ЕЛЕКТРОННО СПИСАНИЕ „ИКОНОМИКА И КОМПЮТЪРНИ НАУКИ“, БРОЙ 6, 2017,
ТЕМАТИЧЕН БРОЙ „СЧЕТОВОДСТВО“, ISSN 2367-7791, ВАРНА, БЪЛГАРИЯ
ELECTRONIC JOURNAL "ECONOMICS AND COMPUTER SCIENCE", ISSUE 6, 2017,
THEMATIC ISSUE "ACCOUNTING", ISSN 2367-7791, VARNA, BULGARIA

One approach for minimising the average turnaround time in Varna West Port Terminal

Tanka MILKOVA[1], Radan MIRYANOV[2]

[1] University of Economics, Varna, Bulgaria
tankamilkova@ue-varna.bg

[2] University of Economics, Varna, Bulgaria
miryanov@ue-varna.bg

Abstract. One of the most important criteria for port efficiency nowadays is the average turnaround time. More and more port terminals are assessed by this indicator, so its value turns to be one of the crucial factors for ports competitiveness and consequently minimising the turnaround time becomes one of the most important objectives of the ports. The purpose of this research paper is to propose one interesting tool for optimising this indicator by using the famous Simplex method of linear programming. After giving the approach some exemplary models are solved with real values based on statistics for Varna West Port Terminal which will make the design of the paper original in both directions – theoretical and practical, so that despite some limitations concerning the trade secret, the scope of the material is large enough to be used for any port with any data, even exemplary and/or approximate. The aforementioned practical implications could be pointed out as the main contribution of this paper and the easy way for calculating the final results makes the algorithm really applicable so that each port can make its own conclusion based on its particular statistical data.

Key words: linear optimisation, port efficiency, turnaround time.

1. Introduction

Port management has never been an easy and simple process but the dynamics of the modern world economics makes it more and more complicated. Each port tries to operate in a way which minimises its costs and overall expenses (Nikolaev et al. 2014). One of the most important factors that may lead to big loss of both money and customers if not minimised is the turnaround time for the incoming vessels. Exactly the average turnaround time in ports represents one of the major changes in maritime logistics for the last 50 years (Baniela et al. 2014).

The main purpose of this paper is to demonstrate an economic-mathematical model for minimising the turnaround time while satisfying all the restrictions the port may have from technical and/or economical point of view. This aim will be achieved by using the Simplex method of linear programming (Atanasov et al. 2015). Afterwards the constructed model will be demonstrated for minimising the turnaround time of Varna West Port Terminal, using some exemplary realistic data with calculations made by means of MS Excel Solver tool.

2. One linear model for minimising the average turnaround time

Let us assume that a given port terminal has k berths which can be grouped into m berth groups $(k \geq m)$ for technical, logistical or other reasons (e.g. depth, length, facilities, etc.). Each berth group has a capacity which depends mainly on the technical characteristics of its berths and some other specific details. Let the corresponding capacities of the berth groups are c_i , $i = \overline{1, m}$.

For a given period of time (e.g. week, month or year) the port is expecting n incoming vessels (nowadays the contracts are very strict and we may assume that the port authorities have this information in advance). Then we can choose the variables $x_{ij} = \begin{cases} 0 \\ 1 \end{cases}, \ i = \overline{1,m}, \ j = \overline{1,n}$ resulting 1 if a berth from the $i-$th group services the $j-$th vessel and 0 if the berth servicing the $j-$th vessel is not from the $i-$th group, assuming that no change of the group is needed during the service procedure.

Let the turnaround time for the $j-$ th vessel if serviced at a berth from the $i-$ th group is t_{ij}, $i = \overline{1,m}$, $j = \overline{1,n}$. So the total turnaround time for the given period of time will be equal to $\sum_{i=1}^{m}\sum_{j=1}^{n} t_{ij} x_{ij}$, while the average turnaround time will be $\frac{1}{n}\sum_{i=1}^{m}\sum_{j=1}^{n} t_{ij} x_{ij}$.

It can be easily seen that $\sum_{i=1}^{m} x_{ij} = 1, \ j = \overline{1,n}$ and $\sum_{j=1}^{n} x_{ij} \le c_i, \ i = \overline{1,m}$. So the linear model for minimizing the total turnaround time for the given period of time will be:

$$\min : \sum_{i=1}^{m}\sum_{j=1}^{n} t_{ij} x_{ij} , \tag{1}$$

subject to

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

$$\sum_{j=1}^{n} x_{ij} \le c_i, \ i = \overline{1,m}, \tag{3}$$

$$x_{ij} = \begin{cases} 0 \\ 1 \end{cases}, \ i = \overline{1,m}, \ j = \overline{1,n}. \tag{4}$$

We can put a stress once again on the simple fact that no change of the groups is needed during the service, i.e. it is not logical some part of the work to be done in one berth group while the rest to be in another although in practice there are some insignificant exceptions.

