the value of the total traveled distance 1340. Using model (8)–(14) leads to route length of 1370. But when we calculate the fuel consumption depending on vehicle load, resulting values are those: 1764.20 in the case of model (1)–(7) and 1661.90 in the case of model (8)–(14). Using CVRPVL model enables decreasing fuel consumption of 5.8 percent. Changes are caused by routes structure when rearrange nodes following the goal of minimizing the consumption according to the vehicle load.

3. CONCLUSION

Classic routing problem take into account only one factor affecting the cost of delivery, which is the traveled distance. When realizing real distribution the costs are affected by several factors: traveled distance, the weight of goods, route gradient, weather situation, etc. The authors constructed a model that enables taking into account not only traveled distance but also the weight of the loaded goods.

The first part of the paper is devoted to classic model of distribution, while the second part is aimed at its modification based on the increase in consumption depending on the weight of loaded goods. The next section gives an example of using mentioned models, while justifying the difference in the results obtained. Also the results of illustrative example show that when solving practical problems it is necessary to include the weight of the load, since that parameter largely affects the individual routes. Using of CVRPVL model enables to achieve reduction in fuel consumption by 5.8 percent.

ACKNOWLEDGMENT

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LOGIC

HEURISTIC APPROACH TO INVENTORY CENTRALIZATION

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Abstract: For production or maintenance system inventories are necessity as well as additional cost incurred by capital that is invested in those inventories as well as warehousing (equipments, objects, workforce). By inventory centralization it is possible to achieve system wide reduction of inventory level trough risk pooling effect, and therefore costs reduction. In the same time, inventory centralization increases transportation distances and service times which leads to costs increase. In this paper we describe heuristic approach to inventory centralization of spare parts in multi-echelon storage for an arbitrary maintenance system. Objective function of the proposed model has three main segments: inventory costs, transportation costs, and workforce costs. The heuristic approach is based on the model developed for one utility company in Republic of Serbia.

Keywords: Inventory centralization, heuristics, spare parts, warehouse locations.

1. INTRODUCTION

Inventory centralization to fewer warehouses incurs system wide reduction of inventory level, while increasing transportation distances and therefore service times which is very important quality measure in maintenance industry of technical systems. By maintenance industry we refer to maintenance of large technical systems (country wide) that requires network of warehouses with spare parts inventories used for preventive and corrective maintenance where long downtimes are typically very expensive. Warehouses are used to hold inventories of spare parts and therefore are usually a part of maintenance centers. These technical systems can be large public and cargo transportation systems, utility companies (generation and transmission or distribution of electricity, gas, water, or heating power to general public), etc. In the problem of inventory centralization two sub-problems are closely depended, determining the level of centralization and choosing the locations of warehouses in which stock will be held. The main goal of solving these problems is to minimize total costs (e.g. inventory costs, warehouse costs, transportation costs, manpower costs) while ensuring adequate service level which is represented by the level of inventory stock-outs and service response times especially in corrective maintenance (directly correlated to length of system downtime). There are many research papers in the available literature related to inventory centralization and maintenance industry of large technical systems. In the following we outline few of the most relevant to our topic. Centralization of warehouse locations can lead to cost savings through the reduction of the total level of the stock, but on the other side centralization has a negative effect on the necessary transport of goods, as noted by Das and Tyagi (1997). That is, to optimize warehouse operations in terms of inventory centralization, it is essential to respect the impact on transport

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costs. Basten and Houtum (2014) observed models for inventory management of spare parts in different systems. They stated that the location of warehouses and maintenance centers are very important segments of optimization. Perrier et al. (2013) observed the models and algorithms for warehouse locations and service zones for utility company with emphasis on corrective maintenance, where they state that transportation needs in the maintenance has high impact. Berg (2013) looks at the allocation of materials in multi-echelon storage system at the Dutch utility company, considering primarily the methodology of allocation of parts for emergency response (as most important) from the rest of the materials and parts, as well as the allocation of those goods in the warehouses of different levels.

In this paper we describe methodology and heuristic approach to inventory centralization of spare parts for an arbitrary maintenance system. The heuristic approach is based on the model developed for one utility company in Republic of Serbia. The remaining part of this paper is organized as follows. The problem and methodology description is given in Section 2. The heuristic approach is described in Section 3. Section 4 presents test instances and computational results. Finally, some concluding remarks are given in Section 5.

2. PROBLEM DESCRIPTION

In this paper we analyze the system with the four hierarchical levels. It is assumed that the central warehouses (1ˢᵗ tier) and 2ⁿᵈ tier warehouses have large storage capacities (also, its capacity could be potentially increased if necessary), while 3ʳᵈ and 4ᵗʰ tier warehouses are auxiliary and have very limited opportunities for expansion. Additionally, not all locations from the first two hierarchical levels are adequate for centralization mainly due to the lack of available storage capacity for different spare parts, expansion restrictions and legislative reasons. Also, it is assumed, accordingly to previous experience, that some of warehouse locations are well developed, have strategic importance and that they are crucial for company's operations. Therefore, those warehouses must be included in the solution.

The territory covered by the service network is divided into service zones where each zone is defined by its spatial centroid and expected monthly consumption (spare parts demand). Spare parts are classified in clusters, with known average demand, and its standard deviation. Also, for each cluster - group of spare parts is also known expected number of maintenance runs during the one observed period (one month), which is based on the maintenance history data and maintenance plans on the one year level. The clustering of spare parts (groups of components and parts) is based on the type, dimensions and technical characteristics. Inventories can be centralized on the level of cluster. In other words it means that it is possible to centralize spare parts from different service zones in the same warehouse, but only considering all parts belonging to the certain cluster. It should be noted that groups of spare parts with high maintenance intensity is preferable to be close to maintenance location and therefore less likely to be centralized, due to high transportation costs incurred. Also, when centralizing inventories from one zone to some location outside that zone service response time should be always respected. In the proposed heuristics mentioned requirement is included as a constraint counting travel time to the service zone. In the following chapter we describe the heuristic approach to solving the inventory centralization problem.

3. HEURISIC APPROACH

Inventory centralization optimization is based on the idea of determining the effects of risk pooling where centralized inventory results in lower safety stock and average inventory in the system. Centralization of a safety stocks at one place results in the same level of the stock-out risk while having lower safety stock quantity. In our heuristic approach, without loss of generality, we presume that the demand for spare parts can be represented by Normal

Distribution $N\sim(\mu,\sigma)$ where μ stands for mean of demand for spare parts and σ stands for standard deviation of that demand in the observed period (replenishment time or lead time). For two warehouses with identical demands (same mean and standard deviation) total stock can be represented by equation $2\cdot(\mu+k\cdot\sigma)$, while in the case of centralization total stock can be represented as $2\cdot\mu+\sqrt{2}\cdot k\cdot\sigma$ (square root law). In the case of inventory centralization of three warehouses with identical demands total stock can be represented by equation $3\cdot\mu+\sqrt{3}\cdot k\cdot\sigma$, etc. In our model we exploit square root law equation to approximate total stocks in centralized locations (locations in which multiple zones hold its spare parts). Coefficient k is used to determine the size of safety stock, where higher value means higher probability of having enough stock to satisfy the demand, e.g. in case of $k=3$ system would have 99.7% probability of no stock-outs. This value for k, referring to high service level, is used in the model with the idea of avoiding stock-outs and system downtimes which are typically very expensive. It is obvious by looking at square root law equation that the total stock level in system is reduced by higher level of centralization which leads to lower costs of bound capital (opportunity costs) and warehousing, while at the same time transportation needs to transit longer distances which in turn increases total costs. Therefore, objective function of the proposed model has three main segments as given by Eq. (1): inventory costs; transportation costs; workforce costs.

$$\min \to T_{inv} + T_{tran} + T_{workf} \tag{1}$$

Inventory costs (given by Eq. (2)) are defined by lost opportunity costs (given as percentage of total value of stock in system) and by cost of handling and storage of inventories in objects (where costs depend on number of storage units) and open storage space (where costs depend on occupied square meters of space).

$$T_{inv} = \sum_{i\in I}\sum_{j\in J}\sum_{a\in A} x_i^{ja} \cdot Z_i^{ja} \cdot C^c + \sum_{i\in I}\sum_{j\in J}\sum_{b\in B} x_i^{jb} \cdot Z_i^{jb} \cdot C^{unit} + \sum_{i\in I}\sum_{j\in J}\sum_{h\in H} x_i^{jh} \cdot Z_i^{jh} \cdot C^{m2} \tag{2}$$

i - warehouse location ($i\in I$)

j - service zones ($j\in J$)

a - spare parts group ($a\in A=B\cup H$)

b - spare parts group which is primarily stored in warehouse building ($b\in B$)

h - spare parts group which is primarily stored at open space warehouse , ($h\in H$)

$x_i^{ja}, x_i^{jb}, x_i^{jh}$ - binary variable that is equal to 1 if warehouse i serves zone j with spare parts group a, b and h respectively

$Z_i^{ja}, Z_i^{jb}, Z_i^{jh}$ - average inventory stock in warehouse i for zone j of spare parts group a, b and h respectively (these values are calculated by square root law equation for those warehouses that have inventory centralization, i.e., store spare parts groups from different service zones)

C^c - percentage of stock value used for calculation of lost opportunity costs

C^{unit} - unit cost of storing one unit in warehouse buildings

C^{m2} - unit cost of occupied square meters open space warehouse

Transportation cost (given by Eq. (3)) depends on the expected number of transportation runs initiated by maintenance demand, and distance of a service zone from warehouse location.

$$T_{tran} = \sum_{i\in I}\sum_{j\in J}\sum_{a\in A} x_i^{ja} \cdot F^{ja} \cdot D_i^j \cdot C^t \tag{3}$$

F^{ja} - expected number of transportation runs in service zone j which include spare parts group a

D_i^j - travel distance from warehouse location i to the centroid of service zone j

C^t - unit transportation costs

Workforce costs are defined by Eq. (4) and (5). Those costs depend on the intensity of operations. It is assumed that the intensity of operations depends mostly on the number of maintenance orders.

$$T_{workf} = \sum_{i \in I} r_i \cdot C^{workf} \tag{4}$$

$$r_i = \frac{\sum_{j \in J} \sum_{a \in A} x_i^{ja} \cdot \frac{Y^{ja}}{D}}{N} \quad \forall i \in I \tag{5}$$

r_i - required number of workers in warehouse i (integer value round to first ceiling value)
C^{workf} - monthly costs of one worker
Y^{ja} - number of maintenance orders per month for spare parts group a in service zone j
D - number of working days in one month
N - nominal number of maintenance orders can be done by one warehouse worker

Algorithm of the proposed heuristic approach is presented in Fig. 1, and comprises four local search improvement neighborhoods. It is greedy heuristics based on the best improvement concept. When there is no improvement in one neighborhood, improvement phase continues to the next one until the final neighborhood of swapping pairs of warehouses.
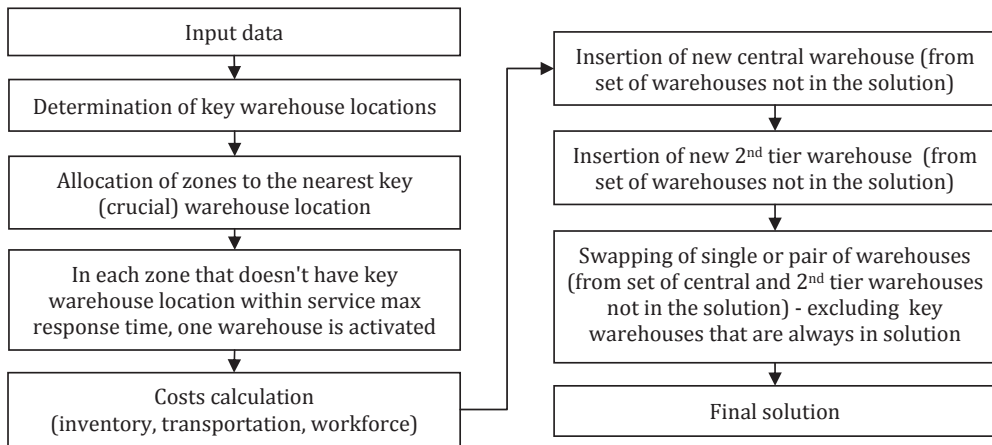
Figure 1. Heuristic approach algorithm (left - construction phase, right - improvement phase)

4. COMPUTATIONAL RESULTS

To test proposed heuristics we used general input parameters given in Table 1.

Table 1. General input parameters for the model

DATA	VALUE	
Transportation cost	0.25	per km
Open storage cost	3.30	per m² per month
Cost of storage in closed objects (warehouses)	1.25	per storage unit per month
Workforce cost	580.00	per worker per month
Replenishment period		quarterly
C^c - percentage of stock value	12	%
Service max response time	2.5	h
N - norm for one warehouse worker	150	output (storage units) daily

System we considered consists of 120 service zones and 57 warehouse locations which included 7 predefined locations that must be included in the solution. The best solution found (Fig. 3) includes 28 centralized locations, while multiple run of proposed heuristics for predefined range of centralized inventory locations (24 to 33 locations) showed its impact to the total system costs (Fig.2). Heuristic model was implemented in Python 2.7 programming language on PC Intel(R) Core(TM) i3 CPU M380@2.53GHz with 6 GB RAM memory.
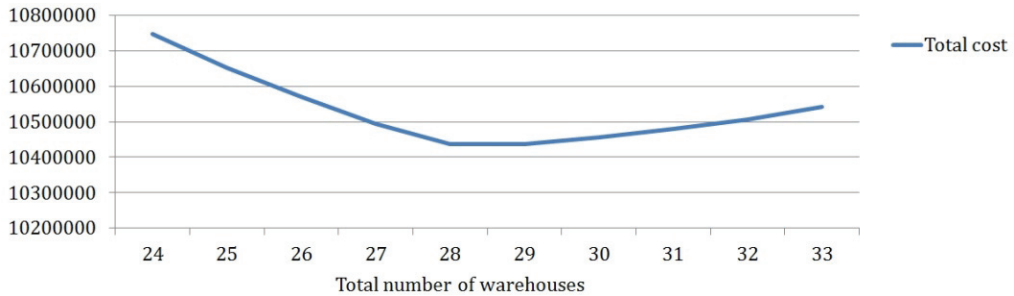
Figure 2. Total costs for different level of centralization (number of warehouses in solution)

Table 2. Computational results for the best heuristic's solution (28 centralized locations)

Locations from Fig. 3	Number of allocated zones	Total annual costs	No. of warehouse workers	Warehouse capacity in storage units	Warehouse capacity in m² of open storage	Annual travel distance of vehicles in km
1	7	1 200 131	4	4 876	5 133	1 764 291
2	6	687 067	3	7 085	2 141	1 063 169
3	2	471 782	2	5 163	2 464	472 985
4	4	583 687	2	6 203	2 056	989 194
5	2	429 353	2	3 687	2 374	500 255
6	5	510 793	2	5 193	1 995	710 655
7	2	358 731	2	4 750	1 644	373 159
8	2	369 804	2	3 752	1 859	392 430
9	3	391 384	2	4 512	1 480	525 202
10	1	272 479	1	2 780	1 835	193 903
11	1	271 910	1	3 303	1 666	136 659
12	9	516 870	2	4 692	1 191	935 163
13	4	505 809	2	4 769	1 127	836 907
14	2	284 408	1	3 117	1 364	244 432
15	9	536 259	1	1 713	1 561	1 413 514
16	11	463 795	1	2 287	1 159	1 080 435
17	4	246 465	1	3 316	895	296 288
18	5	340 201	1	3 513	783	609 490
19	5	240 733	1	2 526	771	285 053
20	6	199 367	1	830	902	366 833
21	3	367 616	1	1 394	725	971 486
22	3	195 979	1	2 074	548	182 456
23	3	222 543	1	1 307	699	427 310
24	3	209 100	1	1 070	519	438 234
25	4	159 661	1	420	592	314 980
26	4	143 898	1	633	338	309 102
27	8	112 693	1	677	315	178 115
28	2	144 961	1	607	261	319 305
Centralization (sum for 28 locations)		*10 437 479*	*42*	*86 248*	*38 398*	*16 331 002*
Without centralization		*12 273 065*	*122*	*112 687*	*43 650*	*9 089 528*
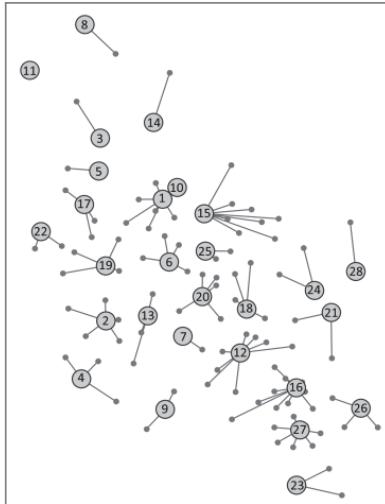
Figure 3. Best solution obtained from heuristic with total of 28 warehouses

5. CONCLUSION

In this paper we outlined the heuristic approach to inventory centralization of spare parts which was based on the model developed for one utility company. Results show that inventory centralization is justified where expected total costs can be reduced by significant amount (in our approximated model that reduction is near 15 %) by reducing total stocks, workforce and warehousing. On the other hand, transportation costs are significantly increased by 80 % (increased travel distances) which can have negative impact on service response times and on duration of system downtimes. Further research should explore the effects of increased maintenance transportation travel times on the duration of system downtimes, as well as to include in the analysis new potential locations of warehouses. Also, our idea is to develop optimal nonlinear formulation for this type of location inventory model and to analyze other possible solution approaches.

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LOGIC

A MULTI-OBJECTIVE MODEL FOR UNDESIRABLE FACILITY LOCATION

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Abstract: This paper presents a bi-objective mixed integer mathematical model for siting landfills. The first objective minimizes total cost of facility establishing and entire demand satisfaction while the second objective minimizes total number of end users undesirably influenced by landfills. The model is tested on small scale illustrative example and all Pareto optimal solutions are obtained. The solutions are presented and discussed.

Keywords: landfill location, bi-objective mixed integer modeling, Pareto optimal solutions.

1. INTRODUCTION

Landfilling represents the oldest form of municipal solid waste management and the least desirable option according to waste treatment hierarchy. However, only in the EU in 2010 total waste production was around 2.5 billion tons of which 36% was recycled, while the rest was landfilled or burned (EC, 2017). Hence, the landfilling of waste unfortunately is still dominant waste treatment option even in the countries with strict environmental laws.

Landfills are facilities that pose environmental risks and fall in the category of undesirable facilities. In most practical problems locating undesirable facilities involves multiple objectives that are often conflicted. In the case of landfill locations, for example, most people want landfill to be located as far as possible from population centers. However, landfill locations tend to be close to highly populated areas as important waste generation sites to minimize transportation costs. Additionally, landfills pose serious environmental risk due to pollution of the local environment manifested in contamination of groundwater or soil, generation of dangerous gases, air pollution, reduced local property values, etc.

The last two decades have seen many new multi-objective models and approaches in landfill selection. Caruso et al. (1993) presented multi-objective model, in which three different objectives (the overall cost, the waste of recyclable resources, and the environmental impact) were took into account. The three objectives were then combined into a parametric single objective according to the weighting method. A set of approximate Pareto solutions was searched through an add-drop heuristic. Rahman and Kuby (1995) proposed a multi-objective model locating transfer stations, where the focus was the compromise between minimizing transshipment costs and maximizing the distance of the facilities from the residential zones. They tested their model on actual data from Phoenix, Arizona. Nozik (2001) developed fixed-charge location problem (FCLP) with coverage restrictions. In this paper the objective was to minimize cost while maintaining an appropriate level of service for determining facility

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locations. Two heuristics based on Lagrangian relaxation were used and tested on real data collected from networks in the USA. Rakas et al. (2004) developed a bi-objective model for landfill location proposed to appropriately address uncertainty associated with this class of location problems. The methodology developed in this study is tested using the real-world data from a county in USA. Erkut et al. (2008) examined solid waste management and measured a decreasing function of distance from facilities. A multi-objective MIP model was developed for the location–allocation municipal problem at the regional level. The multi-objective problem was formulated as a lexicographic minimax problem aiming at finding a non-dominated solution with all normalized objectives as close as possible. Interesting multi-criteria approach was introduced by Eiselt and Marianov (2014). The authors examined where to locate landfills and transfer stations in the network, and formulated problem as a bi-objective mixed integer optimization problem. They proposed two objectives, the first one, to minimize costs, as usual, while the second to minimize pollution. The model was tested on real data collected from a region of Chile. Ghiani et al. (2014) provided great review paper about operations research applications in solid waste management. They focused on strategic and tactical issues, and covered more than 65 papers.

In this paper we focused on the model for locating landfills which is based on two objectives. The first objective function, as in the classical FCLP (Balinski, 1964), aims to minimize total facility and transportation costs. The second objective function, inspired by Minimum Covering Location Problem with Distance Constraint (MCLPDC) introduced by Oded and Rongbing (2008), minimizes the total number of end users undesirably influenced by landfills.

The paper is structured as follows. Description of the problem as well as mathematical formulation is represented in Section 2. In Section 3 numerical results are presented, while Section 4 summarizes our findings and provides some thoughts regarding future research.

2. PROBLEM DESCRIPTION AND MATHEMATICAL FORMULATION

Even if most people want landfills to be located as far as possible from their communities, the tendency is to locate them closer to highly populated areas as important waste generation sites to minimize transportation costs which is one of the usual objectives when locating landfills. Also, minimizing the number of residents affected by negative impacts of landfills represents another objective when it comes to choosing appropriate landfill site. Because landfills pose serious environmental risk, when locating them, a restriction is imposed that no two selected landfill sites are within a specified distance from each other.

We considered a problem, where end users i are represented by population centers located at known sites. Typically, population is aggregated at these centers, and we assume v_i residents are located at site i, each one generating q_i kg of waste per day. That means that $q_i v_i$ kg of waste will be generated at site i. All generated waste from end users should be collected and transported to the closest landfill. In order to formulate mathematical model, we defined two radiuses, where R_1 represents minimal acceptable separation distance between any two located facilities and R_2 represents separation distance between any landfill location and end users (Figure 1). We are locating landfills so as to minimize overall costs (landfill establishing and entire demand satisfaction) while keeping them on a certain predefined distance from each other and in the same time to minimize their impact on end users.

Following notation is used for mathematical formulation of the described problem.

Sets and parameters:

N - discrete set of nodes representing potential landfill sites and end users

J - set of nodes representing potential landfill locations

I - set of nodes representing end users

$N = I \cup J$

j, k - indices used to represent potential landfill locations

i - index used to represent end user

d_{ij} - the shortest distance between end user i and potential location j

f_j - fixed cost of locating a landfill at potential location j

v_i - number of residents located at site i

q_i - quantity of waste generated per person at end user i

$w_i = q_i v_i$ -demand of end users i

c_{ij} - unit waste transportation cost from i to j

Q_j - capacity of a landfill at potential location j

R_1- minimal acceptable separation distance between any two located landfills

R_2 - separation distance between any landfill location and end users

$N_j = \left\{ k \in J \mid d_{jk} < R_1, j \neq k \right\}, \forall j \in J$ - set of potential locations that are on distance less than R_1 from particular location j, excluding itself

$\Pi_i = \left\{ j \in J \mid d_{ij} < R_2 \right\}, \forall i \in I$ - set of potential locations that cover end user i within R_2

M -large positive number

Variables:

$$x_j = \begin{cases} 1, \text{if landfill is located at potential location } j \\ 0, \text{otherwise} \end{cases}$$

$$y_{ij} = \begin{cases} 1, \text{if end user } i \text{ is associated to landfill } j \\ 0, \text{otherwise} \end{cases}$$

z_i - number of landfills that cover end user node i

Formulation of the problem:

$$\min \quad OF_1 = \sum_j f_j x_j + \sum_i \sum_j w_i c_{ij} d_{ij} y_{ij} \tag{1}$$

$$\min \quad OF_2 = \sum_i v_i z_i \tag{2}$$

s.t.

$$Mx_j + \sum_{k \in N_j} x_k \leq M, \forall j \in J \tag{3}$$

$$\sum_j y_{ij} = 1, \forall i \in I \tag{4}$$

$$\sum_i w_i y_{ij} \leq Q_j x_j, \forall j \in J \tag{5}$$

$$\sum_{j \in \Pi_i} x_j = z_i, \forall i \in I \tag{6}$$

$$x_j \in \{0,1\}, y_{ij} \in \{0,1\}, z_i \in N_0 \ \forall i \in I, j \in J \tag{7}$$

In the objective function (1), the aim is to minimize total facility and transportation costs, i.e. the total cost of facility establishing and entire demand satisfaction. Second objective function (2), minimizes the total number of end users undesirably influenced by landfills. This objective function is created to account for multiple landfill locations covering an end user, e.g. if some end user's node is covered by two landfills then its population will be counted twice in the objective function because the impact on that population is doubled. Constraints (3) are characteristic for Anti-covering location problem (ACLP) (Moon and Chaudhry, 1984) and MCLPDC. They are referred as Neighborhood Adjacency Constraints. If node j is selected for facility placement (i.e. $x = 1$), then the term Mx_j equals the right hand side term M and forces $\sum_{k \in N_j} x_k = 0$. Thus, if site j is

used, then all sites k within the R_1 distance neighborhood of site j, N_j, are restricted from use. Those constraints are practically oriented aiming at landfills dispersion. Constraints (4) and (5) are regular FCLP constraints, where (4) guarantee that each end user is served from one facility, while constraints (5) play a double role: ensure that the capacity of facilities is not exceeded and prevent users from being allocated to non-open facilities. With constraints (6), number of facility locations that negatively affect particular end user, i.e. the gap between them is less than predefined separation distance R_2, are determined. Consequently those constraints determine which users are covered and by how many landfills. Constraints (7) describe problem variables. Other specific constraints could be added according to the specific problem.
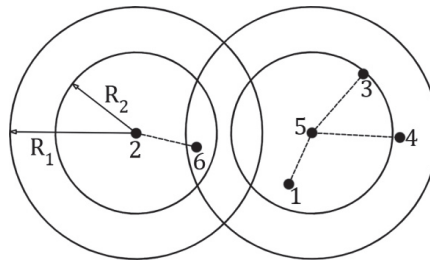
Figure 1. Illustration of separation distances for the numerical example

3. NUMERICAL EXAMPLE

In this section, we tested proposed bi-objective model for landfill locating on one illustrative example. The observed area consists of 6 nodes which are simultaneously potential landfill sites and end users. All inputs are illustrative and time based costs are normalized at daily level. Daily quantity of waste generated per person at end user i (q_i) is adopted to be 0.8 kg for all $i \in I$, while the capacity of landfill sites is put to be sufficient enough that cannot be exceeded in this example. Let transportation unit waste cost be 0.8 €/km per truck load between all $i \in I$ and $j \in J$. If we assume the truck capacity of 10000 kg then c_{ij}=0.00008 €/km·kg. Fixed cost (f_j) of locating a landfill is uniform for all $j \in J$ and reduced to a daily amount of 1500 €. In Table 1, input parameters for proposed bi-objective model for landfill location are presented. Value of big M is set to 10. Values of R_1 and R_2 are set to 250 and 160 km, respectively.

Problem was developed using Python 2.7 programming language and solved by Cplex 12.6 software (IBM, 2012). Results for numerical example including all Pareto optimal solutions are presented on Figure 2. Marginal solution for OF_1 is x=(0,1,0,0,1,0) and OF_1=9,680.46 €, while marginal solution for OF_2 is x=(0,0,0,1,0,0) and OF_2=208,895 residents. For the marginal solution for OF_1 (Figure 1), OF_2 is 1,192,758. Next Pareto solution is (1,1,0,0,0,0) and OF_1=11,200.52 while OF_2=1,074,463, and so on until marginal solution for OF_2 where OF_1 is 22,682.42. All those solutions are valuable for the decision maker because they provide complete insight into the necessary information in finding the most preferred solution when deciding on landfills'

locations. In this small scale example it was possible to find all Pareto solutions, which is difficult for larger and almost impossible for real world data cases. It is usual that the decision maker has preferences for certain objectives (e.g. costs), so one solving approach could be relaxed lexicographic method to support such preference expressed by their order. If the decision maker chose in this model OF_1 as preferable objective then if for example he/she allows the total cost to increase for 23.5% from the optimal OF_1 (from 9680.46 to 11,955.01 €), OF_2 could decrease for 40.7% (from 1,192,758 to 707,529 residents).

Table 1. Values of the input parameters: d_{ij}, v_i and w_i

i/j	1	2	3	4	5	6	v_i	w_i
1	0	366.89	268.85	283.33	111.38	178.19	284929	227943
2	366.89	0	421.23	435.8	317.13	123	187581	150065
3	268.85	421.23	0	132.99	158.14	313.76	118295	94636
4	283.33	435.8	132.99	0	173.07	329.27	90600	72480
5	111.38	317.13	158.14	173.07	0	210.71	290900	232720
6	178.19	123	313.76	329.27	210.71	0	311053	248842
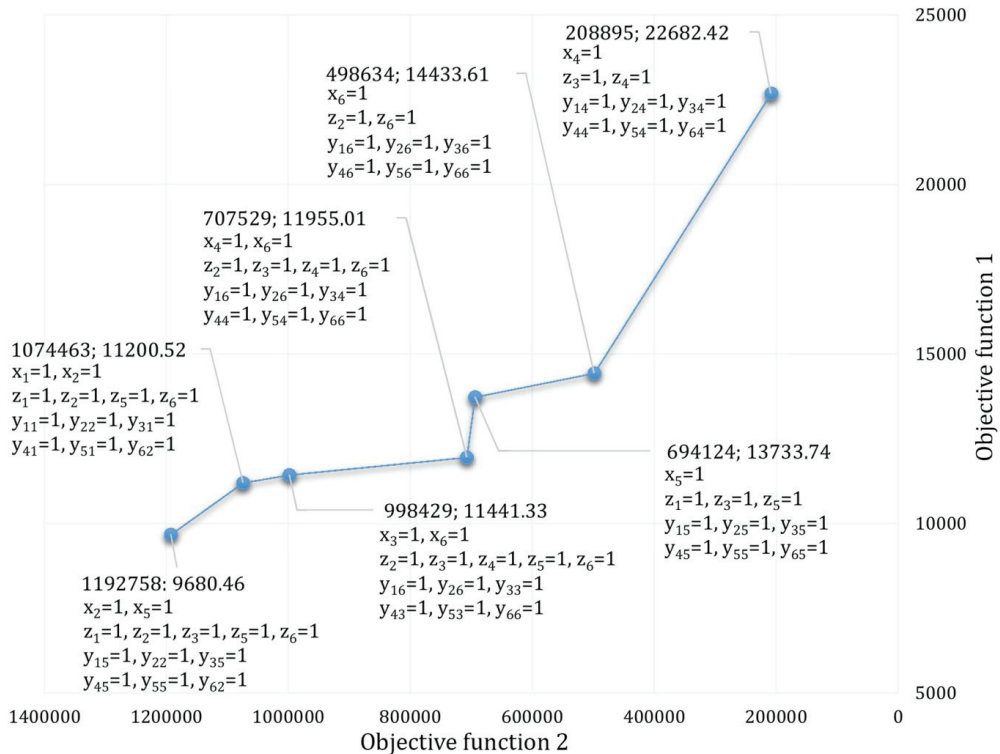
Figure 2. Pareto optimal solutions for numerical example

4. CONCLUDING REMARKS

This paper presents bi-objective model for determining landfill locations, in which the most common cost minimization function is utilized as first objective and as second objective function we minimized number of end users influenced by the negative impact of the landfills. This model

combines approaches and ideas from several location problems, such as FCLP, ACLP and MCLPDC. We presented one numerical example, with all Pareto optimal solutions and an illustration of the relaxed lexicographic method usage. The model should be understood as the beginning of our research in this area. Future research will focus on real world data problem testing, involving different approaches for problem solving, as well as on model upgrading to include location of transfer stations etc. We believe that proposed model has potentials and can be beneficial for the government organizations, local authorities as well as other organizations related to waste management issues.

ACKNOWLEDGMENT

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LOGIC

OPTIMIZATION OF FLEET SIZE WITH BALANCED USE OF VEHICLES: CASE OF SUGAR BEET TRANSPORTATION

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Abstract: In order to make sugar beet collection and transportation processes efficient and economical, it is needed to define optimal fleet size and to define tours which are suitable to be realized by the same vehicle. Mentioned task of assigning particular tours to a certain vehicle corresponds to the problem of "packing tours to the vehicles", that can be easily recognized as a well known one-dimensional bin-packing problem. In case of sugar beet transportation we are not only interested in determining schedules providing sugar beet supply with the fewest number of vehicles, but also in providing well-balanced vehicle schedules. Therefore, in this paper we analyze possibilities for fleet size optimization considering equity and fairness criteria. We propose modeling approach and some numerical results obtained from the model application.

Keywords: Vehicles scheduling, Fleet sizing, Bin packing, Load balancing.

1. INTRODUCTION

Sugar beet is well known industrial culture which is widely used for sugar production in Europe, and particularly in Serbia. The sugar beet harvesting period, which usually lasts two or three months, depending on the weather conditions, starts from September or October. In this period, known as campaign, transport demand is very high, and in average, in the case of Serbia, cca 100 vehicles need to make more than 200 tours between storage piles of harvested beet and a sugar mill every day. This huge transport demand is usually served by different 3PL providers, hired by the sugar company. In the process of collection and transportation of sugar beet different companies are engaged, some with small, and some other with large vehicle fleets. Depending on the distance between a sugar mill and sugar beet storage piles, but also depending on the length of the queues in front of the mill, vehicles make between one and several tours (usually up to five) during the working day lasting 24 hours.

All vehicles, i.e. transport companies, are hired on the basis of the predefined schedules including locations of sugar beet storage piles, quantities and required number of tours for any particular day in the planning period of three to six days, while those short term plans are based on the monthly or plans for the whole period of campaign. Hence, to make sugar beet collection and transportation processes efficient and economical, and to schedule and hire vehicles optimally, it is needed to define fleet size to be hired, and consequently, to define tours which are suitable to be realized by the same vehicle. Mentioned task of assigning particular tours to a certain vehicle, which obviously corresponds to the problem of "packing tours to the vehicles", can be easily recognized as a well known one-dimensional bin-packing problem (BPP). The BPP

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consists of packing objects of different sizes into a finite number of similar bins (containers), in a way that the number of used bins is minimized (Trivella and Pisinger 2016). This problem is one of the most famous in combinatorial optimization which has been studied since the 1939, when Kantorovich, among the other problems in organizing and planning production, considered scrap minimization, which corresponds to the BPP. His study, originally written in Russian, later is translated and published in English (Kantorovich 1960). Since then, the problem and its extensions continually occupy research interest, so the literature on these problems is huge. This problem was also paradigm for new approaches to the analysis of approximation algorithms and, because the problem is strongly NP-hard, many heuristic and metaheuristic approaches have been proposed. To the more interested reader we propose excellent research report of Delorme et al. (2015).

The bin-packing problem has very wide application in different areas and, as it is mentioned above, one possible application is in the fleet size optimization. This application is intuitively clear and corresponds to the problem of finding minimal number of vehicles needed for realization of all tours visiting defined set of nodes, when each vehicle performs sequence of assigned tours during its working time. However, as it is correctly stated by Trivella and Pisinger (2016), sometimes "we are not only interested in determining a packing with fewest bins, but also obtaining well-balanced packings". It is of particular importance in defining vehicles' schedules for the case of sugar beet collection and transportation, because vehicle tours of all hired vehicles should be based on equity and fairness principles. This means that the predefined schedules should be balanced, including as similar as possible tours' sequences, with similar transportation distances and collected quantities.

In general, literature offers different equity objectives and work load balancing criteria which are applicable for different types of vehicle routing, fleet size determination and bin packing problems as it can be seen in Matl et al (2016), Trivella and Pisinger (2016), Cossari et al. (2012), etc. Some of those approaches are based on one criterion, while the others are multidimensional. Also, to measure workload, different measures are proposed. Ho et al. (2009), and recently, Cossari et al. (2012), used criterion based on square errors, that they called "the normalized sum of square for workload deviations (NSSWD)", which is quite logical to be used from the statistical perspective, but because it is non linear, needs appropriate heuristics. Since the equity and fairness principles for the case of sugar beet transportation include two parameters: transportation distances and collected quantities, our approach in its nature is bi-criteria. In our model we include those parameters as constraints, keeping the model linearity by restricting absolute difference of equity measures (traveled distance and collected quantity), between every pair of vehicles, within a defined threshold. We consider two possible approaches. One based on partial consideration of the traveled distance and collected quantity, and another based on compound measure which corresponds to freight carriage unit *tkm*.

Remaining part of the paper is organized as follows. The problem description is given in Section 2. Proposed modeling approach and mathematical formulation is described in Section 3. Section 4 presents test instances and computational results. Concluding remarks are given in Section 5.

2. PROBLEM DESCRIPTION

Supply area of a sugar mill includes numerous sugar beet fields, and lot of potential locations for the storage piles. During the campaign, harvested beet is brought to those locations which then become sugar beet supplying nodes. Quantities of sugar beet stored on those locations can vary considerably, but it is always required to be multiple visited by collection vehicles. Supply nodes, i.e sugar beet storage piles are spread in the mill supply area on different distances, usually in the range of 5 to 50 kilometres, so that collection vehicles visiting storage locations close to the mill are able to make several tours, four to five, while those visiting farthest location make only one of two tours during the day. During the campaign, sugar mill has more or less constant

production rate, which needs constant supply of sugar beet which means realization of required vehicle tours every day. Daily vehicles' schedule aims to provide required supply intensity, while respecting different criteria like weather conditions, sugar beet freshness, vehicle capacity utilization, fairness and equity principles, etc. Freshness of the sugar beet stored on piles at different locations is very important because it longer stay means deterioration and lesser sucrose content which, together with weather and road conditions in a supply area, can be considered as primary criterion defining storage piles to be visited during a day.

Defining the vehicles' schedule which minimizes a needed fleet size to be hired, and provide required beet collection intensity from the set of predefined storage piles locations, while respecting available working time of vehicles as well as equity and fairness in tours assignment, is the second planning phase, and the problem considered in this study. Transport network which represent the problem considered in this study is shown in the Figure 1.
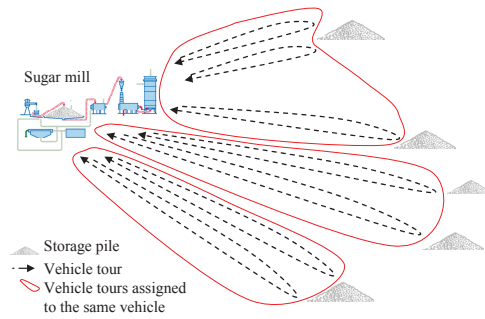
Figure 1. Sugar beet supply network

If there are M tours, and each lasts t_i time units, where $i \in M$, and each vehicle $j \in N$ is available during its working period T_j, then the problem of finding minimal number of vehicles N^* needed for realization of all tours, when each vehicle performs sequence of assigned tours during its working time, corresponds to the solution of the bin-packing problem. Note that, without loss of generality, it is possible to remunerate all tours visiting different storage piles locations, making M tours where some visit the same location. Fairness and equity in tours assignment are respected here through the balancing of the total traveled distance and quantity collected by vehicles. More precisely, we balance total time needed for realization of all tours assigned to a vehicles, as well as number of tours vehicle performs, because the quantity collected in a tour can be assumed to be equal.

3. MODELING APPROACH AND MATHEMATICAL FORMULATION

To formulate the problem we model the BPP in the usual form as an Integer Linear Program (ILP) with two binary decision variables x_j, and y_{ij}. Binary variable x_j equals *1* if vehicle $j \in N$ is used in the solution and it is equal to *0* otherwise. Binary variable y_{ij} equals *1* if vehicle $j \in N$ performs the tour $i \in M$, where M and N respectively represent sets of collection tours and vehicles. The proposed model is formulated as follows.

$$Min \sum_j x_j \tag{1}$$

$$\sum_{i \in M} y_{ij} \cdot t_i \leq x_j T_j \quad \forall j \in N \tag{2}$$

$$\sum_{j \in N} y_{ij} = 1 \quad \forall i \in M \tag{3}$$

$$y_{ij} \in \{0,1\} \quad x_j \in \{0,1\} \quad \forall i \in M, \forall j \in N \tag{4}$$

The objective function (1), tries to minimize vehicle fleet size, while the constraints (2) impose that the working time T_j of any used vehicle $j \in N$ is not exceeded by assigned set of tours each lasting t_i time units. Constraints set (3) ensure that all tours are realized, but only once. Constraints (4) define variables domains.

To introduce fairness and equity principles in tours assignment, we extend standard form of the BPP model (1) - (4) with additional vehicles' workload balancing constraints. We analyze two concepts of vehicles' workload balancing constraints. In the first concept we use two sets of constraints (3a) and (3b). Constraints (3a) restrict absolute difference of the total time needed for realization of all tours assigned to the vehicles, between every pair of vehicles $u,v \in N$ used in the solution. This difference should not be greater than the given "time difference threshold" - τ. Similarly, constraints (3b) restrict absolute difference of the total number of tours assigned to the vehicles, between every pair of vehicles $u,v \in N$ used in the solution, This difference should not be greater than the given "number of tours difference threshold" - δ.

$$\left| \sum_{i \in M} y_{iu} \cdot t_i - \sum_{i \in M} y_{iv} \cdot t_i \right| \leq \tau + M_1(1 - x_u) + M_2(1 - x_v) \quad \forall u,v \in N, u \neq v \tag{3a}$$

$$\left| \sum_{i \in M} y_{iu} - \sum_{i \in M} y_{iv} \right| \leq \delta + M_3(1 - x_u) + M_4(1 - x_v) \quad \forall u,v \in N, u \neq v \tag{3b}$$

In the second concept of defining vehicles' workload balancing constraints, our idea was to use compound measure which corresponds to freight carriage unit *tkm*. However, because the quantity collected in a tour is assumed to be equal for all vehicles, it is enough to consider only total travelled distance. Since the travel distance corresponds to the travel time, as an estimate of difference in *tkm* realized by different vehicles, we used above given set of constraints (3a).

Based on previous consideration, to model the fairness and equity principles in tours assignment, accordingly to the first concept we used the model (1) - (4), with additional constraints (3a) and (3b), while to model the second concept we used the model (1) - (4), extended only with constraints (3a). Values M_1, M_2, M_3 and M_4 are large enough constants (big M), used to introduce "*and*" statement in the constraints (3a) and (3b), since the threshold values τ, and δ are only applied when tours, performed by both vehicles x_u, and x_v, $\forall u,v \in N, u \neq v$, are in the solution. Note that shown form of the constraints (3a) and (3b) include absolute values of the differences which make the model nonlinear. However, those expressions can be easily linearized by standard transformation of the absolute values, which in total makes four sets of inequalities.

4. COMPUTATIONAL RESULTS

To verify proposed approach, we tested the model on several problem instances. Because the BPP is strongly NP-hard, our problem instances are smaller than the real world problems' sizes. Supply area has 10 storage pile locations which are randomly distributed around the sugar mill, on the distances which correspond to the tours' realization time randomly generated from the uniform distribution U(2,8). Total daily transportation demand was 1000 t of a sugar beet. Values of constants M_1, and M_2 are assumed to be equal to the vehicles availability period of 24 time units, which is the same for all vehicles. Values of constants M_3, and M_4 are assumed to be equal to the total number of the vehicles' tours |*M*|. Results of the model application are shown in the Table 1. The model was implemented in CPLEX 12.2, on 64 bit HP desktop, 3.20 GHz Intel Core i5-3470 with 8 GB RAM memory.

Table 1. Impact of the balanced and non balanced tours assignment

Problem instance	Number of vehicle tours (T) and average vehicles' usage (U) **Without balance**			
	Min T	Max T	Min U	Max U
1	3	5	0.851	0.968
2	3	5	0.842	0.990
3	3	4	0.471	0.985
4	3	8	0.521	0.990
5	3	5	0.805	0.996
6	2	5	0.346	0.986
7	4	5	0.806	0.971
8	5	7	0.881	0.964
9	3	5	0.863	0.998
10	3	6	0.287	0.986
Average	**3.2**	**5.5**	**0.667**	**0.983**
Min/max	**2**	**8**	**0.287**	**0.998**

Problem instance	Number of vehicle tours (T), and average vehicles' usage (U) - **Balanced (3a+3b)**															
	τ=min{t$_i$}, δ=1				τ=min{t$_i$}, δ=2				τ=2, δ=1				τ=2, δ=2			
	Min T	Max T	Min U	Max U	Min T	Max T	Min U	Max U	Min T	Max T	Min U	Max U	Min T	Max T	Min U	Max U
1	4	4	0.829	0.960	3	5	0.850	0.988	4	4	0.855	0.932	3	5	0.850	0.932
2	4	4	0.828	0.960	4	4	0.805	0.984	4	4	0.857	0.938	3	5	0.852	0.933
3	3	4	0.808	0.965	3	4	0.808	0.965	3	4	0.843	0.923	3	4	0.871	0.945
4	4	5	0.853	0.942	4	6	0.571	0.926	4	5	0.852	0.926	4	6	0.845	0.921
5	3	4	0.786	0.979	3	4	0.853	0.972	3	4	0.890	0.972	3	4	0.883	0.965
6	3	4	0.830	0.986	3	4	0.830	0.985	3	4	0.830	0.876	3	5	0.859	0.939
7	4	5	0.845	0.995	4	5	0.882	0.970	4	4	0.804	0.885	4	4	0.805	0.883
8	5	6	0.885	0.966	5	6	0.885	0.974	5	6	0.887	0.964	5	6	0.894	0.974
9	4	4	0.863	0.992	3	5	0.841	0.992	4	4	0.890	0.949	3	5	0.885	0.963
10	4	5	0.814	0.918	3	5	0.838	0.945	4	5	0.838	0.919	4	5	0.838	0.917
Average	**3.8**	**4.5**	**0.834**	**0.966**	**3.5**	**4.8**	**0.817**	**0.971**	**3.8**	**4.4**	**0.855**	**0.929**	**3.5**	**4.9**	**0.858**	**0.938**
Min/max	**3**	**6**	**0.808**	**0.995**	**3**	**6**	**0.571**	**0.992**	**3**	**6**	**0.804**	**0.972**	**3**	**6**	**0.805**	**0.974**

Instances	Number of vehicle tours (T), and average vehicles' usage (U) - **Balanced (3a)**							
	τ=min{t$_i$}				τ=2			
	Min T	Max T	Min U	Max U	Min T	Max T	Min U	Max U
1	3	5	0.831	0.960	3	5	0.850	0.932
2	4	4	0.813	0.990	3	5	0.853	0.934
3	3	4	0.808	0.965	3	4	0.852	0.922
4	3	7	0.842	0.937	3	8	0.845	0.927
5	3	4	0.808	0.973	3	4	0.876	0.958
6	3	4	0.830	0.986	3	5	0.859	0.940
7	4	5	0.882	0.994	4	4	0.805	0.883
8	5	7	0.869	0.990	5	7	0.886	0.964
9	3	5	0.842	0.992	3	6	0.885	0.964
10	4	6	0.818	0.937	4	5	0.838	0.917
Average	**3.5**	**5.1**	**0.834**	**0.972**	**3.4**	**5.3**	**0.855**	**0.934**
Min/max	**3**	**7**	**0.808**	**0.994**	**3**	**8**	**0.805**	**0.964**

Obviously, reported results show that the proposed concept of introducing fairness and equity in tours assignment, based on defined balancing criteria provide very good results, where the compound criterion gives slightly wider range of the average assigned number of tours, and average vehicle capacity usage, while maximum and minimum values are very close. This also means that the proposed approach and defined criteria should be considered as good candidates

that could provide efficient balancing mechanism to control fairness in defining vehicles' schedules.

5. CONCLUSION

In this paper we analyze the idea of introducing equity and fairness principles for the case of sugar beet transportation. The proposed approach to defining balanced schedule of vehicles used in sugar beet supply is based on two parameters: transportation distances and collected quantities. In the model we include these parameters as constraints keeping the model linearity by restricting absolute difference of equity measures between every pair of vehicles, within a defined threshold. Two possible approaches have been considered. One based on two measures: traveled distance and collected quantity, and another based on single compound measure which corresponds to freight carriage unit *tkm*.

Results of numerical experiments are very promising, since the model give expected results, keeping the workload balance, while simultaneously determining the minimal fleet size. However, because BPP is strongly NP-hard, numerical experiments were limited to smaller instances. The fact that the real word problems of this type are much larger, immediately opens one of the most important future extension of this research which is related to development of appropriate heuristics and metaheuristic approaches able to respond to sugar beet supply system of real size. Other possible research directions are in the field of the further analysis of defined balancing criteria and their comparison with other possible fairness and equity measures.

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Part II   LOGISTICS CONCEPTS AND STRATEGIES

LOGIC

IMPACT OF LOGISTICS MANAGEMENT AND SUPPLY CHAIN STRATEGY ON SHAREHOLDER VALUE

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Abstract: *There are many different ways for measuring corporate effectiveness and efficiency. One of the most important contemporary approaches to this issue is a stakeholder approach. The most important stakeholder group of a corporation includes its shareholders, and they estimate corporate efficiency primarily by financial results. Shareholder value can be defined as net present value of future free cash flows, which can be calculated as cash flows from operations minus capital expenditures minus changes in net working capital. Factors of such defined shareholder value are numerous, but the most important ones include revenue growth, operating cost reduction, fixed capital efficiency, working capital efficiency and tax minimization. Logistics management and supply chain strategy of corporations are among key driving forces of shareholder value and the subject of this paper is related to their impact on key factors of shareholder value.*

Keywords: *shareholder value, logistics management, supply chain strategy, free cash flow.*

1. INTRODUCTION

Concepts of effectiveness and efficiency are essential for every company. These concepts link the company's goals with the resources used to achieve these goals. Thereby, effectiveness can be defined as the ability of a company to acquire the appropriate resources and use them to achieve the goals. On the other hand, efficiency can be expressed by relation between outputs and inputs, i.e. as the ability of a company to maximize its outputs or minimize its inputs. Effectiveness relates to the achievement which the company set out to achieve, while efficiency relates to the ratio of outputs to inputs (Wilson and McHugh, 1987). If a company is effective, that means that it is doing the right things, while an efficient company is doing the things right.

There are many different ways for measuring corporate effectiveness and efficiency. Daft (1992) summarized the traditional approaches to this issue, which include approaches focused on achievement of goals, on ability for acquisition of resources and on internal processes. Therefore, effectiveness and efficiency can be evaluated by the level of realization of company's objectives, by company's ability to acquire scarce and valuable resources from the environment, as well as by the state of internal environment and efficiency of internal processes which transform inputs into outputs.

A common characteristic for all aforementioned traditional approaches refers to their partiality, i.e. to their focus on only one phase in the process of creation of value added. On the other hand, many new contemporary methodologies developed a more complex approached for measuring corporate effectiveness and efficiency. These approaches respect the fact that each company has various goals and that all companies use numerous resources to achieve their goals. Therefore,

new methodologies try to combine different indicators of efficiency in order to measure it. One of the most important and most commonly used contemporary approach for measuring effectiveness and efficiency is a stakeholder approach. This approach explains the behaviour of companies in the best way and identifies the most important factors which determine the efficiency and effectiveness of companies (Blazek and Castek, 2009).

In the following chapters, the paper's focus is on stakeholder approach, i.e. on shareholder value, which represents a key indicator of the level of owners' satisfaction. Furthermore, the paper investigates how logistics management and supply chain strategy can contribute to increase shareholder value.

2. STAKEHOLDER APPROACH FOR MEASURING EFFECTIVENESS AND EFFICIENCY

Stakeholder approach is based on measuring the level of satisfaction of different stakeholder groups which include owners, managers, employees, customers, creditors, society, suppliers, authorities and many others. Each stakeholder group evaluates effectiveness and efficiency by comparing what they get from the company with what they invest in the company. Owners, for example, evaluate effectiveness and efficiency by financial results, employees by working conditions and level and dynamics of wages, customers by quality of products and services, creditors by company's ability to service its debt, society by company's contribution to solving social problems and level of social responsibility, suppliers by regularity of payments and satisfactory transactions, government by compliance with law and rules, tax obligations etc. (Jones, 2001).

Table 1. Stakeholder groups and appropriate indicators of effectiveness and efficiency

Stakeholder group	Indicators of effectiveness and efficiency
Owners	Financial results
Employees	Satisfaction of employees, wages
Customers	Quality of products and services
Creditors	Credit rating
Society	Contribution to solving social problems
Suppliers	Satisfactory transactions
Authorities	Compliance with law and rules

At the very beginning, stakeholder approach suggests identification of key stakeholder groups for the company and key goals of each stakeholder group. Beyond doubt, owners and in some cases managers, when the managerial function is separated from the ownership function, represent the most important stakeholder group. Carpenter et al. (2015) give at least three reasons for superiority of owners and managers:

- Influence as either originator or steward of the company's mission and vision;
- Responsibility for formulating a strategy that realizes the mission and vision;
- Ultimate role in strategy implementation.

What is company worth to its owners, can be measured by a concept of shareholder value. Shareholder value can therefore be defined as a key measure of corporate performance and is determined by the net present value of future free cash flows. It is very important to make a distinction from profit, which is a difference between revenues and expenditures and does not

take accounts payable and accounts receivable into consideration. On the other hand, shareholder value, measured by free cash flows, refers to the money remaining after all supplier bills have been paid, all outstanding payments owed by buyers have been collected, and all money needed for investments has been accounted for. What is left, must therefore be free, i.e. distributable among all the investors, whether they are shareholders or debtholders.

In the next chapter, the financial concept of shareholder value, as well as key driving forces of shareholder value are presented.

3. FINANCIAL CONCEPT OF SHAREHOLDER VALUE AND ITS KEY DRIVERS

Free cash flow (*FCF*) is consisted of three important components:

- Cash flow from operations (*CFO*);
- Capital expenditures (*CAPEX*);
- Change in net working capital (*ΔNWC*).

Cash flow from operations (*CFO*) refers to the cash flows generated by the on-going operation of a company and can be calculated in the following way:

$$CFO = NOPAT + A + D \qquad (1)$$

Where A represents amortization, D depreciation and $NOPAT$ net operating profit after tax, which can be calculated as:

$$NOPAT = EBIT * (1 - t) \qquad (2)$$

Where $EBIT$ represents earnings before interests and taxes, and t is the tax rate.

Earnings before interests and taxes (*EBIT*) refers to all the benefits that a company has created before distributing to debtholders in the form of interests, to the government in the form of taxes, and to the shareholders in the form of profit. Since the government is only a stakeholder and not an investor, net operating profit after tax (*NOPAT*) reflects the benefits created that are distributable to the only investors of the company – the debtholders and the shareholders. Amortization and depreciation have to be added back because they do not necessary mean cash outflow and not adding back these categories would mean counting these costs twice.

Capital expenditures (*CAPEX*) refer major cash outflows for buying new fixed assets and equipment, or cash inflows from sale of equipment.

Net working capital is money that is necessary for keeping the operation going. It represents the money tied up in the operation, without which company would not be able to reach the desired results. Change in net working capital (*ΔNWC*) can be calculated in the following way:

$$\Delta NWC = (CA_t - CL_t) - (CA_{t-1} - CL_{t-1}) \qquad (3)$$

Where CA refers to current assets, CL current liabilities and t refers to time dimension.

An important consideration for working capital is that since working capital is simply capital that is working for the operation, it will be able to recover all the outstanding working capital at the end of the project.

Finally, free cash flow can be expressed by the following formula:

$$FCF = CFO - CAPEX - \Delta NWC \qquad (4)$$

As we already emphasized, shareholder value can be identified as net present value of future free cash flows of the company. In order to be calculated, all future free cash flows have to be discounted by appropriate discount rate, which is usually average interest rate on the market. Therefore, shareholder value (*SV*) amounts to:

$$SV = \sum_{t=1}^{n} \frac{FCF_t}{(1+i)^t} \qquad (5)$$

Where *i* refers to interest rate, and *t* to time dimension.

Christopher (2010) identified five key drivers of such defines shareholder value (Figure 1):

- Revenue growth;
- Operating cost reduction;
- Fixed capital efficiency;
- Working capital efficiency;
- Tax minimization.

Figure 1. The drivers of shareholder value

Revenue growth has a positive impact on net operating profit after tax, which is a component of cash flow from operations. Operating cost reduction, as well as tax minimization, also impact net operating profit after tax. On the other hand, fixed capital efficiency means that a company can achieve better results by using less fixed capital, and improvement of fixed capital efficiency directly impacts capital expenditures. Working capital efficiency means that a company achieves better results by using less net working capital, and improvement of working capital efficiency therefore means positive impact on changes in net working capital.

Srivastava et. al. (1998) suggested that corporate strategies should be evaluated in terms of how they either enhance or accelerate cash flow (Figure 2).
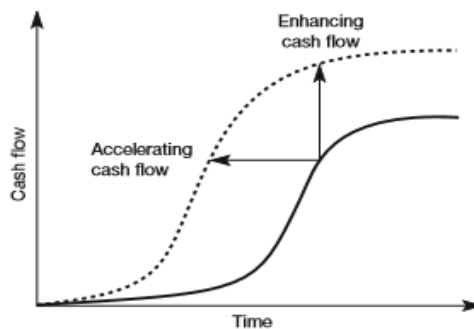

Figure 2. Changing the cash flow profile

4. LOGISTICS MANAGEMENT AND SUPPLY CHAIN STRATEGY AS DRIVING FORCE FOR SHAREHOLDER VALUE

Logistics management and supply chain strategy can have considerable impact on each driver of shareholder value and thereby represent a very important determinant of shareholder value. There are various channels for such an impact of logistics.

Primarily, logistics services have a strong impact on sales volume and customer retention. Cristopher and Ryals (1999) presented results of different studies indicating a positive causality between logistics service and sales. They emphasize that more reliable and responsible logistics service can strengthen the likelihood that customers will remain loyal to a supplier, and the higher levels of customer retention lead to greater sales, while revenue growth is among key drivers of shareholder value.

Furthermore, logistics and supply chain management possess a significant potential for reduction of operating costs. A large proportion of operating costs of a company (including transportation, storage, handling and order processing costs etc.) is often driven by logistics decisions and the quality of supply chain relationships. Cristopher and Ryals (1999) recognized that time compression in the supply chain can significantly reduce costs through the reduction of non-value-adding activities. Bearing in mind that operating cost reduction is also among key drivers of shareholder value, logistics and supply chain management can impact shareholder value also through this channel.

Logistics activities are often fixed capital intensive. For example, investment in transport vehicles and distribution centers needs high amounts of money and often negatively impact the overall return on investment rate. Therefore, instead of significant fixed investment, management can decide to use services from the third-party logistics service sector, and thereby decrease investment in fixed assets. In this way, logistics management can have significant positive impact on shareholder value through the channel of fixed capital efficiency.

Supply chain strategy and logistics management can also realize their impact on shareholder value through the channel of working capital efficiency. Namely, logistics is also fundamentally linked to the working capital requirement within the business. These requirements can be significantly decreased by time compression and by reduction of non-value-adding time in the supply chain, as Christopher (2010) noticed.

Furthermore, companies that are operating on international markets need to include even more elements in their assets allocation decision. Tax regimes are becoming one of the most important factors for choosing where to locate production or service centers for multinational companies. Differences in tax regimes can be so vast that they tip the balance from profit to loss. In that sense, it is not just the corporate tax rate that makes the difference, but also customs regulation, environmental taxes, different duty on fuel and energy and other rules that are even more differentiated among the countries. Every time when large global company have production and service facilities in different countries with dispersed distribution centers, total tax expenditures will largely depend on supply chain decisions. Therefore, these decisions will also influence shareholder value.

5. CONCLUSION

Achieving effectiveness and high level of efficiency is an ultimate goal of every corporation. Nowadays, a widely accepted approach for measuring company's effectiveness and efficiency is a stakeholder approach, which measures the satisfaction of all stakeholder groups of a company. Beyond doubt, owners represent the most important stakeholder group and they evaluate company's effectiveness and efficiency by financial results, and by dynamics of shareholder value. Shareholder value can be defined as net present value of all future free cash flows, which include cash flows from operations minus capital expenditures minus changes in net working capital.

There are many factors which determine the level and dynamics of such defined shareholder value. Among key driving forces, there are revenue growth, operating cost reduction, fixed capital efficiency, working capital efficiency and tax minimization. Logistics management and supply chain strategy of corporations are among key driving forces of shareholder value.

Logistics have a strong impact on customer retention and thereby on sales volume. Logistics and supply chain management possess also a significant potential for reduction of operating costs, having in mind that large part of operating costs is often driven by logistics decisions. Logistics decisions, like time compression in the supply chain and reduction of non-value-adding activities can achieve positive impact not only on reduction of operating costs, but also on improvement of working capital efficiency. Furthermore, location decisions in global logistics have significant impact on tax expenditures and thereby on shareholder value, as well.

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LOGIC

ENVIRONMENTAL CHALLENGES IN MARITIME TRANSPORT

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Abstract: Maritime transport is by definition the most environmentally friendly mode of transport per ton of cargo transported, but in recent years, its negative impacts are being emphasized more often, although the International Convention for the Prevention of Pollution from Ships (MARPOL) convention exists since 1973.

Negative impacts of maritime transport occur mainly during ship's sailing, but also those arising during operations in ports should not be neglected, mainly due to the proximity of ports to residential areas.

In this paper, the authors provide an overview of the environmental challenges in shipping industry that have to be tackled by ship-owners, ship-operators and ports in order to achieve greener maritime transport. Also, the examples of best practice resolving specific issues are mentioned and the estimates of costs in achieving greener shipping are provided.

Keywords: Maritime transport, green maritime transport, air pollution, sea pollution

1. INTRODUCTION

Shipping is the most cost-effective mode of transport for majority of commodities. In some cases it is the only possible mode of transport, so it is not surprising that around 80 (UNCTAD, 2014) to 90 percent (ICS, 2015) of all commodities in international trade are at some point transferred to the sea. Shipping is also the most environmentally friendly mode of cargo transport. In fact, only around 37% of all transport generated carbon dioxide (CO_2) emissions in international trade were attributable to maritime transport in 2010 (OECD/ITF, 2015a). According to the estimates presented in the Third IMO GHG Study from 2014, international shipping emitted 796 million tonnes of CO_2 in 2012, which accounted for no more than about 2.2% of the total CO_2 emissions for that year (IMO, 2015).

However, although most often emphasized, the environmental concerns regarding maritime transport are not limited to engine air emission alone, or even just to CO_2 emissions. Besides air emissions, also water damage and noise pollution from maritime transport occur on regular or random basis.

The aim of this review paper is to present the main environmental challenges in maritime transport, both during ships' sailing and ships' staying in ports and to provide the state-of-the-art estimation of the environmental impacts of maritime transport.

2. CURRENT ENVIRONMENTAL FOOTPRINT OF MARITIME TRANSPORT

Shipping is the most energy-efficient way to move large volumes of cargo, in fact in 2010 ships produced a total of 60,053 billion tonne-kilometres and are projected to produce 256,433 billion tonne-kilometres in 2050 (OECD/ITF, 2015a). In 2015 seaborne trade surpassed 10 billion tonnes (UNCTAD, 2016); however maritime transport is producing, as said before, certain environmental damages, which can be grouped into air pollution, sea pollution and noise pollution. In this paper, the authors are focused on air and sea pollution originating directly from the provision of maritime services.

2.1 Air pollution from maritime transport

Ships burn heavy and low quality fuel, which can have a sulphur content of up to 2,000 times higher than fuel used by road vehicles. As a result from 2007 to 2012, average annual totals of nitrogen oxides (NO_x) and sulfur oxides (SO_x) reached 20.9 million and 11.3 million tonnes from all shipping activities respectively, and as such represent about 15% and 13% of global NO_x and SO_x from man-made (anthropogenic) sources respectively (IMO, 2015). In addition, 2.7 % of CO_2 emissions can be attributed to international shipping.

Ships emit also carbon monoxide (CO), methane (CH_4) and particulate matters (PM) both during sailing and in-port operations; however, the in-port emissions represent barely around 2% of total international shipping emissions (OECD/ITF, 2015b).

Nevertheless, these emissions, together with the emissions produced by sailing in coastal areas (according to IMO (2009), 70% of maritime traffic occurs within 200 nautical miles from shore, even more fascinating 44% and 36% occur within 50 and 25 nautical miles respectively) can have significant impact on human health, besides damaging the environment; they can cause respiratory problems and bronchitis symptoms. In fact, Corbett and others (2007) have determined that PM from shipping activities are responsible for approximatelly 60,000 cardiopulmonary and lung cancer deaths wordlwide annually. As a matter of fact, a single large container ship can emit cancer and asthma-causing pollutants equivalent to that of 50 million cars (Winkler, 2008) or with other words, 16 super-ships can emit as much sulphur as the world fleet of cars (Varsami et al., 2011). Maritime flows and consequentially majority of in-port and open seas emissions from maritime transport are expected to increase, so also the number of deaths related to maritime transport is predicted to increase; the prediction for 2012 was 87,000 (Corbett, et al., 2007). If the emissions of SO_X and NO_X from ships continue to grow at the current rate, shipping will become the biggest single emitter of these pollutants in Europe, surpassing all land-based sources combined, by 2020 (Rahm, 2015), while in 2050 ships are projected to emit 2,630 million tonnes of CO_2 in comparisson to 779 million tons in 2010 (OECD/ITF, 2015a).

Furthermore, shipping emissions cause considerable external costs; conservative estimation suggest that emissions of NO_X, SO_X and PM caused almost 12 billion EUR of external costs in the 50 largest ports in the Organization for Economic Cooperation and Development (OECD) (Merk, 2014). External costs of airborne emissions from shipping in European waters are estimated to 19.6 billion EUR per year (Sieber and Kummer, 2008).

To diminish the negative effect of heavy oil burning, International Maritime Organization (IMO) has declared four emissions controlled areas, namely Baltic Sea, the North Sea, the US Caribbean and the coastal waters of Canada and the United States. In these areas, cleaner fuel has to be used, that is a fuel with 0.1% of sulphur content since 1st of January 2015 (global limit is still 3.5%), or ships must be adequately equipped to produce cleaner emissions. For example, instead of using marine diesel, cleaner and more expensive marine fuel, shipping operators can choose to substitute fuel power by renewable or more sustainable energies (eg. solar power, LNG or

heat recovery systems) or to cut their sulphur emissions by fitting engines with scrubbers or other exhaust gas cleaning technologies.

In addition, China has voluntarily established a marine sulphur limit of 0.50% applicable to fuel used while at berth in specific ports in the Pearl River Delta Area, the Yangtze River Delta Area, and the Bohai Sea Area. They will extend the application of this regulation firstly (in 2018) to all ports in these three areas and later to ships transiting these Sea areas (in 2019).

The following measures are proposed to reduce shipping emissions (OECD/ITF, 2015b):

- Alternative fuels or power sources;
- Operational measures that cover the operation of ship itself (hull condition, propeller condition, trim/draft optimization) and routing measures, such as voyage execution and weather routing (avoiding navigation in areas with bad weather conditions);
- Technical measures that cover machinery and measures under water (propeller and hull);
- Structural changes including port efficiency, vessel speed reduction (through fleet increase) and cold ironing (using power while at berth).

2.2 Sea pollution from maritime transport

Maritime transport is damaging sea with accidental or deliberate:

- spills of liquids, like ballast water, bilge water, bunker fuel, tank washing water or oil;
- dumping of solids like dunnage or garbage or
- dumping of mixed waste like sewage or cargo residuals.

Closer to the shore these activities occur, the larger the damage is.

In 2014, 3,025 marine casualties were reported, among which, 251 cases of pollution; in 216 the sea was affected, while the remaining 35 were air pollution. In the majority of cases (165), sea pollution was caused by the release of the ship's bunker and other pollutants (EMSA, 2015). In 2014, there were 126 reported cases of pollution; 108 were sea pollution and 18 were air pollution (EMSA, 2014). These numbers suggest the deterioration, but the truth is, that the reporting system is improving, so the casualties causing pollution are being more often reported.

The biggest threat for marine environment is the oil spill from tanker ships; however, since 1970s the number of oil spills (oil spill of more than 700 tonnes) has been declining continuously. For example, in the period from 1970 to 1979 in average 24.5 oil spills happened per year, while in the period from 2010 to 2014 in average only 1.8 yearly oil spills occurred. This can be related to strickter legislation for tankers which resulted from several devastating oil spills. The most important changes include the requirement for tankers of 5,000 dwt and more ordered after 6th of July 1993 to fitted with double hulls, and the neccessity to convert or take out from service the tanker built before that date when it reaches a maximum of 30 years.

Another issue directly arising from maritime transport is the introduction of invasive species following the ballast water exchange. Ballast water is indispensable for safe operation of ships, but the transfer of harmful organisms can create ecological and health problems. An estimated 10,000 marine species are transported around the world in ballast water every day (NOAA). Currently, more than 30 treatment systems to combat this potentially huge environmental hazard are under development. In addition, all ships in international will need to manage their ballast water to an agreed standard and according to approved ship-specific ballast water management plan. Ships will aslo need to carry a ballast water record book and have a valid international ballast water management certificate after 8th of September 2017 when International Convention for the Control and Management of Ships' Ballast Water and Sediments will enter into force.

In addition, ships are submerged into sea, and anti-fouling paints are used to coat the bottoms of ships to prevent sea-life organisms from attaching to the hull, and consequently slowing down the ship and increasing its consumption. These paints include chemicals and metallic compounds, which are persistent in the water, thus provoking lasting damage to the marine environment.

3. ECONOMIC IMPACT OF SELECTED MEASURES

In order to achieve economically efficient transport, shipping companies have been ordering ever bigger ships. However, the increase in size in usually linked to the necessity to install more powerful engines, which have bigger fuel consumption, and finally the emissions increase. This was happening until the environmental performance of the engines was not a subject of international regulations. But, studies show that substituting a string of ships with a string of bigger ships of same number, going at a slower speed so that total throughput remains the same, will reduce total fuel bill, hence total emissions (Psaraftis, 2009).

In October 2008 IMO member states agreed that the sulphur content of all marine fuels will be capped at 0.5% worldwide from 2020. Also, the NO_X emission standards for new ship engines were strengthened; in 2016 they needed to be reduced by 80% in comparison to the year 2000. Both will affect capital expenses of shipping companies, while sulphur requirements can pose also significant burden to the operating costs as well (in regards to method of emission abatement selected). In fact, the decrease of sulphur content from 3.5% to 0.5% is estimated by the OECD to cost between 5 and 30 billion US$ in additional fuel costs for the world container fleet alone, beginning in 2020 (WSC, 2017).

Table 1. Overview of environmental regulations and their impact on costs of shipping companies; Source: (Rahm, 2015)

What?	When?	Where?	Impact on OpEx	Impact on CapEx
SO_X	2015, 2020	Regional, global	High	High
NO_X	2016	Regional	Limited	High
CO_2	2018	Regional	High	High
Ballast water	Uncertain	Global	Limited	High

Note: OpEx – Operating expenses, CapEx – Capital expenses

In general, the costs for reducing pollutant emissions from shipping are estimated within a range between 0.5 and 4 EUR per kg of SO_2 and from 0.01 to 0.6 per kg of NO_X (CSC, 2011). Cleaner ships' exhaust is estimated to save 26,000 people a year in EU, resulting in up to 34 billion EUR saved in health costs each year if the IMO fuel standards were transposed into the EU legislation (T&E, 2017). EU recognizes the benefits of decreased emissions and thus supports the initiatives to achieve cleaner maritime transport also with tangible projects; for example the EU's TEN-T Programme has supported with almost 4 million EUR the pilot construction of the UK's first LNG bunker and the liquefied natural gas (LNG) propulsion system of two new ships (EC, 2014) and invested almost 600,000 EUR in a study for the promotion of LNG use in Greek maritime transport (EC, 2015).

In addition, World Ports Climate Initiative (WPCI), which includes majority of major worldwide ports, is aiming to stimulate the improvement of ships' emissions. One of their main goals is to develop an Environmental Ship Index (ESI), which can be used by the ship owners and by the ports as a label of good performance, and as a way to calculate discounts on port dues. The formula combines the ships' performance in terms of SO_X, NO_X and CO_2 emissions as well as the availability of on board connection for Onshore Power Supply (OPS). The index is intended to be used by ports to reward ships when they participate in the ESI and will promote clean ships, but

can also be used by shippers and ship owners as their own promotional instrument (ESPO, 2012).

In accordance to new rules, ballast water exchange requires huge capital investment due to the installation of adequate treatment systems. The physical exchange will pose some extra running costs as well, namely pumping costs comprising the use of additional fuel, energy and labor as well as machine maintenance costs associated with running ballast water pumps as well as the delay costs including the deviation or the necessity to slow down ship (Challinor et al., 2014).

4. CONCLUSIONS

Shipping is by far the most energy efficient mode of freight transport. Nevertheless, recently it is more often criticized for its environmental performance, so efforts to find ways to improve efficiency of shipping operations and shipping design must continue. At the moment one tonne of marine bunker in average produces: 3.17 tonnes of CO_2 (independently of fuel type or engine type), $0.02 \times S$ tonnes of SO_2, where S is the percentage of sulphur content in fuel, and 0.057-0.087 tonnes of NO_X depending on engine (Psaraftis, 2008). Total emissions from maritime transport are predicted to increase, although there currently exist many approaches and technologies to reduce environmental footprint, especially air emissions. However, for most of them, both certain advantages as well as certain disadvantages exist and the trade-offs between cost and efficiency or efficiency and complexity of installation or implementation must be done. In any case, the final cost of maritime transport will increase and final consumers will consequently pay more for the products they buy.

In addition, shipping is not (yet) included in the Kyoto global emissions reduction target for CO_2 and other greenhouse gas emissions. This could change as EU Parliament wants to include vessels in its Emissions Trading System (ETS), although there are several countries, led by China, India and Brazil that together with the shipping companies furiously oppose to this idea. But when there's smoke, there's fire, and another environmentally triggered impact on shipping costs is to be expected in forthcoming decades.

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SUSTAINABILITY OF THE CITY LOGISTICS INITIATIVES

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Abstract: Problems and complexity of logistics in the urban areas caused the development of different initiatives, i.e. concepts of city logistics which should enable mobility and sustainable development. However, their sustainability depends on the degree of acceptance and interest of the key actors. For this reason, it is important to identify the problems and assess the impacts of solutions on all stakeholders. The absence of these analyzes may result in incorrect effects assessment and selection of unsustainable solutions. This paper performs the ranking of the sustainable infrastructure city logistics initiatives. Evaluation criteria weights are obtained by applying the fuzzy Delphi method, and the ranking of initiatives is obtained by applying the fuzzy VIKOR method.

Keywords: city logistics, initiatives, sustainability, stakeholders, multi-criteria decision-making.

1. INTRODUCTION

With the growth of the world population, urbanization, flows of goods and unsustainable impacts of their implementation on the environment, the interest in city logistics also grew. In order to reduce the negative impacts of logistics activities on economic development and living conditions in the city, various measures, initiatives and concepts of city logistics are developed and tested. All solutions require larger or smaller changes of the system actors' behavior, and successful implementation and sustainability depend on the degree of acceptability by all stakeholders, i.e. analysis of the impact on the entire city logistics system. Such analyzes require a certain level of knowledge about the logistic activities' nature, which is usually not the case (Tadić & Zečević, 2015a). This paper performs the ranking of sustainability of the infrastructure city logistics initiatives that change the existing context of the urban environment. Fuzzy Delphi method is used to obtain the criteria weights, and fuzzy VIKOR for evaluating and ranking the initiatives.

2. RANKING OF THE CITY LOGISTICS INITIATIVES SUSTAINABILITY - PROBLEM STRUCTURE

City logistics initiatives can be structured by various criteria (Tadić & Zečević, 2016b). According to the required changes, they can be divided into initiatives without significant changes in the context of the urban environment (aimed at refurbishment) and those with radical changes. This paper deals in more details with the initiatives related to the infrastructure, as the initiatives that change the existing context of the urban environment (Tadić & Zečević, 2016a, Tadić, et al., 2014). The following describes the initiatives and criteria for evaluating the success of the initiatives.

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2.1 City logistics initiatives

Logistics centers (I_1). This type of initiative includes the use of the appropriate structures (centers) to consolidate transport flows and merge transport activities within the given area, i.e. city. Logistics centers are founded on traffic-favorable locations on the periphery of the cities or within the urban areas itself and they connect the inbound/outbound flows, i.e. they coordinate the flows of supplying and extracting the goods to/from the urban areas. Depending on the size and characteristics of the cities, the number, size, functions and locations of the logistics centers vary. The basic idea of the logistics, i.e. consolidation centers is the separation of the freight transport flows into two parts: flows within the urban area or the city and flows outside the area or the city. By applying this initiative, the implementation of inefficient transport activities in the city is avoided, the loading factor is increased and the number of vehicles in the central city parts, congestion on the streets, the fuel consumption and all negative impacts on the environment (air pollution, noise, vibration etc.) are reduced, while the quality of life in the urban areas is increased. In addition, the initiative of logistics, i.e. consolidation centers allows the use of more environmentally friendly vehicles for the final deliveries to the users and increase the positive effects in terms of the environment and society. Application of the advanced information and communication technologies enables better planning and implementation of the logistics operations and improves inventory control, product availability and customer service. On the other hand, better control and visibility of the supply chain enables the transformation from the pulled into pushed flows. Likewise, the concentration of the flows enables the offer of various VAL (Value Added Logistics) services, while the concept enables the reduction of the delivery costs and better resource utilization in the delivery points (Roca-Riu & Estrada, 2012, Tadić & Zečević, 2016a, Tadić, et al., 2014). However, despite a number of advantages, this type of initiative has certain disadvantages. The investments may be relatively high, especially in the initial phase of the logistics center construction and establishment of the consolidated delivery. Beside the investments, the operating costs of the center can be quite high as well. Many studies have shown that the cost of delivery increases as a result of additional steps in the supply chain, i.e. an additional transshipment of goods. Also, this initiative causes the loss of the direct contact between the shipper and receiver, and there is also a possibility of a monopolistic situation which eliminates the competition (Tadić & Zečević, 2015b).

