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SOLVING CONCRETE PROBLEMS IN NAVAL FRAMEWORK THROUGH CANONICAL MATHEMATICAL MODELS

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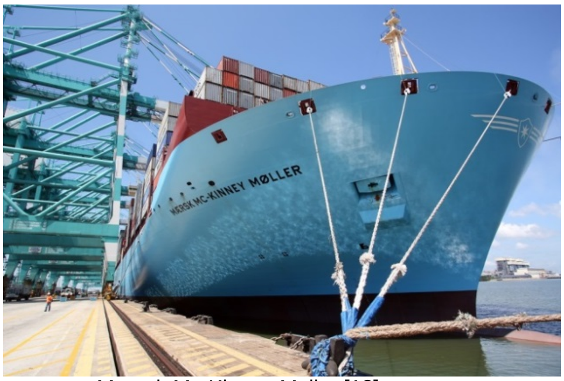
Abstract:*The paper aims is to point out how good results in the management of shipping might be achieved through canonical mathematical models.*
Key-words:*mathematical model, North-west corner method, minimum element method, mixed differences method.*

INTRODUCTION

Between June 2012 and February 2013, in the port of Okpo in South Korea, Daewoo and Marine Engineering worked to build the largest container shipping vessels, named Maersk Mc-Kinney Moller. It measures 400 meters length, 59 meters width and has a height comparable to a 20-storey building,while the transport vessel has a capacity of 18000 containers,each of 20 feet [2], [4].



Maersk Mc-Kinney Moller [12]

Note the fact that, a container of 20 feet has the length - 20 ft (5.9 m), the width - 8 ft (2.4 m), the height - 8ft (2.4 m) and thevolume - 33m³[10], [11].

For its construction, steel was used such as for eight Eiffel Towers and a single transport capacity could bring 111 million pairs of sneakers (in a 20 feet container, arround 6000 pairs can be carried on) or 182 million iPads (about 10100 iPads/container). Putting all the containers one over the other, an amazing height of 47 km would be reached[2],[5],[7].

Its purpose is to serve the trade route between Asia and Europe and bring in the ports of Europe millions of products manufactured in China, Malaysia, Taiwan and Korea [6], [7].

Fuel reduction is spectacular, from 214 tons per day to only 160 tons. The maximum speed of the vessel is 23 knots and has a large contribution to reducethe fuel consumption. The maximum speed would have been limited to 21 knots, but we opted for the flexibility of moving quickly in case of delay, for whatever reason, in order to follow the schedule and eliminate certain potential additional costs for delays [8].

PRESENTATION OF THE PROBLEM

To streamline costs more for Maersk Mc-Kinney Moller, we imagine that we can apply the mathematical model for a transportation problem for a shipment of 10 000 containers on the route Asia - Europe. We considered the following ports: Algeciras, Hamburg, Rotterdam and Marseilles and with the demand of vacuum cleaners, footwear, and TVs (LCD). These products are necessary for containers in the following amounts: b_1 = 10, b_2 = 30, b_3 = 35, and b_4 = 25(to easier make calculations we understand that 10 means 1000 containers).We used the next notations for ports:

- Hamburg = P1
- Rotterdam = P2
- Algeciras = P3
- Marseille = P4

For the current transport, one container can hold 1000 vacuums or 6000 pairs shoes or 2000 LCD TVs.
Note suppliers:

- LG Electronics Inc. = F1
- Nike = F2
- Samsung Smart TV = F3

The transport costs per unit (note $ 100 = 1u.m.) are: 4,3,2,1; 3,2,1,2; 3,4,1,2; monetary units from F1, F2 and F3. The mathematical model of the transport problem can be solved by three methods: the North-west corner method; the Minimum element method; the Mixed differencesmethod [1].

For the beginning we use the North-west corner method to find an initial solution. Ifx_{ij}denotes the amount of products that will be transported from the provider F_i, i = 1,2,3, to the port P_j, j = 1,2,3,4, we obtain the following mathematical model:

$$X_{11} + X_{12} + X_{13} + X_{14} = 50$$
$$X_{21} + X_{22} + X_{23} + X_{24} = 20$$
$$X_{31} + X_{32} + X_{33} + X_{34} = 30$$
$$X_{11} + X_{21} + X_{31} = 10$$
$$X_{12} + X_{22} + X_{32} = 30$$
$$X_{13} + X_{23} + X_{33} = 35$$
$$X_{14} + X_{24} + X_{34} = 25$$

$X_{i,j} \geq 0$, i = 1, 2, 3; j= 1, 2, 3, 4.

$$(\min) f = 4X_{11} + 3X_{12} + 2X_{13} + X_{14} + 3X_{21} + 2X_{22} + X_{23} + 2X_{24} + 3X_{31} + 4X_{32} + X_{33} + 2X_{34}$$

Or in a table form:

$F_i \backslash P_j$	P_1	P_2	P_3	P_4	Available
F_1	4 X_{11}	3 X_{12}	2 X_{13}	1 X_{14}	50
F_2	3 X_{21}	2 X_{22}	1 X_{23}	2 X_{24}	20
F_3	3 X_{31}	4 X_{32}	1 X_{33}	2 X_{34}	30
Necessary	10	30	35	25	100

To find the initial solution with the North-west corner method,the procedure consists in the next steps: we choose X_{11} = min(10, 50) = 10; then $X_{21} = X_{31} = 0$. Then X_{12} = min(30,40) = 30 and $X_{22} = X_{32} = 0$. Next is X_{13} = min(35,10) = 10 so X_{14} =0. Further X_{23} = min(25,20) = 20, and X_{24} = 0 and finaly X_{33} = min(5,30) = 5 and X_{34} = 25.

