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## Launching work orders into production of wood enterprise with the multi-criteria decision-making method

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### Abstract

Quality information is crucial for planning and running of production in wood industry companies. Information of crucial importance is the following: quality in the production process according to work orders and types of product, the information on the missing materials i.e. constituent parts according to projects i.e. work orders and the information on launching work orders into production. The method of multi-criteria decision-making was used for determining the order of launching group products into production. We studied three main criteria: market factors, organisation-production factors and economic factors. For computer support, we chose the computer programme DEXi, which represents the framework of the expert system for multi-criteria decision-making.

**Key words:** wood enterprise, launching work orders, organization, multi-criteria decision-making method

## *Lansiranje delovnih nalogov v proizvodnjo lesnega podjetja z metodo večkriterijskega odločanja*

### Izvleček

*Za planiranje in vodenje proizvodnje v lesnih podjetjih so ključne kakovostne informacije. Zelo pomembne so informacije o kakovosti v proizvodnem procesu glede na delovne naloge in vrste izdelkov, informacije o manjkajočih vrstah materialov oz. sestavnih delov glede na projekte oz. delovne naloge ter informacije o lansiranju delovnih nalogov v proizvodnjo. Metoda večkriterijskega odločanja nam je služila za določitev vrstnega reda lansiranja družin izdelkov v proizvodnjo. Proučevali smo tri glavne kriterije: trženjske dejavnike, organizacijsko-proizvodne dejavnike in ekonomske dejavnike. Za računalniško podporo smo izbrali programsko orodje DEXi, ki predstavlja lupino ekspertnega sistema za večkriterijsko odločanje.*

**Ključne besede:** lesno podjetje, lansiranje delovnih nalogov, organizacija, metoda večkriterijskega odločanja

## 1 Introduction

### 1 Uvod

Globalisation is increasing the number of markets facing wood-industry company, together with the fact that the number of competitive companies is increasing as well. There are changing demands of customers, who are looking for products of higher quality and lower prices together with fast and reliable delivery. The life cycle of products is getting shorter and it is necessary to constantly invest into development of new products. The ever bigger needs on the markets for faster and continuous supply are leaving traces also in the relatively high value of common stock (NOVAK 2006).

The main objective of each company is efficient and successful operation. There is a general economic principle:

to achieve the maximum result with the minimum of means. Other than that, the constant changing of the business environment and technological innovations demand for a fast and efficient adjustment of business operation methods and along with that a need for a good command of the working processes in a company (KROPIVŠEK / OBLAK 2005).

Intense globalisation has marked the business operation in the last decade. Some production companies in Slovenia have already concluded the transitional period and adjusted themselves to market rules, whereas other companies are only beginning to gear up for this in the high competition world and transition is coming along more or less successfully (NOVAK 2006).

The basic activity of a production company is its own manufacturing. This is why companies are always

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looking for new possibilities of lowering production costs. All production companies share one goal, namely efficient monitoring of materials use and monitoring of work costs needed for production. This, however, does not suffice for being competitive on foreign markets. For this reason, successful companies include as part of efficient production handling also connected planning of production and the level of stock (RUSJAN 2002). In this process, the information on launching work orders into production is information of crucial importance.

There are many developed approaches (SCHMENNER 1993; PETERSON / SILVER 1985; NAHMIAS 1993; LJUBIČ 2000; HEIZER 1990; ARMSTRONG 2001; LEHMAN 2005) to launching work orders into production in the world, each using different methods. In general, it is not possible to talk about a good or a bad method, or even clear cut planning models. Each of the methods originates in a special business environment, for which a level of company culture was specific with developed business customs, an adopted pattern of behaviour of people and development of technology, whereas the methods alone derive from basic characteristics of the production process of a specified type of production. The main objective of this study was to develop a new approach - launching work orders into production of wood enterprise with the multi-criteria decision-making method.