Underground logistics systems (I_2). They belong to the group of the most radical and financially demanding city logistics initiatives. The initiative seems very innovative, considering the complicated system of underground networks, the amount of investment and a high degree of automation. The negative effects of logistics and freight transport in the city can be almost completely eliminated by the development and implementation of the underground logistics systems. In addition to the significant environmental and social benefits (increase of the city attractiveness and the reduction of the traffic congestion, energy consumption, emissions and noise, etc.), better management and improvement of the delivery performance (faster and more reliable deliveries, lower costs and greater safety and security of the deliveries, etc.) can also be achieved by applying the dedicated infrastructure and automated systems (Egbunike & Potter, 2011, Howgego & Roe, 1998, Tadić & Zečević, 2016a). However, these effects are achieved with very high start-up costs. In addition, there is no clear position on the mode and form of the stakeholders' engagement and who would be responsible for the functioning of the system. The most important observation is that such systems are possible only with significant government subsidies. (Egbunike & Potter, 2011) There are also big risks in the development of underground logistics systems, such as the collapse or damage to the historic city center, the unknown operation and maintenance costs of the system and the methods of financing, problems of the technology acceptance, the ability to connect with the intermodal transport flows, the lack of support for the acceptance of the system (insufficient government support), design and construction problems, competition with the conventional modes of transport (Egbunike & Potter, 2011), as well as other risks that are difficult to assess.

Standardization of loading units (I_3). Development and application of standardized loading units for the distribution of goods has been fueled by the success of the overseas containers.

Loading/unloading operations take a significant portion of the time and cost structures in the transport chain, particularly in the final distribution of the goods. These processes can be significantly faster and cheaper if the standard logistics units and equipment for vehicle loading/unloading is used (Dell' Amico & Hadjidimitriou, 2012, Jahre & Hattelan, 2004). Various units are used in the logistics flows. Larger units (containers, swap bodies) are used in the macro-distribution flows, while smaller logistic units (mini containers, logistics boxes, pallets, parcels and manufacturing or packaging units) dominate in the micro-distribution. The aim is to set the standards for a limited number of units (ideally one), with similar requirements towards the handling and transport equipment, which will be accepted by all actors of the city logistics chains. The development of the units is not a difficult task, but their standardization and wider application is (Jahre & Hattelan, 2004). Studies have shown that the use of standardized units increases the level of service, and reduces the emission of gases, energy consumption, traffic congestion and damage to the urban structures (Dell' Amico & Hadjidimitriou, 2012). It also leads to the increase of accessibility, transport efficiency and reduction of logistics costs. The main problems are the large initial investment costs for the companies that decide to implement the units, as well as their mass application. A possible way to overcome these problems would be the initiative by the big, important actors which would together have the potential to impose the certain loading unit as a standard for the market (Tadić & Zečević, 2016a, Tadić, et al., 2014).

2.2 Criteria for the evaluation of the city logistics initiatives

Fifteen criteria, divided into 4 groups: technical, social, economic and environmental, are defined for the evaluation of the described initiatives. The criteria are described in the Table 1

Table 1. Criteria for the evaluation of the city logistics initiatives

Criterion	Definition
- Technical criteria	
Service quality (C_1)	Customer satisfaction change as a result of the increased service quality.
Loading factor (C_2)	Vehicle's cargo space utilization change.
Customer coverage (C_3)	The possibility of serving a larger number of users in a particular geographic area.
Trip effectiveness (C_4)	Effectiveness change in terms of number of deliveries, distance, time of transport, reliability, etc.
Delivery size (C_5)	Changes in the amount of cargo handled during the deliveries.
- Social criteria	
Mobility (C_6)	Changes of the mobility of passenger and commercial vehicles in the city.
Accessibility (C_7)	Changes in access to the shipping/receiving locations.
Freeing of public spaces (C_8)	The possibility of freeing the public spaces.
Accidents (C_9)	Changes in the share of accidents caused by the delivery vehicles.
- Economic criteria	
Revenues (C_{10})	Revenues generated by the delivery service.
Costs (C_{11})	Costs of implementing the initiative and the operating costs.
- Environmental criteria	
Energy conservation (C_{12})	Reduction in consumption of fossil fuel by transportation resources.
Congestion (C_{13})	Changes in the traffic congestions in the city.
Air pollution (C_{14})	Changes of the greenhouse gasses and particle emissions into the air.
Noise, vibrations (C_{15})	Changes in the noise and vibration emissions.

3. CITY LOGISTICS INITIATIVES EVALUATION

For the evaluation of the city logistics initiatives a model that combines fuzzy Delphi and fuzzy VIKOR methods is used in this paper. Fuzzy extensions of the Delphi and VIKOR methods is used due to the linguistic evaluations, i.e. ambiguity and vagueness in the decision makers' thinking. Fuzzy Delphi method is used for obtaining the criteria weights, and fuzzy VIKOR for ranking the initiatives. In order to obtain the criteria weights it is first necessary to evaluate the criteria in relation to the stakeholders: residents, shippers/receivers, logistics providers and city administration. Linguistic scale that can be transformed into triangular fuzzy numbers (Table 2) is used for the evaluations.

Table 2: Linguistic terms and corresponding fuzzy values

Linguistic term	Abbreviations	Fuzzy scales
None	N	(1, 1, 2)
Very Low	VL	(1, 2, 3)
Low	L	(2, 3, 4)
Fairly Low	FL	(3, 4, 5)
Medium	M	(4, 5, 6)
Fairly High	FH	(5, 6, 7)
High	H	(6, 7, 8)
Very High	VH	(7, 8, 9)

After the criteria evaluation, the unification of the evaluations is performed using the equation (Hsu & Yang, 2000):

$$\tilde{w}_j = \left(\alpha_j, \beta_j, \gamma_j \right) \tag{1}$$

$$\alpha_j = \underset{h}{Min}\left(l_{jh} \right), \quad j = 1,...,n; \ h = 1,...,o \tag{2}$$

$$\beta_j = \left(\prod_{h=1}^{o} m_{jh} \right)^{1/o}, \quad j = 1,...,n; \ h = 1,...,o \tag{3}$$

$$\gamma_j = \underset{h}{Max}\left(u_{jh} \right), \quad j = 1,...,n; \ h = 1,...,o \tag{4}$$

where α_j, β_j and γ_j are lower, medium and upper values of the unified fuzzy evaluation $\tilde{w}_j$, respectively, and $\alpha_j \leq \beta_j \leq \gamma_j$. l_{jh}, m_{jh} and u_{jh} are lower, medium and upper values of the triangular fuzzy evaluation which indicate the importance of the criteria j in relation to the stakeholder h. n is the number of criteria and o is the number of stakeholders. For obtaining the final values of the criteria weights it is necessary to deffuzify the values $\tilde{w}_j$ using the equation:

$$P\left(w_j \right) = \left(\alpha_j + 4\beta_j + \gamma_j \right)/6 \tag{5}$$

Stakeholders' evaluations are unified using the equations (1)-(4) and defuzzyfied using the equation (5), and then normalized using the equation:

$$w_j' = w_j \bigg/ \sum_{j=1}^{n} w_j \tag{6}$$

Stakeholders' evaluations, unified, defuzzyfied and normalized values are given in Table 3.

Table 3. Criteria evaluations and final values of the criteria weights

Criterion	Residents	Shippers/Receivers	Providers	Administration	$\tilde{w}_j$	w_j	w_j'
C_1	VH	VH	VH	H	(1.20, 1.89, 2.70)	1,91	0,077
C_2	FH	FH	VH	H	(1.00, 1.64, 2.70)	1,71	0,069
C_3	FH	FH	H	FH	(1.00, 1.52, 2.40)	1,58	0,064
C_4	FH	VH	VH	M	(0.80, 1.62, 2.70)	1,66	0,067
C_5	M	VH	VH	M	(0.80, 1.54, 2.70)	1,62	0,065
C_6	VH	FH	H	VH	(1.40, 1.76, 2.40)	1,81	0,073
C_7	VH	H	H	FH	(1.00, 1.70, 2.40)	1,70	0,069
C_8	VH	M	M	H	(1.20, 1.49, 1.80)	1,50	0,061
C_9	VH	M	H	VH	(1.20, 1.68, 2.40)	1,72	0,070
C_{10}	M	H	VH	FH	(0.80, 1.56, 2.70)	1,63	0,066
C_{11}	FH	H	H	H	(1.00, 1.64, 2.40)	1,67	0,067
C_{12}	FH	M	FH	VH	(1.00, 1.50, 2.10)	1,52	0,062
C_{13}	H	FH	M	VH	(1.20, 1.56, 2.10)	1,60	0,065
C_{14}	H	FH	M	VH	(1.20, 1.56, 2.10)	1,60	0,065
C_{15}	H	M	M	VH	(1.20, 1.49, 1.80)	1,50	0,061

After obtaining the criteria weights, the evaluation of the initiatives in relation to the criteria is performed using the fuzzy VIKOR method (Opricovic, 2011). First, the fuzzy preference matrix is

formed ($\widetilde{D}$) elements of which are $\widetilde{f}_{kj} = \left(l_{kj}, m_{kj}, u_{kj} \right)$ triangular fuzzy evaluations of the alternative I_k in relation to criterion C_j (Table 4).

Table 4. Evaluation of the city logistics initiatives in relation to criteria

	C₁	C₂	C₃	C₄	C₅	C₆	C₇	C₈	C₉	C₁₀	C₁₁	C₁₂	C₁₃	C₁₄	C₁₅
I₁	H	H	FH	VH	VH	FH	FH	M	M	FH	FL	FH	FH	FH	FH
I₂	FH	FH	VL	FH	FL	VH	VH	VH	H	FL	N	VH	VH	VH	VH
I₃	VL	FL	VH	FL	FH	L	L	VL	VL	VL	VH	FL	M	FL	FL

The ideal $\widetilde{f}_j^* = \left(l_j^*, m_j^*, u_j^* \right)$ and the nadir $\widetilde{f}_j^\circ = \left(l_j^\circ, m_j^\circ, u_j^\circ \right)$ values of the criterion functions, representing the evaluations of the initiatives in relation to criteria are obtained>

$$\widetilde{f}_j^* = \max_k \widetilde{f}_{kj}, \quad \widetilde{f}_j^\circ = \min_k \widetilde{f}_{kj} \qquad (7)$$

Values of the normalized fuzzy difference $\widetilde{d}_{kj}$ are obtained afterwards:

$$\widetilde{d}_{kj} = \frac{\widetilde{f}_j^* (-) \widetilde{f}_{kj}}{u_j^* - l_j^\circ} \qquad (8)$$

Maximum group utility $\widetilde{S}_k$ and minimum individual regret $\widetilde{R}_k$ are then obtained:

$$\widetilde{S}_k = \sum_{j=1}^n w_j{}'(\times)\widetilde{d}_{kj} \qquad (9)$$

$$\widetilde{R}_k = \max_j w_j{}'(\times)\widetilde{d}_{kj}. \qquad (10)$$

Based on them, the overall distances of the alternatives from the ideal solution $\widetilde{Q}_k$ are obtained:

$$\widetilde{Q}_k = v \frac{\widetilde{S}_k (-) \widetilde{S}^*}{S^{\circ u} - S^{*l}} (+)(1-v) \frac{\widetilde{R}_k (-) \widetilde{R}^*}{R^{\circ u} - R^{*l}}, \qquad (11)$$

where $\widetilde{S}^* = \min_k \widetilde{S}_k$, $S^{\circ u} = \max_k S_k^u$, $\widetilde{R}^* = \min_k \widetilde{R}_k$, and $R^{\circ u} = \max_k R_k^u$. The v represents "the majority of criteria" strategy weight. By applying the equation (5) the values $\widetilde{S}_k$, $\widetilde{R}_k$ and $\widetilde{Q}_k$ are defuzzyfied. The ranking of the initiatives is performed according to the ascending crisp values (Table 5).

Table 5. Results of the fuzzy VIKOR method

		I₁	I₂	I₃
$\widetilde{S}$	Sˡ	-0,092	-0,093	0,255
	Sᵐ	0,221	0,220	0,567
	Sᵘ	0,533	0,524	0,880
	Crisp S	0,221	0,218	0,567
	Rank	2	1	3
$\widetilde{R}$	Rˡ	0,017	0,042	0,033
	Rᵐ	0,034	0,059	0,055
	Rᵘ	0,052	0,067	0,077
	Crisp R	0,034	0,058	0,055
	Rank	1	3	2
$\widetilde{Q}$	Qˡ	-0,316	-0,304	-0,140
	Qᵐ	0,001	0,012	0,179
	Qᵘ	0,321	0,324	0,502
	Crisp Q	0,001	0,012	0,180
	Rank	1	2	3

The initiative $I^{(1)}$ is proposed as the compromise solution since it was ranked as the first in relation to the Q, and both conditions were satisfied: (**Co.1.**): *Adv ≥ DQ* where

$Adv = \left[Q\left(I^{(2)}\right) - Q\left(I^{(1)}\right) \right] / \left[Q\left(I^{(m)}\right) - Q\left(I^{(1)}\right) \right]$ and $DQ = 1/(m - 1)$; (**Co.2.**): Alternative $I^{(1)}$ was also best ranked according to the R.

4. CONCLUSION

Solving the problems of city logistics depends on the selection and application of the appropriate initiatives in the given circumstances. When selecting the initiative one must take into account the vast number of criteria, which is the reason why this paper used the fuzzy Delphi method for obtaining the criteria weights and fuzzy VIKOR method for ranking the initiatives. The applicability of the model is demonstrated by ranking the infrastructure initiatives. Future research could be related to ranking and selecting initiatives belonging to some other groups.

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AIR CARGO TRANSPORT IN SERBIA: ANALYSIS, DRIVERS AND TRENDS

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Abstract: *This paper attempts to provide an overview of air cargo transport development in Serbia in terms of volume and network flows. The air cargo side of the industry in Serbia has been often underestimated, yet just below 1% of the total cargo transport is carried by air. After a long period of stagnation, air cargo is recording an upturn in the recent years, with average growth rate over 25 % in last three years. In order to continue this trend, it is important to understand the air cargo transport development and to identify the key drivers and constraints of this industry in Serbia. Taking into account that air cargo plays an important role in the transport chain and in the globalized economy, this analysis offers valuable information for better management and regulatory decisions.*

Keywords: *air cargo, network flows, key drivers*

1. INTRODUCTION

It is well known that air transport is preferred solution for carrying higher value, time sensitive and economically perishable goods, i.e. the goods for which the most important parameters are speed, reliability, and security. According to Arcandia Consulting (2016), 30% of shipped goods are perishables (by nature: food or flowers, or by destination: press); and the 70% are manufactured goods (spare parts, chemicals, pharmacy, etc.).

The demand for cargo transport, including air cargo, is dependent on economic activities. Trading activity between countries pulls the air cargo traffic. Although economic activity (expressed through the GDP per capita, foreign direct investment (FDI), international trade of goods (IT_g)) is the primary influence on air cargo development (Kuljanin et al.), other factors must be considered such as inventory management techniques, modal competition, environmental regulations, globalization, market liberalization, national development programs, and the introduction of new air-eligible commodities, (Boeing, 2016). Therefore, the aim of this paper is to research which factors have been responsible for air cargo growth in Serbia in last few years.

Namely, 27 million tonnes of freight is carried from/to Serbia by all mode of transport in 2015 (54% by road, 19% by river, 15% by train and 12% through pipelines). Despite low volume (less than 1 permille of total tonnes), the value of goods carried by air is high, which is in accordance with the world trend. The demand for air cargo transport in Serbia grew 31% in 2014, 29% in 2015 and 17% in 2016. In order to understand what drives this trend, it is important to analyse the air cargo transport development and to identify the key drivers of this industry in Serbia. This paper attempts to provide an overview of air cargo transport development in Serbia in terms of volume and network flows. We try to reveal what are the main causes of the air cargo

growth in Serbia. Analysis in this research is based on data from Statistical Office of the Republic of Serbia (SORS) database.

2. AIR TRANSPORT SYSTEM IN SERBIA

2.1 Airports

There are two airports in Serbia - "Nikola Tesla" in Belgrade and "Constantine the Great" in Niš which handle the air cargo traffic from/to Serbia through the scheduled and chartered freighter services. Airport "Nikola Tesla" is dominant in terms of cargo volume - in 2015, it handles the greatest air cargo volume taking into account airports in countries such as Croatia, Bosnia and Herzegovina, Macedonia and Montenegro. In recent years Belgrade has been one of the fastest growing air cargo airports in the region and its development is closely related to three recent events in Serbia: liberalization of air transport market, liberalization of foreign trade and transformation of loss-making JAT Airways into Air Serbia.

The share of total air cargo volume, handled by Niš Airport over the period 2004-2016 was below 5% with exceptions in 2010 (17%) and 2016 (12%). These exceptions are results of ad hoc charter flights. Excluding these two years, the average share of Niš Airport in total air cargo volume in Serbia was 4.4%. The growth is expected to be continued in following years, since Turkish Airlines started the schedule cargo flights in the winter season 2016/2017 between Niš and Istanbul. Niš Airport management plans to benefit from their geographical location and to develop the regional center for cargo traffic through which the goods will be exported from Bulgaria and Macedonia.

2.2 Airlines

There are four type of operators in air cargo industry: *combination carriers*—passenger airlines offering cargo services, *all-cargo airlines* offering chartered and/or scheduled services, *integrated carriers* offering door-to-door services by combining air and land transport, and *leasing companies* providing aircraft on dry or wet lease (World Bank Report, 2009).

More than ten combination carriers operate regular scheduled and charter flights at Belgrade Airport. Besides combination carriers, four cargo airlines offer direct scheduled cargo flights from/to Belgrade airport. Turkish Cargo operates once per week on the route Istanbul Ataturk (via Moscow Vnukovo) – Belgrade – Istanbul Ataturk. European Air Transport Leipzig offers every working day flights from Budapest to Belgrade and further to Linz or Leipzig, as well as Mediterranean Air Freight on the route Ljubljana – Belgrade – Ljubljana. Finally, Swiftair operates every working day from Cologne/Bonn to Belgrade, and then to Sofia. European Air Transport Leipzig is one of DHL's subsidiaries which offers services in Europe and parts of the Middle East and Northern Africa Region. This airline belongs to the group of integrated carriers.

3. ANALYSIS OF AIR CARGO TRANSPORT IN SERBIA

Over the past three years, Serbia has a sharp rise in air cargo traffic, with average growth rate more than 25% (Fig. 1). In 2016, Airport Niš had notable contribution in terms of freight tonnage (nearly 2000 t). Fig. 2 shows the development of air freight between 2004 and 2015. It can be observed that from 2004 to 2013 air cargo industry showed stagnating level (close or over 8000t carried by air). In 2013 and 2014 air cargo volume grew on average 30% per year. It is clear that foreign airlines penetrated the Serbian market from the beginning of process of liberalization (the Open sky agreement was signed in 2006 and ratified in 2009). The air cargo market share of foreign airlines increased from 50% in 2004 to more than 80% in 2015.
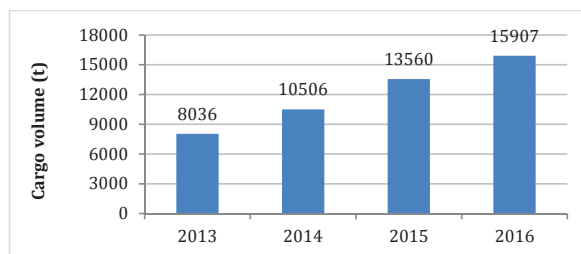
Figure 1. Total air cargo in Serbia, 2013-2016
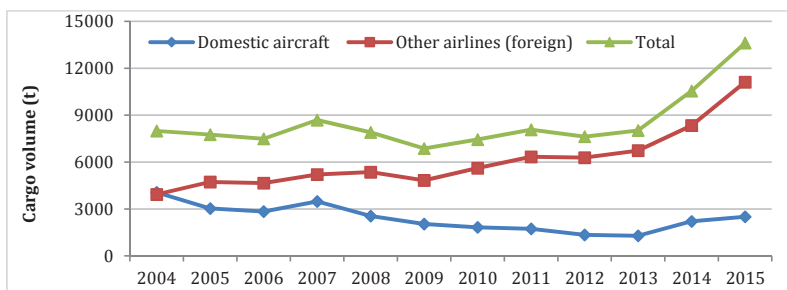
Figure 2. Total air cargo, air cargo carried by domestic and foreign aircraft in Serbia, 2004-2015

Although, the liberalization of Serbian market started back to 2006, the government protected its flag carrier (JAT Airways) up to 2013. In 2013 the Government of Serbia and Etihad Airways entered into an agreement which reorganized the operations of JAT Airways and renamed it Air Serbia. The flag airline had over 50% in 2004 of the total air cargo market share which was reduced step by step over a time. The average air cargo market share of national airline in last four years was 18% (Fig. 2).
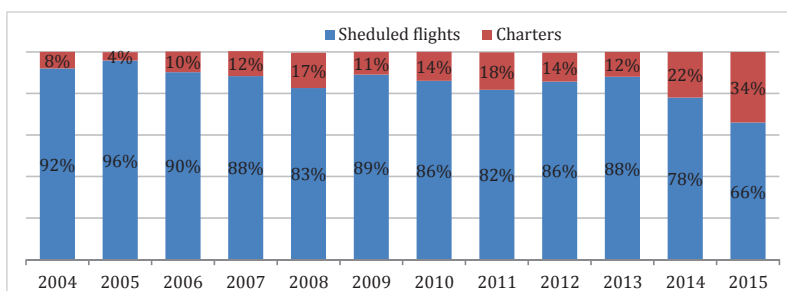
Figure 3. Shares of scheduled flights and charters

The air cargo traffic from/to Serbia from 2004 to 2013 was performed mainly by scheduled flights (on average of 88% of total traffic per year). In last few years this share is changed. In 2015, one third of air cargo traffic was operated by charters flights (Fig.3).
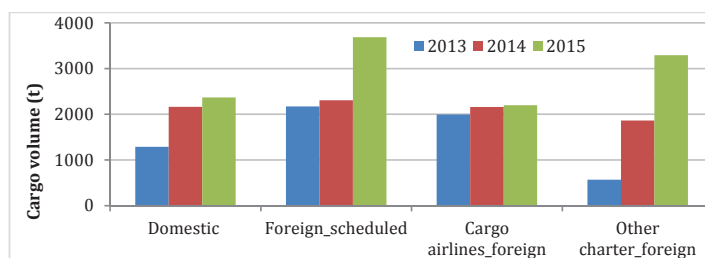
Figure 4. Total air cargo carried by domestic aircraft and foreign airlines (scheduled, cargo and other charter flights)

Fig. 4 shows total air cargo carried by domestic aircraft, cargo airlines and other charters excluding all airlines with schedule flights from/to Serbia. Air cargo volume served by cargo airlines (scheduled flights) in last few years was 2000t on average. Air Serbia recorded the modest performance related to air cargo volume. In 2014 and 2015 Air Serbia carried app. 2000t per year, too. It is very interesting the fact that in 2014 and 2015 there is significant increase in carried freights by ad-hoc charters (570t in 2013, 1863t in 2014 and 3292t in 2015).

4. AIR CARGO FLOWS

The main air cargo flows are presented in terms of cargo volume (Fig. 5), showing that the key markets for Serbia air cargo are the EU, Turkey, Middle East and Russia. The flow Serbia-Turkey grew in 2015 from 1500 to near 2500t. As it can be seen, the air cargo volume Serbia-Turkey is larger than total air cargo volume Serbia-EU (all countries, including Germany). Air cargo flow Serbia-Germany is largest among all countries in European Union (share is app. 23% of total Serbia-EU air cargo volume). The flow to/from Middle East is the third largest flow, which is in accordance with the forecast of Boeing (2016). Serbia has the advantage of trade with Russia in respect to the countries of the EU, because of EU sanctions and impeded exports/imports to Russia. Serbia took this advantage of free trade in goods between Serbia and Russia, but considering the amount of carried freight between these countries, all the potentials and benefits have not been used yet.
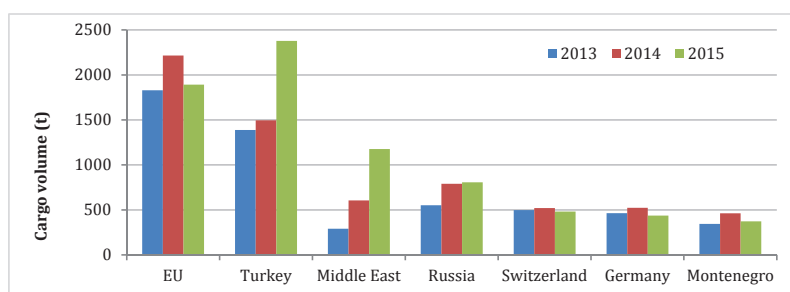
Figure 5. Main air cargo flows from/to Serbia, 2013-2015

Several airlines operate on route from Serbia to Turkey (two full-service carriers Air Serbia and Turkish Airlines and one low-cost Turkish carrier Pegasus). As can be seen in Fig. 6, Turkish Airlines is dominant operator on routes from Serbia. Pegasus has minor contribution related to the transported freight. However, Air Serbia (JAT Airways) did not benefit from this free trade agreement with Turkey, and its share stayed very low over the observed period.
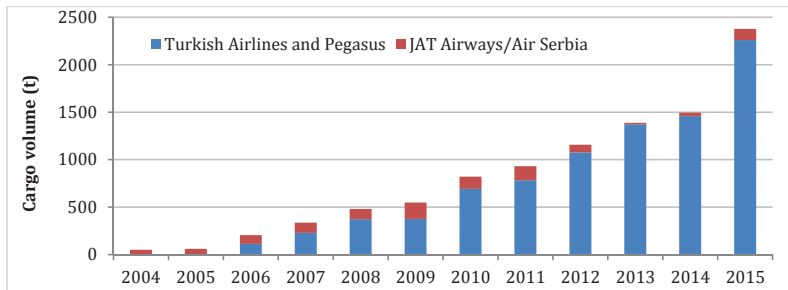
Figure 6. Total air cargo between Serbia and Turkey, 2004-2015

In recent years, Turkey has made significant investments and legal arrangements to improve and diversify its transportation system including the aviation sector. These efforts had positive impact on production and contributed to the development of its foreign trade (Transportation in Turkey, 2011). Moreover, liberalization of foreign trade in Serbia contributed significantly to growth of exported values. Medar et al. (2016) stated that the best indicator of such a contribution is the value of exports growth in the year of trade liberalization. For example, in the year 2011 when free trade agreements came into force between Serbia and Turkey (this agreement was signed in 2009), the average value of exports more than quadrupled (from the 34.2 EUR mil. to 151 EUR mil.). The average growth rate of exports for Turkey increases from 5.2% before liberalization to 43.6% after liberalization. All above mentioned facts can explain impact of Serbia-Turkey air cargo flow to air cargo development in Serbia.
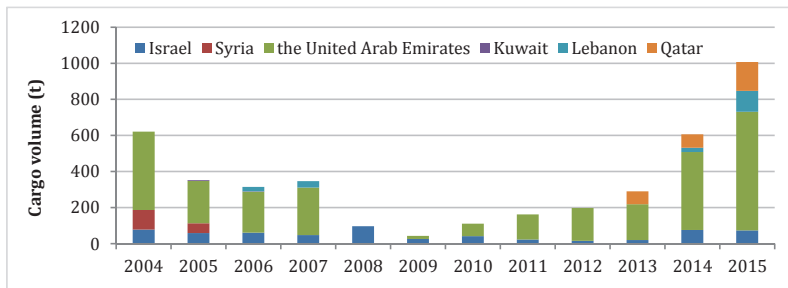
Figure 7. Total air cargo between Serbia and Middle East, 2004-2015

Although very important, the flow Serbia-Middle East significantly varied in the last decade (Fig. 7). Namely, in the period 2004-2012 the national carrier JAT Airways operated on route Belgrade-Dubai and this flow is only constant with small oscilations (along with the Serbia-Isreal flow, but the amount of transported good on this flow is much lower). Other destinations such as Syria, Kuwait, Lebanon are also covered by Serbian national airline or some ad-hoc charter flights, but these flows were not steady in the reporting period. "The Arab Spring", world economic crisis and deterioration of JAT had a strong impact on existence of these flows. Fortunately, in the recent years the flows to Middle East showed the signs of recovery. Particularly, all the credits of their re-growth goes to the airlines from Midlle East. Arabian Gulf-based airlines are among the fastest growing full service airlines in the world. Whereas world scheduled freight traffic, measured in freight tonne-kilometres, grew strongly by 4.6% in 2014, Middle Eastern airlines recorded the fastest performance in freight traffic with a growth of 11.3% (Arcandia Consulting, 2016). Two of „big three" Gulf airlines (Etihad Airways and Qatar Airways) operate at Belgrade Airport as well as Flydubai, low-cost airline with hub in Dubai. Fly Dubai started with operations in Belgrade in 2011. Qatar Airways introduced flights from Belgrade to Doha in 2012. Etihad Airways started to fly every day from Belgrade to Abu Dhabi in

2013. The most prosperous countries of the Middle East (i.e. oil-producing) invested substantially in the aviation sector and created positive conditions for airlines which started to benefit from both geographical positions, cost structure which allows tremendous savings in many cost categories and additionally generated demand for air cargo, (Kuljanin et al., 2015). A portion of these investments spilled over to the trends towards Serbia air cargo transport.

5. CONCLUSION

Based on this analysis, it can be concluded that a sharp rise in air cargo traffic in Serbia may be explained on following way. Besides the common drivers (GDP, FDI and IT$_g$), the liberalization of Serbian aviation market, penetration of some fast growing airlines, as well as bilateral free trade agreements with some countries, are certainly the additional reasons that pull air cargo traffic in Serbia. Precisely, based on data analysis, it is obvious that Turkish airlines and Middle East airlines contributed mostly on the increment of the air cargo transport in this part of region.

However, the significant contribution to the air cargo upturn in Serbia in the recent years gave the ad hoc charter flights. Their share in 2015 was 25% in total air cargo volume. Unfortunately, what drives this segment of flights is not transparent from the SORS data in available publications.

ACKNOWLEDGMENT

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LOGIC

SERVICE QUALITY IN RIVER TRANSPORTATION: BELGRADE CASE STUDY

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Abstract: *In this study the authors analyze users' perception of the service quality of river transportation in Belgrade. The users' reasoning was polled and modeled by approximate reasoning. The developed fuzzy system was tested on the polled users' answers and a very good results match was noticed. In future it could be used by service provider when investing in the river transportation characteristics which should influence improvement of the service quality.*
Key words: *River transportation in Belgrade, Approximate reasoning, Service quality*

1. INTRODUCTION

Evaluation of service quality is vital to improve productivity, increase profits and users satisfaction. Since service is not a physical item, but an experience, service quality is strictly linked to user satisfaction. Actually, user's perception of quality is an antecedent of his/her satisfaction level with the service (Falk et al., 2010). Developing valid and accurate measures of service quality is not a simple task since these measures deal with abstract and intangible services. Researchers have attempted to develop such measures over the years, none of which has been completely successful. This lack of success indicates that there is no single best measure for service quality. On the other hand, service quality assessment is closely related to the type of a transportation process, so existing approaches and measures which are used in passenger and freight transportation usually differ. In this context Rudel (2005), and Beuthe and Bouffioux (2008) present different performance indicators in freight transportation, while Nathanail (2008) considers passenger transportation case. One of the most important methods for evaluating the service quality using users' perceptions is the survey methods because detailed information is provided about user comments, it makes clear the concept of service, it shows the problems, and it offers possible solutions. In realistic situations, users may not provide quantitative or numerical evaluations. Rather, they may be comfortable providing qualitative assessments such as good, very good, poor, very poor, etc.

In this study service quality of river transportation in Belgrade is analyzed. Although we present possible performance measures for the assessment of service quality in a freight transportation, modeling of service quality is tested on the passenger transportation system, as a consequence of data availability. The assessment of service quality was obtained by users' poll during the summer of 2008 (Ivankovic, 2008). The analysis of the poll results showed which characteristics of the river transportation, in users opinion, influence most the service quality. The objective of our study is to develop the model which would imitate the poll results and could be used for assessment of service quality of future river transportation. The input variables which describe the service quality, as well as the service quality itself are suitable for the modeling by linguistic

or fuzzy variables. Application of approximate reasoning for modeling of human reasoning and decision making in presence of uncertainty is justified (Teodorovic and Vukadinovic, 2012).

The paper consists of five sections. The first section is the introduction. The second one introduces concept of a service quality and basic measures for evaluation within freight and passenger transportation systems. In the third section authors presented the considered case study. They selected the characteristics which, in users' opinion most influence the service quality. Also, the section gives short description of the poll process. The model in form of fuzzy system was developed and the service quality of river transportation was evaluated in section four. The proposed model was tested. The analysis of results and the conclusive considerations were given in the fifth section.

2. SERVICE QUALITY EVALUATION

The main objective of the river transportation is to reduce the environmental impacts of road traffic. The intense usage of river transportation contributes to reduction of pollution and noise rate. However, ports are constantly exposed to the challenge of improving quality of service offered to users and, on the other hand, managing all processes efficiently with the aim of reducing the costs. In general, cost analysis is relevant to logistics management. It can be used to understand the level of resources that are required to operate a transportation system, with the goal of maximizing service quality of the system while minimizing the cost of resources (Abdallah, 2004). The transport of users, as a service activity has its principal objective: to satisfy the users' needs. It is impossible to accomplish this without thoroughly knowing users' wishes, attitudes and interests and the way they perceive them. One of the methods to assess whether the users are satisfied with the service provided is the direct interview or the poll of the users. Examples of mentioned approaches for the case of freight transportation can be found in Rudel (2005) and Beuthe and Bouffioux (2008), as well as in Nathanail (2007), for passenger transportation.

Due to the need to evaluate to what extent the users of river transportation were satisfied with the service, different measures are proposed. In the freight transportation, the following measures are usually used: *frequency* of service per week actually supplied by the carrier or the forwarder; *time*, as door-to-door transport time, including loading and unloading; reliability as percentage of on-time deliveries; *flexibility* as percentage of non-programmed shipments that are executed without undue delay; *loss* as percentage of commercial value lost from damages, stealing and accidents; *cost* as out-of-pocket door-to-door transport cost (Beuthe and Bouffioux, 2008). In case of passenger transportation, standard EN 13816 defines a set of eight qualitative criteria for evaluation of public passenger transportation*: availability, accessibility, information, time, customer care, comfort, security, and environmental impact*, where each criterion comprises more detailed sub-criteria.

To assess in which way and in what extent those characteristics influence the service quality is the subject of different analysis of data collected usually through interviews or pools. The main purpose is in better understanding of the role played by these factors, but also in assessing its relative importance in providing transportation service. Then, the answer based on those findings may indicate needed improvements, or can be served as an estimate of the position of the transportation service provider on the market.

However, availability of representative data is in practice, not rarely, very limited, particularly in case of new services, and application of certain modeling approaches which can imitate users' perception and attitudes. Development of one such modeling approach, based on fuzzy logic approach, is the objective of this study. Although the idea followed in the process of the fuzzy logic model creation is general, values of input variables were based on the set of service quality measures similar to above given standardized criteria of the passenger transportation quality, because of availability of data used to test the model.

3. CASE STUDY OF RIVER TRANSPORTATION IN BELGRADE

Due to the need to evaluate to what extent the users of river transportation were satisfied with the service, the poll was carried out. The poll lasted four weekdays and one weekend day. During that period 130 users of the river transportation were polled within three river boats. The lines are: New Belgrade-Branko's Bridge and New Belgrade-Ada. Three river boats were employed in these two lines: two in the first and one in the second line. The boats were the catamaran type, registered for 56 users. The interval between the boat departures at both lines was 35 minutes.

The poll consisted of twelve questions divided in two groups. The first group of questions requested the river transportation users' information according to relations, sex, age, type of the tickets bought: the initial and the final point of their journey, reasons for the service usage and frequency of river transportation usage.

The second group referred to the evaluation of certain characteristics of river transportation and service quality of the entire system. In addition, the users had the possibility to give their suggestions and remarks according to their own needs and attitudes.

The polled users evaluated the characteristics of the river transportation and service quality itself in numerical scale from 1 to 5 (Ivankovic, 2008). In this study, the authors represent the evaluation of the characteristics of the river transportation by fuzzy sets to which the following linguistic values were assigned: 'small', 'medium', 'large'; 'bad', 'good', 'very good', 'excellent', 'low', 'medium' and 'high'. The river transportation characteristics are modeled by fuzzy variables: how well informed, accessibility, punctuality of boat schedule, staff kindness, safety, comfort, connection to city public transportation bus and tram lines and service quality, because it is impossible to imagine strict limits between different categories, that is, values of input and output variables.

The processed results of the poll showed which characteristics of the river transportation should be reconsidered and improved in order to make the service quality better: how well informed, port accessibility and connection to city public transportation lines. These characteristics were differently evaluated by the users (Figure 1).
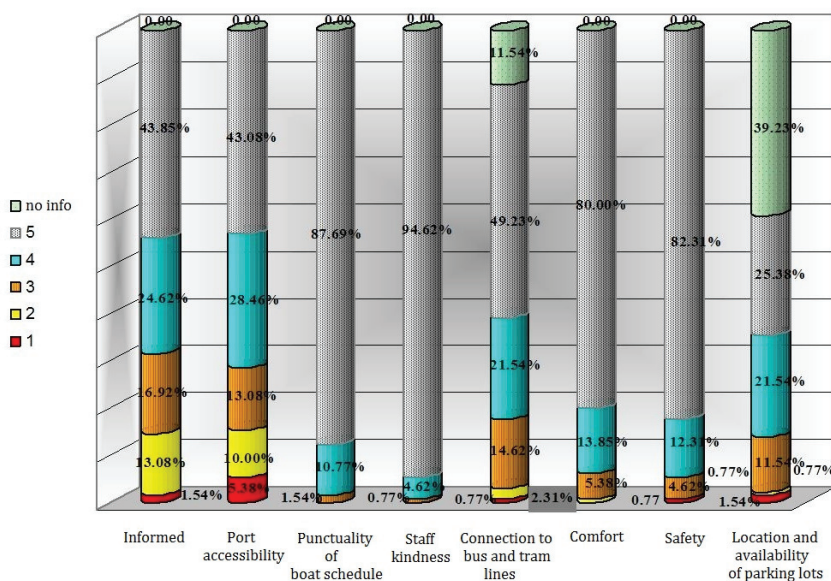
Figure 3. Graph of the evaluations of river transportation characteristics by users

4. MODELING OF USERS' REASONING

In this study, the authors developed a model in form of fuzzy system to determine service quality of river transportation in Belgrade. Most characteristics of river transportation on which the entire service quality depends, as well as the service quality itself, can be considered as fuzzy variables due to the presence of uncertainty and the way the users perceive them. The first step in design of a fuzzy system is fuzzyfication. In this study the experts' subjective opinions as well as analysis of the answers obtained by the poll, influenced the positions and shapes of the membership functions of fuzzy sets of input and output variables.

How well informed, port accessibility and connection to city public transportation lines are considered as input variables which describe service quality of the river transportation. Final shapes of fuzzy sets are obtained by tuning initial shapes using the trial and error method.
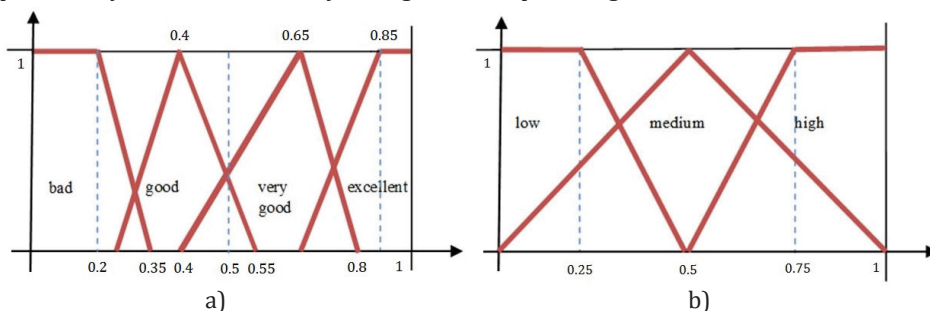
Figure 4. Membership functions of fuzzy sets: a) "bad", "good", "very good" and "excellent" "Level of information", b) "low", "medium" and "high" "Port accessibility"

It is supposed that the users distinguished and subjectively evaluated four categories, that is values of the first fuzzy variable "Level of information": "bad", "good", "very good" and "excellent" which are represented by fuzzy sets with the corresponding membership functions (Figure 2a). The "Port accessibility" was described by three values: "low","medium", and "high" (Figure 2b).
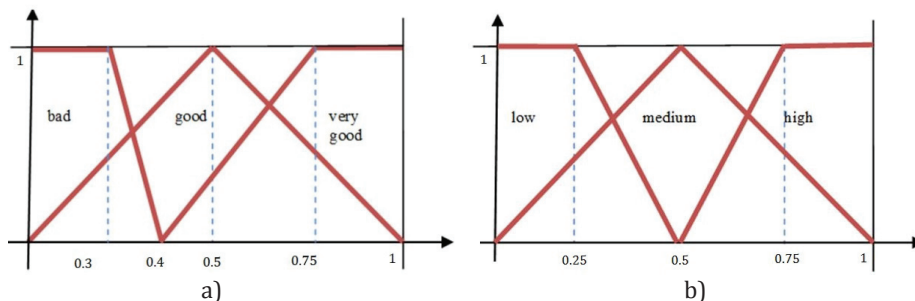
Figure 3. Membership functions of fuzzy sets: a) "bad", "good" and "very good" "Connection to city public transportation lines", b) "low", "medium" and "high" "Service quality of river transportation in Belgrade"

The users distinguished three categories of input variable "Connection to city public transportation lines": "bad", "good" and "very good" (Figure 3a). The users evaluated the output variable "Service quality of river transportation in Belgrade" in three categories modeled by fuzzy sets: "low", "medium" and "high" (Figure 3b).

Approximate or fuzzy reasoning is the deduction procedure or the way conclusions are made from assumptions within a set of fuzzy rules. In this study the authors defined the set of "IF THEN" rules which are used to determine the Service quality of river transportation in Belgrade. The tables below show the conclusions of fuzzy rules, in other words, values of output variable

"low", "medium" and "high" "Service quality of river transportation in Belgrade" (LSQ - Low Service quality; MQ - Medium Service quality; HQ – High Service quality). For example, IF the "Connection to city public transportation lines" is very good AND IF "Port accessibility" is low AND IF "Level of information" is bad THEN the "Service quality" is low.

IF CONNECTION TO CITY PUBLIC TRANSPORTATION LINES IS BAD AND IF

Information / Port accessibility	bad	good	very good	excellent
low	LSQ	LSQ	MSQ	MSQ
medium	LSQ	MSQ	MSQ	MSQ
high	MSQ	MSQ	MSQ	MSQ

OR

IF CONNECTION TO CITY PUBLIC TRANSPORTATION LINES IS GOOD AND IF

Information / Port accessibility	bad	good	very good	excellent
low	LSQ	MSQ	MSQ	MSQ
medium	MSQ	MSQ	MSQ	MSQ
high	MQ	MSQ	HSQ	HSQ

OR

IF CONNECTION TO CITY PUBLIC TRANSPORTATION LINES IS VERY GOOD AND IF

Information / Port accessibility	bad	good	very good	excellent
low	LSQ	MSQ	MSQ	MSQ
medium	MSQ	MSQ	HSQ	HSQ
high	MSQ	HSQ	HSQ	HSQ

In this study the approximate reasoning is carried out with "Max-Min composition", that is, the Mamdani's model of fuzzy system is used (Teodorovic and Vukadinovic, 2012). By the algorithm of approximate reasoning the fuzzy set with determined degrees of membership of possible numerical values of the output variable is obtained as a result. Defuzzyfication makes the fuzzy information restricted and represented by numerical information. In this study, the Center of gravity method is used to determine a single output numerical value from the resulting fuzzy set.

5. RESULTS AND CONCLUSION

The developed model of fuzzy system was tested. The comparison of the results obtained by the fuzzy system and the evaluation of the service quality of the polled users was done. The whole sample was included in the testing. The results of the fuzzy system match 80% with the poll results. The difference between the results obtained by fuzzy system and the poll results was created because the users were not consistent, in other words they did not make decision about the service quality assessment based on the grades they gave to the same characteristics of the river transportation system. On the other hand, the poll included more characteristics of the river transportation in Belgrade than it is case with fuzzy system (and perhaps for some users of the service those were the parameters which most influenced the service quality). In the future research the proposed fuzzy system can be expanded and it can include more characteristics of the river transportation in Belgrade, in other words it can provide better results. The proposed model of fuzzy system largely imitates the poll results and therefore it is considered to be

acceptable. The opinion of the river transportation users about quality of service provided is important for evaluation of the system in year 2008 as well as for its improvement. By processing the poll results authors concluded which characteristics of river transportation influence most the service quality of the studied system. Based on the poll results the model of fuzzy system was developed with the aim to determine service quality of river transportation in Belgrade. The proposed fuzzy system was tested on the answers of all polled users and a very good match was noticed. The fuzzy system shown and the results it provides could be applied in future with the objective to maintain service quality and its improvement. It is also possible to apply and use the developed model in larger number of lines and ports (in the initial phase there were only two lines and three ports). Finally, very important future application of the presented concept, based on slightly adjusted fuzzy logic system, with modified qualitative criteria, will be related to assessment of the service quality in river freight transportation. Since the proposed model of fuzzy system presented here largely imitates the poll results, it can be concluded that obtained results are also very promising for the case of freight transportation analysis.

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LOGIC

LOGISTICS IN THE RIVER CRUISE PRODUCTS

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Abstract: *The topic of this paper concerns the analysis of logistics in river cruise products. There are a lot of possibilities to exploit rivers to complete the whole tourist experience and that is the reason for writing this paper. This paper analyzes the main characteristics of river cruises, importance of river cruising and logistics of main river cruise products – accommodation, dining, bars, entertainment, shore excursions, shops, photography, casinos and other segments like different celebrations (weddings, renewal of vows...).*

Keywords: *river cruising, cruise products, cruising flow, river tourism, logistics in river cruise*

1. INTRODUCTION

Tourists today have shorter stays at destinations and they look for a new kind of tourist product and experience. The main reason for analyzing this topic is that there are a lot of possibilities and opportunities in this kind of tourist aspect, but it is insufficiently exploited.

Regarding all these various possibilities, there are a lot of different products in river cruising, and their logistics is interesting and very comprehensive. The number of products depends mostly on the size and luxury of the cruise ship and company. Larger cruise ships mostly feature multiple casinos, spas, swimming pools, adventure parks and lots of activities, while smaller cruise ships are typically more luxurious and offer a different kind of cruise experience.

According to the abovementioned, river cruise products are very important, the most common being: accommodation, dining, bars, entertainment, shore excursions, shops, photography, casinos and other segments like different celebrations (weddings, renewal of vows...). Their logistics is a part of this paper. They do not necessarily have to be all included in the river cruise package, but some of them always are. Some of them bring extra revenue to the cruise company, while others are there just to raise the river cruise experience to a higher level.

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2. MAIN CHARACTERISTICS OF RIVER CRUISE

The cruise is quite a new tourist branch and has the possibilities for a quick growth in the classic global tourist services. Multiple-day river cruises have been flourishing at the beginning of this century as a response to the swift rise of sea cruises. The main features are accommodation on board, a variety of restaurants, bars and commercial services, entertainment, leisure, recreation, sightseeing different towns and exploring their culture. Some of the characteristics are:

- there are two types of infrastructure demands for the river cruise industry – tourist and operational demands. Tourist demands are: pier / quay close to the city center and easy accessibility for buses and taxis, while operational demands are: waste reception facilities, sewage handling facilities, shore-side power supply, accessibility, fresh water and bunker supply (www.ccr-zkr.org/files/documents/workshops/wrshp081013/6 _HGrammerstorf_en.pdf 4.3.2017);

- the average river cruise ship built in 1996 had a width of only 11m, draft around 1.5m and length around 110m (capacity of 140 passengers), while today ships are 135m long, 17m wide and have a capacity of 220 passenger (Vojvodić, 2006);

- the importance of river cruises can be found in 12,000 direct jobs onboard, 10,000 jobs involved outside vessels, € 1.1 bn. new building investment within two years, € 1.3 bn. passenger expenditure and € 0.5 bn. shore side expenditure in Europe according to the Central Commission for the Navigation of the Rhine (www.ccr-zkr.org /files/documents/workshops/wrshp081013/6_HGrammerstorf_en.pdf 4.3.2017);

- the biggest river cruise region is Europe, whereas the country with the most developed river transport is Germany (rivers Rhine, Main, Danube). According to the German Travel Agents Council, the average tourist on a river cruise ship is 57 years old and is inclined towards themed cruises, highlighting topics such as golf, music, art, cooking and wellness. Citizens of Germany, France and Great Britain show the greatest demand for river cruising in Europe (Seatrade Cruise Review 2004);

- the average price for river cruises in Germany in 2007 was € 1,180, while in 2015 it was € 1,027, so there is a trend in the price-drop of river cruises (www.statista.com/ statistics/537438/average-river-cruise-price-germany 7.3.2017);

- operators in Europe have different routes and offers, so tourists can choose between one-day short river cruise or just dinner cruise, and a one week cruise in down, middle or upper part of the Danube River. The lower part of the Danube River usually starts in Budapest (Hungary) including Croatia, Serbia, Bulgaria and ending at the Black Sea in Rumania;

- the average number of days spent on river cruises in Germany was 7.2 days in 2015, whereas in 2007 it was 7.76 which means that there is a trend in shortening the duration of river cruising by 0.7% yearly (www.statista.com/statistics/537464/average-river-cruise-duration-germany 7.3.2017).

These characteristics reveal that river cruising is growing, and their logistics is starting to be quite challenging. Therefore, the following topic brings some examples of river cruise logistics.

3. LOGISTICS IN THE RIVER CRUISE PRODUCTS

In every tourism branch there are several products, therefore river cruise products are no exception. These products have three economic features: heterogeneity (mix of different products), inelasticity (these products cannot be stored if they are not sold) and complementarity (several different products taken together make a complete cruise experience).
(http://v5.books.elsevier.com/bookscat/samples/9780750666374/9780750666374.PDF 6.3.2017)

Figure 1 shows products of the river cruise, followed by an explanation of the logistics of these products.
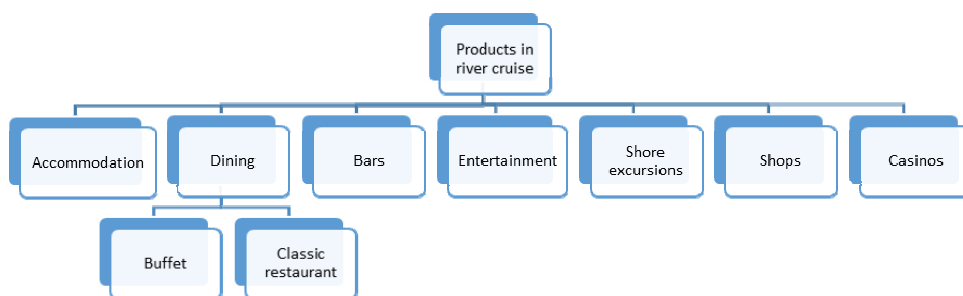
Figure 5 River cruise products

Some cruise companies refer to accommodation as cabins, but terms such as staterooms, mini suites and suites are frequently used to replace this nautical term. Some of the largest, most luxurious and most expensive options are probably penthouse suites (Mancini, 2000). The cabin size normative is between 18 to 23 square meters, but there are also some cabins (penthouse suites) with over 85 square meters. All cabins on a modern cruise ship have a shower, room and toilet – ensuite (Dervaes, 2003). Everything needs to be inside limited dimensions, so storage areas are designed to maximize the use of space, and areas that can generate revenue are the biggest ones. Brochures and cruise brand websites can help customers to select the best room for their needs. The most common way of identifying cabin locations is by using deck plans. Cabins that are on the lower decks are less expensive, while cabins that are on the higher decks are more expensive.

Basic cabin facilities include the following: two single beds (king-size bed) with possibility of an extra two upper beds, bedside tables, writing desk, storage areas, mirrors, chair, TV and radio, safe, hairdryer, minibar, direct-dial phone and air conditioning. Mirrors are used strategically to enhance space and light. Making beds, changing linen and towels, checking the room minibar, cleaning and vacuuming are the daily tasks of the steward. Housekeeping supervisors and managers inspect cabins to ensure that standards are maintained. Some suites and penthouse suites are allocated a butler to provide more personal service. (Gibson, 2006)

Dining on board is the next product, as the cruise ship is a place to enjoy good food, wine and company. Costs of eating on board are mostly included in the price of the cruise. There are several styles of cuisine (Italian, Mexican, Chinese…). Most large cruise ships operate at least two large 500 seats restaurants that are located on either side of a galley with a double-ended servery or hotplate. This arrangement facilitates the service of large number of people at dinner without creating lines at the door. Also, a major part in avoiding line is linking dinner service with entertainment schedules. Coordinating breakfast or lunch is usually a smaller problem

because passengers have alternatives such as buffet or room service, and port visits are mainly during the day.
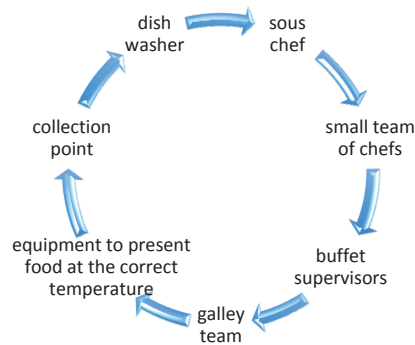
Figure 6 Logistics cycle of buffet

Figure 2 shows the logistics cycle of buffet. The buffet requires fewer staff than the traditional restaurant. A small team of chefs under the supervision of a sous chef services the buffet. The galley team is supported by buffet assistants and supervisors who help customers, clear tables, and serve drinks. The buffet employs equipment that is designed to present food at the correct temperature. Menus are changed daily according to the duration of the cruise itinerary. Tables are cleared to a collection point, from where dirty plates are taken by a trolley to the dish washer. (Gibson, 2006)

The main restaurants tend to reflect a style and standard of more formal dining. The menu is configured to meet the demands of passengers from different countries. Service ranges, depending on the brand and passenger expectation, from fully silver service on luxury ships to plated or buffet service combination on budget ships. Table sizes vary, from those for two to eight people.

The next products are bars. They start to get busy after dinner, but there are a lot of opportunities for passengers to purchase drinks at other times: sailing day (departure celebration), pre-ordering dinner, theater, nightclubs, during the day (pool bars), lounges....

Figure 7 Logistics team of entertainment products

Figure 3 shows the logistics teams of entertainment products. Entertainment is the product that does not create additional revenue, but it adds to the entire cruise experience. The theaters are the largest gathering areas (musicals, comedy clubs, cabaret, magic shows...), but they can also be used for emergency and as a meeting point. Every entertainment activity on the river cruise ship is published in the ship's newspaper, so all passengers are informed about them. These activities can differ, ranging from scuba diving, dance groups, culinary demonstrations to wine tasting, wellness and spas. Musicians are employed to provide support for theatrical productions, show bars, bar areas and deck parties. A technical team provides cinema support, IT support for computers, stage support for lightning, sound and similar. The leisure staff provider support for sporting activities such as golf, water sports or even tennis. (Gibson, 2006)
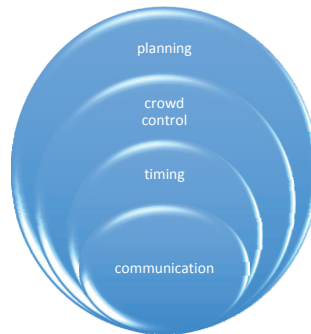
Figure 8 Logistics function in shore excursions

Figure 4 shows the logistics of the next product. The logistics of shore excursions is done before and during the river cruise. Shore excursions can include visits to different cities inland, or even Christmas markets during the Christmas time. They are convenient for passengers (between 50 and 80 percent buy an excursion in each port) and provide solid revenue. Shore excursions often use third-party tour operators to provide tours that best suit destination offers. Mostly, if passengers are disappointed with this product, they blame the port not the cruise ship. In some destinations, as little as 10 percent of the amount collected for a shore excursion is paid to the person that actually provides the tour. This leaves the shore excursion provider in an uncomfortable position of being paid $10 for a product that passengers expect to be worth $99 (Klein, 2008). The range of transport options depends on the port of call, and can include traveling by bus, train, bicycle, or taking a helicopter trip. The logistics of tours for passengers is like military logistics, involving planning, crowd control, careful timing and efficient communication.

Another part of river cruise products are shops. They are mostly duty free and can range from jewelers, gift shops and fashion stores to classic markets. They are located in the central area within the ship, resembling the shopping mall in bigger cities inland.

Photographers are also part of the cruise products. They give passengers the possibility to buy professional pictures in special presentation packs as best gift and memory reminders. Cruise companies have invested a lot of money in digital technology to process all these photos. Pictures are presented in corridor display areas so as to be easily viewed by passengers who may be on their way from a restaurant to a show bar. It is hard not to stop and look at the pictures. Sale can be confirmed with the application of carefully considered sales techniques. Some photographers are employed directly by cruise brands, others are contracted by concessionary operators. (Gibson, 2006)

Casinos on the river cruisers give the most revenue. They offer passengers the possibility to have a "James Bond moment". Games are played with cashless chips. Passengers receive a card that allows them to purchase goods on-board and credit that to their account. Casinos are generally operated by strict codes, and players must be over 18. Most casinos have a dress code and are operated with minimum and maximum bets.

Other things worth mentioning are weddings, renewal of vows and other special celebrations. While on board, passengers can celebrate special occasions, because where the law allows, the ship's captain can perform a marriage ceremony. Other passengers can purchase a package to renew their vows and the package can be customized to include spa treatments, champagne, and a formal ceremony. Birthdays, anniversaries, honeymoons, New Year's Eve and other special celebrations can all be catered to as part of a package.

The logistics of these products is very important, as they directly influence the categorization of the river cruise ship. According to the Berlitz Guide category, which takes 5 factors into account: ship, accommodation, dining, services and program, there are categories from three to five plus stars. Also, there are three "life style" categories: standard, premium and luxury, and according to them the cruise company can set a price for the river cruise. (Worldwide Cruise Ship Activity, 2003)

4. CONCLUSION

In conclusion, river cruising has a great potential, but it requires great efforts of all entities involved. If it is properly operated, the river cruise industry can boost tourism of every country. River cruise products are becoming more diverse, and operators are seeking new ways to satisfy passengers' needs and expectations. Today, the logistics of those products is more important than ever before. If everything is not perfect, the passenger will probably be unsatisfied and disappointed. The result of an unsatisfied passenger will probably be a bad review on the internet, and according to that, a drop in the sale of the river cruise packages and products.

Without high technology and simulations there is no relevant logistics progress. The most important and crucial link in the logistics chain of river cruise products is man, as it is a service business. Man can surely make a big difference between two similar competing companies with similar cruise ships, and in the end even provide survival on the market.

ACKNOWLEDGMENT

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LOGIC

EVOLUTION OF UNPLANNED COORDINATION IN A MARKET SELECTION GAME - DELIVERY COMPANIES CASE STUDY

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Abstract: *This paper examines the possibility of using evolution of unplanned coordination among independent distribution companies (agents) in a market selection game. The proposed model is a non-cooperative repeated game with several agents on many markets. Every agent is supposed to simultaneously choose a set of markets (cities) for maximizing its own revenue obtained by providing delivery service at the selected markets. It is assumed that the total volume of logistic units (pallets) is determined by the total number of agents on that market, their prices and service levels. The point of the market selection is to choose a set of markets for each agent that is optimal taking into account the specificities of each agent. In addition, it is proposed to expand model by evolutionary computation and fuzzy logic.*

Keywords: *game theory, logistic units, coordination.*

1. INTRODUCTION

The market of good distribution is characterized by the existence of highly developed competition between all participants involved in it. The existence of competing companies has a big influence on all aspects of their operations (the price of shipments, quality of offered services, the volume of shipments, etc (Čupić, 2014)). In such conditions, companies are faced with the uncertainty of what will be the consequences of decisions taken in specific situations and circumstances. As is often the case, the consequences of business decisions does not depend only on one side which brings them but also by interacting with decisions brought by other side (Krčevinac et al., 2006). Since the interests of participants at the market of good distribution are almost always antagonistic, i.e. the companies operating on this market are in conflict, the business decisions that they bring are interdependent and monitored with uncertainty, this phenomenon is possible to describe such a game. Area of operations research which analyzes these problems and finds optimal solutions is called game theory (Krčevinac et al., 2006). Game theory is a very important area of possible applications of evolutionary computation. Special importance has the study of evolution of possible strategies applied by individual players.

1.1 Literature review

The large number of authors dealt with game theory to diverse problems from various branches of engineering. Ishibuchi et al. (2001) have studied the evolution of unplanned coordination of independent agents. They studied a market selection game by a large number of independent agents. This paper, among others, was the inspiration for this research so that it will hereinafter

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be described. Ishibuchi and others suggest that a game involving agents should be uncooperative, should consist of a large number of rounds and should be repeated. Within each round, all agents who seek to maximize profit at the same time choose one of a number of possible markets where they will sell their products. The product price is determined by the total supply on the market (in a particular market is high if at the market appears very few agents, and inversely). After consideration of the effects that have been achieved in a given round, agents in the next round again elect market for its operation. Agents can use different strategies for the market selection. Ishibuchi and others are through application of genetic algorithms determined the best schedule of agents by markets. The authors showed that achieves about the same average profit per agent in the event of "unplanned" and in the "planning coordination."

Witteloostuijn and Boone (1997) are used game theory to show how inert player can displace from the market more flexible player. Some authors have used game theory to clarify sociological and evolutionary phenomena pertaining to the greater effectiveness of cooperative individuals in relation to the non-cooperative individuals, during the game (Wang et al., 2015). In more recent papers Adami et al. (2016) have dealt with the evolutionary game theory where the agents, as opposed to the classical theory, were modeled individually simulating thus the heterogeneity of the population of participants in the game.

2. UNPLANNED COORDINATION IN A MARKET SELECTION GAME

The market of goods and services distribution is characterized by a large number of companies that participate in it. Their positions are different for several reasons: the size and technology development of company, the structure of the fleet, the geographical position in relation to customers and so on.

In practice, situations in which more companies have interaction whose outcome depends on the mutual strategy two or more parties that have a conflict of interest is not unusual. The solution of these problems is possible by applying the game theory, which according to (Krčevinac et al., 2006) define the following:

- players who are parties of the conflict;
- gain/loss that is the result of the game;
- a set of strategies (strokes, alternative) that represent the behavior of each player.

During the game, through a number of rounds will come to evolution of market selection strategy applied by individual agents (distributors). Consider the n agents who in each round completely independently make decisions regarding the selection y of m markets $(y \leq m)$. Agents randomly elect a new market selection strategy from a set of predefined possible strategies. It is also advisable when choosing a strategy to use the genetic mutation operator. Each agent has its own node from which it goes on the market and in which he returns. That node presents head of distribution centers or hub. Agent is completely independent in its decision making process. Profit derived by an agent depends on the number of other agents who have chosen the same market, as well as transport costs which have agent during collection and distribution of pallets. Any strategy selected by the agent is characterized by a particular value of the fitness function. The value of fitness function includes the profit generated by agent.

Respectively i and j are indexes of agents and markets $(i = 1,2, ..., n; j = 1,2, ..., m)$. The T is the total number of game rounds. The t $(t = 1,2, ..., T)$ denotes the index of the round.

We introduce into consideration binary variable m which describes the decision of the i agent in the t round. This variable is defined as follows:

$$x_{ij}^t = \begin{cases} 1 & \textit{If agent i choose market j during round t} \\ 0 & \textit{in other cases} \end{cases} \qquad j = 1,2,...,m \qquad (1)$$

Since the agent i should choose y of m of potential markets, it must be fulfilled the following relations:

$$\sum_{j=1}^{m} x_{ij}^t \le y \tag{2}$$

The total number of items/pallets collected by the agents in the market j during round t is equal to:

$$X_{j}^{t} = Q_{j} \; \frac{\sum\limits_{i=1}^{n} p_{i}}{p_{i}} \Bigg/ \sum\limits_{i=1}^{n} \frac{\sum\limits_{i=1}^{n} p_{i}}{p_{i}} \tag{3}$$

The unit transfer price that during the round t agent charges in each market is denoted as p_i^t. The total number of items/pallets generated by the market in the node j is denoted by Q_j.

The agent i during round t has transport costs caused by transfer, processing and distribution of logistic units. That costs originating from performing at particular market j and they are calculated as in (Čupić, 2014), denoted as C_{ij}^t.

Profit derived by the agent i during the round t at the market j is equal to:

$$r_{ij}^t = X_{j}^t \cdot d_{j} - C_{ij}^t \tag{4}$$

where d_j is the average distance for transport of item/pallet at j node.

On the basis of relations (3) and (4) it can be concluded that the agent's profit does not depend only of the choices that he made but also of the choices that have made all the other agents.

Denote with s_i^t strategy of choice of agent i in the round t (in fact, it is a set of markets chosen by agent). In the initial round agents select markets randomly. Because there are m markets, the probability of selection of each market is equal $1/m$. In the present case, profit represents the value of the fitness function of the chosen strategy by the agent and can be marked as $r_{ij}^t\left(s_i^t\right)$ for market j.

We denote by $N(i)$ the neighborhood of the node i. Total number of nodes in the neighborhood is equal to N. Ishibuchi et al. (2001) have suggested that the neighborhood of the node i is a set of nodes to which belongs the node i and its nearest $N-1$ nodes. In addition to this definition, a neighborhood of nodes can be defined in some other way.

When playing the next round agent can keep the same strategy, i.e. the same set of nodes, or to choose a strategy from their neighborhoods for each individual selected market, i.e. for the city that covers by its transport network.

It is clear that, in the case of distribution companies, each agent has full information about the strategies that have been used in previous rounds of his neighbors.

Suppose that the agent has full information about the amount of logistic units that in some nodes took over his neighbors, although this is less likely. It should be noted that competition in some place generates profit (e.g. because of the proximity of the distribution center) while agent who observes his neighbors would make losses by including the same node in its transport network. The P_r indicates the probability with which the agent i when playing the next round changes the existing strategy s_{ij}^t for the observed node j by strategy s_{kj}^t of its neighbor k ($k \in N(i)$). Probability of strategy replacement is calculated as suggested by Ishibuchi et al. (2001):

$$P\left(s_{kj}^{t}\right) = \frac{r_{kj}^{t}\left(s_{k}^{t}\right) - r_{\min}^{t}\left(N(i)\right)}{\sum_{k \in N(i)}\left\{r_{kj}^{t}\left(s_{k}^{t}\right) - r_{\min}^{t}\left(N(i)\right)\right\}} \tag{5}$$

where $r_{\min}^{t}\left(N(i)\right)$ is the minimal profit made in the neighborhood of *N(i)*, i.e.:

$$r_{\min}^{t}\left(N(i)\right) = \left\{r_{k}^{t}\left(s_{k}^{t}\right) : k \in N(i)\right\} \tag{6}$$

After the operation of strategy replacement performs the operation of mutations. Strategy obtained after replacement operation will be replaced with one of the other strategies of the neighborhood, with the probability of mutation *Pm*. Strategy obtained after replacement and mutation operations denotes with S_{ij}^{t+1}. In other words, the agent *i* will use a strategy S_{ij}^{t+1} *(i = 1,2,...,n)* during the round *(t+1)*, with respect to node *j*.

Algorithm of evolution of market selection strategy consists of the following steps (Ishibuchi et al., 2001):

- Step 1: Determine randomly initial strategy of each agent;
- Step 2: Play a round of games with selected strategies and calculate the profit of each agent;
- Step 3: With the probability of performing replacement, replace agent's strategy in each individual market with one of the strategies of agent neighbors;
- Step 4: With the probability of performing mutation, replace agent's strategy by new strategy different from the existing one;
- Step 5: If they are not fulfilled conditions for completion of the algorithm, should return to step 2.
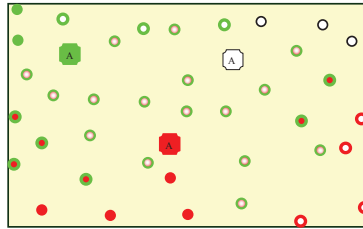
Figure 1. One stage in the evolution of market selection strategy

In the previous figure we can see an illustration of a stage in the evolution of market selection strategy. Nodes are colored. That represent each agent so in Figure 1 we have monochrome nodes which are covered only by one agent, nodes with two colors that covered by two agents and nodes that operate all agents. It is expected that the nodes which are extremely distant and have a small amount of logistic units are covered by a small number of agents, and vice versa.

3. EXTENSION OF THE MODEL BY EVOLUTIONARY COMPUTATION AND FUZZY LOGIC

The proposed model has several shortcomings that should to overcome through extensions given further more. In the first place, companies can have a completely different logic in forming strategies. Different logic is not the result of differences in the rationality of players but result of their different positions in the market, the location of processing and distribution centers, techno-economic performance of the companies themselves. The solution that is proposed is the introduction of fuzzy logic rules by which agents change their strategy. Rules are formed for

each agent based on its indicators. The probabilities of changing the strategy of each agent are different because there are more or less inert companies.

It is therefore necessary to introduce multiple criteria decision making in the given model as described in Čupić (2014). With this expansion agents would be able, during the rounds, to change the price and offered quality of services. That would affect the number of clients they attract, transport and sorting costs and, finally, the change in profit. The probability of strategy replacement could be calculated for each indicator and it would made selections of each market, also as the quality of service that is offered by market. Unit price would be offered for each round but the same for all selected markets, which reflects the uniqueness of tariffs throughout the territory.

In the case of observing different company in some other game, the price can vary from market to market. Agents are interested for competitive prices, for percentage of the market that the competition attracted by those prices and the offered quality of services. Based on all available information, management makes a decision on changing the tariff policy. The only way for properly presentation of this process, in the opinion of authors of this paper, is writing fuzzy logic rules for each player that would be obtained by interviewing management on how to react to the given market situation. In the proposed model, all markets are the same in all, except the amount of logistic units that is collected on them. It is known, however, that markets react differently to the services offered.

In some markets the main parameter for agent selection is offered price of services, while on the other market the main parameter is quality of service. Modification could be applied to the expression (3) where each agent could receive a certain percentage of logistic units in market depending on the offered price and quality (assessment of service quality is marked with KV_i). The quality which is offered by agent sometimes is not technologically possible to change (due to travel time, storage capacity, etc.) or the costs of such a project are extremely high. This fact must be taken into account when defining the probability of change of strategy related to quality of service.

If it turns out that the flexibility of agents with respect to changes in the quality of service they offer is low, then this parameter should be excluded from observation but only as part of a strategy that the agent can change. In any case, quality of service affects the probability of selection of a particular agent by the client. Also, percentage of conquered market depends of quality of service. The difference between markets would be obtained by defining the weight coefficients W_1 and W_2 expressing customers' preferences (price, quality) in this market (7):

$$X^t_j = Q_j \left[W_1 \frac{\frac{\sum_{i=1}^{n} p_i}{p_i}}{\sum_{i=1}^{n} \frac{\sum_{i=1}^{n} p_i}{p_i}} + W_2 \cdot \frac{KV_i}{\sum_{i=1}^{n} KV_i} \right] \tag{7}$$

Besides the rational parameters, clients often choose some distributor on the basis of subjectivity that is commonly recognized as a loyalty to distributor. In this sense, it is difficult to conquer new markets because the agent must 'hijacks' customers. This phenomenon could be included in the model through previous expression (7) by multiplication with an index of loyalty. Index of loyalty could minimize amount of logistic units to which the agent can count to the advent at the new market in the next round minimized. When agent stay at market, amount of logistic units could be magnified. In this way, agents were stimulated or not to win/retain markets. Since customer loyalty varies from market to market, this index should be determined specifically for each market [7].

From all the above it can be seen that it is very difficult to agent to determine the optimal strategy under conditions of competition. Therefore, the observed problem should be solved by evolutionary game.

4. CONCLUSION

The proposed model can be used in several ways depending on which the problem is solved. The first scenario is: all of the companies are already on the market of distribution of logistic units, have their own transport networks that are not fixed and have processing and distribution centers which are fixed (in special cases can be moved with additional costs). The game consists of changing the price, set of nodes and, consequently, the terms of collection/delivery. The second case is when an agent is new and has the freedom that, besides strategies with no additional costs, to the end of the game receives the topology of the transport network and timetable of lines that should be established. The last case is that all agents are new, new service is at the market and all players start from beginning and define all the parameters of its operations related to the service. It is necessary to compare the results of unplanned with planned coordination, where the central planner could deploy agents although access of planning coordination is not realistic in the case of distribution of goods.

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LOGIC

INLAND FREIGHT TRANSPORT IN SERBIA:
TRENDS AND CHALLENGES

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Abstract: *Road freight transport is a dominant mode of transport in Serbia, and during the period 2005-2015 its share increases. Rail transport is constantly falling while inland waterway transport is oscillating around same value. The records for pipeline transport have the biggest decrease. Empirical evidence, using the Logistics Performance Index (LPI), confirms that some of the indicators can be used as input for improvement of inland freight transport performances. The paper provides an analysis of inland freight transport market and its comparative sighting with rank of LPI. This paper will provide useful knowledge to policy makers and other interested in where are the possible challenges.*

Keywords*: transport market, freight flows, Logistics Performance Index*

1. INTRODUCTION

The Eastern Europe has been the cross road for international freight transport from and to the European Union for decades. Three TEN-T Freight Corridors pass through this region but the Serbia has not been connected yet. Due to the relatively limited surface area of the Eastern Europe countries, as well as to the position in the Europe continent, freight transport in these countries is highly international and can be competitive, as inland freight transport has been connected by corridors. This position is marked by freight volume in hubs in Croatia, Serbia, Romania and Bulgaria and, among other things, by the river ports on Sava and Danube and main sea port Constance.

Serbia is one of the Eastern European countries that intend faster to increase competitiveness in the contest of co-modality over the coming years. Today, international inland freight transport in Serbia reaches about 27 million tonnes, the level before world economic crisis. The question is: What are the challenges for freight transport development in Serbia over the coming years? Better and competitive inland freight transport is important for international trade and economic growth but constrains as transport infrastructure quality and development, miscellaneous obstacles during transport operation and governance issues may slow down developments within Serbian freight transport sector. One answer can be found by analyzing inland freight transport performances using LPI ranks to detect the places for improvements. This paper is attempt to do so by analysis of inland freight transport market in Serbia in chapter 2 and LPI scores in chapter 3. In chapter 4 some conclusions are given.

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2. ANALYSIS OF INLAND FREIGHT TRANSPORT MARKET IN SERBIA

Total volume of Serbia's external trade in tonnes for the period 2005 – 2015, after falling in 2009 and 2012, increased slightly in 2015 and reaches a maximum of about 27 million tonnes (Table 1). Similar trend can be seen for inland transport. The differences can be explained due to methodological differences for the external trade and transport statistics. Additionally, the difference in 2015 can be explained with lack of data in transport statistics, data on goods cleared within the New Computerized Transit System (NCTS).

Table 1. Total volume of external trade and inland transport, Serbia 2005-2015 (million tonnes)

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
External trade	19.16	23.57	25.96	26.58	22.07	24.41	24.66	22.48	23.3	24.5	27.07
Inland transport	20.38	23.32	25.71	25.65	19.09	23.35	22.92	21.61	23.3	24.33	24.76

Source: Based on SORS Statistical Database, SORS Bulletins and SORS Statistical Releases SV31

Road freight transport is a dominant mode of transport (Figure 1), and during the same period its share increases. Since 2011 road transport share is higher than 50%. Rail transport is constantly falling, although after biggest dropping in 2012, it has slow, but constant grow having a share of 13.6% in 2015. Inland waterway transport is oscillating around 5 millions of tonnes and 20% market share. The records for pipeline transport shows decrease except for the 2015. In further analysis the pipeline transport will not be considered due to its share just in import flows and low impact on other inland transport markets.
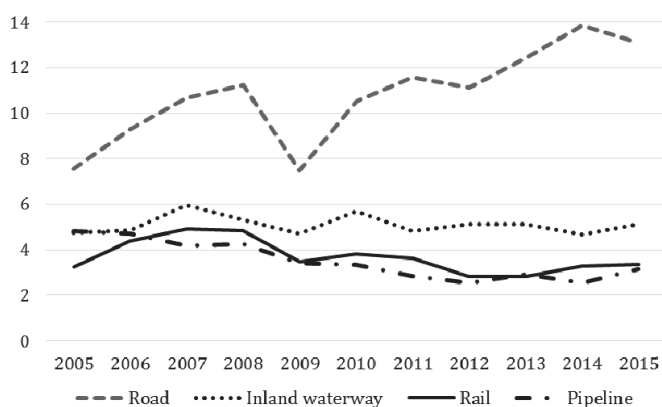
Source: Based on SORS Bulletins and SORS Statistical Releases SV31

Figure 1. International inland freight transport in Serbia, 2005-2015 (million tonnes)

The share of Serbian transport operators in total volume of foreign trade is more than 60% but there are significant differences between modes. In railway transport all goods have been transported by national operators as the transport market wasn't open yet. Last years, Serbian hauliers transported by road around 60% of goods, and in waterway transport, Serbian flag vessels transported around 20% (Figure 2). In road transport more than 30% goods transported by foreign from Bosnia and Herzegovina, followed by Montenegrin (~15%), Macedonian (~10%), Croatian (~7%), and Slovenian (~6%) – the hauliers from ex-Yugoslavia republics dominate among foreign hauliers (Medar et al., 2016). Situation is different in inland waterways where more than half of goods are transported by Romanian and Ukrainians vessels, 41% and 20% respectively in 2015.
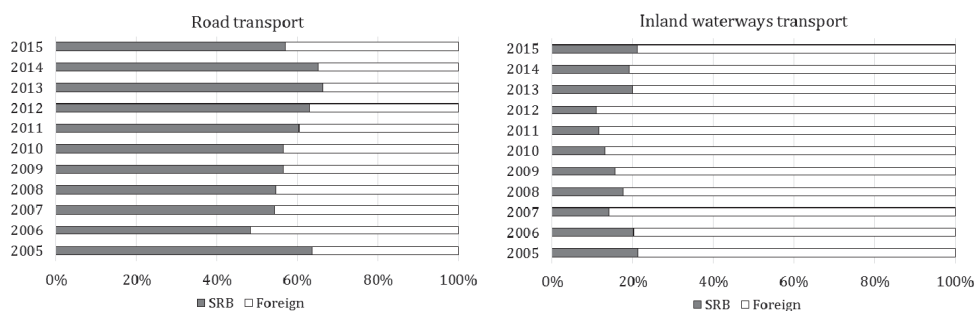
Figure 2. Share of Serbian and foreign operators in road and inland waterway transport

At the end of 2016, more than 1000 Serbian hauliers performed international road transport operations having vehicle fleet of more than 10000 vehicle combinations with drawing vehicles average age of about 7.8 years. At the same time 11 railway operators has been licensed, and one of them is national operator – Serbia Cargo. Serbia Cargo performs around 95% operations, and has more than 260 locomotives and 8500 wagons. Average age of locomotives is around 30 years. In inland waterways Serbia has 9 licensed carriers for international transport, with less than 180 vessels average age more than 35 years.

