# NEW SUPPLY CHAIN CREATION FOR LOGISTICS CENTRE WORK OPTIMISATION

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**Abstract**

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

The task lies in decision-making regarding the way selection from choosing raw materials until final product creation that allows a company getting maximum profits.

This task could be solved by using the method of dynamic programming. In this case it means to make a 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 the 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

During the last years, several tendencies have been developing in the world transport area. The transport systems are going through certain transition such as acquisitions and mergers and it is evident that the number of service providers will be further reduced.

At the same time there are substantial changes in the nature of transport business: 10 – 15 years ago sea transport was based on the point-to-point service in geographically defined areas connected by certain hubs.

Today that is a global service network covering the whole world and the transport companies can offer true global coverage. However this can lead to overcapacity in certain areas.

General trends in the transport industry are:

- The transport companies increasingly participate in the logistics chain of their customers and must understand their requirements. This requires strategic partnership with systematic integration of main business processes of a supply chain.
- IT systems and continuous flow of information supposed to be the base for efficient transport and inventory control.
- Clients get access to new technology and better utilisation of capital.
- Logistics costs tend to be variable, but not fixed for clients.

Logistics and supply chain management continue to transform the competitive landscape and have become one of today's key business issues. Competitive advantage comes from responding to and serving the needs of end-customers. Logistics has a vital role in delivering this advantage, through the supply chain, in terms of short- to medium-term management tasks and longer-term strategic plans.

The objective is to simplify the supply chain, minimise storage time and volume and maximise the speed and efficiency of deliveries. The essential part is information technology and efficient flow of information between members of the chain as well as understanding the business and needs of clients. The main disadvantage of such approach is its long-run effect. It is a real paradigm shift not only for the company, but also for all its clients and suppliers. This approach is actually based on trust and common values of the partnering companies.

The contribution of logistics to competitiveness and value creation is a prime topic in today's market. A practical, integrated and international strategy (approach) to logistics includes:

- Competing through logistics - an introduction to logistics and its contribution to competitiveness and value creation.
- Leveraging logistics operations in a customer context.
- Working together - supplier partnerships, interfaces and the challenges of integration.
- Changing the future - leading-edge thinking in logistics and the future challenges ahead.

Successful development of the logistics processes of any company is defined by the well-organised supply chain.

## 2. Problem setting

Let us look at the sample when, in order to optimise the supply chain process, the management of Production Company Logistic Centre makes a decision to create a new supply channel for basic materials and sales of ready-made goods.

It is necessary to make certain decisions regarding related 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. There are offers from three main production companies. The first of them offers high technological and specialised materials of the best quality according to existing market prices. The second one is ready to supply widely used material of good quality with a discount of 15% from market price. The third producer makes middle class materials of lower quality according to confirmed standards and gives a discount of 20% 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. When choosing the way of transportation, 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 demanding certain time. 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 usual.

Following the delivery cargo could appear in three conditions:

1) materials are delivered to final destination and come to production process;
2) cargo is delivered to a transit terminal (cargo warehouse, sea port airport) and further delivery to a production place is necessary. At the same time, perhaps part of materials could be stocked temporarily in terminal by any reasons;
3) there is a probability of cargo damages and shortage.

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

1) through a company's own sales net;
2) through wholesalers;
3) through foreign distributors.

Each products realisation scenario features one of 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 costs for goods creation they are not profitable, but sales cover the losses,
3) in spite of all efforts, products do not attract customers, sales figures are very low, and company has losses.

Let's consider the following effectiveness criteria of making decisions:

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

In the best-case scenario, with high demand and successful sales, the goods collection should be performed in the minimum time.

Consequently, the task lies in making a 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 until final products creation that allows getting the maximum profits to the company.

## 3. Construction of the mathematic model of the decision choice

The concerned decision-making process could be presented as a net structure *T*, as it is shown on the Figure 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.

