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Transport and Telecommunication Institute, Lomonosova 1, Riga, LV-1019, Latvia

OPTIMISATION OF THE SUPPLY CHAIN PROCESS FOR THE LOGISTICS CENTRE

Olga Girvica

Riga Technical University
Kalku Str.1, Riga, LV-1658, Latvia
Ph.: +371 29203422. E-mail: olga.girvica@rtu.lv

In this paper the problem of decision-making process for creation of the new supply and distribution channel of the Logistics centre is observed. The task consists in decision-making regarding the way selection from choosing the raw materials till final products creation that allows getting the maximum profit 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 in order to get the maximum profit for the Logistics centre.

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 the same time perhaps a 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 channels 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 criteria for effectiveness of making decisions let's look at as follows:

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 Choice

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 arcs and vertices of two kinds.

Circle points describe state of the system after decision taking moment. All circle points have the ordinal numbers from 0 to 10. Then state without entering arcs is named source point and corresponds to the initial moment of decision-making process. Further vertices 1, 2, 3 describe the condition related to the suppliers. For instance, state 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 state to others. Terminals are the states without running out arcs. They correspond to the final moments of decision-making. In Table 1 is described sense of all 10 states.

Table 1. Status Description

State 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

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

Table 2. Vertexes Allocation of Decision-Making Tree

State number / ***Development stages***	**0**	**1**	**2**	**3**
1-st 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	-
2-nd 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
3-rd 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 state after this decision-making.

Making of concrete decision does not mean getting of single result. On the vertex running out arcs probabilities of possible further state are mentioned. In total probabilities sum is equal to 1. For instance, after choosing the producer of basic materials the system could be found in state 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 state with probability 0,8 if the third producer is chosen. State 2 is the final as the activities come to unsuccessful result and have no further development. So there are two states with future development left.

The next row of diamonds (2nd stage) is choosing of the transport company and delivery way from basic material production till the place of further processing. There diamonds num`bers show the choice of the early mentioned transporters.

The last third row of diamonds (3rd stage) present the choice of ready-made goods realisation way.