Other performances important for the market analysis are transport flows. The main flows of goods transported by road, rail and inland waterways are with neighboring countries, especially ex-Yugoslavia, Italy and Germany. The biggest trade volume is between Serbia and Romania of around 3 million tonnes in 2013, 2014 and 2015, followed by Bosnia and Herzegovina ($\sim$ 2.7 mil.) and Italy ($\sim$ 1.7 mil.) (SORS Database). Goods from and to Romania are transported mainly by inland waterways. Actually, trade volume between Serbia and Romania makes more than 70% of goods moved in inland waterway transport, followed by Ukraine (14.4%), mainly in imports, and Hungary ($\sim$5%) (SORS Bulletin). Cereals and cereal preparations make 75% of commodities transported by inland waterways from Serbia, and 95% of them are transported to Romania. In import, coal, coke and briquettes make about 20% of goods transported to Serbia by inland waterways. Situation is different in road and rail transport (Figure 3).
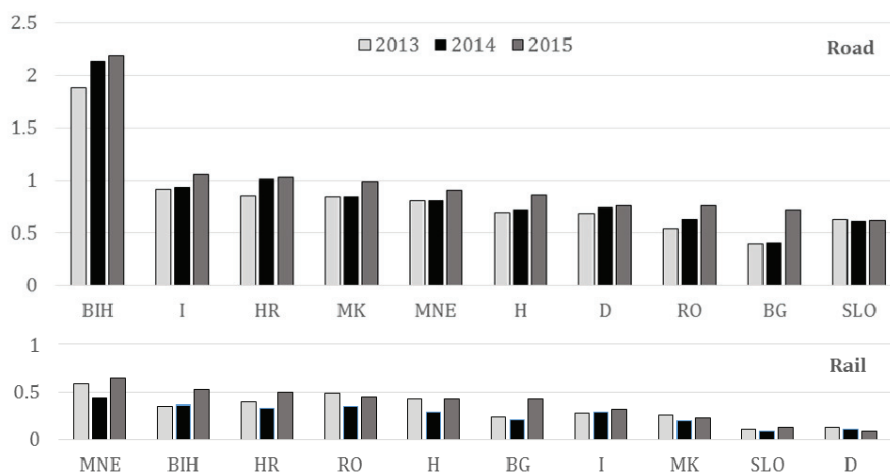
Figure 3. Main road and rail flows from/to Serbia (million tonnes)

In road transport the biggest flows are with Bosnia and Herzegovina (15% of all tonnes transported by road) followed by Italy and Croatia with around 7% each, and in rail transport Montenegro (more than 15% of all tonnes transported by rail), followed by Bosnia and Herzegovina (12,6%) and Croatia (~12%).

Further analysis of transport flows from and to Serbia for 2015 show imbalance between import and export flows (Figure 4). The biggest differences are with Montenegro and Macedonia where exports are around 60% greater than imports. Next are Italy, with 36% greater exports, and Hungary, with 36% greater imports. Looking at individual modes, the most significant differences are in inland waterways import from Ukraine (more than 99%), in rail transport exports to Macedonia (~ 90%), Italy (~ 82%) and Slovenia (~76%), and in road transport exports to Montenegro (~ 71%).
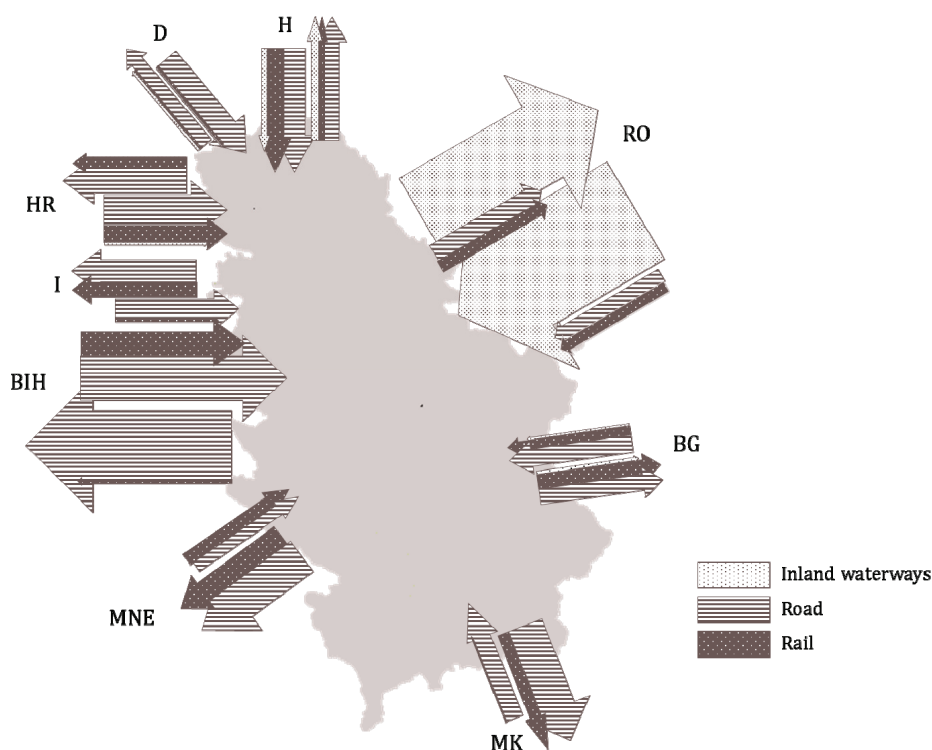
Source: Based on SORS Bulletins and SORS Statistical Releases SV31

Figure 4. The most important transport flows from and to Serbia, 2015

3. LOGISTICS PERFORMANCE INDEX

In order to identify the challenges and opportunities in the Serbian transport market the Logistics Performance Index (LPI) will be considered as an interactive benchmarking tool. LPI will help to face in with performance on trade and what it can do to improve its performance. The LPI was created by the World Bank in 2007 (WB, 2016). The logistics performance of a country is measured via a series of figures as indicators, while at the same time a global survey is held among more than 1,800 logistics managers that are active worldwide. The overall LPI rank and score of a country is composed based on 6 sub-indicators considered into two main categories. The first one represents areas for policy regulation, indicating main inputs to the

supply chain (customs, infrastructure, and services), and second one denote supply chain performance outcomes (corresponding to LPI indicators of time and reliability: timeliness, international shipments, and tracking and tracing).

In respective period, only three Eastern European countries are in the range between 40 and 60 of overall LPI, and unfortunately Serbia is at the lower position. Serbia needs to take measures in direction to catch up better position, especially comparing respective performances with Romania and Bulgaria. By that, Eastern Europe region's LPI score will be harmonized. This will enable Serbia to develop a policy within the Eastern Europe aimed at learning from each other's performance in inland freight transport and further improving the position of the Eastern Europe region in global freight transport over the coming years.

Serbia's LPI rank has deteriorated in 2016 comparing to 2014 and 2012 (Figure 5). Challenges for the competitive position and co-modality for Serbian inland freight transport will be considered by looking at the quality of the physical infrastructure, efficiency of customs procedures indicators, international shipments and timeliness. In 2016 the rank of customs procedures has been improved in contrast to the rank of quality of the physical infrastructure and international shipments which are worst.
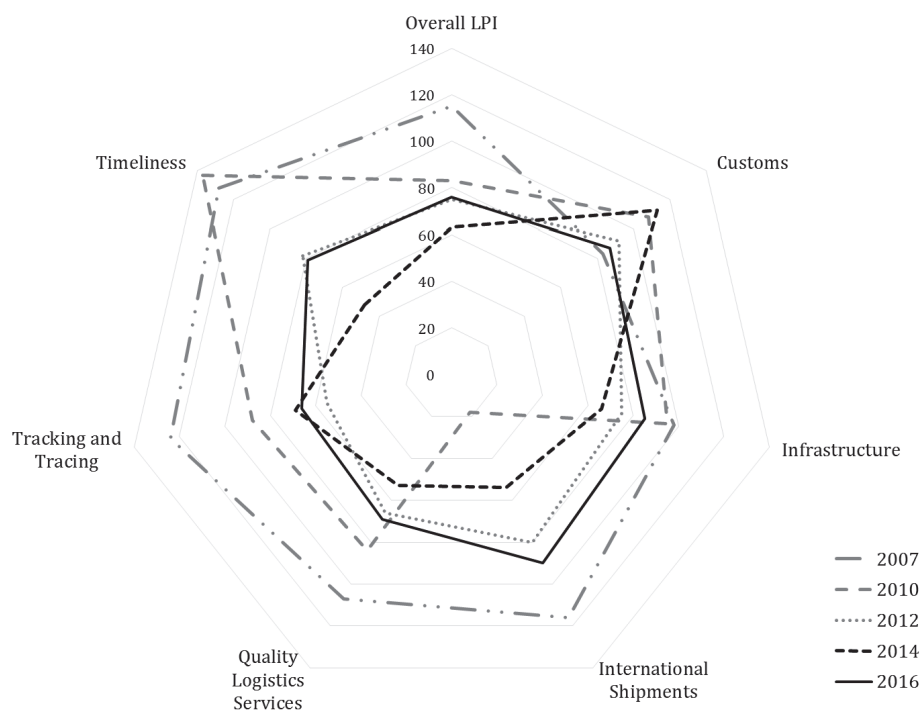
Source: Based on WB LPI Global Rankings

Figure 5. Serbian LPI rankings, 2007-2016

Serbia is small open economy which depends, or will need to depend, to varying degrees, on trade for sustainable economic growth. In that sense it is possible to follow up indicators used as main inputs to the supply chain (areas for a policy regulation). Customs procedure efficiency and international shipments require significantly lower financial resources than the construction of costly infrastructure. Improvement of ranking is presented only at customs procedure efficiency even though international shipments also require law financial resources. But, enhancing the quality of the physical infrastructure, as more attractive for international finance institutions,

will influence and attract flows of goods and enable connectivity of Serbia freight transport to Southeast Europe and EU corridors. At least, the timeliness as an index which pointed out to the service delivery performance also demonstrates deterioration. This will be next challenge for Serbia if it needs to influence on the trade position.

4. CONCLUSIONS

Policy attention is needed on volume of goods in order to be able to continue to handle the modest and still growing volume of freight transport in the Serbia in an efficient and sustainable manner in the future as well. The smooth and sustainable handling of the flows of goods must be maintained high on the policy agenda in terms of infrastructure, multimodal transport, regulations and traffic management (e.g. ITS). The focus is on active collaboration and coordination of policies in the Eastern Europe region in order to in particular make possible the administrative simplification of the documents associated with the various modes of transport. An active participation in and fast execution of activities in the three EU freight corridors are also desirable in order to achieve the greater export.

Finally, the analysis of the competitive position of the Serbia shows the varying performance in annual world ranking of LPI and its indicators. 'Best practices' within the Western Europe in the area of transport infrastructure should be mutually recognized, and common policy to implement these should be developed. As well as, we should not forget that expensive transport infrastructure will not be fully effective if non-physical barriers, which include regulatory and procedural constrains at border crossings and along corridors are not removed (REBIS, 2015).

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ROAD TRANSPORT OF DANGEROUS GOODS AND IMPLEMENTATION OF THE ADR AGREEMENT IN GREECE

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***Abstract:** In the present study focus is placed on road transportation of dangerous goods and on the respective implementation of the existed institutional framework, for the particular case of Greece. The aim of the study is 1) to conduct a thorough literature review of the terms dangerous goods, road transportation, legislative framework and ADR Agreement; 2) to properly reflect the conditions of DG transportation in Greece; 3) to assess whether the implementation of ADR Agreement by carriers is satisfactory and 4) to test the sufficiency of the control process by the responsible control authorities. The study was conducted into two levels, namely in a secondary and a primary survey.*

***Keywords**: Road Transportation, Dangerous Goods, Fuel, ADR Agreement.*

1. INTRODUCTION

Dangerous Goods (DG) consist of materials that pose a risk to the environment, society, life, health of human beings and animals and to public safety. The most commonly used and transported DG include: flammable liquids (gasoline, oil), flammable pressurized gases (LPG, medical gases), oxidizing and corrosive substances, toxic substances (pesticides), explosives and infectious waste (hospital). The majority of DG (more than 70%) transported to Greece and to other European countries is held via roads. In case of a transportation accident where DG are involved the leakage of the transported product leads to consequences disproportionally destructive and irreversible. Thus the road transportation of DG has been extensively studied by the graduate program of the Logistics Department (TEI of Central Macedonia, Greece) with an emphasis placed on capturing the conditions of DG transportation in Greece. A thorough review of the efficiency and the implementation of the ADR agreement has been conducted. Data provided by the a) Hellenic Statistical Authority (HSA); b) European Statistics (EUROSTAT); c) Ministry of Infrastructure, Transport and Networks; d) Union of Hellenic Chambers and e)General Commercial Registry, have been used for assessing the statistics of DG transportation in EU with a particular interest on Greece case. These data provide useful insights on the number of vehicles eligible for DG transportation, the percentages of driver training certificates and on the number of companies involved in DG transportation. For further analysis questionnaires regarding DG transportation were designed and distributed to people involved. For control and implementation of the ADR agreement, the survey focused on the Transportation and Communication Departments of the Regional Units of Greece. To that end the main focus of that research is placed on: 1) Definition of the terms: DG, road transportation, Legislative framework and ADR Agreement, 2) Identification of EU and Greek transport conditions, and 3) Assessment of ADR implementation and of control mechanisms efficiency. Though previous studies deal with DG transportation in a national level (i.e. Greece), the implementation of the respective legislation framework has not been investigated yet. Instead focus was placed on the

relationship between road safety and the infrastructure. This study is organized as follows: Section 1 describes the significance of road transportation; potential consequences of DG accidents while the conceptual approach the aim and the hypotheses used in the study are clearly stated. A thorough literature review where the relationship between road transportation and the efficient administration of supply chains and logistics are analyzed is conducted in Section 2. Additionally the research objectives and questions are presented. Section 3 deals with the methodology developed. Collection of real data and their analysis took place in order to capture the Greek reality for DG road transportation. Empirical data collection was carried out using structured questionnaires with closed-ended questions sent to transport and communication services to DG transportation companies. Section 4 discusses the results drawn from this research and finally in Section 5 conclusions and suggestions for future work are presented.

2. LITERATURE REVIEW

Supply chain is defined as a link between production and distribution and includes all the necessary processes such as the purchase, supply, transport and storage of natural products (Papadimitriou and Shinas, 2004). In Greece, the supply chain is estimated at about 10% of GDP, and there is much scope for further growth in the sector as the country's dynamics has not been fully exploited due to its geographical location (the smallest distance between Europe and the Suez Canal). The development of the logistics sector can play an important role in the recovery of the Greek economy, as the reduction in import and export costs can have a positive effect on domestic GDP due to the overall growth of the sector. On the other hand the attempt to group the fragmented domestic Economies will bring about an improvement in economies of scale and productivity. According to David A. Taylor, the supply chain consists of set of facilities linked to transport channels. Facilities based on their primary function are distinguished in production and storage facilities. Transport channels are categorized according to the selected mode of transportations, which may be terrestrial (road, rail), waterborne, sea, air or pipeline (Taylor, 2004). Road freight transport (RFT) is a subsystem of the transport system. In that respect the national transport system is a subsystem of the global transport system, influenced by international developments (Naniopoulos, 1988). RFTs occupy the first place in all inland transport operations in EU and especially in Greece where their share exceeds 95% of total land freight traffic. Based on the conditions that RFTs take place, three conclusions can be drawn: 1) According to EUROSTAT data, by the end of 2012, 1659 km of motorway, 9299 km of main national network, 30864 km of sub-network and 75600 km of other roads were delivered to Greece, 2) Trucks in Greece can be divided into two categories according to the use of the vehicle in a) private trucks (PT), which operate to meet the transport needs of the company to which they belong and in b) public transport trucks (PPT) which offer transport services to third parties, and 3) Approximately 50% of the goods transported worldwide can be categorized as dangerous goods. The hazards that DG pose are attributed to their nature and their properties. DG can be transported at any phase, either as a gas, as a liquid or as solid. The phase of the transported goods is significant due to the risks that may arise. For example, powders could enter the respiratory system and contact with liquids may damage the skin (Kouloheris, 2013). Transporting DG, even in small quantities, may cause serious accidents. The necessity of transporting goods leads in many cases to roots through public and crowded areas such as motorways and railway stations. Accidents with DG can be also seen as an unforeseeable and undesirable leakage of the transported material during transportation, loading and / or temporary storage (Abkowitz and List, 1987). Accidents involving DG evolve in a specific way and potential ramifications are: 1) Liquid leakage or DG gas dispersion. In the case of leakage of large amounts of toxic gas, toxic fog can be formed which, depending on the prevailing conditions, such as weather and soil morphology, can be transferred affecting a wider area. In case of liquid leakage, a jet is created and a pond is formed on the ground. Typical examples of

toxic gases are chlorine and ammonia, 2) Fire. Possible causes are road accidents, short circuits, smoking, static electricity, mechanical stress, strong electromagnetic emissions. Even the material itself poses risk of fire due to chemical instability and high reactivity. Fire can be distinguished in: a) gas flame which is generated by the combustion of a flammable gas cloud with very low flame transmission rates and thermal radiation; b) Fire spheres: this type is usually associated with liquefied gases and is usually manifested after a tank explosion under pressure. In this case, the explosion can be done with or without fire; c) Lake fires are created by burning the lake of a flammable liquid with constant flame propagation. Liquid lake fire usually occurs when a flammable liquid leaks to the ground and ignites and (d) Torch fires: Torch fires are created by burning a flammable gas during gas leakage under pressure. This type of fire occurs when a flammable gas under pressure exiting a pipe or other opening, ignites to form a flame in the form of a beam (Poulios et al., 2007), and 3) Explosion. Generally, explosions are considered to have a destruction potential greater than that of fire, but less than that of the leakage of toxic chemicals. Possible types of explosions include explosion of gaseous cloud and explosion of effervescent liquid expanding gas. Explosion of gaseous cloud is created by the burning of a flammable gas cloud with very high velocities of flame transmission and overpressure. Explosion of effervescent liquid expanding gas is created during the complete bursting and loss of the flammable liquid content of a tank exposed to flames and flammable liquid (Vayokas, 2010). EU countries keep a record not only on the amount but also on the type of DG transported. Figure 1 displays the type of DG transported during 2014. As expected the category that exceeds half of the total DG transported is that of flammable liquids. Gases followed by corrosives consist 14% and 10% respectively. The methodology used for the collection of the data varies for different countries, a fact that increases uncertainties regarding the absolute values and the distribution of the data. However, for the majority of the countries the percentage of the flammable liquids and gases exceeds ~70%. Though DG accidents occurring in RFMs consist a small proportion of total road accidents, they result in devastating and often irreversible consequences. Apart from their primary consequences such as fatal injuries, they may result in secondary ramifications such as soil contamination, threatening and affecting the flora and fauna. DG RFMs taking place in Europe are regulated by the European Agreement on International Road Transport DG, known as "ADR", the acronym of the French name "Accord Dangereux Routier". The agreement regulates DG terrestrial transportation and entered into force for the first time in 1957 in Geneva under the aegis of the United Nations Economic Commission for Europe. Freight transport of Dangerous Goods is subject to registration at European level due to the increased risk involved. This record is kept and maintained by EUROSTAT and is updated on an annual basis (Eurostat, 2016). For most countries, the proportion of DG migrants fluctuated around 4%. All major economies recorded rates between 4% and 8%, except for Poland, the second largest transport industry in Europe, which had a lower rate (3.5%). Cyprus has the highest percentage of DG transport (27.3%), while Slovakia, the Netherlands, Lithuania, and Latvia ranged only between 1% to 2%. Greece range is slightly above 5%. Variation on the records are caused by the lack of data and therefore post processing of data does not cover the total DG transported units.

3. METHODOLOGY DEVELOPED

The present study addresses the following research questions: 1. What is the current situation for DG road freight transportation in Greece? 2. In what extent is the ADR agreement implemented by DG carriers? 3. How adequate are the controls of the transported DG? These questions are answered respectively. Primary and secondary surveys for the collection of statistics were be conducted. In particular primary surveys consist of data collection from the following three categories of questionnaires; a) Dangerous Goods carriers b) companies whose activities are related to Dangerous Goods and c) the DPEs of the Regional Units. Statistics provided by the Hellenic Ministry of Infrastructure, Transport and Networks and from the Union

of Hellenic Chambers were used for the secondary survey, respectively. Addressing the second question includes a primary survey that aims to DG carriers and DG-related companies. The third question was addressed by employing a primary survey on Transport and Communications Services. The study of the current situation in DG road transport started with the implementation of quantitative research. The main objective was to extract specific measures based on statistically reliable data. The necessity of addressing the three questions within a questionnaire format emerged the use of telephone and e-mail communications. Both types provide coverage in both urban and remote areas and facilitate the accommodation of larger participation sample. To that end it was concluded that the distribution of questionnaires to workers of DG RFT field, DG production and logistics companies would be more efficient. The majority of participants showed a willingness on contributing to the research. Carriers, contact details provided by their association and internet research participated to a satisfactory degree. In that sense the participants were categorized into three groups: DG Carriers (drivers and companies), Companies involved in any of the following field: production; process; distribution; extraction; generation of DG and Transport and Communication Authorities. Assessing the research objectives required data collection from all of the three groups. Difficulties encountered included the separation of DG carriers and companies, due to the format of the official authorities. The sample of companies was randomly selected.

4. DISCUSSION ON THE RESULTS

Fuels (liquids and gases) consists more than 80% of DG road transport. To that end studying the movement of fuels provides approximately a global picture of DG traffic. According to secondary research data from EUROSTAT, the total volume of transported liquid fuels of the last five years (years of financial crisis) was at the level of 43943.1 thousand tonnes of oil. Considering that the latter number corresponds to 80% of the total DG transported we estimate the total volume of DG (57536.8 thousand tons of oil). From the results it was also shown that the first type of liquid fuel transported is oil (more than 50%), followed by gasoline, while other types have a negligible contribution to the total amount. By comparing the transported quantities of fuel in Greece with the corresponding countries with similar populations, it was observed that only Belgium demonstrates similar behavior with Greece regarding fuels transportation. As far as gaseous fuels are concerned, the fluctuations in LPG were steadily rising even during financial crisis, while natural gas was on a downward path. In particular, over the course of the financial crisis years (2010-2014) the total volume of transported liquid fuels was approximately 43943.1 thousand tons of oil while the respective total volume in the period before the crisis (2004-2008) was 62,264.7 thousand tons. The drop of in the transported quantities of liquid fuels is significant (30%). In Greece the number of registered and active companies trading DG is 1084. Statistics of these companies were provided by the Union of Hellenic Chambers. The majority of these companies (54%) operates in the field of petroleum transport that are carried via tanker vehicles, followed by companies involved in production of petroleum products, bitumen and asphalt. Two hundred and sixty (216) companies are active in the collection, processing and disposal of Dangerous Waste, most of them licensed after 2013. Companies active in the production of weapons, ammunition, bombs, missiles, gunpowder and various munitions amount to seventy (70)), a number considered extremely high for a country with the population of Greece. The geospatial distribution of companies operating in the DG sector denotes a preference on large size cities. In particular, the headquarters and facilities of these companies are located in the ten largest cities of Greece, with more than half locating in the two major urban centers namely, Athens and Thessaloniki. Most of the DG transportation is held by entrusted transport companies. In total, fifty (50) transport companies responded to the survey. Given the number of companies active in DG transportation in Greece, this sample is considered representative to provide valuable information. From the answers given, the following outcomes can be drawn:

- Approximately 90% of the responding companies have legal form of individual enterprises. They own one to three vehicles and employ one to three people in DG transport driver posts. In that sense the size of these companies is small, a fact the represents the major trend of self-employment in Greece. Despite the guidelines and strategic planning of the government, carriers are denying effective co-operation with each other in any form of companies and hence this sector is still fragmented.
- All transport companies are engaged only in transport and do not provide other logistics services. As mentioned the majority of the transported products belongs in liquid fuels category, while other DG phases consist less than 10% of the total DG products carried. As a result, the largest volume of transport is carried out by tanker vehicles.
- Financial crisis has affected DG transport companies in the period 2010-2015. About three-quarters of the companies show a drop of more than 20%. The same applies for distances traveled. Only one out of ten companies is able to increase the distance traveled dropping the amount transferred simultaneously. According to companies involved in DG transport 80% records a decrease in the distance traveled and 10% increase of the distance traveled over the last 5 years. There is also correlation between the distance traveled and the amount of DG transported. In particularly, an increase on the distance traveled is correlated to a slight decrease on the amount transported.
- Regarding the existence of a tracking system in vehicles, two-thirds of the companies asserted that they use a tracking system. Concerning the employment or cooperation of DG transport companies with the DG Transport Safety Advisor (DGTSA), less than half responded that they either employ or cooperate with DGTSA.
- DG transport companies pay particular attention on road safety issues. All drivers hold a certificate on professional training A.D.R with three-quarters of them undergoing medical examinations more often than prescribed by law (five years). 30% of the companies also stated that they provide their drivers with additional DG transport training and all without exception have taken measures to deal with a possible leakage or accident. In the key question about the history of company vehicles in terms of accidents and leaks, only 6% of companies claimed either an accident or a leakage, a percentage considered satisfactory. Additionally, it was concluded that oil companies impose rules stricter than those imposed by legislation.

Analysis of the statistics provided by the Ministry of Infrastructure, Transport and Networks lead to the following outcomes: 1) The number of drivers licensed by the ADR agreement exceeds 101,00, and 2) The majority of drivers holds an ADR license that falls into the category "Basic education and tracks". DG carriers' opinion on ADR license realization can be summarized as: 1) The majority of companies (98%) asserts that legislation for DG transport is not extremely strict, while only 2% believes that it is extremely strict, 2) Realization of the ADR agreement is considered absolutely satisfactory according to 75% of the drivers, with the rest of the sample asserting that the agreement is merely realized, 3) DG transport and distribution companies, impose stricter internal legislation for safety purposes, and 4) Potential reasons for not complying with the agreement for some drivers include the high cost and the combination of other minor reasons (ignorance, indifference, lack of control, complexity of the legal framework). Conflicting views regarding the implementation of the ADR agreement were reported by the Directorates of Transport and Communications (DTC). Twenty-six out of fifty-one of the DTCs consider the ADR Agreement to be applied by road carriers "not at all" to "moderate" while the rest of them believe that the ADR applies "very" and "fully". The percentage of DTCs that chose extreme values namely "no" or "full" was limited. Likert scale was used for the questionnaires design. The adequacy of DG transport controls by Transport and Communications Divisions of the Regional Units was assessed by designing questionnaires targeted on these Services. According to the questionnaires analysis the following results can be drawn: 1) Employees of DTCs licensed to control DG transport vehicles consist approximately 50% of the total employees, 2) The lack of control mechanisms is highlighted by the fact that

only 70% of DTCs provide this service. Additionally 30% of DTCs control mechanisms consist totally of Roadside Inspections, while only 10% provides Roadworthiness Test Centre (MOT Test) services. Finally, 30% of DTCs provide all the legislated control mechanisms, and 3) Information regarding the control of the ADR Agreement shows a lack of qualified staff, followed by a lack of financial resources.

5. CONCLUSIONS AND RECOMMENDATIONS

From the analysis conducted it is suggested that attention should be paid to DG road freight transport. The first concern regards a new legislative framework that should be in harmony with European law. This framework should take into account the social and economic conditions of the country as well as the needs of the industry and it should be also accompanied by the introduction of new administrative sanctions. It is also proposed to upgrade and modernize DG transport vehicles, co-financed by the European Union if possible. The driver of a DG transport vehicle is an important factor in road safety and therefore it is crucial to provide high-level education covering the provisions of the ADR Agreement. All the responsibilities of the Transport and Communications Directorates related to the ADR Agreement are proposed to be coordinated and controlled by the Ministry of the Environment and the Directorate-General for Road Safety. Finally, databases development that would allow record of DG traffic at a national level is highly recommended. Future work would include comparisons of the current situation in Greece and other European countries. It is also possible to compare the control mechanisms of Greece with those of the EU countries in terms of constitution, operation and effectiveness. This would serve to identify the appropriate actions by the central administration to improve any deficiencies. In any case, the use of tools other than questionnaires (such as unstructured interviews with open-ended questions to those involved in the movement of dangerous goods) would give greater credibility to the survey, and it would depict a clear picture of the reality. Lastly, the impact of financial crisis on Greece would be interesting to assess. Therefore, should the financial situation in Greece being balanced, a comparative analysis between the pre and post crisis DG transport conditions will be conducted.

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COMPLEX RELATIONSHIPS IN LOGISTICS MULTIADS: AN AUTOMOTIVE INDUSTRY INSIGHT

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Abstract: The paper objective is investigation of complex relationships in supply chains and supply networks with a focus on logistics multiads. Supply chain characteristics and requirements strongly depend on industry segment. In ever changing automotive industry, complex supply chains are developing into multi-tiered international supply networks. Most papers in supply chain management focus on primary partners in supply chain, investigating its basic unit – logistics dyad (buyer-supplier relationship). In this paper, relationships with logistics service providers are included into analysis, aiming to get better insight into relationships following the theoretical concept of logistics triads in real environment. Within supply network, a logistics multiad is identified, briefly analyzed through dyadic relationships, and then aggregated into triads from different perspectives.

Keywords: Logistics outsourcing, logistics triad, logistics multiad, relationships, automotive industry

1. INTRODUCTION

Supply network coordination and reliable interorganizational relationships between buyers, suppliers and logistics service providers are challenges for all specialists in supply chain management. Increase in number of participants in supply chains makes the coordination harder, the coordination risks increase, while the links become more vulnerable.

Overall success of supply chain depends on level of integration between all parties. Transparent, efficient and "seamless" material and information flows are among the most important preconditions, and also indicators of successful relationships in the supply chain.

Modern supply chains, and particularly supply networks build complex logistics multiads, which could be decomposed on logistics dyads or triads. Most of papers in supply chain management literature are focused on relationship between primary partners in supply chain and logistics dyad, i.e., supplier-buyer relationship. However, a contemporary approach indicates that a basic unit of analysis should be logistic triad – supplier, buyer and logistics provider.

Following this research stream, the paper objective is to explore applicability of logistics triad as a basic unit of analysis in a real and complex setup for describing nature of relationships. An

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example from automotive industry is used to illustrate complexity of problem and possible viewpoints in logistics relationships analysis. Within supply network, a logistics multiad is identified, analyzed briefly through dyadic relationships, and then aggregated into triads from different perspectives.

2. LOGISTICS TRIAD AS A BASE UNIT IN LOGISTICS RELATIONSHIP RESEARCH

In the literature on supply chain management, the most frequent unit of analysis is logistics dyad, which refers on supplier-buyer relationship. The triad relationships, as a more complex form, are much less covered (Larson and Gammelgaard, 2001; Skjoett-Larsen et al., 2003; Stefansson, 2006). However, increasing trend of logistics outsourcing, and significance of long-term and strategic logistics outsourcing arrangements have impacted that research focus was partly shifted toward logistics triad. Initially, logistics triad refers on shipper, receiver and carrier, as "a minimum unit of analysis" for logistics research (Beire, 1989). Later definitions and research highlight the importance of qualitative relationships, cooperation and integration between elements. Larson and Gammelgaard (2001) and later Stefansson (2006) describe logistics triad as a cooperative, three-way relationship between a buyer of goods, supplier of those goods and logistics service provider moving and storing the goods between buyer and supplier. Some authors also explore supplier-supplier-buyer triad within the supply network (e.g. Choi and Wu, 2009; Wu et al., 2010). These triads will not be considered in this paper, although some observations could be generalized and applied in such setup in future research.

Complex supply chains with high logistics requirements usually assume long-term contracts and strong relationships with logistics specialists, capable to meet all customers' needs and ready to develop own resources and solutions together with their strategic partners. Logistics service provider moves goods and shares information with all included participants, influences their relationships, and add the value to delivered product (Beire, 1989). He has a crucial role in terms of seamless information and material flows from primary supplier to end customer. He can provide single-service e.g. transport or warehousing, bundled services, integrated or highly customized solutions, and so be recognized as 2PL, 3PL, 4PL, 5PL or even 7PL provider. In complex supply chains and networks, there are usually several logistics providers with different roles who jointly work to meet customer needs. They may be connected horizontally, e.g. to be responsible for complementary parts of delivery according to Incoterms. They may be also connected vertically and create sometimes international and complex subcontracting logistics network between supplier and buyer, parties in successive supply chain tiers, or even in competitive supply chains. In all cases, introducing logistics triad as a unit of analysis, and a kind of "cell" which builds supply chain, may contribute to getting better overview on logistics relationships.

Forming additional interorganizational relationships could be also risky for supply chain on a whole. Among the main factors that cause a lack of logistics provider's integration within the triad are high customer demand for transport flexibility, disconnections between sales and logistics departments at the company level and lack of integration between carriers and customers (Sanchez-Rodrigues et al., 2010). Therefore, with the increase of the supply chain complexity, better integration with a logistics service provider is also needed.

Long-term relationships within the triad usually include cooperation and different types of integration both between "complementors" and competitors in supply chain. Collaboration assumes technical, technological, organizational and informational integration within and between organizations. However, it is not limited on exhaustive information exchange and good links at operational level of activity. If organizations integrate their processes only at an operational level, missing to do it on tactical and strategic levels, performance benefits of integration will be limited (Barrat, 2004). Integration in management means joint management in reaching common goals in supply chain, and common work on conflict of interests, which

implies good communication on strategic level of management and bridging cultural gaps (Barrat, 2004). One of the main common goals is to be more competitive than other supply chains in the same industry on the market.

Logistics collaboration primarily assumes collaboration in demand forecasts, inventory management and transport management between involved parties. Collaboration in some extent usually exists within strategic logistics contracts between companies, tending to make stronger, hybrid relationships and more porous boundaries between strategic partners in supply chain. These viewpoints will be briefly illustrated on a case study in the automotive industry.

3. LOGISTICS MULTIAD IN COMPLEX SUPPLY NETWORKS – AN EXAMPLE FROM THE AUTOMOTIVE INDUSTRY

3.1 Research methodology

To explore the nature of logistics multiads in real environment, a Tier 1 supplier to the original equipment manufacturers (OEMs) in automotive industry in Germany was observed as a focal company. Company's relationships were observed through purchasing and logistics processes and activities during the 6-month period. A comprehensive documentation and its flows were explored, including e-mail correspodention, financial documents, transport documents, reclamations, claims, certificates, reports about quality control, contracts with suppliers, buyers and logistics providers, etc. Interviews with employees on various hierarchical levels in sales and logistics departments have been also performed. The research aimed to identify the roles of main players in logistics multiad and main characteristics of their relationships by using logistics triad as a base unit for analysis. From the buyer side, one company was selected for the purpose of analysis. Two companies involved into multiad were identified as strategic logistics providers and the roles of both are briefly described.

3.2. Results and discussion

Automotive industry has seen a rapid change in the recent period, recording expanding requirements. Consequently, supply chains will require systemic transformational change to address new complexity. The way for improvement is integration of supply chain processes and activities across the supply network, more control and visibility into production delivery events and logistics costs and processes, and collaborative alignment with partners (Heaney, 2015).

Supply chain complexity and sourcing collaboration are recognized as major competing priorities and capabilities in automotive industry. There is also a strong increase of awareness among the companies in automotive industry that strategic supplier and logistics provider selection should be performance based and long-term focused. Across a complex set of competing priorities and across an evolving automotive marketplace, a need to coordinate supply chain activities and processes in a „multi-party, dynamic fashion" is recognized (Heaney, 2015).

Automotive industry is the largest industry sector in Germany, with the turnover of EUR 404 billion, or 20% of total German industry revenue, and with a workforce of around 792 500 in 2015 (GTAI, 2016). Further, Germany has the largest concentration of OEM plants in Europe. With 41 OEM sites located in Germany, German OEM market share in Western Europe was more than 51% in 2015 (ibid.). Our focal company belongs to this cluster as a Tier 1 supplier, directly delivering to the OEMs their customized parts for serial production of vehicles.

Observed company is lights manufacturer in automotive industry, here denoted as S, with more than 100 years long tradition in Germany. After a series of transformations, manufacturer became a part of global company, with production plants in US, Mexico, China, Germany and UK, while its majority shareholder is another global cross-industry company. Portfolio of buyers -

customers include mainly OEMs in Germany, delivering the customized parts to different production facilities globally.

All logistics processes are performed by four organizations – focal enterprise as a Tier 1 supplier S, buyer (here denoted as B), logistics intermediary and logistics provider. Logistics intermediary, here recognized as 4PL, is integrated with manufacturer through the ownership – both of them belong to same majority shareholder. Thus, complete supply, issuing the orders and execution is given to sister company - 4PL provider, while the supplier company is focusing on its core competences and providing the innovative development solutions and products for the customer. 4PL has an exclusive right to provide logistics services to S. Also, there exists high level of management, process and information integration through common Enterprise Resource Planning (ERP) system, common internal quality control, etc. These two companies act on market as the unique entity, after acquisition of S by major shareholder.

4PL provider owns only IT infrastructure and skilled staff. It doesn´t have own-account logistics infrastructure, facilities and capacities; thus, execution of the complete logistics service is transferred to 3PL provider, while management and control is kept by 4PL.

3PL provider has a long-term cooperation with 4PL through strategic and revolving contracts. 3PL is responsible for performing all logistics services for S and completely capable to perform transport, distribution and warehousing, reverse logistics, as well as all value-added operations - picking, packing, order assembly, labeling, inventory control etc. However, 4PL is responsible for distribution management. On operational level, 3PL is strongly informationally integrated with both 4PL and S. Buyer exchanges information about confirmed deliveries with 3PL, and operational, real time shipping information with 4PL. In that sense, 4PL act as a 3PL from the buyer's perspective, while 3PL has a role of carrier. 3PL-B relationship is the slackest one in multiad; it is completely defined by contract clauses between supplier and buyer, as well as between 4PL and 3PL.

After executing logistics service, 3PL provider service is evaluated by the 4PL. The performance reports are regularly made and submitted to the S management, the overall key performance indicators are reviewed and the buyer's satisfaction evaluated. All three companies exchange relevant information in real-time; however, 3PL does not have a common information system with other two companies. 4PL is responsible for all order processing and their transformation into logistics demands to 3PL. It was noticed that their common work give efficient, flexible and responsive logistics chains even in case where buyers change demands.

Primary buyer - supplier relationship is based on revolving short or middle-term contracts for supplying with specifically designed products. Supplier has to provide reliable dynamics of delivery and expected quality of products and logistics service to the buyer B in Figure 1. Crucial contract elements are: price, quality, reliability of service and contract duration. The S-B relationship is actually based on a competitive bidding model. The buying company is always searching for the cost reductions in order to increase its own leverage. Global sourcing supports replacement of the actual supplier on a price and performance base. Due to this situation, only operational level data are shared – forecasts, inventory levels, pricing, supplier performance reports, allocations, etc. Although they are strategic partners, S is not motivated to establish higher level of informational integration with B, to share all information, to work proactively and, most important, to invest its engineering and logistics knowledge and experience in order to continuously improve the existing products. The main focus stays at the fulfilling the contract obligations as a supplier. Thus, this relationship seemed to be the weakest chain in the multiad, due to internal risks.

First insight into relationships in observed multiad shows that parties create different kinds and levels of dyadic integration in term of common planning and management, informational integration, functional integration, share of operational and strategic interests. If we would like to present four main elements as logistics triad by aggregating two elements in one, we could

use at least two triads, depending on criteria and focus of analysis. The reason is that in reality, the triad is usually not built as an equilateral triangle, and particularly not from different perspectives – organizational, functional, information integration, power balance, trust, shared interests, etc. If we recognize that stronger dyadic relationship brings closer some parties, like a "glue", we could get a criterion for aggregation parties into logistics triad.

Two strong relationships were identified - between S and 4PL, and between logistics providers. Following them, multiad is transformed into two logistics triads. In functional sense, 4PL and 3PL can be integrated into logistics party within the triad (Fig. 1a). However, supplier and 4PL provider could be also observed as unique element in triad, following the same ownership, high organizational, managerial and informational integration (Fig. 1b). Therefore, multiad could be transformed into two logistics triads for the purpose of analysis. Both triads can be argued as appropriate for describing the system, and both have some advantages and weaknesses. Depending on focus and aims of analysis, researcher could select more suitable aggregation in a particular case.

a) Functional perspective   b) Organizational perspective
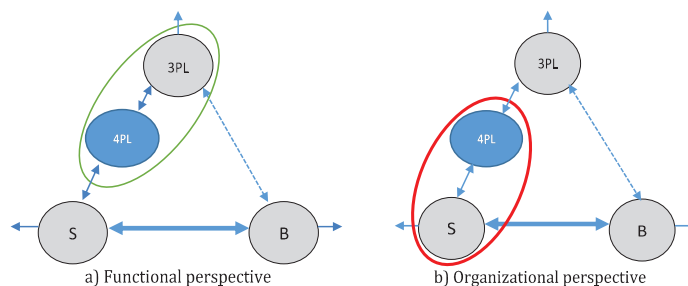
Figure 1. Possible aggregation of elements into logistics triads within logistics multiad

Involved parties both share interests and have some conflicts of interests with all other parties in multiad. In real environment, conflicts and shared interests, both operational and strategic, may be changeable, or their importance may be changeable for parties. Thus, they should be reconsidered after significant market changes, or before contracts revolving.

Standardized processes, clear roles and tasks among the partners, functional and operative integration are important in forming and development of collaborative relationships as an ultimate goal in integrated supply chains.

To increase the overall competitiveness of the supply chain, partners included in logistics multiad should clearly recognize and continue to develop common goals, talk about risks and conflict of interests and ways to hedge them. Supply chain strategy and related goals should be commonly identified, and aligned with logistics and transport outsourcing goals (Stojanović et al., 2013). Further integration within the multiad is possible with active involvement of all parties, following path from the strongest dyadic relationships toward the weaker ones. Building these relationships could bring to the full information sharing and, more important, to proactive collaborative work on improvement of existing products in terms of design and engineering, increase of production efficiency, improvement of logistics services and ensuring a more coherent supply chain.

4. CONCLUSION

Increasing complexity of processes, growing logistics requirements throughout supply chains, number of engaged players in logistics chains, as well as organizational and functional interdependence impact on growing need for complex logistics multiads in automotive industry.

One of such multiad was analyzed by using contemporary theoretical approach for logistics setup – logistics triad.

Triads can be created by decomposition or aggregation of elements in supply network. Case study exemplifies that aggregating parties within the multiad could create different triads depending on focus of analysis. In observed case, triads were formed from organizational and functional perspectives. Further research of examples from different industries, particularly in complex setups, may contribute both to better understanding of collaborative relationships and their further development in practice.

ACKNOWLEDGMENT

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ASSESSMENT OF THE POSSIBILITIES OF TRANSFORMING RAIL FREIGHT UNDERTAKINGS AS A LOGISTIC OPERATOR

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Abstract: Rail system in its nature represents a huge logistics potential. Due to increasing demand for international freight transport and logistics services, the biggest rail freight operators have recognized the needs of offering comprehensive logistics solutions in order to be positioned in the freight transport and logistics market as the leading logistics service providers globally. In the line with the European best practices, it is needed focus on the in-depth restructuring of the Western Balkan rail system. Development of modern dynamic rail freight system in the line with logistics concept by introducing new change management concepts, consistent implementation of defined measures for improvement of efficiency and enhanced services are crucial for the future sustainable development of the Western Balkan rail system. The aim of this paper is to assess the trends of logistic principles implementation in rail freight sector as the opportunity to create more competitive rails in the region.

Keywords: rail, freight, logistics, restructuring

1. INTRODUCTION

Global logistics supply chains are becoming more complex and the requirements to implement coherent and consistent policies on safety, environmental and reliability are more demanding. In the last three decades the European rail sector has been faced with the deep restructuring, changing the concept of the traditional rail freight services into the logistic concept as core pillar of its development and competitiveness. Nevertheless, the rail liberalization reform and harmonization of the sector policies with the EU rail framework of directives and regulations is a slow process across the region of the Western Balkan, resulting in the poor performances of these rails and questionable financial viability. Inadequate financial architecture, fragmentation of infrastructure, technical and technological obsolescence of capacity, and low quality of rail services imply market un-competitiveness and the marginalization of the importance and potential of this system. The rail infrastructure facilities and equipment of rail freight system are key to develop logistics services.

2. RAIL LOGISTICS DEVELOPMENTS

2.1. Logistic performance indicators

Efficient logistics connects domestic and international markets through reliable supply chain networks. In general term, logistics performance depends on the availability to offer reliable

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supply chains and predictable service delivery. Logistic performance indicator (LPI) analyses six variables separated in two areas: (1) policy regulation indicating the main inputs to supply chain management (the efficiency of customs and border clearance management, quality of transport infrastructure and services), and (2) supply chain performance of time and reliability: timeliness, international shipments and the ability to track and trace consignments.

Table 1. LPI ranking per countries

WB countries	LPI rank	Infrastructure	International shipments	Logistics quality	Tracking and tracing	Customs	Timeliness
Albania	103	137	97	99	127	123	73
Bosnia and Herzegovina	85	76	111	92	94	71	79
Macedonia	109	79	127	108	122	126	101
Montenegro	113	111	89	125	107	105	120
Serbia	72	81	74	66	62	96	71
Croatia	50	54	60	48	53	45	64
Slovenia	43	37	53	37	43	48	49
Germany	1	2	7	1	1	2	2
Austria	11	15	9	9	5	16	12
Japan	10	8	14	8	10	12	8
France	14	14	12	8	13	17	11
Russia	98	90	114	76	83	152	83

Source: Logistics Performance Index 2016, World Bank

Logistics supply chains are determined by soft and hard infrastructure. The low quality of the Western Balkan countries transport infrastructure indicates persistence of the logistics gap (Table 1). These countries with the low logistics performance are facing with the high transportation costs and unreliable supply chains, gapping the integrating in global value chains.

2.2. Analysis of the rail logistics market

The total transport volumes transported in 2014 was in amount of 18,6 bn tonnes. Rail transport has participated with the 7%, what represent more than ten times less than the volumes transported by road (78%), shown in Figure1.
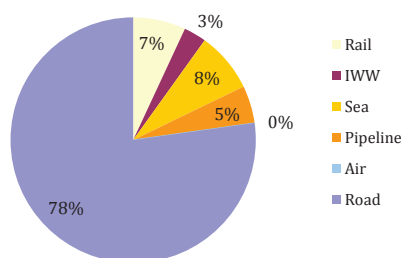
Figure 9. Modal split of European transport volumes in 2014
Source: Fraunhofer, 2016

The rail freight network has been experiencing difficulties for more than thirty years for a number of reasons: changes in industry, the development of motorways, and new logistic requirements on the part of companies.

In order to respond to these the EC has launched a policy for the revitalization of rail transport based on progressively opening up transport services to competition, effective for all freight since 1 January 2007, and developing the interoperability of rail systems. Regulation EC 913/2010 concerning a European rail network for competitive freight. The Regulation concerning a European rail network for competitive freight had a purpose of increasing international rail freight's attractiveness and efficiency in order to increase rails competitiveness and market share on the European transport market. Regardless of the EC rail policy, due to the

slow development of competition and interoperability and the lack of capacity of good-quality and reliable infrastructure allocated to international freight, the slow progress has been made with rail freight and the most of European rail freight undertakings cannot offer satisfactory services and cover their costs, that continue to lose market shares in favor of the road transport.

Freight transport logistics is primarily a business-related activity and focuses on the planning, organization, management, control and execution of freight transport operations in the supply chain. Production and distribution networks depend on high-quality, efficient logistics chains to organize the transport of goods. Freight Logistics Action Plan (EC, 2007) as policy initiative aimed, among rest, to improve the competitiveness efficiency and sustainability of rail freight transport in Europe and beyond. Main actions are focused on: (1) e-Freight and Intelligent Transport Systems**,** (2) eliminating bottlenecks solutions, (3) improving performance in freight transport logistics chains, (4) benchmarking intermodal terminals, (5) simplification of administrative compliance through establishing a single window (single access point) and one-stop-shop for administrative procedures in all transport modes, (6) establishing a single transport document for all carriage of goods, (7) define green transport corridors and (8) developing a freight-oriented rail network.

Rail logistics is based on the wide range of services offered and demand-specific facilities availability, providing: (1) full-service for rail logistics of goods with special requirements single wagons and block train traffic , (2) innovative and flexible logistics solutions adapted to special transport demands, (3) freight management and operations monitoring, (4)warehouse logistics storage facilities, (5) on-site management, (6) value added-services (re-packing, labelling, picking, customs, waste disposal management, ect.), and (8) individual and personal support.
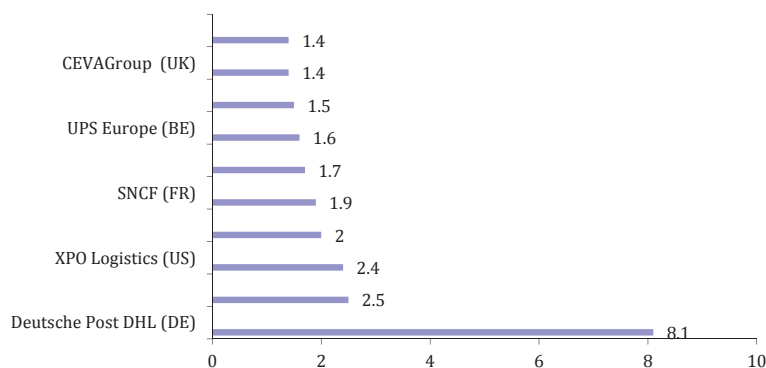
Figure 10. Market segment share in Contract Logistics (%)
Source: Fraunhofer, 2016

The processes of rail logistics system necessitating a high degree of cooperation and failures in effective communication between the stakeholders results in increased costs and inefficient operations for all partners in the system. Impacts failures within the rail logistics system will impact both rails and their customers.

Logistic economically optimised transport concept includes far-reaching and comprehensive optimization of the rail system. Due to the complexity of the rail system the key components to increasing the competitiveness of the freight rail logistics system are service quality and customer orientation, interfacing processes between rails and their customers. Improvements in quality and customer satisfaction must lead back to growth in the core business and increasing of efficiency what is important to offer services at competitive costs, as the rail in its nature has high fixed costs. Improvements in quality and lower production costs should increase rail network utilization.

The demand for international freight transport and logistics services is rising due to increasing internationalization and the shift towards cross-border production structures and flows of

goods in our customers' markets. The total European logistics market accounts in year 2014 was 960bn EUR, of what the transportation costs were 425bn EUR, representing 44,3% of total logistics cost (Fraunhofer, 2016). Market segment share in contract logistics in global context is shown in Figure 2. Rail freight undertakings implemented logistics concept offering comprehensive logistics solutions and global supply chain management in contract logistics are positioned in the freight transport and high growth logistics market leading logistics service customer-oriented providers globally (Table 2).

Table 2. Freight rail operators as logistics providers incomes in 2014

Logistics provider (Europe)	Logistics revenue in 2014 (bn. €)	Logistics provider (World)	Logistics revenue in 2014 (bn. €)
DB MOBILITY LOGISTICS (DE) diversiied via DB SCHENKER LOGISTICS and DB SCHENKER RAIL	15,1	Union Pacific Railroad US	18,6
DB Schenker Rail (part of DB Mobility Logistics AG) DE	4,8	BNSF Rail Company US	18,4
		Indian Rail IN	11,1
SNCF SA FR	9,1	CSX Corporation US	10.1
Rail Cargo Austria AT	2,1	Norfolk Southern Rail US	9,6
Russian Rails RU	16,9	Canadian National Rail CA	8.1

Source: Fraunhofer, 2016

Further development of the rail undertakings as logistic operators is determined by: growth and dynamics of heterogeneous economic areas, well-developed rail infrastructure, regulatory framework, in order develop effective institutional mechanisms for integrated infrastructure development and integrated IT solutions implementation.

3. ASSESMENT OF THE WESTERN BALKAN RAIL FREIGHT SECTOR

Regarding rail infrastructure, in terms of the density (Figure 3) of the existing network, it is more than two times lower (2,6 km/100km^2) than the EU average which is 6,8 km/100km^2 (STAREBEI, 2016).
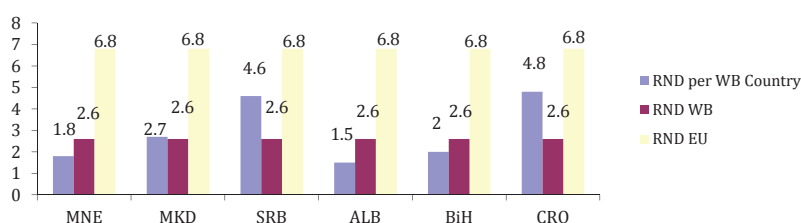
Figure 11. Rail network density-RND (km of rail /100km^2)
Source: STAREBEI, 2016

The low quality and density of Western Balkans rail networks influence the costs of inputs, production and distribution, and therefore low national competitiveness. It is evident that there is no consistent development for all modes of transport networks, what creates the huge inter-modal gaps. Namely, the trend of high investment in road infrastructure (almost 10 bn EUR) in the Western Balkans is present continuously from 2004, while the trend of rather small investments in rail infrastructure projects is changing slowly (just 1.6 bn EUR). For the same period in airport infrastructure has been invested four hundred million EUR, and for seaport Infrastructure just one hundred million EUR. Regarding the Bosnia and Herzegovina case, for 1.505 km of roads it has been invested 3 bn EUR, and in the same time for almost the same length of rail network it has been invested ten time less, just 385 mil EUR**.** The Western Balkan rail network rehabilitation needs are presented in Table 3.

Table 3. Western Balkan rail network rehabilitation needs

Rail network	Utilisation level	Action needed	km	% of total
Total length		-	3530	
Length with no capacity constrains	utilisation less than 40%	-	2262	64
Length with minor constrains	utilisation 40%-65%	Minor rehabilitation needed	788	22
Length with significant constrains	Utilisation 65%-80%	Major rehabilitation needed	178	5
Length with significant constrains	Utilisation more than 80%	Construction of new line is needed	149	4
Missing links	-	-	211	6

Source: SEETO, 2016

Maintenance of the rail infrastructure is still one of the major challenges in the region (Figure 4).
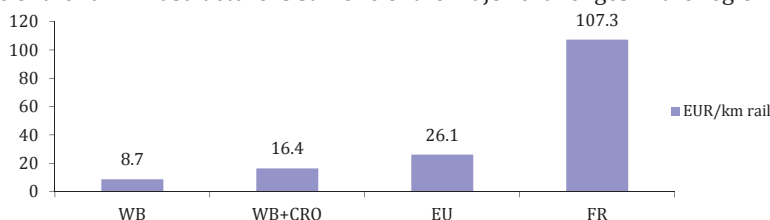
Figure 12. Rail infrastructure maintenance expenditures average for 1995-2011
Source: STAREBEI, 2016

The price of maintenance per km is greatly different among the region economies and there is no consistent methodology among them for defining maintenance costs based on the level of maintenance. Poor maintenance for a prolonged period of time resulted in a disastrous state of the tracks, the destruction of the infrastructure and a very limited average speed on a great part of the routes on the region rail networks.
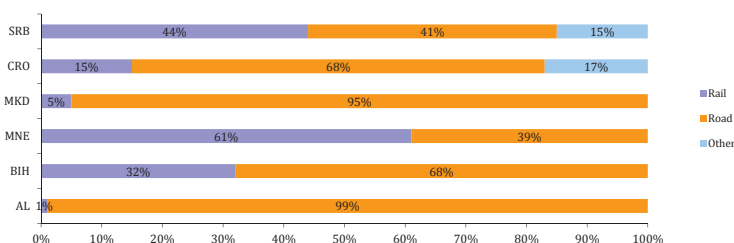
Figure 13. Freight structure in the Western Balkan countries (2013)
Source: STAREBEI, 2016

The deficiencies in the region rail infrastructure reflected on the limited rail service quality level, with average speed of trains which does not exceed 60km/h, common delays of trains, and limited efficiency resulted in decline in rail demand, even the rail freight transport is highly important for the economy of the Western Balkan countries. The mobile capacities for freight are outdated and poor maintained. The rail market in the Western Balkans is still closed facing with the low level of technical interoperability compared to the EU and further actions towards rail liberalization are needed. In the field of inter-modal transport solutions, there is a clear regulatory and institutional gap, as well as a lack of financial funds for their development. Complex and *long-lasting* cross border procedures directly decreasing the level of service quality and have a negative impact in terms of the rail market share (Figure 5). The general objective is the Extension of a EU rail freight corridor to one or more candidate countries of the Western Balkans (SEETO region) – transfer of best practice solutions. The main expected outputs are an

inventory of rail freight facilities on the Core Network Corridors in Western Balkan including Alpine-West Balkan rail freight corridor including an implementation plan1 in accordance with Regulation EC 913/2010 concerning a European rail network for competitive freight, which will facilitate inclusion of the Western Balkans area into the Rail Freight Corridor initiative (SEETO, 2016). This will create additional possibilities for transforming the traditional rail freight undertakings in to the logistics rail operators.

3. CONCLUSION

In the paper there were assessed the trends of logistic principles implementation in rail freight sector and identified the main obstacles in the Western Balkan rails development. Fragmentation of the rail sector has resulted in huge gaps in infrastructure development levels, particularly between the EU and Western Balkan countries. These barriers contribute transport costs increasing reliability of logistics supply chains decreasing the economic potential of the region, as whole. By removing physical and non physical barriers and creating efficient rail systems on logistics principles can increase the volume of trade and movement of goods through decreased cost of trade, thus contributing to higher growth. An in-depth rails restructuring in Western Balkan countries will result in the organizational consolidation rail competences and create the conditions for increased efficiency and synergy effects in the logistics rail system as a whole, in order to increase focus on customer needs.

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LOGIC

REVERSE AUCTION ON SPOT TRANSPORT MARKET – INTERCLEAN CASE AND POSSIBLE IMPLEMENTATION FOR OTHER COMPANIES

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Abstract: *In order to achieve business requests such as shorten the time of booking the transport of goods at a fair price with best delivery dates specific methodologies need to be applied. This paper presents an application of the reverse auction methodology in booking international transport of goods. It is the real interCLEAN Serbia case described from an idea, proof of concept and test of possible implementation for other companies. This may be used as an example in other businesses and companies in order to improve transport procurement.*

Keywords: *reverse auction, spot transport market, e-auction*

1. INTRODUCTION

Small and medium enterprises (SME) usually use a few „reliable„ carriers in a process of booking of transport of goods. In the best case scenario SME will pay market price for good service (delivery time, prompt communication etc.). For unregular full truck loading and less than full truck loadings situation is even worst, because „reliable„ carriers have to forward requirement to their own „reliable„ circle with additional margins included. On the other hand, only in Serbia there are 1.191 companies that are doing international transport of goods, with 10.942 truck all over Europe at this moment. [1] One way to approach to this problem is to increase number of reliable carriers, but for SME it is, even more, time consuming process. Online, so called freight exchanges have emerged (Timocom.com, Cargoagent.net), but there are no price, so SME has to do all process of phone calls/chat conversations to find the „market„ prices manually. There is also some risk involved doing business with new, unknown carriers. On the other side there is a trend of transport portals, more user friendly for SME (shippers-owners of the goods) with pre-determined prices (uship.com, ucandeliver.ru) and with/without transparent bidding between carriers (uship.com, nestcargo.com).

1.1 Reverse auction

A reverse auction is a type of auction in which the roles of buyer and seller are reversed. In an ordinary auction, buyers compete to obtain goods or services by offering increasingly higher prices. In a reverse auction, the sellers compete to obtain business from the buyer and prices will typically decrease as the sellers underbid each other. [2] E-auction is online, real-time auction

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between a buying organization and two or more invited suppliers, where suppliers can submit multiple bids during the time period of the auction, and where some degree of visibility exists among suppliers regarding the actions of their competitors. [3]

1.2 Contract/spot market

Figure 1 presents the structure of the USA trucking industry [4]. Since private carriage refers to trucks and drivers owned and operated by shippers, this sector is not included in the trucking contracting market. In order to procure for-hire services, shippers either write longterm contracts with carriers, usually for one or two years, or outsource to common carriers that mostly operate in spot markets. A spot market is where shipments are handled on a one time load-by-load basis. It is used by almost all shippers and carriers to some extent. Typically shippers and carriers participate in spot markets on a "per job" basis. Spot markets, or in online marketplaces, are increasingly being used to match shipper demand and carrier capacity, because of the ability to generate market prices in real-time.
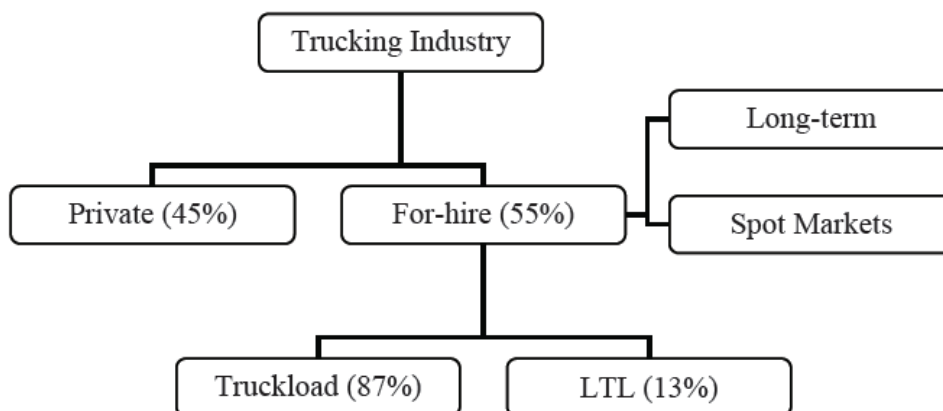
Figure 1. Structure of the Trucking Industry in USA

Spot freight trucking market in USA is responsible for 15 to 20 percent of for-hire trucking freight movements that are worth more than $10 billion in billings per year for thousands of transportation companies. [5] The best load boards provide rate analysis tools based on actual transactions on every lane in North America, since their databases hold a wealth of pricing information. For example, Dial-a-truck (DAT) offers RateView for carriers, brokers and shippers, providing access to shippers' contract rates and spot market (broker buy) rates. Spot market rates, the "broker buy" rates that freight brokers (freight forwarders) and 3PLs pay to the carrier, are typically 10 to 15 percent lower than the rates that shippers pay to carriers as part of an ongoing contract. Spot market rates vary with the season, however, so that carriers in certain markets often command top rates during periods of high demand.
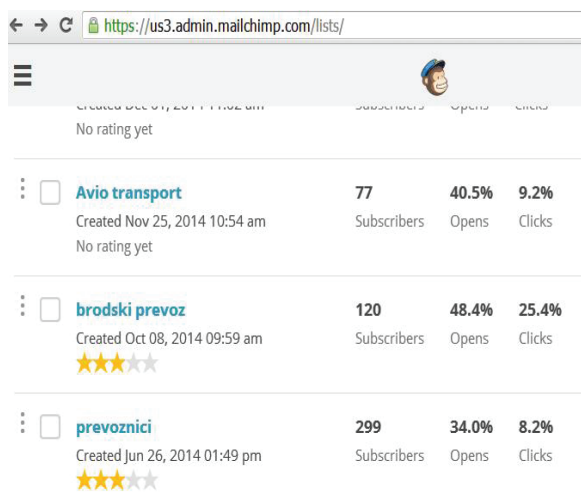
While reverse auction is widely used on contract transport market, there is no much research about usage of reverse auction on spot market. However, some researches [6] have similar results like ours (up to 30% lower prices for shippers).

2. HOW IT ALL STARTED?

There was a need for faster, easier, less time consuming booking of transport of goods, according to the budget or market price and level of service. The mix of free on-line tools is used (Google spreadsheet , mailchimp.com) to create my own auction site [7]. The idea was to save time

through transparent procedure, but after more than 100 auctions it show up that costs savings are significant i.e. 50-400EUR (up to 30% lower costs of transport) per booking compared to other offers or interCLEAN budget.

List of approved carriers is manually added according to previous contact or business experience with them. List of approved carriers is additionally segmented to contacts specialized for truck transportation, container transport and air cargo. Below (Figure 2.) is report from Mailchimp software about open rate of interCLEAN quote request for each mode of transport (for air cargo/Avio, container/brodski and trucks/prevoznici) and statistics about the how many of contact carriers and freight forwarders (agents) have gone to Google spreadsheet (view only) auction site.

Figure 2. MailChimp statistics

Offer from carriers are received through e-mail, skype, phone call and manually added to view only google documents, so carriers could all be aware of the best possible offer at that moment. From SME (shipper-owner of the goods) point of view additional decision parameters, beside price, are important e.g. loading date, unloading date, additional warehouse costs etc. The whole process could be work intensive and time consuming for carriers, so shipper transparency is highly recommended. Regarding, that interCLEAN has manually added all offers to auction site, the main problem was that time limited auctions ware the most intensive during the last minutes. The solution for this problem was automatization of the process using web application [8] (technology used: Laravel v.5.1 + JS - Jquery - Google Viz on Azure cloud platform). Together with Mr. Perica Aleksov, web developer, less than full truck loading calulator was developed in order to have idea about the referent market price [9] (google map API is used for distance km input). From shipper point of SME (shipper) the question is are you able to find even lower price pushing container agents to reverse auction bidding. The answer is yes, for both less than full containers loading and full container loadings [10]. Air freight (cargo) deliveries have been also tested successfully for reverse auction bidding [11]. Short review of reverse auction methodology used on spot transport market is the following:

- Create list of preselected carriers and freight forwarders and invite them to participate in online auction;
- All logistic details are availabale (loading date, gross weight, number and dimensions of pallets, customs clearance contacts etc) or quickly available upon request and confirmed back to all interested parties;

- Auction is time limited (a few hours is usually enough);
- Shipper is accepting one of the offers right after auction is ended

3. CHALLANGES

Advantages (benefits) of automated revese auction on the spot market is transparency, time and costs savings. Automated reverse auction means you are using dedicated online platform like http://cargobid.me/auth/login . Costs savings are possible due to large list of preselected carriers and freight forwarders , so you have a better chances to find perfect match between empty truck and shippers goods, as well as freight forwarders are willing to decrease their margin in order to get the job.

A good summary of some of the conditions, which favor a reverse auction, versus those which do not, is provided as Table 1.

Tabel 1. Conditions which favor a reverse auction vs. which do not [12]

FAVOR REVERSE AUCTION	FAVOR ALTERNATIVE
Many qualified suppliers	Few qualified suppliers
Commodity or standardized product	Specialized or custom product
Transactional prevalent suppler relationships	Long-term, strategic relationship is important
Buyer is important to suppliers	Buyer's business is small or transactional to suppliers
Excess capacity in industry	Little or no excess capacity
Price is the key selection criterion	Other issues are as, or more, important than price
Buyer is willing to award business based on results of reverse auction	Buyer is not fully committed to awarding based on results (desire flexibility)

The most important challenge encountered in reverse auctions is the suppliers' impression that buyers are acting opportunistically and taking advantage of suppliers. The most negative feedback was from some carriers and 3PLs. However, it seems that reverse auction is particularly well suited to service industries, such as transportation, whose output can't be stored and its excess capacity would otherwise be lost.

Through startup project CargoBid.co reverse auction has been promoted for other companies as a way to save money and time during booking of transport on spot market. However, the most of auctions for other companies ware not successful. There are various reason for this.

3.1 Possible solutions for some of the challenges:

- Request for offer is standard way to check the price with a few relaiable carriers without much obligation. However, automated reverse auction with large predefined list of preselected carriers is more like market research at given point in time and costs of work involved are much higher, so it seems to be that there should be a fee paid by shipper to cover this costs to keep carriers and freight forwarders motivated to send price offers;.
- Risk of not be paid by shipper or other business parties could be partly avoided by pre-screening of credit rating of the company through available online services (e.g. Cube.rs ,

Coface.com) or manual checking through publicly available services (e.g. nbs.rs , apr.gov.rs). Also, older 5 digit Timocom user numbers are used as a good business rating reference amonge carriers and freight forwarders. However, real solution is not only advance payment, but so called internet escrow services. Escrow generally refers to money held by a third-party on behalf of transacting parties.[13] uShip.com, USA fast growing startup internet company that operates online marketplace for shipping services is using successfully this internet escrow model. [14] So shipper is sending full amount or booking deposit which is a percentage of the accepted bid price to third (escrow) party. Carrier or freight forwarder will receive money only after prearranged conditions are met. (e.g. as soon as copy of signed CMR is uploaded and confirmed by shipper);

- Although cargo thefts are relatively rare in this part of the world [15] it is one of greatest fear for shippers. Solution for this as well some other risks is cargo insurance by shipper, but it is not a standard practice for the most SME. CMR insurance and third party limited partial insurance could help to relax a tension between new business parties. Lower level of service then usual when dealing with new carriers could be overcome through online rating platforms and/or through more specific escrow contract terms;

- No complete shipping logistic data could usually be overcomed by prompt communication, but in the case some problems occurred during transport, escrow negotiations (through majority voting system) could quickly solved any financial issues;

- Starting auction without target price by shippers and no good will to accept offers should be penelized through advance paid auction fee.

Through future implementation of above solutions, CargoBid.co is hoping to match customer needs for less time consuming, more cost effective and more transparent booking. However, regading that this is no standard way of doing business like: paying in advance for service, be more responsible for data you are putting on online platform etc. project could move forward, pivot or part of the solution could be use in any different way.

The big picture is that through centralized automated platform, data about average spot market priced could be collected for various destinations, and this kind of data are the building blocks for potential future development of freight derivatives especially for trucking. [16]

3. CONCLUSION

During 24 months interCLEAN - import department succeeded from bringing idea to gain enough basic knowledge about reverse bidding auction approach. The first testing started at the beginning July 2014. and now after more than 100 auctions we could confirmed proof of concept, about reverse auction bidding on spot transport market in region. The main goal in this paper was to report a successful use of on-line reverse auction bidding in a company that has not previously used it and, as a result, cost savings in its business operations. Initial interCLEAN solution (view only google documents + email software) is low cost - almost free, with small know-how barrier to test it as a pilot project for most of other companies. However, simple copy/paste of online tools used is not enough, but different mindset approach by shipper is needed to make reverse auction beneficial.

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Part III   **LOGISTICS TERMINALS**

MULTI-CRITERIA EVALUATION OF THE INTERMODAL TERMINAL TECHNOLOGIES

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Abstract: Intermodal transport allows energy, costs and time savings, improves the quality of services and supports sustainable development. Major subsystem of the intermodal transport is intermodal terminal representing the place of change of the transport mode and storage of the intermodal transport units. Efficiency of the intermodal terminal greatly depends on the subsystems technologies. Accordingly, the subject of this paper is the evaluation and selection of the appropriate technologies for the realization of the transport units' transshipment and handling operations in the intermodal terminal. As the decision-making process is affected by different economic, technical, technological and other criteria, fuzzy DEMATEL (for obtaining criteria weights) and fuzzy VIKOR (for alternatives ranking) methods are used. The applicability of the proposed methodology is tested by solving a real-life example.

Keywords: intermodal transport, terminal, technology, multi-criteria decision-making.

1. INTRODUCTION

Intermodal transport is defined as the movement of goods in one and the same loading unit or a vehicle, by successive modes of transport without handling of the goods themselves when changing modes (ECMT 1993). One of the major subsystems of intermodal transport is intermodal terminal (IT) defined as the place equipped for transshipment and storage of intermodal transport units between modes of transport (UNECE 2009). The most commonly solved IT problems are related to the terminals location (Roso et al., 2015, Zečević et al., 2017), terminal network design (Sorensen et al., 2012), terminals' performance measurement (Wang, 2016), etc. Since the efficiency of IT functions largely depends on the subsystem technology, subject of this paper is multi-criteria evaluation of technologies for handling intermodal transport unit (ITU). The objective is the selection of the most appropriate handling equipment (HE) by analyzing various criteria and terminal characteristics.

ITs can be structured by different criteria (Zečević, 2006), but for the HE selection the most important is the classification on the basis of size and flows intensity and connection of the transport modes. This paper discusses in more detail the HE selection for small road-rail terminal, with 1 or 2 tracks and turnover of about 80 000 ITUs per year, which is the case with the planned IT in Belgrade, Batajnica (EC, 2010-2012). Medium to large ITs (with 4 or more handling tracks) are generally equipped with bridge cranes for transshipment of the ITUs and with other HE for handling them inside the terminal. In smaller ITs, usage of bridge cranes is not justified, therefore they use the HE

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that can be used both for transshipment and internal transportation of the units. This equipment is cheaper, easier to use and can be faster put into use in the early stages of the IT development. As the HE selection is influenced by numerous economic, technical and technological criteria, this represents a multi-criteria decision-making (MCDM) problem and MCDM model that combines fuzzy DEMATEL (for obtaining criteria weights) and fuzzy VIKOR (for ranking the alternatives) is defined for its solution. More detailed model description is given below, after which the case study of the HE selection for the planned IT in Belgrade is solved. Final conclusions and future research directions are given at the end.

2. COMBINED FUZZY DEMATEL - FUZZY VIKOR MODEL

MCDM model proposed in this paper consists of two parts. The first part is the fuzzy DEMATEL method used for obtaining the criteria weights. The aim of DEMATEL (Gabus & Fontela, 1972) is to convert the relation between elements, causal dimensions from a complex system to an understandable structural model. In the second part of the model fuzzy VIKOR method is used for the alternatives evaluation in relation to the criteria and obtaining the final rank. The VIKOR method (Opricovic, 1998) is convenient for the selection problems because of its stability and ease of use with cardinal information. The method focuses on ranking and selecting from a set of alternatives against various, and in most cases conflicting and non-commensurable, decision criteria and determines compromise solutions for a problem. As the decision makers' judgments on decision criteria and alternatives are often imprecise, vague and ambiguous, the methods are solved in the fuzzy environment. Linguistic scale with corresponding triangular fuzzy numbers (Table 1) is used for the pair-vise comparison of criteria and evaluation of the alternatives in relation to the criteria. The following describes computational steps of the proposed model.

Table 1. Linguistic terms and corresponding fuzzy values

Linguistic term	Abbreviations	Fuzzy scales
None	N	(1, 1, 2)
Very Low	VL	(1, 2, 3)
Low	L	(2, 3, 4)
Fairly Low	FL	(3, 4, 5)
Medium	M	(4, 5, 6)
Fairly High	FH	(5, 6, 7)
High	H	(6, 7, 8)
Very High	VH	(7, 8, 9)

Step 1: Define the evaluation model. After defining the alternatives, i.e., HE in this paper, the set of criteria for their evaluation is formed.

Step 2: Establish causal relations between the criteria using fuzzy DEMATEL (Wu & Lee, 2007).

Step 2.1: Acquire fuzzy direct-relation matrix. Decision makers are making sets of the criteria pair wise comparisons, i.e., forming an $n \times n$ matrix $\widetilde{A}$ whose elements, triangular fuzzy numbers $\widetilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$, represent the degree to which the element i affects the element j, where l and u represent the lower and upper boundaries, and m the most probable value of the fuzzy number $\widetilde{a}$.

Step 2.2: Acquire normalized fuzzy direct-relation matrix $\widetilde{X}$ obtained from the matrix $\widetilde{A}$:

$$\widetilde{X} = s \times \widetilde{A} \qquad (1)$$

where $s = 1/\max_{1 \le i \le n} \sum_{j=1}^{n} u_{ij}$ and $\widetilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$.

Step 2.3: Acquire fuzzy total-relation matrix $\widetilde{T}$ by applying the equation:

$$\widetilde{T} = \widetilde{X}(1 - \widetilde{X})^{-1}. \qquad (2)$$

Step 2.4: Obtain the criteria weights. In order to obtain criteria weights from the matrix $\widetilde{T}$, variables r_i and c_j are introduced:

$$r_i = \sum_{j=1}^{n} \widetilde{t}_{ij} \tag{3}$$

$$c_j = \sum_{i=1}^{n} \widetilde{t}_{ij} \tag{4}$$

where r_i indicates the degree of influence of the criterion i on all other criteria, and c_j indicates the degree of influence of all other criteria on criterion i. $r_i + c_j$ indicates the criterion importance degree for the entire system. The criteria weights are obtained by the equation:

$$\widetilde{w}_j = \frac{r_i + c_j}{\sum_{i=1}^{n}\sum_{j=1}^{n} r_i + c_j}, i = j \tag{5}$$

Crisp values of the weights are obtained after the defuzzyfication using the following equation:

$$P(w_j) = (l_j + 4m_j + u_j)/6 \tag{6}$$

Step 3: Evaluate the alternatives by using fuzzy VIKOR. The procedure is adapted from the paper (Opricovic, 2011), and computational steps are described below.

Step 3.1: Construct the fuzzy performance matrix ($\widetilde{D}$) elements of which $\widetilde{f}_{kj} = (l_{kj}, m_{kj}, u_{kj})$ indicate triangular fuzzy evaluations of the alternative HE_k in relation to criterion C_j.