## 2 Methods

### 2 Metode

#### 2.1 Multi-criteria decision-making method

##### 2.1 Metoda večkriterijskega odločanja

Decision-making is a process where we need to choose from more than one alternative (possibility, variant, option), the one that best suits the set goals or demands. Besides choosing the best alternative we wish to rank these from the best to the worst. If we want our decision

to be optimal, we need to consider a wide range of factors influencing the quality of our decision. In such cases, the decision-maker can help himself with various methods and computer programmes for decision-making support (BILOSLAVO 1999). Here alternatives are objects, variants, actions, scenarios and consequences of the same type or a comparable type (BOHANEK / RAJKOVIČ 1995; JEREB / BOHANEK / RAJKOVIČ 2003).

One of these methods successfully being used in practice for solving demanding decision-making problems is the method of the multi-criteria decision-making. The essential element of this method is to break the decision-making problem into smaller sub-problems, which are later dealt individually. They are separated into individual parameters (attributes) and are evaluated separately. By combining their evaluations, we get the final evaluation, which is the basis for choosing the best option (KROPIVŠEK / OBLAK 1997).

First, we need to define the problem and then determine and produce a list of criteria we consider to be relevant. These criteria are described by attributes and need to be structured for the purposes of the model, i.e. they need to be hierarchically arranged where mutual dependency and contextual links need to be considered. Thus, we get a tree of criteria. Each criterion in this tree is given a measuring scale i.e. an estimated value it can take in evaluation (BOHANEK / RAJKOVIČ 1995). The structure of multi-criteria decision-making tree is presented in Figure 1.

The decision maker is faced with making one choice among several possibilities which we call variants, the set of these variants forming what is called the choice set. To make his choice from this set, the decision maker adopts several points of view, often contradictory, which we call attributes. These attributes are at least partially contradictory in that, if the decision maker adopts one of the points of view, for example risk minimization, he will not choose the

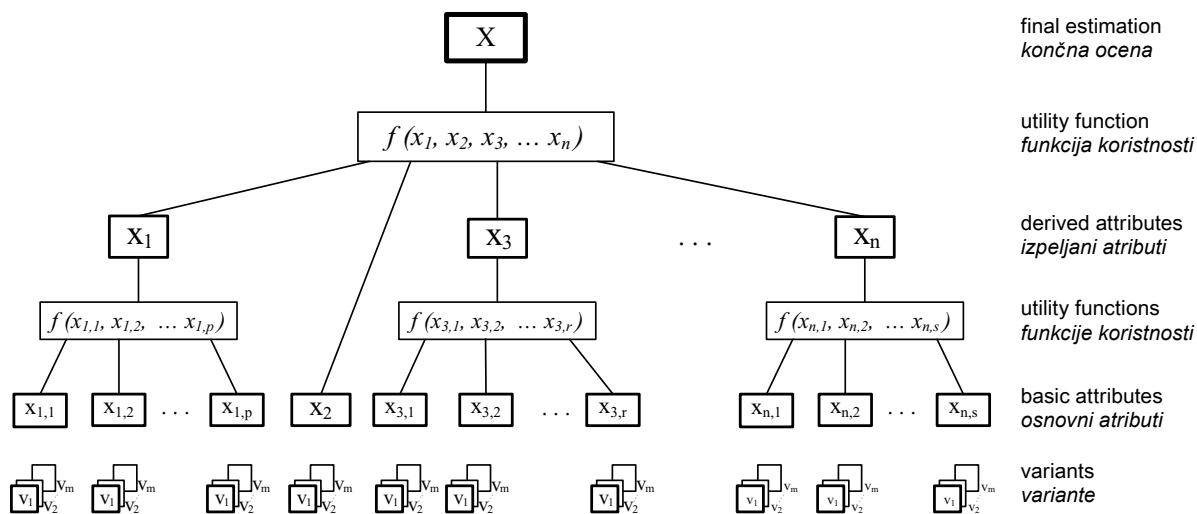


Figure 1: Multi-criteria decision-making tree (source: LIPUŠČEK 2005)

Slika 1: Večkriterijsko drevo odločanja (vir: LIPUŠČEK 2005)

same variant as he would from the standpoint of another attribute, for instance best yield.