Another situation may occur more often – a berth to be “forbidden” for some ship or ships. The reasons can be various – technical, economical, logistical, etc. If so the corresponding values of t_{ij} is chosen to be “too big” so that the algorithm avoids that choice. In practical problems where the average turnaround time is approximately 24 hours (Ducruet and Merk, 2013), choosing value of 1000 hours for example is enough.

3. Application of the algorithm for Varna West Port Terminal

Let us demonstrate the aforementioned approach based on some realistic data from Varna West Port Terminal. This terminal has 19 berths which are usually divided into four groups (fig. 1). The first group consists of 7 berths (1A, 1, 2, 3, 4, 5 and 6) close to each other with distance from water level to top of hatch coaming maximum 16 m. The second group is smaller with 2 berths only (7 and 8) and the distance from water level to top of hatch coaming is even less – maximum 12 m. The third group is similar to the first with 9 berths (9, 10, 10A, 11, 12, 13, 14, 15 and 16) with distance from water level to top of hatch coaming maximum 16 m. The fourth group has only one berth (number 17) but the distance from water level to top of hatch coaming is up to maximum 21 m.

Let us observe an exemplary future 1-week period and the expected number of ships in Varna West Port Terminal is 15. Having in mind the 4 berth groups, we have to determine the values of the variables x_{ij}, $i = \overline{1,4}$, $j = \overline{1,15}$. For technological reasons the capacities (c_1, c_2, c_3, c_4) are $(8, 2, 8, 2)$. The approximate values of t_{ij}, $i = \overline{1,4}$, $j = \overline{1,15}$ are given in table 1.

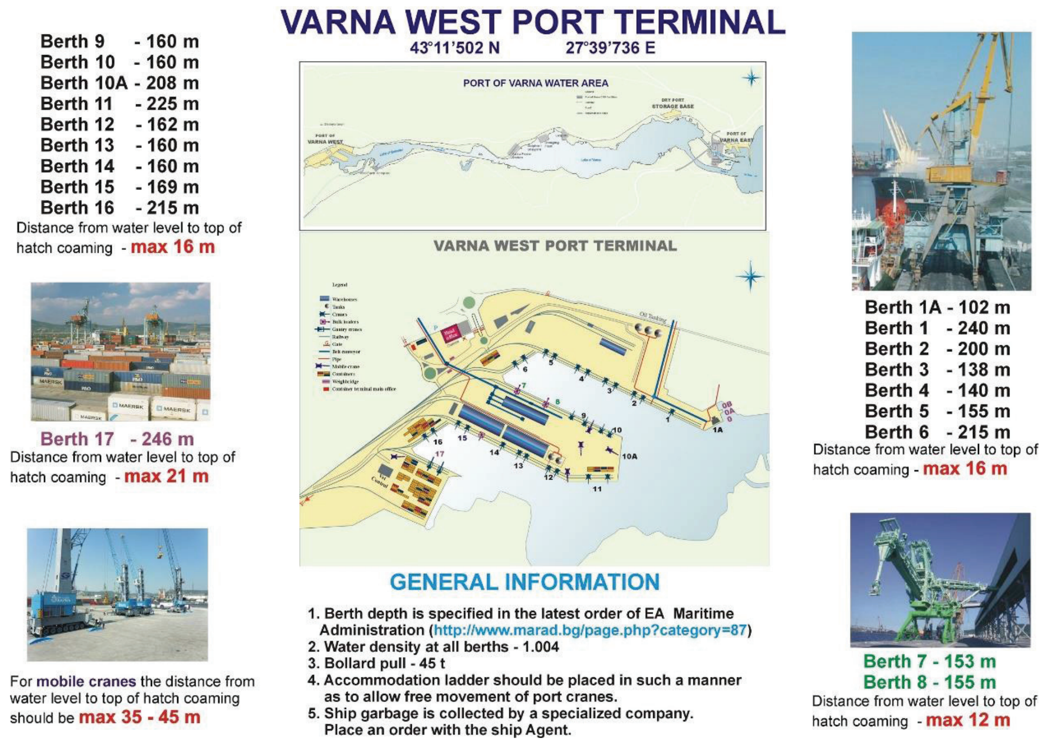

Figure 1. Varna West Port Terminal
Source: www.port-varna.bg

Table 1.

