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A model for stock management in a woodprocessing and furniture manufacturing company

Model upravljanja zalihama u poduzeću za preradu drva i proizvodnju namještaja

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ABSTRACT • *Stock management includes processes such as stock monitoring, restocking i.e. ordering new stock and preventing stock sell-out. Stock is essential for smooth operation, supply and purchasing. This article develops a model for stock management in a hypothetical woodprocessing company, where part of production is intended for an unknown customer. We designed a model for periodical monitoring of product group stock by using simple exponent regulation and ordering up to the target stock. The adjusted quantities of sales budget are launched into production with the help of a multi-criteria decision-making model. The designed model enables an optimum level of intermediate product stock, unfinished production and the final product stock. Flowchart technique is used for showing the reshaped process of presenting the sales budget and ordering of materials.*

Key words: *woodprocessing, furniture manufacture, stock management, modelling, multi criteria decision making*

SAŽETAK • *Upravljanje zalihama obuhvaća ove procese: praćenje zaliha, obnavljanje, tj. naručivanje novih zaliha i sprečavanje ostajanja bez zaliha, koje su bitne za ublažavanje operacija, nabavu i kupovanje. U članku je razvijen model za upravljanje zalihama u hipotetičkom poduzeću za preradu drva i proizvodnju namještaja, u kojemu je dio proizvodnje namijenjen nepoznatom kupcu. Projektiran je model periodičnog praćenja grupa proizvodnih zaliha primjenom eksponenta regulacije i naručivanja do ciljanih zaliha. Opisano je ispravljanje prodane i uspostavljene količine lansirane u proizvodnju uz potporu modela multikriterijalnog donošenja odluka. Projektirani model omogućio je optimalnu razinu zaliha u procesu, nedovršenoj proizvodnji i gotovim proizvodima. Dan je novi oblik prikaza prodajnih količina i naručivanja materijala tehnikom karte toka.*

Ključne riječi: *prerada drva, proizvodnja namještaja, upravljanje zalihama, modeliranje, mutikriterijsko donošenje odluka*

1. INTRODUCTION
1 UVOD

The main objective of each company is efficient and successful operation. A general economic principle is to achieve maximum results with minimum resources. Furthermore, the ever-changing business environment and technological innovations demand a fast and efficient adjustment of business methods and hence also a good control of working processes in a company (Kropivšek and Oblak, 2005).

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The basic activity of a production company is its own manufacturing. This is why companies are always looking for new possibilities of lowering production costs. All production companies share one goal – to achieve efficient monitoring of materials use and monitoring of work costs needed for production. This, however, does not suffice for being competitive in foreign markets. For this reason, successful companies also include, as part of efficient production handling, connected production planning and stock level (Novak, 2006).

Stock has always been and will remain an important part of the company's assets. It appears in all stages of the process, and due to a tie-up of financial resources in stock, companies try to use different approaches to lower the level and value of stock (Rusjan, 2003). From the sales point of view, the stock is increasing adaptability to customers in realising the sales orders, from the point of view of purchasing it enables more favourable purchasing conditions and lower prices, and from the point of view of production, the stock is welcome due to lowering of risks of fall-outs in production (Schmenner, 1993). According to the above, the only financial concern in the company is that of not running out of stock. The optimum level of stock is a combination of considering all the criteria important for the sales, production, purchasing, finance and ever more important logistics.

Many approaches to production planning have been developed 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 method originates in a special business environment, with a specific level of company culture and with developed business customs, an adopted pattern of behaviour of people and development of technology, whereas the methods alone derive from the basic characteristics of the production process of a specific type of production.

The starting point of the research was the principle rule of ordering the stock management system with periodical monitoring of product group stock. The basic rule of ordering is a somewhat altered rule determining the level of production (Nahmias, 1993). Using the rule enables levelling of orders and levelling of the stock situation. The basic rule was the starting point for deriving simple rules of ordering stock management systems, whose function is described in the research.

Increasing of all types of stock in a woodprocessing company presents a serious problem in the global market. We suppose that an actual decrease of stock can increase flexibility towards the customers and shorten delivery times (Weaver, 1998). Precise and organised monitoring of demand is the basis for developing the sales budget. Such production plan accurately defines the material needs, which will later be planned deterministically and stochastically on the basis of the ABC and XYZ analyses. This key change in stock management at raw material warehouse will shorten the planning period, which in turn will reduce errors in forecasting sales.