With the help of decision-making support software (in this case we used the programme DEXi), we define the utility functions. The utility function presents a “joint” utility measurement according to all criteria. It is a criterion function which helps us determine utility of variants on the basis of individual parameters and their connections (KRAPEŽ / RAJKOVIČ / WECHTERSACH 2000). On the basis of these functions, the computer determines the best from among all the options, which are previously described with values of the basic criteria.

### 3 Results and discussion

#### 3 Rezultati in razprava

For defining importance of an individual group at the beginning of the launch into production, we used the multi-criteria decision-making model, and for the computer support we chose the software DEXi, the framework of the expert system for the multi-criteria decision-making. The work itself proceeded in the following steps:

- setting the criteria,
- hierarchical structuring of the criteria,
- setting the measuring scale,
- setting utility functions (decision-making rules),
- choosing and describing individual variants,
- estimating and analysing the variants.

#### 3.1 Setting and hierarchical structuring of the criteria

##### 3.1 Določitev in hierarhično strukturiranje kriterijev

The first step in the decision-making process was determining the criteria later serving as the basis for evaluation of options. We studied three key criteria, influencing the launch of work orders into production. These criteria are market factors, organisational-production factors and economic factors. “Market factors” refer to market characteristics of the group of products.

- The importance of the group: annual sale according to the planned price, expressed in a share, is the basis for setting the importance of the individual group of products.
- The width of the market: monitoring the number of markets in which the individual group of products appears. Along with that, the importance on such a market is considered.
- The share of necessary items: the ratio of the quantity of different packets in the work order vs. the entire number of packets within the group gives us the share of the items necessary in the next planned period.

We tried to capture characteristics of the group of products in the criterion “Organisational-production factors” which are directly related to the production itself.

- The complexity of production: it includes the technological demands of handling the individual group. The complexity is monitored throughout all the sections of production.
- The size of the order: expressed in the number of packets within one group.

The “Economic factors” apply to the economic indicators of efficiency.

- The volume of the ordered group of products: the volume in m<sup>3</sup> being important especially for warehousing and its expenses.
- The value of the ordered group of products according to the planned price: it is sensible to first produce the groups of products with a higher value of ordered packets as this enables an earlier execution of the higher value production and an earlier dispatch.
- The factor of the turn of the stock: groups with a high factor of turn have an advantage as demand for these packets is usually more constant and more predictable.

From among the list of criteria we build a tree-like structure of content-joint criteria, which represents the structure of the decision-making problem. The criteria are arranged hierarchically where mutual dependencies and contextual connections are considered. The criteria at a higher level are dependent on those at lower levels.

#### 3.2 Setting the measuring scale

##### 3.2 Določitev merske lestvice

The next step was determining the measuring scales or estimated values which can be used in evaluation. In the DEXi programme the estimated value of the criteria, named attributes in the programme, are made up of descriptive variables (parameters). It is recommendable to sort the estimated values from the bad to the good (from the least desirable to the most desirable) as only this enables the use of weights in determining utility functions, as shown in Table 1.

#### 3.3 Setting utility functions (decision-making rules),

##### 3.3 Določitev funkcij koristnosti (odločitvenih pravil)

The next step in forming the multi-criteria decision-making model is defining the utility functions i.e. the decision-making (“if-then”) rules. The rules need to be developed for all the criteria, which have a dispersed structure underneath themselves in the decision-making tree. This means all except the criteria on the lower branches of the decision-making tree. We can present them in the form of a table for each group of criteria. What we need to be careful about when developing the decision-making rules is the consistency between the defined rules for certain combinations of the criteria values. Since developing the decision-making rules is one of the key tasks of the decision-maker, we use computer programmes to help ourselves with that (OBLAK / KRIČEJ / LIPUŠČEK 2006).