Step 3.2: Determine the ideal $\widetilde{f}_j^* = (l_j^*, m_j^*, u_j^*)$ and the nadir $\widetilde{f}_j^\circ = (l_j^\circ, m_j^\circ, u_j^\circ)$ values of all criterion functions according to the benefit (J^b) or cost functions (J^c).

$$\widetilde{f}_j^* = \max_k \widetilde{f}_{kj}, \ \widetilde{f}_j^\circ = \min_k \widetilde{f}_{kj} \quad for \ j \in J^b$$
$$\widetilde{f}_j^* = \min_k \widetilde{f}_{kj}, \ \widetilde{f}_j^\circ = \max_k \widetilde{f}_{kj} \quad for \ j \in J^c \tag{7}$$

Step 3.3: Compute the normalized fuzzy difference $\widetilde{d}_{kj}$:

$$\widetilde{d}_{kj} = \frac{\widetilde{f}_j^* (-) \widetilde{f}_{kj}}{u_j^* - l_j^\circ} \ \ for \ j \in J^b \qquad \widetilde{d}_{kj} = \frac{\widetilde{f}_{kj}(-)\widetilde{f}_j^*}{u_j^\circ - l_j^*} \ \ for \ j \in J^c \tag{8}$$

Step 3.4: Compute the values $\widetilde{S}_k = (S_k^l, S_k^m, S_k^u)$, which represent the normalized fuzzy difference, i.e. the maximum group utility, and $\widetilde{R}_k = (R_k^l, R_k^m, R_k^u)$, which represent the maximum fuzzy difference, i.e. minimum individual regret, by the relations:

$$\widetilde{S}_k = \sum_{j=1}^{n} w_j (\times) \widetilde{d}_{kj} \tag{9}$$

$$\widetilde{R}_k = \max_j w_j (\times) \widetilde{d}_{kj}. \tag{10}$$

Step 3.5: Compute the values $\widetilde{Q}_k = (Q_k^l, Q_k^m, Q_k^u)$, i.e. the overall distances of the alternatives from the ideal solution, by the relation:

$$\widetilde{Q}_k = v \frac{\widetilde{S}_k (-) \widetilde{S}^*}{S^{\circ u} - S^{*l}} (+)(1-v) \frac{\widetilde{R}_k (-) \widetilde{R}^*}{R^{\circ u} - R^{*l}}, \tag{11}$$

where $\widetilde{S}^* = \min_k \widetilde{S}_k$, S^{*l} is the lower value of the triangular fuzzy number $\widetilde{S}^*$, $S^{\circ u} = \max_k S_k^u$, $\widetilde{R}^* = \min_k \widetilde{R}_k$, R^{*l} is the lower value of the triangular fuzzy number $\widetilde{R}^*$ and $R^{\circ u} = \max_k R_k^u$. The

value v is introduced as a weight for the strategy of "the majority of criteria" (or "the maximum group utility"), whereas $1 – v$ is the weight of the individual regret.

Step 3.6: Defuzzify $\widetilde{S}_k$, $\widetilde{R}_k$ and $\widetilde{Q}_k$ using Eq. (6).

Step 3.7: Rank the alternatives, HEs, sorting by the crisp values in increasing order. The results are three ranking lists $\{HE\}_S$, $\{HE\}_R$ and $\{HE\}_Q$ according to *crisp(S)*, *crisp(R)* and *crisp(Q)*, respectively.

Step 3.8: Propose as a compromise solution the alternative *HE⁽¹⁾* which is the best ranked by the measure *Q,* if the following two conditions are satisfied:

Co.1. "Acceptable Advantage": Adv ≥ DQ where $Adv = \left[Q\left(HE^{(2)}\right) - Q\left(HE^{(1)}\right)\right] / \left[Q\left(HE^{(m)}\right) - Q\left(HE^{(1)}\right)\right]$ is the advantage rate of the alternative *HE⁽¹⁾* ranked first, *HE⁽²⁾* s the alternative with second position in $\{HE\}_Q$, and *DQ = 1/(m – 1)* is the threshold.

Co.2. "Acceptable Stability in decision making": The alternative *HE⁽¹⁾* must also be the best ranked by *S* or/and *R*.

If one of the conditions is not satisfied, then a set of compromise solutions is proposed, which consists of: **CS1.** Alternatives *HE⁽¹⁾* and *HE⁽²⁾* if only the condition Co.2 is not satisfied, or **CS2.** Alternatives *HE⁽¹⁾*, *HE⁽²⁾*, ..., *HE⁽ᴹ⁾* if the condition Co.1 is not satisfied; *HE⁽ᴹ⁾* is determined by the relation $\left[Q\left(HE^{(M)}\right) - Q\left(HE^{(1)}\right)\right] / \left[Q\left(HE^{(m)}\right) - Q\left(HE^{(1)}\right)\right] < DQ$ or maximum *M* (the positions of these alternatives are "in closeness").

3. CASE STUDY

The proposed model is used for selection of the HE for the planned road-rail IT in Belgrade, Batajnica, in the first stage of the development (EC, 2010-2012). For HE selection, 3 groups of criteria are defined: technical (productivity - C_1; capacity - C_2; speed - C_3; lifting height - C_4; required manipulation area - C_5), economic (price - C_6; maintenance costs - C_7; life cycle - C_8; operating costs - C_9; costs of the terminal preparation - C_{10}; applicability in the next stages of the terminal development - C_{11}) and technological (fitting with other technologies - C_{12}; need for planning/organization - C_{13}; automation possibility - C_{14}; training requirements - C_{15}). The following potential HE are evaluated: Front Lift Tractor (HE₁), Side Loader (HE₂), Reach Stacker (HE₃), Self Loading Trailer (HE₄) and Straddle Carrier (HE₅). Front Lift Tractor and Side Loader are characterized by small turning radius, but not that small aisle width. Their prices are low and they do not require special training or operating license, but their ability for automation is low. In addition, Side Loader has a lower productivity, capacity and lifting height than the Front Lift Tractor. Reach Stacker is characterized by high lifting height with not so large turning radius. It fits easily with other technologies and has the ability for automation of the certain processes. On the other hand, its price is slightly higher and requires short training and operating license. Self Loading Trailer is characterized by low price, high speed, operating without special training and licenses, but on the other hand has low productivity, low lifting height and a large turning radius. Reach Stacker is quite expensive, not suitable for rail transshipments and requires special training and operating license, but on the other hand it has great productivity, speed, capacity and ability for the complete automation.

Causal relations between the criteria are established by applying the linguistic terms (Table 2) which are transformed into triangular fuzzy numbers thus forming the direct-relation matrix $\widetilde{A}$, which is then normalized by the equation (1) in order to obtain the matrix $\widetilde{X}$. By applying the equation (2), the fuzzy total-relation matrix $\widetilde{T}$ is obtained, based on which the values r_i and c_j are obtained by applying the equations (3) and (4), respectively. By applying the equation (5) for the obtained values

of r_i and c_j, fuzzy criteria weights $\widetilde{w}$ are obtained, which are then defuzzyfied by applying the equation (6) in order to obtain the crisp values of the criteria weights w. The following criteria weights are obtained (0.108, 0.082, 0.101, 0.098, 0.092, 0.109, 0.090, 0.074, 0.084, 0.067, 0.105, 0.087, 0.073, 0.090, 0.065).

Table 2. Evaluation of the criteria causal relations

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
C_1	/	FL	L	L	FL	VH	H	M	M	M	L	M	M	L	L
C_2	H	/	M	L	L	FH	FH	FL	M	FL	VL	L	L	LI	VL
C_3	VH	VL	/	N	H	FH	FH	FL	FH	VL	FH	FL	L	VL	VL
C_4	M	VL	N	/	M	H	H	FL	FL	FL	H	M	M	L	FH
C_5	L	VL	M	L	/	FL	VL	VL	L	H	M	L	L	L	L
C_6	L	VL	VL	VL	VL	/	VH	FL	L	N	N	M	N	VH	VL
C_7	L	VL	L	L	N	VH	/	FH	VL	N	N	N	N	N	N
C_8	N	VL	N	L	L	FH	M	/	N	N	N	N	N	N	N
C_9	N	N	L	L	L	FH	VL	N	/	VL	M	VL	N	N	VL
C_{10}	N	N	FL	L	L	VL	N	N	N	/	N	N	N	N	N
C_{11}	FL	FL	M	H	M	FL	FL	FL	FH	FL	/	L	FL	FL	FL
C_{12}	L	N	L	N	L	L	N	VL	FL	L	L	/	H	H	M
C_{13}	L	N	L	N	N	N	N	N	VL	VL	L	FL	/	M	N
C_{14}	FH	N	FL	N	L	M	L	VL	L	FL	FL	L	FL	/	FL
C_{15}	L	N	N	N	N	VL	N	L	FL	N	L	N	VL	N	/

Once the criteria weights are obtained, the evaluation of the HEs in relation to the criteria is performed (Tabela 3) by applying the liguistic terms given in Table 1, which are then transformed into triangular fuzzy numbers thus forming the matrix $\widetilde{D}$.

Table 3. Evaluation of the handling equipment in relation to the criteria

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}
HE_1	H	FH	FH	M	M	FH	M	H	FH	FH	FH	VH	VH	VL	VH
HE_2	FL	L	M	L	VH	VH	FH	H	VH	H	L	H	VH	VL	VH
HE_3	H	M	FH	VH	FL	M	FL	H	FH	FL	VH	H	H	FH	H
HE_4	FL	FH	VH	L	M	H	H	VH	VH	VH	L	FL	L	L	VH
HE_5	VH	VH	H	FH	H	L	H	FL	FH	FL	M	FL	H	VH	L

Table 4. Results of applying the fuzzy VIKOR method

		HE_1	HE_2	HE_3	HE_4	HE_5
$\widetilde{S}$	S^l	-0,050	0,004	-0,050	-0,003	-0,028
	S^m	0,396	0,450	0,396	0,443	0,417
	S^u	0,841	0,895	0,842	0,889	0,863
	Crisp S	0,396	0,450	0,396	0,443	0,417
	Rank	1	5	2	4	3
$\widetilde{R}$	R^l	0,045	0,045	0,031	0,045	0,047
	R^m	0,067	0,075	0,061	0,075	0,078
	R^u	0,090	0,108	0,092	0,108	0,109
	Crisp R	0,067	0,075	0,061	0,075	0,078
	Rank	2	3	1	4	5
$\widetilde{Q}$	Q^l	-0,443	-0,418	-0,450	-0,421	-0,432
	Q^m	0,004	0,033	0,001	0,030	0,019
	Q^u	0,452	0,486	0,452	0,483	0,471
	Crisp Q	0,004	0,033	0,001	0,030	0,019
	Rank	2	5	1	4	3

By applying the equation (7), the ideal and the nadir values are obtained based on which the values of normaized fuzzy difference $\widetilde{d}_{kj}$ are obtained by applying the equation (8). By applying the equations (9-11), the values $\widetilde{S}_k$, $\widetilde{R}_k$ and $\widetilde{Q}_k$ are obtained, based on which the ranking of the alternatives is obtained (Table 4). It can be seen from the table that the best ranked alternative is the HE_3 – Reach Stacker.

4. CONCLUSION

The efficiency of the transport and handling processes in the IT is largely dependent on the equipment. When selecting the equipment it is necessary to consider the large number of criteria, therefore this represents the MCDM problem. This paper used the fuzzy DEMATEL method for obtaining the criteria weights, and fuzzy VIKOR method for ranking and selection of the HE. The applicability of the model is demonstrated by solving the case study of selecting the HE for the planned IT in Belgrade. Future research could be related to the HE selection for other types of the intermodal terminals, in terms of the present transportation modes, sizes and flow volumes.

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THE ROLE OF GIS IN PORT HINTERLAND MODELLING BASED ON PORT CHOICE

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Abstract: *Geographic information systems (GIS) play more and more important role in port hinterland modelling. They appear in illustrating and assessing of port hinterlands, and consequently in assisting of port planning and development. Three basic GIS constituent parts of such model are transportation network system, consisting of nodes and weighted links, different kinds of additional spatial data and visualization. In our research we present one option to model port hinterlands, although the conventional representation of port's hinterland has drastically changed in recent years. We introduce a model, which is based on the results of port choice modelling, where shippers' port choice is a trade-off between various objective and subjective factors. We upgrade the model by sophisticated visualization where three-dimensional GIS tools are effectively utilized.*

Key words: *GIS, 3D GIS, port hinterland modelling, port choice, visualization.*

1. INTRODUCTION

Port hinterland presents the inland area surrounding a port from which goods are either distributed, or at which they are collected for shipping to other ports. In other words, the traditional concept of hinterland conceives it as the area whose contour is a continuous line bounding the port economics with influence on the shore (Ferrari, Parola, & Gattorna, 2011). The conventional representation, based on distance decay, is being replaced with spatial discontinuity and clustering (Notteboom & Rodrigue, 2007). Here we find the connection between the definition of the hinterland and the port choice problem. Among the decision-makers belong shippers, forwarders, shipping companies and terminal operators (Sys & Vanelslander, 2013), while some authors indicate also port authorities and government agencies as influencing port choice.

A number of mathematical programming models have been developed, with respect to the many involved factors, in order to minimize the total operation cost by selecting an appropriate port as the most favourable one to call. In general, all models treated the problem of port choice as a multiple criteria decision-making problem.

In this paper we spatially model the port hinterland which is based on port choice problem (Kramberger, Rupnik, Štrubelj, & Prah, 2015). Different authors have also used GIS in modelling

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and visualizing port hinterlands. For example, GIS was used to illustrate and asses captive and contestable port hinterlands, and the results have been recognized as useful in port planning and decision-making (Kronbak & Cullinane, 2011). GIS was also used in studying the port development due to the containerization process, and the methodology was applied in a case study of the port of Rio Grande (Pizzolato, Scavarda, & Paiva, 2010). In another study a multi-layered hinterland classification of major Indian ports for containerized shipments was developed. The approach integrates GIS visualization and data mining methods (Thill & Venkitasubramanian, 2015).

2. PROBLEM DEFINITION

The aim of the paper is to visualize port hinterland modelling in an advanced way. Here we used three-dimensional GIS, since it allows observing the data in true perspective, which consequently allows to make better decisions, and to communicate the ideas more effectively and efficiently.

The problem discussed in the paper focuses on modelling the port's hinterlands and their visualization using GIS. Port hinterland modelling of European ports is done by observing the cargo flow from the origin (Asian) to the destination (European) ports, and from those toward consumption destinations. The question that arises is what hinterland area is covered by which of the destination ports. Using the subjective factors to estimate the preference of individual ports allows for constructing a decision model (Chou, 2010).

The cargo flow follows from production destinations to origin ports using land transport, following shopping via sea routes to destination ports, and land transport from destination ports to consumption destinations across Europe. The focus is on finding out which destination port is optimal for supplying each consumption destination, which represents the hinterland of the respective port. The visualization is then focused on grouping the consumption points supplied by the same destination port.

3. METHODOLOGY

The main idea of the methodology is that if the certain port is port of choice for a certain consumer point, then this consumer point lies within this port's hinterland. As the purpose of the model is to find the hinterlands of destination ports, the only observed cargo shipping direction is in sequence from production points S_K towards consumer points C_L. The model operates on the distances between the elements of each set as well as preference rates of each individual port, both on the origin as well as on the destination side (Kramberger, Rupnik, Štrubelj, & Prah, 2015):

- x_{ki} – edges between production points $S_k \in S_K$ and origin ports $P_i \in P_I$
- x_{ij} – edges between origin ports $P_i \in P_I$ and destination ports $P_j \in P_J$
- x_{jk} – edges between destination ports $P_j \in P_J$ and consumer points $C_l \in C_L$
- PR_i – preference rates of origin ports $P_i \in P_I$
- PR_j – preference rates of destination ports $P_j \in P_J$
- $sup_k, cons_l$ –supply of production points and consumption of consumer points
- $k = 1 \ldots K, i = 1 \ldots I, j = 1 \ldots J, l = 1 \ldots L$
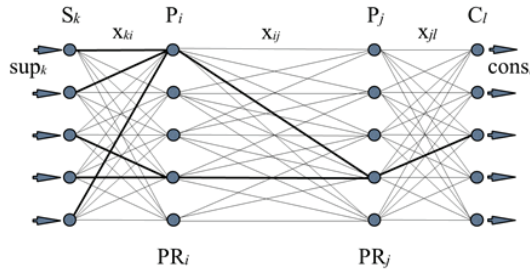
Figure 1. One of the port choice problem solutions (Kramberger, Rupnik, Štrubelj, & Prah, 2015)

The model is presented in Figure 1. The goal is finding the optimal destination ports $P_j \in P_J$ for each of the consumer points $C_l \in C_L$ based on both transportation costs and port preference rates.

As we stated before, consumer point C_l lies within the port's P_j hinterland, when the port P_j is port of choice for consumer point C_l. Let C_L be a set of all consumer points that are uniformly distributed in a predefined geographical area E. Each consumer point $C_l \in C_L$ is connected to the destination ports via railroad connections. Distances d_{jl} are measured as sum of aerial distance from each C_l to the nearest railroad section and from there to the destination ports $P_j \in P_J$ by railroad distances.

The second stage of the methodology consists of three sub-stages as follows: implementation of AHP, definition of the weights and port selection using LP. The methodology with all sub-stages is explained more details in the paper (Kramberger, Rupnik, Štrubelj, & Prah, 2015). Along with the distances, each port is assigned a preference rate, which is calculated using the Analytic Hierarchy Process (AHP) using various subjective factors that are described in greater detail in (Button, Chin, & Kramberger, 2015) .

3.1 Optimal port selection using LP

Figure 1 reveals that the costs for moving goods from S_k to C_l are the sum of land transport cost to move goods along the edge x_{ki}, the costs of maritime transport along x_{ij} and land transport cost along the edge x_{jl}. Therefore the costs of different parts of transport process can be expressed as a sum of weights w_{ki} , w_{ij} or w_{jl} assigned to certain edge respectively. The cost of this situation can be mathematically expressed by Linear Programming model (LP) below:

$$\min W = \sum_{k=1}^{K}\sum_{i=1}^{I} x_{ki}w_{ki} + \sum_{i=1}^{I}\sum_{j=1}^{J} x_{ij}w_{ij} + \sum_{j=1}^{J}\sum_{l=1}^{L} x_{jl}w_{jl} \tag{1}$$

$$\sum_{i=1}^{I} x_{ki} \geq \frac{sup_{s_k}}{\sum_{k=1}^{K} sup_{s_k}} \quad k = 1,2,\dots,K \tag{2}$$

$$\sum_{k=1}^{K} x_{ki} - \sum_{j=1}^{J} x_{ij} \geq 0 \quad i = 1,2,\dots,I \tag{3}$$

$$\sum_{i=1}^{I} x_{ij} - \sum_{l=1}^{L} x_{jl} \geq 0 \quad j = 1,2,\dots,J \tag{4}$$

$$\sum_{i=1}^{K}\sum_{j=1}^{L} x_{ij} = \begin{cases} 1; if\ there\ is\ a\ connection\ to\ P_j \\ 0; otherwise \end{cases} \tag{5}$$

$$\sum_{i=1}^{I} x_{jl} \geq \frac{cons_{C_l}}{\sum_{l=1}^{L} cons_{C_l}} \quad l = 1,2,\dots,L \tag{6}$$

The constraints ensure that the flow from S_k to P_i is greater or equal the supply at S_k divided by the sum of all supplies (2). Constraints (3) and (4) represent the incoming and outgoing flow at the departure or destination ports, which needs to be greater than or equal to zero. To ensure that only one port is selected at a time, the sum of all x_{ij} in constraint (5) is either 0 or 1 for each destination port, however all the variables are of general type. The port with the sum of 1 appears in the solution. Like supply, the last constraint is required for the flor from destination ports to consumer points, which is greater or equal to the demand of consumer points divided by the sum of all demands. LP set to minimize costs is applied in order to find the optimal destination port.

3.2 Ports' hinterland area calculation and visualization

To present visualization more sophistically, a three-dimensional GIS was used. In this process, the digital elevation model (DEM) for observed part of Europe was prepared first. Further several ArcGIS geoprocessing tools were used (ArcGIS for Desktop: Release 10.2.2., 2014): tool Mosaic Dataset to merge different data sheets, and tool Extract by Mask to cut DEM for observed region. Due to relatively large observed area the size of the raster cells was increased from 25x25 meters to 100x100 meters. Finally the tool Raster to TIN (ArcGIS for Desktop: Release 10.2.2., 2014) was used to convert a raster to a triangulated irregular network dataset. Here the height coordinates were inflated for better visualization. Example of 3D visualization can be seen in figure 2.

4. DATA AND CALCULATIONS

4.1 Data sets

Port hinterlands were modelled using available data that consists of origin ports in Asia (Singapore, Hong Kong, Busan, Kaohisiung, and Port Klang), destination ports in northern (Rotterdam, Hamburg, and Bremerhaven) and southern (Koper, Rijeka, Trieste, Venetia, and Ravenna) Europe. Sailing times between origin ports and destination ports were calculated by assuming the most common cruising speed of 21 knots over the standard sea routes. The sailing days were acquired from a web service (Sea rates, 2011). The data for operating costs was acquired by surveying shippers, logistics providers, and retailers. Preference rates were calculated using analytic hierarchy process (Kramberger, Rupnik, Štrubelj, & Prah, 2015). The preference rates for origin ports can be seen in table 1, and preference rates of destination ports in table 2.

Table 1. Operating costs and preference rates of origin ports (Kramberger, Rupnik, Štrubelj, & Prah, 2015)

Ports P_I	Operating costs (in \$)	Preference rate
Singapore	5,420	0.211
Hong Kong	5,820	0.211
Busan	17,004	0.202
Kaoshiung	7,115	0.196
Port Klang	5,275	0.180

Table 2: Operating costs and preference rates of destination ports (Kramberger, Rupnik, Štrubelj, & Prah, 2015)

Ports P_J	Operating costs (in \$)	Preference rate
Koper	34,033	0.097
Rijeka	35,814	0.095
Trieste	37,164	0.106
Venice	35,630	0.101
Ravenna	34,095	0.100
Rotterdam	43,052	0.168
Hamburg	35,900	0.167
Bremerhaven	36,350	0.166

4.2 Calculation

LP results are used as input for ArcGis, which is used to construct the Voronoi diagram over consumer points and to assign the Voronoi region of each point to its designated destination port. Further, the Voronoi regions assigned to the same destination ports are merged, forming their hinterlands (Kramberger, Rupnik, Štrubelj, & Prah, 2015). The results can be seen in figure 2.
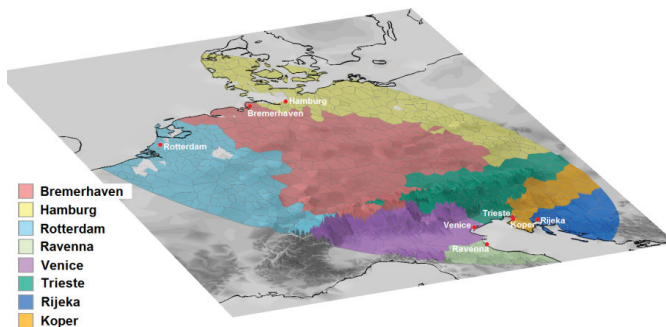
Figure 2. Port hinterlands

3D visualization allows us to see whole area even more plastically. We can recognize Alps as mountain barrier, where hinterlands of Rotterdam, Bremerhaven and Venice meet, while is the hinterland of Trieste focused mainly on eastern alpine and subalpine region.

Undoubtedly, the terrain influences the transportation network significantly. Especially young fold mountains like Alps represent great natural barriers. But, not only natural - Trans Alpine area represents an important example of a physical/political/economic "arena", and transalpine freight transport represents one of the most challenging operational and policy issues of freight transport development. Freight transport operators are on the one side confronted with a limited capacity of the Trans-Alpine transport infrastructure and with environmental constraints, and on the other hand, there is a permanent need to serve the growing demand in a more efficient manner. This applies even more since we know that the traffic in the Transalpine-chain will continue to grow (Reggiani, Cattaneo, Janic, & Nijkamp, 2000).

5. CONCLUSIONS

The main restrictions of the model are due to the data availability. The hinterlands were modelled based on the surveys that include the three northern and four Adriatic ports. This case only represents the hinterland competition of the stated ports. Other ports also play a role in forming the hinterlands and given the data, the results would differ.

The benefit of 3D visualization is to explain the extension of port hinterlands in connection with terrain characteristics, such as flatlands, mountains, valleys etc. We can do the analysis, which comprises both variables – hinterlands and terrain. Even more since we know that physical characteristics influence political and economic characteristics which overall influence transport and accessibility characteristics in region. The methodology of hinterland modelling, presented in the paper, takes into account many different factors that influence the port choice. The hinterland displayed on the figure 2 is calculated according to present data. The data such as port charges, land transport costs or preference rates can change over time. This should consequently change the shape and size of the hinterland of certain ports. Therefore, the presented methodology could be used to simulate different scenarios and different relations between the influencing factors. The results might send a strong signal to policy decision-makers and their efforts to achieve better results in comparison with competing ports.

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GRAVITATIONAL ZONES OF THE PORT OF RIJEKA

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Abstract: *Port of Rijeka is classified as the only TEN-T basic Croatian sea port. Apart from the maritime traffic, it has an excellent connection to road traffic, it is located near the airport, the oil pipeline system connects the Port of Rijeka with several states inside and outside the European Union, and rail traffic is growing despite the poor infrastructure. In this paper, gravitational zones of the Port of Rijeka will be defined along with their spatial and economic characteristics. The location and traffic connections of the Port of Rijeka will be more detailed and described, whereupon the gravitational zones of aforementioned terminal will be described. The most important elements of the analysis of the relevant resources and the economic development of the potential micro-location and the gravitational zone of the Port of Rijeka will be given. The purpose of this paper is to describe the location and geotraffic position of the port of Rijeka and to show the criteria that define the gravitational zones of Rijeka.*

Keywords: *Gravitational Zones, Port of Rijeka, Multi-modality.*

1. INTRODUCTION

A gravitational zone of a terminal is defined as the area where the transport flows of goods and people are initiated, so one stage of their movement includes passing through the terminal. The port of Rijeka has been named as one of the fundamental ports in the TEN-T map. It is Croatia's largest port, whose advantage lies in the water depth of the natural channel in the Adriatic. According to the statistics provided by the port of Rijeka authority, the largest amount of traffic is the transit-cargo traffic, the highest traffic is the transit cargo, with lines connecting it to the hinterland of Central Europe. To expand the gravitational zones of the port, it will be necessary to ensure the port's interoperability and accessibility and complete the development strategy of the port with the essential development of the road and railway infrastructure, as well as logistical areas. The purpose of this paper is to describe the location and geotraffic position of the port of Rijeka and to show the criteria that define the gravitational zones of Rijeka.

2. THE LOCATION OF THE PORT AND ITS GEOTRAFFIC POSITION

The city of Rijeka lies in western Croatia, 131 kilometres south-west from the capital Zagreb, on the northern coast of the Bay of Rijeka, which is a part of the Kvarner Gulf, in the Adriatic Sea. The port of Rijeka, the largest and most important seaport in Croatia, is located in Croatia's third biggest city, which is the administrative centre of Primorje-Gorski Kotar county (INSTITUT IGH,

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2011). The geographical and traffic position of the port of Rijeka, as well as its traffic network, was described in more detail by Furdić (2015) in "Gravitational zones of intermodal terminals".

Table 1 lists the port of Rijeka's road and rail distances to some European cities. It is evident that the road distances are lower compared to rail. However, considering the harmfulness of roadway transportation, as well as the fact that a train composition can transport several dozens of containers, whereas a road cargo vehicle can fit only a single container, the railway transport is much more profitable.

Table 1. The distances between the port of Rijeka and European capitals towards which it gravitates (www.lukarijeka.hr)

CITY	ROAD DISTANCE (km)	RAIL DISTANCE (km)
Zagreb	145	228
Budapest	504	592
Bratislava	550	686
Vienna	490	572
Prague	810	844
Belgrade	569	669
Sarajevo	456	490

The advantage of north Adriatic ports over the ports in the North Sea or the Baltic results from the shortest maritime link between Europe and the Near, the Middle, and the Far East. Figure 1 illustrates the relationship between the distances (in nautical miles) between the north Adriatic and the North Sea ports from the five main world ports. The northern Adriatic is 2270 Nm closer to Far East seaports than the North Sea is, which amounts to approximately six additional days of navigation (Marković et al., 2003).
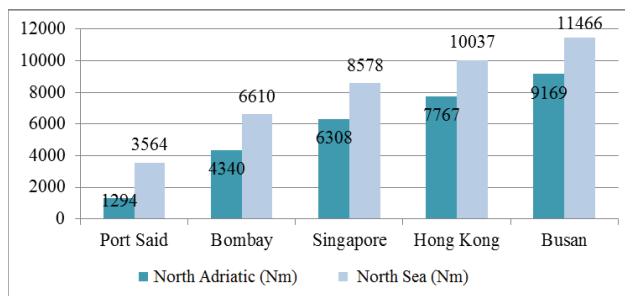
Figure 1. The distances between seaports in northern Adriatic and northern Europe, and some seaports in the world (Marković et al., 2003)

3. GRAVITATIONAL ZONES OF THE PORT OF RIJEKA

The port of Rijeka is situated in the Kvarner Gulf, a protected natural heritage, and through Kupa Valley there is a great connection potential to Zagreb and Pannonian basin, and consequently, to the Danube region and Central Europe (Marković et al., 2003). The port of Rijeka's favourable position places it within the gravitational area of Central European countries (Croatia, Hungary, Slovakia, Czechia, Austria, Slovenia, Southern Poland and Southern Germany), as well as Eastern Europe (Bosnia and Herzegovina, Serbia, Montenegro, Bulgaria, Romania and Western Ukraine). Figure 2 shows the gravitational tendencies of the port of Rijeka.

The main advantage of the port of Rijeka, apart from its excellent location, is its intermodality. Directly and indirectly, it is a junction of five traffic branches (road, railway, air, maritime and

pipeline traffic). The current investments in the expansion and modernisation of the port will have great impact on the increase of the size of the maritime traffic. However, if the Republic of Croatia wishes to realize the full potential of the port, it will have to commence with the development and restoration of the railway traffic and infrastructure, connecting the port to its gravitational hinterland as soon as possible.

Figure 2. Gravitational zones of the port of Rijeka (www.lukarijeka.hr)

During the twentieth century, the port of Rijeka used to be the tenth largest European seaport with a strong gravitational area of the Austro-Hungarian Monarchy. It was connected by a railway track in both directions to Vienna and Budapest, providing the cities with a direct access to the sea. The accession of Slovenia, Hungary, Czechia, Slovakia and Poland to the European Union in 2004 enabled that the port of Koper have the traditional and most important markets, which stayed beyond the border reach for the port of Rijeka. As Croatia entered the EU, the port of Rijeka gained the same starting position and opportunity for a fair competition against the neighbouring ports, with which it shares the same gravitational hinterland.

The geotraffic position and gravitational area are determined by various criteria, so the next part will analyse some of them, in order to define the gravitational zones of the port of Rijeka.

3.1 The Existing Domestic and International Traffic Flows and Transit

Most of the port traffic of Croatian seaports takes place in the port of Rijeka, which normally generates over 50 per cent of seaport traffic in the entire country.

The traffic capacity of every seaport is different, amounting to 23,100.000 tones annually in total. Together with the capacity of the Adriatic Oil Pipeline in Omišalj, Krk, 20,000.000 tons, the total capacity of the main seaports in the Republic of Croatia exceeds 43,000.000 tons of cargo per annum.

The analysis of the maritime and coastal traffic in the Republic of Croatia and the data obtained from the Croatian Bureau of Statistics on the traffic of goods in seaports shows that the most of the traffic in Croatian seaports is transit and international traffic. Figure 3 illustrates the relationship between the international and domestic traffic and transit in the period 2009-2015. During this time, transit traffic decreased by 32 per cent, the unloading in domestic traffic by 12, while the loading in domestic traffic dropped by 24 per cent. The unloading in international traffic in 2014 suffered the greatest drop, compared to 2009, by 5 per cent, while the growth in 2014-15 reached 13 per cent. In the seven years, the lowest loading was in 2012, and after the increase by 26 per cent in 2014, the following two years in international traffic the loading was in a decline.
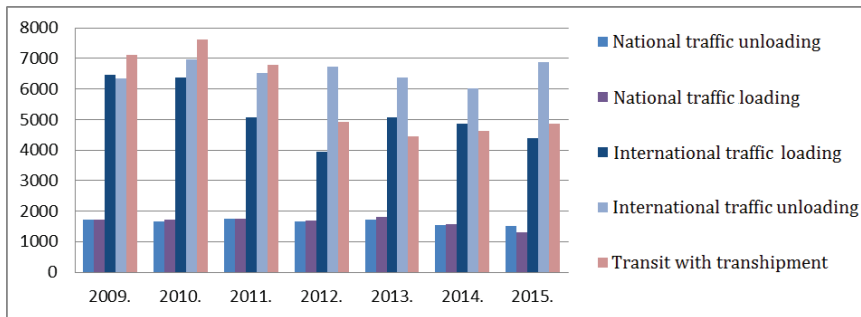
Figure 3. The relationship between the domestic and international traffic of goods in seaports in the Republic of Croatia [10^3 t] (Croatian Bureau of Statistics, 2015)

Figure 4 illustrates the comparisons of container traffic in Croatian seaports in the period 2012-15, comparing the traffic in the port of Rijeka to the total traffic in all other Croatian ports. It is clear that around 86 per cent of the containers in Croatian ports comes through the port of Rijeka. Between 2012-15, there was an increase in traffic by 21 per cent, and in 2014-15 the growth rose to 30. On a state level, the increase was even higher – 33 per cent in 2015 compared to the previous year.
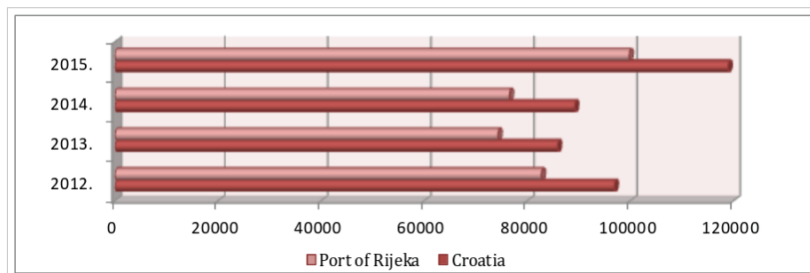
Figure 4. Container traffic comparisons in Croatia and in the port of Rijeka (Croatian Bureau of Statistics, 2015)

3.2 The Development of Traffic Network and Possibility of Connecting to Certain Roadways, the Depth of Aquatorium at Seaports, Connecting to at least two branches of traffic

The Mediterranean corridor of the Central Trans-European Traffic Network TEN-T is of crucial importance for the Republic of Croatia, because it passes through the countries stretching from Gibraltar to Ukraine. It goes from the south of the Iberian peninsula, over Spanish and French Mediterranean coastline, through the Alps on the north of Italy, entering Slovenia and continuing towards the Hungarian-Ukrainian border. This is a roadway and railway corridor, and its integral part is the route Rijeka-Zagreb-Budapest (railway and roadway link, which is here referred to as VB corridor) (www.mppi.hr). The port of Rijeka is the starting point of the Mediterranean corridor, which indicates its special importance for the European traffic network.

The port of Rijeka is the main and largest national port, and that is why it should have enough traffic capacity on the infrastructure available for all the goods arriving by sea to be delivered to their final destinations as quickly as possible, with no interruptions, congestions or bottlenecks. The port is the best case of multi-modal terminal in Croatia. Apart from the maritime transport, it is well-connected to the roadway infrastructure, and there is an airport nearby, as well. The oil pipeline system connects the port to several non-EU and EU states, and the railway transports

about 25 per cent of the goods that arrive in the port of Rijeka, while the rest of it is transported by road.

The traffic connection of the port to other traffic branches and important roadway links include:

- Motorway A6 (Mediterranean corridor) – Rijeka – Zagreb
- Motorway A8/A9 – Rijeka – The Istrian Y
- the Rijeka Bypass
- Railway (Mediterranean corridor). Šapjane – Rijeka – Zagreb – Koprivnica – Botovo
- Railway line M502: Rijeka – Pivka
- Rijeka Airport – Krk: 17 kilometres aerial distance, 25 kilometres road distance
- Oil pipeline system that connects the refineries in Croatia, Hungary, Austria, Bosnia and Herzegovina, Serbia, Czechia and Slovakia
- Connection to the Rhine – Danube corridor of the TEN-T Network and X corridor, passing through the Republic of Croatia
- The Baltic-Adriatic corridor – Venice – Trieste – Kopar – Ljubljana – Budapest: 115 km

The aquatorium depth is also one of the criteria that have impact on determining the gravitational zones of seaport terminals. The Rijeka bay is approximately 60 meters in depth, which is enough for even the greatest ships to dock, which is what made Rijeka an important seaport. However, the development of cargo ships demands greater draught (ship squat), and the port of Rijeka is inadequately equipped to dock newly-constructed ships.

The basin depth in the area of the port authority are listed as follows: (www.portauthority.hr)

- Rijeka / Sušak basin – container terminal, passenger terminal, Ro-Ro terminal, conventional general cargo, grain, conditioned cargo, timber terminal
  o Water depth: 5 – 14 meters (container and Ro-Ro terminal (Brajdica) – 11–12 meters)
- Bakar port basin – bulk cargo, Ro-Ro terminal
  o Water depth: 18 meters
- Port basin Omišalj – oil, oil derivatives terminal
  o Water depth: 30 meters
- Raša port basin (Bršica) – general cargo, livestock, timber terminal
  o Water depth: 8 meters

3.3 Environmental Impact

In her work, Furdić (2015) describes the different ways of negative impacts of ports and ships on environment as a criteria for determining gravitational zones. The harmful gas emissions largely affect the environment of the port. The negative effects on the sea can also be expected due to the water pollution resulting from fuel, oil or other chemical leakage during loading and unloading, illegal release of waste water, perchlorination surface runoff on the parking spaces or due to the thermal pollution of water. Noise is another important ecological issue in ports.

As explained by European Union (2014) the operation of seaports can have a negative impact on the soil, mostly due to oil and chemical leakage. The sedimentation of the polluted sediments is the other potential impact connected to water pollution, resulting from the ship movement, and there is also the possibility of soil erosion. Seaports have significant negative results related to waste.

3.4 The Surface Size Intended for the Port of Rijeka

The port of Rijeka comprises several port terminals that represent separate unities which interact to form a unique port authority area. Within the port there are: bulk terminal, container terminal, Ro-Ro terminal, grain terminal, conventional cargo terminal, multi-purpose terminal Bršica. Every terminal handles a certain type of cargo and holds appropriate transport,

warehouse and transport equipment.

The total surface of the terminals in concession of the port of Rijeka is 1.176.043 m², which includes the closed warehouse spaces and furnished warehouse surfaces. The length of the operational coastline is 5.052 meters and it is intended to be used for docking ships of great and long coastal navigation.

The total surface of the Adriatic Gate Container Terminal (AGCT) is 16.8 ha, with the annual capacity of 250,000 TEU. Škrljevo terminal is a warehouse complex with the surface of 417.413 m², with a free zone status. It is 10 kilometres away from Rijeka, a 3 kilometres from Bakar.

4. CONCLUSION

The gravitational zone of the terminal is the starting point for merchandise traffic flows, which at one stage of their movement pass through the terminal. The zone is determined by the geographical location, domestic and international traffic flows, economic and political factors as well as the number, structure and locations of the users of the service provided by the intermodal terminal.

The port of Rijeka is Croatia's largest port and a starting point of the Mediterranean corridor. Besides the maritime traffic, it is ideally connected to road traffic, and the airport is also nearby. The oil pipeline system connects the port with several states within and outside the EU, and the railway traffic, despite its outdated infrastructure, is on the rise.

Due to its favourable position, the port of Rijeka belongs to the gravitational area of central European countries (Croatia, Hungary, Slovakia, Austria, Slovenia, southern Poland and southern Germany) as well as Eastern countries (Bosnia and Herzegovina, Serbia, Montenegro, Bulgaria, Romania and western Ukraine).

In order for the port to continue operating successfully, it is necessary to ensure its interoperability and accessibility through the absolutely essential development of the railway and road infrastructure, and logistical areas. Every investment in the port makes it more competitive with surrounding ports, which leads to a greater satisfaction among the existing users and attracting new ones, which will ultimately result in an increase of traffic, income and expansion of gravitational zones.

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PERFORMANCE ANALYSIS OF TRANSSHIPMENT PROCESSES IN CROSS DOCK TERMINALS

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Abstract: *A cross dock terminal is a distribution center that receives, sorts and dispatches goods, usually paletised, without storing, or with minimum storage time, in accordance with the needs of various participants in a supply chain. The organization of internal transport during transshipment from inbound to outbound vehicles is a very complex problem. This paper gives a simulation model of transport-transshipment process that enables comparison of different strategies of transshipment and dispatching rules.*

Keywords: *Cross Dock, Dispatching rules, Simulation Model, Performance Indicators, TOPSIS.*

1. INTRODUCTION

A cross dock terminal is a distribution center that receives goods from suppliers and carries out sorting and shipment of these goods. The cross dock system reduces the need for storage of goods and level of stocks. The organization of internal transport during transshipment from inbound to outbound vehicles is a very complex problem. The aim of this paper is to develop a simulation model which enables comparison of different operative work strategies by chosen performance indicators.

The paper comprises of seven parts. The second part describes a cross dock terminal, the basic functions, transshipment strategies and problems to be solved. The operative strategy description is given in the third part. The fourth part describes the simulation model developed in this paper and the fifth part describes the method of valuing simulation models by applying TOPSIS method. The sixth part gives the example on which the developed model was tested and gives the output results. A conclusion is given in the seventh part.

2. CROSS DOCKING

A cross dock terminal is a distribution center in a supply chain that receives, sorts and dispatches goods without storage or with minimum storage time (up to 24 hours), in conformity with the requirements of different participants. The basic goal is to directly transfer goods from inbound vehicles to outbound vehicles, whereby the two most expensive operations in classic distribution centers are eliminated: storing and order picking (Van Belle et al., 2011).

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The functions of a cross dock terminal are: receiving of goods, sorting of goods and dispatch of goods. Reception of goods is carried out in inbound unloading docks. Vehicles with goods wait on the parking lot and are assigned to inbound docks where unloading and reception of goods is carried out. If temporary storing is necessary, the goods are placed on the cross-dock next to inbound or outbound doors or in zones between them. The goods are sorted according to users' locations thereby prepared for dispatch. The shipment vehicles are assigned to outbound doors, the goods are loaded and vehicles effect shipment. Most of the cross dock terminals are rectangular facilities (I, L, T, X, U and E shapes) with several doors. The terminal doors may be intended only for loading or unloading, or a combination.

In contrast to traditional warehousing, the cross dock system enables the following (Van Belle et al., 2011): reduction of costs, consolidation of deliveries, shorter delivery terms, less space necessary for warehousing, less risk of damage during warehousing, better service to users, faster capital turnover, etc.

A large number of studies have been published recently that deal with the problems of cross dock systems on various levels of management: operative, tactic and strategic. The most frequently analyzed problems were (Van Belle et al., 2011; Sheikholeslam and Emamian, 2016): Location of cross-docks, Layout design, Cross-docking networks, Vehicle routing, Dock door assignment, Truck scheduling, Temporary storage, Internal traffic, etc.

3. OPERATIONAL STRATEGIES

Managing a transshipment process in a cross dock terminal may be viewed as making managing decisions on distribution of resources and objects with the objective of meeting transshipment requirements. Transshipment demand is defined by arrival times of vehicles and volume of transport between inbound and outbound dock doors. On the basis of transshipment requirement and available resources (cross-dock facility characteristics, handling devices, space, people), an adequate transshipment strategy is necessary to be applied. There are various strategies of cross dock terminal operation in literature (Van Belle et al., 2011):

- One-touch transshipment strategy means the goods are unloaded from inbound vehicles and directly loaded on outbound vehicles.
- Two-touch transshipment strategy or single-stage storage means the goods are unloaded from vehicle, transported to temporary warehouse, and later loaded on vehicles.
- Multi-touch transshipment strategy or two-stage storage means the goods are temporarily stored at inbound door. There it is sorted, transported to warehouse zone at outbound door, stored and then loaded on vehicles.

There are operation strategies where loading or unloading is possible in order to serve vehicle with priority. Some types of goods always require one-touch transshipment without additional storage and detention. Furthermore, there are strategies when goods are prepared for buyers at the suppliers, which significantly speeds up operation of cross dock terminals. In practice, one cross dock terminal may apply different strategies of operation in conformity with additional requirements of goods, vehicles and users. The management decisions on the choice of operative transshipment strategies directly affect productivity and efficiency of cross dock terminal operation.

Managing transshipment vehicle means defining an assignments of the handling equipment into a set of requests for transshipment by applying corresponding dispatching rules. There are numerous dispatching rules in literature which can be applied in cross dock terminals (Le-Anh and De Koster, 2004). Dispatching rules can be based on single-attributes or multi-attribute rules on the basis which managing decisions are made (travel distance, travel time, waiting time, queue length etc.).

This paper observes a cross dock terminal where centralized dispatching is applied on the basis of current state by applying two dispatching rules:

- Shortest travel distance first (STDF) and
- Modified multi-attribute dispatching rule (Multi-mod)

The STDF rule minimizes empty vehicle travel time. When a handling equipment completes a task, it is assigned the next one, which is closest to its current location. If there is no task, the equipment is returned to the depot.

Multi-mod rule is based on two criteria: length of empty travel and service waiting time. The objective function is (Le-Anh and De Koster, 2004):

$$f_{v_i}(D_{vi}, W_{vi}) = \alpha \times D_{v_i} + \beta \times (W_{vi})^p; \ \alpha + \beta = 1 \qquad (1)$$

where D_{vi} is length of empty travel, W_{vi} is vehicle waiting time v for request i and p is integer value.

4. SIMULATION MODEL

A simulation model of cross dock terminal operation has been developed in this paper for the purpose of analyzing various operation strategies and dispatching rules. The basic idea was to test different strategies for the same scope of transshipment tasks – internal traffic between inbound and outbound doors. In the model, the known data are the type and quantity of inbound and outbound flows, arrival time of vehicles to terminal and distribution of vehicles at inbound and outbound doors. The simulation model has been based on the following assumptions:

- All delivered goods to the terminal must also be shipped from the terminal.
- Terminal parking lot has unlimited number of parking spaces.
- The order of servicing vehicles at one door corresponds to the order of their arrival at terminal.
- The vehicle at the inbound/outbound doors is served by only one handling device at the same time.
- The size and weight of goods do not affect time of loading, unloading, transport or storage.
- Loading/unloading operations cannot be interrupted and vehicle replaced.
- All available handling equipment may be used in realization of any of tasks.

The Model includes:

- Two transshipment strategies – one-touch and two-touch cross dock,
- Two dispatching rules – STDF and Multi-mod,
- Three data sets – different arrival times of vehicles, and
- Availability of needed number of handling devices.

A set of performance indicators which enable analysis of different strategies is obtained for all stated variants. The simulation model was developed in Microsoft Visual Studio 2010, C#, Net Framework 4.0. Model classes and objects were defined in C#CrossDockLib.

5. EVALUATION OF OPERATIONAL STRATEGIES

An evaluation of transshipment strategies is a complex problem which should provide the decision makers an insight into the quality of applied strategies. The choice of the best operational decisions in this paper was made according to the following criteria:

- number of engaged handling devices (b),
- total distance travelled by handling devices (s),
- handling devices usage rate (p),

- order of vehicles waiting for service (r),
- service time of inbound and outbound vehicles (k),
- usage of inbound and outbound doors (v), and
- total service time in terminal (t).

Multi-criteria ranking of operative strategies is done by applying TOPSIS method (Chen, 2000). This method values all alternatives based on their weighted coefficients and distance to positive-ideal and negative-ideal solutions. The best alternative is the one which has the smallest distance to positive-ideal solution and greatest distance to negative-ideal solution (Lai et al., 1994). The aim is to choose a strategy which, at the same time, maximizes use of handling equipment and minimizes all other criteria.

6. EXAMPLE

In this paper, a simulation of a cross dock terminal, I-shaped, 58m in length and 26m wide, with 8 inbound and 8 outbound doors was done (figure 1). Locations for every handling unit were previously determined, in order to provide direct loading from inbound to outbound vehicles. Temporary storage space was organized in front of outbound doors (3 rows, 17 places each). There are 16 forklifts in the terminal. Forklift travel speed, loading and unloading time of cargo are stochastic variables with the normal distribution.
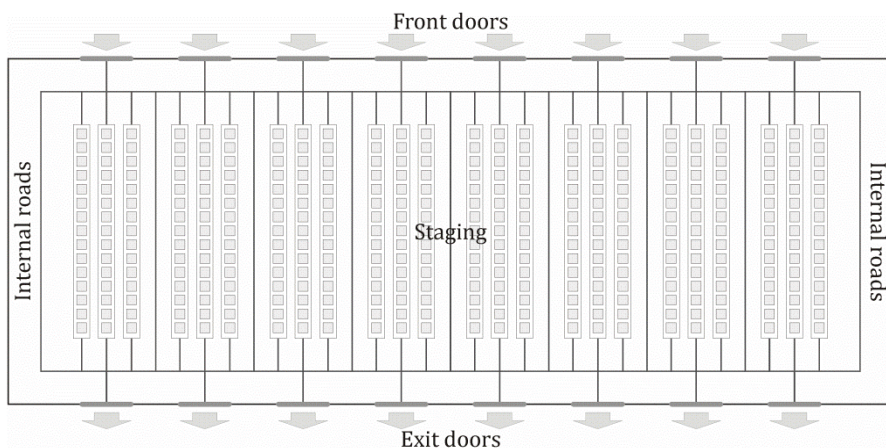
Figure 1. Schematic view cross dock terminal

The simulation covered one working day. Delivery was carried out by 80 vehicles that delivered 28 units of cargo each (total 2240). Shipment was carried out by 84 vehicles. Three sets of inbound data that consist of various vehicle arrival times in the observed period for transshipment strategies were defined as it is shown in figure 2. For each set of data, two transshipment strategies were applied, two dispatching rules (parameters were α=0.8, and p=3) and different number of transshipment vehicles varying from 12 to 16. Table 1 shows the results of simulation for Data Set 1. The results for Data Set 2 and Data Set 3 were obtained in the same way.
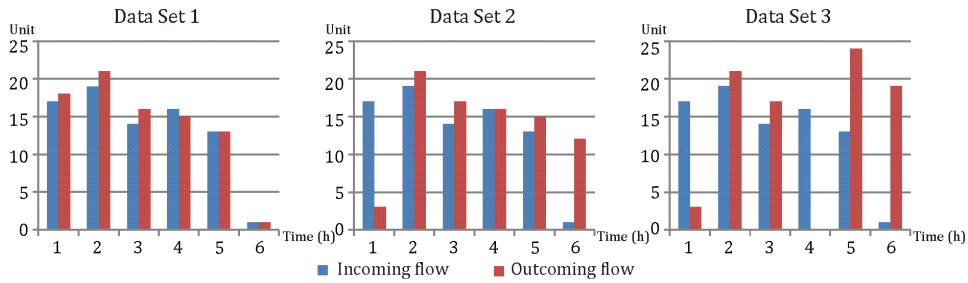
Figure 2. Distribution of vehicle's arrivals

Table 1. Performance Indicators for Data Set 1

OS	Tr (s)	Forklifts			Doors		Vehicles			Cargo (s)
		b	s (m)	p (%)	In (s)	Out (s)	In (s)	Out (s)	Max r	
Pn	19300	12	195038	94.51	117955	139149	135103	153624	7	1997191
Pm	19309	12	194950	94.43	115138	137763	122696	146903	6	2065735
Pn	19315	13	202351	91.26	106863	130158	109973	132206	5	1805085
Pm	19314	13	200090	90.27	107049	129433	109331	131389	5	1837449
Pn	19309	14	206897	86.97	103859	124608	105446	125061	5	1724840
Pm	19331	14	205989	86.9	103920	124947	104945	125224	5	1753870
Pn	19319	15	210730	83.51	101939	121645	102745	121753	5	1696491
Pm	19309	15	210188	83.54	101926	122162	102533	122387	5	1714002
Pn	19321	16	214977	80.8	100883	119851	101531	119962	5	1677676
Pm	19310	16	214096	80.57	100922	120095	101156	120212	5	1691662
Jn	21369	12	185445	99.44	128612	158690	197858	295734	20	3991610
Jm	21848	12	187302	98.63	134245	163616	211758	316355	21	4150858
Jn	20077	13	184490	98.18	110841	150976	150402	239615	15	3312734
Jm	20113	13	185485	98.76	112911	151441	145667	235662	14	3335587
Jn	19300	14	187922	97.14	89839	138387	97950	170743	9	2710569
Jm	19299	14	189031	97.81	92526	141960	101431	175812	8	2695297
Jn	19292	15	201865	95.81	67711	122597	67997	126656	5	1998363
Jm	19291	15	204059	95.95	71283	126444	72035	130751	5	1961214
Jn	19288	16	215058	94.57	61798	116515	61763	118042	5	1807962
Jm	19305	16	217874	94.43	63005	120871	63371	123359	5	1756443
Pn – one-touch cross-docking + STDF					Jn – two-touch cross-docking + STDF					
Pm – one-touch cross-docking + Multi-mod					Jm – two-touch cross-docking + Multi-mod					

Multi-criteria ranking of operative strategies was carried out by applying TOPSIS method. In this example it was assumed that all criteria have the same weighted factors. The ranking results are shown in Table 2.

Table 2. TOPSIS Ranking

Data	The Best Strategy
Data Set 1	One-touch cross-docking + STDF 12 transshipment vehicles
Data Set 2	Two-touch cross-docking + Multi-mod 16 transshipment vehicles
Data Set 3	Two-touch cross-docking + Multi-mod 16 transshipment vehicles

Data Set 1 includes with uniform arrival of vehicles to the terminal. The best strategy for this set is one-touch cross-docking, STDF rule while the process realization requires fleet of 12 handling devices. Data Set 2 and Data Set 3 include non-uniform arrivals of vehicles to terminal. In these cases, 16 handling devices are needed, while the best strategies are two-touch cross-docking and Multi-mod rule.

7. CONCLUSION

The goal of this paper was the development of a simulation model for analyzing performances and comparing operational strategies of managing transshipment processes in a cross dock terminal. The model presents an approximation of the real system, considering predefined set of the performance indicators. The TOPSIS method was used in this paper for ranking different operative strategies.

Improvement and further development of the simulation model may be in following directions:

- evaluating multiple strategies and dispatching rules,
- applying handling equipment of different characteristics,
- respecting additional vehicle requirements, freight units and users,
- limiting the number of parking spaces in terminal,
- possibility of longer storing of goods, etc.

ACKNOWLEDGMENT

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LOGIC

CONSIDERATION OF THE PORT OF BRČKO CONTAINER TERMINAL IN THE CONTEXT LOGISTICS SERVICE IMPROVEMENT

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Abstract: *Port of Brčko for years occupies an important place in the overall transport-logistic system of Bosnia and Herzegovina and the wider region. The economy of Brčko District generates significant demand for all forms of transport, are evident and significant cargo flows that transit the region. Railway line Tuzla-Brčko-Vinkovci connects Tuzla region and Brčko District with railway Corridor X linking the a railway line Tuzla - Doboj is connection to Corridor Vc. The road network of the Brčko District and the region is well developed and connects Bosnia and Herzegovina with neighbouring countries Serbia and Croata. The Sava River connects Bosnia and Herzegovina with the world inland waterways. The aim of this paper is to underline importance sport construction of a container terminal in the Port of Brčko as a part of well-designed policy of development of transport logistics system in Bosnia and Herzegovina.*

Keywords*: port, logistics, container, terminal*

1. INTRODUCTION

All attempts at defining the transport policy in Bosnia and Herzegovina at the end of the twentieth and early twenty-first century are its key principles based the on line logistic freight-transport centres (FTC). For each region in Bosnia and Herzegovina is planned one FTC with designed container terminal. In order to offer a correct score of such an approach to solving transport policy in BiH, arguments it can be argued that in relation to other centres of Brčko has the advantage over the others. The needs for the use of container forms of transport are the most demanded. There should be an integrative factor for railway, road and river transport, which is the face in such a way that each of these forms of transportation offers its share in providing complete transport services. Container transport integrates all types of transport and allows full transport service in the logistics transport chain from sender to receiver on the principle "door to door". The further development and elaboration of the issue construction of container terminals in the Port of Brčko in general does not need to be questioned. It is necessary to locate and dimensioned its capacity but in terms of solving traffic problems in the region and the town of Brčko. The existing traffic solutions, particularly land transport in the town of Brčko, have become a bottleneck braking the further development of the economy. In order to provide a comprehensive solution that will be a service to the economy and citizens, hereinafter will next define the basic parameters of the container terminal in Port of Brčko, to be

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offered and commented on other issues in the field of transport in the region. The construction of container terminal will be a key step on the road towards completion of the intermodal centre in Brčko District.

2. KEY CONTAINER TERMINAL PROJECT ASPECTS ASSESSMENT

It is undeniable that the current handling capabilities of the Brčko District have not been sufficiently exploited and to offer a chance to get through quality planning and investment comes to durable solutions. Complete this matter can be observed and elaborate from several aspects.

2.1. Development aspect

Brčko Port is located on the right bank of the Sava River at 220 km from the confluence of the Sava and Danube rivers, and it is the only international port in Bosnia and Herzegovina. The current port was built in 1913 and rebuilt in the period of 1952-1962, and in 1953 an officially has established the company for river traffic and dock. Commercial waterway stretching on almost 600 km and linking Belgrade and Sisak in Croatia, about 50 km from Zagreb. Navigability of the Sava River is the AGN in the class IV and the Brčko up to Sisak, class III. Generally speaking, waterways class IV and above are considered of international importance. The key technological aspects of the distance from the Danube, 220 km, provided that the availability of the Port of Brčko 266 days a year for barges depth gauge of 180 cm and a load of about 1,000 tons. The main quality of this port is in its three modal resources, customs terminal and almost ideal position in the basin area of heavy industry in BiH. The port is provided with road and rail links, allowing it to connect on the highway Zagreb-Belgrade, and good connections with Corridors X and Vc, which are connected by rail link with the European railway network. The port is owned by the Brčko District of Bosnia and Herzegovina and since year 2004, as a public company. According to the disposition in relation to the inland waterway, it is classified as a port of the open coast. These geographical, technological and administrative parameters create a real basis for long-term and quality development of the Port of Brčko.

2.2. The economic aspect

Brčko District contains a variety of existing production and processing capacities, especially in the field of agriculture and food industry, which represent a significant potential for economic and social development. At the same time, these facilities provide opportunities for the development of the wider region, which gravitates to the District so the entire BiH. In recent years there has been significant growth and expansion of capacities in the area of food production and processing in these companies which requires primarily high-quality logistic support. In addition to the need for supply of existing resources generated by the economy of Brčko District many goods transit the region various modes of transport and the space make a great crossroad of roads. This refers to the logical conclusion that the prospects of economic development of the Brčko District and the wider region should be based on investing in two key activities, such as production and processing of food and transportation. The result of this approach will be primarily an increase in employment in the region, then modernization of transport infrastructure and the improvement of standards and living conditions of the local population. The final scores will be economic development of the region and other economic benefits that investments bring.

2.3. The spatial and location aspect

The method and conditions of use of the area belonging Port of Brčko defined by legislation. Area Port of Brčko is divided into two main territories: (1) Land space (territories) and (2)

Water area (waters) on the right bank of the Sava River. From the point of use of the total territory with the aim of defining of functional, area of the Port of Brčko is divided into sub-areas. Land area is divided into four dedicated areas affected and each is reserved for certain types of goods and manipulation. The water space is divided into three anchors each of which has its uses.

2.4. Traffic connections

Port of Brčko is located in the north-eastern part of Bosnia and Herzegovina, on the right bank of the Sava River waterway (44 52'N, 18 48'E). (221/224 RKM). Over Port of Brčko it is possible to achieve direct commodity flows on the Sava River with the Danube ports of Western and Eastern Europe, as well as to ports on the North and the Black Sea. With the European railway network is connected to the traffic road Tuzla-Vinkovci and Tuzla - Doboj. In the immediate vicinity of Port is the dual carriageway M14.1. Good connections by land roads opens up the possibility for the establishment of transit cargo flows and flows whose destination is in a narrow gravitational field of the Port of Brčko. Distance industrial centres by the different modes of transport are shown in Table 1.

Table 4. Regional connections-distance Brčko of the destinations in the region (Salketić & Ajanović, 2013)

Brčko -	Sisak	Sl. Brod	Beograd	Smederevo	Novi Sad	Vukovar	Osjek	Zenica	Sarajevo
by IWW	358	140	226	281	310	388	457	-	-
by Rail	265	105	213	292	189	86	104	253	337
by Road	240	90	168	239	158	75	99	164	194

In the center of all the possible combinations for plotting potential routes for the development of of intermodal transport in the Western Balkan region and beyond, Brčko is an essential location. Corridors not only the direction and scope of transport flows, but are each other's competition and, more importantly, compete with alternative routes in the country and the region. Transport network of Brčko District has connections on the Pan-European corridors, a connection to Corridor Vc in Bosnia and Herzegovina, and with Corridor X in Croatia Corridor VII across the Sava River. Across the river Sava and the Danube Brčko District connecting the inland waterways around of the world. When it comes to transport flows, the economy of Brčko District generates significant transport and they are by train, road and river traffic is distributed to the desired destination.

3. MARKET ANALYSIS

Due to natural and strategic position of the city of Brčko are prerequisites for its quality development into a regional economic and transport centre.

3.1. The main economic resources

The main industrial potentials are based n food production. The largest users of transport services are the SCO Studen Agrana with 180,000 - 200,000 tons/year of raw sugar to bring the rail from the Port of Ploče and processing factory in Brčko. Processed sugar consumption is shipped in different directions mainly by truck. Then, Bimal oil producer with annual processing of 100,000 to 120,000 tons of oil and produces 50 to 60,000 tons of oil. Certain amounts of crude oil that is used in the production, approximately 10,000 tons of containers coming through the port of Rijeka and rail to Brčko. There are also other food products, among which an important place occupied by about 1,500 tons of coffee that are transported by trucks, as well as the bread-making industry whose production is on the rise. The complete range of these food products is very suitable for container transport. Besides the industrial potential of the region of Brčko as

potential users of transport services a very important role is played by transit transport flows. Railroad Tuzla-Brčko in recent years, in addition to raw materials and products of food industry in significant quantities transported following types of goods: coke, anthracite, coal, soda, salt, wire rod and other steel products, liquor, alumina, coal tar, hydrate, fuel oil, ammonium, sodium, etc. products of the chemical industry. Certain amounts listed goods are always transported on the Sava River and primarily coke, coal, anthracite, and wire and steel products. Using containers and becoming larger transport units most goods from food industry of Brčko economy also can be dispatched by river transport.

3.2. The transport facilities and transport volumes

On the railway network of Bosnia and Herzegovina, the average annual transports about 15 mil.t of goods. These are mostly raw materials and products for the needs of mines, power plants and metal industry.

Table 5. Freight rail transport on the Tuzla- Brčko (www.zfbh.ba)

Year	Plan(t)	Realised(t)	Import(t)	Export (t)	Transit (t)
2012	175.000	296.198	88.052	38.526	169.620
2013	225.000	264.784	59.904	46.482	158.398
2014	265.000	318.881	104849	124.209	89.823
2015	255.000	256.542	67.458	75.584	113.500
2016	270.000	261.000	64.135	78.550	127.315

The share of food and textile industry is around 5% or approximately 750,000 t. On rail line Tuzla-Brčko and generally in the Brčko region mostly dominated by goods from the food industry, which largely cover the 5% of the total railway transport in BiH rail network. Table 2 and Table 3 shows the volume of transport on the railway line Tuzla-Brčko and Brčko railway station in the period 2012-2016. So the structure that is there for over 50% of goods in the field of food industry.

Table 6. Railway station Brčko transport manipulations (www.zfbh.ba)

Year	Loading/railcar	Loading/t	Unloading/railcar	Unloading/t	Handover/t
2012	1148	56.578	37806	185.486	242.064
2013	1115	50.267	4301	206.254	256.512
2014	1266	50.239	3130	150.071	200.310
2015	1376	64.801	3541	167.158	231.959
2016	1411	68.305	3617	169.132	237.437

Given the nature and structure of economic resources in Brčko and dominated by food industry a number of raw materials suppliers are from the region and the neighbouring states of Serbia and Croatian. A certain quantity of goods for processing in factories in the Brčko is mainly delivered by road and truck transport from the Croatian and Serbia because the raw materials from these areas. A significant part in the shipment of finished products of food industry performs regional truck companies from Bosnia and Herzegovina.
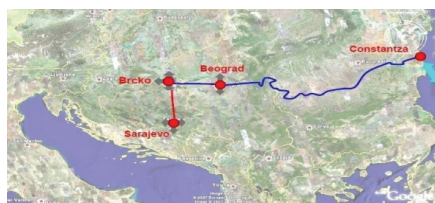

Figure 1. Inland water way: Constanza – Beograd - Brčko (DB International, 2008)

For serving the economy of Brčko District and further inland in Bosnia and Herzegovina can be used overland forms of transport by rail and road. One of likely solution is to use navigational capabilities River Basin (Figure 1). Barges on the Danube, in Constantza to the river Sava and Danube in Belgrade (here mainly offered a series of separation pushed), after which the loads and vice versa Brčko to be carried by Sava River. Belgrade is the main container centre in the Western Balkans region, which is well integrated into the trans-European container flows and could become a place of consolidation for container flows from the East in BiH. Belgrade, as the main centre in South East Europe, could be a great source of goods in railway transport to BiH, because the second container flows could add to the quantity of Constantza.

Table 4. Handling of the goods in te Port of Brčko and railway station (www.lukabrcko.ba)

Godina	Handling in the Port (t)	Handling in rail station(t)	Handling Total(t)
2012	71.272	242.064	313.936
2013	62.242	256.512	318.754
2014	115.994	200.310	316.304
2015	80.104	231.959	312.063
2016	149.187	237.437	386.624

Further transport from the Port of Brčko at the place of destination in BiH and wider in the region can be made by road or rail traffic. Table 4 presents handling goods in the Port of Brčko in the period 2012th-2016th years. In year 2016 has recorder maximum operation of 150,000 tons reloading. According to data from the previous period, reloading in year 1989 reached approximately 300 000 tonnes.

4. ANALYSING THE SPATIAL AND TECHNICAL TRANSPORT VOLUME POSSIBILITIES OF CONTAINER TERMINAL IN THE PORT OF BRČKO

The territory of 14 hectares of Brčko Port is a resource that leaves room for long-term planning, design and creation of new related content. Most of the area consists of the coast with auxiliary and supporting facilities, open and closed warehouse and workshop space. When it comes to local waters, near the operative coast there are three anchorages, formed in accordance with the technological operations and the type of goods can accommodate 12 vessels. Length built operative coast with hair quay is 104 m and 76 m with vertical quay. Along the wharf there are four shunting tracks total length of 2,586 m. With the main train station of Brcko, the port is connected to single-route of the railway. When it comes to reloading mechanization current capacity of two cranes are about 1 million. tons of goods per year and two storage capacity of approximately 60,000 open and around 15.000m² closed area. In addition, there is a quality network of access roads, parking and reloading manipulative space. What is the key fact is that all these capacities may expand and new upgraded.

In the previous period few documents were done dealing with the forecast of the volume of goods flow in Brčko District: Brčko Port, Industrial Zone and Railway station Brčko. Of the listed documents exist three that dealt with deeper analysis and projection is properly prospective need for transport for the period from 2016 to 2030. That are: (1) The study of intermodal transport in Bosnia and Herzegovina, DB International GmbH, 2009, (2) PPIAF Reform of management Brčko Port - Advisory program for public-private infrastructure, Public - Private Infrastructure Advisory Facility, 2009, (3) The project of rail siding Railway station Brčko New - Port of Brčko, Saraj ENGINEERING, 2012. The estimations were made by types of goods and users of services and the calculation has been made by the containerization factor. The obtained parameters were used as relevant for locating and sizing of container terminal in the Port of Brčko. At this point it can be concluded that the planned processes in the field of development of transport in Brčko District place on the line presented forecast but much slower.

Notwithstanding the slower realisatoin of forecasts, issue of the construction of intermodal transport center in Brčcko with container terminal in the port remains only a matter of time.

5. CONCLUSION

The geographic, strategic and geographical location of the city of Brcko, which is located on the Sava River and right next to the border of the three neighboring countries (Bosnia and Herzegovina Croatia and Serbia) make it predestined for connecting and linking regions, economy and population. Transport possibilities offered by existing resources, the Sava River, railways and roads that pass through the Brcko can be developed to unexpected proportions. The economic resources of the Brcko District and the region generates considerable amounts of goods that need to be transported and that with transit flows of goods represent a very serious challenge for the profession and are looking for modern solutions.

This paper listed the current capabilities and capacities of all modes of transport in the Brčko District. An overview of quantity, volume of transport that are realized in the last five years. Given the state of capacity and transported it is obvious that offer much greater opportunities to be well thought out policy of transport. In this sense, it is necessary to use chance offered to improve logistics services. Development of transport capacities in Brčko District should be planned in such a way that the existing forms of transport are each other's help and not competition. The construction of container terminals in the Port of Brcko, for which there are all preconditions, should be an integrative factor for river and land transport and that leads to the realization of the project "Regional intermodal center on the Sava".

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Part IV

QUALITY MANAGEMENT AND PERFORMANCE MEASURES IN LOGISTICS

LOGIC

MULTI-CRITERIA DECISION MAKING APPLICATIONS TO INTEGRATE SUSTAINABILITY INITIATIVE INTO THE THIRD PARTY LOGISTICS PROVIDER SELECTION PROCESS: A LITERATURE REVIEW

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Abstract: *The purpose of this article is to answer following research questions: (1) Are criteria related to environmental sustainability involved in the process of selecting a third party logistics service provider (3PLP)?, Which of these criteria are most commonly used?, Are they well-defined?, (2) What type of multi-criteria decision making methods (MCDM) method best suits the selection of a 3PLP? Which individual MCDM methods are most commonly used and why? What are their strengths and weaknesses? Is any difference evident in the methods used in the case of sustainable 3PLP selection? A literature review was undertaken to first review most useful selection criteria and MCDM methods for selecting a 3PLP. Secondly, the focus was on analyzing the usefulness of MCDM methods for the logistics industry as well as selection criteria and their classification with a focus on environmental selection criteria and thirdly, to critically evaluate the results. A literature review revealed that fuzzy AHP and fuzzy TOPSIS integrated approaches were most frequently applied. Costs were found to be the most frequently used criteria, followed by information technology (IT), accurate delivery time and accurate quality and quantity. Environmental criteria were less frequently used criteria.*

Keywords: selection of third party logistics service provider, 3PLP, multi-criteria decision making techniques, MCDM, selection criteria, sustainability, a literature review

1. INTRODUCTION

The competitiveness of any company largely depends on effective supply chain management. In turn, supply chain management depends on various factors such as top management commitment, use of modern technologies, information sharing with supply chain partners, integration with and trust in supply chain partners, higher flexibility, long term vision, focus on core strengths, the efficient management of the logistics chain and recently, increasingly, on sustainability (Lambert and Cooper 2000, Kumar et al. 2015). All the above-mentioned factors are interdependent, which in turn means that poor management or ignoring of any of these factors makes the supply chain less efficient and consequently decreases the competitiveness of companies and their existence on the market.

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Many studies and publications have focused on all of the above mentioned success factors (Thakkar et al. 2008, Singh 2011, Tejpal et al. 2013, Kumar et al. 2014) including sustainability, which has only recently joined the group of success factors. All these publications relate to all key partners of the supply chain, from suppliers, manufacturers, distributors, retailers to the 3PLP, since the efficiency of the supply chain depends on the integration of all partners of the supply chain (Christopher 2016). The exceptions are studies in the field of sustainability. Studies on sustainable initiatives of 3PLP are rare. Moreover, two significant problems were highlighted during a brief literature review. First, unlike other supply chain partners who 'have already put significant emphasis on sustainability, the progress of 3PLP lags behind' (Bajec and Tuljak-Suban 2016) and second, sustainability issues with 3PLPs are rarely included in the selection process. Given the fact that sustainable awareness significantly affects the company's image, higher profits, marketing exposure etc. (Srivastava 2007) and that the sustainable supply chain depends on the eco-efficiency of all partners of the supply chain (Rao and Holt 2005), the above mentioned problems may affect and may already be affecting the competitiveness of the company's supply chain. Taking action in this area is therefore essential but depends on the willingness and goodwill of not only the company (the buyer of logistics services) but also the 3PLP. It therefore seems logical to integrate environmental requirements into the selection process of a logistics service provider, starting with the identification of proper selection criteria and the selection of an appropriate method or combination of methods with which to select a 3PLP.

This article is the logical continuation of the content of the article published by Bajec et al. (2015), the aim of which was to prepare a framework in order to answer the following questions, one related to selection criteria and the other to selection methodologies:

1. 'Are criteria related to environmental sustainability involved in the process of selecting a 3PLP? Which of them are most commonly used? Are they well-defined? Do they cover the entire area of environmental sustainability? Is there any relevant difference between the frequency of the use of environmental sustainability criteria between continents? Is there any difference between the evaluation criteria by continents?' (Bajec et al. 2015).

2. 'What type of MCDM method best suits the selection of a 3PLP? What individual methods are most commonly used and why? What are their strengths and weaknesses? Is any difference evident in the methods used in the case of sustainable 3PLP selection? Is the choice of methods conditioned by the industry wherein the third part logistics activities?' (Bajec et al. 2015).

The aim of this paper is to present the results which answers the above stated research questions. The rest of the article is organized as follows: firstly, a brief overview of MCDM methods and selection criteria are presented; research methodology is described in section two, followed by results presented in section three and critical analyses presented in section four; the article finishes with the conclusion.

2. MCDM TECHNIQUES AND SELECTION CRITERIA IN GENERAL

Problems containing many criteria (tangible, intangible, qualitative, quantitative, subjective, objective, conflicting etc.) and at least two alternatives are treated as MCDM problems. They could be resolved by using MCDM methods which are useful and appropriate for solving various issues, including problems in the logistics sector. Although the field of MCDM techniques is still relatively young, more than 70 different methods exist (Zardari 2014), divided into various groups according to their similar characteristics. A significantly diverse classification of methods was detected during the review, however, the most commonly used classifications are as follows (Aguezzoul 2011, Schramm and Morais 2013, Zardari et al. 2014): (1) Probabilistic methods, (2) Outranking methods, (3) Statistical approaches, (4) Mathematical programming, (5) Artificial Intelligence, (6) Methods based on costs, (7) Linear weighting models, which were also employed in the review.

MCDM problems always contain several alternatives among which decision maker must choose that which is most appropriate. Which alternative is best depends on the criteria identified by the selector (the buyer of a particular service) and must be satisfied by the alternative (the provider of the service). The criteria are the requirements of the selector such as the ability of the provider, performance cost, quality of performance, flexibility etc. Dozens of criteria were found in the literature arranged into very different groups. However, selection criteria are most frequently classified into following groups: (1) operational capability, (2) service level, (3) costs, (4) provider status, (5) environmental capability.

3. RESEARCH METHODOLOGY

A systematic literature review was conducted in three steps: (1) Planning the review, (2) Implementation of the review, (3) Reporting the results (Bajec and Tuljak-Suban 2016). Planning the review included the determination for a review and settling on a research target. Three facts influenced the review on this topic. Firstly, there are many gaps in the existing knowledge regarding the selection process; secondly, the selection of a 3PLP is one of the key risks of outsourcing and third, a large number of MCDM methods which contributes to even greater chaos in the selection process (Bajec and Tuljak-Suban 2016). The implementation of a review started with the determination of the keywords ('decision making methods' AND 'selection of the third party logistics provider OR 'selection of 3PLP'), continued with the determination of a time-frame (studies published from 1999 to 2015) and search boundaries (journal articles as well as conference proceedings, master's theses, books and book chapters were reviewed) and finished with exclusion criteria (studies not written in English and not related to 3PLP). The collection of articles started with reviews of those journals related to multi-criteria decisions and scientific journals in the field of transport, logistics and the supply chain. After that, Google and Web of Science were manually searched, followed by tracing citations from previously found studies. 108 publications in the field of 3PLP selection process were analyzed and critically evaluated. The results of the literature review are presented in the next paragraph.

4. REPORTING THE RESULTS

4.1 Analysis of MCDM techniques for selecting 3PLP

26 of the most frequently used MCDM methods for 3PLP evaluation and selection were classified into seven groups and were reviewed: (1) Probabilistic methods, (2) Outranking methods, (3) Statistical approaches, (4) Mathematical programming, (5) Artificial Intelligence, (6) Methods based on costs, (7) Linear weighting models. Most frequently used MCDM method for selecting a 3PLP was AHP (applied in 38 studies), followed by TOPSIS (applied in 22 studies), ANP (applied in 16 studies), Linear Programming (applied in 10 studies), VIKOR and DEA (applied in 9 studies) and DELPHI (applied in 7 studies). All the other methods were applied in less than 6 studies.

Two MCDM methods were integrated together in most studies (30 studies), three methods in 22 studies, four methods in 3 studies and five methods in just one study.

Integrated fuzzy MCDM approaches appeared in 38 articles, most frequently in combination with AHP and TOPSIS and less frequently with other MCDM methods. Integrated fuzzy MCDM approaches in combination with Linear Programming appeared in 6 articles, with ANP in 5, with DELPHI in 4 articles, with VIKOR in 3 articles and with ISM, QFD and DEMATEL in 2 articles.

4.2 Analysis of criteria for selecting 3PLP, with an emphasis on environmental criteria

35 frequently used criteria were detected. Costs were still found to be a key factor when selecting a 3PLP, followed by IT application (operation capability group), accurate delivery time and accurate quality and quantity (service level group). Second place was occupied by IT capability which was quite surprising but does confirm the positive influence of various IT tools on the effectiveness of logistics services. All of the above criteria were applied in more than 50 studies (Bajec and Tuljak-Suban 2016).

The above criteria were followed by many sub-criteria in the area of service level and operational capability. They were detected in less than 50 but more than 20 publications. Value added services, employee satisfaction, performance monitoring and all environmental criteria were used in less than 20 cases. Environmental criteria was found in less than 10 articles. The most frequently used environmental criteria were environmental expenditures, return order process, reverse logistics costs, pollutant released, energy consumption, clean materials and energy use.

