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OPTIMISATION OF THE SUPPLY CHAIN PROCESS FOR THE LOGISTICS CENTRE

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In this paper the problem of decision-making process for creation of the new supply and distribution channel of the Logistics centre was observed.

The task consists in the taking decision regarding the way selection from choosing the raw materials till final products creation that allows getting the maximum profits to the company.

This task could be solved by using the method of dynamic programming. In this case it means to make decision for each unit individually.

The solution of the real task for Logistics centre in Latvia is observed in this paper as the numerical sample of decision-making process for the new supply and sales channel development for the Logistics centre in order to get the maximum profit.

Keywords: *decision-making, supply chain, dynamic programming*

1. Introduction

In order to optimise the supply chain process through the Logistics Centre the management of the textile company makes a decision to create the new supply channel for materials and sales of ready-made goods.

It is necessary to make certain decisions regarding relating parts of supply chain process such as purchase and delivery of raw materials, production and sales of ready products. Therefore the model with different possible scenarios of development has been created.

The first stage is choosing the producer of basic material (clothing). There are offers from three main production companies. The first of them offers the high technological and specialised materials of the best quality according to existing market prices. The second one is ready to supply wide use material of good quality with discount of 10% from market price. The third producer makes middle class materials of lower quality according to confirmed standards and gives discount of 25% from market price. It is necessary to foresee three scenarios of development for each producer that are 1) materials will be produced in time; 2) materials will not be produced by any reason; 3) materials will be produced with delays. Two months are planned to spend for material production.

The second stage is delivery of materials to the final goods production place. Choosing the transport way it is important to pay attention to delivery time, safety and transport rates. Transportation could be provided by shipping line using combined cargos sea container, by air, by road and using the express delivery by courier mail. If materials are produced in time, the low cost transportation ways are preferable, for example, delivery by sea as the cheapest but certain time demanded. Aircraft delivery usually is chosen for quick deliveries. Delivery by road is effective for rather short destinations. In case of time shortage priority of delivery belongs to express service of courier mail as the quickest possible, however the most expensive as a rule.

After delivery cargo could appear in three conditions:

1) materials are delivered till final destination and come to production process;

2) cargo is delivered till transit terminal (cargo warehouse, sea port airport) and further delivery till production place is necessary. In same time perhaps part of materials could be stocked temporarily in terminal by any reasons;

3) there is probability of cargo damages and shortage.

The third stage is sales of the ready-made goods. There are three current channel of goods realization:

1) through company's own shops net;

2) through the wholesalers;

3) through the foreign distributors.

Each products realization scenario has one of the three uncertain results:

1) goods have high demand that create successful sales and high profit,
2) goods take middle market position and taking into account the costs for goods creation they are not profitable but sales cover the losses,
3) in spite of all efforts, products are not interested the customers, sales figures are very low, and company has losses.

As the criterions for effectiveness of making decisions let's look at

1) maximum probability of the best effect achievement
2) average profit maximization .

In the best way, with high demand and successful sales the goods collection should be realized for the minimum time.

Consequently, the task consists in the taking decision regarding the basic materials suppliers, transport way selection and sales channel. In other words it is necessary to choose the way from selecting the raw materials till final products creation that allows getting the maximum profits to the company.

2. Construction of the Mathematic Model of the Decision Choosing

Concerned decision-making process could be presented as a net structure *T*, as it shown on the Fig. 1. "Taking decision tree" images the immediate and future decisions regarding materials supply and goods realisation channel. The net includes tops (points) and arcs.

Circle points describe position of the system after decision taking moment. All circle points have the ordinal numbers from 0 to 10. These points correspond to the system status in different moments. The top (state) without entering arcs is named source point and correspond to the initial moment of decision-making process. Further points 1, 2, 3 describe the condition related to the suppliers. For instance, point 1 – the most successful status, to be exact materials produced in time.

At least one or more arcs enter all states except of number 0. Arcs correspond to transitions from one condition to others. Terminals are the states without running out arcs. They correspond to the final moments of decision-making. In Table 1 is presented the correspondence between the states numbers and possible conditions of the system.