**Table 1:** Suggested estimated values of the criteria for the decision-making model of groups of products

**Tabela 1:** Predlagane zaloge vrednosti kriterijev za odločitveni model družine izdelkov

Criterion	Estimated value
GROUPS OF PRODUCTS	low; medium; high; <b>very high</b>
Market factors	bad; good; very good; <b>excellent</b>
Importance of the group (according to sale)	<b>less important</b> ; important; <b>very important</b>
Width of the market	<b>small</b> ; medium; <b>large</b>
Share of necessary items	<b>low</b> ; <b>high</b>
Organisational-production factors	bad; good; very good; <b>excellent</b>
Complexity of production	<b>high</b> ; medium; <b>low</b>
Size of the order	<b>small</b> ; medium; <b>large</b>
Economic factors	bad; good; very good; <b>excellent</b>
Volume of the ordered group of products	<b>very big</b> ; big; medium; <b>small</b>
Value of the ordered group of products	<b>low</b> ; medium; high; <b>very high</b>
Factor of the stock turn	<b>low</b> ; high; <b>very high</b>

Kriterij	Zaloga vrednosti
DRUŽINE IZDELKOV	<b>nizka</b> ; srednje visoka; visoka; <b>zelo visoka</b>
Trženjski dejavniki	<b>slabi</b> ; dobri; zelo dobri; <b>odlični</b>
Pomembnost družine (po prodaji)	<b>malo pomembna</b> ; pomembna; <b>zelo pomembna</b>
Širina trga	<b>majhna</b> ; srednja; <b>velika</b>
Delež nujnih artiklov	<b>nizek</b> ; <b>visok</b>
Organizacijsko-proizvodni dejavniki	<b>slabi</b> ; dobri; zelo dobri; <b>odlični</b>
Zahtevnost proizvodnje	<b>visoka</b> ; srednja; <b>nizka</b>
Velikost naročila	<b>majhna</b> ; srednja; <b>velika</b>
Ekonomski dejavniki	<b>slabi</b> ; dobri; zelo dobri; <b>odlični</b>
Volumen naročene družine izdelkov	<b>zelo velik</b> ; velik; srednje velik; <b>majhen</b>
Vrednost naročene družine po PC	<b>nizka</b> ; srednje visoka; visoka; <b>zelo visoka</b>
Faktor obračanja zalog	<b>nizek</b> ; visok; <b>zelo visok</b>

Decision-making rules formed with the help of the computer programme DEXi for the one level of the decision-making tree (organisational-production factors) are presented in Figure 2.

### 3.4 Choosing and describing individual variants

#### 3.4 Izbira in opis posameznih variant

For deciding upon the choice of the launching work orders into production of wood enterprise with the multi-criteria decision-making method, we need data for all

options (groups of products) for the criteria on the lower branches of the decision-making tree. A hypothetical case of describing individual variants, with the help of the computer programme DEXi, is presented in the Figure 3.

### 3.5 Results of a hypothetical case, estimating and analysing the variants.

#### 3.5 Rezultati hipotetičnega primera, vrednotenje in analiza variant

Evaluating the variants is a procedure of determining the final estimation of the variants on the basis of their description according to the basic criteria. The evaluation is undergone from “the bottom up”, in accordance with the structure of the criteria and utility functions. The variant with the best evaluation value is usually the best, in so far as no major errors occurred during the estimation. The final estimation is namely influenced by many factors and at each of these factors an error may occur. Besides, the final estimation does usually not suffice for the full picture of an individual variant, therefore variants need analysis.

The results of the evaluation are presented graphically with the use of diagrams, or textually with the use of tables. The computer programme DEXi then according to the number of chosen parameters shows the results in a column chart (only one parameter chosen), correlation chart (two parameters chosen at the same time) or a joint chart (three or more chosen parameters), where each axis corresponds to one of the chosen parameters. Results of a hypothetical case, with the help of the computer programme DEXi, are presented in the Figure 4.

### 3.6 Executing the mentioned steps and discussion

#### 3.6 Izvajanje naštetih korakov in diskusija

Executing the mentioned steps did not proceed only straight forward. We returned to the previous steps many times, for example from setting utility functions back to setting the measuring scales. The interactive performance of building the model is enabled and supported also by adequate possibilities of the computer programme DEXi in connection with presenting results, modelling and estimating of variants.

Optimization of a function having a real value, is often defended against multicriterion choice. Provided we forget that the function to be optimized is arbitrary, or at best reflects the preferences of a hidden decision maker, partisans of optimization are in a comfortable position. If however we choose to face up to complexity and try to analyze what is arbitrary, what is personal and what can be shared, multicriterion analysis is incomparably superior to optimization.

