OPERATIONAL ANALYSIS TOOLS IN SOLVING TRANSPORT TASKS

Radka Prívarová[1]

Summary: The article describes the operational analysis as an essential tool for optimizing decision-making process. I focus on those parts of the operational analysis, which is used in transport and distribution, as well as a thriving company based transportation service processes. I cite an example calculation optimizing transport service customers using the tools of operational analysis.

Key words: operational analysis, transportation, operation

INTRODUCTION

There are a large number of tools and applications that facilitate our everyday life and work. Almost all of the technical, economic, military and other fields, in which there is a decision, we can meet the operational analysis. In the article I mention the division of disciplines operational analysis. Of all the basic disciplines I choose two, which is most commonly used in the field of transport and solving problems associated with transportation. The article focuses on basic descriptions of two basic disciplines of operational analysis. On the two examples I mention the possibility of optimizing the activities of the company using transport, using the tools of operational analysis.

1. OPERATIONAL ANALYSIS

Operational analysis as an oriented multidisciplinary scientific field is one of the most important tools for optimal and objective decisions. Operational analysis uses deterministic and stochastic methods. Operational analysis methods include a large number of processes. The basic distribution is shown in the following Fig. 1. Alternative or related terms are:

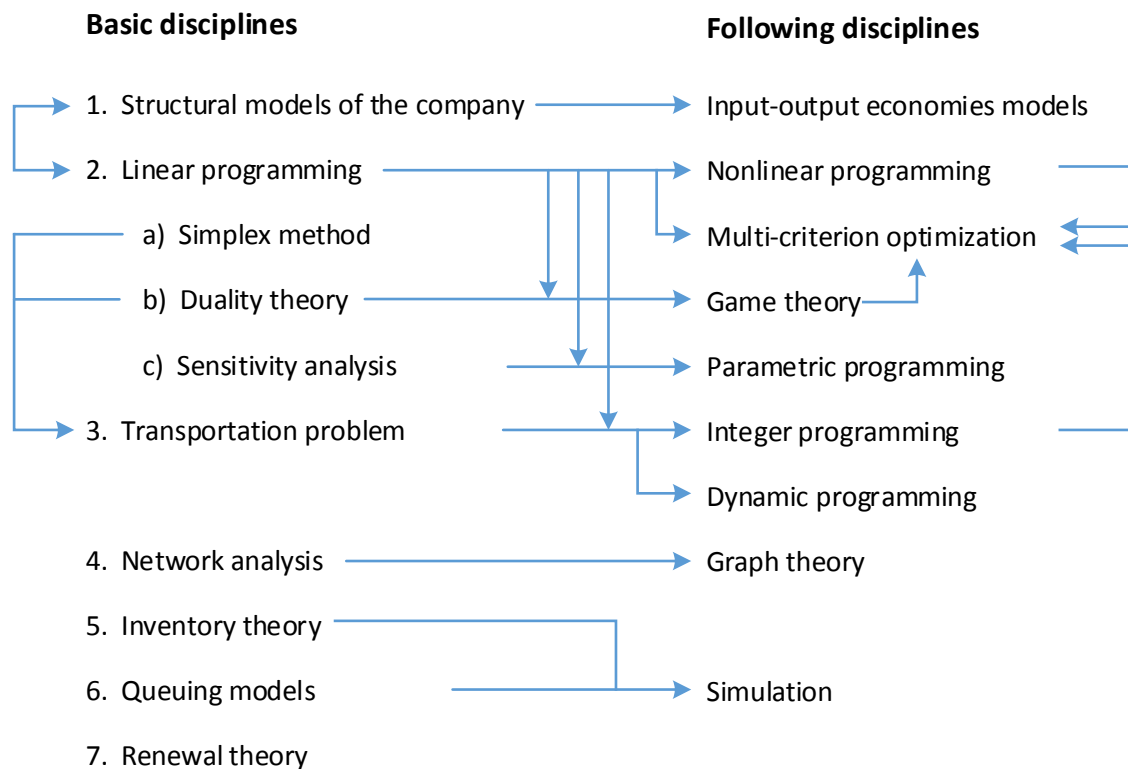- Operations Research
- Operations Management (4)

Operations research is methodologically comprehensive approach to solving complex decision problems based on mathematical modeling and the use of computers.

