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# A MODEL FOR STOCK MANAGEMENT IN A WOOD-INDUSTRY COMPANY

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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. The article develops a model for stock management in a hypothetical wood-industry company where part of the 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 the 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. The reshaped process of presenting the sales budget and ordering of materials is shown with the Flowchart technique.

KEY WORDS: wood-industry company, stock management, modelling, multi-criteria decision-making

## INTRODUCTION

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 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 and Oblak 2005).

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, 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 (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 companies are, due to a tie-up of financial resources in stock, trying different approaches to lower the level and value of stock (Rusjan 2003). From the sales point of view the stock is increasing adaptability to the 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 stock is welcome due to lowering of risk of fall outs in production (Schmenner 1993). According to the above mentioned, the only financial function in the company is that of not wanting stock. The optimum level of stock is a combination of considering all the criteria important for the sales, production, purchasing, finance and in the ever more important logistics.

There are many developed approaches to production planning 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 starting point of the research was the principle rule of ordering the stock management system with a periodical monitoring of product group stock. The basic rule of order is a somewhat altered rule determing 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 a derivation of simple rules of ordering the systems of stock management, the function of which is described in the research.

Increasing of all types of stock in a wood-industry company presents a serious problem in operation on 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 producing the sales budget. Such production plan accurately defines the material needs, which will later be planned deterministically and stochastically on the basis of the A-B-C and the X-Y-Z analyses. This key change in stock management at the warehouse of the raw material 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 demands, among other things, an urgent introduction of the model of stock management. The purpose of this research is to develop a model for stock management for a hypothetical company on the basis of theoretical findings, where part of production is intended for a known and the other part of production for an unknown customer.

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

- adjustments of the information system for monitoring and forecasting demand in the purchasing chain with the task of cutting the time from making the plan to starting production into two,
- reducing the stock of raw materials,
- lowering the value of unfinished production,
- reducing the stock of final products,
- shortening delivery times.

# METHODS

## The A-B-C analysis

Performing the A-B-C and the X-Y-Z analyses of items should be one of the functions and a component of each information system covering material operation. The criterion of the issued value is namely quite an appropriate criterion for seeking of sources of high value stock. It is similar where all items are classified according to the criterion of the sales value of issued quantities. The value is determined by the product of the sales price of the item and the issued quantities.

A large number of material items appears in the environment of the production system, all of which are not as important for operation 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 in operation, meaning they are either used in large quantities or they are 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) the period of one year, which makes them very important for the operation,
- class B items present the medium group, where we can most commonly find 20 to 30% of the total material items which cause 20 to 30% of material costs; their importance is big as well,
- finally, class C contains a large number, 50 to 70% of all material items; these are mostly small material items of no great value (the standard merchandise easily obtainable) yet used in large quantities and presenting only 5 to 10% of the total material costs, therefore being of lesser importance.

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

## The X-Y-Z analysis

For a reasonable decision-making especially in planning material needs the A-B-C analysis does not suffice as it does not consider the needs 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 the use of which is constant, in all time scale units, in the long term it remains firm, approximately the same in all time scale units, it is possible to forecast it reliably,
- class Y consists of items the use of which 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 totally unreliable forecast.

