International Conference on Economic Engineering and Manufacturing Systems
Braşov, 25 – 26 October 2007

METHODOLOGY AND PROCEDURES FOR APPLYING THE FORWARD-LOOKING GRAPHICAL-ANALYTICAL MODEL DEVELOPED TO FORECAST THE TECHNICAL-ECONOMIC ENVIRONMENT IN MANUFACTURING HEAT-INSULATION CARPENTRY

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Abstract. The paper presents the methodology and procedures used to apply a forward-looking mathematical model developed to forecast the technical-economic environment in manufacturing heat-insulation carpentry.

The methodology follows thirteen steps, each step including the procedure for calculating different parameters. The conclusions regarding the model viability are presented at the end of the paper.

The conclusion shows that the model was submitted to a two-year test in a factory manufacturing heat-insulation carpentry, being proved its viability.

Keywords: mathematical model, technical-economic environment

1. Object of the paper

The authors present the methodology and procedures used to apply a forward-looking mathematical model, which is to be explored on a short-term basis, with linear extrapolation; the model is developed in an uncertain real manufacturing environment for manufacturing heat-insulation carpentry. The model presented was validated after being submitted to a two-year test in a real manufacturing environment [4, 5].

2. Methodology and procedures

The use of the model requires the fulfillment of the methodology following 13 steps [7, 8, 9]:

1) Defining the products or processes P_k, $1 \leq k \leq n$, which are studied in the present case $\{P_k\}$={FF, FR, FRB, UPVC, UAL, C}.
2) Defining the technical-economic a_{ij} parameter which is to be studied; in the present case the forward-looking probability p_{ij} of manufacturing metallic and PVC carpentry;
3) Establishing alternatives (V_i variants) and states of nature (states of technical-economic environment, S_j) and writing down one [A] dim mxn matrix, for each product, process, with m lines and n columns.
4) Completing the $\forall(V_i \bigcap S_j$ crossings, $1 \leq i \leq m$, $1 \leq j \leq n$) from [A] matrix of manager's decisions with a_{ij} values. For this very goal the production manager will consult a team of specialists from planning, marketing and financial departments; teams are made up of two persons - one with aversion to risk and one with indifference to risk. They will offer guiding values with initial data of $Q_{f,(t,p),k}$, $Q_{v,(t,p),k}$, $Q_{f,(t,p),T}$, $Q_{v,(t,p),T}$. quantities. The manager will decide whether the model is designed on the basis of a_{ij} quantities, with aversion or indifference to risk or a mean value of the two. The total responsibility belongs to the manager and the analyst has to follow it. Once the values of a_{ij} elements are defined, they will be recorded in decision matrices. At the same stage the manager has to make different estimations on $\forall(V_i \bigcap S_j)$, or I_a coefficients or r_a risks

   It is recommended that τ (preferably L and A) should be stated, seasons (preferably Sr, Ss, Sc) should be defined and season lengths in months should be defined at this stage as well.
5) The analyst may calculate the values by relating them to times (t) and (p) of $p_{f(t,p),k}$ and $p_{v(t,p),k}$ share, which will be included in tables similar to matrices.
6) Evaluating the forecasted probabilities. By consulting the marketing department, the manager has to frame the method used to define the forecasted probabilities – experimentation method or indirect calculation method. Provided the experimentation method

will be used, even in case the marketing department records the values of forecasted probabilities, the manager is in charge of total responsibility. In case the method based on indirect calculation is used, by consulting the marketing department, the manager has to decide the decisions conditions: determinist probalistic environment or uncertain environment. Provided the decision is made in a determinist probalistic environment and the calculation of forecasted probabilities is done on the basis of the balanced optimism criterion – Hurwicz, the manager has to send the analyst the a_{ijmax}, a_{ijmin} şi a_{ijopt} values so that the analyst could calculate p_{opt} from the relation:

$$a_{ijopt} = \max_i [a_{ij\max} * p_{opt} + a_{ij\min} * (1 - p_{opt})] \quad (1)$$