The aim is to create an operating model analysis (formal description) of the situation and then make its optimization.

The basic tools of operational research are mathematical models. Models and model approaches is an open model tools whose principal aim is to describe a theoretical replacement (simulation) the main features of the processes taking place in reality. (4)

---

[1] Ing.Radka Prívarová, University of Žilina, Faculty of Security Engineering, Department of Technical Sciences and Informatics, 1. mája č.32, 010 26 Žilina, tel.: 0041-513 6866, E-mail: Radka.Privarova@fbi.uniza.sk

The greatest importance modeling is that it enables decision-makers to understand intellectually complex relationships, connections and links between systems and to provide a basis to carry out a rational intervention and control them.

Basic disciplines   **Following disciplines**

1. Structural models of the company ————→ Input-output economies models

2. Linear programming ————————→ Nonlinear programming

    a) Simplex method   Multi-criterion optimization

    b) Duality theory ————————————→ Game theory

    c) Sensitivity analysis ————————→ Parametric programming

3. Transportation problem ——————————→ Integer programming

                                Dynamic programming

4. Network analysis ——————————————→ Graph theory

5. Inventory theory

6. Queuing models ————————————————→ Simulation

7. Renewal theory

Source: (1), edit author

Fig. 1 - Disciplines of operational analysis

2. TRANSPORTATION JOBS

Transportation jobs belong to the categories of linear programming. In this category, we are able to solve various modifications of distribution problems in transport. Transportation jobs are the specifics:

- Every transport task is feasible solution.
- There is a feasible solution, which has no more than m + n - 1 positive components.
- If all a_1 and b_1 nonnegative integer, then each admissible basic solutions integer X, i.e. all components of matrix X are integers.
- Every transport problem has a solution. (2)

In practice it may be used several methods and algorithms for optimization of transport tasks and determining the starting basic solution. Transport tasks can be solved using linear programming and the simplex method, but due to the large number of potential outputs are added special algorithms. They are written to clear tables. The most common methods include:

- Northwest corner method;
- Index method;
- Vogel´s method. (1)

2.1 Northwest corner method

The method is based on a spreadsheet solution when assigning values of basic variables as the first non-zero value of a variable x_{11} b in the northwest corner of the table. Assign it maximum possible value, so we ran out of options first vendor or fulfilled requirements of the first customers, thereby solving the basic variables either discarded in the first row or the first column. Solving then continues in a row or column with unspent capacities towards the southeast. We continue this way proceed until not satisfied all the desired capacity. The disadvantage of this method is that variables are assigned regardless of the cost. (1)

2.2 Index method

This method, unlike the method northwest corner assigns the maximum possible values of the variables, depending on their rate, thereby trying to eliminate the disadvantages of previous methods. Assigning further works on the same principle as stated in the previous method. Assigning carried out according to the same principles as the method northwest corner. Variables with the lowest rate, is assigned to the maximum possible amount to suit the restrictive conditions. In attributed continues in order rates if not filled the capacity of all suppliers and requirements of all customers. (1)

2.3 Vogel´s method

Vogel approximation method is obtained starting admissible basic solution at less extensive transport tasks commonly approaching the optimum solution, which minimizes the number of these steps to obtain the optimal and effective solution. Based on the consideration that effective is to find such a division of the quantities transported between suppliers and customers, which takes into account the biggest savings between their two lowest values of transport costs (for suppliers and consumers). Algorithm Vogel approximation methods literature is often differently modified. (1)

2.3.1 A practical example

The following example is one of many types of exercises which can be solved by methods of transport jobs. An example is a simple graphic with a small number of data, but the benefits of the program, through which we can solve problems by operational analysis, is the ability to enter large amounts of input data and obtain accurate calculations of extensive character.