Table 1. Status Description

Point Number	Condition
0	Initial moment of decision-making process
1	Materials are produced in time
2	Materials are not produced by any reason
3	Materials are produced but with delay
4	Materials are delivered to destination point and given to further production
5	Materials are delivered to transit terminal (cargo warehouse, sea port, airport) and demand further delivery till production place
6	Destroying or missing of materials
7	Part of materials is put on stock for future production
8	Goods have high demand that create successful sales and high profit
9	Goods take middle market position and taking into account the costs for goods creation they are not profitable but sales cover the losses
10	In spite of all efforts, products are not interested the customers, sales figures are very low, and company has losses

Each diamond point corresponds to making decision. Diamonds 0, 1, 2 correspond to producer's choosing. For example, the point 0 is the 1st above described producer. The equivalence between point number and above mentioned decision is presented in Table 2.

Table 2. Points Allocation of Decision-Making Tree

Point number / ***Development stages***	**0**	**1**	**2**	**3**
1st stage – choosing of producer	Producer of the high technological and specialised materials of the best quality according to existing market prices	Producer of wide use material of good quality with discount of 10% from market price	Producer of middle class materials of lower quality according to confirmed standards and gives discount of 25% from market price	-
2nd stage – choosing of transport	Delivery by sea as the cheapest but time-consuming	Air delivery as more expensive but rather quick	Express service of courier mail as the quickest possible, however the most expensive	Delivery by road is effective for rather short destinations
3rd stage – choosing of realisation way	Through own shops net	Through the wholesalers	Through the foreign distributors	-

Diamond entering arc shows the concrete making decision. Running out arc shows the system possible condition after this decision-making.

Making of concrete decision does not mean getting of single result. On the points running out arcs probabilities of possible further condition are mentioned. In total probabilities amount are equal to 1. For instance, after choosing the producer of basic materials the system could be found in condition 1 with probability 0,1 if the first producer is chosen. In case the second producer is chosen it will be there with probability 0,5. The system could be in the same 1 condition with probability 0,8 if the third producer is chosen. Status 2 is the final as the activities come to unsuccessful result and have no further development. So there are two conditions with future development left.

The next row of diamonds is choosing of the transport company and delivery way from basic material production till the place of further processing.

Diamonds numbers show the choice of the early mentioned transporters. The last third row of diamonds present the choice of ready-made goods realisation way.

Let us describe the mathematic view (conception) of initial data.

States are known for each position following for the previous ones. They are presented by matrix *T*, shown on the Table 3. Rows of the matrix correspond to different decisions, columns include the numbers of current states, and matrix elements show numbers of the future positions. Here the symbol –1 means the absence of future status (state).

Table 3. Matrix *T*

$$T := \begin{pmatrix} 1 & 4 & -1 & 4 & 8 & 4 & -1 & -1 & -1 & -1 & -1 \\ 2 & 6 & -1 & 5 & 9 & 7 & -1 & -1 & -1 & -1 & -1 \\ 3 & -1 & -1 & 6 & 10 & -1 & -1 & -1 & -1 & -1 & -1 \end{pmatrix}^{T}$$

To make the matrix understandable for the MathCAD 14 program it has to be transposed into one shown bellow by Table 4.

Table 4. Matrix *T*

T =

	0	1	2
0	1	2	3
1	4	6	-1
2	-1	-1	-1
3	4	5	6
4	8	9	10
5	4	7	-1
6	-1	-1	-1
7	-1	-1	-1
8	-1	-1	-1
9	-1	-1	-1
10	-1	-1	-1