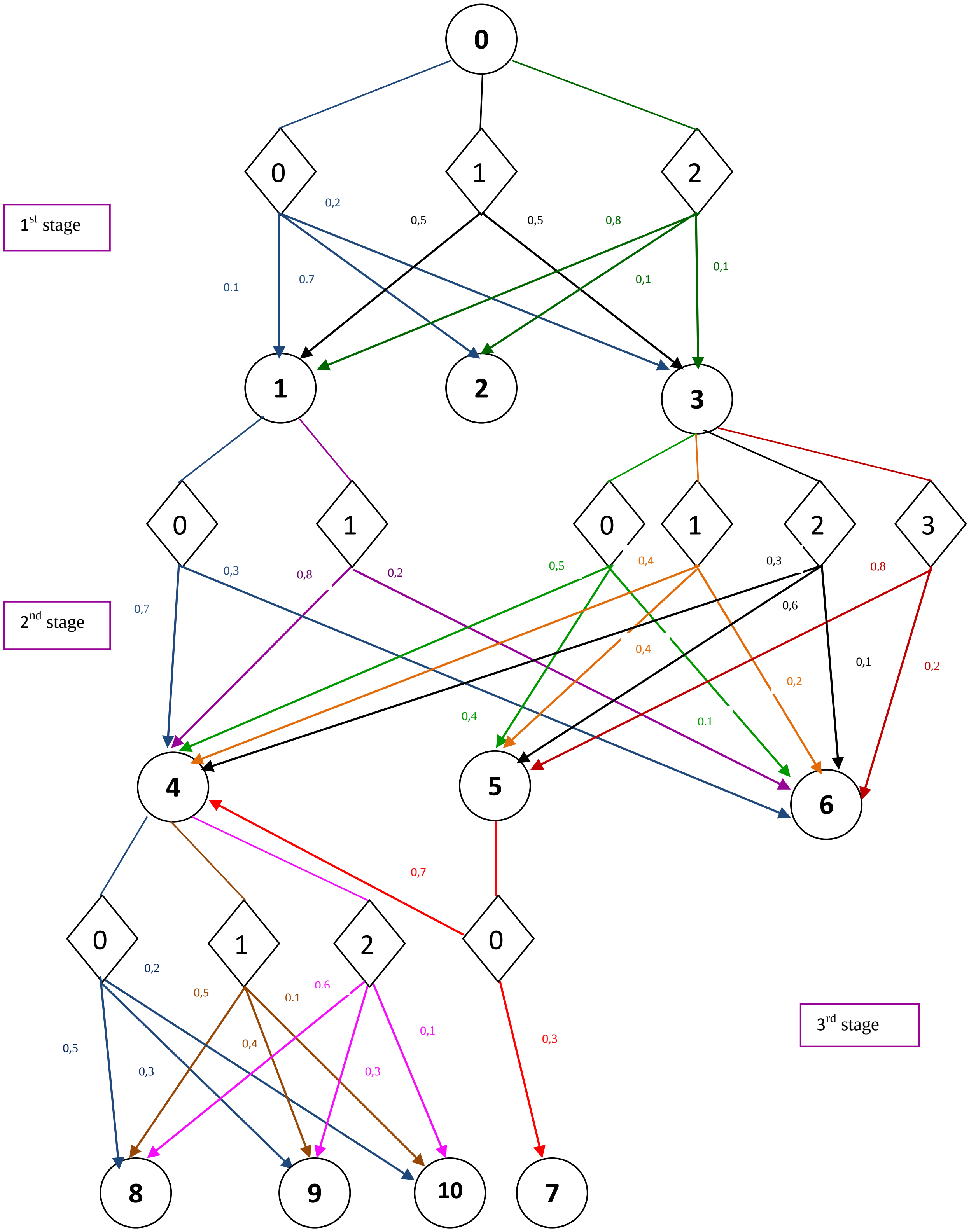


Figure 1.Net structure “Decision-making tree”

Circle points describe the system's state after a decision is made. All circle points have the ordinal numbers from 0 to 10. Then state without entering arcs is called a "source point" and corresponds to the initial moment of the decision-making process. Further vertices 1, 2, 3 describe the condition related to 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 0. The 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. Table 1 provides the description of all 10 states.

Table 1

**Status description**

| State number | Condition |
|---|---|
| 0 | Initial moment of decision-making process |
| 1 | Basic materials are produced in time |
| 2 | Basic materials are not produced by any reason |
| 3 | Basic materials are produced but with delay |
| 4 | Basic materials are delivered to destination point and given to further production |
| 5 | Basic materials are delivered to transit terminal (cargo warehouse, sea port, airport) and demand further delivery till production place |
| 6 | Destroying or missing of basic materials |
| 7 | Part of basic materials is put on stock for future production |
| 8 | Ready goods have high demand that create successful sales and high profit |
| 9 | Ready 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 a decision. Diamonds 0, 1, 2 correspond to producer's choice. For example, the vertex 0 is the 1st above described producer. The equivalence between vertex number and the above mentioned decision is presented in Table 2

Table 2

**Vertexes allocation of a decision-making tree**

| ***State number*** / ***Development stages*** | **0** | **1** | **2** | **3** |
|---|---|---|---|---|
| 1-st stage: choosing of producer | Producer of the high technological and specialised basic materials of the best quality according to existing market prices | Producer of basic material of good quality with discount of 15% from market price | Producer of middle class basic materials of lower quality according to confirmed standards and gives discount of 20% 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 sales net | Through the wholesalers | Through the foreign distributors | - |

A diamond entering an arc shows the concrete decision-making. The running out arc shows possible state of the system after this decision-making.