Warehouses supplies in case of an actual crisis are supplied from rain spots. There are 5 stocks emergency supplies, which demand 120, 150, 180, 200 and 220 units of goods for the period from 10 suppliers. Suppliers are able to provide from 50 to 190 units of goods, as shown in Fig.2. The numbers in the table represent the costs of individual suppliers, depending on the vendor and location of the warehouse. The task of supply management is to create a plan for supply and distribution, of the structures that produce the contractors were

brought to the warehouses at the lowest possible cost. Solve an example of using the WIN QSB.

Tab. 1 – Task table in the WIN QSB

From \ To	Destination 1	Destination 2	Destination 3	Destination 4	Destination 5	Supply
Source 1	8	11	8	12	10	50
Source 2	12	10	9	12	8	80
Source 3	10	8	10	9	7	70
Source 4	8	8	12	9	13	90
Source 5	8	13	9	8	8	90
Source 6	14	10	8	10	11	100
Source 7	10	8	10	9	9	120
Source 8	9	8	12	8	12	180
Source 9	12	9	11	10	14	190
Source 10	8	14	9	9	11	190
Demand	120	150	180	200	220	

Source: author

Input values enter into the table in WIN QSB, using features network modeling, transporting problem. We write to the table shipping costs for individual suppliers.

I chose to deal with the *Vogel´s Approximation method* (VAM). The problem is automatically solved and as output we get table with data.

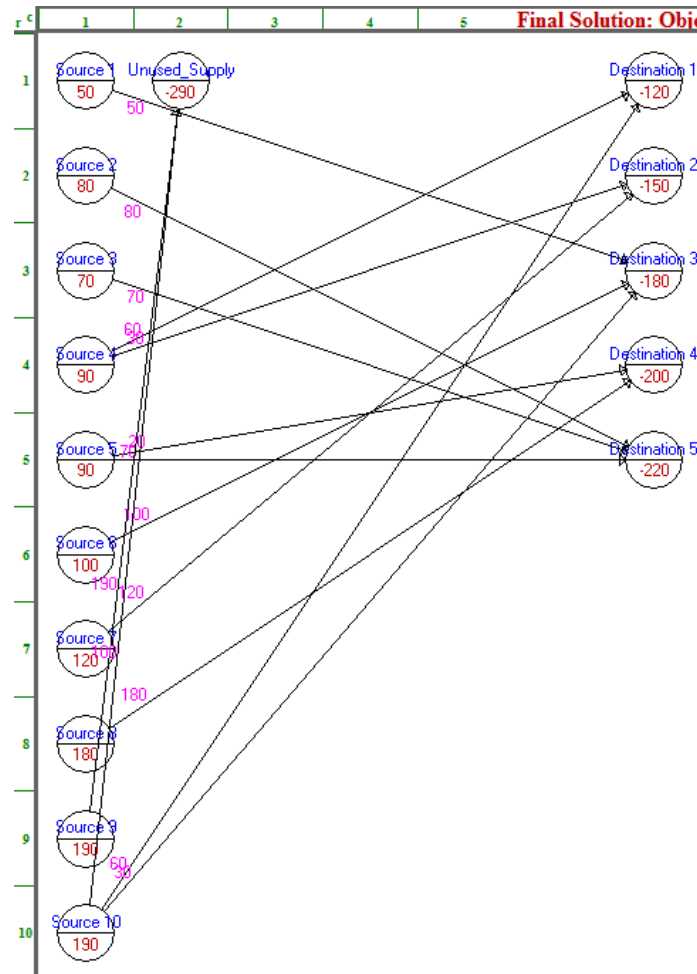Tab. 2 – Table solution in the WIN QSB

05-18-2016	From	To	Shipment	Unit Cost	Total Cost	Reduced Cost
1	Source 1	Destination 3	50	8	400	0
2	Source 2	Destination 5	80	8	640	0
3	Source 3	Destination 5	70	7	490	0
4	Source 4	Destination 1	60	8	480	0
5	Source 4	Destination 2	30	8	240	0
6	Source 5	Destination 4	20	8	160	0
7	Source 5	Destination 5	70	8	560	0
8	Source 6	Destination 3	100	8	800	0
9	Source 7	Destination 2	120	8	960	0
10	Source 8	Destination 4	180	8	1440	0
11	Source 9	Unused_Supply	190	0	0	0
12	Source 10	Destination 1	60	8	480	0
13	Source 10	Destination 3	30	9	270	0
14	Source 10	Unused_Supply	100	0	0	0
	Total	Objective	Function	Value =	6920	

Source: author

The solution we gain the allocated number of inventory units from various suppliers based on cost optimization. The table then enumerated, what number of supply units is delivered every supplier to individual stores. Total costs = 6920 CZK.