where $a_{ijopt}=a_{ijN}$ is a target value, also known as nominal value a_{ijmax} and a_{ijmin} are the upper and lower limits of a_{ij} parameter dispersion. Provided the decision is made in the determinist probalistic environment on the basis of the pessimist criterion – Wald, the manager has to send the analyst the values a_{ijopt} and a_{ijmin}, with the above-given significances, so that:

$$p_{pes} = \frac{a_{ij\min}}{a_{ijopt}} \quad (2)$$

Provided the decision is made in uncertain environment, of maximum indetermination on the basis of equiprobabilities criterion – Laplace, the manager has to send the analyst the probabilities values for each V_i and each S_j and then:

$$p_{(ech)i} = \frac{1}{n}\sum_{j=1}^{n} p_{ij} \text{ or } \sum_{i=1}^{m} p_i = 1 \text{ and}$$
$$p_{(ech)j} = \frac{1}{n} \text{ or } \sum_{j=1}^{n} p_j = 1 \quad (3)$$

or the values of a_{ijN} elements and then:

$$a_{j\max} = \max_j (\frac{1}{m}\sum_{i=1}^{m} a_{ij}), \text{ and } p_{jopt} = \frac{\overline{a_j}}{a_{j\max}}$$
$$a_{i\max} = \max_i (\frac{1}{n}\sum_{j=1}^{n} a_{ij}) \text{ and } p_{iopt} = \frac{\overline{a_i}}{a_{i\max}} \quad (4)$$

where the arithmetic environments of a_{ij} elements are expresses:

$$\overline{a_i} = \frac{1}{m}\sum_{i=1}^{m} a_{ijN} \qquad \overline{a_j} = \frac{1}{n}\sum_{j=1}^{n} a_{ijN} \quad (5)$$

7) Validating the values of calculated probabilities. The calculation and definition of one single value of a_{ij} parameter in the decision matrix doest not guarantee that the value is correct. This is the reason why it has to be validated by restricting it by other conditions.

The main validation condition according to [4] consists of framing it in an imposed dispersion field, determined by the squared mean deviation σ, so that:

$$a_{ijN\min} \le \overline{a_{ij}} - \sigma^2$$
$$a_{ijN\max} \le \overline{a_{ij}} + (1{,}7...2)\sigma \quad (6)$$

and for $a_{ij}=p_{ij}$ it is required:

$$\text{for } a_{ijmin} \Rightarrow \sigma_p = (0{,}1...0{,}2)\, p_{ij}$$
$$\text{for } a_{ijmax} \Rightarrow \sigma_p = (0{,}01...0{,}05)\, p_{ij} \quad (7)$$

8) The evaluation of the assumed risk r_a is carried out with the same procedures used to evaluate the forecasted probabilities, following r_a.
9) Calculation of fundamental values. The values of previously defined quantities are used to calculate the values of fundamental quantities $Q_{f(t,p)\tau,k}$, $Q_{f(t,p)\tau,T}$, $Q_{v(t,p)\tau,k}$, $Q_{v(t,p)\tau,T}$, $Q_{f(v)\tau,k}$, $Q_{f(v)\tau,T}$, $Q_{v(v)\tau,k}$, $Q_{v(v)\tau,T}$.
10) Recalculating the monthly, seasonal and total share $p_{f(t,p),(L,S),k}$, $p_{f(t,p),T}$, $p_{v(t,p),(L,S),k}$, $p_{v(t,p),T}$.
11) Recalculating the products $(p_{(v)}*r_{a(v)})$: $(p_{f(v),(L,S),k}*r_{af(v),(L,S),k})$, $(p_{v(v),(L,S),k}*r_{av(v),(L,S),k})$, $(p_{f(v),T,k}*r_{af(v),T,k})$, $(p_{v(v),T,k}*r_{av(v),T,k})$.

Following the explanation given to r_a values by the managerial authority, the analyst may calculate the $p_{(f,v)}$ values. Calculated data are recorded in table, similarly to decisional matrices.