The method of multi-criteria decision-making was successfully used for determining the order of launching group products into production in our hypothetical case and it can be used in practice for solving such decision-making problems in wood enterprises.

Complexity of production (Zahtevnost proizvodnje)	Size of the order (Velikost naročila)	Organizational production factors (Organizacijsko-proizvodni dejavniki)
1 high (visoka)	small (majhna)	bad (slabi)
2 high (visoka)	medium (srednja)	bad (slabi)
3 high (visoka)	large (velika)	good (dobri)
4 medium (srednja)	small (majhna)	bad (slabi)
5 medium (srednja)	medium (srednja)	good (dobri)
6 medium (srednja)	large (velika)	very good (zelo dobri)
7 low (nizka)	small (majhna)	good (dobri)
8 low (nizka)	medium (srednja)	good (dobri)
9 low (nizka)	large (velika)	excellent (odlični)

Figure 2: Decision-making rules for the organisational-production factors

Slika 2: Odločitvena pravila za organizacijsko-proizvodne dejavnike

Varianta	Variant 1 (Varianta 1)	Variant 2 (Varianta 2)	Variant 3 (Varianta 3)	Variant 4 (Varianta 4)	Variant 5 (Varianta 5)
Importance of the group (Pomembnost družine)	important (pomembna)	very important (zelo pomembna)	important (pomembna)	less important (malo pomembna)	important (pomembna)
Width of the market (Širina trga)	small (majhna)	large (velika)	medium (srednja)	small (majhna)	medium (srednja)
Share of necessary items (Delež najhujših artiklov)	low (nizki)	high (visoki)	low (nizki)	low (nizki)	high (visoki)
Complexity of production (Zahtevnost proizvodnje)	medium (srednja)	low (nizka)	medium (srednja)	medium (srednja)	medium (srednja)
Size of the order (Velikost naročila)	large (velika)	medium (srednja)	large (velika)	small (majhna)	small (majhna)
Volume of the ordered group of products (Volumen naročene družine izdelkov)	medium (srednje veliki)	medium (srednje veliki)	big (veliki)	medium (srednje veliki)	small (majhni)
Value of the ordered group of products (Vrednost naročene družine po PC)	high (visoka)	very high (zelo visoka)	high (visoka)	medium (srednje visoka)	high (visoka)
Factor of the stock turn (Faktor obračunavanja zalog)	low (nizki)	very high (zelo visoki)	high (visoki)	low (nizki)	low (nizki)