The goal of every single company is to be successful in the long run. Reaching this goal demand, among other things, requires an urgent introduction of the stock management model. The purpose of this research is to develop a stock management model for a hypothetical company on the basis of theoretical findings, where part of production is intended for a known customer and the other part of production for an unknown one (Grladinović, 1996).

The purpose of the research is to optimise stock upwards in the delivery chain. To this end our deliberations will proceed in the following way:

- adjust the information system for monitoring and forecasting demand in the purchasing chain with the task of cutting the time from planning to starting production into two,
- reduce the stock of raw materials,
- lower the value of unfinished production,
- reduce the stock of final products,
- shorten delivery times.

2 METHODS
2. METODE

2.1 The ABC analysis
2.1. ABC analiza

Performing the ABC and XYZ analyses of items should be one of the functions and components of each information system covering material handling. The criterion of the issued value is quite an appropriate criterion for seeking the sources of high value stock. It is similar when all items are classified according to the criterion of the sales value of issued quantities. The value of individual products is determined by the item sales price and the issued quantities.

A large number of material items appear in the environment of the production system, all of which are not equally important from the point of view of expenses. It is therefore practical to group material items into three categories, class A, B and C (Ljubič, 2000):

- material items belonging to class A present the highest expense, meaning that they are either used in large quantities or very expensive or both; class A items usually amount to 5 to 10% of the total company items, yet they present 70 to 80% of all material costs in (usually) one year period, which makes them very important for the business operation,
- class B items present the medium group, where 20 to 30% of the total material items may usually be found causing 20 to 30% of material costs; their importance is also considerable,
- finally, class C contains a large number of material items - 50 to 70% of all material items; these are mostly small material items of no great value (standard easily obtainable merchandise) yet used in large quantities and presenting only 5 to 10% of the total material costs, and therefore being less important.

The starting point for good stock management is the right classification of all items according to the value and frequency of use. The ABC analysis of stock is based on the Paret principle and says (Heizer, 1990) that there are only a few critical items in the entire stock management, whereas many are quite unimportant

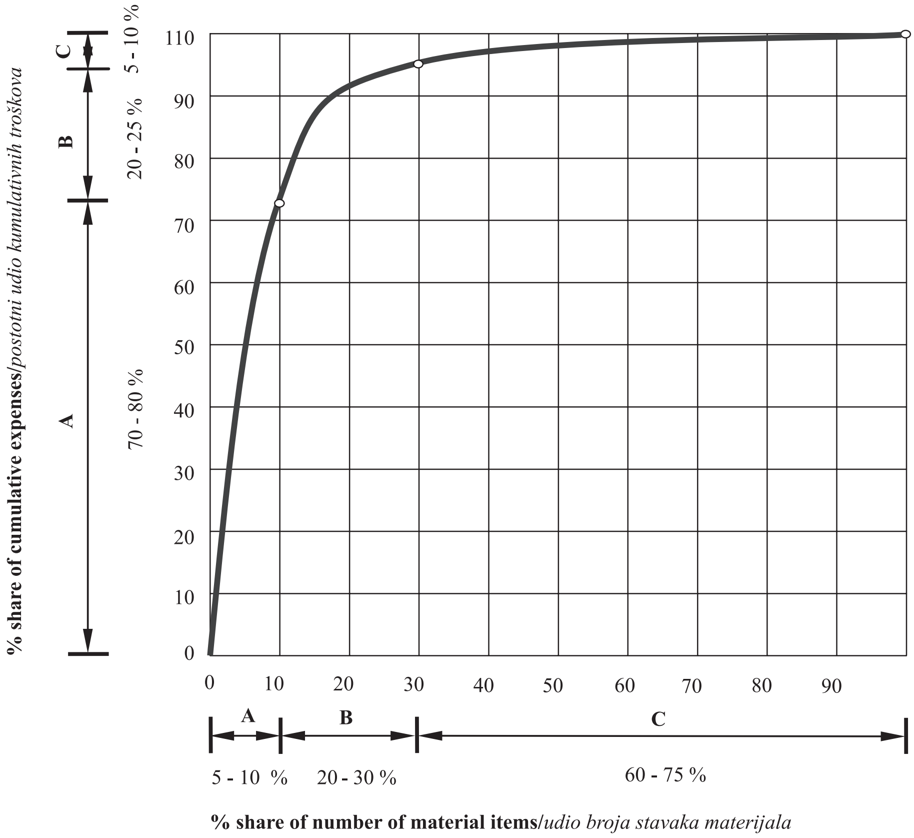

Figure 1 The Lorenzo curve of the ABC classification of material items (Ljubič 2000)
Slika 1. Lorenzova krivulja ABC klasifikacije stavaka materijala (Ljubič, 2000)

from the point of view of value and stock and production planning. The specified limit values between individual classes are recommendable, yet the exact definition is in the individual company's domain.