In the column "*from*" see, from which supplier is best suited to take the goods for witch destination and in the column "*shipment*" there is the number of goods units.

The program offers multiple variations of the results, for example. Graphically as we can see in the following picture.

Fig. 2 – Table graphical representation in the WIN QSB

The different types of jobs that we are dealing with the traffic, transport logistics, etc., can be used in other disciplines of operational analysis.

3. SERVICE PROCESSES MODELING

Modeling service processes will remain the operator theory. Operator theory is based on mathematical models, the aim of which is to determine whether the system operator has the premise to cope with the resulting service requirements. (2)

3.1 Queueing models

Queuing models based on mathematical models and the purpose is to determine how, and how successful we are able to fulfill the capacity requirements for transport. When solving transport tasks not possible mechanical approach. Role must be adapted to the material and economic substance of the problems.

3.1.1 *Multi-channel model without waiting*

On illustrative example I will demonstrate how we can use the method of operation analysis to the creation of service processes in a company engaged in the local transport business.

Transport company providing orders in the city, has three vehicles with irregular occupancy. If a customer calls with a focus on transport and available at the moment neither is empty vehicle, the company will appeal to another carrier. During the day, call the company's average of 7 candidates for transport. One vehicle is specified busy transporting an average of 5 hours. The daily cost per vehicle is 130 CZK and costs associated, with the loss requirement is 25 CZK. Find out what is the probability that there will be no vehicle available when a customer calls? As the vehicles will be utilized? Company owner wants to know the basic indicators of execution request and use service channels. Furthermore, the company owner wants to know how many cars have run to the final cost was minimal. Solve an example of using the MS Excel.

We find and calculate and input data: n = 3; the mean service time t_0 = 5 hours (it´s 0,21day); the intensity of the operator; the intensity of the input current requirement / day;

Using formulas assigned to the appropriate cells in MS Excel calculate the output value. In the Fig. 3, you can see the calculations.

	A	B	C
1			
2	**Multi-channel model without waiting**		
3			
4	**input values**		
5	Costs loss requirement	25	
6	The costs of operation of the vehicle 1	130	
7	Number of channels	3	
8	The intensity input	7	
9	Average service time	0,208333333	5
10	The intensity of service	4,8	
11	**The output value**		
12	load factor	1,458333333	
13	The probability p0	0,247609552	
14	The probability p1	0,495219103	
15	The probability p2	0,495219103	
16	The probability p3	0,330146069	
17	The probability of loss	0,330146069	
18	relative capacity	0,669853931	
19	absolute capacity	4,688977518	
20	diameter requirement	2,476095516	
21	Time spent in the system	0,208333333	
22	Number of occupied channels	2,476095516	
23	The number of free channels	0,523904484	
24	utilization factor	0,825365172	
25	coefficient of downtime	0,174634828	
26			
27	Loss probability requirement at 1 channel	0,593220339	
28	Loss probability requirement at 2 channel	0,301947252	
29	Loss probability requirement at 3 channel	0,127993098	
30			
31	Total costs for the use of vehicle 1	233,8135593	
32	Total costs for the use of vehicle 2	312,840769	
33	Total costs for the use of vehicle 3	412,3987922	
34			
35			

Source: autor

Fig. 3 – Excel calculation of multi-channel model

Description of the picture:

- Average service time in hours in cell B9, defined as $a = C9 / 24$
- The intensity of service corresponds to a defined cell
    - $B10 = 1 / B9$
- Load factor corresponds to a defined cell
    - $B12 = B8 / B10$
- The probability that no customer is on the line P_0 corresponds to defined cell
    - $B13 = 1 / (1 + B12 + B12 \wedge 2/2 + B12 \wedge 3 / (2 * 3))$
- Probability (p_1, p_2, p_3) corresponds-defined cell
    - $B14 = 2 \wedge 1 * B13 /$ factorial (1)
    - $B15 = 2 \wedge 2 * B13 /$ factorial (2)
    - $B16 = 2 \wedge 3 * B13 /$ factorial (3)
- The likelihood of loss = probability that all channels are occupied corresponds to a defined cell $B17 = B16$
- Relative capacity - the probability of serving corresponds to a defined cell
    - $B18-B17 = 1$
- Absolute capacity corresponds to a defined cell
    - $B19 = B18 * B8$
- Average Requirement corresponds to defined cell
    - $B20 = B14 + B15 + 2 * 3 * B16$
- Time spent in the system corresponds to a defined cell
    - $B21 = B9$
- Number of occupied channels corresponds to a defined cell
    - $B22 = B20$
- The number of free channels corresponds to a defined cell
    - $B23 = B7-B22$
- The occupancy rate corresponds to a defined cell
    - $B24 = B22 / 3$
- Coefficient of downtime corresponds to a defined cell
    - $B25 = B23 / 3$
- The probability of rejection of requests in the system in n channels corresponds-defined cells:
    - $B27 = B12 / (1 + B12)$
    - $B28 = (((B12 \wedge 2) /$ factorial (2)$) / (1 + B12 + ((B12 \wedge 2) /$ factorial (2)$)))$
    - $B29 = ((B12 \wedge 3 /$ factorial (3)$) / (1 + + B12 (B12 \wedge 2 /$ factorial (2)$) + (B12 \wedge 3 /$ factorial (3)$)))))$
- Total cost at n wagons corresponds-defined cells:
    - $B31 = ((B27 * * B8 B5) + (1 * B6))$
    - $B32 = ((B28 * * B8 B5) + (2 \times B6))$
    - $B33 = ((B29 * * B8 B5) + (3 * B6))$

The probability that nobody is interested in the services of vehicles is 0.24761, which is 24.76 %. The probability that the system will be one requirement is 49.52 %, two requirements is 49.52 % and 33.01 %, three requirements.

Indicators of execution request are:

- The probability that all cars will be busy is 0.330146 , which represents 33.01 %;
- Relative capacity is 0.669854 implying the likelihood of serving;
- Absolute capacity is 4.688978 , which is complete at least 4 serving clients per day;
- Average number of requests for dispatching is 2.476096 customers a day;
- The average time of stay requirement in the system is 0.208333 hours.

Indicators of use of service channels – vehicles are:

- The average number of occupied vehicles 2.476096;
- The average number of available vehicles is 0.523904;
- Vehicle utilization rate is 0.825365;
- Vehicle downtime coefficient is 0.174635.

I found that vehicles are utilized to 82.54 % and 17.46 downtime employed. The owner of the company should operate only one vehicle, because during the interrogation just one vehicle, the total cost and lowest active CZK 233.81.

CONCLUSION

We found many examples of good practice, where our operating analysis may help to correct, decisions quickly and effectively. There are also plenty of software tools to aid calculations, even if sometimes we just have MS Excel spreadsheet or its extensions, and accessories. Another good tool is Matlab. It is desirable that the possibility of providing inputs to the flexible variations caused by the uniqueness of each decision-making process.

REFERENCES

(1) Brezina,I., Ivanovičová,Z., Pekár,J., Operačná analýza, Bratislava, LURA edition, 2007, 241pp.

(2) Chocholatá, M., Čičková, Z., Furková, A., Operačná analýza – zbierka príkladov, LURA edition, 2007, 171pp.

(3) Janáček, J., Operačná analýza I.Žilina: Žilinská univerzita v Žiline, 1997. 232 pp. ISBN 80-7100-396-4

(4) Máca, J., Leitner, B., Operačná analýza I. Košice: Žilinská univerzita v Žiline, 2002. 181 pp. ISBN 80-88829-39-9.

(5) Malá,H., Lineární programování. Diplomová práce, Masarykova Univerzita v Brně. 2005. 69pp.

(6) Unčovský,L., Stochastické modely Operačnej analýzy, ALFA, Bratislava, 1980. 415pp.