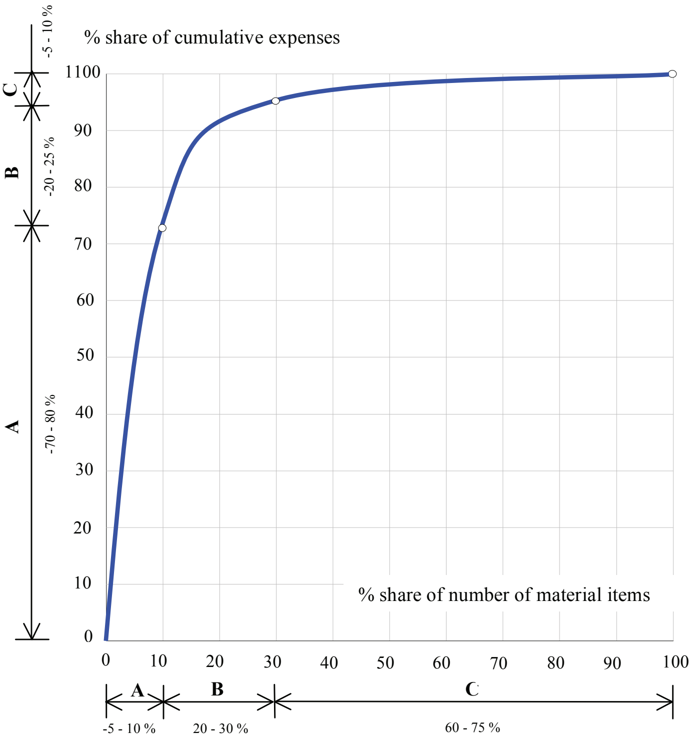


*Fig. 1: The Lorenzo curve of the A-B-C classification of material items (Ljubič 2000)*

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

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

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.

For each time scale unit in continuation, we determine the absolute value of deviation of use from the average use and later calculate the average deviation of use in the corresponding time frame.

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

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

In the last stage we calculate the average oscillation in the corresponding time frame and express it in percentages. According to the average oscillation of use we classify the items 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%.

## Exponent regulation

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

The exponent regulation is an operation where we calculate the forecast for the future period 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 reached 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 written as follows (Peterson and Silver 1985):

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

where $\alpha$ is the regulation constant and it is true 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 needs to be emphasised that with $D_t$ we mark the actual demand forecast 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 estimation was made. Therefore in the period $t$-1 we put down an estimation 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 continue in the next periods as well. As we are considering only a share of the error in the forecast, we are basically making a decision to what level 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 in a great way, we believe that the error reflects the actual change in demand for more time periods. The share of the error is determined by the demand regulation constant $\alpha$ 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 suppositions 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 $\alpha \rightarrow 1$: $\hat{D}_t \approx D_t$.

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 from the actual demand of the last period. By choosing low regulation constants we are worsening 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 are regulating demand. The choice of the parameter $\alpha$ is thus a choice between the response and the demand regulation.

## Multi-criteria decision-making

Decision-making is a process where it is necessary to choose from among many variants (alternatives, possibilities) the one which best suits the set goals i.e. demands (Kropivšek and Oblak 1997). Besides choosing the best alternative we wish to categorise these 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).

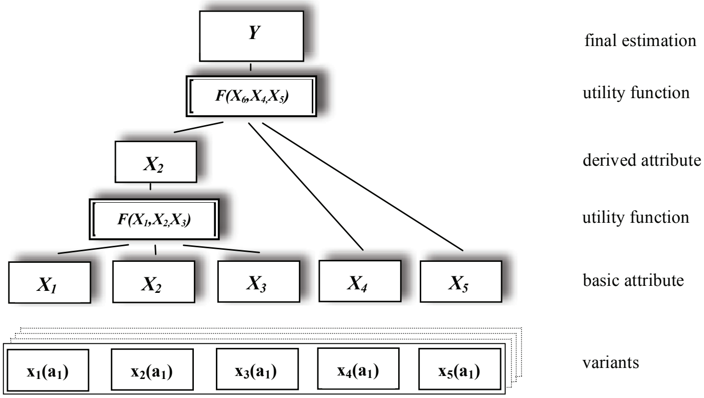


*Fig. 2: Multi-criteria decision-making tree (Bohanec and Rajkovič 1995)*

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.

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.

Executing the mentioned steps did not proceed only 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 enabled and supported also by adequate possibilities of the computer programme DEXi in connection with presenting results, modelling and estimating of variants.

# RESULTS AND DISCUSSION

## Results of the A-B-C and the X-Y-Z analyses

The basis for determining material needs was the sales budget arising from careful monitoring of demand at the end of the supply chain. The making of the simulation of giving orders included items being marketed by a hypothetical company on different markets for different customers. For producing all the items we need a large number of different material items, which had been classified according to the A-B-C and the X-Y-Z methods.