2.2 The XYZ analysis
2.2. XYZ analiza

For a reasonable decision-making especially in planning material needs, the ABC analysis does not suffice as it does not consider the needed dynamics (e.g very expensive material used only periodically, a few times a year, and in small quantities is put into class C even though it may be highly important for business operation). That is why it is upgraded with the analysis of constancy (stability) and steadiness (stationariness) of use and with the analysis of reliability of forecasting use. This analysis groups material items into classes X, Y and Z, where:

- class X consists of material items whose use is constant in all time scale units, in the long term it remains firm, approximately the same in all time scale units, it provides reliable forecast,
- class Y consists of items whose use is usually constant in all time scale units, but unstationary and the forecast is therefore of medium reliability,
- class Z consists of material items with an occasional (random, sporadic) use and quite unreliable forecast.

According to experience, class X consists of around 50% of material items (irrespective of classification in the ABC), the Y class consists of approximately 20% of material items and class Z of about 30% of material items (Oblak and Podlesnik 2005). The use in a certain time period can be determined for each material item according to time scale units, and the average for a suitable number of time scale units.

$$\overline{R} = \frac{\sum_{i=1}^{n} R_i}{n} \qquad [1]$$

where $\overline{R}$ = the average quantity of use in the researched time frame,
R_i = the actual quantity of use,
i = the index of time scale units,
n = the number of time scale units.

The absolute value of deviation of use is determined for each time scale unit from the average use and then the average deviation of use is calculated in the corresponding time frame.

$$\overline{D} = \frac{\sum_{i=1}^{n} \left|(R_i - \overline{R})\right|}{n}, \qquad [2]$$

where $\overline{D}$ stands for the average deviation of use in the time frame.

In the last stage, the average oscillation is calculated in the corresponding time frame and expressed in percentages. According to the average oscillation of use, the items are classified into:

- class X if the average oscillation is less than 50%,
- class Y if the average oscillation is between 50 and 100%, and
- class Z if the average oscillation is over 100%.

2.3 Exponent regulation
2.3. Eksponent regulacije

With stock management systems, we deal with the future. We try to order as much as we are going to need for meeting the demand in future periods. This is why we operate with a forecast of demand, instead of the actual demand, which is basically unknown for future periods. For this reason the level of order is the function of the forecast demand and not of the actual one. The actual demand is information from the past, which helps us in forecasting demand in future periods.

The exponent regulation is an operation where the forecast for the future period is calculated by altering the forecast for the last period with a part of errors in the forecast for that latter period. The correction, presenting a share of the error in the forecast for the last period, is obtained by multiplying the error in the forecast for the last period with the regulation constant. The value of the regulation constant is between zero and one. The equation for a simple exponent regulation is as follows (Peterson and Silver 1985):

$$\hat{D}_t = \hat{D}_{t-1} + \alpha(D_t - D_{t-1}) \qquad [3]$$

where α is the regulation constant provided that $0 \leq \alpha \geq 1$.

The forecast of demand for the time period t, $\hat{D}_t$ is reached by the forecast for the last period $\hat{D}_{t-1}$ is altered for the share of error in the forecast for that period. It should be emphasised that with D_t the actual demand forecast is marked by $\hat{D}_{t-1}$. Time t in the first case tells us when the demand was registered and in the second case when the estimate was made. Therefore in the period t-1 an estimate is made for the actual demand in the period t. In practice we cannot be sure whether the error in the forecast is the consequence of a random change in demand or whether there have been actual changes in demand, which will also continue in the following periods. As we consider only a part of error in the forecast, we basically have to decide to what extent the error is going to be considered at all. If the error is not considered, we believe that the change in demand was merely a consequence of a random leap in demand. If the error is considered seriously, we believe that the error reflects the actual change in demand for more time periods. The share in the error is determined by the demand regulation constant α which is low in the first case and quite high in the second. A lower regulation constant presumes the demand in the next period to be similar to the forecast of the last period $\alpha \rightarrow 0$: $\hat{D}_t \approx D_t$. This is in accordance with our assumption that this was merely a temporary change in demand. A high regulation constant on the other hand means that demand will follow the change and it is therefore suitable for the forecast to take the actual demand of the last period $\alpha \rightarrow 0$: $\hat{D}_t \approx D_t$.