5. CRITICAL ANALYSIS

5.1 Evaluation of environmental selection criteria

A literature review also revealed that environmental selection criteria are well defined and include various environmental logistics activities. Given the variety of criteria as regards the terminology and importance, a sensitive classification of criteria was necessary (Bajec and Tuljak-Suban 2016). The literature in the field of green and reverse logistics, environmental logistics activities etc. was examined and it was found that most authors divide this field into three main groups, namely reverse logistics processes, waste management and green logistics activities. Environmental selection criteria was divided into two groups: (1) ability to offer green logistics services and (2) ability to offer reverse logistics services. The first group includes pollutant released related sub-criteria, energy consumption related sub-criteria, clean material and energy use related sub-criteria and environmental expenditures related sub-criteria. The second group was divided into waste disposal capabilities related sub-criteria and value-added reverse logistics services capabilities (Bajec and Tuljak-Suban 2016).

5.2 Appropriateness of the most commonly used MCDM methods for the logistics industry

When analyzing the most commonly used methods in the selection of 3PLPs it appeared to be the case that the authors of the studies apply very different methods or combinations of methods without previously verifying whether these methods are indeed the most appropriate for the logistics industry.

The logistics industry is like any other area, unique and having its own characteristics, such as: (1) qualitative and quantitative criteria, (2) subjective criteria, (3) often conflicting criteria, (4) lots of criteria etc. Each of the most frequently used methods was therefore analyzed according to following criteria: the possibility of processing qualitative data, the possibility of processing quantitative data, the ability to eliminate or not eliminate subjectivity, the ease of calculation, which results in fast and simple calculation and availability of software (Table 1). The results of this analyses presented in Table 1 highlight two key issues namely, (1) which method is more appropriate for the characteristics of the logistics industry and which is less useful (2) which methods could be combined together to satisfy all the characteristics of logistics.

Table 1. Strengths and weaknesses of most frequently used MCDM methods

CRITERIA	Outran-king methods		Mathematical programming					Artificial intelligence			Methods based on costs								Linear weighting models		Fuzzy logic
	Promethee	Electre	DEA	MOP	MIP	Linear prog.	DELPHI	ANN	CBR/RBR	EXPERT SYSTEM	ABC	TCO	DEMATEL	VIKOR	QFD	SMART	ISM	ANP	TOPSIS	AHP	Fuzzy logic
Qualitative	×	×					×	×	×	×			×	×	×	×	×	×	×	×	
Quantitative	×	×	×	×	×	×					×	×	×	×	×	×		×	×	×	
Subjective						×		×	×	×				×		×	×	×	×	×	
Objective	×	×	×	×	×	×	×				×	×	×			×					
Ease of use	×												×	×	×			×	×	×	
Availability of software	×	×	×			×	×						×	×	×			×	×	×	

6. CONCLUSION

Logistics plays a very important role in a company's supply chain. 3PLPs, which now increasingly manage an enterprise's logistics chain, are thus entrusted with an important role. The role of the company in selecting a 3PLP is no less important. Knowledge of the selection process of LSPs focused on applying the most suitable method or combination of methods for the logistics industry as well as proper and well-defined selection criteria is therefore essential.

The results of the literature review revealed that the fuzzy integrated approach was the most frequently used, followed by AHP, ANP and TOPSIS (belonging into Linear weighting models group), DEA, VIKOR, DELPHI and DEMATEL. Other methods were rarely used. It was found that not all methods are suitable for the logistics industry and as a result an analysis was done of the

most commonly used methods. At the same time, it was found that fuzzy logic is an effective tool that could solve problems connected with vagueness, but the rules on which it is based must be taken into account consistently and without exception.

As regards the selection criteria, the review of the literature has shown that costs are still a key factor when selecting a LP, closely followed by IT support and various factors related to the quality of service. Criteria connected with environmental protection are located at the bottom of the list. They are, however, quite well-defined and cover the whole area of environmental protection.

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LOGISTICS PERFORMANCE AND TRANSPORT INFRASTRUCTURE

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Abstract: Logistics plays a vital role in the economy of a country, not only by enabling the operations in diverse industrial sectors, but also through the profit actualized. For the implementation of logistics processes, logistics systems utilize a variety of strategies, resources and a wide range of services within and beyond the individual companies, while their performance is measured by different logistics indicators. For the evaluation of logistics at the national level, the World Bank has established a logistics performance index (LPI), targeting six key areas. One of the key areas for the evaluation of logistics at the national level is the transport infrastructure. The objective of this paper is the analysis of quantitative and qualitative indicators of transport infrastructure in order to identify differences between the Republic of Serbia and some better positioned country in the LPI list.

Keywords: logistics, transport infrastructure, logistics performance index.

1. INTRODUCTION

The importance of logistics for the economic system of a country can be observed from several aspects. At the level of individual companies, logistics supports the movement of material goods (and information) intended for production or consumption, thus sustaining the process of their production and sales activities. When the economy of a country develops, the production and consumption grow as well, resulting in the increased volume of goods flow and an increase in the demand for a variety of logistics activities. The globalization of production and trade created the global supply chains that represent the backbone of the international trade and require a fast, reliable and inexpensive flow of goods. In such conditions, the logistics sector has been recognized as one of the key pillars of a country's development, not only through the support of national production and consumption, but also through the income that logistics realizes as an independent sector.

The functioning of a logistics system, which results in the transfer of material goods, is based on the application of diverse logistics strategies and in the use of a wide range of resources and services within and beyond the individual companies. Logistics performance, apart from the potentials of individual companies, largely depends on the macro-logistics potentials of the region where these logistics processes are implemented. Macro-logistics system is composed of (i) shippers, traders, and consignees; (ii) public and private sector logistics service providers;

(iii) provincial and national institutions, policies, and rules; and (iv) transport and communications infrastructure (Banomyong, 2009).

This paper focuses on the analysis of transport infrastructure in the Republic of Serbia, as a component of the macro-logistics system of the country. The analysis includes the basic characteristics of the existing transport network, the infrastructure indicator as the important part of the logistics performance index (LPI), and the comparison with the corresponding values in Austria and the Czech Republic, as countries selected for comparison. The goal is to utilize the comparative analysis to perceive differences and objectives which are to be achieved so that Serbia can approach European standards in this matter.

2. TRANSPORT INFRASTRUCTURE

In the context of economic globalization, the transport infrastructure has become one of the main instruments of economic development of a country and its regions. One of the results of the transport infrastructure development will be an effective transportation and logistics service which allows providing the most efficient and high-quality transport service the region needs (Vakhitova and Gadelshina, 2014). The establishment of a competitive transport system is much more than the construction of transport infrastructure. However, quantitative and qualitative characteristics of transport infrastructure, its compliance with the neighbouring countries, as well as the integration into the regional and European network, present the basis for the establishment of a competitive transport system. The analysis of the development of transport infrastructure in Serbia was carried out by the comparison with two EU countries, Austria and the Czech Republic. These countries were selected for several reasons: they do not have the access to the sea; the extent of their territory and population has similar characteristics to Serbia; according to the level of the economic development, they are significantly ahead of Serbia; and, they can be role models for the development of infrastructure in the country (according to the value of GDP for 2015, Austria is in 29th place, the Czech Republic is in 49th place, and the Republic of Serbia is ranked 91st (World Bank, 2017a)) (Table 1). The analysis includes the transport infrastructure of road, railway and river (and canal) transportation.

Table 1. General data (European Commission, 2016)

Country	Area (1000 km²)	Population (million)	GDP (billion EUR)
Austria	83.9	8.585	329.3
Czech Republic	78.9	10.538	154.7
Republic of Serbia	88.4	7.112	33.3

The length of roads in Austria, the Czech Republic and the Republic of Serbia is provided in Table 2 according to the importance, while Table 3 presents the characteristics of roads in Serbia according to the type of surfacing. The indicators of the density of road transport network specify the following:

- According to the territory, Serbia has 2.9 times less roads than Austria and 3.2 times less than the Czech Republic;
- According to the population number, the length of road network in Serbia is 2.3 times longer than in Austria and 1.9 times longer than in the Czech Republic.

Table 2. Length of the road network (at the end of 2013) (European Commission, 2016)

	Motorways (km)	Main or national roads (km)	Secondary or regional roads (km)	Other roads (km)	Total (km)	Density	
						Km/ 1000km²	Km/ mill popul.
Austria	1,719	9,997	23,640	88,759	124,115	1,479	14,457
Czech Republic	776	6,250	48,736	74,919	130,681	1,656	12,401
Republic of Serbia	603	4,794	10,341	29,271	45,009	509	6,329

Table 3. Roads by the type of surfacing in the Republic of Serbia, 2015. (Statistical Office of the Republic of Serbia, 2017)

Length in km	Total	Modern surfacing					Macadam	Earthen
		All	Out of all, motorways	Asphalt	Concrete	Cubes		
Total	45688	30438	693	30306	75	57	7685	7565

The total length of railway lines and the indicators of the density of railway transport network (Table 4) indicate the following:

- According to the territory, Serbia has 1.4 times less railways than Austria and 2.8 times less than the Czech Republic;
- According to the population number, the length of railway in Serbia is 1.1 times longer than in Austria and 1.7 times longer than in the Czech Republic.

Table 4. Railways and inland waterways (European Commission, 2016)

	Length of railways			Length of inland waterways (km)		
	Railways (km)	Density		Inland waterways (km)	Density	
		Km/ 1000km^2	Km/ mill. popul.		Km/ 1000km^2	Km/ mill popul.
Austria	5058	60	589	351	4	41
Czech Republic	9456	120	897	687	9	65
Republic of Serbia	3809	43	536	1364	15	192

Table 5. Effective length of railways in the Republic of Serbia, 2015. (Statistical Office of the Republic of Serbia, 2017)

	Construction railway length	Real exploitation railway length (km)					
		Total	Single-track	Double-track	Electrified		
					All	Single-track	Double-track
Total	3739	37669	3471	295	1279	984	295

More detailed characteristics of the railways in Serbia are presented in Tables 5 and 6. In Serbia, 34.0% of the lines is electrified; this is approximately the same as in the Czech Republic, in comparison to 69.7% of railways being electrified in Austria. The total of 71% of railways in Serbia have the permissible speed below 60km/h, while only 2.3% have the permissible speed greater than 100 km/h.

Table 6. Length of railway in the Republic of Serbia according to the permissible speed (Statistical Office of the Republic of Serbia, 2017)

	Total (km)	Permissible speed (km/h)												
		Not known	up to 20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91 - 100	101-110	111 - 120	over 120
Construction railway length	3739	535	206	361	567	702	268	147	406	37	423	-	87	-

The length of inland waterways (Table 4) is determined primarily by the natural conditions, so that:

- According to the territory, Serbia has 3.7 times more inland waterways than Austria and 1.7 times more than the Czech Republic;
- According to population number, the length of inland waterways is 4.7 times longer in Serbia than in Austria and 2.9 times longer than in the Czech Republic.

Through the territory of the Republic of Serbia, there is a European Corridor, The Rhine-Danube Corridor, which connecting the central regions around Strasbourg and Frankfurt via Southern Germany to Vienna, Bratislava, Budapest and finally the Black Sea. Part of the Danube flowing

through Serbia plays an important role in the functioning of this corridor. More detailed characteristics of inland waterways in Serbia are provided in Table 7.

Table 7. The length of inland waterways in the Republic of Serbia, 2015* (Statistical Office of the Republic of Serbia, 2017)

	Length of waterways (km) per ship capacity				
	150t	400t	650t	1500t	3000t and more
Danube	588	588	588	588	588
Sava	211	211	211	211	-
Tisa	164	164	164	164	-
Tamiš	41	3	3	3	-
Bega	67	67	35	9	-
Danube-Tisa-Danube Canal	522	505	449	13	-

*Data on the length of inland waterways in the Republic of Serbia presented in Tables 4 and 7 are different, even though they are taken from the official statistical reports.

For the functioning of the river transport, except waterways, important infrastructural complexes are inland ports as well. Inland ports on the Danube are the following: Apatin, Bogojevo, Bačka Palanka, Novi Sad, Belgrade, Pančevo, Smederevo and Prahovo; on the river Sava are Šabac and Sremska Mitrovica, and on the river Tisa there is Senta. In the developed regions, inland ports have developed and transformed from the places of integration of river and road transportation modes, where traditionally the processes of transhipment and storage of goods were performed, into centres that combine all important logistics activities in distribution and transport, i.e. into logistics centres. Unfortunately, this does not apply to the inland ports in Serbia.

Transport infrastructure is only one, yet a very important component of the macro-logistics system of a country, having one of the major roles in the overall development of a society at all levels. Without the developed infrastructure, there are no developed economies. Its construction, modernization and maintenance require large investments; however, it contributes to raising transport and logistics services to a higher level. The presented data demonstrate that in all segments the existing transport infrastructure lags behind the infrastructure in Austria and the Czech Republic.

3. LOGISTICS PERFORMANCE INDEX

The globalization of production and trade created global supply chains that represent the backbone of the international trading and require a fast, reliable and inexpensive flow of goods. In these circumstances, the logistics sector has been recognized as one of the key pillars in the development of a country and more than before, there is a demand to establish logistics standards as a means of insight into the differences between countries. A significant progress in this field has been achieved by the publication by the World Bank: Trade Logistics in the Global Economy – The Logistics Performance Index and Its Indicators. Reports on the value of Logistics Performance Index – LPI are based on data collected from the operators of logistics in the countries in which they operate and it presents a global benchmarking indicator for the comparison of key areas related to the logistics capacity of different countries (Nikoličić at al, 2016). The LPI reports integrate qualitative and quantitative values related to the key logistics areas, which can be helpful in determining the logistics capabilities of different countries.

LPI allows the comparison of countries in six key fields (World Bank, 2017b): (1) the efficiency of customs and border management clearance; (2) the quality of trade and transport infrastructure; (3) the ease of arranging competitively priced shipments; (4) the competence and quality of logistics services; (5) the ability to track and trace consignments; (6) the frequency with which shipments reach consignees within scheduled or expected delivery times.

No single area can fully enable the complete evaluation of the logistics performance. The evaluation is performed in the range from 1 (worst grade) to 5 (the maximum grade).

The position of the Republic of Serbia on the LPI list from 2007 to 2016, as well as the values of individual indicators, is presented in Table 8. In 2016, in comparison to 2014, the Republic of Serbia has dropped 13 places on the list, while the indicator of infrastructure fell from 2.73 down to 2.49. LPI for Austria and the Czech Republic are given in Table 9 and their comparison in the Figure 1.

Table 8. Ranking of the Republic of Serbia according to LPI (World Bank, 2017b)

Year	Total countries	LPI Rank	LPI Score	Customs	Infra-structure	International shipments	Logistics competence	Tracking & tracing	Timeliness
2007	150	115	2.28	2.33	2.18	2.25	2.29	2.07	2.54
2010	155	83	2.69	2.19	2.30	3.41	2.55	2.67	2.80
2012	155	75	2.80	2.39	2.62	2.76	2.80	3.07	3.14
2014	160	63	2.96	2.37	2.73	3.12	3.02	2.94	3.55
2016	160	76	2.76	2.50	2.49	2.63	2.79	2.92	3.23

It can be stated that both Austria and the Czech Republic are significantly better positioned than Serbia, if one observes the following:

- Overall LPI: In relation to the LPI of Serbia, Austrian LPI is better by 48.6% and LPI of the Czech Republic for 33 %;
- Indicator of infrastructure: In relation to Serbia, the infrastructure in Austria is better for 64% and the infrastructure of the Czech Republic by 35%.

Table 9. LPI values for Austria and the Czech Republic in 2016 (World Bank, 2017b)

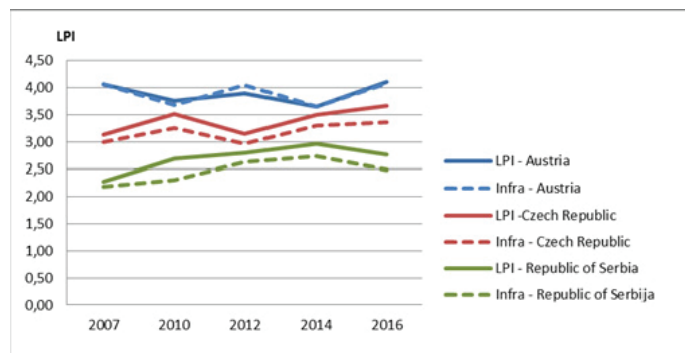|	Total countries	LPI Rank	LPI Score	Customs	Infra-structure	International shipments	Logistics competence	Tracking & tracing	Timeliness
Austria	160	7	4.10	3.79	4.08	3.85	4.18	4.36	4.37
Czech Republic	160	26	3.67	3.58	3.36	3.65	3.65	3.84	3.94

Figure 1. LPI score and componente of infrastructure (based on World Bank, 2017b)

4. CONCLUSION

The improvement of the competitiveness of domestic products and services in domestic and regional markets, as well as the inclusion in the global flows of goods, are the way to the sustainable economic development of Serbia. For the modernization and the development of transport infrastructure as a component in the social development, it is necessary to observe the characteristics of the current state and prospects of the development of the entire transport subsystems in the country, the region and Europe.

Through the limited analysis in the paper, it has been demonstrated that the infrastructure of road and railway transport in Serbia lags significantly behind Austria and the Czech Republic, as the countries selected for comparison. It also demonstrates that the great potential for Serbia is the Danube (and its inland ports). Serbia, despite the geographical advantages, has been erased from the map of the European corridors built next to the Serbian borders with Romania and Bulgaria, which should be the last warning to all the governments. The infrastructure is the potential of Serbia, which can and should be utilized.

The development of national and regional transport and logistics infrastructure has to be faster and with precisely defined priorities in order for Serbia to become closer to European standards. The fact is that the current situation is far from the minimum acceptable and competitive in the open market. Infrastructure development strategies have to include clear objectives, the size of the investment, construction deadlines, funding resources and methods of payment during the exploitation in the international market competition. Several times smaller GDP in comparison to the reference countries cannot be the justification for the neglected infrastructure, or for poor technical performance of newly built or reconstructed infrastructure, since the infrastructure hypothesis, i.e. the basis for economic development is in attracting foreign investment capital and sustainable development.

In addition, it has been observed that there are differences in the data from the official statistical reports by the European Commission (European Commission, 2016) and the Statistical Office of the Republic of Serbia (Statistical Office of the Republic of Serbia, 2017), which in its turn: (1) creates confusion and provides a false idea about data that are significant for ranking in the world, and (2) Sends the wrong message about following the regulatives in the country.

ACKNOWLEDGMENT

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LOGIC

FAILURE MANAGEMENT IN DISTRIBUTION LOGISTICS APPLYING FMEA APPROACH

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Abstract: The negative effects of failures in logistics are recognized in literature and practice. In the last decade, more attention is paid to failure management in logistics systems. Failures in logistics processes have significant negative impact. As a results of failures logistics companies have additional costs, time losses, unsatisfied customers, marketing problems, etc. In this paper Failure mode and effects analysis (FMEA) approach is used for failure recovery in distribution logistics. For each of 36 identified processes severity, occurrence and detection are identified and risk priority number is calculated. In the observed example the most critical processes are transportation, goods control (quantity, quality, expiration date, damage) and goods extraction and putting on pallets. Corrective and preventive measures for failure reducing are also proposed in paper.

Keywords: distribution logistics, failures, FMEA

1. INTRODUCTION

Customer service has been recognized as one of the most important goals of logistics systems. Customer service, in general, can improve customer relationships by three ways: (a) developing new services to be offered to the customer; (b) activating existing services or service element in a business relation c) turning the goods into a service element in the customer relationship (Gronroos, 1988). The importance of logistics service quality is recognized in literature and practice. Failures and customer complaints are one the most frequently used indicators of logistics service quality. Logistics service quality is equally important for logistics service providers and customers. Different methods and approaches are used in the literature for identification of failures in logistics and for measuring logistics service quality in general. Distribution is very important part of logistics. Failures in distribution are the most frequent and cause the customer complaints. Service recovery may be understood as a set of activities that a company performs to resolve complaints and to change the attitude of unsatisfied customers trying to keep them as loyal customers. One of the most important factors is how the complaint is handled. Logistics and distribution are very important in the execution of a business strategy, because directly create value to customers. Failure recovery is very important for customers. Thus, it is very important to plan, follow up and evaluate the failure recovery process (key customer services attribute) throughout the supply chain and not only in the final chain stage when there is a contact with the end consumer (Flores and Primo 2008). The role of logistics providers is very important in supply chain, because of the contact with at least two supply chain members and the making products available to customers. Thus, if customer service management must be seen as a supply chain process, failure recovery, as an integral customer

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service feature, must be seen in the same way (Flores and Primo 2008). The aim of this paper is to proposed new approach for failure recovery in distribution logistics. The next section describes FMEA approach in more details. The third section describes application of FMEA in distribution systems. Concluding remarks are given in the last section.

2. FAILURE MODE AND EFFECTS ANALYSIS (FMEA) APPROACH

FMEA is method, which was developed for the study of failures in different systems and processes. The procedure of this method is based on the failure characteristics and structure of observed systems and processes. For the purpose of the description of this method, is needed to define two basic terms:

Failure – ending the ability to perform the desired function object (the object after failure error, which can be partial or total). Failure is an event, error and condition (Šolc, 2012)

Fault – state of the object is characterized by its inability to perform a required function for reasons other than failure of preventive maintenance or other planned actions, or due to lack of external resources. In terms of product quality – failure is a condition where the product or service not meets customer requirements (Šolc, 2012).

The main objective of FMEA is to analyze potential defects/faults in the observed system and corrective measures that can reduce the risks. There are different benefits of failure detection: increasing the safety of functions and service reliability, reducing warranty and service costs, shortening the development process, better compliance of the planned terms, increasing process efficiency, increasing customer satisfaction, etc. FMEA discover and prioritize failures by computing risk priority number (RPN) which is a product of several risk factors: severity (S), occurrence (O) and detection (D). Severity describes the seriousness (effects) of the failure. Each effect is given a severity number from 1 (no danger) to 10 (critical). In this paper, we use severity ratings proposed in Chin et al. 2009 (Table 1).

Table 1: Traditional ratings for severity of a failure (Chin et al. 2009)

Rating	Effect	Severity of effect
10	Hazardous without warning	Very high severity ranking when a potential failure mode effects safe system operation without warning
9	Hazardous with warning	Very high severity ranking when a potential failure mode affects safe system operation with warning
8	Very high	System inoperable with destructive failure without compromising safety
7	High	System inoperable with equipment damage
6	Moderate	System inoperable with minor damage
5	Low	System inoperable without damage
4	Very low	System operable with significant degradation of performance
3	Minor	System operable with some degradation of performance
2	Very minor	System operable with minimal interference
1	None	No effect

Occurrence describes the probability of failure appearance. Ratings for failure probability proposed in Chin et al. 2009 are used in this paper (Table 2).

Table 2: Traditional ratings for occurrence (probability) of a failure (Chin et al. 2009)

Rating	Probability of occurrence	Failure probability
10	Very high: failure is almost inevitable	>1 in 2
9		1 in 3
8	High: repeated failures	1 in 8
7		1 in 20
6	Moderate: occasional failures	1 in 80
5		1 in 400
4		1 in 2000
3	Low: relatively few failures	1 in 15,000
2		1 in 150,000
1	Remote: failure is unlikely	<1 in 1,500,000

Detection can be defined as the ability to detect the failure before it reaches the customers. The assigned detection number measures the risk that the failure will escape detection. A high detection number indicates that the chances are high that the failure will escape detection, or in other words, that the chances of detection are low (Ambekar et al. 2013). Detection ratings used in this paper are shown in table 3.

Table 3: Traditional ratings for detection (Chin et al. 2009)

Rating	Detection	Likelihood of detection by design control
10	Absolute uncertainty	Design control cannot detect potential cause
9	Very remote	Very remote chance the design control will detect potential cause
8	Remote	Remote chance the design control will detect potential cause
7	Very low	Very low chance the design control will detect potential cause
6	Low	Low chance the design control will detect potential cause
5	Moderate	Moderate chance the design control will detect potential cause
4	Moderately high	Moderately high chance the design control will detect potential cause
3	High	High chance the design control will detect potential cause
2	Very high	Very high chance the design control will detect potential cause
1	Almost certain	Design control will detect potential cause

After these three basic steps, risk priority number (RPN) is calculated. After ranking the severity, occurrence and detectability, the RPN can be easily calculated by multiplying these three numbers: RPN = S × O × D. The failure modes with the highest RPN should have the highest priority for corrective actions.

3. APPLICATION OF FMEA IN DISTRIBUTION SYSTEMS

Distribution process analyzed is this paper is shown on figure 1. The first process is product ordering. The first aspect of product ordering is ordering from suppliers, while the second is customer ordering. All activities in this process relate to information flow. The next process is warehousing. Activities in this process may be divided in two segments. In the first segment, are activities of goods receiving and storage, while the second are activities of order processing and preparing for delivery. Warehousing largely depends on speed of information exchange. Order picking process is the crucial process in warehouses. The following is the process of packaging. Packaging process is realized through merging goods from different segments, forming transport units, goods inspection, as well as the loading goods in vehicles. Packaging is in direct relation with the order processing and distribution (transport). The transport is key processes in the product distribution process (Andrejić et al, 2016). This process largely affects customer satisfaction. The process that is related to all mentioned processes is inventory management. The last process is unloading goods in the retail stores (Andrejić et al, 2015).
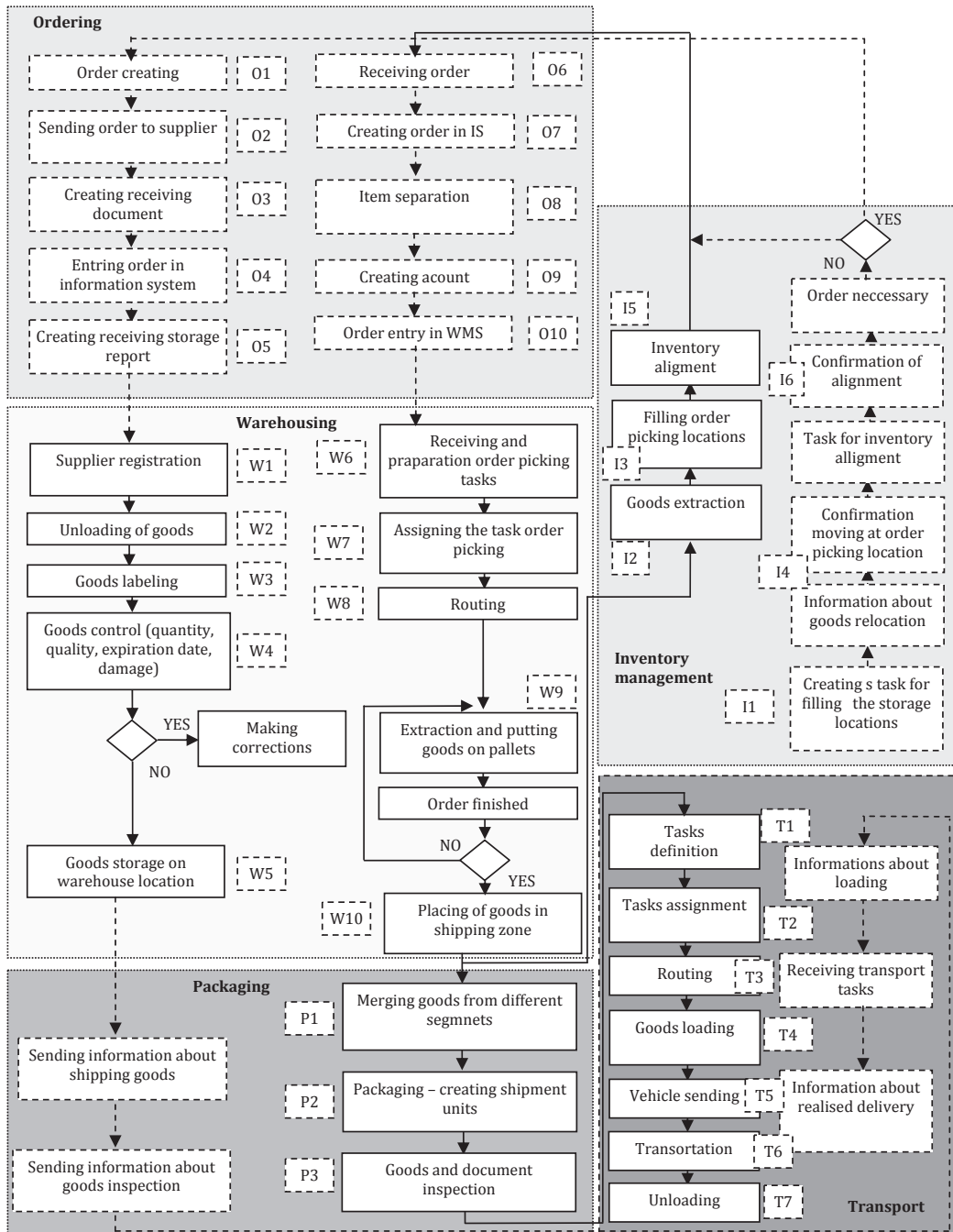
Figure 1. Distribution process decomposition (Adapted from Andrejić et al. 2015)

All activities in each process are marked as shown in figure 1. In observed example ten activities are identified in ordering process (O1-O10), ten in warehousing process (W1-W10), three in packaging process (P1-P3), six in inventory management process (I1-I3) and seven in transport

process (T1-T7). For each activity, necessary parameters are calculated. As a result risk priority numbers are calculated for all 34 activities as shown in table 4.

According results the most critical is transportation process with the largest risk priority number. There are numerous potential risk and failures in transportation process. Transport failures greatly affect delivery process and customer complaints. There are different aspects of transport failures in literature. Delayed shipping is the most important and the most frequent. The potential reasons of this mistake are driver, congestion, wrong route calculation, etc. Damage of goods in transportation process is also important.

The next is goods control with the risk priority number 294. There are problems in the warehousing process when supplier supplies the goods of low quality and short expiration date. One of the basic steps is to define the level of quality and dimensions (specific checklists) of each unit of goods for each supplier. A relative small number of employers in this process limit the level of control. Putting away is very important activity in warehouse. A large number of mistakes are generated in this process. In real systems, order pickers realized this activity. Frequently relocation of order pickers from picking to putting away and control process greatly affects the occurrence of failures and reducing the level of customer service. They realize this process with insufficient attention. Assignment of smaller number of workers that will realize only putting away and control process should reduce failures to minimum. Inappropriate organization of space may affects failures. Managers in warehouse often have the goal of minimizing the space for order picking. One of the main aim is to reduce the effort in the order picking process. However, a large number of similar items at very short distances can cause failures (Andrejić et al. 2015).

Table 4. FMEA parameters calculation

Process	R (Severity)	P (Probability)	N (Detection)	RxPxN (Risk Priority Number)		Process	R (Severity)	P (Probability)	N (Detection)	RxPxN (Risk Priority Number)
O1	6	5	3	90		W10	4	3	3	36
O2	3	3	3	27		P1	8	5	5	200
O3	4	5	4	80		P2	3	4	3	36
O4	6	7	5	210		P3	6	5	5	150
O5	4	5	4	80		P4	2	3	4	24
O6	2	2	3	12		I1	3	4	4	48
O7	6	5	5	150		I2	6	6	5	180
O8	5	6	3	90		I3	4	3	4	48
O9	7	5	4	140		I4	4	4	4	64
O10	4	5	4	80		I5	7	6	5	210
W1	2	2	2	8		I6	4	5	4	80
W2	8	5	4	160		T1	6	5	5	150
W3	5	5	4	100		T2	4	3	4	48
W4	7	6	7	**294**		T3	7	6	5	210
W5	4	5	6	120		T4	7	7	4	196
W6	5	4	4	80		T5	4	3	3	36
W7	3	3	3	27		T6	8	7	7	**392**
W8	8	6	5	240		T7	7	7	4	196
W9	6	6	7	**252**						

The third process with the highest risk priority number is the goods extraction and putting on pallets. This part of order picking process is the most critical which confirms the value of risk priority number. There are different criteria for identification of failures in order – picking process. According place of identification there are internal (in house) and external (outside) failures. External failures in the most cases cause customer complaints. In the literature there are four basic categories of failures: typing failures (addition, confusion, etc.), failures in amount (shortage, excess, etc.), omission failures and condition failures (damage, lack of packaging, labeling). The failure rate depends of type of order picking system: pick-by-voice (0.08%), voucher (0.35%), labels (0.37%), pick-by-light (0.40%), mobile terminals (0.46%), mob. terminals + labels (0.94%). Order picking process is work and labor intensive process. Failures may be reduced if the order pickers strictly follow information system, and do not make decisions alone. Like in the process of order picking process the same situation is in the order processing, packaging and loading. It is very important to assign workers for particular processes. (Andrejić et al. 2013).

3. CONCLUSION

The importance of failure recovery in logistics is recognized in the literature and practice. There are numerous failures in distribution logistics. In this paper FMEA approach is used for failure identification and correction in distribution process. In observed example 36 processes are identified. For each process severity, occurrence and detection are identified, and in that basis risk priority numbers are calculated. According results the most critical processes are: transportation, goods control (quantity, quality, expiration date, damage) and goods extraction and putting on pallets. Proposed measure can reduce failures and improve distribution process. Future research should be dedicated to application FMEA, and other hybrid approaches in different logistics systems.

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EFFICIENCY OF LOGISTICS PROCESSES IN CUSTOMS PROCEDURES

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Abstract: *Nowadays, international trade growth is very high. Customs are very important links in international supply chains. Due to losses in time, the changes in customs operations are necessary for easier crossing the border. Efficient customs operations are prerequisite for faster supply chains. In this paper efficiency of logistics processes in customs procedures is analyzed. PCA-DEA approach with one input (labor) and eight outputs (number of realized customs procedures) are used in this paper. Proposed approach increases discriminatory power and shows its great applicability. Customs houses in Serbia should increase efficiency increasing the number of realized services and optimizing number of customs officers.*

Keywords*: Logistics processes, Efficiency, Customs procedures, PCA-DEA*

1. INTRODUCTION

The evolution and the growth in international trade is very intensive in the last two decades. Many economies recognized that the trade play major role in the economic growth. International trade has made the changes in customs services. International trade involves goods crossing borders in different procedures. The role of customs are: protection of financial interests, protection and improvement of international trade, protection of society, etc. Customs clearance is the most important factor in international trade. Country competitiveness is result of customs service efficiency and effectiveness (Zamora - Torres et al., 2013).

The problem of measuring efficiency in public sector is more complex than efficiency measuring in private sector. The main problem in efficiency measuring in public sector is identification of relevant inputs and outputs (Benazić, 2012). Organizational changes in Serbian customs influenced the efficiency of customs services. The main objective in this paper is to develop approach for measuring efficiency of customs services in Serbia.

The paper is organized as follows. The next section analyzed basic approaches for customs efficiency measurement. The third section described Serbian customs system in more details. The proposed model is used for evaluation of fourteen customs offices in Serbia. The concluding remarks and future research directions are given in the last section.

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2. APPROACHES FOR CUSTOMS EFFICIENCY MEASUREMENT

Regardless of the ownership each organization (public or private) tends to realize activities on efficient way. Evaluating performances in public sector has been investigated in the literature for a long time (Boyle, 2006). In the public sector problem is a lack of direct correlation between revenues and expenses. Also political factors influence public organization to focus on goals achievement, rather than resource optimization.

In the literature there are different approaches for efficiency measurement. The European Commission has established its Measurement of Results (MoR) project for the customs services of member states. Work on measuring the results of customs activities performed by member states is underway and the results achieved enable member states to compare their performance to the Community standard and act to improved customs operations where necessary (Benazić, 2012).

The importance of customs efficiency is also recognized in World Bank Organization. This organization developed LPI (Logistics Performance Index). The main element of LPI is efficiency of customs (Arvis, 2016). In that manner there are different aspects of customs efficiency evaluation:

- Customs efficiency in International LPI (the efficiency of the clearance process (i.e. speed, simplicity and predictability of formalities) by border control agencies, including customs);
- Customs efficiency in Domestic LPI (quality and competence of service of customs agencies, clearance and delivery of imports and exports, transparency of customs clearance, provision of adequate and timely information on regulatory changes, number of agencies for imports and exports, number of forms for imports and exports, etc).

Special emphasis in LPI is on efficiency of customs administration. In that manner this index includes the efficiency of customs procedures perception by the private sector, as well as the extent of services provided by customs authorities and related agencies. The effectiveness and efficiency of clearance processes (time, documents, costs, etc) by customs as well as related, border control agencies is also important element of LPI.

The most of the approaches in the literature are based on DEA (Data Envelopment Analysis) method. However, DEA method have some disadvantages and in some situations could not be applied. In this paper new approach is proposed.

3. SERBIAN CUSTOMS SYSTEM

The Serbian customs system is organized in six division and fifteen customs houses as shown in figure 1. *Division for customs affairs* and international customs operations, among others, performs following activities:

- monitoring and analyzing implementation of customs, foreign trade, foreign exchange and other regulations, that are implemented in goods treatment permitted by the customs;
- control of Custom Houses operations within affairs of conducting customs permitted treatment of goods and customs administrative procedure and provides professional assistance to Custom Houses at these activities;
- participates in preparation of regulations that are implemented in goods treatment permitted by the customs;
- monitors carrying out of signed conventions and agreements, their amendments and implementation, estimation of needs and possibilities for bilateral and multilateral customs agreements conclusion, drafts preparation and adjustment, realization of their adoption procedure in line with national legislations and monitoring of their execution;

- monitoring of EU regulations within the scope of customs, monitoring World Customs Organization and regional initiatives and other activities within the scope of Division's competence, etc.
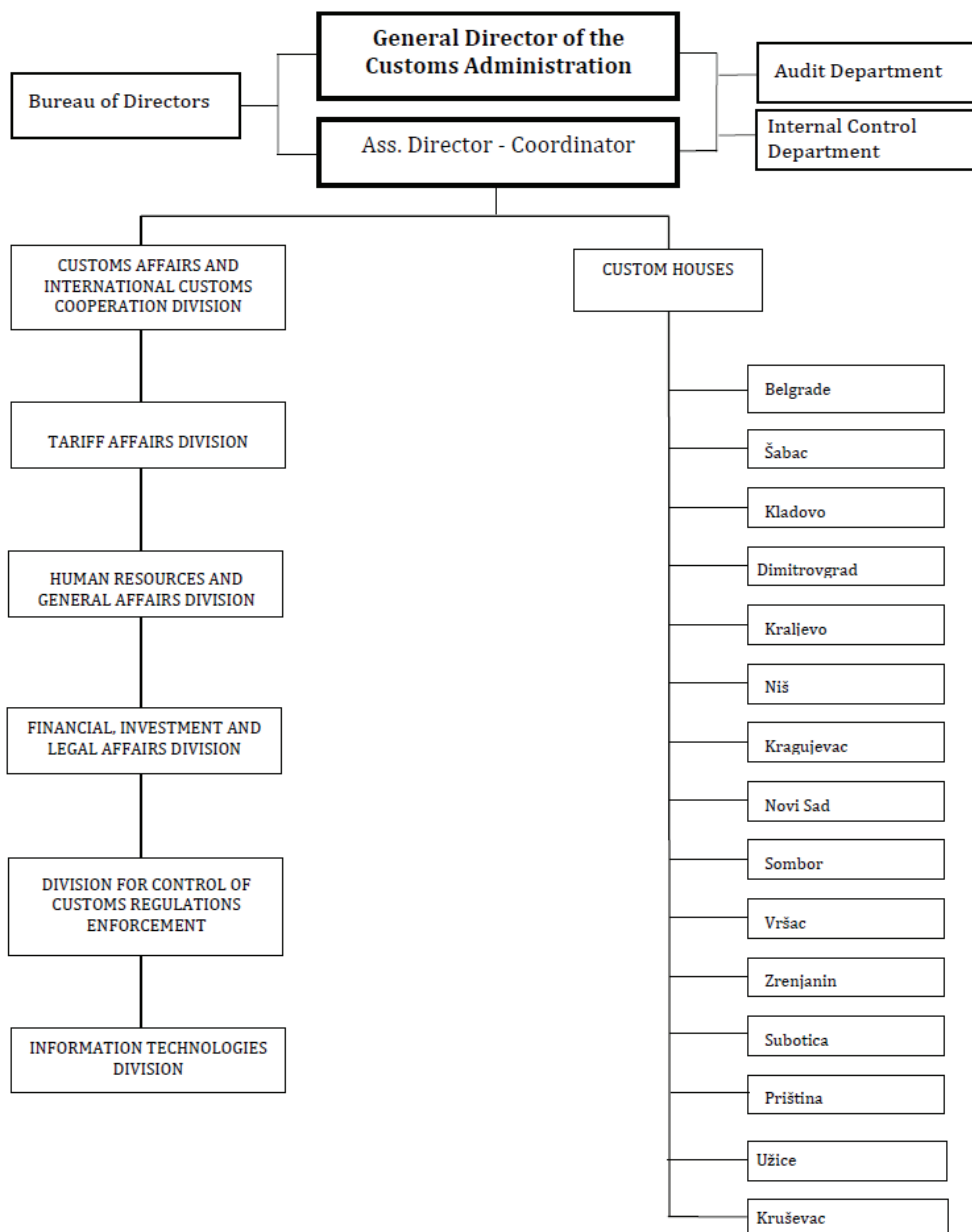

Figure 1. Customs administration organizational structure (source: http://www.upravacarina.rs/en/Pages/Default.aspx)

The basic operations of *division for tariff operations* are: monitoring and analyzing implementation of customs and other regulations within the scope of Customs tariff, customs

value, taxes and excises; monitoring, analyzing and control of Rules of Origin implementation and preferential; monitoring and analyzing of tariff policy instruments; external audit operations; customs laboratory operations; data processing and maintenance operations within Integrated Tariff of Serbia, etc.

As private companies customs administration also has *division for human resources and general affairs*. The main activities of this division are: analyzing and monitoring customs service organization and development, giving opinion on requests justifiability and procurement of conditions for opening new as well as for merging and abolition of existing Customs Administration internal units; implementing regulations within the scope of employment; participating in preparing draft law that regulates scope of Custom Houses' employment and proposals of the Customs Administration general acts which relate to rights, obligations and responsibilities within the scope of employment, salaries and other benefits, vestments and overalls, official designations and IDs of authorized Custom Houses, etc. *Division for financial, investment and legal affairs* performs following activities: preparing draft of the customs service medium-term development and modernization program; setting up annual plans and estimations of funds for regular business, equipment procurement; creating periodical and annual business analysis, etc.

Very important is *division for control of customs regulations enforcement*. This division deals with: suppressing trafficking, customs investigations and intelligence operations; legitimacy control of Customs Administration internal units in customs clearance operations, customs surveillance, temporary import-export, material and financial operations, collection of duties, prevention of illegal entry of weapons, drug, currency and other more severe violations of customs regulations, etc. Nowadays, for successful and efficient operation of customs operation crucial is information system. *Division for information technologies* performs following operations: monitoring development of customs service information and communication technologies; ensures functioning and rational exploitation of customs service information system; taking care on duly and uniform implementation of all regulations that are applied in performing customs service functions, etc.

4. NUMERICAL EXAMPLE

In this paper focus is customs administration efficiency. In accordance with the previous sections we analyzed set of fourteen customs houses and measured their efficiency. For efficiency evaluation one input and eight outputs are used. For customs service the most important resource is labor (table 2). As outputs in this paper, number of successfully realized customs procedures expressed in number of declarations are used. There nine basic customs procedures are identified: export (C1), temporary export (C2), re-export (C3), import - release of goods for free circulation (C4), temporary import (C5), re-import (C6), customs warehousing (C7), processing under customs control (C9).

Table 2: Inputs and outputs for efficiency evaluation (source:
http://www.upravacarina.rs/en/Pages/Default.aspx)

Customs house	Labor (No)	Customs procedures (number of declarations)							
		C1	C2	C3	C4	C5	C6	C7	C9
Belgrade	399	178403	15842	29362	426455	9629	7328	66940	1057
Kladovo	106	7844	249	1854	10249	1274	228	2493	1
Dimitr.	122	2617	15	6459	13620	565	80	3727	4
Kraljevo	110	41878	313	3341	35720	1809	296	5803	47
Niš	191	48038	1594	9916	56115	5840	1339	7446	134
Kragujevac	93	63209	3179	21690	41688	8578	2105	46567	54
Novi Sad	249	79760	2140	11405	106536	6963	974	13640	46
Sombor	69	17182	3103	2043	6508	1828	2937	4339	5
Vršac	82	11045	1651	1127	11367	456	962	667	1
Zrenjanin	65	26590	2112	6535	17729	5535	997	4904	1
Subotica	232	28188	817	21808	81044	5163	637	35800	6
Šabac	158	60765	851	12886	76504	8790	666	7594	28
Kruševac	35	24516	380	3791	20228	3701	78	4349	0
Užice	103	24698	222	8194	25706	2427	242	3214	103

For efficiency measurement we use the PCA–DEA approach. The PCA–DEA model for DMU_a used in this paper has the following form (Adler and Yazhemsky, 2010; Andrejić et al, 2013):

$$\max_{U_{PC},V_{PC}} U_{PC}Y_{PC}^a \tag{1}$$

Subject to:

$$V_{PC}X_{PC}^a = 1 \tag{2}$$

$$V_{PC}X_{PC} - U_{PC}Y_{PC} \geq 0 \tag{3}$$

$$V_{PC}^t L_x \geq 0 \tag{4}$$

$$U_{PC}^t L_y \geq 0 \tag{5}$$

$$V_{PC}, U_{PC}, free \tag{6}$$

The results of the proposed model are shown in the table 3. Proposed PCA-DEA model has the large discriminatory power than the standard CCR DEA model. The average efficiency score in the proposed model is 0,45 with only one efficient customs office, while the average efficiency score according CCR model is 0,66 with fourth efficient customs offices. According results it is easy to see that customs house Belgrade and Kragujevac are the most efficient. The reason is relatively small number of customs officers and large number of realized services. In contrast to mentioned efficient customs offices, there are several customs offices with relatively low efficiency scores. In that manner customs offices Kladovo, Dimitrovgrad, Novi Sad and Užice realized relatively small number if customs procedures with large number of customs officers. According results it is easy to see that inefficient customs offices should improve efficiency reducing resources and increasing number of realized services.

Table 3: Resulting efficiency scores

Customs house	Standard CCR DEA	PCA DEA model
Belgrade	1,00	0,94
Kladovo	0,15	0,09
Dimitr.	0,23	0,11
Kraljevo	0,58	0,26
Niš	0,48	0,31
Kragujevac	1,00	1,00
Novi Sad	0,54	0,29
Sombor	1,00	0,75
Vršac	0,46	0,28
Zrenjanin	0,94	0,58
Subotica	0,53	0,31
Šabac	0,69	0,42
Kruševac	1,00	0,73
Užice	0,56	0,26
Average	0,66	0,45
Number of efficient	4	1

5. CONCLUSION

The importance of measuring efficiency of customs operations is recognized in the literature and in practice. The main problem is identification of representative input and output variables. In this paper proposed approach overcame the lack of existing approaches and increased discriminatory power. The efficiency of fourteen customs offices is evaluated using one input (number of customs officers) and eight outputs (basic customs procedures). The results show the great applicability of proposed approach. In order to increase efficiency inefficient customs office need to increase number of realized customs procedures and to reduce number of customs officers. In the future research it is important to include other indicators of customs operations such as quality indicators, indicators of corruption, time indicators, etc. In that manner it is also important to define new corrective action for efficiency improvement.

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EXPLORING LOGISTICS PERFORMANCE INDEX USING I-DISTANCE STATISTICAL APPROACH

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Abstract: *The paper analysis the structure of the World Bank's Logistics Performance Index -LPI. . Weighting procedure applied to construct LPI is explored using a statistical I-distance technique. Based on LPI data, the importance of each variable is obtained and ranking of countries is performed. The results revealed that index based on I-distance better encapsulates six LPI indicators. Some discrepancies between LPI and I-distance based ranking, appear to be more significant among lower ranking countries.*

Keywords: *logistics performance evaluation, statistical analysis, country rankings.*

1. INTRODUCTION

Logistic performance index (LPI) is a monitoring instrument devised by World Bank in 2007 and has since been updated every two years. It is in fact a cross-country dataset providing information on logistic performance across 160 countries. LPI is developed to help countries in monitoring their logistic performance and define future development strategies that will support economic growth. It covers several key aspects such are perceptions of logistics environment, efficiency of customs, quality of transport and infrastructure, timelines of shipments in reaching destination, domestic logistics costs. The data for LPI are collected using web survey and structuralized questionnaire. Using principal component analysis (PCA), responses in form of scores are aggregated to a single index (Arvis et al., 2010). Results are disseminated through reports and online scoreboard for two types of indices. The first one is international LPI and reflects the state of play in an observed country based on the opinions of its main trade peers. The other is domestic LPI - in which respondents provide information on the logistics environment in the country where they work.

The main benefit of LPI is that it offers a comprehensive, open source cross-country data set that can be further exploited in logistic performance evaluation. For example Gogoneata (2008) used regression analysis and domestic LPI data to analyse the influence of chosen macroeconomic variables on logistics sector in Central and Eastern Europe countries. Dasan (2013) relied on LPI data to determine whether small and medium enterprises that trade internationally have better performance. Coto-Millán et al. (2013) proposed global dynamic aggregate production function to determine the contribution of logistics performance to world economic growth. Their findings were about how much the LPI increase can generate an increase of world economic growth. To determine the importance of logistic performance for EU exports, Puertas Medina et al. (2013) used LPI data and gravity equations.

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Methodological framework of LPI has however, not been much questioned. One example is the work of Jane and Laih (2012) who used LPI to evaluate their own index Rb,d and concluded that Rb,d resolves the problem of integrating reliability into logistics performance, which was emphasized in 2010 LPI report.

In this paper we deal with weighting of indicators that constitute international LPI. The construction of composite indicators (CI) has several steps and each of them entails a proper method which heavily affect the ranking results. As indispensable part of index construction, weighting and aggregation methods have a substantial effect on the outcome of the composite indicator (Saisana and Tarantola, 2002; Freudenberg, 2003; Singh et al., 2009; Hudrliková, 2013). In this paper we examined the I-distance method (Ivanović, 1973; Ivanović and Fanchette, 1973), as an alternative to principal component analyses (PCA) used in LPI. By using a statistical I-distance technique, the importance of each variable (LPI indicator) is obtained and ranking of countries is further appraised.

The paper is organized as follows. In the next section we briefly recall the methodology used to construct international LPI. Section three is about I-distance statistical method and its appliance in the domain of composite indicators. The subsequent section contains results of applying I-distance on LPI data and discussion. The paper ends with concluding remarks.

2. INTERNATIONAL LPI METHODOLOGY

Logistic performance index (LPI) is based on the survey of perception of operators in charge of moving and trading goods on six key performance topics. In 2016, 1,051 logistics professionals participated in the survey for the LPI (WB, 2016). The international LPI is based on qualitative data - respondents' opinions. For each country, collected data (answers) are aggregated into single score (LPI) using PCA. LPI results as well as full data sets are available for 2007, 2010, 2012, 2014 and 2016. World Bank provides various online visualisations tools allowing to explore global LPI rankings and countries' scorecards. It also allows to compare countries performance against: top performer for the observed year; country's region and income group; top performer in region and top performer in income group.

2.1 Indicators and data

LPI includes six indicators categorized as input or output indicators (WB, 2016). The input indicators indicate areas for policy regulation, while the output indicators are about service delivery performance (Table 1).

Table 1. Indicators for international LPI (authors' compilation from WB, 2016)

	Topic	Indicator	Rated from- to	Category
1.	Customs	The efficiency of customs and border management clearance	"very low" (1) to "very high" (5)	input
2.	Infrastructure	The quality of trade and transport infrastructure	"very low" (1) to "very high" (5)	input
3.	Shipments (international)	The ease of arranging competitively priced shipments	"very difficult" (1) to "very easy" (5)	output
4.	Services quality	The competence and quality of logistics services	"very low" (1) to "very high" (5)	input
5.	Tracking and tracing	The ability to track and trace consignments	"very low" (1) to "very high" (5)	output
6.	Timeliness	The frequency with which shipments reach consignees within scheduled/ expected delivery times	"hardly ever" (1) to "nearly always" (5)	output

Indicators for LPI are developed based on systematic research, both empirical and qualitative studies i.e. practical experiences of logistic providers. The responding countries are selected based on the most important export and import markets of the country where the respondent is

located, and, for landlocked countries, on neighbouring countries that connect them with international markets. From 2012 the countries are chosen using Uniform Sampling Randomized (USR) approach in order to include responses from countries with lower trade volumes as much as possible.

Qualitative data are in form of scores since the respondents evaluate six core dimensions on a scale from 1 (worst) to 5 (best) with proper linguistic terms (see Table 1).

2.2. Constructing international LPI - Normalisation, weighting and aggregation

The international LPI is constructed from six indicators (Table 1) on the basis of principal component analysis (PCA). Before being subjected to PCA, scores (answers to questions 10-15) are averaged and normalized using standardization (z-scores) approach.

The results from all PCP rounds (LPI editions) indicate that a single principal component can be taken to encapsulate the data for all six topics (based on Kaiser Criterion and the eigenvalue scree plot). This component accounts for 92 percent (data from 2016 LPI edition) of the variation and represents the international LPI.

The next step is weighting and aggregation using PCA. LPI weights are obtained based on the maximization of the percentage of variation in the LPI's original six indicators that is accounted for by the summary indicator. The component loadings reflect the weight given to each original indicator in constructing the international LPI. Once component loadings are obtained the international LPI is calculated simply – the normalized scores of each of the six indicators is multiplied by their normalized component loading (Table 2) and then summed.

Table 2: Weights (component loadings) for international LPI based on PCA approach (authors' compilation from LPI reports)

	2016	2014	2012
Indicator	*w*	*w*	*w*
Customs	0.41	0.40	0.41
Infrastructure	0.41	0.42	0.41
Shipments (international)	0.41	0.40	0.40
Services quality	0.41	0.42	0.42
Tracking and tracing	0.41	0.41	0.41
Timeliness	0.40	0.40	0.40

It can be noted that the loadings exhibit similar values, thus the international LPI is close to the simple average of the six indicators. Also the weights remain steady across LPI editions (two-year reports) indicating comparability.

It is also of importance to stress that sampling errors are controlled by confidence intervals. That is, a statistically significant improvement in a country's performance is not accounted unless the lower bound of the country's current LPI score (e.g. in 2014) exceeds the upper bound of its previous LPI score (e.g. in 2012).

2.3. Some methodological issues of LPI and the scope of the study

Some notes on LPI results should be considered. For instance, the validity of LPI results in poor countries may fail to capture the performance of national logistic providers that often have special arrangements with government agencies (WB, 2016). Similar validity issue goes for isolated island countries, for which LPI cannot reflect the reforms associated with transit routes.

One more issue is the reliability as the part of LPI. Although emphasized this feature not resolved within the LPI and requires additional performance indicators to address it (as the

index developed by Jane and Laih (2012) that models the real-world logistics systems as stochastic flow networks).

Additional questionable LPI feature is its validity as a ranking tool. As highlighted in LPI methodological note (WB, 2016), due to inevitable sampling errors (that go with this kind of survey samples) the rankings may be elusive for decision makers.

To test the validity of LPI ranks we propose to rely on Composite I-distance Indicator (CIDI) methodology. This approach contributes to more reliable approach in defining weighting scheme and thus obtaining more stable results using the statistically sound framework (Dobrota et al., 2016).

3. I- DISTANCE AND COMPOSITE INDICATORS

Composite I-distance Indicator (CIDI) methodology is recognized as useful for obtaining more stable ranking (see Dobrota et al., 2015), and its roots can be traced down to I-distance method (Ivanovic, 1973). In the process of constructing indexes, I-distance can be used to obtain weights for indicators. To achieve this it is necessary to calculate I-distances and to obtain I-distance rankings accordingly. I-distance is in fact a metric distance in an n-dimensional space. The square I-distance between entities $e_r=(x_{1r}, x_{2r}, ... x_{kr})$ and $e_s=(x_{1r}, x_{2r}, ... x_{ks})$ is calculated as in (1) (Ivanovic & Fanchette, 1973):

$$D^2(r,s) = \sum_{i=1}^{k} \frac{d_i^2(r,s)}{\sigma_i^2} \prod_{j=1}^{i-1} (1 - r_{ji.12...j-1}^2) \tag{1}$$

where $X^T=(X_1, X_2, ... X_n)$ is the selected set of indicators that characterize the entities, $d_i(r,s)$ is the discriminate effect, σ_i is the standard deviation of X_i and $r_{ji,12...j-1}$ is a partial correlation coefficient between Xi and Xj (Jeremic et al., 2011). The Pearson correlations between the I-distance and input indicators values is calculated to test stability of each of the compounding indicators. The weights are computed in a way that values of correlations are divided by the sum of correlations (2):

$$w_i = \frac{r_i}{\sum_{j=1}^{k} r_j} \tag{2}$$

where r_i, *(i=1...k)* is a Pearson correlation between i_{th} input variable and I-distance value. The final sum of weights equals one (Dobrota et al., 2015). After obtaining weights, they are incorporated into LPI indicators framework and aggregated CIDI score is obtained.

4. EXPLORING INTERNATIONAL LPI WITH CIDI

We applied CIDI approach and calculated new country rankings for years 2016, 2014 and 2012. The data for LPI indicators are from *full LPI data set* for last three LPI rounds and are provided online from World Bank.

We can first discuss about the importance of each indicator, based on the Pearson correlation coefficient between I-distance and each indicator (Figure 1). We can conclude that all the indicators show high correlation with I-distance. *Customs* and *Infrastructure* remained stable across the observed years while there were some changes regarding the importance of the rest of the indicators. *Shipments* and *Service quality* switched places in 2014 and 2012. The same goes for *Tracking&Tracing* and *Timeliness* in 2014. Compared to the weights obtained based on

component loadings (Table 2) we can say that unlike LPI approach which employs almost equally weighting scheme, our results show that weights should be more discriminating.
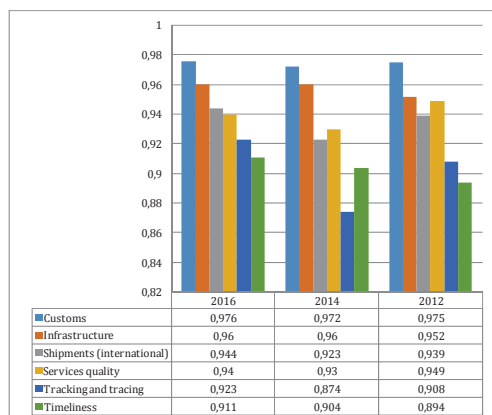

	2016	2014	2012
■Customs	0,976	0,972	0,975
■Infrastructure	0,96	0,96	0,952
■Shipments (international)	0,944	0,923	0,939
■Services quality	0,94	0,93	0,949
■Tracking and tracing	0,923	0,874	0,908
■Timeliness	0,911	0,904	0,894

Figure 1: Correlation between I-distance and international LPI indicators

I-distance based rankings are more accurate. Namely, the international LPI accounts for 92 percent of the variation in the six components (for 2016), while this value for I-distance based LPI is 94 percent (meaning that our solution better encapsulates six LPI indicators).

The rankings obtained by CIDI are very similar to the ones obtained on the basis of LPI. For example the position of Serbia remained stable across all observed years based both on LPI and CIDI results. Figure 2 is a box-plot that represents discrepancies between LPI and I-distance based rankings. Existing discrepancies appear more among lower ranked countries. Venezuela is with the highest sum of difference mostly due to 2012 results.
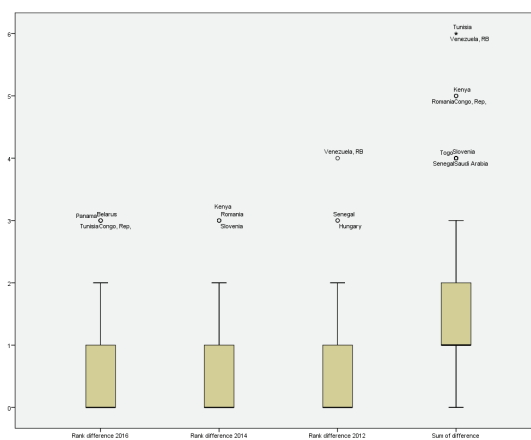
Figure 2: Discrepancies between LPI and I-distance based rankings

6. CONCLUSION

In this paper we explored weighting and aggregation used to construct international LPI. Composite I-distance Indicator (CIDI) methodology was used to obtain new index and compare it with international LPI. The results revealed that there are some discrepancies in ranking for less successful countries. Also it was found that CIDI approach offers better validity of results reflected in higher percentage of variation extracted from six LPI indicators. Accordingly, CIDI methodology can be considered as a viable alternative for international LPI.

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IMPORTANT CHARACTERISTICS OF CARRIER LIABILITY INSURANCE

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Abstract: There are many needs for the insurance in the field of transport and logistics, with special emphasis on the carrier liability insurance. In this paper it has been indicated what exactly the insurance coverage according to the CMR Convention means, and what exclusions are there. The sub-limit of coverage has been defined, along with the method of determining the amount of damages. Some experiences and differences present on the market have been described, as well as some examples of case law related to the loss of the right to limitation of carrier's liability.

Key words: insurance, CMR, carrier liability, coverage, sub-limit of coverage

INTRODUCTION

Carrier liability insurance is one of the most important insurances needed in the field of transport and logistics. The object and purpose of this paper, which was based on the practice of Wiener Städtische insurance company, is to define the most important characteristics and to clarify the coverage in accordance with the CMR Convention. The first chapter lists the types of insurance needed in transportation and logistics. The second chapter explains the insurance coverage according to the CMR Convention, as well as the exclusions. Third chapter describes the use of sub-limit of coverage, while in the fourth some examples and differences present on the market have been listed.

Wiener Städtische Osiguranje a.d.o. Beograd (further WSO) is one of the members of VIG (Vienna Insurance Group), founded in 1824 in Austria. From local insurance company, it has developed to a leading international insurance group, which in Central and Eastern Europe has been operating for more than 25 years and has around 50 companies in 25 countries with nearly 24.000 employees. In Serbia, WSO has been operating since 2003 and today has over 1.000 employees in more than 40 outlets throughout Serbia. It occupies the top position in life insurance, while the total product portfolio is among the leading insurance companies in the domestic market. It offers a wide range of life and non-life insurance services, dedicated to population, retail, small business and the economy.

1. NEEDS FOR INSURANCE IN TRANSPORT AND LOGISTICS

Transport and logistics, as a wide-range field, involve series of activities that carry different risks. Therefore, in certain phases of different logistics chains insurance is needed in order to reduce the harmful effects of these risks. It is necessary to insure the goods and means of transport itself, but also the liability of the carrier. Thus, the types of insurance that are used within the road transport of goods are:

1. Insurance related to the motor vehicles:
   - Motor third party liability insurance,
   - Motor Casco insurance,
   - Road assistance insurance;
2. Insurance related to the goods:
   - Goods in transit insurance;
3. Insurance related to transport and logistics service providers:
   - Carrier liability insurance,
   - Forwarder liability insurance.

Motor third party liability insurance (MTPL) is obligatory insurance for all owners or users of motor vehicles. It refers to liability insurance of vehicle owners for damage caused to third parties and in Serbia it is defined by the Law on Compulsory Insurance in Traffic.

Combined insurance of motor vehicles (Casco) insurance is voluntary and it represents insurance protection from destruction and damage to the vehicle and its components as a result of the realization of certain risks, which may be: traffic accident, fire, lightning, storm, hail, snow avalanches, fall or impact of an object, the sudden thermal or chemical operation from the outside, explosion, fall of an aircraft, events or demonstrations, malicious processes or prank of the third party, damage to the upholstery of the vehicle resulting in the provision of assistance to persons who were injured in a traffic or other accident, intentionally causing damage to insured items in order to prevent greater damage to that or other things or persons, flood, torrent and high water, landslide, dipping, damage caused by animal bites on rubber hoses, cables, upholstery and isolation materials, unauthorized use of a vehicle, vehicle theft and robbery. Road assistance insurances covers costs in case insured vehicle is not drivable or is unsuitable for further safe driving. The user is provided with help within 24 hours every day, in case of realization of some of the following risks: failure, damage, destruction, theft, accident. The insurance is valid throughout Europe.

Goods in transit insurance in domestic and international transport by ship, rail, road, aircraft and postal traffic, remains the only true protection of the owner of goods from losses that may be suffered. During transport from the place of departure to the destination, goods are exposed to various risks that may cause their damage or loss. The insurance coverage should be selected depending on the type of goods, relations, means and conditions of transport and can include the following risks: marine or traffic accidents, natural disasters, fire or explosion, theft and non-delivery, handling risks, other risks.

2. CARRIER LIABILITY INSURANCE - COVERAGE IN ACCORDANCE WITH THE CMR CONVENTION

CMR insurance is a common name for carrier liability insurance for damages in the international road transport of goods, since it refers to the CMR Convention (Convention on the Contract for the International Carriage of Goods by Road). According to the Article 1 of the CMR Convention [1], "This Convention applies to every contract for the carriage of goods by road in vehicles, irrespective of place of residence and nationality of the parties, if the place of acceptance of your shipment and the place provided for the delivery, according to their designation in the contract, are in two different countries, least one of which is a contracting country." The subject of insurance is liability of carrier, as the insured, for damages caused to transport shipments of goods from the moment of take up to the moment of delivery, due to [2]:

- total or partial loss of goods and for damage thereto, which occurred between the time of acceptance of the goods and its release,
- delay in delivery.

It is important to note this definition of coverage, because many insurance companies offer carrier liability insurance, which is called CMR insurance, although its coverage is not in accordance with the CMR Convention, since it includes insurance protection only in the case of realization of some of these three risks: **traffic accident**, **fire** and **theft**. Some insurers do not even cover the risk of theft. According to the Article 17 of the Convention, "carrier shall be relieved of liability if the loss or damage arises from the special risks inherent in one or more of the following:

a) vehicles' use of open and unsheeted, when their use has been expressly agreed and specified in the consignment;

b) missing or defective packing, if the goods, because of its natural properties, in the absence or faulty packaging, are vulnerable to loss or damage;

c) manipulation, loading, stowage or unloading of goods by the consignor or the consignee or person acting on behalf of the sender or recipient;

d) the nature of certain goods, may cause total or partial loss or damage, especially through breakage, rust, decay, dry, leakage, normal wastage, or the action of insects and rodents;

e) insufficiency or inadequacy of marks or numbers on the packages;

f) transport of live animals. "

Experience has shown that the transport of certain types of goods carries with it an increased risk, especially of theft. Therefore, **unless otherwise agreed**, carrier liability and related costs are excluded from the insurance coverage in the following cases: transport of cars, tobacco, cigarettes, alcoholic beverages, tires, damage to goods incurred as a result of failure of the cooling device, the temperature difference, defrost of refrigerated or frozen goods in trucks, oversize transport, transport of museum and art objects, numismatic and philatelic collections, antiques and other things. Carrier liability and related costs in the case of transport of postal items, cash money, securities, precious metals, gems, precious stones, furniture (migration service), live animals and already damaged items, are also excluded from the insurance coverage and **cannot be additionally agreed**.

4. THE SUB-LIMIT OF COVERAGE AND DETERMINATION OF DAMAGE COMPENSATION

Compensation for total or partial loss or damage to the goods shall be calculated according to its value at the time and place of its takeover. Goods owners and carriers often believe that, if the damage occurs, the full invoiced value of the goods will be refunded, but in reality this is not necessarily the case. The reason for this derives from Article 23 of the CMR Convention [3], according to which ''compensation cannot exceed 8,33 SDR (Special Drawing Right) per kilogram of gross weight.'' In this way the **sub-limit of coverage** is defined, which always applies to the calculation of damage compensation. The value of SDR unit is calculated daily by the International Monetary Fund, and it represents the average of the four currencies of the strongest exporters in the last five years, as today are the US dollar, euro, Japanese yen and British pound. Nowadays 8,33 SDR/kg is equivalent to approximately 10 EUR/kg gross weight of the damaged or lost goods. Only in the case of declaration of higher value goods or contracting of special interest for the delivery, the compensation may exceed specified sub-limit, as referred to Articles 24 and 26 of the Convention [4]. Table 1 provides examples that show the way in which the compensation is determined according to the agreed limit of coverage, the market value of the goods in shipment and sub-limits of coverage.

Limit of coverage is indicated in the insurance policy and represents the total maximum obligation of the insurer per each and every loss and aggregate for insurance period, **per vehicle**. What does that mean in practice? Suppose that the coverage limit of 300.000 EUR is contracted, and the damage of 100.000 EUR occurred: until the expiration date of the policy, for

any subsequent damage that may occur, the compensation of maximum 200.000 EUR can be paid. Likewise, all 300.000 EUR could be paid for the first damage occurred, but after the exhaustion of the sum insured, the insurance contract shall terminate.

Table 1. Determining the amount of compensation

	Example 1	Example 2	Example 3
Limit of coverage agreed	50.000 EUR	50.000 EUR	50.000 EUR
Type of goods	raspberries	computers	aluminum windows
Amount (t)	10,00	1,00 (500 pieces)	6,00 (300 pieces)
The market value of goods in the point of consignment	15.000,00 EUR	45.000,00 EUR	70.000,00 EUR
8,33 SDR/kg	10 EUR/kg	10 EUR/kg	10 EUR/kg
Max obligation for the insurer (8,33 SDR/kg)	100.000,00 EUR	10.000,00 EUR	60.000,00 EUR
Compensation	**15.000,00 EUR**	**10.000,00 EUR**	**50.000,00 EUR**

Some insurers apply an aggregate coverage limit, which is the total maximum obligation of the insurer per each and every loss and aggregate for insurance period **for all vehicles**. Example: one insurance policy covers 5 vehicles and limit of coverage contracted is 200.000 EUR; the theft of goods worth 150.000 EUR from one of the vehicles occurs; for this vehicle, as well as for the other 4, for all possible damages or losses that would occur prior to the expiry of the insurance policy, there is still a total of 50.000 EUR.

All of the above relates to the liability of carrier in case of total or partial physical loss or damage to the goods. In case of delay in delivery, the insurer's obligation is the proven actual damage, maximum to the invoiced freight charges and it cannot be paid simultaneously with the compensation for damage or loss of goods.

5. EXPERIENCES AND DIFFERENCES PRESENT ON THE MARKET

Chapter 3 indicated the importance of distinguishing coverages offered by different insurers on the market. Statistical analysis conducted in WSO in 2015 showed that 30% of the damages in road transport do not occur as a consequence of some of the three risks: traffic accident, fire or theft. Damages caused by overturning of pallets in the cargo area due to heavy breaking are very common and are recoverable only if the insurance coverage is completely in accordance with CMR Convention. One of the interesting examples is the damage caused when a driver dropped his cell phone in the cargo hold tanker, which was transporting milk. The total damage was declared, but it would not have been payable if the complete coverage according to the CMR Convention had not been agreed, since it did not occur due to traffic accident, fire nor theft. Another interesting example is the case when a tanker, after carrying raspberries, was not properly cleaned and afterwards it carried milk. Upon the arrival to the place of unloading, it was found that the content was contaminated and total damage was also declared. It should also be noted that definition of traffic accident refers to collision with one or more known vehicles. In case when a car transporter skidded off the road (which was not the result of a collision) and on this occasion 10 new vehicles were damaged, the damage was compensated due to the fact that coverage according to the CMR Convention was agreed. Therefore, it is important for carriers to be well informed about the coverage offered by the insurer.

Different insurers have different ways of treating damage arising as a result of theft. According to WSO Terms and Conditions, carrier loses the right to limit his liability and is obligated to

indemnify the insurer to the full amount of compensation paid to the injured party, if the damage caused by partial theft or theft of the whole vehicle with goods occurs in the following way:

- if the vehicle at the time of theft occurrence was not parked in an organized, arranged and lighted parking lot;
- if the vehicle during transport of the excise goods (tobacco, cigarettes, alcoholic beverages, tires) at the time of theft occurrence was not parked in the parking lot with 24-hour security service;
- if, in the case of theft of the entire vehicle with the goods, insured fails to submit to the insurer for review and verification all the original keys of the vehicle.

Thus, if the carrier has taken all actions in order to reduce the risk of theft to a minimum, but the theft still occurs, the damage will be compensated. However, some insurers in their terms and conditions treat this in the opposite way: if the carrier has taken all measures to prevent or reduce the risk of theft, it is considered there is no carrier's responsibility for the damage occurred, and therefore damage is not payable. This interpretation is unfavorable for the carrier who performs his activities in an honest way.

The carrier loses the right to exclude or limit his liability stemming from Article 23 of the Convention and is obligated to pay damages to the full amount of the invoiced value of the goods, according to the Article 29 "if the damage was caused by his willful misconduct or by such default on his part as, in accordance with the law of the court or tribunal seized of the case, is considered as equivalent to willful misconduct". What causes large differences in court practices of different countries, is the interpretation of Article 29 of the Convention. The primary reason for this are the basis on which courts of law define carrier's behavior as negligence of a certain degree. Due to the very wording of Article 29 which involves national law, it is clear that there are many problems in finding unique and harmonious interpretation of the Convention in a wide range of signatory countries. The key is the difference between terms "willful misconduct" and ''negligence''. From the comparative analysis of the case law in Europe conducted by the author Nikoleta Radionov Radenković in her study "Loss of the right to limitation of liability of the road carrier with reference to court practice" [5], it is clear that there is an agreement for gross negligence to be considered as negligence to such degree that can and should be equated to intention, i.e. willful misconduct. However, courts of law differ in ease of declaring certain carrier's behavior as grossly negligent. German and Austrian courts are leaders in very rigorous trial and impose very high standards of attention to carriers, while the practice of Benelux countries is much more lenient to carriers, who lose their right to exclusion or limitation of their liability in very rare cases.

Equalization of gross negligence with intention led to a large number of judgments in favor of the owner of the goods, whereas carrier lost his right to exclude or limit his liability. Some examples are [5]:

- transport of valuable goods to Poland during which the driver slept in a truck in a lighted parking lot;
- leaving the truck unattended for one hour at a rest stop along the highway in Italy;
- transport of goods on which there is a very high risk of theft through Italy with only one driver, regardless of the fact that this part of the road has no safe resting/parking lots.

In rare cases of theft courts have decided that there is no lack of attention of the carrier, so he reserved the right to limit his liability, and some of these cases are as follows [5]:

- theft during the night in Italy near the very frequent and very lit gas station;
- theft of computer printers in the Netherlands, which were being transported in a fully closed and secured container, while the driver slept in the vehicle;

- theft from vehicle in the customs office parking lot in Sofia (Bulgaria), while the driver slept in a vehicle within which the goods were locked and secured.

Another contentious situation is the case of delayed delivery. The definition of risk in this case is entirely taken from the Article 19 of the CMR Convention [6], which, simply said, means that delay occurres if the carrier fails to deliver the goods within a period which is considered adequate for a particular relation. The damage would be compensated only if the delay is carrier's responsibility, but delays due to congestion at border crossings, acts of government authorities and similar, carrier cannot be held responsible. Below are few examples, vividly explaining the above:

a) The vehicle had a breakdown after loading, for which it was kept in service all day, and this caused a delay in arrival to the place of unloading. Due to a malfunction in the vehicle itself, the damage is payable and the carrier is responsible for it.

b) Three shipments, one of which is subject to phytosanitary control, are being transported from the EU for three different recipients in Serbia. The inspector noted that the documentation for the shipment is incorrect and required to submit appropriate. Responsibility for this failure falls on the consignor, and due to delivery of proper documentation the vehicle was kept at the border crossing for two days, resulting in delivery delay of all three shipments. In this case there is no carrier's responsibility.

c) The shipment is being delivered from Serbia to the country in the EU, whereby scheduled unloading day is Thursday. Upon arrival of the vehicle to the place of unloading, the breakdown of the unloading machinery occurred and caused delay in unloading. For this reason the vehicle arrived too late in the loading dock for the next shipment. The carrier is not responsible for the failure of the reloading machinery that caused the delay, so damage is not payable.

CONCLUSION

The most important element of carrier liability insurance is the width of insurance coverage, because the experience has shown that a large number of claims occur due to other risks, apart from traffic accident, fire and theft. In addition, the sub-limit of coverage is a factor of which many carriers are not aware, although it has great influence on the amount of the damage compensation. It is recommended for carriers to be well introduced to the terms and conditions of the particular insurer and to develop awareness of differences in the interpretation of CMR Convention.

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[2]   CMR Convention, Article 17, points 1 and 2

[3]   CMR Convention, Article 23, point 3

[4]   CMR Convention, Articles 24 and 26

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[6]   CMR Convention, Article 19

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Part V

WAREHOUSING AND INFORMATION TECHNOLOGIES IN LOGISTICS

LOGIC

ELECTRIC VEHICLES AS AN ELECTRICITY STORAGE IN ELECTRICITY SUPPLY CHAIN

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Abstract: *Electricity supply and demand must match all the time. It is not easy to achieve, because of a highly variable nature of electricity demand and a lack of electricity storing capacities. By introducing electricity from renewable energy sources, a variability occurs on the supply side as well. As electricity demand keeps rising and renewable energy sources become more and more in use, achieving an electricity supply-demand balance becomes more difficult. As one of the results, new resources are needed for dealing with that raised variability on both sides. In this paper, we consider the idea of using batteries of electric vehicles (EVs) as a resource for balancing electricity supply and demand. The idea implies charging and discharging of EVs batteries for keeping electricity supply and demand balanced. We observe batteries of EVs engaged in that process, as an electricity storage in electricity supply chain (ESC). In light of this, we explain the proposed idea, concepts of its realization and its feasibility.*

Keywords: *electric vehicles, storage, supply chain, V2G*

1. INTRODUCTION

Electricity supply chain (ESC) has its own specifics, but there are also many similarities between ESC and supply chains of material goods. ESC includes producers of electricity, distributors, transporters, consumers, and others. However, unlike a supply chain of material goods, supply must match demand in ESC all the time. Hence, the supply needs to be constantly adjusted according to the forecasted demand. By introduction of renewable energy sources, it becomes necessary to forecast and plan the electricity production as well. Therefore, ESC management is a challenging and responsible task.

ESC management would be much easier if the electricity could be stored in larger quantities. Nowadays, alternative ways (pumped hydroelectric storage, hydrogen storage, compressed air energy storage, etc.) are mainly used for the purpose of electricity storing. However, capacities of such resources are insufficient to follow the increasing demand for electricity and the growing demand for the integration of electricity from renewable energy sources. Batteries, as the most efficient way for storing electricity, still do not have a significant capacity. However, a rapid development and an increasing use of electric vehicles (EVs) could change the situation. As the number of EVs is growing, a potential electricity storage made of EVs batteries is growing as well. Knowing that cars spend most of the time in the standby mode, it is clear that EVs can also be used for other purposes.