Approximate turnaround time (in hours) for the $j-$th vessel if serviced at a berth from the $i-$th group

Vessel \ Group	1	2	3	4
1	27	25	28	26
2	28	26	26	29
3	29	27	25	28
4	25	26	27	28
5	24	23	26	25
6	26	25	28	27
7	29	27	30	28
8	26	27	28	29
9	27	26	25	28
10	24	25	26	28
11	25	26	24	27
12	26	32	28	29
13	31	28	32	30
14	28	29	30	31
15	30	27	29	27

Source: Own calculations

The linear problem (1)-(4) can be easily solved by means of using MS Excel Solver tool and the results are given in table 2.

Table 2.

Incoming vessel to berth group distribution with no restricted groups

IS\BG	1		2		3		4	
1	27	0	25	1	28	0	26	0
2	28	0	26	0	26	1	29	0
3	29	0	27	0	25	1	28	0
4	25	1	26	0	27	0	28	0
5	24	1	23	0	26	0	25	0
6	26	1	25	0	28	0	27	0
7	29	0	27	0	30	0	28	1
8	26	1	27	0	28	0	29	0
9	27	0	26	0	25	1	28	0
10	24	1	25	0	26	0	28	0
11	25	0	26	0	24	1	27	0
12	26	1	32	0	28	0	29	0
13	31	0	28	1	32	0	30	0
14	28	1	29	0	30	0	31	0
15	30	0	27	0	29	0	27	1
Tmin	387	7		2		4		2

Source: MS Excel Solver

We can see that after the optimisation the capacity of the smallest berth groups (second and fourth) are used up to the maximum while the biggest group has the smallest percentage of use. For such reason or for some different management issues the port authorities may decide to put some additional restrictions in other to receive a more balanced result. Such an example for putting some "big turnaround time obstacles" for particular vessel and berth groups is given in table 3, where group 1 must not service ships 5 and 10, while groups 2 and 4 must not service ships 1 and 15 correspondingly. The results can be found in table 4 and although the total turnaround time is slightly increased, the distribution seems more balanced.

Table 3.

Approximate turnaround time (in hours) for the $j-$th vessel if serviced at a berth from the $i-$th group with restrictions put on some vessels and groups

Vessel \ Group	1	2	3	4
1	27	1000 (forbidden)	28	26
2	28	26	26	29
3	29	27	25	28
4	25	26	27	28
5	1000 (forbidden)	23	26	25
6	26	25	28	27
7	29	27	30	28
8	26	27	28	29
9	27	26	25	28
10	1000 (forbidden)	25	26	28
11	25	26	24	27
12	26	32	28	29
13	31	28	32	30
14	28	29	30	31
15	30	27	29	1000 (forbidden)

Source: Own calculations

Table 4.

Incoming vessel to berth group distribution with restricted groups for some ships

IS\BG	1		2		3		4	
1	27	0	1000	0	28	0	26	1
2	28	0	26	0	26	1	29	0
3	29	0	27	0	25	1	28	0
4	25	1	26	0	27	0	28	0
5	1000	0	23	1	26	0	25	0
6	26	1	25	0	28	0	27	0
7	29	0	27	0	30	0	28	1
8	26	1	27	0	28	0	29	0
9	27	0	26	0	25	1	28	0
10	1000	0	25	0	26	1	28	0
11	25	0	26	0	24	1	27	0
12	26	1	32	0	28	0	29	0
13	31	0	28	1	32	0	30	0
14	28	1	29	0	30	0	31	0
15	30	0	27	0	29	1	1000	0
Tmin	391	5		2		6		2

Source: MS Excel Solver

4. Conclusion

As a result of this theory research and practical calculations some important conclusion can be made. For example the total turnaround time for Varna West Port Terminal without any restricted groups is 387 hours which means 25,8 hours average per vessel, while with some groups forbidden for particular ships the total time slightly increases to 391 hours. This is obviously not significant for ship owners and if the port authorities succeed in obtaining a more balanced distribution it seems a better solution. Another point that should be mentioned is the simplicity of the approach and the fact that it can be applied easily for any port terminal if statistical data exist. The present paper shows how useful the economic-mathematical modelling can be for optimising the complicated management of such objects of crucial importance for logistics and economics as port terminals.

Literature

Atanasov, B. et. al., 2015. Operations research (in Bulgarian). *Science and economics, Varna.*

Baniela, S. et. al., 2014. Textbook of maritime medicine. *Norwegian Centre for Maritime Medicine*.

Ducruet, C. & Merk, O., 2013. Examining container vessel turnaround times across the world. *Port Technology International*, Edition 59.

Nikolaev, R. et. al., 2014. Mathematics with application in economics (in Bulgarian). *Science and economics, Varna.*