As a rule the regulation constants are low, somewhere between 0.2 and 0.6, which suggests that the forecast of demand follows the forecast from the last period and is less dependent of the actual demand of the last period. By choosing low regulation constants, we worsen the response to the change in demand. On the other hand, by putting more stress on the forecast of demand from the past periods we regulate demand. The choice of the parameter α is thus a choice between the response and the demand regulation.

2.4 Multi-criteria decision-making
2.4. Multikriterijsko donošenje odluka

Decision-making is a process in which it is necessary to choose from many variants (alternatives, possibilities) the one which best suits the set goals i.e. demands (Kropivšek and Oblak 1997). Besides choosing the best alternative, they should be categorised from the best to the worst. Here alternatives are objects, actions, scenarios and consequences of the same type or a comparable type (Bohanec and Rajkovič 1995, Jereb et al. 2003).

The utility function presents a "joint" utility measurement according to all criteria. It is a criterion fun-

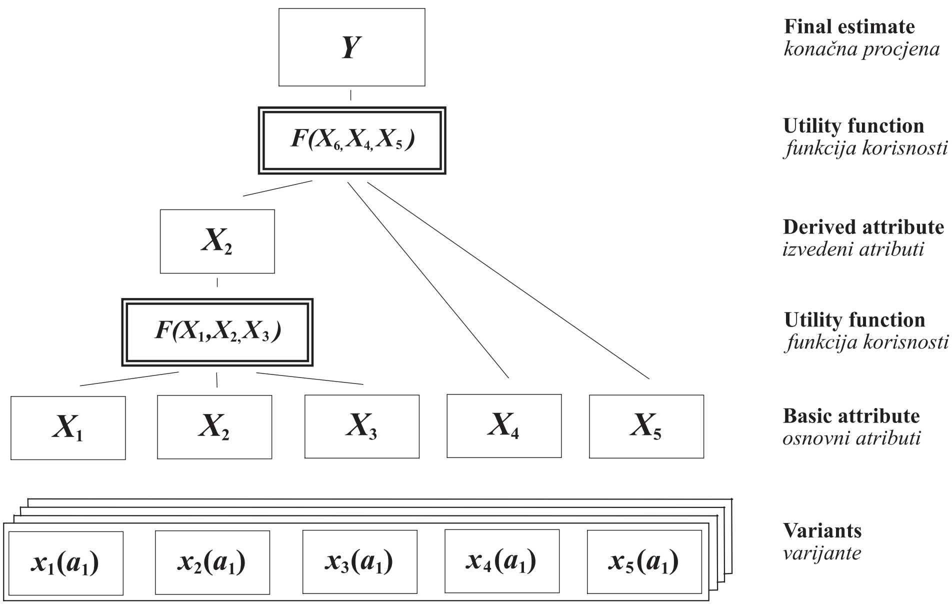

Figure 2 Multi-criteria decision-making tree (Bohanec and Rajkovič 1995)
Slika 2. Stablo multikriterijsokg odlučivanja (Bohanec and Rajkovič, 1995)