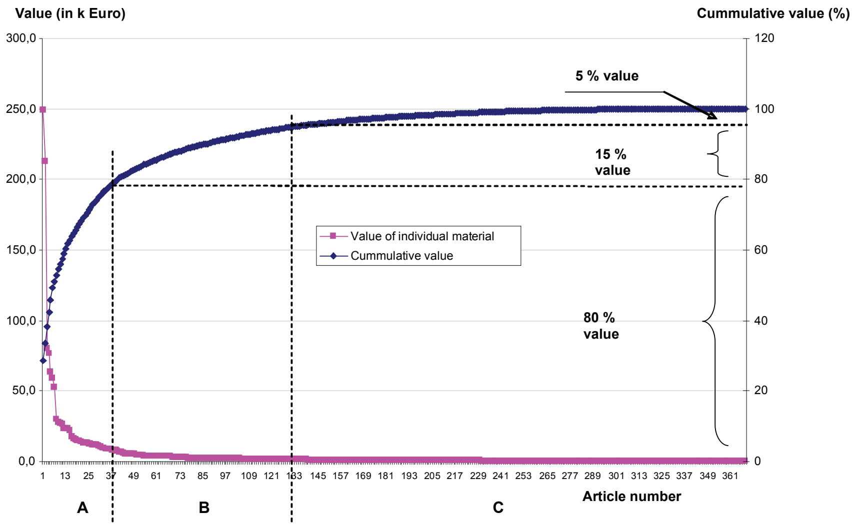


*Fig. 3: Materials analysis according to the purchasing price criteria (Novak 2006)*

In Tab. 1 we can see which material items will be planned deterministically (the shaded areas in the table) and which stochastically.

## Forecasting demand by using simple exponent regulation

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 (Ljubič 2000).

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

*Tab. 1: Setting the planning methods of material items*

| | | Value of use in the last period | | |
|---|---|---|---|---|
| | | ***A*** | ***B*** | ***C*** |
| Reliability of the forecast and the stationarity of use | **X** | very high value of use, high reliability of forecast, stationary use | medium value of use, high reliability of forecast, stationary use | low value of use, high reliability of forecast, stationary use |
| | **Y** | very high value of use, medium reliability of forecast, low stationary use | medium value of use, medium reliability of forecast, low stationary use | low value of use, medium reliability of forecast, low stationary use |
| | **Z** | very high value of use, low reliability of forecast, unstationary use | medium value of use, low reliability of forecast, unstationary use | low value of use, low reliability of forecast, unstationary use |

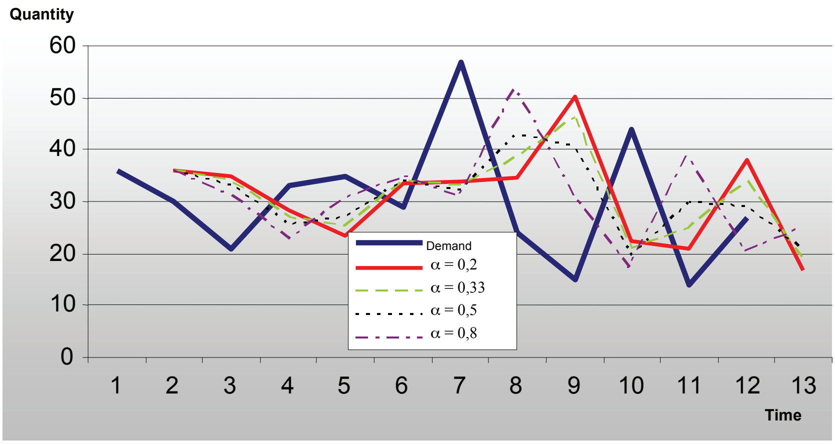


*Fig. 4: Representation of demand and orders set with the choice of regulation constant for a chosen packet from the group of products of a hypothetical company*

**Results of launching groups (work orders) of products into production with the multi-criteria decision-making method**

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 techological 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 $m^3$ 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.

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.

The next step is 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 words and numerical intervals. It is sensible to lower the estimations of the criterion in such a way that the decision-making model remains sensitive enough and differs between the key differences among the variants. 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 Tab. 2.

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 mark 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 (Novak 2006).