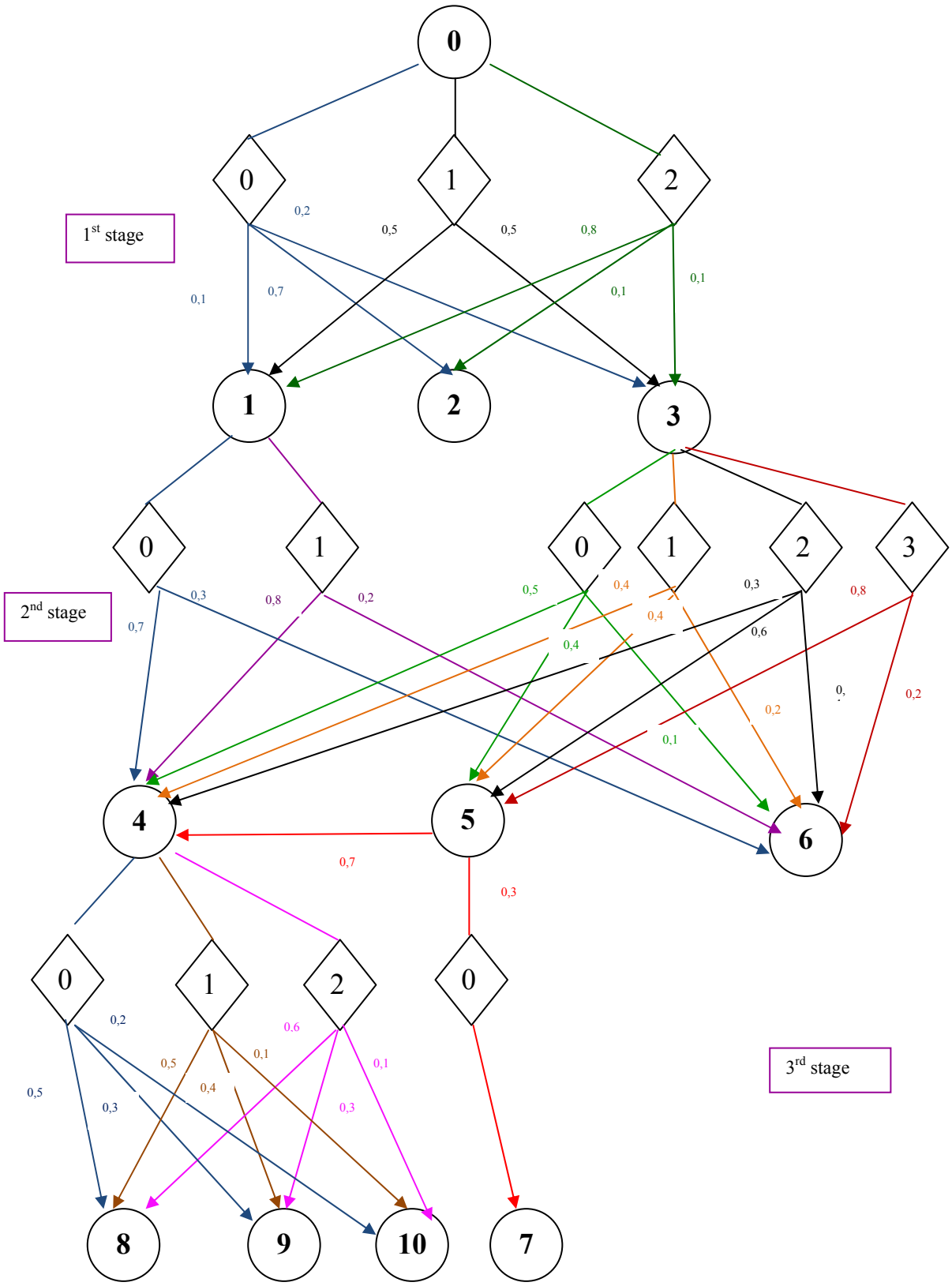

Figure 1. Net structure "Decision-making tree"

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

States are known for each position following for the previous ones. For example, they are presented by matrix T, shown in the Table 3. Rows of the matrix correspond to current states, columns corresponds to different decisions. Matrix elements show numbers of the future states. Here the symbol – 1 means the absence of future state.

Table 3. Matrix *T*

$T^T =$

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

One single decision should be made from several ones in each state except of terminal. The probability of transition to the next state is changing depending on taken decision. Let $Prj_{i,k}$ be a probability of a transition from state *i* to state *k* if decision *j* has been chosen. A corresponding matrix is named as *Prj*. For instance matrix *Pr0* in bellow table 4. Rows of the matrix *Prj* correspond to different vertexes, columns corresponds to different states. Matrix *Prj* elements show corresponding probabilities. For that numbers of states are determined by matrix *T*.

Table 4. Matrix *Pr0*

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

We have expected revenue amount for achieving of all states. They are presented by vector *c*. Table 5 contents corresponding example.

Table 5. Expected revenues for each state *c.*

State, j	Profit, cj	Probability Coefficients, ĉj
0	0	0
1	-10000	0
2	-500	0
3	-12000	0
4	-5000	0
5	-500	0
6	-5000	0
7	-2000	0
8	30000	0
9	40000	0
10	60000	1

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

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

Reward of different states sum up together. Total value is a random variable as result of random transition. The task is to choose the decision for each state in such way that the average amount becomes maximal of total profits.

Method of Dynamic Programming will be used for this aim.

3. Method of Dynamic Programming

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

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

$$F(j) = \underbrace{\max}_{k \in D(j)} \left\{ c_j + \sum_{i \in \mathrm{Sjk}} \Pr j_{i,k} F(i) \right\}, \tag{1}$$

where
S_{jk} – set of state numbers, following the state *j* if decision *k* is taken
$D(j)$ – a set of possible decisions in state *j*.

These equations should be used starting from the terminal states and going to the root (initial state). Terminal states are final, so the first item leaves in brackets in the formula (1). In the same time decision *k** is fixed for each state as the optimal one. For this decision the value in brackets coincides with $F(j)$ in formula (1). So this procedure is named as *the inverse running* of dynamic programming.

Direct running gives the quantities (order) of optimal decisions for all states. It is realised in opposite direction of the above mentioned inverse running – from the root to the end units, each time moving from state *j* to one of the following states that corresponds to optimal decision *k** in the state *j*. Direct algorithm is finished when all the states are calculated till that ones who have no future states.

4. Computer Realization

The described algorithm is realized by program *OptValue*. This programme gives the matrix that has two columns: the first one corresponds to maximum profits $F(j)$, the second one corresponds to optimal decisions *k** for each position *j*. This program was created by using the mathematical package MathCAD 14

Primary data for program is the following:

- Matrix *T*, describing the examined net. Rows of the matrix correspond to net states, rows elements show numbers of the further states. Value –1 means the absence of the next states.
- Vector *c* describes profit that comes for achieving each state.
- Matrix *Prj* of transit probabilities for state *j.* Rows of the matrix correspond to different decisions *k*, but columns correspond to the next state (with respect to the matrix *T*), main program *OptValue* uses the auxiliary program *Pr*(*j*) that gives the matrix *Prj* according to number *j*.

5. Numerical Results

For our example we have the following numeric data mentioned in Tables 3, 5, 6.

Table 6. Matrixes of the probabilities

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

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

As the criteria we choose optimisation of achieving the state 10, as the profit vector $\hat{c} = (0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 1)^T$.

The next step is using the program *OptValue*, to make the calculation for optimal decisions and maximum average profit, done by known rules for Markov chains. Table 7 presents the results of calculations.

Table 7. Maximum Probability of The Best Effect Achievement

State number	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

Using the data from Table 5 we calculate the average profit maximization in terms of money. Here the profit vector is $c = (0\ -10000\ -500\ -12000\ -5000\ -500\ -5000\ -2000\ 30000\ 40000\ 60000)^T$

Table 8. Maximum Average Profit for Vector c

State number	0	1	2	3	4	5	6	7	8	9	10
Profit in money term	15600	16200	-500	15000	34000	-2500	-5000	-2000	30000	40000	60000
Making decision	1	1	0	3	2	0	0	0	0	0	0

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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