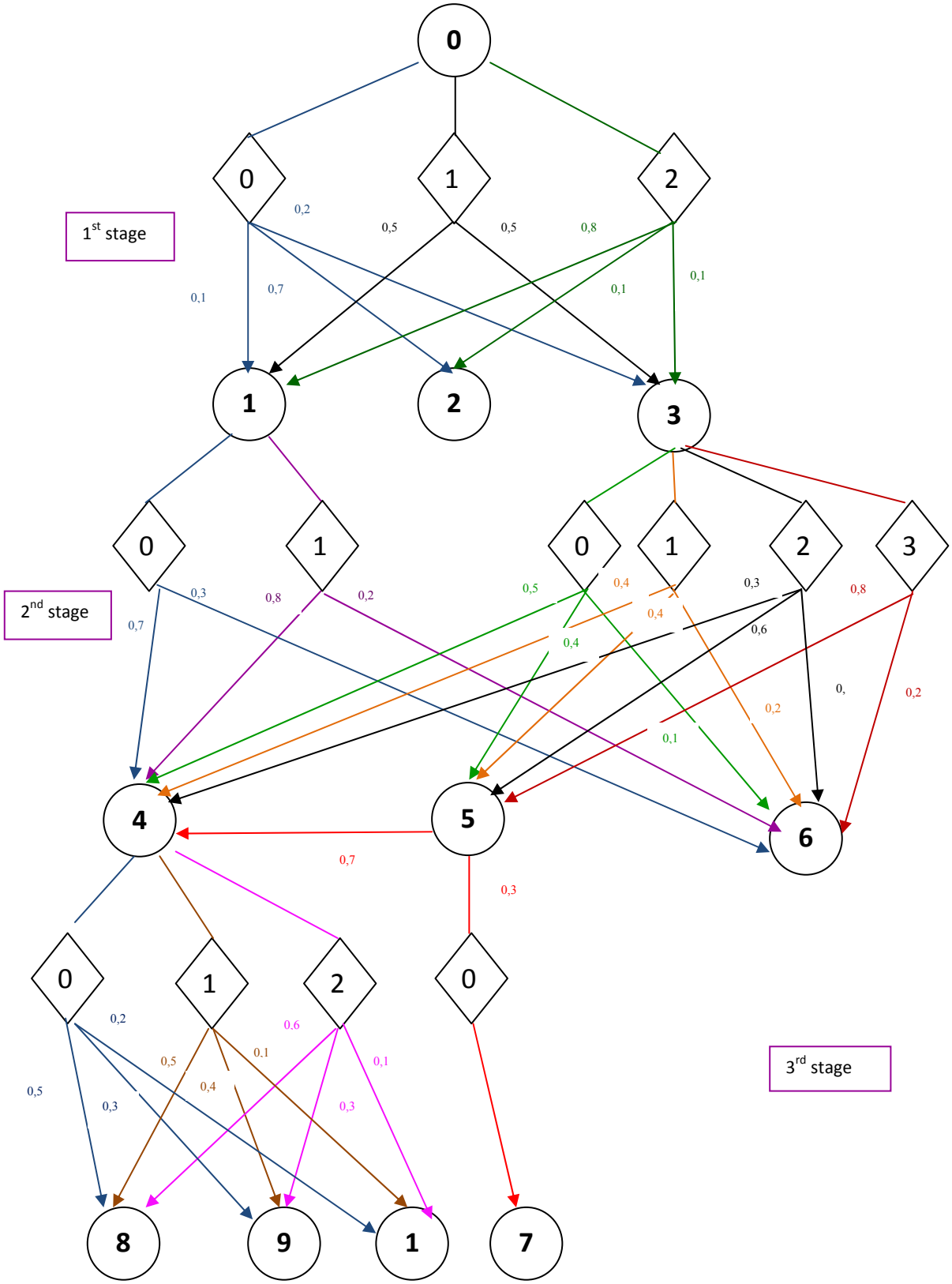

Figure 1. Net structure "Decision-Making Tree"

One single decision should be made from several ones in each point except of terminal. The probability of transfer to the next state is changing depending on taken decision. All this determined by matrix of passage probabilities *Prj* for condition *j*, as it shown for instance by matrix *Pr0* in bellow Table 5. Rows of the matrix correspond to different decisions, but columns conform to probability of passage into new conditions, set by matrix *T*.

Table 5. Matrix *Pr0*

$$Pr0 := \begin{pmatrix} 0.1 & 0.7 & 0.2 \\ 0.5 & 0 & 0.5 \\ 0.8 & 0.1 & 0.1 \end{pmatrix}$$

Expected revenue amount for each position as a result of achieving of this position is showed in Table 6.

Table 6. Expected revenues for each point

Position	**Profit**
0	0
1	-10000
2	-500
3	-12000
4	-5000
5	-500
6	-5000
7	-2000
8	60000
9	40000
10	30000

There are several criterions for effectiveness of making decisions could be offered:

1) maximum probability of the best effect achievement,
2) average profit maximization.

The last is the case when in position *j* adds on revenue c_j. Revenues from different positions sum up together. Total revenue is a random variate as passages into further positions are random. The task is to choose the decision for each point in such way that the average amount of total profits becomes maximum.

Criteria are calculated taking into account:

1) net structure,
2) passage probabilities by different decisions,
3) revenues.