Making a concrete decision does not mean getting a single result. On the vertex running out arcs probabilities of possible state are mentioned. In total, the sum of probabilities equals 1. For instance, after choosing the producer of basic materials, the system could be found in the 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 can be in the same state 1 with probability 0.8, if the third producer is chosen. State 2 is final as the activities come to unsuccessful result and have no further development. Hence two states with further development are left.

The next row of diamonds (2nd stage) shows the choice of a transport company and delivery way from production of basic materials to a place of further processing. Diamond numbers indicate the choice of abovementioned transporters.

The last, third row, of diamonds (3rd stage) presents the choice of sales ways of ready-made goods.

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

The states are known for each position following the previous ones. For example, they are presented by matrix T, shown on Table 3. Rows of the matrix correspond to current states, columns correspond to different decisions. Matrix elements show numbers of 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 out of several ones in each state, except terminal. The probability of transition to the next state changes depending on the taken decision. Let $Prj_{i,k}$ be a probability of a transition from state *i* to state *k*, if a decision *j* has been chosen. The corresponding matrix is called *Prj*. For instance, the matrix *Pr0* in Table 4 below. Rows of the matrix *Prj* correspond to different vertexes, columns corresponds to different states. Matrix *Prj* elements show the corresponding probabilities. The number of states is determined by matrix *T*.

Table 4

**Matrix *Pr0***

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

We expect certain revenue amounts for achieving each state. They are represented by vector *c*. Table 5 illustrates the corresponding example.

Table 5

**Expected revenues for each state *c***

| State, j | Profit, $c_j$ | Probability Coefficients, $\hat{c}_j$ |
|---|---|---|
| 0 | 0 | 0 |
| 1 | -2000 | 0 |
| 2 | -100 | 0 |
| 3 | -2400 | 0 |
| 4 | -1000 | 0 |
| 5 | 4000 | 0 |
| 6 | -1000 | 0 |
| 7 | 4000 | 0 |
| 8 | 60000 | 0 |
| 9 | 80000 | 0 |
| 10 | 120000 | 1 |

There are several criteria for the decision-making effectiveness that could be offered:

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

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

The Method of Dynamic Programming will be used to achieve this.

## 4. Method of Dynamic Programming

The dynamic programming assumes a step-by-step decision-making. In our case it means the decision-making for each state individually. Let's consider 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, the states with bigger then *j* numbers should be checked until that moment.

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

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

where

*Sjk* – 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 to the root (initial state). The terminal states are final, so the first item stays in brackets in the formula (1). At the same time, a decision *k** is fixed for each state as the optimal one. For this decision the value in brackets coincides with *F(j)* in the formula (1). Therefore this procedure is called *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 abovementioned inverse running – from the root to the end units, each time moving from state *j* to one of the following states that correspond to optimal decision *k** in the state *j*. Direct algorithm is finished, when all the states are calculated until the ones, which have no future states.

## 5. Computer realisation

The described algorithm is used by the program *OptValue*. This programme gives out a 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 programme was created by using the mathematical package MathCAD 14.

The primary data put in the programme 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)*.

The main program *OptValue* uses the auxiliary program *Pr(j)* that gives the matrix *Prj* according to number *j*.

## 6. Numerical results

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

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 application of the program *OptValue*, to make the calculation for optimal decisions and maximum average profit, in line with the rules known as Markov chains. Table 7 shows the results of calculations.

Table 6

**Probability matrixes**

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

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

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 maximisation in terms of money. Here the profit vector is C = (0 -2000 -100 -24000 -1000 4000 -1000 4000 60000 80000 120000) $^T$

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** | 52710 | 26360 | -100 | 263600 | 259000 | 8000 | -1000 | 4000 | 60000 | 80000 | 120000 |
| **Making decision** | 2 | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |

## 7. Conclusions

The task of the decision-making process for Logistics Centre Supply Chain optimisation through creation of new supply and sales channel in optimal way was described. Various decisions could be taken at each stage of the process development. The ways differ from each other by necessary resources and profits. Two aspects, such as maximum probability of the best effect achievement and average profit maximisation, are taken as the criteria for the decision-making effectiveness.

The task can be solved by using the method of *dynamic programming*, created by Richard Bellman. Using the MathCAD 14 package, the special programme, which helps to make the necessary calculations, was created.

Using the dynamic programming method, the 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 the optimal profit is found.

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