*Tab. 2: Suggested estimated values of the criteria for the decision-making model of groups of products*

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

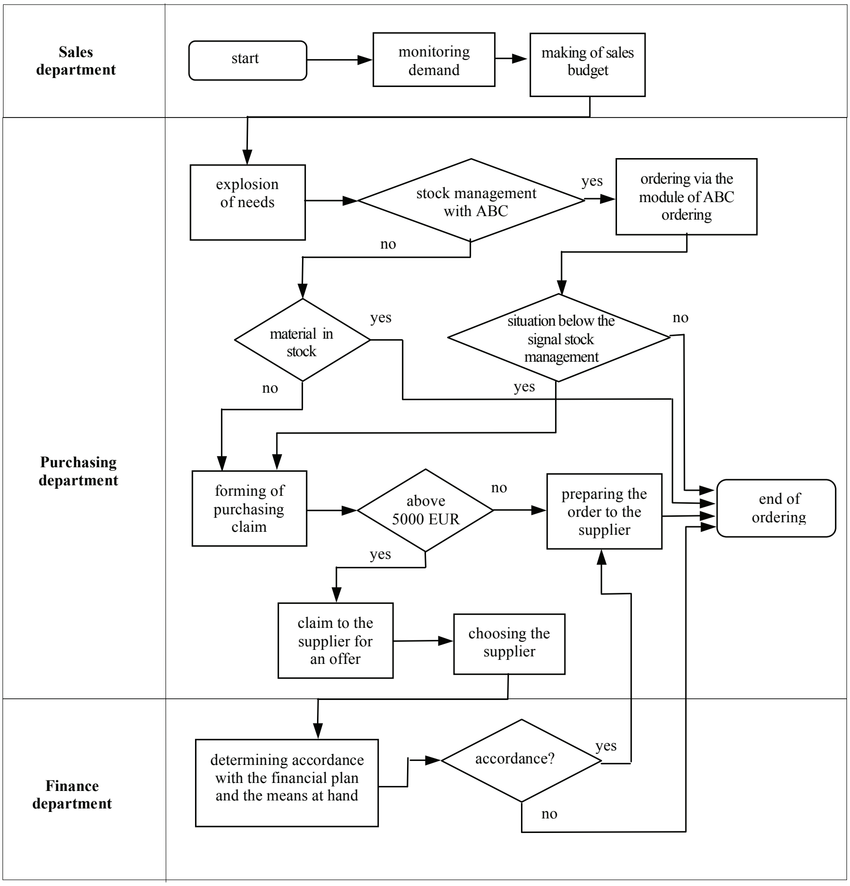


*Fig. 5: Example of the diagram of the course of ordering the material*

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), corelation 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.

### The diagram of the course of ordering the material

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

From the diagram we can see the course of ordering the material in a hypothetical wood-industry company, the stages of the process, the recurrent loop and decision-making in individual stages of the process. It is possible to use this model for an actual wood-industry company but it needs proper modification.

## CONCLUSIONS

The article shows and studies a system of stock management. We developed a model needed 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 came to realise that we can monitor one part of the material stock as if we were dealing with independent demand while the rest can be monitored via the sales budget, which is the basis for creating work orders. Which materials these are was shown to us by the A-B-C and X-Y-Z analyses. For individual classes we create orders on the basis of individual needs from the sales budget, for others it is sensible to combine material needs of more time units together, and for some the orders are created according to annual contracts and optimum order quantities. Thus, we have an important influence on running down stock for raw materials, which otherwise presents a big part of all stock in a wood-industry company.

Final products stock usually presents around 2/3 of all stock in a wood-industry company. It is possible to run this stock down with a well thought-out sales plan. The article presented a 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. With the method of optimising the quantity of packets for group products and by using the constant $\alpha$ of simple exponent regulation, we can calculate the needs for individual products.

The method of multi-criteria decision-making serves 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. For computer support, we chose the computer programme DEXi, which 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 the changes in the information technology they present an automatism in stock management.

The research does not give any empirical data on savings, percentages of reducing the stock and a shorter delivery time. It does, however, present a model shaped for a hypothetical wood-industry company, from which it is evident that stock management according to the presented model is possible.

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