Formally it is necessary to know what decision is making in each possible state. Method of Dynamic Programming will be used for this.

3. Method of Dynamic Programming

Dynamic programming supposes the decision-making step by step. In our case it means decision-making for each position individually. Look at the moment of time when it is need to make a decision for position *j*. Here it is important to mention that if unit *j* is not terminal, till that moment should be checked points with bigger then *j* numbers.

Let's enter Bellman function $F(j)$ – this is the maximum average profit, which could be getting starting from unit *j* till the end moment of decision-making process. To calculate these functions we have the following Bellman equation:

$$F(j) = \underbrace{\max}_{m \in D(j)} \left\{ c_j + \sum_{i \in T_{j\bullet}} \Pr j_{m,i} \times F(i) \right\}, \quad (1)$$

where
$Tj,\bullet = (Tj,0, Tj,1,...)$ – quantity of unit numbers, following the unit j,
$D(j)$ – quantity of decisions possible in condition j.

These equations should be used starting from the terminal units and going to the root. Terminal units are final, so the only first item leaves in braces in the formula (1). In the same time decision m is fixed for each unit as the optimal. For this decision the meaning in braces coincides with $F(j)$ in formula (1).

4. Computer Realization

In order to solve the task the program was created by using the mathematical package MathCAD 14.
Primary data for program is:

- Matrix T, describing the examine net. Rows of the matrix correspond to net units, rows elements show numbers of the further units. Value –1 means the absence of the next units.
- c – vector of profit, that comes for achieving each unit
- Ci,j,k – profit for achieving the position j if the previous position was i and k decision was made.
- Prj – matrix of passage probabilities for position j. Rows of the matrix correspond to different decisions, but columns conform to probability of passage into new positions, set by matrix T.

The following programs solving the above mentioned stages of dynamic programming method are created. $Pr(j)$ – gives the matrix Prj according to number j.

OptValue – main program gives the matrix of two columns. The first column includes maximum profits $F(j)$, the second column presents optimal decisions for each position j.

5. Numerical Results

For our example we have the following numeric data mentioned in Table 7.

Table 7. Numerical data

$$Pr0 := \begin{pmatrix} 0.1 & 0.7 & 0.2 \\ 0.5 & 0 & 0.5 \\ 0.8 & 0.1 & 0.1 \end{pmatrix} \qquad Pr1 := \begin{pmatrix} 0.7 & 0.3 \\ 0.8 & 0.2 \end{pmatrix} \qquad Pr2 := 1$$

$$Pr3 := \begin{pmatrix} 0.5 & 0.4 & 0.1 \\ 0.4 & 0.4 & 0.2 \\ 0.3 & 0.6 & 0.1 \\ 0.8 & 0.2 & 0 \end{pmatrix} \qquad Pr4 := \begin{pmatrix} 0.5 & 0.3 & 0.2 \\ 0.5 & 0.4 & 0.1 \\ 0.6 & 0.3 & 0.1 \end{pmatrix} \qquad Pr5 := (0.7 \quad 0.3)$$

The net structure is presented above in Table 4. Passage probabilities matrixes *Pr0 – Pr5* from Tables 5 and 7 determine the probability of transfer into the next state.

As the criteria we choose optimisation of achieving the state 8, as the profit vector c = $(0000000001)^T$.

The next step is using the program *OptValue*, to make the calculation for maximum average profit, done by known rules for Markov chains. Table 8 presents the results of calculations.

Table 8. Calculation of Maximum Average Profit

№ position	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Profit	0.16	0.16	0	0.16	0.2	0	0	0	0	0	1
Making decision	1	1	0	3	0	0	0	0	0	0	0

6. Conclusions

The task of the decision-making process for Logistics centre Supply Chain optimisation through the creation of the new supply and sales channel in optimal way was observed. There are some various decisions could be taken at each stage of process development. The ways differ from each other by necessary resource and profit receiving. Two aspects, such as maximum probability of the best effect achievement and average profit maximization are taking as the criterions for effectiveness of making decisions.

The task is solving by using the method of *dynamic programming*, created by Richard Bellman. During the work using the MathCAD 14 package the special program which helps to make the calculations is created.

Using the dynamic programming method the real formulated task of decision-making process for the new supply and sales channel development for the Logistics centre in Latvia is solved and the solution for getting of optimal profit is found.

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