12) $p_{(f,v)(t,p,v),(L,S),(k,T)}$, $p_{(f,v)(v),(L,S),(k,T)}$, diagrams and histograms are drawn up if $Q_{(f,v),(t,p,v),(L,S),(k,T)}$ is necessary whereas $p_{(f,v)(v),(S),(k,T)}$.histograms are compulsory
13) From available diagrams and histograms the management draws conclusions referring to:
   - monthly, seasonal share of each Pk product in company's total production and, therefore, the value-oriented importance of each product;
   - monthly, seasonal, annual forecasted probabilities or for any τ=n*A interval and the level of the assumed risk;
   - the strategy of the company's policy defines the seasons (Sr, Ss, Sc)=f(t,p,v) and $\varphi(p_{f(t,p,v)}, p_{v(t,p,v)})$; the length of season is expressed in months;
   - there is stated the degree of seasonal/annual increase in manufacturing and the

importance of each product in the production program through the share coefficient.

- there is stated the dynamics of manufacturing evolution at (v) time and there are established the future tendencies in composing, structuring and organizing the manufacturing system (further development of the manufacturing system).

3. Application

The model presented was applied in paper [6], its results being published in papers [1, 2, 3]. The model proved its viability in a real manufacturing environment on an interval of τ=2 years.

The following application represents a partial application of the model, i.e. the model making reference to the evaluation of the dynamics of product manufacturing and probabilities of manufacturing products on seasons, during the interval 2003-2007.

In the presented case study, the historical statistical data from the years 2003, 2004 and those known until August 2005 have been used to define the historical dynamics of the production, and based on it, the future dynamics of the factory's production could be predicted.

Using the statistical data of a carpentry factory in Romania, Figure 1 shows the dynamics of the total production during the period 2003-2007, while Figure 2 shows the dynamics of the production for the main products, in the same time period. From the total production diagram, it follows that the carpentry production had a 33% growth rate until 2005 and will grow at a rate of about 20% in 2006 and 2007, as compared to 2003.

From the diagram of the production by products, it follows that the combined panels (C) have the greatest share in the total production, with a growth rate of about 25 times that of the tilt-and-turn windows (FRB), which have a growth rate about 1.5 times that of the (FR, UPVC, FF) group. UAl has the lowest growth rate, up to 2.5 times lower than that of FR.

The diagram in fig. 3, showing the variation of the various products' production probabilities in the three states of the production environment, calculated and predicted for the 2003-2007 interval, was made on the basis of the diagrams in fig. 1 and fig. 2.

From the diagram in fig. 3, it follows that the carpentry production is a seasonal production, which is carried out in three types of economic environments, determined by the three states of nature: economic stagnation, economic decline or recession and economic growth.

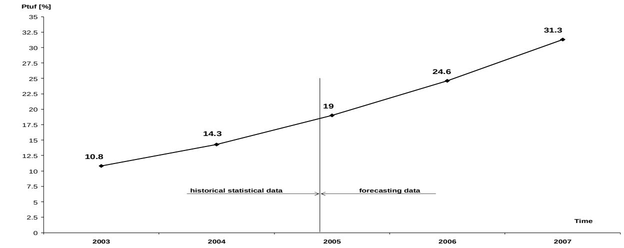


Figure 1. Forecast Dynamics of Total Production

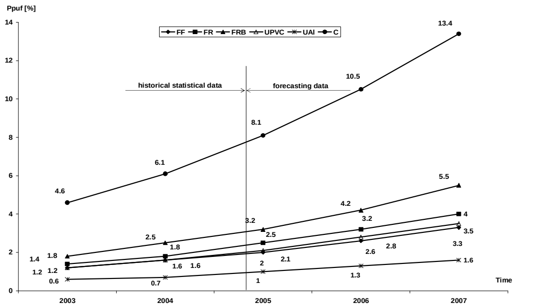
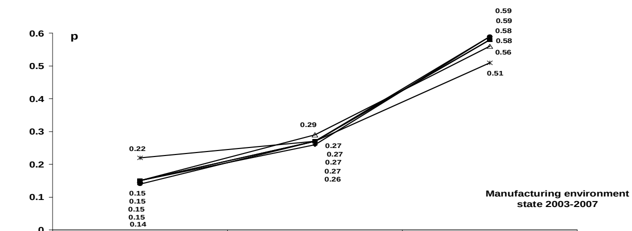


Figure 2. Forecast Dynamics of Production by Products



	R	S	G
FF	0.15	0.26	0.59
FR	0.15	0.27	0.58
FRB	0.15	0.27	0.58
UPVC	0.15	0.29	0.56
UAl	0.22	0.27	0.51
C	0.14	0.27	0.59

Figure 3. Probabilities of Various Products' Production in the Three States of the Production Environment, Calculated and Forecast for the Years 2003-2007

The three states of nature result from the variation of the (FF, FR, FRB, UPVC şi C) product group production loads.