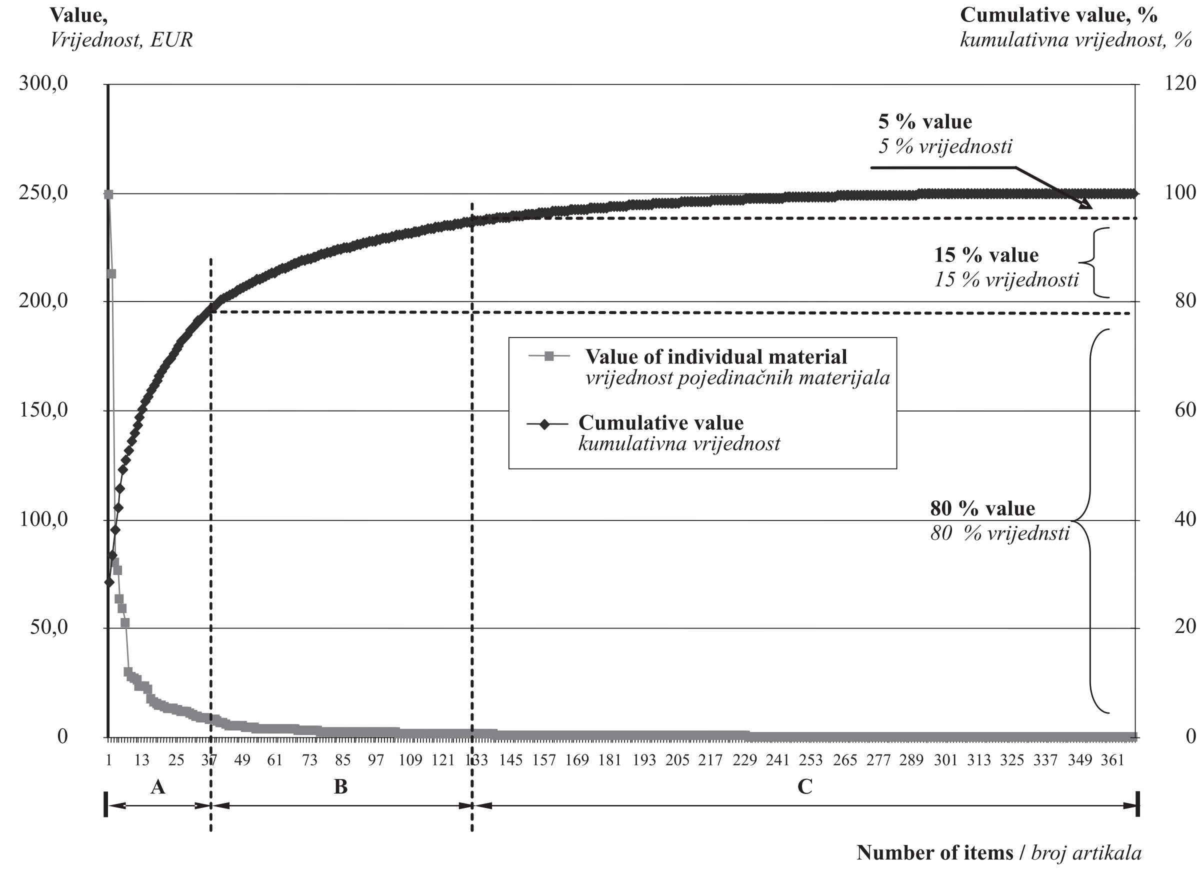

Figure 3 Materials analysis according to the purchasing price criteria (Novak 2006)
Slika 3. Analiza materijala u skladu s predviđenim kriterijem cijena (Novak, 2006)

ction used for determining utility of variants on the basis of individual parameters and their connections.

We used the multi-criteria decision-making model for defining the importance of an individual group at the beginning of the production launch, and we chose the software DEXi, the framework of the expert system for the multi-criteria decision-making, for the computer support. 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.

The above steps were not carried out in a linear way and we returned to the previous step many times; for example from setting utility functions back to setting the measuring scales. The interactive performance of building the model is also enabled and supported by the appropriate computer programme - DEXi intended for presenting results, modelling and estimating of variants.

3 RESULTS AND DISCUSSION
3. REZULTATI I DISKUSIJA

3.1 Results of the ABC and the XYZ analyses
3.1. Rezultati ABC i XYZ analize

The basis for determining material needs was the sales budget arising from careful monitoring of demand at the end of the supply chain. Development of the simulation of giving orders included items being marketed by a hypothetical company in different markets for different customers. For producing all the items we need a large number of different material items, which have been classified according to the ABC and the XYZ methods.

Table 1 shows which material items will be planned deterministically (the shaded areas in the table) and which stochastically.

3.2 Forecasting demand by using simple exponent regulation
3.2. Predviđanje potražnje primjenom eksponencijalnog regulatora

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 minor 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 then determining the quantities of these products. The joint volume of output should be harmonised with the production programme plan (Ljubič, 2000).