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The idea of using EVs as an electricity storage in the process of electricity supply is not new. As far as authors of this paper know, it is introduced by Kampton and Letendre (1997). They propose using EVs for storing surpluses of electricity in their batteries, and for driving electricity from their batteries when it is necessary. EVs can achieve the role of storage also by allowing only storing electricity. EVs, as an electricity storage, can be integrated in different parts of ESC (at the producers, distributors and/or at electricity consumers).

The idea of using EVs as a storage of electricity in ESC implies also benefits for owners of EVs. They would acquire certain benefits by making available their EVs for this purpose. In that way, the price of EVs would be reduced, and their number would be increased. The realization of this idea could be particularly important for a greater integration of electricity from renewable energy sources. Using EVs as an electricity storage could help mitigate the problem of the variability of electricity from renewable energy sources. On the other hand, to have EVs as the clean form of transport, EVs need to be supplied by a clean electricity. Hence, the realization of the idea of EVs as a storage of electricity in ESC would connect these two environmentally friendly solutions and enable their growth. Thereby, the whole society could benefit from the realization of this idea.

Because of all these potential benefits, EVs as an electricity storage in ESC is the subject of this paper. The aim of the paper is to describe the place and role of such storage in ESC, and to present the ways of realization of its storing function. The accent is on the realization of storage function of EVs through the Vehicle to Grid (V2G) concept. In accordance with the set aim, the paper is organized as follows. The next chapter discusses ESC management. The third chapter describes concepts that enable realization of the storage function of EVs within ESC. The fourth chapter talks about feasibility of the use of EVs as electricity storage through the V2G concept. The last chapter gives concluding remarks.

2. ESC MANAGEMENT

ESC management, among the other things, has to ensure the electricity supply-demand balance. Generally, ESC management in an electric system is started by producers (suppliers) of electricity, continued by electric distribution companies (EDCs), and ended by the system operator (SO). Producers and suppliers are those which deliver electricity to EDCs. EDCs distribute electricity to consumers. SO monitors the production-consumption imbalance all the time and carries out actions to keep that imbalance within the prescribed limits.

Usually, EDC first purchases an electricity that should meet the forecasted minimal demand (base load). The base load power is purchased much earlier than it is distributed, and in a larger amount. It is purchased in accordance with the forecasted minimal demand of EDC clients. Another type of electricity, which EDC purchases, is the peak power. EDC purchases the peak power in accordance with the forecasted demand, made one day before. The peak power is an additional electricity which covers peaks in demand during the day. If the forecast suggests that demand will be lower than the base load, EDC sales a surplus one day before. A final adjustment in the amount of electricity that is supplied, EDC does according to the forecasted demand an hour before. In this case, an hour before, EDC sales the surplus or buys the additional amount of electricity for the next hour.

ESC management ends with actions of SO aimed at maintaining the electricity supply-demand balance. The most important services of SO are load following, regulation and spinning reserve. Load following is the service of adjusting the supply according to the forecasted demand every 5 to 15 minutes. It implies reducing the difference between the electricity power scheduled for supply an hour before and the forecasted demand in the next interval of 5 to 15 minutes length. Regulation is carried out after the load following action, with the aim of aligning supply and demand in a short interval. It is carried out by calculating the area control error (ACE) every 2 to 4 seconds (Guille and Gross, 2009). Based on ACE, the output power of certain generators is

automatically adjusted (reduced or increased) every 2 to 4 seconds. With the regulation action, the final adjustment of supply according to demand is performed.

SO is also responsible for repairing electricity supply-demand imbalances which are the result of an unexpected interruption in the electricity supply. These interruptions occur as the consequence of breakdowns in the infrastructure for electricity supply. SO repairs this type of imbalance, by using various reserves. Among the most important is the spinning reserve. Spinning reserve is an unexploited capacity of generators which are scheduled for the electricity supply in the electric system. These generators differ from other generators because they can quickly increase or decrease their production.

All three mentioned actions require reserving a certain capacity at generators that supply electricity within the electric system. These generators must meet the requirements about the speed at which they change their output power (the ramping rate). Load following and regulation require reservation of the capacity for the power increase and reservation of the capacity for the power reduction. Spinning reserve requires only a capacity for the power reduction. Using the electricity storage made of EVs for providing these actions, could be the most useful function of this storage. Instead of keeping an unused capacity at scheduled generators, an extra amount of electricity can be taken from EVs batteries. Also, instead of reducing the power of generators, the excess amount of electricity can be stored in EVs batteries.

3. CONCEPTS OF THE USE OF EVs AS AN ELECTRICITY STORAGE IN ESC

The use of EVs as an electricity storage in ESC can be achieved through several concepts. Some of the best known are Vehicle To Home (V2H), Vehicle To Building (V2B), Grid To Vehicle (G2V), and Vehicle to Grid (V2G).

V2H involves the use of EVs as a storage of electricity at the end of ESC. Every single EV, as a small storage of electricity, is managed by its owner. Based on this managing, when EV is at home, EV is used for supplying household appliances. The EV owner has the opportunity to store electricity in EV battery when electricity is cheap and use it when electricity is expensive. Also, the owner of EV can use electricity from EV battery when there is an interruption in the electricity supply. According to Weiller and Neely (2014), a 24 kW EV battery can provide an individual household with electricity for 2 hours. A special benefit through this concept can achieve the EV owners who own solar panels or wind turbines. Thanks to the electricity storage in the form of EV battery, they can store the excess electricity from their power plants and use it when the production of these power plants is insufficient. Among the first companies who started a V2H business are Mitsubishi with MiEV Power Box and Nissan with the Leaf-2-Home Energy Station (Weiller and Neely, 2014). In parallel, these two companies offered their products on the Japanese market in 2012. The maximum power supply that MiEV Power Box can provide for a home is 1.5 kW. Leaf-2-Home Energy Station can provide the power of 6 kW.

Like in case of V2H, in the V2B concept EVs batteries are used as a storage at the end of ESC. However, unlike V2H, the V2B concept implies using multiple EVs for storing electricity by a client of EDC. Hence, management of charging and discharging EVs batteries is more complex. EVs that participate in this concept can be owned by the owner of building or privately owned. In the first case, it is about buildings of companies that have fleets with EVs. In the second case, it is about buildings where people come with their private cars (office buildings, shopping centers, schools, etc.). As far as authors of this paper know, this concept has not yet been used for a commercial purpose. Though, Nissan successfully tested the V2B concept in 2013. In this experiment, six Nissan Leaf cars supplied the Office of the Nissan Advanced Technology Center in Atsugi City, Japan (Nissan Motor Corporation, 2013).

The G2V concept involves using EVs, only for storing electricity in their batteries. However, load following, regulation and spinning reserve services may be provided through this concept. It is achieved by reducing the electricity for charging EVs, which is equal to sending a new electricity into the grid. Also, the G2V concept enables participating in the valley filling process (the process of increasing demand). The G2V concept has the advantage over the other because it does not cause an excessive degradation of the EV battery. Also, it requires no special upgrade of the current electric system. On the other hand, because of the one-way flow, the G2V concept does not enable the utilization of all potentials of EVs as a storage resource in ESC.

The V2G concept allows for the greatest utilization of EVs as a storage of electricity in ESC. According to this concept, EVs as storage of electricity can be used for storing and supplying electricity. This storage is integrated into the middle of EDC. Kempton et al. (2001) first introduced the term V2G in 2001, to the best knowledge of this paper authors. They defined V2G as "using the electric storage and/or generation capacity of battery, hybrid and fuel cell vehicles to send power to the grid."

There are two dominant proposals for the implementation of the V2G concept. The first one implies that a new entity (aggregator) executes aggregation of EVs. Aggregator would manage the storage of aggregated batteries of EVs and sell storage services on the market. In practice, managing this storage would be carried out through aggregator's managing of charging and discharging of each EV battery in accordance with the contract made with each EV owner. The owners of EVs would receive compensations for making available EVs to the aggregator. Under the second proposal, each EV owner would participate separately in the electricity storage market. EV owner would negotiate the provision of storage services directly with some of the existing entities (EDCs, SO, producers, etc.). The first proposal with the aggregator seems to be a more realistic option. It is hard to expect that one of the existing subjects would connect and manage with each of EVs. However, the application of the second proposal would bring higher revenues to EVs owners.

4. FEASIBILITY OF THE USE OF EVs AS AN ELECTRICITY STORAGE THROUGH THE V2G CONCEPT

By introducing the V2G concept, Kempton et al. (2001) pointed out that it is feasible to use EVs for providing peak power, regulation, and spinning reserve services. Regulation and spinning reserve are feasible to provide with EVs because they are paid per a delivered energy and per a capacity placed at SO disposal. Supply of the peak power in some situations may be feasible, but not in the others. Other authors evaluate the feasibility of the V2G concept as well. Richardson (2013) reviewed several papers that assess the profit of providing services for supporting the supply of electricity through the V2G concept. He points out that estimates of the profit range from the negative 300 $ to the positive 4,600 $/vehicle/year and more. The most common range is 100-300 $/vehicle/year.

There are also totally negative opinions about the feasibility of the V2G concept. One of them is the opinion of Tesla Motors' first man for car batteries. He argues that this concept is unfeasible because of the cost of battery degradation and connection costs (Shahan, 2016). Costs of degradation and cost of infrastructure are also reasons of many other negative opinions. Because of that, it is interesting to consider results of Wang et al. (2016). They examine how much degradation of EV battery occurs by providing various services for supporting electricity supply through the V2G concept. Simulation results indicate that if EVs are used for the regulation/peak shaving each day in the period from 7 p.m. to 9 p.m. during ten years, then the loss of battery capacity is increased by 3.62% and 5.6%, respectively.

In case of using EVs for the load following during the distribution of electricity from renewable energy sources, the loss of capacity is increased by 22% in the period of ten years. In this case, EVs are used for providing the load following during all day. Although the results of Wang et al.

(2016) are encouraging, the feasibility of V2G concept may come into question because of another reason. According to Sortomme and El-Sharkawi (2012), if batteries are improved and the number of EVs is increased, then prices of services (regulation, load following, etc.) could be quickly reduced by increasing the number of EVs participating in V2G. In that way, the use of EVs for providing these services may become unfeasible as well as the V2G concept. If it comes to that, it may also happen that investments in equipment and infrastructure for V2G do not pay off.

Therefore, a general assessment of the feasibility of the V2G concept does not exist. The results about the V2G feasibility depend on the way of calculation and set assumptions. Though, on a practical level, the first steps towards the realization of V2G concept are made. They are still in the form of pilot projects. Some of the most famous V2G projects are V2G project of University of Delaware, V2G project of US Department of Defence, V2G project of carmakers and Electric Power Research Institute, and V2G project of Nissan and Enel. The V2G project of Nissan and Enel is particularly interesting. It implies installation of 100 V2G points in the UK (Campbell, 2016). However, equipment costs (primarily the costs of bidirectional chargers) and connection costs (costs of infrastructure) are still significant obstacles for a bigger practical implementation of this idea.

5. CONCLUSION

Using EVs, as a storage of electricity in ESC could bring many benefits. Existing electricity producers would reduce the provision of services for supporting the supply of electricity, such as load following and regulation. That will help them operate at the full capacity longer, and ensure new quantities of electricity for the supply, without building new power plants. The costs of wear, at these power plants, would also be reduced. Providing services for supporting the supply of electricity cause wearing of power plants, because of permanent change of the output power of generators. The pollution, which also occurs because of changes in the output power of generators, would be also reduced.

Using EVs for supporting the integration of electricity from renewable sources has a particular importance. Hence, authors of this paper will examine the idea of using EVs as a resource for providing the load following service during distribution of the electricity from PV panels. As far as authors of this paper know, this idea is poorly considered in the literature. Kempton and Tomic (2005) mention load following as the activity where EVs could be engaged. However, they state that although it might be feasibly to use EVs for this purpose, they do not considered that option. On the other hand, Wang et al. (2016) have already calculated the cost of EV batteries degradation caused by the use of EVs for load following during distribution of electricity from renewable energy sources. Thus, authors of this paper will attempt to calculate the benefits that can be achieved with the use of EVs for load following during the distribution of electricity from PV panels.

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POSSIBILITY OF CASE UNITS ORDER PICKING AUTOMATION - PRESENT TRENDS

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Abstract: *Trend of requirements continual increase related to the level of warehouse performances, as well as achieved technology level, have led to use increase of automated solutions in this field of logistic systems. At this moment, in the warehouses, great set of different automated technologies/solutions has been implemented, from automation of certain operations/processes to complete automated processes. Order picking, as specially complex, demanding and significant warehouse process, presents particularly and interesting field related to automation due to direct influence on warehouse performances, and therefore supply chain performances. Therefore, this paper aims to give preview of present trends in this field, where the primary is limited to case-units picking automation. Also, the paper considers possibilities of appliance of particular automated solutions through analyzes of relevant parameters / input values necessary for decision-making/ choice of particular case-picking technological solutions.*

Keywords: warehouse, order-picking, case-units, automation

1. INTRODUCTION

Present market conditions, reflected in the steadily increasing range and reducing the size of the batch of products forced the research, development and application of new solutions in production. Also present are the increasing requirements in the sphere of realization of logistics processes, which are characterized by an increasing level of service. This is characterized by a tendency for faster delivery, lower level of error and others, with simultaneous requirements on reducing logistics costs. In such conditions warehouse systems, as certain elements of the supply chain, are also met with increasingly complex tasks and requirements. These requirements are reflected in the reduction of response time for the ordered items (increase of working speed), error reduction in the formation of delivery units and damage, but also in the increase of the accuracy level, energy efficiency, humanization, labor safety, etc. [1], [2], [4] Comprehensive surveys on warehouse and industrial warehouse system topics have been proposed by De Koster et al. [2], Gu et al. [4] and Dallari et al. [1].

The introduction of automation in warehouse systems is one of the reactions on the presence of such requirements. It is for a longer period encountered in the field of the use of different variants of AS/RS, AGV, etc., but also in considerable automation related to IT [7]. The results of these automation solutions had significant effects on some warehouse processes. It is noted that applied solutions or order picking (OP) technologies have primary influence on the performance

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of the warehouse system at the warehouses in which order picking is the dominant task. OP is one of the prime components of labor and warehouse-associated costs.

The researches have shown that manual technology is dominant in this area even today [2], [8]. Since case-picking (CP), as one task class of OP is still very present in warehouses [10], the automation of these processes has increased significance. From that reason, the presentation of results of these researches and present trends in area of CP technology are the aim of this paper, and the authors intended to make the evaluation of given technologies and their convenience for usage in some OP task classes.

Having that in mind, the paper has several chapters. After the introduction, the second chapter gives definition of OP, but also (a) review of classification of technologies present in OP of unit loads: with (b) special accent on typical automation solutions. The third chapter is dedicated to the relevant parameters which allow comparison of given alternative automated CP conceptions. The fourth chapter gives recommendations to logistic experts, who deal with the development of warehouses systems, on what they should have in mind when developing and deciding on choosing the solution of automated CP. The final, fifth chapter, gives comment on some other aspects of present trends, also tendencies of automated solutions for OP of broken case units.

2. BRIEF DEFINITION AND CLASSIFICATION OF THE ORDER - PICKING TECHNOLOGIES

OP is the collection and consolidation of required quantities from an assortment of articles due to given orders. [5]. VDI 3590 have defined as a process to assemble, and to organize within a specific time, based on customer orders, placing the stock directly in order-lines, releasing the order downstream and providing a picking process at the right place at the right time. In other words, OP can be defined as order fulfillment, from withdrawing items from storage to satisfying a number of customer orders.

The use of very wide range specter of different solutions is possible for realization of OP task - in theory there is over 1000 OP systems (OPS), from which around 50 basic OPS are met in praxis [5]. These OPS are, depending on aim, classified in different ways [2], [5], where different classification criteria were used: the ratio of the movement of goods and/or orderpicker(s), applied technical level of MH (mechanization, automation, etc.), appearance of OP unit (allocation), etc. For the purpose of this paper the classification of OPS according to the type of the load unit and according to the level of process automation applied picking is used.

2.1 Classification of order picking technologies according to the OP load unit type

In relation to the type of the OP units, the literature meets three basic forms: - pallet unit, case unit and piece unit. With **pallet OP unit**, the whole pallet unit with content meets the requirements of order. **Case OP unit** meets the requirements of orders has the characteristic that demands for amount of good in orders are the same with content in the box (this type of order picking task is in the focus of this paper). **Piece OP unit** has the characteristics that the order for order picking amount is less than content of the box (usually is equal to the piece unit).

2.2. Classification of CP technologies according to the automation level

The solutions in this domain are met in versions of separation of some case units and version of separation of complete layers from pallet. Due to limited space, this paper will give the review of some CP automation solutions based on use of AGV/robots, conveyors, gantry/robot system, AS/RS and Layer picking.

- **Automated guided vehicle (AGV)/mobile robot-based case picking systems (CPSs)**

Appears in form of robot (Figure 1) within two basic OPS types „picker to load" and „load to picker". The development of AGV and robots with different picking devices created the preconditions to replace man-picker with the combination of robots set on AGV that allows palletizing and depalletizing. In practice, these solutions may be appropriate in the case of relatively small productivity and lower range of forms of goods, because it reduces the number of different picking devices. Otherwise, the price of the picking devices, their frequent replacement and adjustment of operating conditions can be irrational.
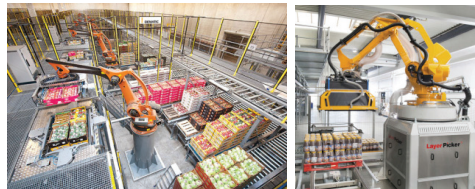
Figure 1. Mobile robot-based case picking systems with AGV

- **horizontal and vertical conveyor based CPSs**

Conveyor based system solutions can be used for intensive OP processes. In ***horizontal conveyor based solutions*** version (Figure 2a) unit delivery is done by roller or a belt conveyor where they are directed to the one of the lines which are only provided for the respective orders through an automated device (that scans the tag to the unit). After completing the units according to the order, the content of one line is delivered to the further process (usually palletizing) for shipping.
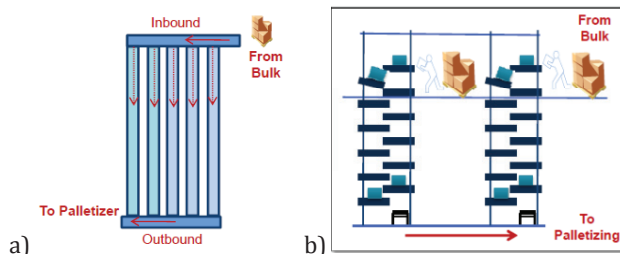
Figure 2. Horizontal (a) and vertical (b) conveyor based solutions

The key innovation of ***vertical conveyor based solutions*** is the ***design of vertical SKU "pick/dispensing towers,"*** (Figure 2b) which consists of short cascading trays or gravity flow conveyor sections. The towers are loaded with product at the top (the towers can be filled and replenished either automatically, via a conveyor running across the top of the towers, or manually via operators.), and (as shown in the illustration below) dispense cases at the bottom in any sequence required for customer orders and pallet building. These cases then travel on the shipping conveyor system from the pick area to the order consolidation shipping sorter [3].

- **Gantry robot-based solutions CPSs–**

These systems (Figure 3) involve use of a "gantry". For these purposes a gantry as a bridge-like structure which moves horizontally back and forth along a set of overhead tracks connected to conveyor for pallet delivery. Attached to the gantry are any of various devices capable of selecting individual cases or groups of cases from pallet – typically using some form of vacuum head. Picked cases are then delivered by the gantry to a takeaway conveyor for sorting/shipping (see Figure 3). [3]

Figure 3. Examples of Gantry robot based CP solutions

Because of their techno-exploitation characteristics, these solutions are very suitable for systems with high productivity for palletizing and depalletizing. The number of different engagement devices that are installed on a working device is in operation range of forms of goods.

- **Automated storage and retrieval system (AS/RS)-based CPSs**

Solutions are based on this technology (Figure 4) enables to pick/put unit from/to the storage areas (stored in the racks) by different variants of the engagement devices. Since these units are easy to handle, the speed of operation of these systems is high, especially in versions with the shuttle - devices.
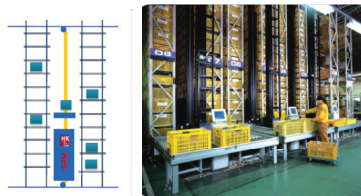
Figure 4. Principle of AS/RS based solutions CP

In order picking process, ordered unit is delivered to the entry/exit point of rack passage where it is grabbed and sent to the further phases of shipping process.

Layer picking

In situation of frequent orders - grabbing number of units that matches the layers of units on pallet, so called Robotic Layer Picker is suitable solution (Figure 5 a). In this solution, pallet with homogenous content (at least for one layer) is delivered to the working area of robot who grabs entire layer from pallet and put it on demanded spot.

a)   b)
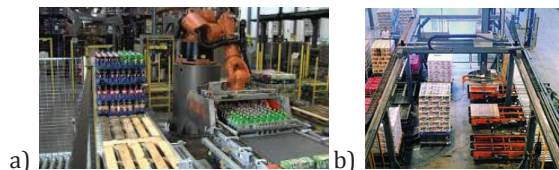
Figure 5. Layer case picking

After order picking, the pallet is returned to storage zone, or if empty, to the place of empty pallet drop. The technical solutions of engagement devices (due to higher capacity and complexity) in this version could have high price, but they can make significant productivity. This solution can be made as one version of gantry robot (Figure 5 b).

3. APPLICABLE PARAMETERS FOR ALTERNATIVE AUTOMATED CP CONCEPTIONS COMPARISON

The comparison of conceptions needed for making project decisions and choosing solutions, needs to define/chose whole of various applicable criteria - techno-technological, economical, working conditions, etc. By rule, applicable parameters for alternative CP conceptions comparison are: ***Productivity*:** refers to the pick rate, which can be expressed as cases per hour; ***Costs:*** There are many kinds of costs. In the context of this research, the most important types of costs can be divided into fixed costs and operating costs; ***Cycle time:*** This term refers to the time an order takes from its entrance to the system until it reaches the shipping area; ***Accuracy:*** Accuracy could be defined as the system's ability to avoid errors occurring while the processes are running, especially in OP procedures. It has a great effect on customer service level; ***Flexibility:*** Flexibility can be defined as the ability of a system to adapt to a wide range of operating conditions; ***Maintenance*** (costs and time delays) that is close connected with reliability of the OPS.

It is clear that these parameters can have different significance depending on the order picking task. In concrete terms, it is necessary to "wage" each of them in order to value alternative solutions.

4 RECOMMENDATIONS FOR DEVELOPMENT AND MAKING DECISION ON SELECTION OF SOLUTION OF AUTOMATED CPSs

It is interesting that despite the increasing interest in warehouse automation, clear guidance in selecting an automated OP solution is not present in literature. There are global recommendations concerned on factors that should be respected during automated design of CPSs (one is presented on Figure 6) [6]. Very interesting recommendation in this area is given in [9] - this recommendation respects two factors - Package Variability and SKU (Storage Keeping Unit) velocity in warehouse system, as it is shown in Figure 7.
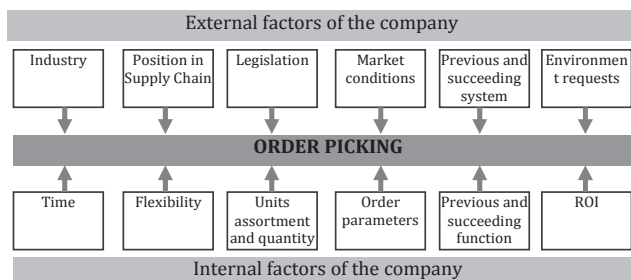

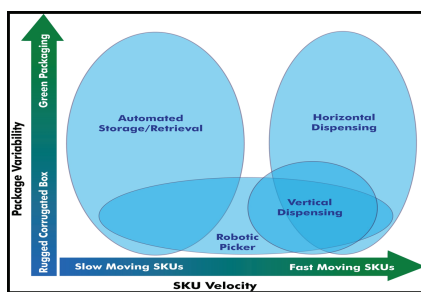Figure 6. Respective Factors during design of automated CPS systems

Figure 7. Respective factors during automated design of case OP systems

It's important to notice, that such selection is not sufficient and logistics experts have to investigate more details concerned on productivity, different costs, space, labor, complexity, risk, flexibility and scalability, ROI etc. Only when those analysis are performed, design of CPS could be appropriate.

5. CONCLUSION

By analyzing presented technologies, it can be concluded that there are lot of new, automated CPS solutions, more and more present, despite of some implementation problems concerned on few factors described in this paper. This trend is present in developed countries, where labor costs are high, and required service level in logistics is permanently growing - resulting with various automated CP solutions. Development in of robotics is very intensive at all as well in the application in OPS. One fact that confirm this trend in the recent time is development of automated piece unit (broken case) picking solutions which are present on the market and practice. Everything mentioned above shows that logistics experts, especially ones that deals with OP, have to permanently follow trends in this area, but also to have in mind and respect all relevant factors when dealing with application of this solutions.

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INTERNET OF THINGS IN LOGISTICS

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Abstract: *Internet of Things is based on the most contemporary information and communication technologies that enable marking, identification, communication and intelligent management of things. In this concept, things become smart objects that have the possibility of identification, communication and interaction. The paper gives a description of IoT, a proposal for the architecture and shows the possibilities and significance of applying the IoT concept in the field of logistics.*

Keywords: *Internet of Things, Logistics, Identification, Communication.*

1. INTRODUCTION

Internet of Things (IoT) is a new business paradigm that is based on unique identification of things and modern wireless communications (Atzori et al., 2010). Various things – objects from the real world are equipped with IoT devices that enable their identification, location, generating and receiving information. Full realization of IoT will enable formation of a virtual model of reality, in which business systems will be able to manage processes and activities in real time based on timely information on current state of their facilities. The aim of this paper is to outline the possibilities and significance of the IoT concept in the field of logistics. Initial IoT solutions that connect objects, users and companies through the Internet are already being applied in logistic processes. The paper consists of five parts. The IoT concept is described in the second part. The third part gives a proposal for IoT architecture and the four basic layers. The fourth part reviews the possibilities and effects of applying IoT in logistics. A conclusion is presented in the fifth part.

2. INTERNET OF THINGS

IoT is a new model of connecting real world objects into a unique system whose elements will be able to communicate with one another. The basic idea of this model is the existence of various devices (tags, sensors, mobile phones, etc.) that can exchange information through a wireless network in order to achieve mutual goals. The term Internet of Things was first introduced by Kevin Ashton in 1999 when he was researching new possibilities of applying RFID technology and the Internet in Procter & Gamble supply chain. Most of the data available on the Internet were created by human beings, by manually entering data, pressing a record button or scanning a bar code. The basic problem is that people have limited time, attention and accuracy, which means they are not good enough for acquiring data on things in the real world. If computers had

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all data and information on things, acquired without the help of people, losses and costs would significantly be reduced, planning, decision making and control processes improved (www.rfidjournal.com, 2009). IoT is based on the most contemporary information and communication technologies (ICT) that enable marking, identification, communication and intelligent management of things. In this concept, things become smart objects that have the possibility of identification, communication and interaction.

IoT can be viewed on three levels (Miorandi et al., 2012):

- At the single component level, the IoT is a set of smart objects connected to the Internet network. A smart object is an entity with a physical embodiment, unique identifier, address, characteristics and a minimal set of communication functionalities. A smart object possesses computing capabilities and can trigger activities having an effect on physical reality.
- At the system level, the IoT is a dynamic and distributed networked system, composed of a very large number of smart objects that generate and use information. Smart objects register physical phenomena and translate them into information streams which are further distributed through the network.
- At the service level, the IoT is a set of functionalities offered to the end users in various fields. The architecture of IoT systems is a virtual model of the real world with defined methods of information acquisition from smart objects and distribution of certain information given as services to the end users.

From a user point of view, the IoT will provide a large amount of new services which shall answer all requirements and needs in various fields. The user will receive a service that suits his state, physical surrounding and current conditions. IoT is a new concept of information and management linking which is yet to develop; new models are proposed and new technologies developed which should support identification, communication and control for a large set of objects, various fields and users and a large number of services.

The basic features of the IoT concept are (Miorandi et al., 2012):

- Devices heterogeneity – the IoT comprises of a large number of devices found in physical objects and have different computational and communication characteristics. Management of a heterogeneous set of devices should be supported by architecture of systems and communication protocols.
- Scalability – The development of the real world virtual model and the informational integration of a large number of objects requires scalability with: unique naming and addressing of objects, data exchange and connectivity, information and knowledge management, and service provisioning and management.
- Wireless data exchange – the IoT is based on wireless communication technologies which enable objects and wireless mediums that collect and distribute information to be connected with each other.
- Energy-optimized solutions – IoT comprises of a large number of energy consuming entities. Since IoT is a global system, optimization of energy consumption at all levels is necessary as well as application of solutions that enable reliable operation with minimal energy usage.
- Tracking objects possibilities – Smart objects have the possibility of identification and wireless communication which enables their tracking in the physical realm. This is particularly important in fields where it is necessary to track objects during whole life cycle.
- Self-organization capabilities – Devices that enable automatic identification and communication and make the objects smart also have the possibility of reacting to changes of some parameters in the environment. Smart objects possess the intelligence to independently react to different situations.
- Semantic interoperability and data management – The concept of IoT consists of exchange, safekeeping and processing of a large amount of data. In order to turn data into useful information and knowledge, it is necessary to provide interoperability among various applications and define standardized formats, models and semantic description of data.

- Embedded security and privacy-preserving mechanisms – The concept of IoT should ensure data security and privacy-preserving of participant. The system consists of data on all smart objects and their owners are also the owners of their data. The existence of security procedures is a prerequisite for accepting the IoT concept by the user.

3. INTERNET OF THINGS ARCHITECTURE AND TECHNOLOGIES

IoT architecture consists of all elements, mutual connections, technologies, applications and services in the IoT concept. Various multi-layer models of architecture are proposed in literature, and they include: smart objects, identification, data acquisition, communication networks, data management, applications and services (Atzori et al., 2010; Miorandi et al., 2012; Tadejko, 2015; Gaitan et al., 2015). This paper gives a proposal of IoT architecture concept with four layers (Figure 1):

- Perception layer,
- Network layer,
- Middleware layer and
- Applications layer.
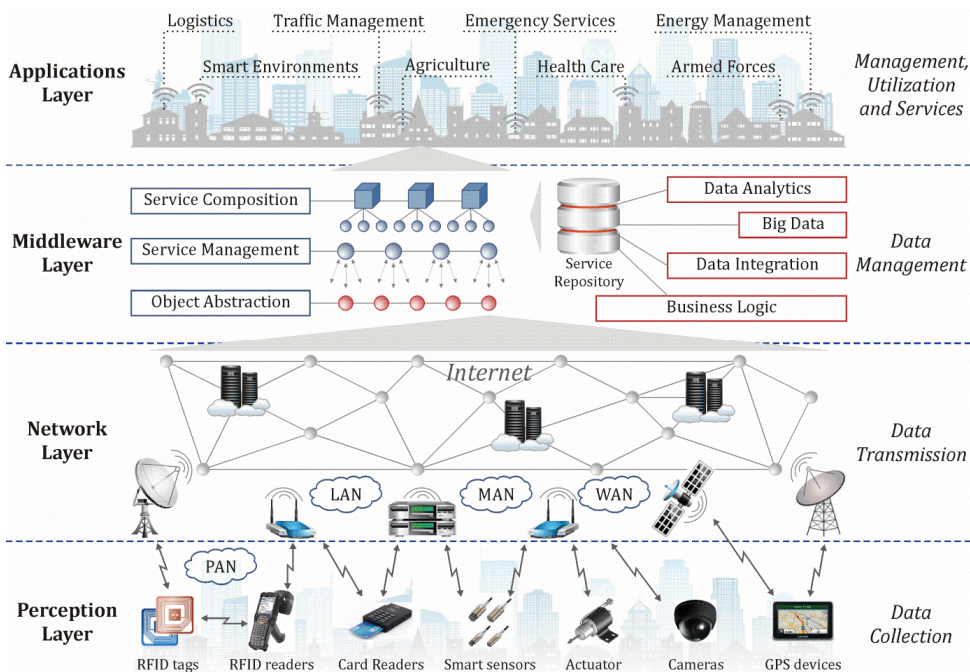
Figure 1. IoT Architecture

Perception layer consists of physical layers equipped with devices which enable identification, computer processing, sending and receiving of communication messages. The most widely used technologies for identification are RFID (Radio Frequency Identification), GPS (Global Positioning System) and WSN (Wireless Sensor Networks). The devices which make objects smart may be RFID tags and readers, card readers, smart sensors, actuators, cameras, GPS devices, etc. The basic challenge of the IoT concept is the use of devices that are low-power, inexpensive, networked and compatible with standard communication technologies (Miorandi et al., 2012). According to some research (www.gartner.com, 2015), it is estimated that more than 20 billion devices will be connected in the IoT concept in 2020. One of the basic problems of

the IoT concept was the unique identification of physical objects. This was overcome by the development of the IPv6 internet protocol which provides 1038 unique addresses, which should be enough for making all objects in the near future (Atzori et al., 2010).

Network layer enables data and information transmission between smart objects and the system which processes them. This layer includes access networks and core networks. Access networks used for sending messages are PAN (Personal Area Network), LAN (Local Area Network), MAN (Metro Area Network) and WAN (Wide Area Network). Intensive efforts are being made in the world today to develop a unique core network and communication protocol (Al-Fuqaha et al., 2015). Data collected from smart phones are transmitted to hubs and further to clouds where they are stored, processed, analyzed, transferred to other systems or returned to devices.

Middleware layer is found between the technological and application levels and contains software systems which process data and information and form services for users in various fields. By applying the business logics rule, data collected from smart objects are integrated in a unique system where different analytical applications are applied. Since a large number of heterogeneous data from various sources are in question, contemporary hardware and software technologies are used for storage and data processing which belong to the field Big Data. The Middleware layer has SOA (Service-Oriented Architecture) architecture which enables breakdown of complex systems to applications and components. Object Abstraction provides a virtual model of a large set of heterogeneous physical objects and their characteristics. Service Management consists of a set of all individual services which are stored in the Service Repository and provide physical objects. Service Composition is a set of functionalities for the complex services composition.

Applications layer consists of a set of all services which are provided to users in various fields. IoT services are the result of processing of data that have been collected from physical objects and enable timely and good-quality decision-making in conformity with the current state of the objects, system and environment. Numerous possibilities in various fields are given in literature: Logistics, Traffic Management, Emergency Services, Energy Management, Smart Environments, Agriculture, Health Care, Armed, Forces, Personal and Social domain, Smart City, Futuristic applications (Atzori et al., 2010; Miorandi et al., 2012; Tadejko, 2015; Borgia, 2014). Today, the fields of applying IoT services are limited only by our imagination (Whitmore et al., 2015).

4. INTERNET OF THINGS IN LOGISTICS

Contemporary logistics is based on information and communication technologies that support realization of business processes and enable connection of users in supply chains It is of great significance in logistics to provide identification of objects and communication among participants. Identification technologies applied to various objects in logistics have led to the existence of smart containers, pallets, packaging, packing materials, vehicles, shelves, forklifts, infrastructure, ports, terminals and others. RFID, GPS and WSN systems have wide uses in logistics and supply chains:

- RFID systems enable automatic identification of objects and wireless data reading. RFID tags can be active, passive and semi-passive and contain a large quantity of data on objects on which they are placed. RFID tags are used for marking traffic, transport and reloading means, logistic units, individual articles and shelves in retail, special types of goods (money, gold, medicine, dangerous goods), post office packages, location and traffic in warehouses, identification cards, documents and others.
- GPS systems enable positioning of objects in real time. GPS devices receive satellite signals, determine their position in space and time, preserve data on location and transmit them to user of system. GPS is used in almost all segments of logistics, providing data on exact position and time where and when some object is found. GPS devices are placed on transport

means of all types of traffic, semi-trailers, pallets, containers and individual goods, industrial and reloading mechanization, any devices that workers use in business processes.

- WSN enable collection and transmission of data between sensor nodes, access devices and network users. A sensor node consists of a set of active and passive sensors and can communicate, preserve and process collected data. Sensors are used for identification of objects and their physical characteristics – characteristics of goods, transport and reloading means, containers, locations in warehouses and sale facilities, equipment and traffic infrastructure, and others.

The application of these systems enabled the development of new business models and the concept of digital logistics in which a company automatically manages business processes and connects with its suppliers and buyers. In logistic systems, there are various models of connection through the Internet which relate to one or more companies or participants in supply chains. These models represent the initial IoT solutions which lead to global connection of all participants and objects. According to some research (Macaulay et al., 2015) 75% of companies used IoT solutions in 2014 in relation to 15% in 2012. The development of the IoT concept and universal communication network will enable a virtual model of business connecting whereby all participants will have data on objects available in real time. In literature, logistics is cited as the first field for application of IoT, (Atzori et al., 2010; Miorandi et al., 2012; Borgia, 2014; Whitmore et al., 2014). The reason for this is that logistics depends on the quality of logistic network, connectivity of all participants in supply chain, fast and reliable information, everywhere and at all times. Logistic decisions are brought on the basis of available information and influence all other participants in supply chains. IoT connects identification technologies (RFID, GPS i WSN), built-in intelligence, advanced analysis of large quantities of data, software applications and systems of decision making at different control levels. The software systems in logistics (LIS, WMS, TMS, OMS, CRM, SCM) will realize maximum effects since high quality data and information on current state of objects on network will be used. Figure 2 shows the application of the IoT concept in logistics. The significance of the IoT concept can be viewed at the level of logistic processes, participants in supply chains and on the global level. The greatest effects in the field of logistics are:

- Monitoring transport and reloading means, logistic units, goods and people in real time.
- Measuring resource performances and planning in conformity with current state.
- Logistic controlling of activities and processes, reacting to deviation and disturbance conditions and applying corrective actions in order to realize the set goals.
- Analytics of all data and information in order to analyze the existing state and identify the possibilities for new business promotions.
- Automating of business processes by eliminating manual work along with improvement of quality and reduction of costs.
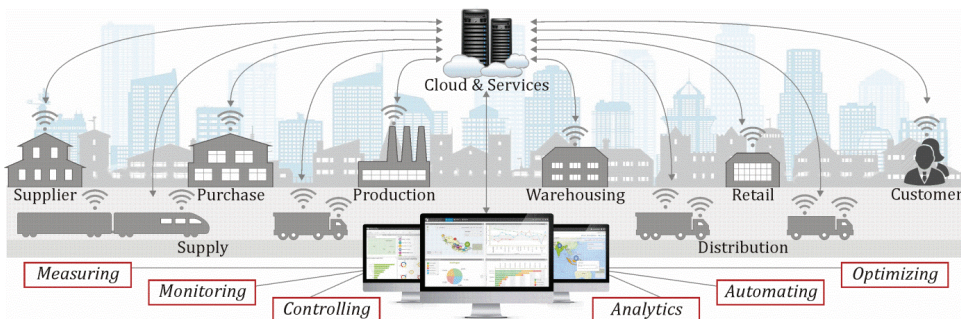- Optimizing people, the system and means and their coordination and integration.

Fig. 2. IoT in Logistics

5. CONCLUSION

This paper describes the IoT concept which will bring great changes in all fields in the near future. According to research on contemporary ICT, this technology is the leading from the aspect of development and future implementation (www.gartner.com, 2015). Intensive efforts are being made worldwide for the development of a unique communication network, standard and protocol which will enable connectivity of all smart objects. The open questions for this concept refer to the security of data and privacy protection.

IoT can be applied to all segments of life and business, but the greatest application and effects are expected in the field of logistics. When all transport and reloading means, equipment, goods, logistic units, individual packaging, objects, positions in objects and devices become smart, when a virtual model of the physical world is developed and IoT services provided to all users, logistics will get a new dimension. IoT will enable the formation of an intelligent network of smart objects between which there is a horizontal and vertical integration along the supply chain.

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LOGIC

ICT IN LOGISTICS: POSSIBILITIES AND THE AREAS OF APPLICATION

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Abstract: *High market requirements in the realization of trade flows impose a need for more efficient and more effective management of all links of supply chains. The overall connection of logistics subsystems and the exchange of timely and correct information is one of the basic pre-requisite conditions for the development of logistics processes. Thereby, the development of information-communication technologies – ICT, gains a significant notation when it comes to the managing of logistics subsystems. Therefore, in this paper, there will be word about ICT as the key aspect of operational cost decrease and increase in overall production and delivery of goods. Some of the technologies which will be mentioned here include Logistic Information System - LIS, electronic data interchange – EDI, radio frequency identification – RFID, Internet of things, Big Data etc. We will present how these technologies work, how they affect the overall supply chains and what their main benefits are.*

Keywords: ICT, LIS, RFID, Internet of things, Big data.

1. INTRODUCTION

In accordance with the market development and the increase in trade flows, the companies require an upgrade in their business subsystems at all levels, which can be achieved with the exchange of timely and high-quality information among all participants in the process. Within supply chains, the exchange of information is one of the key aspects for precise decision making, which increases the importance of the information-communication technologies (ICT). The application of ICT in logistics processes is inevitable, from the development of software and applications for logistics subsystem management – transport, inventory, warehousing, user interaction etc. It is used for managing facilities and outsourcing, to improve customers' satisfaction, developing better supply systems etc. (Obogne and Lidasan 2005). The real time accessibility of information affects the logistics flows realization, provides on-line tracking and gives opportunity of the prompt response to changes and risks when they appear in supply chain. The identification and signing of goods, pallets and vehicles during the realization of logistic flows, allow the businesses to track the goods, while simultaneously increasing significance of RFID technology. However, all those information should be analyzed, processed, stored and then used in the appropriate way, emphasizing importance of data collection and processing technologies, such as Big Data and Internet of Things (IoT). The aim of this paper is to show different ICT already used in logistics and supply chain management, as well as technologies that are developing and are predicted, according to other authors, to become important parts of overall supply chain development in the future.

Remaining of the paper is organized as follows. In the second section we mention Logistics Information System and Electronic Data Interchange as the most common technologies nowadays. Later, we talk about the Big Data for handling excessive amounts of data and finally on Internet of Things, which is still a developing technology.

2. LOGISTICS INFORMATION SYSTEM

The increase in logistics and transportation flows encourages the need for automation and increases the importance of development of Logistics Information Systems (LIS) systems and applications. Logistics information systems allow the interconnection of all participants within a supply chain and create the possibility for efficient management of all logistics processes (Ivanović et al. 2014). LIS usage assumes collection of data from different sources grouping and sorting data in databases, and decision making process based on software tools and systems. Some of the most popular include Customer response system – CRS, Inventory management system – IMS, Transportation management system – TMS, and Warehouse management system – WMS. Another very widespread technology nowadays is Electronic Data Interchange, which is used for supply chain integration – the connection of a company with its customers and suppliers, creating one larger and more complex supply chain.

The realization of logistics flows within a supply chain depends on numerous factors, which are connected with the subsystems and processes, such as warehousing, transportation, materials handling, inventory management, etc., which have significant effect on the costs and profit of a company, as well as provided service level. Therefore, the main role of the mentioned information technologies should be considered as a tool used to smoothen logistics flow realization and make them efficient and cost effective, as it is shown below.

2.1 The application of LIS in warehousing

Within the LIS, great attention is paid to the development of WMS, which is devoted to increasing efficiency of warehouse operations, in this way enhancing one of the key segments of logistics systems. Some of warehousing operations, such as order picking, inventory management etc., have a crucial influence on overall business costs, and therefore, in order to decrease them, require more advanced ways of managing information, processes, technologies and warehouse flows. Since the real word applications comprise different types of warehouse systems, which differ in characteristics and performances, costs of implementation and the goals, regarding to its complexity, following types of software solutions exist: basic WMS, advanced WMS, and complex WMS (Faber et al. 2002). However, the main purpose of WMS is to be able to track the movement, storing and handling goods in warehousing systems, as it is stated in Faber et al. (2002). With the implementation of WMS, better stock management is achieved, along with the better utilization of warehouse capacity and the more efficient realization of warehousing operations. Those improvements are achieved by provision of real time information about the number of SKU's, on the items need to be processed, while giving opportunity of sharing information between all supply chain members. There are numerous best practice examples. In one of the largest retail stores in India, the implementation of the WMS system has brought significant improvement in processes, but in this case, before the WMS implementation. Truck arrival times were unknown and suppliers were forced to wait for up to an hour, before even starting to unload, while the storage space utilization was very low (Rvce et al. 2012). By implementing WMS, there was a chance to improve each of these tasks, by automating the processes and preventing manual data entry, which was one of the main causes of creating mistakes (Rvce et al. 2012).

Similarly, the use of RFID has become more frequent in warehouses. RFID technology allows wireless reading and data transfer, and can be used within a warehouse for identification of

pallets, containers, warehouse zones, picking zones etc. According to the study of Poon et al. (2009), it is firstly required to observe the warehouse system, and then to define which type of RFID device is best to be used. The decision about RFID is made by testing the horizontal and vertical coverage of a reader device. Maximum coverage and performances of a device will be the key to selecting the optimal one. The data collected by RFID devices include quantities and types of SKU's, its storage locations, free space existence, the number of orders determination etc. Another group of RFID devices are related to storage locations, equipment, etc. Based on the results of RFID technology implementation, overall visibility is increased, which further improve operations and the productivity of warehouses (Poon et al. 2009). Chow et al. (2006) analyzed the steps of RFID implementation with the aim of maximizing efficiency and productivity of material handling equipment, so that the operational costs of a warehouse are as low as possible. Findings of their research show that real time information may improve routing decisions related to handling equipment.

2.2 Electronic Data Interchange (EDI)

EDI stands for Electronic Data Interchange, which considers the companies being connected to their suppliers and customers, in order to integrate overall logistics activities. As most companies work within their own network, Intranet, this kind of systems is supposed to interconnect the Intranets of all the companies within a supply chain. The interchange of data in real time would increase the overall productivity of a supply chain, with the companies being able to receive and process correct and timely information, regarding any deliveries, warehousing, stock keeping etc. The EDI framework encompasses all the actors in a supply chain: suppliers of raw materials, producers of intermediate goods, producers of final goods, and finally customers. Internet is a key aspect to keeping an EDI system, since the participants in the supply chain have to have a constant and timely communication amongst each others (Stefansson 2002).

Cloebbecke and Powell (1998) have researched potential cost savings in case of using EDI, and in some cases, they discovered that costs can be reduced by up to 27 billion US dollars per year. However, we have to take into consideration that this paper was published in 1998, which means that most companies were still using only telephone and fax to communicate. The ideal framework for supply chains insisted on interconnection of participants in more ways than simply having EDI installed and functioning. The authors state that a successful information logistics system includes: EDI providing for direct data exchange through electronic submission, Electronic Funds Transfer (EFT), which would simplify payments through data communication networks, activity based costing relating cost information to their sources, article-numbering and bar-coding for identification and addressing of goods and finally databases to store, manage and analyze the collected information efficiently by Cloebbecke and Powell (1998).

Taken that EDI has been a new concept about 20 years ago, a group of researchers has conducted an inquiry in order to show all the benefits of the developing EDI technology, in 2007. The researchers have inquired data from 336 respondents from different companies, regarding the application of EDI system in their company and its respective customers and suppliers, 179 of which have adopted the concept. One of the most important conclusions of the study is that plants would continue to implement EDI systems to connect with their suppliers and customers, for better organization and Supply Chain management. EDI is here mentioned to be one of the most important factors of supply chain integration, especially in B2B sector (Craighead et, al, 2007).

3. BIG DATA

With the increase in the volume of logistics flows, and thereby the activities and processes which need to be controlled within a supply chain in order to realize the logistics flow, companies deal with numerous strategic, tactical and operative decisions that need to be made, and whose quality contributes to the more or less efficient realization of operations within a supply chain. Accordingly, the quantity of data that needs to be analyzed, processed and structured increases considerable. One of the techniques used for analysis, processing and storage of this data is known as Big Data concept. Big Data considers using different kinds of approach and optimization techniques in order to have an insight in overall company business, which further allows the company to improve its operations and processes as is stated by Wang et al. (2016).

There are several studies that consider Big Data application in logistics. Dutta and Bose (2015) have shown the application of Big Data on an example of the company Ramco Cements Limited (RLC), where the collected operational data was expressing stability and firmness of processes in different units of RLC. The data was collected from the ERP system, and was related to users demand, orders, the number of deliveries etc. The study has shown that understanding the business problems, forming a cross-functional team and accepting innovative visualization techniques are crucial for the setting of Big Data. Another study of Tan et al. (2015) was examining SPEC, one of the biggest companies in the eye-glass production industry. Having the goal of making the highest possible profit and becoming more competitive in the market, the company believes that gathering data, both structured and unstructured, is one of the main drivers for achieving it. Therefore, in order to gather and analyze the data in the best possible way, Big Data was used, along with the technique of deduction graphs. The aim of this study was to help in making better decisions regarding to the development of future products, as well as to improve the operations in supply chains.

4. INTERNET OF THINGS

Internet of things (IoT) is a term that considers the idea of interconnecting different objects, "making them smart". This means having different devices connected among each others in such a way that they can share information and coordinate decisions (Al-Faguaha et al. 2015). We can easily notice the possibilities of applying the IoT in logistics with the development of RFID devices for warehousing. With the creation of this idea, a new concept is created, called machine-to-machine (M2M), where machines objects communicate with each others, in order to provide information and coordinate decisions.

As such, Internet of Things consists of five layers: objects layer, object abstraction layer, service management layer, application layer and business layer. Objects layer represents the physical sensors, objects that are interconnected with the purpose of collecting and processing information. Object abstraction layer is a technology used to transfer data from Objects layer to Service management layer. In the case of logistics, especially warehousing, an obvious technology that can be used for data transfer is RFID. Service Management or Middleware (pairing) layer pairs a service with a requester, thus turning data collected by the Object layer into heterogeneous objects, making decisions regarding them in the process. The application layer provides services requested by the customer. Finally, the business (management) layer is there to manage systems activities and services. Apart from that, this layer is created to design, analyze, implement, evaluate, monitor and develop IoT system related elements (Al-Faguaha et al. 2015).

Internet Connected Objects (ICO) are one of the main factors in the development of Internet of Things. Namely, sensor-based information, which is collected through the ICO (the object layer), can collect individual data about consumption and other product activities even within households, which can be transferred to companies in charge of the deliveries and products, in

order to be able to plan and make decisions, according to consumer needs and preferences. This kind of information would directly affect production, especially when it comes to quantities, which would further have effect on stocks, and thus improve stock keeping and warehousing processes. Apart from decreasing costs through timely and correct information, this kind of data collection could have a positive effect on the businesses, especially in tailoring and creating new products, which would also increase the incomes of a business (Scharf et al. 2015).

In order to develop Internet of Things and make it functional, there are six main elements that need to be taken care of: identification, sensing, communication, computation, services and semantics. Identification methods are used to provide clear identity of each object within the network. Sensing considers gathering data from related objects within the network and sending it back to the data warehouse, database or cloud. The collected data is analyzed to take specific actions, based on required services. When it comes to communication within the Internet of Things, it is used to interconnect heterogeneous objects in order to deliver specific smart services as a system. Processing units and software applications represent the "brain" of the IoT. They are used for computation, or, in the logical sense, decision making. There can be four types of services within IoT: identity-related services, information aggregation services, collaborative-aware services and ubiquitous services. Different types of services help create a difference in application of IoT. Finally, semantics is used to extract knowledge by different machines, in order to provide required services (Al-Faguaha et al. 2015).

5. CONCLUSION

From the research, we can definitely say that there are many ways and areas for the application of ICT in logistics. Many technologies have already been implemented, while many are still being developed. The different technologies, are used in business, and everyday life, and also in the logistics subsystems and related activities – transport, warehousing, user interaction etc. As mentioned, the possibility of tracking goods and receiving real time information can be valuable to any supply chain, providing prompt reaction to any potential problem. We have noticed that Logistics Information System (LIS) is one of the most widely used technology, particularly in the form of Warehouse Management System (WMS). Another very common technology nowadays is Electronic Data Interchange. This technology has found its use throughout whole supply chains, since its purpose is to connect all of the participants of a supply chain in order to improve the interchange of timely information, which can directly affect the processes, within all of the companies that belong to the same supply chain.

Big Data is the next technology, slowly becoming popular in modern business. Its point is the collection, storage and interchange of excessive amounts of data, which cannot be easily handled. The main difficulty here is the fact that data can either be structured or not, which is important for processing. Be that as it may, Big Data has found a major application in the business world, and many companies that have used this technology have gained competitive advantage. Finally, Internet of Things, as the last technology mentioned here, can be the most complex in this case, not only due to the complexity of its nature, but also due to the fact that it is still under development, and that it has a widespread use, within and outside of businesses, such as in everyday life. The idea is interconnection of different devices, even within the homes of consumers, in order to give correct information back to the businesses, regarding what should be done with the products. This directly affects production, and thus, obviously all of supply chain. However, this technology is still in development, and thus needs more precise defining and application.

Generally, the ICT is used in logistics already, but there are still more fields, in which it can be applied even further. The truth is that only the future will tell in which direction these technologies will develop, but as of now, we can say with certainty that they affect most parts of supply chains, increasing their productivity and decreasing their costs.

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Part VI

SUPPLY CHAIN MANAGEMENT AND REVERSE LOGISTICS

LOGIC

CONTRACTS FOR SUPPLY CHAIN COORDINATION WITH PRICE-DEPENDENT STOCHASTIC DEMAND

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Abstract: *Supply chain is a decentralized system where material, financial, information and decision flows connect members. When one or more members of the supply chain try to optimize their own profits, the total system may be inefficient. Supply chain contracts are used to provide some incentives to adjust the relationship of supply chain partners to coordinate the supply chain, i.e., the total profit of the decentralized supply chain is equal to that achieved under a centralized system. Double marginalization is a well-known cause of supply chain inefficiency and the problem occurs whenever the supply chain's profits are divided among more members and at least one of the members influences price-dependent demand. When the demand is stochastic than the newsvendor model can be applied. In a standard newsvendor problem the price is assumed to be fixed. The aim of this paper is to analyze contracts for the combined problem of supply chain coordination with price-dependent stochastic demand.*

Keywords: supply chain, coordination, contracts, price-dependent stochastic demand

1. INTRODUCTION

Supply chain is a decentralized system where material, financial, information and decision flows connect members. Recent years have seen a growing interest among researchers and practitioners in the field of supply chain management. Supply chain management is about matching supply and demand with inventory management. When one or more members of the supply chain try to optimize their own profits, system performance may be hurt (Fiala, 2005). Among the solutions, supply chain contracts, which have drawn much attention from the researchers recently (for review Cachon, 2003, Tsay et al., 1999), are used to provide some incentives to adjust the relationship of supply chain partners to coordinate the supply chain, i.e., the total profit of the decentralized supply chain is equal to that achieved under a centralized system. The format of supply chain contracts varies in and across industries.

Double marginalization (Spengler, 1950) is a well-known cause of supply chain inefficiency and the problem occurs whenever the supply chain's profits are divided among two or more members and at least one of the members influences price-dependent demand. Each firm only considers its own profit margin and does not consider the supply chain's margin. When the demand is stochastic than the newsvendor model can be applied. The newsvendor model is not

complex, but it is sufficiently rich to study important questions in supply chain coordination. In a standard newsvendor problem the price is assumed to be fixed.

The aim of this paper is to analyze contracts for the combined problem of supply chain coordination with price-dependent stochastic demand. Contracts are evaluated by desirable features:

- coordination of the supply chain,
- flexibility to allow any division of the supply chain's profit,
- easy to use.

2. PRICE-DEPENDENT DETERMINISTIC DEMAND

Double marginalization (Spengler, 1950) is a well-known cause of supply chain inefficiency. Double marginalization problem occurs whenever the supply chain's profits are divided among two or more firms and at least one of the firms influences demand. Each firm only considers its own profit margin and does not consider the supply chain's margin.

We consider a supply chain with a supplier and a retailer that sells a product. The supplier produces each unit for a cost c and sells each unit to the retailer for a wholesale price w. The retailer chooses an order quantity q and sells q units at price $p(q)$, assuming that $p(q)$ is decreasing, concave and twice differentiable function.

Centralized solution assumes a single agent has complete information and controls the entire supply chain (this is referred as the firs-best solution) to maximize supply chain profit

$$z(q) = (p(q) - c) \, q.$$

Since profit is strictly concave in quantity, the optimal quantity q^0 satisfies

$$\frac{dz(q)}{dq} = 0 \, .$$

Decentralized solution assumes the firms have incomplete information and make choices with the objective of maximizing their own profits. The retailer's profit and the supplier's profit are

$$z_r(q) = (p(q) - w) \, q \quad , \quad z_s(q) = (w - c) \, q.$$

Optimal solution of the problem we denote q^*.

If the centralized and decentralized solutions differ, investigate how to modify the firm's payoffs so that new decentralized solution corresponds to the centralized solution.

It can be shown that the retailer orders less than the supply chain optimal quantity ($q^0 > q^*$) whenever the supplier earns a positive profit and it holds

$$z(q^0) > z_r(q^*) + z_s(q^*)$$

Marginal cost pricing ($w = c$) is one solution to double marginalization problem, but the supplier earns a zero profit. A better solution is a profit sharing contract, where the supplier earns $\lambda \, z(q)$ and the retailer earns $(1-\lambda) \, z(q)$, for $0 \leq \lambda \leq 1$. The wholesale price w is now irrelevant to each firm's profits and the supply chain earns the optimal profit.

3. STOCHASTIC DEMAND

There are some concepts for contracts with stochastic demand (Anupindi and Bassok, 1999, Lariviere, 1999). We consider a supply chain in one-period setting in which a supplier sells to a retailer facing stochastic demand from consumers. We assume that stochastic demand x has a

continuous distribution $F(x)$ that is invertible. The demand distribution and cost information are common knowledge. Define the failure rate function of the x distribution as

$$g(x) = \frac{f(x)}{1 - F(x)}$$

and the generalized failure rate function as

$$h(x) = xr(x).$$

Assume the demand distribution has strictly increasing generalized failure rate property (IGFR). Many distributions have the IGFR property, including the normal, the exponential, the gamma, and the Weibull.

We define the following quantities:

q retailer's total order quantity;
c supplier's production cost;
p retail price.

The setting can be characterized as a newsvendor problem.

Centralized solution

Centralized solution is a benchmark for the decentralized supply chain. The centralized chain is considered as an integrated firm that controls manufacturing and sales to consumers. The profit of an integrated firm for stocking level q is

$$z(q) = (p - c)q - p\int_0^q F(x)dx \,.$$

The problem is concave in q and the optimal solution is given by

$$q^0 = F^{-1}\left(\frac{p - c}{p}\right).$$

The maximum system profit $z(q^0)$ is completely determined by the stocking level q^0. Decentralized solution can be improved by contracting. The contract coordinates the chain if it induces the choice of the centralized system's optimal stocking level q^0.

Wholesale price contracts

With a wholesale price contract the supplier charges the retailer w per unit purchased. The retailer faces a problem analogous to that of the integrated chain with. The principal difference is that the retailer must buy stock at the wholesale price w instead of producing it at cost c.

The retailer's profit is

$$z_R(q) = (p - w)q - p\int_0^q F(x)dx \,.$$

The retailer's problem is concave in q and the optimal solution is given by

$$q(w) = F^{-1}\left(\frac{p - w}{p}\right).$$

The supplier acts as a Stackelberg leader and anticipates how the retailer will order for any wholesale price. The supplier anticipates a demand curve $q(w)$ and the profit

$$z_S(w) = (w - c)q(w) = (w - c)F^{-1}\left(\frac{p - w}{p}\right).$$

The supplier knows exactly what retailer will order at every wholesale price and bears no responsibility for the product. All uncertainty regarding supply profits is foisted onto the retailer. The wholesale price contract coordinates the chain only if the supplier earns a non-positive profit. So the supplier clearly prefers a higher wholesale price. As a result, the wholesale price contract is generally not considered a coordinating contract. The richer contracts differ from wholesale price contracts by allowing the supplier to assume some of the risk arising from stochastic demand. As an example we introduce buy back contracts.

Buy back contracts

With a buy back contract (Pasternack, 1985) the supplier charges the retailer w per unit purchased, but pays the retailer b per unit remaining at the end of the season. A retailer should not profit from left over inventory, so assume $b \leq w$. There is assumed that a returns policy on the decentralized chain introduces no additional cost beyond that incurred by the centralized system.

The retailer's profit is

$$z_R(q) = (p-w)q - (p-b)\int_0^q F(x)dx \,.$$

The retailer still faces a newsvendor problem. The optimal solution is

$$q(w,b) = F^{-1}\left(\frac{p-w}{p-b}\right).$$

4. PRICE-DEPENDENT STOCHASTIC DEMAND

Little work has been done on the combined problem of supply chain coordination with price-dependent stochastic demand. The contracts proposed for coordination with price-independent stochastic demand are not applicable for coordination of supply chains with price-dependent stochastic demand.

We will analyze the multiplicative form of price-dependent stochastic demand

$$D(p, x) = y(p)x \,,$$

a function of p and x, where x is a random variable independent of p and $y(p)$ is continuous, nonnegative, twice differentiable function. The expectation of D is specified by a function $y(p)$ for any given price p:

$$E[D(p, x)] = y(p).$$

The flows in the supplier-retailer supply chain with stochastic price-dependent demand are captured in Fig. 1. Material and unit financial flows are represented by continuous and dash lines, respectively.

The expected profit for centralized solution for any output level q and price p is:

$$z(p, q) = E\{p[\min(q, D(p, x)] - cq\} = E\{(p-c)q - p\max(0; q-D(p,x))\} =$$

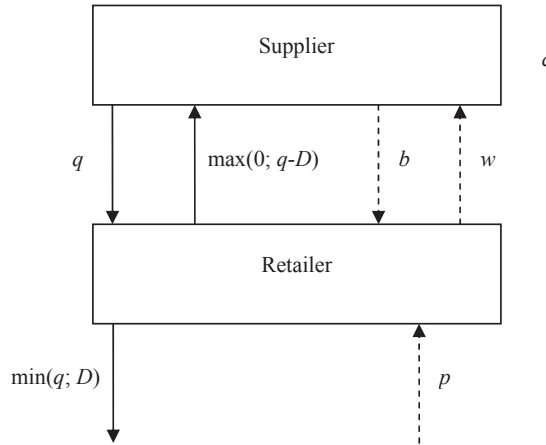$$= (p-c)q - py(p)\int_0^{\frac{q}{y(p)}} F(x)dx \,.$$

Figure 1. Supplier-retailer supply chain with stochastic price-dependent demand

The objective is to choose (p^0, q^0) to maximize the expected profit $z(p, q)$.

By fixing price p the problem reduces to standard newsvendor problem without pricing and the optimal level of inventory

$$q^0 = y(p)F^{-1}\left(\frac{p-c}{p}\right).$$

By substituting it into the expected profit

$$z(p) = y(p)[(p-c)F^{-1}\left(\frac{p-c}{p}\right) - p\int_0^{F^{-1}\left(\frac{p-c}{p}\right)}F(x)dx].$$

The problem is now with only one decision variable p and the optimal price p^0 can be obtained by solving

$$\frac{dz(p)}{dp} = 0.$$

The assumptions of the existence and uniqueness of the optimal solution (p^0, q^0) are concavity of deterministic part of demand function $y(p)$ and IGFR property of stochastic part o demand function x.

The proposed contract for coordination of the decentralized supply chain is a hybrid of wholesale price and buy-buck contract. The wholesale price w and the buy-buck price b are specified:

$$w = \lambda (p - c) + c,$$

$$b = \lambda p, \text{ where } 0 \le \lambda \le 1.$$

By the setting of the prices w and b the retailer's profit and the supplier's profit for any chosen output level q and price p are

$z_R = E\{p[\min(q, D(p, x)] - wq + b \max(0; q-D(p, x))\} = E\{(p - w - c)q - (p - b)\max(0; q-D(p, x))\} =$

$= (1 - \lambda) E\{(p - c)q - p\max(0; q-D(p, x))\} = (1 - \lambda) z$,

$z_S = E\{(w - c)q + b\max(0; q-D(p, x))\} = E\{\lambda (p - c)q - \lambda p\max(0; q-D(p, x))\} = \lambda z$.

From previous expressions of the retailer's profit and the supplier's profit, it is clear that the retailer and the supplier solve the same problem as the centralized supply chain and the sum of the retailer's profit and the supplier's profit is equal to the profit of the centralized supply chain. The parameter λ characterizes a splitting of the total profit between the retailer and the supplier.

5. CONCLUSION

There is a vast literature on supply chain contracts recently. However, little work has been done on the relationships of those supply chain contract models and on the combined problem of supply chain coordination with price-dependent stochastic demand. The proposed contract for supply chain coordination with price-dependent stochastic demand has desirable features. The supply chain is fully coordinated, i.e., the total profit of the decentralized supply chain is equal to that achieved under a centralized system. Flexibility to allow any division of the supply chain's profit is managed by the selected parameter λ in the setting of the wholesale price w and the buy back price b. It has relative advantages in implementation. The supplier needs to monitor the price only, not the quantity sold. The analysis of the simple cases of contracts gives recommendations for more complex real problems.

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LOGIC

EXAMINING PERFORMANCES OF RECYCLING PLASTIC NETWORK

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Abstract: *This paper examines performances of the logistics recycling system. We tested model that simultaneously determine collection points' locations with distance-dependent returns, location of intermediate consolidation points (transfer centers) and the route of the collection vehicle so as to maximize its profit from the collection of recyclables with different input parameters.*

Keywords: *logistics network, performance, recycling*

1. INTRODUCTION

Global plastics production has grown exponentially since the 1960s, reaching 311 million t produced in 2014, a twentyfold increase and it is expected to reach up to 1.2 billion t annually by 2050 (EU, 2016). Properties of plastic materials such as low cost, light weight and durability contributed to these numbers, but plastics materials are not inert and once in the environment it can persist for hundreds of years (EC, 2013). Almost 40% of plastics is used for packaging and in 2014, the EU generated about 25 million t of post-consumer plastic waste of which only 30% was recycled (http://ec.europa.eu/environment/waste/pdf/plastic_waste_factsheet.pdf).

In order to deal with packaging waste, especially plastics waste, European Union imposed several Directives aiming at reducing quantities as well recycling of different packaging waste streams such as Packaging Directive 94/62/EC and Framework Directive on waste 2008/98/EC. In Circular Economy Action Package (December 2015), European Commission proposed raising the recycling target for plastic packaging to 55%, and reducing landfilling to no more than 10% by 2030 (http://ec.europa.eu/environment/waste/plastic_waste.htm).

For achieving imposed recycling targets, it is necessary to establish logistics network structures. that will be convenient for end users (González-Torre and Adenso-Díaz, 2005, Garcés et al, 2002), because end users are responsible for separation of recyclables at their residence and carrying them to designated collection points (CPs). This paper presents extension of the research presented in paper Vidovic et al. (2016).

The location routing (LR) model for designing RN with profit proposed in Vidovic et al. (2016), has the following specificities. Location part of the model includes decisions of the positioning both CPs as a lower level of the network and transfer stations (TSs) at the higher level of the network. The revenue obtained from quantity of recyclables for specific CP is related with the proximity of the CP to the end users. So, we introduced distance dependent quantity of

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recyclables dropped off to CPs introducing collection rate as a function of distance. In this paper we examined recycling systems performance with different shape of function that correspond to collection rate *f(d)*. Namely, we examined system's performance with different input parameter (collection rate function), that is we wanted to see if and how different shapes of collection function rate influences on system's performance.

From here, the paper is structured as follows. Description of the problem in Section 2. In Section 3 numerical results are presented, while Section 4 summarizes our findings and provides some thoughts regarding future research.

2. DESCRIPTION OF THE PROBLEM

Problem considered in this paper is the same as in Vidovic et al. (2016). That is, we considered a problem of designing of recycling plastic system in urban settlements (cities). Today's modern cities structures (block structure) gives an opportunity to address and formulate considered problem as LR problem, where vehicle routing part (VRP) of the LR problem is formulated as a multiple matching problem instead of classical VRP formulations. For mathematical formulation of the considered problem, reader is referred to Vidovic et al. (2016).

We will briefly describe the problem considered and solved in this paper. City blocks can be in a variety of sizes and shapes, characterized with buildings in which residents live and road network within. Term end user refers here to a building inside the specific city block (we aggregated residents to its residential building considering them as a single end user). Each end user is characterized by the volume of waste produced per day which corresponds to the total quantity generated in all households residing in a building. Potential locations of CP are characterized by its capacity and distances to all end users in each city block. Capacitated vehicle originating from transfer station (TS), performs a tour of visiting city blocks and collecting plastics located at CPs. The length of inner streets in city blocks may differ depending of the city block shape and size, but this length of the route through city block is always the same, regardless of the number of stops per CP. This fact enables us to route distance only from TS to city blocks, while route part when vehicle traverse city block is predetermined and included in routing costs. More importantly as stated this fact, gives us opportunity to formulate vehicle routing part of the LR problem as a multiple matching problem instead of classical VRP formulations. Also, we include idling time at each CP in costs calculation.

In order to model the influence of distance between end users and CPs on the collecting of recyclables, we assume that recyclables collection rate $f_d \in [0,1]$ is a known function of distance (figure 1.). This function models the influence of distance between end users and CPs, in way that collection rate is inversely proportional to distance (Berman et al., 2003). We define two characteristic distances *l* and *u* (l < u), between the end user and CP where *l* represents the lower and *u* upper bound of walking distance to CP for each end user (figure 1.). When the distance *d* from the end user to the closest CP is $0 \le d \le l$ then *f(d)=1*, while in case when $d \ge u$, *f(d)=0*. If the distance between the end user and CP is $l \le d \le u$.
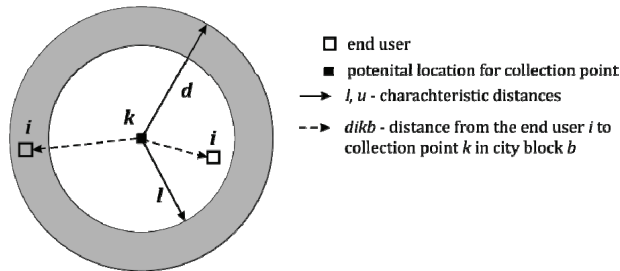
Figure 1. Characteristic distances between end user *i* and collection point *k*

In Vidovic et al. (2016) we assumed that the collection rate corresponds to linear function defined as $f(d) = \dfrac{u-d}{u-l}$. In this paper we examined system's performances with different shape of $f(d)$, that is we defined $f(d)$ as a step function. Different shapes of function f(d) are presented in figure 2, where step function is presented on the left side of the figure 2, while the linear function is presented on the right side of the figure 2.
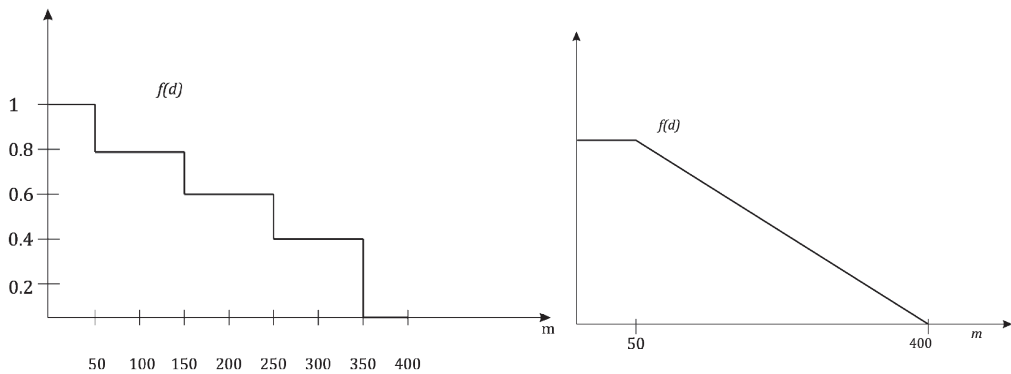
Figure 2. Different shapes of function *f(d)*

3. NUMERICAL EXAMPLE

Due to the complexity of proposed LR model, the instances that can be solved to optimality are typically of small size. So, we tested LR model only on the small instances of the problem, because we wanted to examine systems behavior with different input parameters. In this paper, as stated before, we changed the shape of the collection rate function *f(d)* from linear to step function. Input parameters for testing are presented in Table 1, while the results of the model are presented in table 2 and figures 3 and 4. Problem was developed using Python 2.7 programming language and solved by Cplex 12.6 software (IBM, 2012) on 64-bit PC Intel Core i7 machine with 2.8 gigahertz and 6 gigabyte RAM.

Table 1. Input parameters of the model

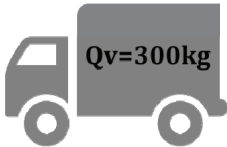| Input parameters	Small	
F_k(€/day)	0.5/0.8	
F_j(€/day)	0	
Costs per stop (€/per stop)	0.002	
revenue(€/kg)	0.12264	
Q_k(kg)	20	50
Q_r(kg)	300	600
l(m)	50	
u(m)	400	
Time horizon	7 days	
No. of city blocks	{4,5,6}	
No. of potential location for transfer points	2	
Number of residents in each city block	Beta (2,5) distribution in the range[48,200]	
Generated quantity of recyclables in (Q_{ib})	Uniform distribution (0.8;0.1)* P (P-% of plastics in municipal waste)	
Number of potential CPs	(Q_{ib}/Q_k)+1	
Distances between city blocks (m)	Randomly generated in the range [100,700]	
Distances between transfer points and city blocks (m)	Randomly generated in the range [1000,10000]	
Distances inside city blocks (m)	Randomly generated in range[400,1200]	
Distances between end users and potential locations for CPs	Beta (2,5) distribution in the range[15,400]	
Cost per km traveled (€/km)	0.0008 (inside the block x3)/	0.001(inside the block x3)
Number of end users in each city block (Randomly generated in the shown range)	[4,7]	

Table 2. Results of the numerical example

Qv	No. of city blocks	Linear f(d)				Step f(d)			
		300		600		300		600	
Qk		20	50	20	50	20	50	20	50
profit	4	35.84	39.55	36.31	40.26	35.84	38.76	36.31	39.47
	5	39.56	43.41	39.33	43.18	39.56	42.59	39.33	42.36
	6	50.81	55.48	50.08	54.75	50.81	54.66	50.08	53.92
collected recyclables (%)	4	94.65	98.78	95.98	98.78	94.65	98.80	95.98	98.80
	5	96.39	98.91	96.39	98.91	96.39	98.86	96.39	98.86
	6	96.84	99.13	96.84	99.13	96.84	99.10	96.84	99.10
Opened collection points (%)	4	95.24	47.62	100.00	47.62	95.24	52.38	100.00	52.38
	5	100.00	50.00	100.00	50.00	100.00	54.17	100.00	54.17
	6	96.67	46.67	100.00	46.67	100.00	53.33	100.00	53.33

As it can be seen from the table 2, In case of a container with the smaller capacity and a vehicle with the smaller capacity, obtained profit is the same for the different shapes of collection rate function. This can be explained with insufficient capacities of collection points as well vehicles, which detailed analysis of the results showed. In case of larger capacity of collection points and smaller capacity of vehicles, there are differences in obtained profit when it comes to describing collection rate as different functions. Profit decreases if the collection rate function is defined as step function instead of linear.

The same conclusion can be drawn for the all combinations of vehicle capacity and collection point's capacity (figures 3 and 4). Namely, when *f(d)* is defined as step function, larger quantities of recyclables are collected but in the same time larger number of collection points are opened, which results in slightly lower profit than in case of linear function rate. Since the routes are the

same, that is transportation costs are the same in both cases of defining *f(d),* it can be concluded that obtained profit highly depends on the shape of the *f(d).* This fact suggests that detailed research on recycling behavior for certain region or city is needed for describing recycling attitude of end users correctly and in that way defining *f(d)* in proper and specific shape.

		routes		vehicle utilization	
No. of city blocks		*Qk=20kg*	*Qk=50kg*	*Qk=20kg*	*Qk=50kg*
Qv=300kg	4	Yts1_1_4_3 Yts1_2	Yts1_1_4_2 Yts1_3	99.08% 31.71%	97.43% 39.08%
	5	Yts1_2_4_5 Yts1_1_3	Yts1_2_4_5 Yts1_1_3	80.52% 67.58%	84.43% 67.55%
	6	Yts1_1_4_2 Yts1_3_6_5	Yts1_1_4_2 Yts1_3_6_5	93.55% 94.55%	97.43% 95.13%
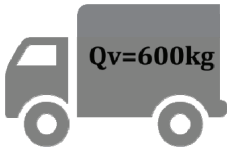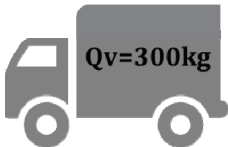
		routes		vehicle utilization	
No. of city blocks		*Qk=20kg*	*Qk=50kg*	*Qk=20kg*	*Qk=50kg*
Qv=600kg	4	Yts1_1_3_4_2	Yts1_1_3_4_2	66.32%	68.25%
	5	Yts1_1_3_4_5 Yts1_2	Yts1_1_3_4_5 Yts1_2	60.45% 15.54%	58.19% 15.86%
	6	Yts1_1_3_5 Yts2_2_4_6	Yts1_1_3_5 Yts2_2_4_6	41.53% 52.52%	41.51% 54.77%

Figure 3. Vehicle utilization in case of linear function collection rate

		routes		vehicle utilization	
No. of city blocks		*Qk=20kg*	*Qk=50kg*	*Qk=20kg*	*Qk=50kg*
Qv=300kg	4	Yts1_1_4_3 Yts1_2	Yts1_1_4_2 Yts1_3	91.71% 39.08%	97.45% 39.08%
	5	Yts1_2_4_5 Yts1_1_3	Yts1_2_4_5 Yts1_1_3	80.52% 39.08%	98.59% 67.52%
	6	Yts1_1_4_2 Yts1_3_6_5	Yts1_1_4_2 Yts1_3_6_5	93.55% 94.55%	97.45% 95.04%
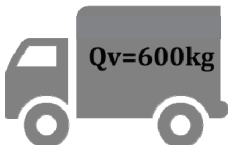
		routes		vehicle utilization	
No. of city blocks		*Qk=20kg*	*Qk=50kg*	*Qk=20kg*	*Qk=50kg*
Qv=600kg	4	Yts1_1_3_4_2	Yts1_1_3_4_2	66.32%	68.27%
	5	Yts1_1_3_4_5 Yts1_2	Yts1_1_3_4_5 Yts1_2	50.46% 15.86%	60.10% 15.86%
	6	Yts1_1_3_5 Yts2_2_4_6	Yts1_1_3_5 Yts2_2_4_6	41.53% 52.52%	41.45% 54.80%

Figure 4. Vehicle utilization in case of step function collection rate

4. CONCLUSION

This paper examines recycling network performance for plastics waste. This research represents extension of research published in Vidovic et al. (2016), devoted to the collection rate function impact. We examined system's performance with different input parameters (collection rate function), that is we wanted to see if and how different shapes of collection function rate influences on system's performance. Although we tested model on small instances, results shows that different shapes of collection rate function strongly influences on obtained profit. Hence, in modeling and solving real and practical problem of collection plastics waste, it is crucial to define collection function rate as a function of socio-economic characteristic of the modeled region. Future research should be focused on precise estimation of plastic's wastes quantities in way that they are not modeled as deterministic parameters, then integrating plastic's waste flows with other recyclables, and modelling those systems, etc.