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Typically, the initial solution is determined in the table, each time decreasing availability and demand, and joining remaining writing. Thus we have:

$F_i \backslash P_j$	P_1		P_2		P_3		P_4		Available
F_1	4		3		2		1		**50; 40; 10**
		10		30		10		0	
F_2	3		2		1		2		**20; 0**
		0		0		20		0	
F_3	3		4		1		2		**30; 25; 0**
		0		0		5		25	
Necessary	**10 0**		**30 0**		**35 25 5**		**25 0**		**100**

The total cost function value for the initial solution is found:
f= 4·10 + 3·30 + 2·10 + 1·20 + 1·5 + 2·25 = 225 u.m, that means that the price is $225 \cdot 10^4$= **2 250 000 $**
This method is very simple but less efficient because it does not account for costs c_{ij} but only for the available values and the requiredquantities.
Using the minimal element method we will find an initial solution to this problem.
Because $X_{14} = X_{23} = X_{33} = 1$ is the minimum cost, we first determine the variable X_{33}, as we get the maximum value (X_{14}=25; X_{23}=20; X_{33}=30). So, we will take X_{33} = 30, which implies: $X_{31} = X_{32} = X_{34} = 0$. Then choose X_{14} = 25, as follows from the minimum value = 1 and the resulting X_{24} = 0. It has remained X_{23} = 5, and the resulting X_{13} = 0. Consider costs equal to 2 and choose X_{22} = 15, this implies X_1 = 15, X_{21} =0, X_{11} = 10.

$F_i \backslash P_j$	P_1		P_2		P_3		P_4		Available
F_1	4		3		2		1		**50;25; 10**
		10		15		0		25	
F_2	3		2		1		2		**20;15; 0**
		0		15		5		0	
F_3	3		4		1		2		**30;0**
		0		0		30		0	
Necessary	**10 0**		**30 15 0**		**35 5 0**		**25 0**		**100**

The value of the objective function is:
f= 4·10 + 3·15 + 1·25 + 2·15 + 1·5 + 1·30 = 175 and that means **1 750 000 $.**
Next, we will use the mixed differencesmethod. The variables have the some values as in the previous methods, but the order is made by another rule. For determination of the following, the smallest difference between two elements (costs) is calculated for each row, each column respectively. Then on the row or column with the maximum difference,variables are determined in the box with minimal cost.

Let's find out an initial solution with the maximum difference method for the transportation problem stated above.
We calculate the differences on lines and columns. We have the following table of differences:

4	3	2	1	1
3	2	1	2	1
3	4	1	2	1
1	1	1	1	

Calculated as follows: 2-1=1 for the first line, 2-1=1 the second line, 2-1=1 for the third row, 4-3=1 fo the first column, 3-2=1 in the second column, 2 -1=1 in the third column, and on the fourth column 2-1=1. It is noted that the differences are all equal to 1. Choose X_{33} = 30 because it gives the largest allocation for minimum prices. Then $X_{31} = X_{32} = X_{34} = 0$.
Recalculating the differences on the remaining rows and columns, we get the table:

4	3	2	1	1
3	2	1	2	1
1	1	1	1	

All differences are equal. Given the minimal cost, choose X_{14} = 25, this implies X_{24} = 0. For rows and columns that are blank we recalculate the differences and get the table:

	3	2	1
3	2	1	1
1	1	1	

Choose X_{23} = 5, the last of the minium cost is 1 and this implies X_{13} = 0.

4	3	1
3	2	1
1	1	

By arranging the values in a table, we have:

$F_i \backslash P_j$	P_1		P_2		P_3		P_4		Available
F_1	4		3		2		1		**50;25;10**
		10		15		0		25	
F_2	3		2		1		2		**20;15;0**
		0		15		5		0	
F_3	3		4		1		2		**30;0**
		0		0		30		0	
Necessary	**10 0**		**30 15 0**		**35 5 0**		**25 0**		**100**

And the value of *f* to the initial solution is:
f = 4·10 + 3·15 + 1·25 + 2·15 + 1·5 + 1·30 = 175, that means **1 750 000 $.**
It is noted that we obtained the same initial solution as we obtained using the minimum element method.

Conclusion
We conclude that using the north-west corner method we got a less efficient solution than that obtained by the minimum element method, and that of the mixed differences method. These solutions can be improved and optimized by using the algorithm of potentials and the results can lead to the confirmation of the fact that mathematical methods could be used more in practice on board.

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