The products of a hypothetical company were categorised into groups according to production programmes, according to a similar technological process and similar treatment. Thus the entire series production was divided into more classes. A few representatives were chosen from each group of products, acting on behalf of the group in setting the optimum regulation constant α. A low regulation constant means that the forecast of de-

Table 1 Setting the planning methods of material items
Tablica 1. Postavljanje metode planiranja stavki materijala

Reliability of forecast and stationarity of use *pouzdanost prognoze i stacionarno korištenje*	**Final value of use** / *vrijednost iskorištenja na kraju*			
		A	**B**	**C**
	X	**Very high value of use, high reliability of forecast, stationary use** *vrlo visoka vrijednost iskorištenja, visoka pouzdanost predviđanja, stacionarno korištenje*	**Medium value of use, high reliability of forecast, stationary use** *srednja vrijednost iskorištenja, visoka pouzdanost predviđanja, stacionarno korištenje*	**Low value of use, high reliability of forecast, stationary use** *niska vrijednost iskorištenja, visoka pouzdanost predviđanja, stacionarno korištenje*
	Y	**Very high value of use, medium reliability of forecast, low stationary use** *vrlo visoka vrijednost iskorištenja, srednja pouzdanost predviđanja, nisko stacionarno korištenje*	**Medium value of use, medium reliability of forecast, low stationary use** *srednja vrijednost iskorištenja, srednja pouzdanost pedviđanja, nisko stacionarno korištenje*	**Low value of use, medium reliability of forecast, low stationary use** *niska vrijednost iskorištenja, srednja pouzdanost predviđanja nisko stacionarno korištenje*
	Z	**Very high value of use, low reliability of forecast, unstationary use** *vrlo visoka vrijednost iskorištenja, niska pouzdanost predviđanja, nestacionarno korištenje*	**Medium value of use, low reliability of forecast, unstationary use** *srednja vrijednost iskorištenja, niska pouzdanost predviđanja, nestacionarno korištenje*	**Low value of use, low reliability of forecast, unstationary use** *niska vrijednost iskorištenja, niska pouzdanost predviđanja, nestacionarano korištenje*

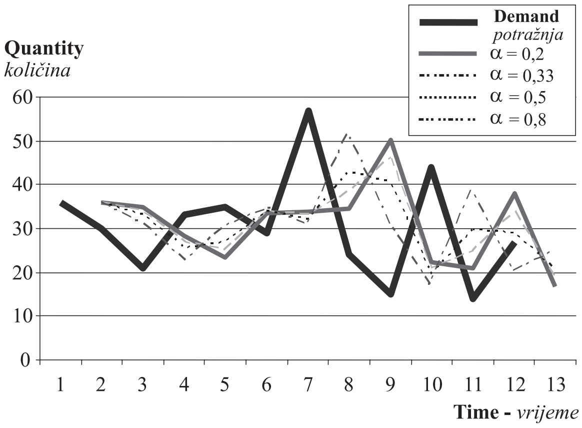

Figure 4 Demands and orders set according the choice of regulation constant for a chosen packet from the group of products of a hypothetical company
Slika 4. Prikaz potražnje i narudžbi poredanih prema izboru regulacijske konstante za izabranu grupu proizvoda hipotetičkog poduzeća

mand follows the forecast from the last period. Such a constant weakens the response to change in demand. Low regulation constants are found in those groups i.e. packets within them with an almost constant sale and demand throughout the year. Figure 4 shows demand and order, set with the choice of regulation constant for a chosen packet from the group of products of a hypothetical company.

3.3 Results of launching a group of product work orders into production by multi-criteria decision-making method
3.3. Rezultati lansiranja grupe radnih naloga proizvoda u proizvodnju metodom multikriterijskog donošenja odluka

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 as 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. The importance in such a market is also 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 the 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 involves technological demands of handling the individual group. The complexity is monitored throughout all production sections.
– The size of the order: expressed in the number of packets within one group.

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

– The volume of the ordered group of products: the volume in m^3 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.