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LOGIC

USED TIRE MANAGEMENT: AN OVERVIEW, PART I

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Abstract: *Worldwide, approximately 19.3 million tonnes of used tires are generated every year. Used tires represent a category of waste whose processing is especially difficult because of their complex structure and varied composition. Improper management of used tires endangers environment and social life. Therefore, the used tires management is a matter of a country's attitude towards supporting the environment preservation and it is emerged as a novel area of scientific research. This paper is the first part of the review paper, which investigates the used tires management research area. However, in this particular paper, due to enacted limit in paper's length, only previous review papers, legislation-oriented research and application alternatives are addressed and systematically analyzed. The purpose of this review paper is to provide an extensive content analysis overview of exclusively peer-reviewed international journal papers published in the period 2006-2017.*

Keywords*: review, content analysis, used tires, legislation, application alternatives.*

1. INTRODUCTION

In the last few decades, the treatment of used tires is becoming more intensive and important (Oikonomou and Mavridou, 2009; Li et al., 2016). There are approximately 19.3 million tonnes of used tires generated annually in the world (Labaki and Jeguirim, 2017), and this figure is going to rise in the coming years along with the expected growth of the world's motor vehicle fleet. In the European Union (EU), the quantity of used tires reached over 3.6 million tonnes in 2013 (ETRMA, 2016). Since used tires are not biodegradable, there is a strong motivation to successfully manage this fast-growing waste flow thus mitigating its negative environmental impact.

Due to the increasing importance of the used tires management subject, a considerable number of research papers have been published. Grey literature is completely excluded from this review paper. Its primary purpose is to categorize, analyze and interpret exclusively peer-reviewed international journal papers published in the period 2006-2017.

2. REVIEW METHODOLOGY

In this paper, content analysis method is adopted for literature review. Content analysis is an observational research method that is used to systematically evaluate the symbolic content of all forms of recorded communication and also helps to identify the literature in terms of various categories (Pokharel and Mutha, 2009).

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Search engines were used to explore ACS Publications, ASCE Library, ASME Digital Library, Cambridge JOURNALS, EBSCOhost, EmeraldInsight, Google Scholar, IEEE Xplore, Inderscience, IntegraConnect, IOPScience, J-STAGE, JSTOR, ProQuest, RSCPublishing, SAGE journals, ScienceDirect, SciVerse, SpringerLink, and WILEY databases for literature. In addition, the references cited in each relevant literature were examined to find out additional sources of information.

3. RESULTS

Recently, several review papers have been published. Sienkiewicz et al. (2012) described different organizational approaches for the management of used tires in the European Union and some possible usages of waste tires as a source of raw materials or alternative fuel. Williams (2013) as well as Martínez et al. (2013) reviewed applications of pyrolysis for waste tires treatment. Ambalal and Dipak (2014) provided a review of applications of the Life cycle analysis (LCA) methodology for solving used tires management problems and highlighted some future research directions. Ramarad et al. (2015) provided an overview of the progress in waste tire recycling with a particular attention to incorporation of waste tire rubber into polymeric matrices. Saleh and Gupta (2016) discussed the methods developed for the preparation of carbon from waste tires and their activation.

As can be seen from contents analysis of previously published review papers, the scope of every paper is limited to a specific area of the used tires management. In this paper, we present a holistic view of environmental engineering issues of the used tires management by covering a wide range of previously published papers. The literature is organized into 4 main sub-areas: legislation-oriented research, treatment options, mathematical modeling approach and application alternatives.

3.1 Legislation-oriented research

European tire producers face an array of extended producer responsibility (EPR) legislations, which make them responsible for financing and organizing the take-back, treatment and recycling of used tires. The legislation on the used tires management has evolved considerably over the years, but there is still much space for improvement.

Regarding the legislation applied on used tires management in the EU, there are three different systems: (a) producer responsibility, (b) tax system, and (c) free market system. McKerlie et al. (2006) outlined lessons from European and Canadian used tires stewardship programs thus highlighting the importance of designing specified extended producer responsibility (EPR) programs. They also provided some recommendations for advancing EPR in Canada. Mayers (2007) analyzed strategic, financial and design implications of EPR principle on waste batteries, end-of-life vehicles and used tires. Since the Portuguese government decided to apply EPR concept to the used tires management, Ferrao et al. (2008) identified producers, distributors, recyclers and retreaders, as well as analyzed present processing infrastructures in Portugal. Uruburu et al. (2008) highlighted that new policies and EPR principle strongly affect overall environmental performances of tires throughout their life cycle. As a good example of an environmentally-sound practice with used tires, the authors mentioned SIGNUS, the Spanish non-profit organization. Milanez and Bührs (2009) concluded that an in-depth study of the scope, main new aspects, objectives and future targets of the used tires management needs to be conducted to provide an updated, more precise and clearer framework.

Santini et al. (2011) found that removal of used tires from end-of-life vehicles is needed in order to fulfill rigorous recycling and recovery targets promulgated by the Directive 2000/53/EC. Antoniou and Zabaniotou (2013) outlined that a general guideline for EU member states is to reach a zero post-consumer amount of tire disposal in landfills, and to accomplish a balance

between economy and environmental protection. Torretta et al. (2015) compared treatment and disposal schemes with used tires in Italy and Romania.

New ISO 10844 test track specification further brings attention to tire noise behavior. For instance, works of Sohaney et al. (2012) and Wei et al. (2016) provide analyses of noise of heavy truck tires and the new ISO specifications. Clar-Garcia et al. (2016) studied the European regulations devoted to reduction of noise generated by the interaction of tires and road surface.

The recent regulations, such as the European tire labeling regulation EC/1222/2009, are devoted to put in focus environmental and safety performances of tires. Elenour and Laz (2014) explored the ideal way of tire exploitation to guarantee maximum safety and life time. Xie et al. (2016) concluded that tire manufacturers are taking measures to modify the structure of tires in order to avoid uneven wear.

3.2 Application alternatives

Environmental concerns and ever-growing quantity of used tires have stimulated the search for novel application alternatives. More and more countries worldwide have been paying great attention to the comprehensive utilization of used tires to protect environment, reduce consumption of natural resources and save energy.

Many researchers have investigated end-of-life tires application alternatives. For instance, Tlemat et al. (2006) demonstrated that steel fibres recovered from end-of-life tires can be successfully used to prepare fibre-reinforced concrete. Lee and Roh (2007) proposed application of recycled tire chips on the culvert walls in backfill areas to reduce the dynamic earth pressure induced by the compaction loading as well as to improve the characteristics of compacted soils. Oikonomou and Mavridou (2009) examined the incorporation of tire rubber granules as a partial replacement for the sand in cement mortars. Fiksel et al. (2011) investigated usage of end-of-life tires in civil engineering applications and concluded that it is environmentally preferable alternative.

End-of-life tires can be used in a variety of civil and non-civil engineering applications. Major application options are numerous and usually include:

- artificial reefs (Chapman and Clynick, 2012),

- dock fenders (Feriha et al., 2014),

- draining material (Pérez et al., 2012; Vila et al., 2012; Torreta et al., 2015),

- embankment stabilizers (Lindt et al., 2008; Li et al., 2016; Rowhani and Rainey, 2016),

- erosion barriers (Edinçliler et al., 2010),

- flooring sports fields (Bravo and Brito, 2012),

- footwear industry (Machin et al., 2017),

- foundation for roads and railways (Chiu, 2008; Sengul, 2016),

- gardening (Fıglali et al., 2015),

- mats (Machin et al., 2017),

- packing material (Karaağaç et al., 2017),

- paving blocks (Ling, 2012; Zhou et al., 2014; Said et al., 2015; Zanetti et al., 2015),

- roofing materials (Torreta et al., 2015; Karaağaç et al., 2017).

4. CONCLUSION

The used tires management strongly affects not only the environmental protection but also the resources preservation, since problems related to the depletion of resources, energy demand and waste management are interconnected thus requiring an integrated approach.

This paper is the first part of the review paper, which investigates the used tires management research area. It presents a holistic review of the state-of-the-art literature published in the period 2006-2017 exclusively in peer-reviewed international journals. In this part, due to enacted limit in paper's length, only previous review papers, legislation-oriented research and application alternatives are addressed and systematically analyzed.

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LOGIC

USED TIRE MANAGEMENT: AN OVERVIEW, PART II

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***Abstract:** This paper is the second and the final part of the review paper, which investigates the used tires management research area. The available system analysis models for the used tires management as well as existing treatment options are reviewed in detail. The distribution list of journal papers published in the period 2006-2017. in peer-reviewed international journals is created to identify primary and secondary publication outlets. Finally, on the basis of the performed review, several important recommendations for the future research are highlighted and briefly discussed.*

Keywords: *review, content analysis, used tires, modeling approach, treatment options.*

1. INTRODUCTION

Rapid social, economic, environmental and technological changes brought human society in front of unprecedented challenges and the need for waste valorization. The problem of managing used tires has become very serious and wide-ranging scientific research efforts are made to reduce their negative impact on the environment. In fact, an effective used tires management is considered vital for mitigating the effect of the continuously growing number of used tires.

This paper is the second and the final part of the review paper, which investigates the used tires management research area. In this part, the available system analysis models for the used tires management as well as existing treatment options are reviewed using the content analysis method. On the other side, in the preceding paper named Used tire management: An overview, part I, legislation-oriented research, industrially tested application alternatives and previous review papers, are identified and systematically analyzed. On the basis of the performed review, several important recommendations for the future research are highlighted and discussed.

2. RESULTS

2.1 Modeling approach

The increased environmental awareness has raised the investigation for economically attractive and environmentally responsive approach to management of used tires. However, the operational research of used tires management systems is still in its infancy and the literature provides only few advanced mathematical models.

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Lebreton and Tuma (2006) developed a linear programming model to assess the profitability of car and truck tire retreading process in Germany. Having in mind that LCA models are becoming important decision support tools of waste management systems, Christensen et al. (2007) created LCA-based model for integrated waste management (including used tires).

Pehlken and Müller (2009) analyzed the separation process of recycling end-of-life (EoL) tires and concluded that modeling such a process is a challenging task, because there are many uncertainties to identify. They highlighted that more research of this matter is needed. Dehghanian and Mansour (2009) proposed a three-objective linear programming model, which is able to simultaneously maximize economic and social benefits as well as minimize environmental impacts, in order to design a network of recycling plants for used tires in Iran. Kannan et al. (2009) formulated a linear programming model for minimizing the costs of a multi-echelon closed-loop supply chain for a tire manufacturer.

Sasikumar et al. (2010) developed a mixed-integer nonlinear programming model for maximizing the profit of a multi-echelon reverse logistics network for truck tire retreading. However, many modeling parameters (e.g. cost parameters) had been identified as deterministic, which limits real-world applicability of this model. Abdul-Kader and Haque (2011) had identified a tire, collection center, recycling plant and retreading plant as "agents" involved in the management of used tires and applied an agent-based simulation approach to tackle the used passenger car tire retreading problem.

Mondaln and Mukherjee (2012) used a simulation approach to plan manpower deployment for labor intensive operations of the tire retreading process. Creazza et al. (2012) formulated a mixed integer linear programming model to optimize logistics network of the tire manufacturer Pirelli. Kop et al. (2012) used the fuzzy Analytic hierarchy process to identify the most efficient EoL tire management option in a Turkish context.

Vinodh and Jayakrishna (2013) applied the fuzzy Analytic hierarchy process for weighting criteria and VIKOR for selecting the best tire retreading process for an Indian manufacturing organization. De Souza and D'Agosto (2013) proposed a conceptual model of the reverse logistics chain of EoL tires and explored financial benefits of their sending to the cement industry.

Pirachicán-Mayorga et al. (2014) analyzed reverse logistics practices in Colombia and proposed a conceptual model of the used tire reverse logistics chain. Dhouib (2014) used the fuzzy MACBETH to assess alternatives in reverse logistics for used tires. Kannan et al. (2014) presented a framework to analyze the motivating factors of EoL tire management in an Indian context and validated it with the assistance of the Interpretive structural modeling. Pehlken et al. (2014) provided a concept for developing a model of EoL tire recycling plant based on Petri nets and neural networks. Dabic-Ostojic et al. (2014) presented a tool based on Bayesian networks for making decisions whether to retread used tires or not.

Subulan et al. (2015) proposed a mixed integer linear programming model for tire closed-loop supply chain and suggested that uncertainty analysis related to various modeling parameters definitely deserves future research efforts. Bazan et al. (2015) presented a reverse logistics mixed-integer linear programming model for minimizing the costs of the tire retreading industry in Canada, which captured the costs for greenhouse-gas emissions and energy usage.

Vorasayan (2016) used the two-player game theory approach to determine prices of a certified retreaded tire with warrantee and a noncertified retreaded tire under cooperative and non-cooperative schemes. Chang and Gronwald (2016) applied four different multi-criteria decision making methods to rank numerous used tires management alternatives and identified retreading as the best option.

Amin et al. (2017) proposed a mixed-integer linear programming model for maximizing the profit of a tire remanufacturing closed-loop supply chain network in Toronto, Canada. They used

a simplistic graphical tool to assess decisions under uncertain demand and returns. Pedram et al. (2017) presented a mixed integer linear programming model for maximizing the profit of a multi-echelon closed-loop supply chain of the tire industry in Tehran, Iran. They used a simple scenario-based approach to represent uncertainties in demand, return rate and quality of used tires. Afrinaldi et al. (2017) proposed a two-objective nonlinear programming model for creating an optimal preventive replacement schedule of a bus tire through minimization of its economic and environmental impacts. Simic and Dabic-Ostojic (2017) developed an interval-parameter chance-constrained programming (IPCCP) model for uncertainty-based decision making in tire retreading industry. The proposed model can examine various admissible risk levels of violating retreading capacities. Compared with the available system analysis models, IPCCP model can incorporate much more uncertain information thus avoiding inferior decisions.

2.2 Treatment options

The primary aim of used tires treatment options is to reduce their negative impact on the environment.

The present rate of economic growth is unimaginable without saving of fossil energy like crude oil, natural gas or coal. If recycling of used tires can be made to function effectively, it represents the most desirable approach. Abdul-Raouf et al. (2009) outlined that recycling of used tires has received much attention in recent years. Wang et al. (2009) presented the current situation on end-of-life tires generation and recycling in China. They analysed the existing industry problems and proposed efficient countermeasures.

Silvestravičiūtė and Karaliūnaitė (2006) analysed the following end-of-life tire treatment technologies: co-incineration in cement kiln, thermolysis, conventional mechanical recycling, baro-destructive mechanical recycling and ultrasound mechanical recycling. Gehin et al. (2008) presented a tool for implementing sustainable end-of-life strategies in the tire development phase. Li et al. (2010) compared four different end-of-life tire treatment technologies in China from environmental and economic perspectives. The following treatment options were evaluated: ambient grinding, devulcanization, pyrolysis and tire oil extraction. Kardos and Durham (2015) outlined the need for discovering additional utilization options for used tires, since stockpiles of used tire in the United States are growing fast. Hita et al. (2016) claimed that pyrolysis of used tires is the most respectful environmental option for treatment of used tires.

One of the most popular approaches for sustainable environmental stewardship of used tires is their retreading. Retreading is especially beneficial for used truck tires, since they could be processed from three to four times. Sharma (2013) described in detail two retreading process, hot and cold, and stated that used tires retreading is profitable business in India. Bazan et al. (2015) found that retreading offers the most resource-efficient strategy for used tires, because it provides the possibility to save both material and energy.

3. DISCUSSION

The distribution list of peer-reviewed international journal papers published in the period 2006-2017 is presented in Table 1.

From the distribution list of journal papers (Table 1) it can be concluded that the primary publication outlets for the used tires management research area are: Waste Management (13.9% share), Journal of Cleaner Production (9.7% share) and Resources, Conservation and Recycling (8.3% share), jointly publishing 31.9% of the total number of identified peer-reviewed international journal papers printed in the period 2006-2017. The secondary publication outlets for the explored research area are: Renewable and Sustainable Energy Reviews (5.6% share) and Construction and Building Materials (5.6% share). From Table 1 it is evident that scientific contribution on the used tires management is increasing, particularly in the last few years. In

fact, approximately two-thirds of all collected research papers are published after 2012. Therefore, the emergence of the explored research area is more than obvious. Finally, in the past several years, numerous top-tier scientific journals have extended their aims and scopes to welcome papers from this research area, like: Progress in Materials Science (IF 2015=31.083), Omega, Expert Systems with Applications, Computers & Industrial Engineering, Applied Mathematical Modelling, Energies.

Table 1. Distribution of journal papers published in the period 2006-2017[†].

Journal	Year of publication												Total
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
Waste Management	–	–	1	–	2	1	1	2	–	2	–	1	10
Journal of Cleaner Production	1	–	1	1	–	–	1	–	–	1	–	2	7
Resources, Conservation and Recycling	–	–	2	2	–	–	–	1	1	–	–	–	6
Renewable and Sustainable Energy Reviews	–	–	–	–	–	–	–	2	–	–	1	1	4
Construction and Building Materials	–	1	–	–	–	–	1	–	–	1	1	–	4
Other (37 journals)	3	2	0	3	2	2	6	1	9	4	7	2	41
Total (42 journals)	4	3	4	6	4	3	9	6	10	8	9	6	72

4. CONCLUSION

In this research (parts I and II of the presented review paper), 72 peer-reviewed international journals papers have been categorized, analyzed and interpreted. Previous figure clearly indicates great relevance and importance of the explored research area.

On the basis of the performed review, the following recommendations for future research are provided:

- The research on *more profitable and ecologically efficient treatment options* represents interesting avenue for further research.
- Uncertainty is the key factor influencing the management of used tires. However, uncertainty analysis is mainly ignored in available research studies. It is strongly recommended to *incorporate uncertainty analysis methods into modeling frameworks*. Only in this way avoidance of erroneous decisions is secured.
- The available system analysis models based on risk-neutral approaches are unsuitable for non-repetitive decision-making problems. Effective *risk measures should be applied* to generate more reliable decision outputs.

Finally, we acknowledge that this review cannot be claimed to be exhaustive due to enacted limit in paper's length, but it does provide comprehensive insight into the state-of-the-art literature on the used tires management. Therefore, this review could provide valuable source of references for other researchers as well as extensive content analysis overview for readers interested in the highlighted research area.

ACKNOWLEDGMENT

[†] All reviewed papers (parts I and II of the review paper) are included in the presented distribution list.

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LOGIC

ECO-DRIVING – POTENTIALS AND OPPORTUNITIES WITHIN GREEN LOGISTICS

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Abstract: *In the era of logistics companies' expansion and their endeavor to maximize profit, on one hand, and environmental protection efforts, on the other, there is also a growing need to solve simultaneously different problems by taking actions in both directions and achieving a best compromise solution. Nowadays, a discipline seeking for such a solution has got its name - „Green Logistics". In this paper, the authors deal with an approach to decrease the negative environmental impact of road vehicles and drivers, whose share in harmful gas emissions is prevailing. Eco-driving initiative is one of the programs that has evolved in the literature and practice as an efficient tool to attain green logistics objectives. The research focuses on potential eco-driving benefits and good practices of logistics companies that already implemented it. Through a survey realized in logistics companies, an analysis of managers' attitudes and preferences regarding eco-driving potentials based on previous experience and/or information is realized. Likewise, this survey will highlight the current condition in this field on our market and provide guidelines for potential future actions.*

Keywords*: logistics managers, survey, driving skills, road vehicles, environmental footprint*

INTRODUCTION

The expansion of logistics activities with the aim of satisfying growing users demand results in increased road transport volumes. Road transport is one of the unavoidable links in supply chains. Besides importantly influencing logistics costs, transport is a logistics activity with an equally high impact on the environment. This is the reason for being one of the main areas for development of green logistics practices. According to TRB & NRC (2014), green logistics refers to innovations in infrastructure, organizational initiatives, or traffic management that can result in more sustainable transport. It may also include increased driver training and other behavioral initiatives. These approaches can result in significant and cost-effective reductions in transport emissions and fuel consumption. Examples of such measures that could impact light- (LDV), medium- (MDV) and heavy-duty vehicles (HDV) are access control (including lane restrictions), urban traffic control measures, road pricing, smart traffic lights that provide more information to drivers on road conditions and traffic, ramp metering, and other fleet and fuel management approaches. The main idea of green logistics is not only to know the level of harmful emissions, but also to reduce emissions and energy consumption.

Thiell et al. (2011) outline that green logistics describes all attempts to measure and minimize the ecological impact of logistics activities. This includes all activities of the forward and reverse

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flows of products, information and services between the point of origin and the point of consumption. The aim is to create a sustainable company value using a balance of economic and environmental efficiency: the so-called eco-efficiency. Green logistics have its origin in the mid 1980's and was a concept to characterize logistics systems and approaches that use advanced technology and equipment to minimize environmental damage during operations.

This paper initially focuses on the eco-driving concept for influencing driver behavior and increase logistics and transport energy efficiency, while decreasing company's environmental footprint. Then, an insight into eco-driving in the field of HDV shows estimated and measured effects through worldwide experiences of logistics companies, as well as their future prospects. Subsequently, the present situation in the field of Eco-Driving Training (EDT) in Serbia and experience-based attitudes of logistics companies' obtained through an online fleet manager survey will be presented. Finally, important conclusions will be drawn including a set of short-term recommendations to overcome presently observed difficulties.

ECO-DRIVING CONCEPT AND TRAINING

Eco-driving, an environmentally friendly and cost-effective driving style, involves safe and responsible driving technique with minimum fuel consumption. It is a driving style adapted to contemporary vehicles and infrastructure technology including effective use of Advanced Driver Assistance Systems (ADAS), as well as available Intelligent Transport Systems (ITS).

As stated by Killian (2012), eco-driving evolved in the USA from the "hypermiling" originally applied in the Mobil Economy Run - an annual coast-to-coast road trip and demonstration taking place from 1936 to 1968, where the idea was to exceed a vehicle's fuel efficiency by modifying driving habits and adopting new techniques. Although not called by its current name, eco-driving was well present during World War II, the 1970's and 1980's oil crisis and later in times of worldwide fuel prices volatility. But as Barkenbus (2010) states eco-driving should be distinguished from hypermiling. While they share the same goal of reducing vehicle costs, they differ in terms of tactics. Hypermiling often involves downhill coasting (turning the ignition off) and drafting by getting as close to the vehicle in front as possible. Clearly hypermiling trades off safety for fuel economy, while with eco-driving there is no tradeoff. In Europe, eco-driving as an idea was initiated in Finland where two state-funded training programs were introduced in 1992: EcoDriving (for passenger car and van drivers) and KEY (for bus and truck drivers). Finland was followed by the Netherlands in 1995 and Germany in 1999. By mid-2000's United Kingdom, Austria, Italy, Poland, Spain, Greece and other European countries followed the path.

EDT has three goals to: 1) improve driving skills and use of latest technological solutions, 2) minimize fuel consumption and extend vehicle/components lifecycle, and 3) enhance safety. Thus, highly influential Barkenbus (2010) gave a general definition of eco-driving characteristics consisting in *"accelerating moderately, anticipating traffic flow and signals, thereby avoiding sudden starts and stops; maintaining an even driving pace (using cruise control on the highway where appropriate), driving at or safely below the speed limit; and eliminating excessive idling."* although referring to passenger car drivers, it is widely applicable.

In matter of MDV and HDV, according to ECOWILL (2013), there are several principles and techniques each driver should know to minimize (fuel) consumption **while driving**: 1) anticipate to avoid unnecessary acceleration or braking, 2) keep steady (lower) speed in highest gear at low RPM avoiding speed fluctuations, 3) apply engine brakes/retarders instead of braking, 4) shift up gears the earliest possible, including block shifting/skipping gears, 5) minimize idling, 6) use cruise control, 9) minimize use of air conditioners and electric equipment, and 10) avoid opening windows at high speeds; as well as **before driving**: 1) plan trip to avoid congestion, 2) monitor energy efficient tires' condition and inflation, e.g. by using tire pressure monitoring system (TPMS), 3) adjust aerodynamics devices (deflectors), 4) avoid overfilling the fuel tank, and 5) ensure proper and timely maintenance.

There are two approaches to EDT through: drivers' licensing or short training courses. In ECOWILL (2013) project, European eco-driving standard regarding eco-driving lessons directed at learner drivers and conducting short duration EDT for licensed drivers was compiled. Moreover, Croatia started an EU funded project for eco-driving curriculum conception for specialist secondary education with a schoolbook (Perotić et al., 2013) involving teachers and future specialist trainers. As stated in DfT (2010), SAFED and other short-duration EDT courses consist of two segments: theoretical lessons and practical (driving) exercises. Theory highlights basic principles, information and projected effects of economical and environmentally friendly driving, as well as all basic eco-driving tips. Practical exercises consist in driving the same route twice (i.e. rides): first prior to theoretical lessons, without trainer assistance and second after lessons, with trainer suggestions and interventions. After both rides fuel consumption, time taken and number of gear shifts are recorded, analyzed and further recommendations are drawn. Some EDT sessions rely on ADAS and on-board Fleet Management Systems (FMS).

Momčilović and Cvetković (2015) outline that the EDT should be supported by follow-up programs for driving skills correction and preservation of acquired knowledge and skills. It is shown that only months after training, the motivation for eco-driving decreases and drivers return to old driving habits and practices. It is therefore crucial for fleet managers to engage drivers into a sort of eco-contest and based on results reward those committed to eco-driving principles or to periodically repeat the training for the others.

ECO-DRIVING TRAINING POTENTIALS AND EXPERIENCES

Although some vehicle manufacturers promote and even ascertain higher fuel savings than 20% especially for HDV drivers, Barkenbus (2010) stresses that in normal driving practices, longer term fuel savings should be calculated at 5% without follow-up support beyond initial training and 10% with continuous feedback. Accordingly, ECOWILL (2013) revealed average fuel consumption on the day of short-duration training was reduced from 9.2% to 18.0%, with a weighted mean of 14.0% in all 13 countries. The long-term training effect for daily driving is estimated, based on experiences of other initiatives, to be around 7.5%. These results are consistent with values reported in the UK Freight Best Practice case studies. In numerous case studies, companies and drivers commonly reported an average fuel efficiency improvement of 5%, with actual results ranging from 1.9 to 17% improvement. According to HDV producers and their eco-driving trainers' attitudes, shown in Momčilović and Cvetković (2015), immediate EDT effects range from 5% to 15%, while only a few drivers may attain fuel savings higher than 20%. Moreover, DfT (2010) gives proof that EDT influences even the best HDV drivers in two UK logistics companies: largest milk delivery whose 2 best drivers participated EDT and although only one reached fuel saving (11%) and the other did not, both decreased gear changes by 19% and 42%; and a distribution company whose best driver improved fuel efficiency by 1.18%, gear changes by 4% and decreased number of faults by 66%. EDT implementation costs is expected to be recovered within half a year to one year. A three-day EDT conducted in Užice (RS) in 2011 with two of the best drivers on a 40 t truck and semi-trailer, described in Momčilović and Cvetković (2015), lead to immediate fuel savings of 2.7% and 4.4%. On the entire fleet of 80 trucks fuel savings were projected at 10%. Further analysis of operation data in 2013 revealed that same drivers degraded their driving style, due to lack of appropriate monitoring, regarding fuel consumption and idling compared to EDT results, but improved the use of cruise control.

As for the future, Transport & Mobility Leuven (2017) states that HDV driving can be optimized by built-in systems, communication systems with other vehicles (V2V) and infrastructure (V2I) and by driver training to: 1) change their behavior and 2) optimally use ADAS and ITS systems. Among other options, logistics and supply chain organization and legislation can be optimized or fundamentally modified with the aim of minimizing fuel consumption. Measures include

improving vehicle load factors, routing, driving at fuel efficient speeds, or using more digital or collaborative transport and logistical solutions. So, EDT will be unavoidable in the future, too.

ANALYSIS OF PRESENT ECO-DRIVING PRACTICES IN SERBIA

An anonymous online survey named "Environmentally and cost efficient driving" was realized in March-April 2017, involving fleet managers from 57 logistics and freight transport companies. The aim of the survey was to collect fleet managers' attitudes and raise their awareness on environmental and financial effects of EDT. They were asked about their number of drivers, fleet size (per categories, i.e. LDV, MDV and HDV), the average annual mileage, dominant transport operations (urban delivery, national and international), and whether (and how, if yes) they currently monitor fuel consumption. Afterwards, they expressed their attitudes toward EDT considering fuel savings, safety and environmental effects, as well as negative impacts on delivery delays or additional driver burden. They had also to estimate immediate fuel savings and expected investment return period. Note that authors suggested to survey participants the aforementioned likely fuel saving percentages: 5% for superior drivers up to 20% for inferior ones. Participants shared if they previously trained their drivers (and reasons, if not) and their experiences with EDT results. The authors decided to illustrate survey results regarding EDT accomplishment by drivers and meeting company's expectations (Fig. 1), as well as the percentage of fuel expected to be saved by EDT (Fig. 2) for the entire survey sample.
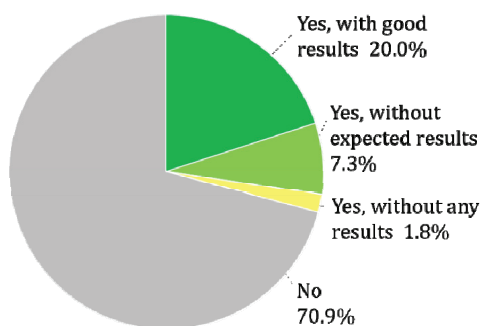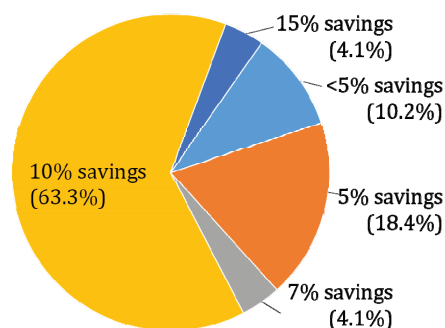

Figure 1. EDT accomplished   Figure 2. Expected fuel savings from EDT

It is obvious from Fig. 1 that the majority of companies did not train their drivers for eco-driving, but from those who did, the greater part were satisfied by the attained EDT results. Majority of managers consider fuel as the most important saving, but some state vehicle components (tires, brake pads, etc.) longer lifecycle, accident prevention and savings in maintenance and repairs. As reasons for not setting up EDT, they stressed backup drivers' shortage, lack of drivers' time for training, drivers' fluctuation, inexistence of reliable training centers, intolerance for longer return of investment period, and previous unawareness of existence and effects of such trainings, etc. The unawareness about EDT is logical since not many training institutions exist, neither the state has put enough stress on this issue. As for Fig. 2, the vast majority opted for 10% fuel savings, but almost ⅓ of respondents (32.7%) expect less than 10% savings: partly considering their drivers' quality, other part being more realistic in expecting important savings due to the present business conditions in Serbia.

For the remainder of the analysis, we have selected HDV as major fuel consuming vehicle category and important harmful and greenhouse gas (GHG) emitters, to display related survey results. The companies whose fleet managers' survey results and practices will be shown in Table 1 and analyzed in detail later are those where the total HDV fleet annual mileage was superior to 5 million kilometers. Let those companies be denoted by C1 – C7.

Table 1. Selected EDT survey respondents' data

	C1	C2	C3	C4	C5	C6	C7
Number of drivers	85	73	140	64	58	35	100
Total fleet size	81	62	134	54	60	64	100
LDV / MDV / HDV	0/3/78	0/2/60	5/0/129	9/0/45	4/0/56	9/5/50	6/2/92
Urban/National/International operations [%]	2/8/90	1/1/98	0/0/100	5/10/85	5/10/85	10/30/60	10/10/80
HDV annual mileage [km]	135,000	121,200	105,000	115,000	100,000	100,000	125,000
Fuel monitoring method*	a/b/c/d	a/b/d	b	a/b/d	a/d	a	b/d
Expected fuel savings [%]	5	3	5	10	10	15	1
Drivers accomplished EDT?	yes	yes	yes	yes	yes	no	yes
EDT fulfilled expectations?	no	yes	yes	yes	yes	/////	yes
EDT is necessary?	yes	yes	yes	yes	yes	yes	yes
EDT is affordable?	yes	yes	yes	no	yes	yes	yes
Investment return period (months)	3 - 6	3 - 6	≤3	≤3	12 - 24	3 - 6	≤3

* a - per vehicle monthly; b - per vehicle per refueling; c - per driver monthly; d - per journey

Regarding Table 1, from selected survey respondents all except C6 accomplished EDT and only C1 considers that it did not fulfilled the expectations. Although considering EDT necessary, C4 considers it not affordable, which seems conflicting with his/her statement about fulfilling expectations, but it is consistent with his/her unreasonably short period for investment return of less than 3 months (same as C3 and C7). Although C1, C2 and C6 are optimistic regarding investment return (3-6 months), only C6 has enthusiastic expectations for fuel savings (15%). From selected fleet managers only C5 is reasonable vis-à-vis investment return.

The respondents were asked about the following 7 attitudes toward EDT, i.e. if they considered it: 1) *fuel efficient driving* where 6 of them agreed, while only C6 partially agreed; 2) *safer driving* where C1 and C6 partially agreed, while the rest agreed; 4) *driving skill upgrade* where four of them agreed (C1, C2, C3 and C7), two partially agreed (C4 and C5), and only one (C6) disagreed; 5) *slower driving and potential delivery delays* where only C3 partially agreed and 6) *additional driver burden* where only C5 partially agreed, while all others disagreed. All 7 agreed about being 3) *a way to safeguard the environment* and not being 7) *unnecessary company expenditure.*

To be able to perform the what if analysis for the selected sample, we should first set some basic calculation assumptions. Let fuel consumption of a HDV (40 t truck and semi-trailer) be 28 l/100 km for all companies and let the diesel price in Serbia be 1.23 €. Total annual mileage of all companies' HDV's being 58.622 million km. For a 5% fuel saving it would then cut the fuel cost for 1.009 M€, while for 10% the saving would make 2.019 M€. If we apply their expected fuel saving rates (shown in Table 1) the total annual fuel cost savings for 7 selected companies for 510 HDV's would be 1.159 M€, which in average would amount to 2,271.97 € per vehicle.

CONCLUSIONS AND RECOMMENDATIONS

EDT is an important topic in developed countries having in mind the foreseen efforts to reach internationally agreed projected emission and energy consumption thresholds for road transport. An essential non-technological measure to attain its long-term sustainability is definitely the eco-driving initiative. This topic is still of high relevance in the European research community, continuously from 2006 onward, having drawn important financial resources mainly meant for cross country actions and wider awareness raising through EU-funded projects as: ECODRIVEN (2006-2008) 1.44 M€, RECODRIVE (2007-2010) 1.18 M€, ECOWILL (2010-2013) 2.90 M€ and ACTUATE (2012-2015) 1.01 M€. There is a strong political support worldwide to this practically soft and inexpensive measure. Serbian government recently

recognized the power of eco-driving in the third Energy Efficiency Action Plan as a measure to impact mileage intensive government employees and public bus drivers, with a vision to include eco-driving in the driving license requirement.

Among all survey respondents and potential benefiters from EDT, there is a positive feeling toward this measure and its influence, although not all respondents were aware of its potential short- and long-term effects. Besides awareness raising of fleet managers in logistics and road freight, another positive aspect of this survey is that 55.6% of respondents recognizes additional benefits beside fuel savings to invest in EDT. Some of those include: generally better trained drivers, safer driving, lower maintenance costs, longer vehicle lifecycle period, etc. The lower environmental impact still is not of great interest to fleet managers, of course, if it is not accompanied by profit or cost cutting related measure.

As for recommendations, eco-driving program should be considered for inclusion in specialist secondary schools curricula in transport and motor vehicle related education. Regarding EDT financing it is recommended that either state provide subsidies to relevant logistics and transport companies, either companies themselves dedicate funds for professional driver training, which having in mind mentioned potential cost savings should be easily refundable in one year at most. On one hand, drivers should commit to stay certain period in the company that financed their EDT e.g. at least one year to be exempted from repaying the training, while on the other hand companies should invest in their training anyway, because they should not ask themselves: what if I train them and they leave, but what if I don't and they stay?

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Part VII   STUDENTS' PAPERS

LOGIC

INTERMODAL TRANSPORT IN THE STRATEGIES FOR THE DANUBE REGION

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Abstract: Intermodal transport (IT) plays a very important role in the EU transport policy. In order to achieve IT's more efficient and effective implementation, international and national development strategies are defined. The principles and objectives of the national strategies should be in accordance with international strategic documents, and at the same time adapted to the specific conditions. Logistics and IT play a significant role in achieving sustainability and high quality transport services in Europe. However, treatment of these areas vary significantly across countries, and in some strategies IT does not merit any attention. The aim of this paper is the analysis of IT in the strategic documents of the Danube region countries by placing emphasis on the mutual disagreements , advantages and disadvantages.

Keywords: intermodal transport, logistics, strategic documents, Danube region

1. INTRODUCTION

Sustainable and efficient transport system (TS) is the main objectives of the EU transport policy (EC, 2011). One way of achieving this goal is the development of intermodal TS and raising awareness of its importance. IT is the system which implies "door-to-door" transportation using at least two modes of transport, without changing the factory handling units, such as containers, swap bodies, parts of or the complete vehicles (Zečević i Tadić, 2015). In this way, the more environmentally friendly modes of transport such as rail and water transport are added to the road TS, which is now dominant.

In order to meet the industrial and individual needs in terms of transport, national and international institutions enact strategic transport documents. Attitudes, goals and measures can vary significantly depending on the strategy and its character. In order to achieve unity and overall efficiency of the entire transport network (TN), compatible infrastructures, adequate regulations and the precisely defined objectives and measures must be provided.

The Danube, the second longest river in Europe, connects Central Europe with the Black Sea via the Republic of Serbia. Danube, alongside the rivers Main and Rhine, makes the so-called European channel which provides a connection between the North sea and the Black Sea, where there are significant freight and transport flows. Countries of the Danube region are Germany, Austria, Slovakia, the Czech Republic, Hungary, Bulgaria, Romania, Slovenia, Croatia, Serbia, Bosnia and Herzegovina (BiH), Montenegro, Ukraine and Moldova. This part of Europe represents an important resource for the development of IT and efficient logistics. Economic,

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natural, traffic and other resources are underused, and with the aim of strengthening and increasing the attractiveness of the region there is a need to adopt adequate strategic documents which will be discussed in detail in this paper. The paper is organized in two chapters. The first one analyzes the importance of IT in the international strategic documents while the other one deals with the national.

2. INTERMODAL TRANSPORT IN INTERNATIONAL STRATEGIC DOCUMENTS

This chapter analyzes the importance and place of IT in international strategic documents that are the basis for further planning in the field of IT. The dominant makers of these documents are the EU and its authorities, but there are also various international organizations and associations.

White paper (EC, 2011), an umbrella strategic document in the field of transport, encourages the creation of a competitive and sustainable TS. The European Commission (EC) in this document focuses on safety, security and environmental standards in transport worldwide, defining the objectives to be achieved by 2050. One of those goals is to maintain climate change below 275K. As one of the measures to achieve this goal they plan to reduce gass emissions by 80 to 95% compared to the level of 1990, and to shift 30% of road freight over 300 km to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050. As a way of achieving an efficient TN they plan to invest in the development of remote and intercontinental transportation, fully functional multimodal trans-European Transport Network (TEN-T) across the EU by 2030, and a network of high-capacity and high quality by 2050 with a corresponding set of information services. In addition, one of the goals is to create the appropriate framework to enable the tracking of goods in real time, the use of IT and "clean" modes of transport, as well as providing support to institutions and promotion of railway, waterway and IT. It sets the framework for the future decision-making.

EC brings document which primarily analyzes the market of combined transport (CT). By analysing the previous and the current state of road, railway and water transport, the development of CT is predicted. There, it is stated that the state of CT is the following: most policy-makers wish to see it play a much greater role in addressing the freight-related issues of transport in the EU; many end users would like to see it become much more commercially attractive; but relatively few customers actually use it, and often without any great enthusiasm (EC, 2015). CT is promoted within the EU through the Council Directive 92/106/EEC of 7 December 1992 (CT Directive) on the establishment of common rules for certain types of CT of goods between Member States. The CT Directive is the main instrument to shift long distance road transport to other modes and contributes to the achievement of the White Paper transport's goal. CT Directive seeks to promote CT operations through inter alia liberalisation of road cabotage, the elimination of authorisation procedures for CT, as well as financial support through fiscal incentives for certain CT operations. The analysis of CT-related support programmes shows that two measures may not only deliver strong growth effects for CT operations but could be applied in every Member State as well: aids (direct grants) for CT operations and direct grants for the construction of CT terminal infrastructure. Both incentives can reduce the total costs of CT operations considerably-cut terminal-to-terminal transport costs by up to 50% or reduce transhipment cost by €30 or more per load unit handled at CT terminals.

IT is also the focal point of the Western Balkans Intermodal Study (City Net, 2016) which deals with Southeast European (SEE) region. Through discussing of potentials of IT of Albania, Bosnia, Kosovo, Macedonia, Montenegro and Serbia the integration of the main corridors and terminals of these countries is encouraged. In order to achieve an efficient TN and high-quality supply chain, a high degree of cooperation and coordination between these countries must exist. The poor, divided and heterogeneous infrastructure in terms of quality is seen as the main problem.

Another major problem cited is institutional obstacles such as bad traffic institutions, poor organization, lack of skilled personnel and lack of departments that will specifically deal with the issue of IT. Of all the countries in the SEE region, only Serbia has a department for IT, which is also integrated with the department of railway traffic. When there are no adequate institutions, the logical conclusion is that none of these countries has a high-quality transport strategy.

Some strategic documents even go a step further in addressing the problems of IT. The port is specified as the source of the problem and a place where significant changes and optimization can be made (Berg, 2015). Benchmarking is also mentioned as the main tool for overcoming the problems that arise during the implementation of IT. The methods and the problems that may arise in the application of this concept are introduced, presenting benchmarking as a key to access transport chain performance (OECD, 2002).

Referring to the White Paper (EC, 2011) the European Parliament conducts research and delivers a document that through analysis of the logistics activities and infrastructures of major European corridors initiates the integration and creation of a unified and efficient TN. It states that the existing state of IT is unsatisfactory and that this mode of transport will constantly develop in the future although very slowly and road transport will continue to be the dominant. The result of this research is the logistics action plan with 34 measures specified for its achievement (EP, 2016) . Measures are related to the improvement of the TS in the EU in six areas: intelligent transportation systems (ITS) and e-Freight, sustainable quality and efficiency, simplification of transport chains and vehicle dimensions, loading standards and green freight transport corridors and urban freight transport logistics. The objective is to develop a framework for an optimal integration of different modes so as to enable an efficient and cost-effective use of the TS through seamless, customer-oriented door-to-door services whilst favouring competition between transport operators (EC, 1997). Intermodality does not aim or relate to a specific modal split, but addresses the integration of modes at three levels: infrastructure and transport means ("hardware"), operations and the use of infrastructure (especially terminals), and services and regulation (from a modal-based to a mode-independent framework). For example, actions for infrastructure and transport means are intensifing intermodal design of the TEN-T enhancing design and functions of intermodal transfer points and harmonising standards for transport means. Final goal is to form coherent european TN (SETA, 2013).

3. INTERMODAL TRANSPORT IN TRANSNATIONAL STRATEGIC DOCUMENTS

Although the importance of IT is well known, countries treat this field differently depending on their development level. Motive for reasearch on this subject is unadequate treatment of IT within national strategic documents (NSDs). Danube region countries exept Austria and Slovakia were analyzed. Austrian NSD was not avaiable while Operational Programme Transport 2007-2013 of Slovakia (MoTPT, 2007) is outdated.

Strategic plans are implemented trough realization of defined objectives. Objectives of NSD should be in accordance with those of transnational but at the same time measures concerning objectives must vary depending on each specific situation within countries. It is not rare case that less developed countries copy parts of developed countries documents in ther own (MoTMT, 2010; Dornier Consulting et al., 2016). NSDs that paid the most attention to IT are German and Romanian, Slovenian and Czechian. German and Romanian differ from other NSD by aproach and extensiveness of analysis.

As the lieder in logistics, Germany is a step ahead when refering to defining objectives and their ineterconnection defining 5 high level objectives and from 4 to 6 lower level objectives for each one at the higher level. Concise and simple to interpret, Germany has following objectives: (1) efficiency of all modes and strengthening Germany as a logistics centre; (2) exploiting the strengths of all modes of transport; (3) promoting the compatibility of transport growth with

environment protection (FMoTDI, 2010). Unlike other NSDs it has the smallest number of measures relating to infrastructure. Attention is brought to enacting new and updated NSDs, promotion of modes and institutional framework, optimization of maritime transport and long-haul road haulage, operations at loading ramps and management on motorways. The most important objectives are to improve the framework for CT and fund innovations, capacity enhancements in IT and to analyze the potential for multimodal transport (MT). Proposed measures for those objective are: (1) the system of funding for CT placed on a new footing by means of amended funding guidelines; (2) programmes to fund innovative technologies; (3) comprehensive study conducted to examine the potential for (MT); (4) modal shift options. Institutional framework followed by strategic documents makes Germany stand out from other countries. In addition, documents review previous ones regarding achivements of defined goals. Besides specialized assosiation for CT, Germany set „Federal Government Coordinator for Freight Transport and Logistics" and assosiations with main duty to promote eco-friendly modes. Assosiation for CT in Serbia is established as dependent company of Serbian Railways. Its services are not avaiable to find on the Internet unlike for those of Germany, Austria, Czech, Croatia, Romania and Slovenia. After the analysis it is concluded that Germany has got a regulated system and much more experience with NSDs and less measures on the operational level as opposed to for example Montenegro (146) and Croatia (180), Moldova (77) and Romania (91) (MoTMT, 2010; MoMTI, 2014; GovMD, 2013; AECOM Ingenieria SRL, 2014).

Examples of objectives that have priority over those of other NSDs are infrastructure efficiency and integration in EU TS, improvement of connections within country borders and management of transport (MoTITC, 2010; MoMTI, 2014; GovMD, 2013). Infrastructure measures are defined per modes. For instance, measures concerning railways are: (1) build a private (industrial) track; (2) enhancment of maximum axle pressure; (3) electrification, reconstruction and building of new railway tracks in order to meet the requirements of TEN-T network or EU standards (AECOM Ingenieria SRL, 2014; MoMTI, 2014; MoI, 2014; MoT, 2013; MoTTE, 2007). Evidently, objectives concerning IT directly are rare. Besides the aforementioned in German NSD, there are two within Hungarian document: Increasing the ratio of goods transported by CT and improving efficiency of intermodal LC.

Discrepancies regarding terminology must be noted. In some NSDs there are no differences among MT, CT and IT. Croatia defined „6 main strategic multimodal objectives and 28 specific multimodal objectives integrating each main objective evenly" (MoMTI, 2014). There are none conserning MT or IT as in German NSD although there are some measures relating to it.

Balkan non-EU countries, Serbia, BiH and Montenegro concur in their NSDs about investments and adjustments of infrastructure to meet EU standards (GovSRB, 2008; BiH Parliament, 2016; MoTMT, 2010). Main objectives of NSD of Serbia are: (1) freight flow planning and controlling; (2) reduction of environmental pollution; (3) increasing level of safety and TS efficiency (GovSRB, 2008), similar to BiH NSD. The difference is that the objectives in second are concretized. BiH NSD objective concerning improvement of TN efficiency is construction of motorways where higher speed limits will be allowed. Soft measures regarding it are definition of framework for implementation of EU freight corridor on Western Balkan (BiH Parliament, 2016). In order to attain efficient TN, Montenegro adds that government traffic institutions encouraging privatization of traffic companies, commercialization of services regarding maintenance and construction of transport infrastructure are needed (MoTMT, 2010). Thus, measures are setting connections between national transport sector institutions and institutions from other countries and providing adequate knowledge exchange. Among these countries, the minimum attention to IT was paid by BiH. NSD of Montenegro states that reconstruction and building of new IT terminals and provision of financial and economic incentives for use of IT are of much importance. In order for IT to be competitive, improvement of technical and technological process at border crossings and terminals as well as in railway infrastructure are

needed alongside with stimulation of road carriers providing services at the ending and starting parts of transport chains i.e. transport to and from terminal (GovSRB, 2008).

Each objective has to have the following defined: (1) responsible parties and authorities; (2) measures and actions; (3) time frame for implementation; (4) performance indicators. Although it is desirable for measures to have defined financial value and defined time frame for implementation, only few of NSDs have those covered (GovMD, 2013; MoT, 2013; FMoTDI, 2010).

Finally, IT needs to be viewed as a system that consists of standardized loading units and means of transportation, infrastructure and organization, network of terminals and LC, telematics and logistics strategies (Zečević i Tadić, 2015). Objectives and measures should be brought after the detailed analysis of aforementioned. If attention is not paid to all of IT subsystems, system has a weak link and is only strong as that link.

3. CONCLUSION

In order to solve the problems regarding IT, one has to be familiar with elements that IT consists of. TN shouldn't be observed only within the country borders since its purpose is international. Thus, NSDs have to be in accordance with transnational strategic documents and must make allowances for the development and support of IT since it is good for solving environmental and traffic flow problems but also cost effective. Based on the research, it is concluded that most of the countries i.e. their governments aren't familiar with the field of IT. Some of them have strategies that are similar to other countries and do not fit their own. Without support of regulatory documents and IT solutions, IT is harder to implement. Development strategy that does not consider IT basis could define neither problems nor solutions. Governments should pay greater attention to this field, conduct researches and consult private sector and scientists if improvements want to be achieved.

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LOGIC

LOGISTICS OF DAIRY PRODUCTS: THE CASE OF DELHAIZE SERBIA

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Abstract: Planning, management, realization and control of logistics chains of perishable goods, in which milk and milk products are included, represent exceptionally complex tasks. Characteristics of these goods set specific demands for every grummet of the chain, but efficient realization requires certain knowledge, skills, technology and continuous conditions control, primarily of temperature. In order to understand complexity of dairy logistics chains better, in this paper all processes and activities which occur during the supply of the stores of Delhaize Serbia are analyzed.

Keywords: Dairy products, Logistics, Cold Chain, Distribution center, Retail.

1. INTRODUCTION

Dairy products are part of perishable goods and are only some of the goods which require certain temperature. Perishable goods can be divided into two types: living products (fruits, vegetables, seafood, etc.) and non-living products (meat, dairy products, frozen products, etc.). Controlling and monitoring the temperature are crucial in order to prevent goods from spoilage (Donselaar et al., 2006; Joshi et al., 2011). Today, perishable products are especially important for the retailers in order to increase their profitability, and quality of the products is the reason why customers choose one retailer over the other (Thron et al., 2007; Joshi et al., 2011). First of all, when talking about cold supply chains, besides product, which is the subject of the certain chain, is temperature. The temperature is the main parameter when talking about cold chains. It is very important to monitor the temperature throughout the whole chain because this parameter determines shelf life for cooled and frozen goods (Bigaj & Koliński, 2017). There are several ways of monitoring the temperature throughout the whole chain. In this paper only two of them will be mentioned. One of them is RFID technology, which uses RFID tags, which are placed together with the product which is being transported. Information about the temperature can be extracted at any point, which helps determining any temperature fluctuations. Another advantage that this technology provides is reducing costs of unloading goods which is not for human consumption anymore due to temperature fluctuations. Another technology which is used in order to monitor the temperature is based on Time-Temperature Indicators (TTI) usage. These indicators, which are attached to the product, are relatively new solution and are not expensive. In case some mechanical, chemical, enzymatic or microbiological reaction occurs, the indicator's label will change the color (Bruzzone et al., 2005; Olivia & Revetria, 2008). Because of everything previously mentioned, management of the cold supply chain is very important task which requires not only certain individual skills, but also cooperation and information sharing between entities in supply chain. In order to understand better the complexity and problems

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which occur in cold supply chains which are managed by Delhaize Serbia, in the following part of this paper one centralized supply chain of dairy products made in Serbia is analyzed.

2. DELHAIZE SERBIA

Ahold Delhaize is one of the biggest retail Group in the world. In Serbia, Ahold Delhaize is doing business through Delhaize Serbia company. Delhaize Serbia has more than 11,900 associates who serve more than 1, 2 million customers in 404 stores. In Serbia they are known for brands Maxi, Tempo and Shop&Go.

There are three types of retail stores, three formats, which differ significantly as flow generators. Tempo format consists of hypermarkets with average size of 4,200 m^2 and average size assortment of 21,500 products. These hypermarkets, mainly located in the suburbs, are open 24 hours a day and the prices of the products are low. There are altogether 12 Tempo hypermarkets through Serbia. Maxi format represents 210 traditional family supermarkets located all over Serbia. Supermarket's average size is 531 m^2, and the average assortment consists of 6600 products. Product prices are a bit higher than in the Tempo hypermarkets. Shop & Go format stores are the type of corner shop, with the average size of 120 m^2 and an assortment of approximately 2,500 products. In total there are 161 stores in this format. Stores of this format are intended for customers who want a quick and easy purchase, and in line with that, prices are higher.

The construction of a distribution center in Nova Pazova, 2015, created the opportunity to build a centralized supply system (85% of all deliveries), which made traceability of information, processes and activities along the entire supply chain. According to some specific characteristics, a small part of articles belongs to decentralized supply system.

Delhaize Serbia divided their articles into five basic groups: Dry food - food products that do not require specific temperature conditions (ambient mode); Non-food - non-food products; Perishable food - the products that have a short shelf life and require specific temperature control; Frozen food - products that require deep freeze and Fresh food - products that require certain temperature conditions, for example meat, fruit and vegetables.

The centralization of supply varies according to product groups. Dry food group has the centralization of 76%. Products of The Coca-Cola Company, the Knjaz Milos company, as products of low value and high volume, and therefore the high cost of transportation, are exceptions and their supplies are still done directly from a supplier. In addition, due to packaging which requires reverse flows, supply of beer is made in a decentralized way. In the non-food category, centralization has reached 59%. Seemingly, a small percentage is determined by the specificity of the type of goods. In fact, this category is characterized by a very large assortment, which varies widely depending on the size and the type of retail store. Percentage of centralized supply of products from the Perishable food is 83%, i.e. eggs and bakery products are delivered directly from suppliers. Frozen food group is centralized by 44%. Fresh food category is almost completely centralized (98%), and only fresh fish is delivered directly from suppliers to special shops with the division for fish. Such a considerable degree of centralization is the result of Delhaize Serbia tendency that the quality of the product apart that company from the competition and to be recognized by this category of foods, which is of great importance to their consumers. Due to the specific characteristics, an analysis of supply of company retail stores of diary product is performed bellow. Dairy products belong to the group of perishable food that require temperature from 0°C to 8 °C during transport.

3. SUPPLYING STORES WITH DAIRY PRODUCTS

Supplying stores with dairy products are 100% centralized for the main suppliers. Four main suppliers ("Imlek", "Meggle", "Silbo" and "Somboled") are delivering goods to the distribution center (DC) in Nova Pazova, where the goods are stored, picked according to demand and delivered to the stores. In order to increase assortment and fulfillment of the customer's demands, smaller, local suppliers are supplying local stores, i.e. up-country stores, directly.

Milk buyers are at the beginning of the logistics chain (which buys milk from smaller producers in region) or bigger, registered milk producers. Next one are the factories that are engaged in the production of dairy products and which are delivering goods to the DC of Delhaize Serbia or perform direct deliveries to up-country stores. At the end of the chain are stores that are in direct contact with customers.

Business ties between the participants, are realized by e-mail or through a procurement specialist who is filling in and forwarding orders to the suppliers. In addition to this, the company has implemented the SAP (Enterprise Resource Planning application software), which is primarily intended for internal communication within the company itself.

Reverse flows which occure in this chain are the flows of loading and handling units, expired or damaged goods. EURO and Roll pallets are the ones that are used in dairy products chain. Goods that have expired or have been damaged, are returned to the DC. It is arranged with the suppliers that there is no goods returning, which means that all of the returned goods need to be sorted in the DC and then handed over to specialized companies for processing, disposal or destruction. Reducing this kind of reverse flows can be achieved with the specially organized sales stickers which are labeled on items, and represents the percentage of price reduction.

4. ANALISYS OF THE PROCESSES AND ACTIVITIES IN DAIRY PRODUCTS CHAIN

The whole process starts with negotiations between Category Management of Delhaize Serbia and producers. When choosing producer to work with, his reputation, reliability and quality are very important. After selection of the potential suppliers, contracts are being signed, assortment, product specification, indicative quantities, prices, sales and expiry date at the moment of delivery are being defined. The policy of the company is that goods can be accepted only if 10-30% of the expiry date has not passed in the moment of delivery, depending on the type of goods. After successful negotiations, information about arranged items are being sent to the logistics sector, department of planning, forecasting and procurement which are ordering items according to the market demand.

Ordering goods from the supplier is done through application which automatically sends filled order using e-mail that is already in the system. Assortment and quantities depend on store demand, the current state of the stock, goods that are already on their way to the stores, defined delivery schedule, etc. Also the company has a 450 items assortment of this kind of goods, approximately 5-10 items per suppliers that supply local (up-country) stores and over 100 items per main suppliers. Delivery deadline from manufacturer to the DC for this type of goods is 24h.

Goods delivery from suppliers to the DC is done by trucks while products are placed on EURO pallets. During delivery there are 32-33 pallets of milk and dairy products. Delivery dynamic for the main suppliers is daily – every working day, from Monday to Saturday. On a daily basis average size of delivery to the DC is 450 pallets of dairy products.

Quantitative and qualitative controls are done when receiving the goods. Quantitative control is done by counting received packaging. Qualitative control is performed by technologist who is measuring and controlling the temperature of the cargo box of the vehicle, documentation and expiry date listed on the product. During delivery of milk and dairy products, only temperature of the cargo box of the vehicle is being checked. Based on this temperature (up to 8º C) it is

determined whether goods can be accepted or not. The percentage of declined goods due to inadequate temperature is negligible.

Upon completion of the receipt of the goods, it is being stored. For storing dairy products in the DC a 460 m^2 area is provided. Goods are stored in selective racks at higher levels, where it is lowered to the picking area if necessary. Lowering the goods from the storage zone to the picking zone is done on the principle of FEFO.

Stores are ordering goods by requisition for the next day on daily basis. Daily number of orders is equal to the number of the stores that are owned by the company, and is now around 404. After processing all of the requisitions, a picking order is formed, whose number is equal to the number of the orders placed by the stores. When picking, S-shape strategy is used. All picked goods are then placed on roll pallet and are ready for loading and distribution.

After receipt goods are stored and then picked according to the stores orders. Picking technology is picked by store, which means that picker visits every rack and is picking goods according to the order of only one store. This procedure is done for every order/store. In order to form a functional pallet package intended for the stores, when picking goods, layout is designed in way that picker is firstly encountering goods with greater mass and volume, and then goods with lower mass and volume. Picking is done only at the level of units of packaging, not the product unit. Pallets with picked goods are then transferred to dispatch front, where pallets are being wrapped, marked and prepared for the shipment. One of the latest solutions which company implemented in delivery of the goods, in order to reduce unloading time, is the usage of the roll pallets. These kinds of pallets do not require the usage of the pallet cart (jack) or forklift while unloading. Because of this, the unloading is much faster and easier. Another advantage of this type of pallet is also the possibility of forming multiple levels on the pallet, which enables the delivery of the wider range of products. During the formation of the above-mentioned pallet, milk and dairy products of larger mass are placed at the lower level, since it's heavy goods, and which are mainly packed in a cardboard box containing about 12 packs of one item.

For distribution to retail exclusively road transport is used. Data on processed orders, available vehicles and store locations are entered in the application for vehicle routing (ORTEC). Output from the application is the route of transport means, which transport means operate on which route, the order of visiting facilities, and the method of loading the transport devices. During the operation of means of transport, consumption of fuel, routes cost, vehicle restraint upon receipt of goods in the shops, the temperature in the cargo area of the vehicle and so on, are controlled. There are electronic locks on vehicles that help to prevent "disappearance" of the goods on the road. The advantage of these locks is that only the manager can open load space of the vehicle with the appropriate key.

After preparation of the documentation, the means of transport are loading for distribution. During the distribution, the temperature is constantly monitored by sensors located in the vehicle and by the software that is responsible for collecting data on temperature. In this way it is possible to read the temperature at any point along the entire chain.

Delivery of goods to retail stores is done in three waves. Stores are graded according to their priority delivery and this determines which store will belong to which wave. This priority can be changed in consultation with the store. The first wave is related to delivery of goods to the first top 50 shops. In these stores, the ordering of goods is done in the morning until 10 am, and delivery time is 8-12 hours. The second wave consist of stores that make requisition goods to 10 am, and the delivery time is 24 hours. The third wave consists of stores that requisitions goods to 18h and delivery time is 24 hours. Applying the wave distribution of goods is achieved by optimization of the use of resources. Thus, significant savings are achieved in terms of reducing the required number of staff, transport and handling means, handling areas, the means of transport etc. Every workday at 10 am a cross section of previous orders is done, checking how

many goods are available in stock, and everything is able to go to the store. If there are not enough goods available in stock, some shops get a whole other partial order. When it comes to meat, fruits and vegetables, redistribution is done and in these cases, all stores receive a reduced amount of ordered goods. Everything described above can be represented by a flow chart of the process, Figure 1.
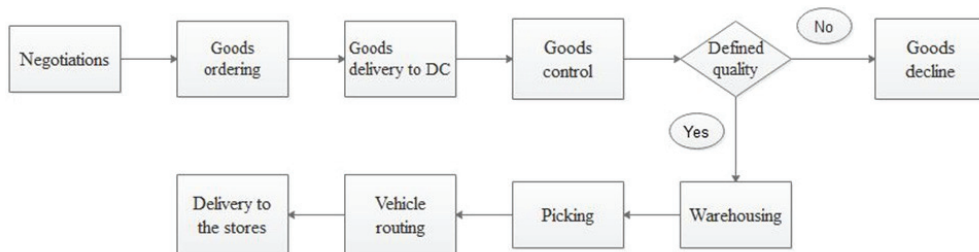

Figure 1. Process flow chart

5. CONCLUSION

By analyzing processes and activities of the logistics chain of dairy products, several points have been identified, which may be subject to optimization in order to achieve better and more precise realization. Using the system for performance control and monitoring, company Delhaize Serbia is monitoring operations of the system, detects critical spots along the chain and fixes the problem when it occurs. Some of the problems which occur and possible solutions for fixing them are given below.

At the strategic level, centralization problem, which company is gradually solving for all groups of goods from its assortment and which is mainly solved for the analyzed goods, stands out. At the lower operational level, the problem of large product packaging units stands out and in smaller shops, with smaller inventory turnover, initiates bigger supplies in stores, which was not in conformity with the strategy of centralization which, among other things, allows you to reduce storage and increase the retail space in stores. This problem is solved by negotiating with the supplier, concerning the reduction of packaging units. In process of goods preparation for delivery, there is a pallet compiling problem, i.e. problem of adequate stacking of the picked goods. The real challenge is to put together different kinds of products with sensitive packaging on the EURO pallet, and at the same time consider the possibility of manipulation, stacking into truck and dismantling at the delivery points. One way to overcome these problems is the use of roll pallets in goods delivery.

Goods distribution and delivery in the city represent the special group of problems. The ability to access, distance between the store and parked vehicle, possibility of goods loading/unloading realization represent significant problems, primarily in central urban areas and especially for perishable goods. On the other hand, planning and regulation of logistics activities is reduced due to the implementation of city ordinances that define the time of delivery, dimensions or capacity of the vehicles which are used in delivery. Since the public administration defines these regulations without analyzing conditions and influence, it only limits the implementation of logistics activities instead of making them more sustainable and efficient. This group of problems could be the subject of the next research.

ACKNOWLEDGMENT

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APPLICATION OF QUEUING THEORY AND SIMULATION IN DIMENSIONING SUBSYSTEMS OF A LOGISTIC CENTER

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Abstract: *Insufficiently dimensioned technological elements of a certain subsystem in a logistic center can make impossible not only normal functioning of the subsystem, but also of the whole logistic system in which the subsystem exists. On the other hand, over dimensioning of technological elements can lead to unnecessary expenses. The subject of this paper is an application of queuing theory and discrete event simulation in dimensioning subsystems of logistic center, which is one of the key parts in the process of designing of logistic center.*

Keywords: *logistic center, technological element, dimensioning, queuing theory, simulation*

1. INTRODUCTION

Within a logistic center there can be a large number of subsystems that can be considered as separate systems: warehouse systems, container terminal, cross-docking terminal, customs terminal, systems for the production, processing and assembly, system for fuel replenishment, system for care, maintenance and repair of vehicles, etc (Zečević 2006). In each of these subsystems appear certain technological demands (Vukićević, 1995). For example, in the warehouse systems, those demands may be: waiting for loading or unloading, loading or unloading, storage, filling order picking zone from the reserve zone, order picking, packing, measuring, etc., in the system for fuel replenishment: fuel storage, waiting for refueling, refueling, etc. Technological demands require appropriate technological elements (Vukićević, 1995). In the warehouse system we need following elements: parking lot, loading dock, forklift, aisles, conveyor, pallet rack, storage zone, order picking zone, forklift driver, order picking personnel, etc., in the case of system for fuel replenishment: underground fuel storage tanks, a place to wait for a refueling, place for refueling, etc. Given this division of logistic center, the process of dimensioning in subsystems of logistic center is aimed at determining the required number of technological elements, their dimensions, capacities, etc. Dimensioning in logistic centers has direct implications on expenses, such as construction, material handling, inventory holding and replenishment; there can also be some lost profits because of time loss while the vehicle is waiting in the logistic center or due to an impossibility to implement services, due to an inadequate implementation of services, etc. That is the reason why the process of dimensioning is realized with a significant amount of attention, inventiveness and creative spirit, and it often goes with an application of branches from mathematics and operational researches.

For each of these subsystems there is a large number of papers that talk about dimensioning of technological elements. Gu et al. (2007) present a review of references that are related to

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determining of required warehouse capacity. In his paper, Gu (2005) gives a solution to a problem of dimensioning of storage and order picking zone. Apart from analytical methods, the best support in resolving dimensioning problems is a simulation. Carteni and Luca (2012) give a detailed review of simulation modeling of processes in ports, container and other terminals in order to achieve better dimensioning, better usage of resources and acceleration of the process.

The following material presents the queuing theory, the analogy of queuing system with processes in logistic center and possibilities of application in dimensioning. In the third section, by applying the queuing theory and simulation, is solved the real problem of determining a required number of technological elements in warehouse system and system for fuel replenishment within a logistic center for mineral fertilizers that is supposed to be designed. The fourth section contains the final considerations, the review of more complex examples of dimensioning than those represented in this paper, and the overview of dimensioning processes on a larger scale.

2. QUEUING THEORY IN LOGISTIC SYSTEMS

Queuing theory represents important branch of operations research, which researches connection between flow of demands for service and the ability of executing demands in queuing system. Within the logistic systems there are many processes that can be presented as queuing system. Elements of the queuing system can have the following meanings in logistic centers, warehouse systems and material handling:

- servers – technological elements: forklifts, cranes, receiving and shipping docks, order picking personnel, gas pumps, machines, etc.
- service – technological demands: loading, unloading, transport, order picking, refueling, production, packing, etc.
- customers: means of transport all modes of transport, containers, pallets, boxes, bags, orders, items, etc.
- queue: trucks on parking lot, orders in the information system which are waiting for an order picking, items on buffer, etc.

Symbols, which were formed by English mathematician David G. Kendall (1953), are standard used for describing queuing models. In this paper, queuing models are described by shorten Kendall's notation $I/II/n/m$. The first letter specifies the inter-arrival time distribution. The second letter specifies the distribution function of the service times. For example, Poisson process – exponentially distributed random variables are notated by M (meaning Markovian or memoryless), for a general distribution the letter G is used, D for deterministic times, etc. The third and fourth letters specify the number of servers and the number of places in queue. Basic input performance measures of queuing systems are: n – number of servers, m – number of places in queue, λ – arrival rate and μ – service rate of one server. By applying certain mathematical relations in queuing models we establish basic output performance measures of queuing systems: p_k – probability of having k customers at service, p_{n+r} – probability of having r customers in queue, $\rho = \lambda/\mu$ – traffic intensity, $\alpha = \lambda/n\mu$ – server utilization, L_q – average number of customers in queue, L_s – average number of customers at service, L – average number of customers in system, W_q – average time spent in queue, W_s – average time spent at service, W – average time spent in system, etc. On the other hand, dimensioning by applying queuing theory usually means defining input performance measures of queuing systems, like required number of servers n and number of places in queue m. Sometimes it involves defining arrival intensity which queuing system can service λ or needed service rate of one server μ.

A larger application of the queuing theory is impossible due to the fact that almost all models, for which exact solutions exist, refer only to the steady state and to the models where the arrivals are according to Poisson process, and where the service time is in line with an exponential

distribution. When the arrivals and/or service time are described by some other probability distribution and/or in a case of non-stationarity, a simulation is used. However, even in those cases, the queuing theory is used as a good verification tool of simulation models. On the other hand, Vukićević (1995) says that throughput capacity and other service characteristics depend relatively little on probability distribution of service time; in most cases, they depend on its average value, and therefore it is often neglected that the service time does not correspond with an exponential distribution, but with some other distribution. Nevertheless, using of exponential distribution of service time can be the cause to an over dimensioning of technological elements (Vukićević, 1995). This happens because of attributing greater stochasticity to the time needed for service than what it really is.

3. OPTIMIZATION OF THE NUMBER OF TECHNOLOGICAL ELEMENTS NEEDED

In this paper, the subsystems for storage and fuel replenishment within a logistic center for mineral fertilizers are dimensioned. The aim of this paper is determining of the following: the number of loading docks, parking lots and forklifts within a warehouse system, as well as the number of replenishment places and places for waiting to be replenished in these subsystems. The first to be presented is input data related to both subsystems, and then the solution to problems in dimensioning in warehouse system, whereas we only give the final result for number of technological elements in the system for fuel replenishment and some aside acknowledgments because of obvious analogy with the situation in warehouse system.

At the warehouse system trucks will arrive according to a Poisson process (i.e. exponential inter-arrival times) during the whole day. The arrival rate λ is 11 trucks/hour. In the 45% of cases, those are trucks in receiving, in which are 16 to 24 pallets with one kind of mineral fertilizer, while the rest of cases are trucks in shipping. In those trucks 14 to 19 pallets can appear, but with different kinds of mineral fertilizers. Since we do not know probability distribution of number of pallets in trucks, we suppose discrete uniform distribution in both cases. If there is some free space, truck goes directly to the loading zone, otherwise the truck is waiting in the parking lot. All material handling operations in warehouse are performed by forklifts that take pallets and put them directly from the truck to the storage and later from the storage directly to the truck. In the warehouse, there is not order picking of bags with fertilizer from pallet, but whole pallets are shipped the way they were. Upon arrival, the homogeneous group of pallets is put in the block stacking storage system according to frequency of a sort of mineral fertilizer – the most frequent sort is assigned to the location that is the nearest to the loading docks. By taking into account the frequency of mineral fertilizers and the position of dimensioned storage zones, we came to a conclusion that the working cycle of forklifts (T_c) can be described by $0,6 + EXPO(0,5)$ in minutes. Logically, the working cycle of forklifts for loading the pallets from storage to truck will be described the same way, but the events will be differently scattered in time – the random function will be different. After having done loading/unloading, about 30% of trucks go to the system for fuel replenishment, while others are leaving the logistic center. However, besides these trucks, this system is used by external trucks, too. The arrival of those trucks is according to Poisson process with an arrival rate of 4 trucks/hour. The time required for fuel replenishment may be described by $TRIA(3,5,7)$ in minutes. The costs of construction of one loading dock is 5000 \$ (c_1), and the cost of a parking lot is 2000 \$ (c_4). The price of one forklift is 14000 \$ (c_2). Battery charging of a forklift is done the following way – the battery is taken away from the forklift, and the new one is put into it so that it can continue to work. In the case of dimensioning of the fuel replenishment system, the costs of construction of replenishment places and places for waiting to be replenished are 3000 \$ and 2000 \$, respectively. The trucks are at a loss while waiting in logistic center because they make money while on route where they could have earned 5\$/hour (c_5). The project lifetime – the period of exploitation of a logistic center is 10 years (τ). The warehouse is supposed to be open 7 days a week, and the working time of the warehouse is 16 hours, in two shifts. A forklift driver is paid 300\$/month (c_3).

The number of forklifts, loading docks and parking lots can be determined by taking into account of all the costs that are in the function of number of servers – loading docks (forklifts):

$$C(n) = (c_1 + c_2 + 2c_3\tau)n + c_4 m + c_5 W_q \tau \lambda$$

(1)

where:
- n – number of forklifts (number of loading docks)[1];
- m – number of parking lots;
- W_q – average time spent on parking lot (h);
- c_1 – costs of construction of one loading dock ($);
- c_2 – price of one forklift ($);
- c_3 – salary of one forklift driver ($/h);
- c_4 – costs of construction of a parking lot ($);
- c_5 – costs of waiting for loading ($/h);
- τ –project lifetime – exploitation period of logistic center (h);
- λ – arrival rate of the trucks in the warehouse system (truck/h).

The task is to find n and m that depends on it, so that the equation (1) has a minimum value. The number of parking lots can be determined so that, during a certain percent of time, the system can receive in adequate way (on loading dock or parking lot) every truck that arrives. Let's suppose that it is 99% of time. Therefore, the task is to find the first m for which is true:

$$\sum_{k=0}^{n} p_k + \sum_{r=1}^{m} p_{n+r} \geq 0,99 \qquad (2)$$

The real system corresponds to the model with n servers, partially mutual help and infinite number of places in queue $M/M/n^{(l)}/\infty$, where the parameter l tells the maximal number of forklifts that can load/unload a truck, so that the productivity and safety of the operations do not degrade. The requirement for the number of places in queue to be unlimited is almost always present during the material handling processes because technological demands, in most cases, cannot be cancelled – they have to be fulfilled sooner or later, and the space for waiting has to be found, even if it is sometimes inadequate. Formulas for steady-state probabilities and average time spent in queue for this model are given in the table 1. For the purpose of understanding the model, the flow diagram is represented in the figure 1.

Table 1. Formulas for steady-state probabilities and average time spent in queue for $M/M/n^{(l)}/\infty$

$$M(\lambda)/M(\mu)/n^{(l)}/\infty$$

$$p_0 = \frac{1}{\sum_{k=0}^{h}\left(\frac{\rho}{l}\right)^k \frac{1}{k!} + \left(\frac{\rho}{l}\right)^h \frac{1}{h!}\left(\frac{\alpha^{n-h+1}}{1-\alpha} + \sum_{k=1}^{n-h}\alpha^k\right)} \quad for\ \alpha < 1$$

$$p_k = \begin{cases} \left(\frac{\rho}{l}\right)^k \frac{p_0}{k!}, & k = \overline{0,h} \\ \alpha^{k-h}\left(\frac{\rho}{l}\right)^h \frac{p_0}{h!}, & k = \overline{h+1,n} \end{cases} \quad h = \left[\frac{n}{l}\right]$$

$$p_{n+r} = \left(\frac{\rho}{n}\right)^r \frac{\rho^n}{n!} p_0, \qquad r = 1,2,3,\dots$$

$$W_q = \frac{\alpha^{n-h+1}\left(\frac{\rho}{l}\right)^h \frac{p_0}{h!}}{(1-\alpha)^2 \lambda}$$

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[1] Loading dock and forklift are considered to be the only server because the time spent on the loading dock is determined only by the load/unload time. If some other operations were included, like, for example, the preparation of the truck for loading/unloading, that would be different.
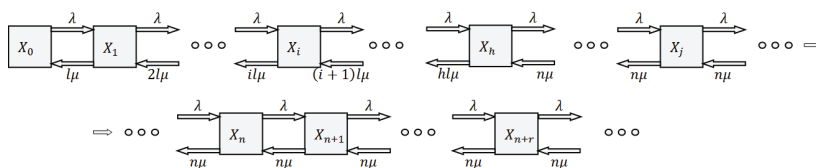
Figure 1. Flow diagram for the model $M(\lambda)/M(\mu)/n^{(l)}/\infty$

By taking into account the ratio of number of trucks in receiving and shipping and the probability distributions of number of pallets in trucks, we get an average number of 18,075 pallets per truck. Given that the working cycle of a forklift is 1,1 min in average, the average time for one forklift to load/unload a truck is 19,88 min, which implies that an intensity rate of one forklift μ is cca 3 trucks/hour. It is estimated that the optimal l is actually 2, so that the model can be described as follows: $M(\lambda=11)/M(\mu=3)/n^{(2)}/\infty$. The arrival of the truck is in line with Poisson process but the time spent on the loading dock is not, it is rather the same general distribution, that has to be included by the simulation. Figure 2 represents a part of a simulation model created in software ARENA, that also modules the fuel replenishment system. The part of simulation model that refers to the warehouse system can be represented this way: $M(\lambda=11)/G(\mu=3)/n^{(2)}/\infty$, and the part of the system related to the fuel replenishment system: $G(\lambda=7,3)/TRIA(3,5,7)/n/\infty$. In this simulation, 365 replications of 16 hours (one working day in a logistic center) are run.
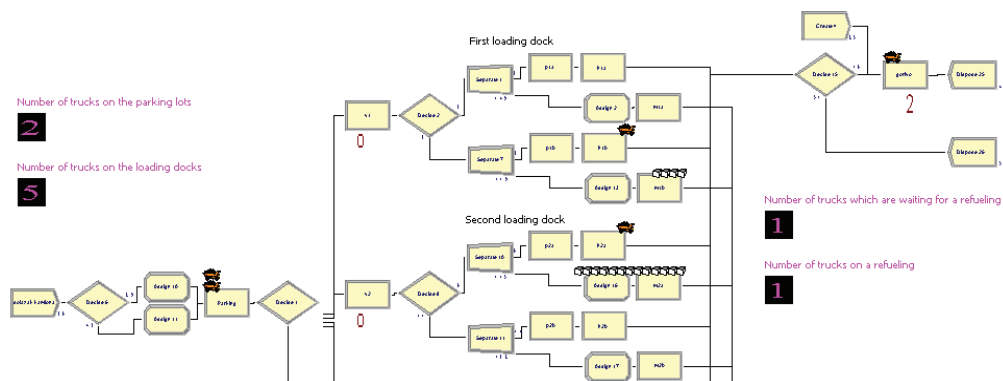

Figure 2. Simulation model

In order for the warehouse system to function in steady state, the service intensity of all servers $n\mu$ has to be higher than the arrival rate λ, which means that n has to be higher than 3.67. This relation shows that the warehouse system must have more than 3 forklifts in order to avoid a large number of trucks. This requirement does not have to be fulfilled in a case where the duration of the simulation is limited, but it is quite unlikely for optimal n to be less than 4. The table 2 presents the number of parking lots and average time spent on the parking lot in the function of number of forklifts, as a result of simulation and analytically, by queuing theory. The expenses chart are given in the figure 3. It is evident that the optimal number of forklifts and places on loading dock is 5 in both types of solution: by a simulation and analytically.