Figure 3: A hypothetical case of describing individual variants

Slika 3: Hipotetični primer opisa posameznih variant

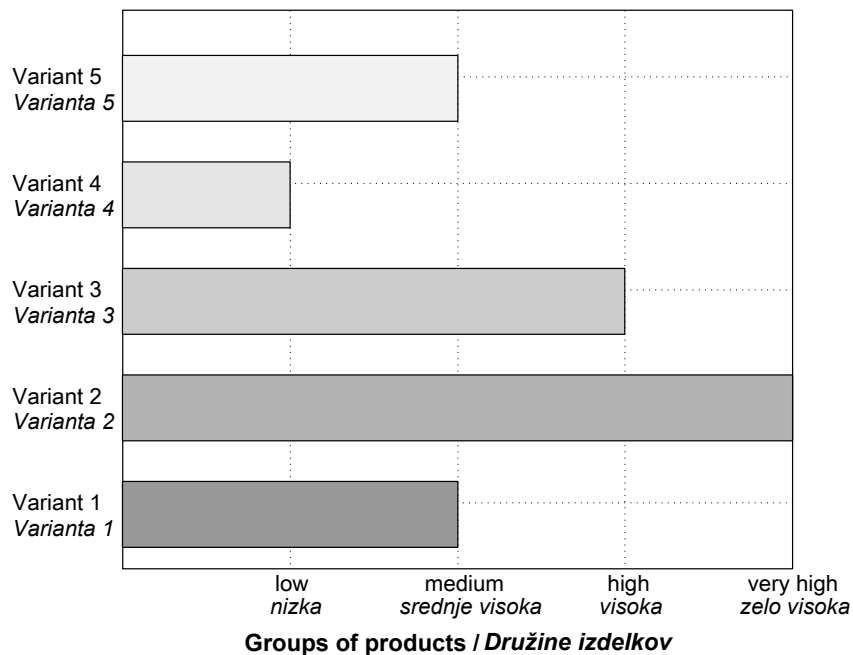


Figure 4: Results of a hypothetical case

Slika 4: Rezultati hipotetičnega primera

#### 4 Povzetek

Lesna podjetja se soočajo z veliko konkurenco, ki vlada na tržišču. Če hoče podjetje še naprej obstajati in ustvarjati zelen dobiček, mora proizvajati konkurenčne izdelke. Da pa bi to zagotovilo, mora med drugim vlagati sredstva tudi v organizacijo proizvodnje.

V mnogih okoljih so stroški za pripravo izdelave družin izdelkov visoki, medtem ko so stroški priprave izdelave posameznih realnih izdelkov v družinah malenkostni in se jih lahko zanemari. Tukaj je oblikovanje osnovnega plana proizvodnje dvostopenjsko: najprej odločanje, katere družine izdelovati v posameznih planskih obdobjih, in potem, kakšne naj bodo količine izdelkov iz teh družin. Skupni obseg proizvodnje mora biti usklajen s planom proizvodnega programa.

Namen raziskave je bil oblikovanje modela, ki temelji na standardnih in delno modificiranih metodah, ki so povezane v zaporedje in preko spremembe informacijske tehnologije pomenijo avtomatizem pri določanju vrstnega reda lansiranja družin proizvodov v proizvodnjo lesnega podjetja. Ena od metod, ki v praksi uspešno rešuje take odločitvene probleme je metoda večkriterijskega odločanja. Proučevali smo tri glavne kriterije: trženjske dejavnike, organizacijsko-proizvodne dejavnike in ekonomske dejavnike. Za računalniško podporo smo izbrali programsko orodje DEXi, ki predstavlja lupino ekspertnega sistema za večkriterijsko odločanje.

Delo je potekalo v naslednjih šestih korakih: določitev kriterijev, hierarhično strukturiranje kriterijev, določitev merskih lestvic, določitev funkcij koristnosti (odločitvenih pravil), izbira in opis posameznih variant ter vrednotenje in analiza variant.

Raziskava ne podaja empiričnih podatkov o prihrankih ali krajšem času dobave, je pa iz modela, ki je oblikovan za hipotetično lesno podjetje razvidno, da lansiranje družin izdelkov v proizvodnjo po predstavljenem modelu to omogoča.

#### 4 Summary

Nowadays wood companies meet with a large competition that rules on the market. If a company wants to still exist and create a desired profit, it must produce competitive products. To ensure that, it must invest means in the development of the production management.

In many environments the costs for organising the preparation of groups of products are high while the costs for organising the preparation of individual actual products from the groups are minute and may be neglected. Here we have a two-step shaping of the basic production plan: first deciding which groups to produce in individual planning periods, and later what the quantities of these products should be. The joint volume of output should be harmonised with the production programme plan.

The purpose of the research was to build a model based on standard and partly modified methods connected

into a sequence and via the changes in the information technology they present an automatism in determining the order of launching group products into production of wood enterprise. One of the methods successfully being used in practice for solving such decision-making problems is the method of the multi-criteria decision-making. We studied three main criteria: market factors, organisation-production factors and economic factors. For computer support, we chose the computer programme DEXi, which represents the framework of the expert system for multi-criteria decision-making.

The work itself proceeded in the following six steps: setting the criteria, hierarchical structuring of the criteria, setting the measuring scale, setting utility functions (decision-making rules), choosing and describing individual variants and estimating and analysing the variants.

The research does not give any empirical data on savings or a shorter delivery time. It does, however, present a model shaped for a hypothetical wood enterprise, from which it is evident that this is possible by launching group products into production according to the presented model.

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