The aluminum doors have a fluctuating, hard-to-define production load, with an alternating variation with three peaks and two valleys in a year.

The curve of the combined panel production follows exactly that of the fixed windows.

The (FF, FR, FRB, UPVC and C) group of products shows similar variations in the production load, differentiating by the shares in physical and value units.

It is on the basis of in-house statistics that the company's policy is established, by which the production economic environments are decided.

Having in view the typological diversity and assortment variety of the products, the seasonal character of the production and the share of the products in the total production, three distinct economic environments are defined from the previous diagrams, as follows:

- The slack economic environment - as being that in which, during the annual time interval, the production growth is zero (state of nature: stagnation - S) and therefore the manufacturing system works within the normal predicted parameters;
- The declining economic environment - as being that in which, during the annual time interval, the production declines (state of nature: recession - R) and therefore the manufacturing system works with values below the normal ones of the predicted parameters;
- The growing economic environment - as being that in which, during the annual time interval, the production grows (state of nature: growth - G) and therefore the manufacturing system works at values above the normal ones of the predicted parameters.

The three states of the annual production are defined as follows by the company's policy, established on statistical bases:

- The state of stagnation (S) for the annual interval including the months: April, May, June, July, August and December;
- The state of recession (R) for the annual interval including the months: January, February and March;
- The state of growth (G) for the annual interval including the months: September, October and November.

The definition of the technical-economic environment underlies the decision of the manufacturing system restructuring and technological development.

4. Conclusions

A forward-looking mathematic model was elaborated, based on a short-term exploration, in manufacturing PVC carpentry, with linear extrapolation, in an uncertain probabilistic environment. The model presented was validated after being submitted to a two-year test in a real manufacturing environment.

References

1. Boncoi, Gh. Et all.: *Technical-economic environment of metal and heat-insulated carpentry inside a medium Romanian enterprise.* Published in: Bulletin of Polytechnic Institute from Iaşi by "Gh. Asachi" University, vol. L (L/V), 2006. (in Romanian)
2. Boncoi, Gh. Et all.: *Actual stage of metal and heat-insulated carpentry inside a medium Romanian enterprise*. Published in: Bulletin of Polytechnic Institute from Iaşi by "Gh. Asachi" University, vol. L (L/V), 2006. (in Romanian)
3. Boncoi, Gh. Et all.: *Tendencies in dynamics of metal and heat-insulated carpentry inside a medium Romanian enterprise*. Published in: Bulletin of Polytechnic Institute from Iaşi by "Gh. Asachi" University, vol. L (L/V), 2006. (in Romanian)
4 Boncoi Gh., Et all.: *Forward-looking mathematical model developed to forecast the technical-economic environment in manufacturing heat-insulation carpentry. Application conditions.* International Conference ICEEMS, Brasov, 2007.
5. Boncoi, Gh., Et all.: *Forward-looking graphical-analytical model developed to forecast the technical-economic environment in manufacturing heat-insulation carpentry*. International Conference ICEEMS, Brasov, 2007.
6. Novac, I.: *Studies and researches regarding management of middle enterprise for manufacturing heat-insulation carpentry*. PhD Thesis. "Transilvania" University, Braşov, 2006 (in Romanian)
7. Stăncioiu, I., Militaru G.: *Management. Fundamentals.* "Teora" Publishing House, ISBN 973-601-846-6, Bucharest, 1999
8. Taguchi, G.: *Introduction to quality engineering. Design quality into products and process.* Asian Productivity Organization, 1986
9. Zaharia, M. et all: *Quantitative method for decision.* "Ecran Magazin" Publishing House, ISBN 973-8281-08-3, Braşov, 2002