Table 2. m and W_q depend on n for models $M/G/n^{(2)}/\infty$ and $M/M/n^{(2)}/\infty$

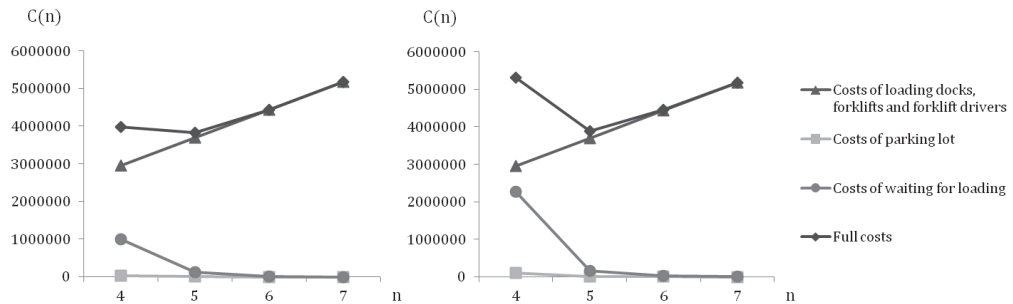|	$M/G/n^{(2)}/\infty$		$M/M/n^{(2)}/\infty$	
n	m	W_q (h)	m	W_q (h)
4	14	0,3096	48	0,7061
5	5	0,0375	9	0,0530
6	0	0,0002	3	0,0074
7	0	0,0000	0	0,0010

Figure 3. Costs depending on *n* for models $M(\lambda=11)/G(\mu=3)/n^{(2)}/\infty$ and $M(\lambda=11)/M(\mu=3)/n^{(2)}/\infty$

For this number of forklifts – loading dock, 5 parking places are required. It is noted that this number is over dimensioned by applying an analytical model because the result is 9. Concerning the subsystem for fuel replenishment, only 1 place for refueling and 2 places for waiting to be replenished are required.

4. CONCLUSION

Obtained results justify the affirmations about the possibility of over dimensioning by applying the queuing theory, but nevertheless, this theory can be used as a verification tool for even more complex simulation models than this one. In the presented example, the input data are given independently of the fact that commodity and transport flows are type of flows that cannot be predicted with accuracy. Therefore it is always needed to represent different scenarios by varying the input data. In some dimensioning problems, there can be a non-stationarity during an exploitation period (phasing), a year (seasonal character) or a day. The non-stationarity sometimes might impose including of a random function instead of random variables in the simulation model. Thereafter, the dimensioning is inseparable from the technology of realization and layout, and it is supposed to be done simultaneously for the whole subsystem of the logistic center. The more complex a subsystem is, the larger is the number of mutual relations that are to be respected when dimensioning, and consequently, the more difficult is a task of an engineer, who has to cope with all those challenges.

ACKNOWLEDGMENT

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IMPLEMENTATION OF ECO-VEHICLES IN CITY LOGISTICS

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Abstract: *Air quality in urban areas is key for the health and well-being of citizens, and urban freight transport is one of the main participants in the emission of harmful greenhouse gases and noise. Furthermore, urban freight transport is dominant in creation of congestion on city roads. Although much has already been done in the last decades for the improvement of air quality and environmental protection, in realization of commodity flows changes are very slow. Regarding sustainability, logistics processes, above all urban freight transport, are far from optimal. Urban freight transport growth, negative impact on the environment, inefficient use of land and the delivery costs growth are all affecting the research and definition of different initiatives of city logistics. This paper describes the initiatives of implementation of eco-friendly vehicles in urban delivery of goods, such as cargo bikes, e-scooters, cargohopper and drones.*

Keywords*: city logistics, eco-vehicles, environmental impact.*

1. INTRODUCTION

Rapid urbanization has a negative impact on urban freight transport. Goods are often transported in ways that are not optimal. Deliveries are more frequent, there are time frames that need to be respected, which requires sending more vehicles onto the city streets, and that is the cause of high energy use and carbon-dioxide emission. Urban freight transport is specifically complex in historic parts of the city, as the streets are often very narrow, utilize one-way system and have access restrictions and speed limitations, which complicates the urban delivery operations even more (Navarro et al., 2016).

Local authorities see logistic operations, primarily urban freight transport, as undesirable and want them forbidden or strictly regulated. In many cities in Europe, by access restrictions, licensing and application of different regulations, local authorities are forcing logistics service providers to make their operations more sustainable (Tadić & Zečević, 2016). Access restrictions are defined based on different criteria (individually or in combination): time frames, vehicle weight, vehicle dimensions, noise emission, air pollution, loading factor (vehicle availability of cargo space), type of goods (dangerous goods, valuable goods, live animals, etc.) (Dablanc, 2007). Still, researches show that measures of prohibition and access restrictions are limiting urban delivery operations instead of making them more efficient and sustainable.

According to several empirical studies urban freight vehicles account 6-18% of total urban travel (Frigliozzi, 2010), for 19% of energy use and 21% of carbon-dioxide emissions (Russo & Comi, 2012; Schliwa et al., 2015). Finding new strategies for increasing the quality of life of their

citizens is essential for cities, along with retention of economic competitiveness and availability of goods and services. Whereby, over 50% of the world's population already lives in urban areas (Grimm et al., 2008), around 75% in Europe (European Commission, 2014), without any significant systematic changes, urbanization trend will lead to constant congestion and environmental pollution growth.

Problems and complexity of logistics in urban areas have caused definition, research and use of different city logistics measures and initiatives. Initiatives differ based on initiator, participants, goals, demands and implementation possibilities, but also the effects on urban sustainability (Tadić & Zečević, 2016). This paper shows initiatives of implementation of eco-vehicles for urban delivery operations. Main goal of these initiatives is reducing the negative impacts of urban freight transport on life in cities. Further, this paper shows the possibilities and effects of using cargo bikes, cargohopper, e-scooters and drones.

2. CARGO CYCLES

One of the ecofriendly solutions to urban delivery operations are cargo cycles. There are different types of cargo cycles on the market, the ones with two, three or four wheels. Main difference is transport capacity, as is locking system during delivery. Transport capacity varies from 80 to 400 kg, or 0,4 to 3 m³. When it comes to locking system, it differs from open cargo boxes, to padlock and electronic devices which open and lock automatically in order to save time per delivery stop and protect goods (Daggers, 2013).

Goods that can be transported by cargo cycles are food, documents, medications, as well as the rest of the small consumer products. Cargo cycles are being used for B2B and B2C transport, but also as solutions for "last mile" package delivery in densely populated areas (Schliwa et al., 2015). Studies in European cities (Koning & Conway, 2016) show that potentially around 42% of courier deliveries can be transferred to cargo cycles. A study that referred to CEP shipments in cities of Europe, it has been noticed that 92% of the bicycle shipments and 56% of car shipments have 10km or less shipment distance, and 99% of the bicycle shipments and 87% car shipments are shorter than 20km (Gruber et al., 2014). Besides, some companies do not use cargo cycles only for transport, but for sale of products, such as coffee, snacks and sweets as well (Koning & Conway, 2016).

Cargo cycles are in advantage compared to electric cars, because of their smaller dimensions and easier adjustments (Navarro et al., 2016). Besides, by comparison of economic (Tipagornwong & Figliozzi, 2013) and traffic performances (Conway et al., 2014) between cargo tricycles and motorized delivery vehicles, it has been determined that cargo tricycles are cost-effective, simpler for maintenance, more reliable and more flexible for parking. However, they also have certain deficiencies such as limited capacity and distance, expensive loading area in densely populated areas and higher number of vehicles and drivers compared to motorized vehicles, which limits their cost competitiveness (Navarro et al., 2016).

The structure of some city centers requires indirectly that smaller vehicles are used, because of the width of the streets, congestion, regulations and historical value that needs to be preserved, as well as requirements for constant improvement of quality of life. A study conducted in Barcelona and Valencia (Navarro et al., 2016) examined the impact of cargo tricycle use in combination with specific loading points, instead of different delivery vehicles. In both cities the same vehicles were used, two electrically assisted pedal tricycles, with closed containers that carry parcels, with a loading capacity of 1.5 m³, and measuring 2.78 m in length, 1.03 m in width and 1.95 m in height. Maximum load per vehicle is 280 kg, although the average weight of transport is 180 kg. Tricycles were used for "last-mile" delivery, from urban consolidation centers in which transshipment from different delivery vehicles was completed. During this study all processes were monitored, and several different effects of initiative implementation were measured, such as economic, energetic, ecological and social effects. The research has

shown that it is possible to save 32 km per each tricycle in vans in Barcelona and 20.5 km in Valencia. These savings are due to car restrictions in the area, which tricycles do not have, and for that reason vans have to detour, while tricycles can drive more directly. Energy savings were minimal, because the whole system is small. It is estimated that it is possible to save approximately 2 tons of carbon-dioxide per year using this solution. Also, regarding society, the whole system showed a high acceptance level (Navarro et al., 2016).

A research conducted in Paris, different environmental impacts of 4 types of vehicles (cargo bicycle, motorized two-wheeler, truck and van) were determined: carbon-dioxide emission, local pollution, congestion and noise emission. Cargo bicycle doesn't generate any kind of costs in regards to local pollution, congestion and noise, and costs for carbon-dioxide emission are significantly lower than any other tested vehicle generates (Koning & Conway, 2016).

3. CARGOHOPPER

Cargohopper is an electric vehicle that is used for distribution of goods in inner city area. Its use had been tested in cities Utrecht (Browne et al., 2012) and Amsterdam (Duin et al., 2013), in which it is currently in use. At the moment, there are two types of Cargohopper. Cargohopper 1 is an electric road train with three trailers, 16 m long and 1.25 m wide, designed for distribution of goods in the small street networks in city centers. Trailers are loaded with containers with parcels that are distributed in urban areas (Browne et al., 2012). Containers are preloaded at a consolidation center outside the city and transported to hub located in the inners city by regular trucks. At the hub containers are loaded onto Cargohopper trailers and are then delivered to the inner city. This vehicle can be used during different time limitations in pedestrian areas. Its implementation lowered the number of freight trips by 4 080 and achieved saving 88 332 km of diesel vehicles. This led to reduction of CO_2 (73%), NO_x (27%) and PM10 (56%) emissions (Rooijen & Quak, 2014).

Cargohopper 2 is electric truck with trailer with solar panels, and its top speed is approximately 55 km/h. Loading space is constructed so it's wide enough to fit two pallets next to each other and high enough to fit roll-containers. Its maximum load capacity is 10 Euro pallets or 16 roll-containers, as well as 500 packages. Operation range of Cargohopper 2 is approximately 100 km, although, considering solar panels that are located on the trailer that range could be increased (Duin et al., 2013).

4. E-SCOOTERS

One of the options for delivering goods with positive environmental impact is electric cargo scooters. Most of the electric scooters available are those with two or three wheels. As there is no legal framework for scooters three-wheelers in Europe, their use hasn't expended. E-scooters are used for transport of lightweight goods, mostly food, like for example. pizza delivery, but there are also examples of books delivery, as their capacity is 40 kg, or 0,08 m³. The advantage of scooter delivery is their speed of 60-100 km/h (Daggers, 2013).

The difference between e-scooter and the traditional one is that e-scooter decreases the greenhouse effect, and also reduces the level of pollutant emission, locally equal to zero. Compared to e-bike, e-scooter has higher capacity, it is faster and has better autonomy, but they are also more expensive. E-scooter is double the price of the e-bike (Lia et al., 2014).

During the project Pro-E-Bike, 39 companies tested 74 e-vehicles for delivery in urban areas. Company TNT GLOBAL Express tested usage of e-scooter instead of the traditional one for letter and smaller parcels delivery in Genoa, during the 6 months' period. The company has notices some savings. Energy costs were reduced by 0.036 €/km, carbon-dioxide emission by 160 kg, or 0.045 kg/km (Nocerino et al., 2016). During the e-scooters usage, fear of battery duration was

present. However, travelled km during the day are often lower than the battery autonomy, thereby enabling charging during the night (Nocerino et al., 2016).

5. DRONES

Negative effects of urbanization, such as congestion, pollution and lower efficiency due to delays of flows of people and goods, affects "door-to-door" delivery. Drones can facilitate delivery in urban areas, by relocating transport from roads to the sky (Heutger & Kückelhaus, 2014).

An airborne first and last-mile network would function in a way where shipments that arrive in city are sorted in certain centers (hubs, warehouses, cross-docking centers), and those meeting certain criteria are separated automatically. Besides classic criteria such as size, weight and time sensitivity, criteria like air pollution, current road conditions or network load would also be considered. Each drone would then take the assigned shipment from a conveyer and take off. On the way back to the hub, drones could deliver smaller "point-to-point" deliveries, located along its route. Routing decisions would be dynamic, meaning that thanks to an advanced network, all users would be served in real time, depending on the load and shipment urgency. If an assignment for urgent shipment appears (e.g., time sensitive shipment of blood from blood bank), this shipment is prioritized (Heutger & Kückelhaus, 2014).

The system uses GPS data from user's smartphone, so it can locate it wherever he is, even if user changes his location after ordering. If user is moving outdoors, drone could meet him and, after identifying him via NFC or QR code on his smartphone, hand over the delivery. In case of return, drones collect shipments from users and transport them directly to hub (Heutger & Kückelhaus, 2014).

6. CONCLUSION

Urban freight transport is one of the main participants in lowering the quality of life in city and negative environment impacts (Tadić & Zečević, 2016). This paper provides an overview of some representatives of eco-vehicles, their characteristics and how they can contribute to the environment.

Although eco-vehicles can't often be seen on the city streets, and aren't used in many cities, they have a wide range of application. E-bikes and e-scooters can be used in CEP delivery, "last-mile", and any short-range delivery of small and medium packages (Navarro et al., 2016). These vehicles have small dimensions, so they can be used in narrow city streets, where the passage of trucks is difficult. Therefore, they can respond to large number of delivery requests in the city area. Considering the rise of e-commerce (Daggers, 2013), and increase of requests for home delivery, these vehicles are ideal for completing these tasks, with positive environment impact and reduced road transport. Also, one of the advantages of eco-vehicles lies in legislation, as there are numerous restrictions applicable to traditional vehicles and not to eco-vehicles, allowing eco-vehicles deliveries during rush-hour and city areas where access for trucks is forbidden (Rooijen & Quak, 2014).

One of the possible reasons of under-representation of eco-vehicles could be a lack of information and knowledge about advantages they bring. Also, it can be hard for a company to change the entire way of doing business. But, the benefits that the implementation of eco-vehicles brings are not just good for the environment, but for the company's image as well. At the time when environmental protection and quality of life are so important, it's crucial not to ignore the impact that urban freight transport has. Only with suitable initiatives on reducing negative environmental impact, a better future of life in city can be assured, and urban freight transport can be an advantage of city's environmental concern, instead of its faultiness.

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LOGIC

ENVIRONMENT AND LOGISTICS: IMPACTS AND TRENDS

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Abstract: *Globalization, urbanization, shorter lifespan of the users, increased ecological awareness, development of new technologies, infrastructural development and other factors which increase complexity of logistics activities and which increase the importance of logistics. Changes in the environment are becoming more intense and are increasing the meaning of pleasing the end user, safety and security in logistics processes, decreasing expenses and adding new technologies. The review of political, law, economical, technological, socio-cultural and ecological impacts on logistics and the changes in the environment is given in this paper. Some of the most significant trends which are the consequence of environmental and market changes are shown.*

Keywords*: logistics, environment, influences, trends.*

1. INTRODUCTION

Changes that happen on the market in modern terms of management affect logistics greatly. They cannot be watched separately from changes in the environment because they have strong interaction. Changes which are caused by political, economical, law technological, cultural or ecological factors influence planning and realization of logistics' activities.

Trends that appear due to these impacts and that are dominant on the market are outsourcing, e-trade, off/on soaring, logistics postponement, multimodality, intermodality and city logistics. In order to make adjustments and assure competitive lead on the market, the companies have to answer quickly to demands, so for now, flexibility and agility of companies are gaining in importance.

2. IMPACTS

To observe all factors that affect logistics' processes is of great importance. However, not all factors have the same impact on logistics and not all factors are dominant in every market. In further work is given the view of factors that have the biggest impact on logistics globally.

2.1 Political

Deregulation of transport on the level of EU (European Union). With the improvement of institutional limits of transport in EU, it comes to strengthening of competition inside and in-between of ways of transport which would increase the efficiency of the transport in general.

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Right now, level of deregulation varies according to the way of transport. Deregulation on logistics market would make redistribution of transport work and improvement of the service level in freight transport, while the increase of competition would lead to the change of performances of freight transport system (utilization of the train park, quality/reliability of services, time of realization) (EC, 2015).

Privatization of the railway. The goal of railway deregulation is greater usage, the improvement of attractiveness and competitiveness and quality of railway transport services by liberalization of national and EU markets. International railway market inside EU has been deregulated since 2007, but there are still some differences between countries. The opening of the national and EU market in the field of transport integrates the networks all around the Europe and with that it decreases the time of travel and the costs of transport and it has positive influence on the environment and health of people. Sequel of liberalization and the increase of competition in rail freight traffic will have positive influence on logistics. Services in railway transport will be more flexible and prices will be lower which could significantly affect the increase of technological involvement of intermodal transport.

The environment. The politics are trying to decrease the pollution and to affect the behavior of customers by encouraging the industry to choose low-energy products and by using renewable sources of energy (Energy Tax Directive 2003/96/EC67) whose goal is to efficiently use the energy and to enable states which are members to offer companies tax reliefs in order to reduce harmful gas emissions. Energy Tax Directive negatively influences logistics because it raises prices of transport services (EC, 2015). However, externalization of transport expenses can have multiple positive effects on long-terms. Putting costs of negative influence on the environment into price of transport increases competition of ecologically acceptable means of transport and greater usage of intermodal transport technologies. In this way total price of realization of logistics' chains doesn't have to be bigger, it will just come to the change of the chain structure (Tadić & Zečević, 2016).

Infrastructural development. Giving the fact that the development of the transport infrastructure is key prerequisite to increase flexibility of the supply chain, EU's goal is to develop TEN-T main network which includes main corridors and terminals of various means of transport. The development of this network provides total coverage of EU and accessibility to all regions, which provides more acceptable redistribution of transport work between means of transport and more efficient realization of commodity costs. (EC, 2015)

Trade restrictions. With liberalization up to speed and growth of global trade, complicated administrative procedures slow down the realization of costs and are becoming bigger problem of logistics chains. With the proliferation of the supply chains, the increase of production and retail processes, barriers in trade will become problem because of increased importance of products that keep losing their value for the end user. Administrative procedures in import and export in some parts of the route, testing certifications of products delay time of delivery, which is a great problem of logistics sector. (EC, 2015) In the future, we can expect different scenarios-from further growth of liberalization and global trade to regionalization and protectionism (Tadić et al., 2013).

2.2 Law

With the increase of global trade, consumer society and changes in customers' demands, it comes to starting a large number of road freight vehicles. In order to increase reliability of the chain supply and safety and security of the driver during driving comes to social regulation. Daily period of driving is included by various regulations, total driving time and weekly and daily resting period during driving. Regulations are referred to freight vehicles in terms of construction, equipment, minimum and maximum of the usual allowed weight and dimensions, including cross-border transport (EC, 2015). EU directives, whose goal is to increase safety and

security in road transport bring additional costs to directive implementation, equipment, driver's training and similar.

2.3 Economical

Countries of EU have partly recovered after global economic crises. The differences in the view of economical activities will equalize between the members of EU in the near future, which will have impact on the type of product that end users consume and by that on logistics sector, too. (EC, 2015) With globalization and making unique market comes to strengthening service sector over production sector which brings to separation and departure of the place of the production and consumption and increase of requests for logistics services. In these conditions, the existence of logistics providers depends on the quality of services. (Tadić & Zečević, 2016) In direction of globalization and economical increase, change of power on financial market is based on dislocation of economical powers and power on economical market (from west to east markets). In the future the sequel of economical activities globalization is expected and the increase of international market efficiency through the increase of intermodality. What could bring to losing capital of logistics companies are stricter conditions of risk evaluation by insurance companies, and because of more extreme weather conditions, which are considered to often interrupt the supply chains and make their planning more difficult (Tadić et al., 2013).

2.4 Technological

New vehicle technologies. Due to bigger climate changes and increased awareness of environmental pollution, vehicles that are better for the environment are developed. Energy efficient vehicles are developed in order to decrease the usage of energy, CO_2 and other pollutants, and vehicles with implemented SCR (Selective Catalytic Reduction) technologies in diesel motors. In order to decrease pollution of the air some hybrid diesel electric motors are developed. When it comes to usage of energy and fuel, the design of the vehicle is very important. In that sense, some heavier or longer vehicles are developed, vehicles with improved aerodynamics and regenerative brake system. The development of new vehicle technologies brings to bigger demand for skilled workface and to larger training costs (EC, 2015). Infrastructural development and standardization of road traffic, railways and waterways are helping the development of new technologies. Improved vehicle and infrastructural technologies lead to greater initial investments and bigger fixed costs but on the other hand, it decreases the time of realization, decreases stop time during unexpected slowdown, increases flexibility and reliability and it decreases the pollution.

3D printers. With the development of 3D printers for home use it comes to personalization of production and change of demands. Individual production and consumption forms will bring to increase of regional trade provide that only data and goods circulation would be done on global level. Market success in these conditions will have only companies which place popular data sets, which supply with goods, produce 3D printers and offer support services like recycling servicing and consulting. Due to personalized production, the increase of total consumption and goods is predicted (Tadić et al., 2013), just like the increase of demands for home delivery and logistics recurrent costs on logistics level (Tadić & Zečević, 2016).

2.5 Socio-cultural

The increase of population in urban areas is projected from 3.6 billion in 2011 to 6.3 billion in 2050 (UN, 2012). Rapid urbanization leads to bigger demands for goods in urban areas which, as a consequence, have starting larger number of vehicles and standstill on roads, which negatively influences life conditions, mobility and the environment (Tadić & Zečević, 2016). Aside from rapid urbanization, it comes to accelerated aging of population. The participation of old people (65 years and more) is predicted about 29.9% by 2050 year in EU25 (CEMR, 2006). From the

logistics aspect, it comes to organization problems and realization of goods costs due to larger number of home deliveries, the increase of buying in local stores, larger number of delivery vehicles and mileage. All of this negatively influences the environment and the living standard in the city. In order to decrease negative influences which are caused by a large number of home deliveries, stations for delivering and taking goods should be developed.

2.6 Ecological

Due to greater need for fast and reliable logistics service it comes to the increase of bad influences which are initiated by freight transport (Tadić et al., 2013). By some researches, global concentration of CO_2 has reached the level of 405.75 ppm with growing trend of 2 ppm per year (ESRL, 2017). The lack of fossil fuels leads to increase of energy costs for production and logistics and development of alternative energy sources which also generate certain costs. Advantages for vehicles with alternative drive, in the sense of taxes, will have positive impact on logistics which could result in larger share of hybrid vehicles. Reduction of the fuel use with the help of streamlined trucks for greater distances in road transport will have very important economical and ecological contribute (EC, 2015).

3. TRENDS

With the growth of the number of factors which affect logistics activities, the number of logistics trends is growing. Full review of trends which were the most dominant in the literature is given in the further text.

Outsourcing. Number and competition of outsourcing companies and providers of logistics services is increasing rapidly. Rapid increase of organizations which have decided to outsource some of their logistics functions has started in the early nineties (Srabotič & Ruzzier, 2012), besides that, globalization and liberalization of the market lead to greater specialization and growth of outsourcing (Tadić et al., 2013). In terms of individualization of production and the growth of consumer society, companies that focus on their main activity, quality of the product and satisfaction of the customer generally, with the help of outsourcing, will have more success.

E-commerce. Growth of consumer society leads to the growth and need for larger assortment of products which, on the other hand, causes certain problems in logistics. With the development of e-trade, the demands for frequent, fast, exact and reliable deliveries of smaller quantity grow (Tadić et al., 2013), and because of increased environmental pollution logistics activities should be organized in ecologically acceptable manner. Companies have to make certain CRM (Customer Relationship Management) in order to follow shopping habits of end users and decrease of level of stochastic demands and more reliable predictions.

Off/On/Shoring. Changes in economy have brought in question the decisions about locations of production and places of providing services. Great companies take their business activities back to domestic market. By transferring from offshore to onshore production it is possible to make positive financial effects, better managing the product and storage capacity (Tate et al., 2014), greater flexibility through logistics postponement (De Treville & Trigeorgis, 2010), decrease of the risk of breaking the supply chains due to errors in the product quality and theft of intellectual property which are more common on offshore locations (Ellram et al., 2013; Zimmerman, 2013) and marketing advantages (Robinson, 2015). The advantage of offshore locations are lower costs of manpower (especially regions in Asia) (EC, 2015), but because of a trend of paycheck equalization among different locations (Li at al., 2012; Tate et al., 2014) we could expect many companies to question their decisions about off shoring and to return or start onshore production.

Logistics postponement. In market conditions where pleasing the end user but also decreasing the supplies which represent opportunity cost to the companies are becoming more and more

important, making the right decisions on various levels of managing is becoming bigger problem. Logistics postponement strategy can reduce the disagreement between predicted production and real demands, decreasing in that way Bullwhip effect in supply chains (Wong et al., 2010). However, using this strategy can cause problems about the level of supplies in the storage and about type of the product which is in the storage (semi-finished or finished product) which represents the biggest dilemma about its usage (Quin, 2011). Still, with the increase of individualization of production and participation of track expenses, we could expect the increase of use of this strategy, partly because it allows the use of intermodality, increase of end user's pleasure and decrease of costs of delivery and of keeping stocks.

Multimodality/Intermodality. Pollution problem getting bigger, fuel prices getting higher, traffic congestion-due to all this, we need new solutions for freight transport. Successful realization of activities in local and global supply chains demands the development of integrated multimodal and intermodal network. What can limit the growth of intermodality is its complex nature and the lack of efficient and effective informational connection among various means of transport. Latest discoveries on ITC field, like cloud computing, social networks and wireless communication have changed the way of sharing information and the structure of the supply chain in a revolutionary way, thus enabled the development of intermodality (Harris et al., 2013).

City logistics. During the last decade, the realization of logistics activities of delivery/collecting goods has become important factor of sustenance of urban environment (Morfoulaki et al., 2015). With urbanization and population aging, e-trade development growth and mulching of trade ways, apropos moving great number of road vehicles which makes great problems in chain realization. In order to define sustainable solutions of city logistics, all the activities have to be looked at, all means of transport technology, all the participants and all freight ways, but also all characteristics of urban area (Tadić & Zečević, 2016).

3. CONCLUSION

In the last couple of years it has come to some great changes when it comes to logistics' companies business. Companies that want to be on the competitive market have to follow new trends that are showing up and that become because of various environmental factors. Each company has to choose the right business strategy which is in terms with its business policy and goals. Will some trend be applied in a specific case depends on costs, incomes, available technologies, its positive or negative influence on the environment and on all participants in the supply chain. Trends have to be followed by efficient flow of information, and also informational and communicational technologies which support them so that supply chains could take place without interrupting and in conditions to needs of the company and end users.

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LOGIC

NEW CONTAINER TERMINAL TECHNOLOGIES

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Abstract: *In this paper, there are presented some of the technologies that are implemented in container terminals as response to globalization and new requirements in terminals. The innovations that are analyzed are implemented to meet requirements for increased productivity and efficiency in subsystems of container terminals. Conceptual systems presented in this paper are linear motor conveyance system (LMCS), automated guided vehicles (AGV), automated storage and retrieval systems (AS/RS), overhead grid rail system (GRAIL), speedport, superdock, flow-through gate, portnet and teustack.*

Keywords*: Container terminal, new technologies, automation*

1. INTRODUCTION

As a result of globalization, international trade has greatly increased and maritime transport obtained central role in the world trade. Consolidation of goods using containers, reduces number of operations with goods, improves safety of goods, reduces risks of damaging and loss of goods and allows faster transport of goods.

Since April 1956, when Malcolm McLean transported fifty-eight 35 foot containers, container transport is developing constantly. In last two decades, maritime container transport has a growth of 7% to 9% per year, while other types of maritime transport have a growth rate of 2% per year (Crainic & Kim, 2007). Economical effects of massive container transport by vessels, led to very fast increase of capacity and size of vessels, from feeder vessels, to big intercontinental vessels and in 2010. these vessels had capacity of 12.000 TEU, and currently there are vessels with capacity of 19.000 TEU. Parallel with development of container transport and container vessels, there was development of technologies and organizational concepts of container terminals worldwide.

Need for faster loading and unloading of vessels, as well as requests for faster turnover, are great problems for container terminals. In order to answer to new requests, container terminals developed new technologies and they are developing methods for continuous optimization and automatization of logistics processe. Usage of decision support systems and reaching of given targets, requires identification and tracking of key performance indicators (KPI) which can be classified as follow (Meersman et al., 2004): service oriented (they track level of service which is given to users of terminal and they are usually expressed as time of turnover of vessels and trucks; they include berth service time (e.g., vessels turnover time and vessels berthed on time) and time which vehicles spend in terminals) and productivity oriented (they track volume of traffic inside of terminals; they include growth of TEU per year, usage of crane (number of TEU

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which are serviced by crane, per year), crane-productivity (moves per crane, per hour) and land utilization (TEU stored per year per hectare)).

2. TECHNOLOGICAL INNOVATIONS IN CONTAINER TERMINAL SYSTEMS

In container terminals, there are three types of handling operations (Kim et al., 2012): vessel operations related to container vessels, hinterland operations which include operations with trucks, trains, management of empty containers, and operations related to warehousing or yard storage of containers. In order to achieve higher efficiency, terminals are seeking for innovations which they can implement to their subsystems for every type of handling operations. Shorter time spent in terminals by vessels can be achieved by using more cranes for loading and unloading operations from vessel to land and vice versa, by making longer quay side so a larger number of vessels can be at port at same time, by high level of synchronicity between transport and handling equipment, by having sufficient number of expert manpower, by fast and efficient processing of paperwork and by using automated systems for guidance and finding of free space where containers can be stored, etc.

Technological innovations have to be developed and used in terminals, so terminals can respond to increased number demands of clients with great efficiency and quality. Terminal must be understood and seen through its subsystems and regarding of that, decision about implementing new technologies can be made. The success of particular technology is based on meeting specified criteria (Kim et al., 2012). The first criterion is flexibility. Proposed technology should be applicable with as less modification as possible and easily adaptable to constant changes of situations and logistics environments in the terminal. One of the criteria is costs that, in addition to the cost of implementation, include operating costs. The potential of innovation should be the less dangerous to the environment, which leads to criterion for lower energy consumption and lower emissions of harmful gases, which is related to transport system at first place (Geerlings & van Duin, 2011; Kim et al., 2012). The last criterion is that particular innovation should return from faulty into the working state, in short period of time and that particular innovation is simple for maintenance.

Technologies which are related to transport subsystems have daily contribution on development of terminal and are based on lowering retention time when handing over containers in terminal, optimizing traveled distance, and lowering power consumption and environment pollution. One of the latest innovations is usage of „multilifting" mode, which is term related to simultaneous handing of multiple units. Technologies that improve transportation system are automated guided vehicles (AGV) and linear motor conveyance system (LMCS). As storage space requirement has increased, stock size has increased significantly. Before globalization took hold, in early days of container terminals, on-chassis systems and forklifts were the major handling systems. The height of stacks of containers in terminals was from one to three tiers. Then, straddle carriers became popular for usage in container terminals. As result of straddle carriers usage, the height of stacks was from two to three tiers. Today, yard cranes are the most popular handling equipment in container terminals and they allow stack height of four to six tiers. One thing that is also innovation is placement of multiple cranes per particular storage area (Kim et al., 2012; Vis & Carlo, 2010.), which is already implemented in container terminal in Hamburg, Germany, which is currently under construction. This terminal will have three cranes per storage area. Trend of increasing the number of cranes per storage area is caused by increased density of storage area, so a larger number of cranes is necessary in order to achieve fast flow of containers through the terminal. However, there is problem with this trend which has to be solved and that problem is primarily related to compatibility and synchronization of large number of cranes, which represents a great task for future. Innovations that are used in terminals and have impact on improving storage systems are automated storage and retrieval systems (AS/RS) and overhead grid rail system (GRAIL) which also improves receiving and

shipping operations, as well as Superdock. Innovations in domain of receiving and shipping operations are based on using new information technologies, at first place. Identification of vehicles is completed by computers and observing the improvements in this area, innovations are yet to come. Innovations which have successful use in terminals are flow-through gate and portnet.

3. TECHNOLOGIES OF CONTAINER TERMINALS

This section provides concepts of new technologies in container terminals. Some of these systems are verified by construction and by testing of the prototypes.

3.1 Linear Motor Conveyance System (LMCS)

Linear Motor Conveyance System represents an innovative solution for the containers inside the terminal. The unique characteristics of this system transfers are supported linear motor that moves on rails fixed network path. The link between the cranes witch working on the vessel and gantry cranes that carry operations at container storage area is carried out "shuttle" vehicles which transport containers to and from storage area using linear motors installed in infrastructure. Positioning "shuttle" vehicle below the cranes is done by management information systems (Zečević & Tadić, 2015). Benefits of LMS system in relation to the automatic guided vehicles are lower maintenance costs, less investment, easy integration into the existing infrastructure and the ability to work in all weather conditions. Other advantages of this system are high positioning accuracy, high reliability, and robustness of the equipment. Also, this system is environmentally friendly because instead of diesel fuel and oil, is using electricity (Kim et al., 2012). One of the drawbacks of this system is large initial investment costs. Due to the limited number of transport routes for the transfer vehicle routing flexibility is significantly lower compared to AGV system (Ioannou et al., 2000).

3.2 Automated storage and retrieval systems (AR/RS)

AS/RS are computer controlled systems with extreme accuracy operating in very narrow aisles. The two major components of this system are the machines for storage and retrieval and storage racks. At the entrance to each aisle there is pick up/delivery station. The station is usually located at one end on the lowest level of each aisle. AS/RS increases capacity of warehouses, reduces the workforce, provides high throughput and allows random access to the target container without any manipulation operation. This system does not require a large area, and expanding of the storage space can be achieved by increasing the number of floors. This is very useful when space is limited and expensive. The disadvantages of this system are the high costs of construction, as well as that the malfunction of one machine leads to stopping of all operations in the particular aisle (Kim et al., 2012).

3.3 Overhead Grid Rail (GRAIL)

GRAIL provides a high productivity, high density of container storage and efficient transport operations. This system consists of electrical "shuttle" vehicles used for storage operations on the terminal storage area, as well as transport from quayside to yard area. Shuttle vehicles are moving on rails which are located above yard, at particular height. The switching mechanisms at the end of each rail allow the shuttles to move from one rail to the next. In addition, it is possible for shuttles to move containers directly between the quay and the rail station by extending the rail from the quayside to the rail station.

The connection points between quay cranes and shuttles are the elevated automated platforms below the quay cranes, where the quay cranes operation and shuttle operation are decoupled,

that is, quay cranes pick up or place containers without caring about shuttle arrivals, and the shuttles put down or pick up containers without waiting for the arrival of quay cranes. This decupling reduces the waiting time for equipment. Driving area for the shuttles is moved to the overhead space. This makes it possible to save the space wasted on aisles and avoid the interference of container transporters with container stacks on the ground and with the traffic of manually operated trucks. However, a more complicated control system should be provided and a high investment cost would be required (Kim et al., 2012).

3.4 Speedport

The concept of "speedport" is an extension rail of the Grail system via ship. The concept of the handling system of speedport terminal is based on the idea that resembles a spider web. Network and this system is a series of moving cross-console covering the entire system at the container terminal. Under this network, moving large number of independent transport-handling unit called spiders that affect containers with special pliers (Zečević, 2006). A large number of spiders can work together on the same boat or the same distance from the plateau, which contributes to higher throughput and the better functioning of the system.

This system enables handling of approximately 470 TEU per hour for a vessel with capacity of 6,600 TEU. Total time of loading or unloading of ships of the same capacity with all operations, in the speedport terminal is about 14 hours. In conventional terminals with loading and unloading on both sides, that time is approximately 22 hours, with a one sided operations, that time is approximately 44 hours. Speedport can handle between 2.5 and 3 million TEU per year, which is significantly higher than in conventional container terminals (terminals in the conventional technology with the double-sided loading about 2 million, and with the technology of a one-sided loading, about 1.2 million TEU) (Zečević, 2006). On the downside, the cost of building facilities and buying spiders are very high. There are several technical problems such as the lack of flexibility when it comes to different types of ships. Spiders need to carry enough cable that can reach deep into the cells when it comes to large container ships (Kim et al., 2012).

3.5 Superdock

The concept of "Superdock" originated as a need for economically and environmentally advanced container terminals in the ports of Los Angeles and Long Beach (Alba & Risemberg, 2011). This system includes the drive conveyor rail, universal storage systems, harbors of great length and several cranes working on the vessel handling. The rails are designed for trains, which allow them to directly access the storage site. This principle allows you to change the mode of transport from road to rail. Application of "Superdock" concept reduces noise and pollution also reduces congestion during handling of intermodal units between ships and trains or trucks. This concept reduces operating costs and improves performance related to handling (Kim et al., 2012). It is estimated that this system will eliminate 70% of the trucks to and from the port (Alba, 2012). On the other hand, this concept requires high investment costs and there is problem with control and management of this complex system, as well.

3.6 Flow-Through Gate

The Flow-Through Gate which was introduced in 1997 is a fully automated system that identifies container trucks and gives drivers instructions within 25 seconds. It handles an average traffic flow of 700 trucks per peak hour, and 9,000 trucks per day. After a manifest is submitted through portnet, the fully automated and paperless process at the gate clears trucks entering the port within 25 seconds, with the following steps: The truck arrives at the in-gate; The driver taps his PSA on the and verifies his identity through a fingerprint biometric reader or keys in his personal identification number; The truck is than weighed at the weighbridge; The

gate picks up the truck's identity from the in-vehicle unit at the dashboard; The gate's container number recognition system captures the container number via closed-circuit television cameras; The system checks the driver's identity, truck's identity, weight and the container number against the manifest and clears the truck for entry; The system sends a message to the driver's mobile phone or mobile data terminal on the exact position in the yard where the container will be stacked. (www.singaporepsa.com).

3.7 Portnet

Portnet system (PSA) helps the entire port and shipping community to increase productivity and efficiency through the greater use of information technology and the Internet. Through constant technological innovation, Portnet has consistently been positioned at the forefront of e-business operations in the maritime and shipping industry. Portnet is the world's first nation-wide business to business which provides the logistics industry with a single sign-on network portal. Through it, PSA has connected shipping lines, haulers, freight forwarders and government agencies, helping them to manage information better and synchronize their complex operational processes.

From managing complex transshipment processes of shipping lines, supporting slot exchanges among alliance partners, enabling companies to monitor performance and make critical business decisions, integrating port documentations seamlessly with the haulage processes and workflow to providing a documentation portal between shipping lines and shippers, portnet simplifies and synchronizes millions of processes for customers moving their cargo. Over 10,000 integrated users rely on the system's unparalleled capability to provide real-time, detailed information on all port, shipping, and logistics processes crucial to their businesses. Portnet processes more than 220 million transactions a year. (www.potrnet.com)

3.8 Teustack

Teustack is handling and storage system for 20 foot and 40 foot, standard and refrigerated containers and upon request for other types of containers, such as high cube containers. Containers are handled by cranes which unload them from vessels. After unloading container from vessel, crane deposits it on the purposely allocated reception device. Once container is deposited, the crane is free to release spreader and start a new cycle. The cycle time of crane is reduced because of short vertical transportation time and elimination of non-productive waiting time. After loading of container on reception platform, that platform moves to first free storage location and returns back to receive new container. This platform is called turn and distributor. Inside of teustack terminal there are shuttle machines. Shuttles provide horizontal movement of containers at each floor of teustack terminal. Shuttles are similar to turn and distributor platforms. Vertical transport in testacy terminal is achieved by elevators which are equally distributed along the aisles. Once it reaches destination floor, the container is stored by shuttle which takes it to its final destination in the teustack terminal. All movements are carried out at the same time on different floors. This allows system to separate horizontal and vertical movements in terminal. Containers stored in teustack terminal can be accessed at any time. Operations on shipping containers from terminal are as same as on storing containers, in opposite order. Usage of teustack systems brings obvious space saving benefit. Eight levels enable to store 6400 TEU in 25.000 square meters versus approximately 100.000 square meters required for conventional storage on two levels. Teustack system has 70% greater productivity than conventional solutions, as well as enhanced safety and reliability (www.youtube.com).

4. CONCLUSION

This paper has reviewed technological innovations which have a goal to enhance productivity and efficiency of container terminals. Increasing service demands and „super vessels" with great capacity represent a challenge for container terminals that, to remain competitive, need to minimize retention of containers in terminal, but as well to service as many containers as required. It is necessary to establish which the system is not achieving satisfaction results, and on that basis, as soon as possible decides on implementing some of the innovations. When making these decisions, the most important part is to determine if the system is going to improve productivity and efficiency in accordance with invested funds, whether system fits in existing logistics environment, what degree of flexibility system has and whether container terminal can be adapted for that particular innovation. There is no doubt that in the technological age we live at the moment will progress and evolution is yet to come.

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LOGISTICS IN LUXURY GOODS TRADE

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Abstract: Specific goods category, due to their characteristics, generate specific demands in logistics. In this paper are shown authentic luxury goods' supply chains. It is about extremely valuable goods with large annual turnover on transport market. There are many subcategories of luxury goods. The market is different in regard to other categories of goods. Regardless the trends, which negatively affect the exchange of goods, luxury industry has turned out to be "resistant" to the usual consequences. In this paper are shown the motives for shopping and categories of luxury goods' buyers. Changes in demands and the importance of online selling of luxury goods nowadays, as well as the change of demands are some of specifics of luxury goods industry about which will be discussed in the paper. The connection which appears between CFS (key factors of success) and supply chain management is very interesting.

Keywords: Logistics, Luxury goods, Chain supplies, Trends.

1. INTRODUCTION

In the industry of modern goods in 2006 has been achieved $170 billion in business around the world (Caniato et al., 2009). Regardless the 2009 crisis, luxury goods trade has significantly increased in the last couple of years. There has been an increase of up to 800 B € in 2013 (Shen et al., 2017), including 223 B € so called "personal luxury goods" (clothes, accessories, matches, jewelry, not including yachts, wine, cars, etc.) (Shen et al., 2017). Despite unfavorable economical cycles, luxury goods mark the increase of market, partly because of the increase of social relevance of luxury goods possession, and partly because of great dedication of luxury companies to branding and communication management (Castaldo & Boti, 1999). According to some authors, the design and communication management are only some of the elements which contribute the success of luxury companies, along with production line management, customer service managing and managing distributive channel (Nueno & Queich, 1998). The industry of luxury goods is interesting to observe from the aspect of managing and supply chains strategies. Besides this, it is important to focus on SC strategies and their connecting to key factors of success (CSF-Critical Success Factors) of goods/markets. Despite of its importance, very few concrete contributions to the luxury are recommended in the existing literature (Caniato et al., 2009). This is one of the motives for writing this paper. The goal is to show the characteristics of luxury goods.

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2. LUXURY GOODS MARKET

Luxury fashion industry is important sector which contributes to the increase of the sales volume on the market (Shen et al., 2017). It is known that consumers of luxury fashion goods are among to satisfy functional and social needs. Consumers who buy luxurious fashion goods are usually led by social needs. They don't buy luxury products because they actually need them, but to point out their social status. In luxury fashion industry, social needs are crucial when it comes to making decisions about buying. Fashion consumers can be divided into fashion leaders or fashion followers, depending on how they act (Amaldoss & Jain, 2015; Zheng et al., 2012). These two groups of consumers affect each other, and due to that, they make great social impact (Almados & Jain, 2015). Namely, fashion followers are more willing to buy luxury fashion products if fashion leaders buy more, while, on the other hand, fashion leaders buy these products less if there are more fashion followers who buy them. It means that if the product is available to larger number of people (in this caste the followers), then fashion leaders don't have great wish to buy that product. Leaders want to have rare and expensive products, so owning something everybody has isn't a satisfaction for them.

Strategies, like giving online retail services, are crucial when it comes to managing the luxury goods supply chains (Brun et al., 2008). The offer can significantly affect the decision about online shopping, for example fast delivery or gift package. More important, online retail services can be adjusted to various consumers (Asaduzzaman & Mahswarn, 2007). Consumers can be more or less encouraged to shop online owing to comments on social media, which can make them to start shopping more or less than usual. These situations lead to the change of demand, an as a result of that, increase or decrease of it happens. The example of this happens often in fashion industry, where great changes of demand happen after an unexpected comment of famous analyst about newest collection (Shen et al., 2017). Participants in luxury market are significantly different, not just for characteristics of products, manufacturing and selling (cars, yachts, wine and liquor, clothes, leather, shoes, accessories, watches, jewelry, cosmetics and perfumes), but also from the aspect of company greatness, property structure and universality of activities in general.

Aside from strong increase in reaching and maintaining certain identity of the brand, in order to make a success in luxury market (Keller, 2009), marketing and branding don't guarantee long-term stability anymore, as it was the case before (Caniato et al., 2011). Concept of "value" is related to services which the whole supply chain is able to give, from getting raw materials, all the way to buyers in retail stores. Many factors contribute the success in luxury industry, from projecting and communicational management to user's services and managing the channel (Castelli & Sianesi, 2015).

3. SUPPLY CHAIN IN LUXURY GOODS INDUSTRY

As it was defined by Supply Chain Council, the supply chain includes every trouble included into manufacturing and delivering the final product from supplier's supplier to the customer's customer. The term "managing the supply chain" is used in order to explain planning and controlling the material, the flow of information and logistics activities, not only inside of the organization, but also those between companies which are included in supply chain. On operational level, SCM gathers functions which are as old as the trade itself – asks for goods, buys, storages and distributes it. I.S.'s goal is to improve performances through better usage of internal and external possibilities, in order to create one extremely coordinated chain of supply (Kannabiran & Bhaumik, 2005).

There are few significant economic trends which have been appearing in the last years: globalization of the market, the increase of outsourcing activities level, evolution of the consumers who demand larger number of innovative products and products in smaller quantity

which are adjusted to them, high quality and high level of service. All of these changes had great impact on the research and practice in management area, which lead to increase of chain supply significance. Managing SC appeared as a base for accomplishing competition. In the terms when most of the activities are automated, cooperation between all participants is of key matter in order to ensure the delivery to the buyer. In order to compete in today's high competitive society, it is necessary that the strategy of the supply chain aims to adjust characteristic of the product to buyers demands (Caniato et al., 2009). In chain supply management department, during the past few years, the competition between companies doesn't exist anymore, but it does exist between supply chains (Rice & Hoppe, 2001). In this new competitive surrounding, projecting mechanisms which will help companies to coordinate their conflict goals, risk division, cooperative costs and profit division as a result of cooperation, has become a challenge. Models of supply chains are usually little applicable to the luxury sector. Managing supply chain is important in luxury companies because configuration and managing SC can affect their CFSs (key factors of success). Here, you can obviously see the importance of SCM in achieving competitive advantage. According to (Caniato et al., 2009) main CFSs for luxury companies are: high quality level, (heritage of craftsmanship), product exclusivity, appeal emotionality, brand's reputation, style and recognizability of the design, connection to the native country known for excellence, uniqueness and creating a lifestyle. These CFSs can also be considered for jewelry production (Chen, 2011; Brun & Moretto, 2012). SC can be described as a set of activities which are happening from the source of raw materials, over suppliers, manufacturers, distributors and companies with other roles in the chain, to ultimate manufacture. It includes every effort included in manufacturing and delivering final product from supplier's supplier to the customer's customer.

Whole process of the production and distribution can be watched as series of events with one goal: giving service to the end user. Some of the main economic trends which luxury companies haven't stayed immune to are: market globalization, development of potential competition in the world, evolution of the users when it comes to looking for diversity, product adjustment, high level of service quality. In order not to waste their effort, companies usually decide to focus on limited set of key operations. Since there is greater usage of outsourcing, companies don't have whole set of needed resources for covering the entire manufacturing and distribution process in their property, the only way to satisfy the more demanding and sophisticated customers on one side, and stockholders' interest on the other, is to manage coordination or cooperation with partners like suppliers, buyers and 3PL providers, in order to point their efforts to same goals (Castelli & Sianesi, 2015).

4. SUPPLY CHAINS AND KEY FACTORS OF SUCCESS IN LUXURY TRADE MARKET

The fact to which we have come in the previous part of this paper, that managing SC is of crucial importance for maintaining the pace with the competition on global trade, isn't enough for luxury companies. They usually need to guarantee profitability and to ensure the delivery of the product to buyers, satisfying their demands in means of function, quality, diversity and giving services. Many authors agree that the real strategy SC is the one which is adjusted with CSF of luxury products (Aitken et al., 2003, Demeter et al., 2006). This is one of the reasons why the same approach to the supply chain isn't convenient in every situation. Strong market orientation is needed more and more in order to achieve compliance with CSF. There are several examples about how characteristics of the industry or product can affect the choices of ways to manage SC in accordance with different structures of CSF (Caniato et al., 2009; Al-Mudimigh et al., 2004).

Case study has included 34 known luxury fashion brands all over the world. They are classified in 18 different groups according to product categories (clothes, shoes, jewelry, leather products, etc.). The sample covers both big and small companies. Each of companies (brands) can be put into one of 3 possible segments: Absolute, Aspirational and Affordable segment (De Barnier et al.,

2012). Absolute luxury brands are characterized by elitism, legacy and uniqueness (ex. Harry Winston, Hermes). This segment includes historical connection to luxury and manufacturer of precious products. Aspirative luxury brands make their status by recognisability and distinguishing characteristics (ex. Gucci and Louis Vuitton). Affordable luxury brands are more affordable than the others. Great number of consumers can buy products of brands like Coach and Hugo Boss, and they are usually bought in order to point out status symbol or the feeling that they belong to "the class". This category of products is mainly bought by medium class in Europe, USA, but in Asian-Pacific too (excluding Japan). Main part of the case study is focused on configuration and managing the choices which are adopted in SC. As a result of tests, goals of LS are obtained, as well as CSF which are mutually coordinated. If we connect luxury CSF and SC goals, we get the list of 745 combinations which make the selection of SC on one hand, and the selection of luxury CSF on the other. The list of 745 pairs of "SC practice-CSF" is reduced to 12 by using Pareto classification (Table 1). Class A (80%) is composed of: exclusivity, extraordinary quality, brand reputation, users satisfaction, (heritage of craftsmanship), country of origin and emotional appeal. Class B is composed of accessibility, design recognition and uniqueness. Class C is composed of the way (style) of life and technique performances.

Table 1. Display of CSF Pareto classification (key factors for success) (Castelli & Sianesi, 2015)

Pareto class	CSF	No. of occurrences in the sample	% in the sample	Cumulate % in the sample
A	Exclusivity	128	172	17.2
	Superior quality	123	16.5	33.7
	Brand reputation	114	15.3	49.0
	Customer satisfaction/service level[a]	89	11.9	60.9
	Heritage of craftsmanship	52	7.0	67.9
	Country of origin	49	6.6	74.5
	Emotional appeal	46	6.2	80.7
B	Accessibility[a]	39	5.2	85.9
	Recognizable design	38	5.1	91.0
	Uniqueness	29	3.9	94.9
C	Lifestyle	24	3.2	98.1
	Technical performances	14	1.9	100.0
Note: [a] Indicates the CSF emerged from the interviews				

Case study has confirmed to a large degree that many choices and practices along SC are matched with CSF on the market. Respondents were able to identify even decisions made on purpose (via choices that were made in order to make greater results in regards to certain luxury CSF) and choices to which luxury CFS was just byproduct, (accident) result of some other activities (Caniato et al., 2011). Most practices which are used in these companies aren't luxury-specific (aren't characteristic for luxury companies) or exclusively important in finding luxury CSF. The difference between luxury and non-luxury companies usually isn't in type of supply chain choice (SC), but in connecting chosen chain to business strategy.

5. CONCLUSION

The luxury goods, as one of specific categories of goods which shows on the market, generates certain specifics in logistics. From that comes that luxury goods supply chain has different characteristics. Trends which have been appearing during last few years haven't had negative influence on the luxury goods market, as it was the case with other goods categories. It is known that consumers who buy luxury fashion products are aiming to satisfy functional and social needs. However, while buying luxury fashion products, they are mainly led by social needs. On the luxury goods market there are 2 groups of consumers, fashion leaders and fashion followers. Fashion leaders buy highly worth goods which isn't on the market in large amounts. On the other hand, we have fashion followers. They are readier to buy luxury fashion products if fashion leaders buy more, while on the other hand, fashion leaders buy these products less if fashion followers who buy that product. Luxury fashion industry is an important sector which contributes to significant increase of sales volume on the market (Shen et al., 2017). The significance of supply chain for luxury companies is seen more and more. However, there aren't a lot of researches in this area, which was the motive for writing this paper. Luxury goods supply chain is different from the usual supply chains, but luxury companies recognize that they don't apply the supply chain which can be said to be for luxury goods only. In the paper has come to connecting key factors of success (CSF) with luxury company's supply chains. They are all put into one of three segments (Absolute, Aspirative and Affordable) in supply chains and key indicators of performances, Pareto classification is made. As a result of this research, we have come to the conclusion that the difference between luxury and non-luxury companies often isn't in the choice of SC, but in connecting the chosen chain with business strategy.

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LOGIC

LOGISTICS SPRAWL AND E-COMMERCE: IMPACT ON CITY LOGISTICS

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*Abstract***:** *Some of the key fragments in development of modern cities are urbanization, new business models, and expanding the logistics center's network. In doing so there needs to be: growth of road transport and growth of requirements in terms of speed, flexibility, reliability, and diversity of logistics services. With a lack of planning activities and long-term plans for city logistics these trends are threatening sustainable development of urban zones. The space intended for logistics activities is declining in cities. Logistics companies are moving out of expensive urban zones and developing their systems around the perimeter of the city. Their goal is being to centralize supply chains. On the other hand, the upward trend in e-commerce changes the structure of supply chains and significantly increases the locations and amount of deliveries. The final goal of this project is to analyze the trail of logistics and growth of e-commerce. While also finding out what kind of impact they have on city logistics. Without adequate conceptual city logistics solutions, these trends pose a serious threat to the functionality of some cities.*

Keywords: *city logistics, e-commerce, logistics sprawl, urban freight transport*

1. INTRODUCTION

City logistics is a very important topic among urban planners in most developed cities and countries. Supplying the cities and returning materials from urban areas were complications present and addressed in accordance with different levels of economic, cultural, and technological aspects of social development. Delivery of goods is a prerequisite for the maintenance of urban life and commercial activities. It allows for the achievement of wealth and development of urban areas (Zečević & Tadić, 2006). However, logistics activities, primarily urban freight transport, are not desired in urban centers. Trucks are making a significant contribution to traffic congestion, negative environmental impacts (emissions, noise, vibration, etc.), and this reduce the quality of life in the city (Tadić & Zečević, 2016). The trend of urbanization and the rapid development of cities in recent years are exceedingly noticeable.

Economic expansion and the advancement of the city is the key motivating force, and simultaneously a "sacrifice" to the development of city logistics and urban freight transport (Tadić & Zečević, 2016). Cities depend on the efficiency of logistics and transport systems. Their further development and economic progression is closely associated with the continued expansion of logistics activities, particularly transportation. Therefore, it is impossible to significantly reduce road freight transport, without affecting realization of the city's needs and its inhabitants. On the other hand, with the growth of vehicle-kilometers ratio, its negative

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impacts on the environment are also increasing, while congestion in urban areas threatens to become an even bigger problem (Tadić & Zečević, 2015, 2016).

The increase in freight vehicle-kilometers ratio in the city is the result of different trends in the environment. Among the most significant are the logistics sprawl and the growth of e-commerce. High land leasing prices and the tendency for centralization of supply chains caused the relocation of logistics systems from central urban city areas to suburban areas. This phenomenon in the literature is known as the logistics sprawl (Dablanc & Rakotonarivo, 2010) or logistics suburbanization (Allen et al., 2012). There are numerous positive effects of this trend, but also some disadvantages. One primary disadvantage is increasing the distances that vehicles must cross from the central zone of the city, therefore higher emissions.

Another significant trend is the growth of electronic commerce (e-commerce). E-commerce includes trade transactions between organizations and individuals, based on digital technology. Since the implementation of orders created by e-commerce carry out home deliveries to customers, this trend in some ways goes against the trend of suburbanization logistics. Delivery size for the home order is small, often no larger than a standard shoe box. Also implementation requires a greater number of start vans, a larger number of stops, and the involvement of more people.

2. LOGISTICS SPRAWL

Logistics sprawl or logistics suburbanization, envisions dispersed logistics systems and distribution centers in urban metropolitan areas. Logistics sprawl is a noticeable trend in the last few decades in major cities around the world, especially in cities with intensive logistic activities (EC, 2016; Dablanc & Ross, 2012). Despite the higher leasing land prices, there is a tendency to concentrate logistics systems and locate them in the "mega regions" rather than in small, isolated areas. Mega regions can be defined as a large city "network" and areas that surround them. Mega regions are spatially and functionally linked to economic, infrastructural, and environmental relations (EC, 2016; Ross, 2009). Reasons for polarization or concentration of logistics activities in large metropolitan cities are: centralization of supply chains, the size and importance of the local market, proximity to major infrastructure nodes, developed labor market, and commercial activities and systems (Tadić & Zečević, 2016a). However, cities are faced with a lack of space in urban planning and logistics systems are suppressed from urban to suburban areas.

Although the logistics sprawl has a strong impact on city logistics, there is not much research on this topic. The most likely reason is the lack of database parameters and their continuous monitoring. This project presents the results and the impact of the logistics expansion in two cities of different size and their geographical characteristics.

Paris (France) on one side, a large monocentric city that is also involved in an important megaregion. The other is Gothenburg (Sweden), a small town, which is not included in the megaregional context, but through its territory passes the important inter-regional corridor that leads to the capital which is 470km away. In Paris, the analysis was done about metropolitan areas and locations of terminal companies engaged in express delivery and realization of parcel shipments, in the years 1974 and 2010. Package and express delivery carriage covers about one third of the urban freight transport (regarding deliveries with commercial vehicles). The average distance from the town center to the terminal ranged from 6.3km in 1974 to 18.1km in 2010. Therefore, relocating logistic centers for shipping and express delivery companies increased the distance between the terminal and the place of delivery of shipments by an average of 10km in each delivery. The relocation of logistic systems away from the city generated an additional 16,500 tons of CO_2 in 2010 compared to 1974 (EC, 2016; Andriankaja, 2014).

In the wider region of Gothenburg, an analysis of deployment and location of logistic systems was done for the years 2000 and 2014 (Heitz et al., 2016). The average distance from the center to which they gravitate increased from 79.3km in 2000 to 81.4km in 2014. At the same time there has been a centralization of logistic systems so that the distance to the nearest neighboring center decreased from 25.5km to 13.3km. Logistic facilities are moved to new locations, near the main road corridor between Gothenburg and Stockholm, and close to the other larger settlements. The existence of large seaport in the area of Gothenburg contributes to the increase of the number of logistic facilities, by more than 30% in a period of 2010-2014 (EC, 2016; Heitz et al., 2016).

Surveys conducted in several cities of Europe, America and Asia for the CityLab project (EC, 2016) indicate a change of the average distance from the center of logistics facilities to the place which they gravitate towards. In all cities with the exception of Amsterdam, Belo Horizonte, Rotterdam and Seattle, there has been a trend of suburbanization, i.e. logistics sprawl, which means an increase in the average distance from the center. The average increase ranged from 1.2km (Toronto) to 11.8km (in Paris). An interesting fact is that the average increase in the distance from the gravitational center within one year amounts to 0.45km (EC, 2016).

3. E-COMMERCE

The trend of development of new forms of commerce (e-commerce or a trade from home) and the growth in demand for home delivery pose special challenges for future planners and decision-makers in the city. Realization of these flows on the existing forms is less economically efficient and environmentally friendly. The largest number of home and courier express deliveries does not draw attention to logistics and its providers, which are not interested in this market segment, due to a number of problems of realization (Tadić & Zečević, 2016a, Hesse, 2002). Prices for these services are relatively high and are considered the biggest obstacle for future growth. In addition, delivery failures that can occur if the customer is not at home at the time of delivery create additional transport and environmental problem (Tadić & Zečević, 2016a, Edwards et al. 2009). In order to address the growing problem of the e-commerce system, it requires the specialization of city logistics, planning, and implementation of a network of stations for the delivery and receiving of goods (CDP, *Delivery Collection Point*). Using this system solves the problem of failed home deliveries while research shows significant effects on the shopping drives (Tadić & Zečević, 2016a, Song et al. 2009).

B2C (Business to Consumer) forms the backbone of e-commerce. Global sales through e-commerce in the form of B2C increased rapidly over the last decade. B2C is driven by the increase in the number of users of modern technologies, particularly the Internet, as well as changes in user's behavior when buying goods and services. It is estimated that in 2014 total worldwide sales of goods and services via e-commerce has reached a value of $1.9 trillion. In the form of B2C e-commerce, China is leading, followed by the United States and the United Kingdom. However, sale of goods and services via e-commerce has achieved more reverse effect than expected. E-commerce, when it comes to goods, increased the number of trucks driving in the city and led to the fragmentation of shipments, increasing the number and frequency of deliveries. According to a study from 2014 conducted in the UK, in 2013, shipments - packages, no larger than a standard shoe box, accounted for 59.5% of the total number of delivered goods that were ordered online, i.e. through a system of e-commerce, with an expected increase in the share of 42% between 2013 and 2018 (EC, 2016). On the other hand, when it comes to services, e-commerce has enabled the elimination of unnecessary movement of customers, allowing services to be purchased online, or that some products such as books, music and similar to be downloaded from the Internet (EC, 2016). Increasing the volume of e-commerce has led to the growth of urban freight transport deliveries to residential and business districts, previously dominated by personal transport, i.e. personal transport vehicles.

3. CONCLUSION

The trends of logistics suburbanization and e-commerce have opposite principles. Suburbanization involves the relocation of the logistic facilities to the outskirts of the city, in order to centralize supply chains and reduce the number of transport vehicles, which delivered the goods to the logistic centers in the city. In contrast, e-commerce requires greater engagement of delivery vehicles for delivering the goods ordered and purchased mostly through the Internet. On the one hand, the goal is to reduce the number of points of receipt in macro-distribution flows (logistic centers), and on the other hand, the number of delivery points in the micro-distribution is significantly increased (delivery on home address). In addition, it is noticeable that the size of single delivery decreased, while at the same time increased the number and frequency of deliveries, especially at home addresses

Both trends have significant negative impacts on the sustainability of the urban environment. Initiating a large number of delivery vehicles, increases the kilometers travelled by each vehicle, increases the energy consumption and emissions, burdens the road network and creates congestion, and reduces the accessibility and safety of traffic in the city. Analysis of these trends should be of concern to local authorities and urban planners. Without an adequate impact analysis and the concept of city logistics, there is a risk of loss of the vitality of the city and the quality of life in the city.

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CROSS BORDER SUPPLY CHAIN SECURITY

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Abstract: *Cross-border supply chains are extremely dynamic, increasingly complex because of a growing number of the participants and vulnerable to a large number of threats and hazards. Securing the supply chain and ensuring its smooth functioning at the same time is essential to the national security and economic prosperity. As people all over the world rely on the goods transported by the global supply chain system, all participants must cooperate in dealing with this problem. The cross-border supply chain security problem and procedures for improving the security are the main topics of this paper.*

Keywords: *supply chain, security, customs, visibility, standards*

1. INTRODUCTION

The terrorist attack on the World Trade Centre 11th September 2001 has changed the world and consequently, the providing of logistic services. It is important to note that these logistics disruptions were not caused by the attack itself, but by the government's response to the attack: closing the borders, closing the air traffic zones and evacuating buildings all over the country. In the decade following the terrorist attacks in New York City, security has taken on a significant role in the global supply chain system. Before the attacks, the main thought was- the right goods at the right time. Today, we may add, safely delivered. The focus of the supply chains is often on the speed of completing the operations, which can hinder monitoring the safety. In order to ensure the supply chain security, it is necessary to use a multiobjective approach to safety which includes well-defined protocols, understanding of world regulations, employee training, physical security measures, performing detailed checks on the participants, video surveillance for warehouses and cargo loading/unloading operations and using safe facilities.

The problem of cross-border supply chain security is the main topic of this paper, which consists of four parts. The first part describes different threats and risks which companies encounter while operating in global supply chains. The second part deals with the role of Customs in international flow of goods. It describes different challenges which cross-border workers encounter, programmes for improving safety on border crossings, different participants interested in cross-border security and importance of non-invasive inspections. The third part refers to different standards for improving supply chain security. The last, fourth part, refers to the visibility problem, ways of improving the visibility and development of different technologies and equipment which can improve cross-border supply chain security.

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2. CROSS-BORDER SUPPLY CHAIN SECURITY PROBLEM

As organizations keep on developing their supply chains, they rely to a great extent on transport providers, with the aim of delivering and protecting their shipments. Transporters need to ensure constant tracking of shipments, in order to avoid freight thefts, hijackings and smuggling. This sector also experience natural disasters threats, which could have negative impact on business and cause delivery delays and damages to goods. With the aim of mitigating these risks, providers need to be able to identify global threats and react quickly to them. Only some of the threats which cross-border supply chains experience will be described in this paper.

Losses and thefts

The term ''inventory shrinkage'' is used for all the losses made between the point of manufacturing or purchase from the supplier and the point of sale. The average shrinking rate is 1.8% of total annual sale. That means that a $ 33.21 billion loss is made annually in the USA. Authors mention four main causes of losses: thefts by employees, thefts in stores, administration errors and frauds by sellers. In European countries, consumer goods have the following losses: 26 % production losses, 8% distribution losses and 66% retail losses. Transport and distribution losses amount to 14% of total sales for all kinds of products. It has been estimated that thefts cause a $10 billion loss in the USA and $30 billion loss worldwide. The value of the cargo stolen in the EU is estimated at EUR 8.2 billion a year. It is extremely difficult, and in some cases even impossible to collect precise data on cargo theft loss.

Terrorism

The word 'terror' comes from Latin, meaning 'to scare'. The lack of universal definition of terrorism can be described with the comment: ''one country's terrorist is another country's fighter for freedom.'' According to the data from the EU, the main threat comes from separatist movements, with Islamic terrorism as the biggest threat. The official statistics concerning the transport lead us to the following conclusions:

- Transportation activities make 4% of goals in 2006 and 5% of goals in 2007.

- The main methods of attack are an armed attack and bombing.

- Target areas of terrorist activity are the Middle East and Asia.

Smuggling of goods

The main target of illegal products is the black market. It consists of places and situations in which suspicious and illegal products are sold. Black market has the same laws of supply and demand as regular markets. Statistic reports show that the trade in counterfeit and pirated products in 2007 amounted to 176 billion dollars. In 2006 three million pharmacy products were proven fake. Supplying of the black market can be illustrated with the example of smuggling of cocaine in the USA. Illegal supply chains come mainly from South America. Smugglers use roads, sea routes and airways to avoid American authorities. The whole distribution of cocaine is controlled by Colombia's organized crime. In recent years, however, they have included Mexican cartels in the process in order to simplify the logistics and share the risk. Colombians have made a business network by making cells for special purposes like storing and transport. In order to be able to supply their customers, these markets are very flexible and resistant to outside influence. The supplying of a typical gray market can be illustrated as an illegal smuggling of counterfeit products. Gray market includes diverting of goods from illegal supply chains. There is a risk that this market could be discovered by the authorities or companies whose products are copied. This diversity results in different supply chain designs. Supply chains of counterfeit products use the same freight routes and port operations as the legal chains. These products best sell in Europe and the USA, whereas transitions are mainly done across Africa [1][2].

Migration crisis

The recent influx of migrants into Europe has lead to the greatest migration crisis since World War II. Conflicts in the Middle East, North Africa and central Asia, which caused this situation, do not seem to subside. Because of the rapid flow of migrants in the last two years, members of the EU have taken extraordinary measures, including imposition of new border controls in the entire region. These measures hinder the free movement of goods in many regions of the continent, which causes serious delivery delays, increases costs of cross-border shipments, whereas attacks at freight carriers cause great losses of expensive goods [3].

3. BORDER CONTROL PROCEDURES AND MEASURES

The increase in global trade and importance of cross-border transactions are forcing the governments to introduce more efficient border procedures. From the logistic point of view, it is essential to implement border actions for the goods in transition across two or more countries, so they could become part of the untroubled process in a supply chain. That requires unique and internationally accepted documents which can be transferred by IT systems. Customs organizations must have well trained and well paid personnel, who are aware of their importance in supply chains. Trade and transport have experienced a number of new risks in the past few years.

3.1 Participants interested in border security and partnership with the private sector

Each control relies on business entities which report the data to agencies responsible for border control. Business entities involved in international trade can be classified into one of the categories: traders, transport and related services, facilities and infrastructure.

Table 1: Business entities which take part in international trade [4]

TRADERS	TRANSPORT AND RELATED SERVICES	FACILITIES AND INFRASTRUCTURE
Small and medium-sized enterprises	Sea companies	Seaports
Big and multinational enterprises	Ferry operators	Ferry ports
Foreign companies and investors	Air companies	Airports
Exporters/importers from the same industrial branch	Trucking companies	Railroad terminals
Exporters/importers from different economic branches	International railway companies	Container port operators
Distributors and retail traders	Logistics services providers	Port operators and workers
Buyers and sellers representatives	Freight forwarder	Freight operator and loading-unloading workers
Foreign companies exporting from developed countries	Customs mediators	Storekeepers
Foreign companies exporting from less developed countries	Banks and financial companies	Transit stores operators
	Insurance companies	Port system service providers
		IT service providers and personnel responsible for the development of IT system

Efficient cross-border procedures depend to a great extent on managing the whole supply chain, from materials providers to end users. Logistic have an important role in managing the supply chain. In practice, end users are connected with manufacturers, final products and spare parts thanks to global supply chains. These chains cross from one country's industry into another country's industry. Participation and collaboration of the users from the private sector initiates enhancement of trading performance and competitiveness. The following table displays different participants involved in these operations.

Table 2: Users from the private sector [4]

TYPES OF PRIVATE USERS FROM THE PRIVATE SECTOR	USERS FROM THE PRIVATE SECTOR
Clients	Buyers, payment sender, recipients, importers
Providers/Suppliers	Sender, payment recipient, seller, manufacturer, exporter
Mediators	Bank, customs mediator, exporter and sender, storekeeper, company responsible for checking the credit, trading representative, export representative, company responsible for inspection, railway wagon drivers, logistics centre officials

3.2 Programmmes for improving safety on border crossings

The goal of all programmes conducted by customs organizations is increasing the security in supply chains and facilitating trade.

Authorised Economic Operator (AEO)

The EU introduced this status because of AEO initiative which encouraged customs organs in the Member States to adopt safety measures in supply chains. The goal of this programme is improving the security of the supply chains and ensuring better efficiency which could reduce the costs. It entered into force January 1st 2008 and it is valid throughout the entire EU territory. Authorised Economic Operator is the party which participates in international movements of goods with any functions which meet standards of the World Customs Organization or equivalent supply chain security standards and are thus approved by National Customs Administration. It consists of manufacturers, importers, exporters, mediators, transporters, freight forwarders, port, airport and terminal workers, integrated operators, storekeepers and distributors. [4]

Customs-Trade Partnership Against Terrorism

One of the first reactions of the US Government after the terrorist attacks on September 11th 2011 was creating a new security environment by adjusting and relying on the existing programmes of partnership with the private sector which by then focused primarily on drug trade. These efforts resulted in creating Customs-Trade Partnership Against Terrorism. This programme applies only to import and covers only sea transport [6].

Container Security Initiative

Uses risk estimation criteria to make a prior selection of high risk containers before loading them on ships in international sea ports and sending them to the USA. It was created after the terrorist attack on September 11th 2011 in order to prevent legal trade containers from being used for terrorist activity. In the beginning, it focused on twenty biggest sea ports having a large trade volume with the USA. At the moment, the initiative comprises over fifty sea ports [5].

Secure Freight Initiative

This initiative is financed by U.S. Department of State Security and Department of Energy. It is directed at upgrading the existing security measures in sea ports, in order to prevent terrorists

from using nuclear and radiological materials for attacking the global sea supply chain and from using freight containers for exporting resources for such attacks. This initiative improves the ability of U.S. Government to scan containers in other countries, so that it can discover nuclear and radiological materials and make better risk assessments of incoming containers by using high technology devices, integrated systems and other technologies made for scanning sea container freights [4].

3.3 Non-invasive border inspections

In the past, all inspections used to be invasive. When a border agency was interested in a shipment, they opened the container or truck. Then they inspected everything that was in it. The agency often had to physically move the freight, inspect it and reload it on the vehicle. Thanks to advances in technology, invasive inspections are no longer necessary and are made only in exceptional cases.

Most non-invasive freight inspections are now made by scanning devices, normally by scanners which use x-rays. Then an operator examines the image in order to identify potential irregularities. There is no need to open or remove a container seal or take any parts of the freight. Scanners also enable manifest verification and detection of certain materials[4].

4. STANDARDS FOR IMPROVING SUPLLY CHAIN SECURITY

Along with different technologies and equipment, different types of standards have been established in order to improve supply chain visibility and security. Some of them will be covered in this paper.

ISO 28000-Supply Chain Security

Is a standard developed especially for logistics companies and other organizations that run supply chain operations. Its final goal is increasing supply chain security. It is a high-level management standard that enables organizations to establish an overall supply chain security management system. ISO 28000 requires the organization to assess the security environment in which it operates, to determine if adequate security measures have been applied and to identify relevant regulatory requirements with which it should comply. If security needs are identified by this process, the organization should implement mechanisms and processes to meet these needs.

Tapa standards

TAPA (The Transported Asset Protection Association) is a unique forum that unites global manufacturers, logistics providers, freight carriers, law enforcement agencies and other participants with the common aim of reducing losses from supply chains. Today, TAPA has over 700 members. It applies global security standards, best industry practices, technology, education, benchmarking, regulatory collaboration and the proactive identification of supply chains crime trends. [7]

5. IMPROVEMENT OF SUPPLY CHAIN SECURITY

Companies are facing different problems today: wasting time, because shipments are scheduled manually and products are tracked from channel to channel, missed opportunities from not knowing the exact quantity of goods in transit and stock availability, strained relationships because of delivery delays. The common element of these problems is a lack of visibility. Supply chain visibility is the ability to view products as they are being transferred from the manufacturer to their final destination. The goal is to improve and strengthen a supply chain in order to make data available to all parties interested in the process, including the buyer. As the

visibility started to gain in importance, different companies have developed different solutions, and as a result, there is a whole spectrum of solutions for improving the visibility.

In order to ensure the freight, vehicles and personnel, different technologies and equipment have been developed over the decades, which are to meet different supply chain challenges. Developing security equipment has been a long process. Today, systems are open, image quality is higher, videos are used more often. A lot of logistics providers have developed new security services in order to gain competitive advantage over other companies at the market. It was essential to develop a service which would enable basic asset tracking in real time. Along with the freight and assets, data are exposed to certain risks. Combining physical and internet security is a market imperative. Despite tremendous progress and highly sophisticated solutions, we still do not have a prefect tracking technology. The best option for companies would be a 24/7 visibility, but there are always some limitations. Despite these limitations, every step to better supply chain visibility is a step in the right direction. [8][9].

6. CONCLUSION

The problem of global supply chain security keeps growing, attracts more and more attention and a lot of authors examine it from different perspectives. The event that has changed the world was the terrorist attack in New York in September, 2001. In the last decade, a lot of effort has been put into improving the global supply chain security. However, with the growth of companies grows the criminal rate. The supply chain is growing in complexity, includes an increasing number of participants, who are difficult to control. Therefore, the first step in increasing security may be choosing and cooperating with partners a company can trust. Along with the traditional deployment of RFID, GPS and barcode marking of companies, they have developed sophistic solutions which use cameras and videos. Some authors also mention a variety of different solutions which will have been applied by 2025. All these technologies and standards should increase the security, without hindering different operations. Border crossings and their official hold the greatest responsibility. New security programmes and technologies which should their work easier and improve efficiency and security are constantly being developed.

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