Table 2 Suggestion of estimated values of the criteria for the decision-making model of groups of products
Tablica 2. Prijedlog procjene vrijednosti kriterija modela za donošenje odluka o grupi proizvoda

Criterion / *kriterij*	**Estimated value** / *procijenjena vijednost*
Group of products *grupa proizvoda*	Low; medium; high; very high *niska; srednja; visoka; vrlo visoka*
Market factors *tržišni čimbenici*	Bad; good; very good; excellent *loši; dobri; vrlo dobri; izvrsni*
Importance of the group (according to sale) *važnost grupe (u skladu s prodajom)*	Less important; important; very important *manje važno; važno; vrlo važno*
Width of the market / *širina tržišta*	Small; medium; large / *mala; srednja; opsežna*
Share of necessary items / *dio potrebnih stavki*	Low; high / *niski, visoki*
Organisation-production factors *oranizacijsko-proizvodni čimbenici*	Bad; good; very good; excellent *loši; dobri; vrlo dobri; izvrsni*
Complexity of production / *složenost proizvodnje*	High; medium; low / *visoka; srednja; niska*
Size of the order / *veličina narudžbe*	Small; medium; large / *mala; srednja; visoka*
Economic factors *ekonomski čimbenici*	Bad; good; very good; execellent *loši; dobri; vrlo dobri; izvrsni*
Volume of the ordered group of products *obujam narudžbi grupe proizvoda*	Very big; big; medium; small *vrlo veliki; veliki; srednji; mali*
Value of the ordered group of products *vrijednost narudžbi grupe proizvoda*	Low; medium; high; very high *niska; srednja; visoka; vrlo visoka*
Factor of the stock turn / *čimbenik obrta zaliha*	Low; high; very high / *niski; visoki; vrlo visoki*

From 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 taking into consideration mutual dependencies and contextual connections. The criteria at a higher level are dependent on those at lower levels.

The next step determines the measuring scales or estimated values, which can be used in the evaluation. In the DEXi programme the estimated value of the criteria, named programme attributes, consist of words and numerical intervals. The estimates of the criterion should be lowered so as to keep the decision-making model sensitive enough and capable of distinguishing the key differences among the variants. The estimated values should be sorted 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 2.

Evaluating the variants is a procedure of determining the final estimate of the variants on the basis of their description according to the basic criteria. The evaluation is carried out from "the bottom up", in accordance with the structure of the criteria and utility functions. The variant with the best evaluation mark is usually the best, in so far as no major errors occurred during the estimation. The final estimate is influenced by many factors and an error may occur in each of these factors. Besides, the final estimate does not usually suffice for the full picture of an individual variant, and therefore variants need analysis (Novak, 2006).

The results of the evaluation are presented graphically by diagrams, or textually in tables. According to the number of chosen parameters, the computer programme DEXi then 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.

3.4 Diagram of the course of ordering the material
3.4. Dijagram toka naručenog materijala

The process of presenting the sales budget and ordering of materials shown in Figure 5 is presented in the form of a flowchart.

The diagram shows the course of ordering the material in a hypothetical woodprocessing company, the stages of the process, the recurrent loop and decision-making at specific stages of the process. This model may be applied to an actual woodprocessing company but it needs proper modification.

4 CONCLUSIONS
4. ZAKLJUČAK

This article shows and studies a system of stock management. We developed a model for total quality stock management on the basis of known theoretical starting-points. Since demand is the driving force of all production companies, we included sensible methods for anticipating demand. In developing the model of stock management, we used the quantitative method of anticipating demand with exponent regulation. We realised that we could monitor one part of the material stock as if we dealt with independent demand while the rest could be monitored via the sales budget, which is the basis for creating work orders. We established

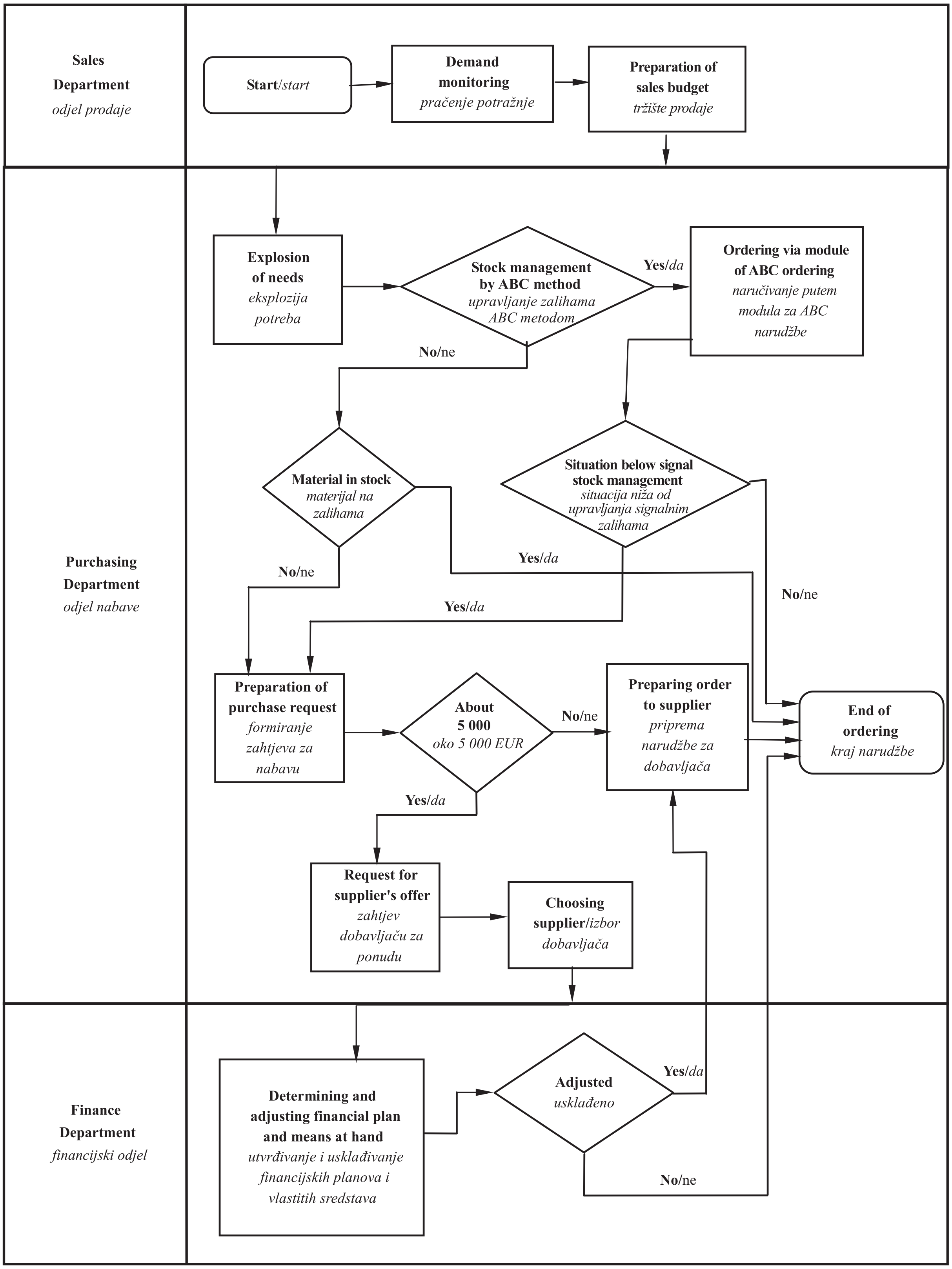

Figure 5 Example of the flow diagram of ordering the material
Slika 5. Primjer dijagrama toka naručenog materijala

which materials these were by making the ABC and XYZ analyses. For individual classes orders are made on the basis of individual needs from the sales budget, for others material needs of more time units should be combined together, and for some the orders are made according to annual contracts and optimum order quantities. Thus, we have an important influence on reducing the stock of raw materials, which otherwise presents a big part of all stock in a woodprocessing company.

Final products stock usually present around 2/3 of all stock in a woodprocessing company. This stock may be reduced by a well thought-out sales plan. This article presented periodical stock management of group products by ordering up to the target stock. By combining similar products into groups, we not only improve the movement through production but also create groups of products, which can be monitored much more easily and thoroughly. The needs for individual products can be calculated by the method for optimising the quantity of packets for group products and by using the constant á of simple exponent regulation.

The method of multi-criteria decision-making may be used for determining the order of launching group products into production. We studied three main criteria influencing the launching of work orders into production: market factors, organisational-production factors and economic factors. The computer programme - DEXi was chosen for computer support, and it represents the framework of the expert system for multi-criteria decision-making.

The purpose of the research was to build a model based on standard and partly modified methods connected into a sequence, and via changes in the information technology they present an automatism in stock management.

The research does not give any empirical data related to savings, percentage reductions in stock levels or shorter delivery time. It does, however, present a model shaped for a hypothetical woodprocessing company, showing clearly that the presented model may be successfully applied to stock management.

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