# 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 fundamental relations of the model and the main graphical models of the seasonal production. There are presented the calculation relations of the production volume developed on physical and value basis, in the present, past and future, taking into account the probabilities and assumed risks, on seasons, in product manufacturing and total production, the share of the product in product manufacturing and total production.

Similarly, five graphical models of the seasonal production and two histograms are presented, resulting in the development tendencies of the production and its dynamics.

The increase in the manufacturing rate is defined on season and the coefficient of the share of the product in global, seasonal and annual production is also defined.

**Keywords:** mathematical model, technical-economic environment

## 1. Object of the paper

The authors present a forward-looking mathematical model to be explored on a short-term basis in manufacturing heat-insulation carpentry, with linear extrapolation in uncertain environment. This model is used to elaborate the strategy of the company's development policy. The present paper is a follow-up to paper [7].

## 2. Graphical and analytical model

Considering the initial data and the previously calculated values, the fundamental mathematical relations of the calculation model will be:

- production volume in physical and value units τ=(t,p):

$$Q_{f,(t,p)\tau,k} = Q_{f,(t,p)A,k} * p_{f,(t,p)\tau,k} \text{ [buc./τ,k]}$$
$$Q_{f,(t,p)\tau,T} = \sum_{k=FF}^{FR,FRB,UPVC,UAl,C} Q_{f,(t,p)\tau,k} \text{ [buc./A]} \quad (1)$$

where (t,p) express the physical values related to „past" or „present" season; A – value annually reported, resulted from historical statistical data of the company; τ=L,S – value related to τ time interval, which may be monthly or seasonal, the season being defined on states of nature: stagnation, recession or economic growth.

$$Q_{v,(t,p)\tau,k} = Q_{v,(t,p)A,k} * p_{v,(t,p)\tau,k} \text{ [uv/τ,k]}$$
$$Q_{v,(t,p)\tau,T} = \sum_{k=FF}^{FR,FRB,UPVC,UAl,C} Q_{v,(t,p)\tau,k} \text{ [uv/A]} \quad (2)$$

indices having the same significances as expressed above.

- production volume in physical and value units for τ=(v):

$$Q_{f,(v)\tau,k} = Q_{f,(p),\tau,k} * p_{f,(v)\tau,k} * r_{af,(v),\tau,k}$$
$$Q_{f,(v)\tau,T} = \sum_{k=FF}^{FR,FRB,UPVC,UAl,C} Q_{f,(v)\tau,k}$$
$$Q_{v,(v)\tau,k} = Q_{v,(p),\tau,k} * p_{v,(v)\tau,k} * r_{av,(v),\tau,k} \quad (3)$$
$$Q_{v,(v)\tau,T} = \sum_{k=FF}^{FR,FRB,UPVC,UAl,C} Q_{v,(v)\tau,k}$$

where indices have previous significances;

- the monthly and seasonal share of products in product manufacturing and total production for τ=(t,p) will be:

$$p_{f,(t,p),(L,S),k} = \frac{Q_{f,(t,p),(L,S),k}}{Q_{f,(t,p),A,k}} \text{ [%]}$$
$$p_{f,(t,p),T} = \frac{Q_{f,(t,p),A,k}}{Q_{f,(t,p),T}} \text{ [%]}$$
$$p_{v,(t,p),(L,S),k} = \frac{Q_{v,(t,p),(L,S),k}}{Q_{v,(t,p),A,k}} \text{ [%]} \quad (4)$$
$$p_{v,(t,p),T} = \frac{Q_{v,(t,p),A,k}}{Q_{v,(t,p),T}} \text{ [%]}$$

- product $p_{(v)}*r_{a(v)}$ in product manufacturing and total production for τ=(v) will be:

$$p_{f,(v),(L,S),k} \cdot r_{af,(v),(L,S),k} = \frac{Q_{f,(v),(L,S),k}}{Q_{f,(v),A,k}}[\%$$

$$p_{f,(t,p),T} \cdot r_{af,(v),T,k} = \frac{Q_{f,(v),A,k}}{Q_{f,(v),T}} \ [\%]$$

$$p_{v,(v),(L,S),k} \cdot r_{av,(v),(L,S),k} = \frac{Q_{v,(v),(L,S),k}}{Q_{v,(v),A,k}}[\%_- \quad (5)$$

$$p_{v,(v),T} \cdot r_{av,(v),T,k} = \frac{Q_{v,(v),A,k}}{Q_{v,(v),T}} \ [\%]$$

The last relations express the share of the product and probabilities to manufacture the product in the annual production of the product as well as in the total production of the factory.

The above relations may be related to τ=1L, 3L, 6L, 1A, nA, one or more seasons in a year, but defined by establishing the months of each season.

## 3. Graphical models of the production

The set of the above written relations defines a forward-looking mathematical model to be explored in the short and very short-term prognosis of any probabilistic and manufacturing technical-economic environment, with linear extrapolation.

The set of the above written relations cannot lead to pragmatic conclusions. For this very aim the graphical representations of these relations appear to be necessary. The graphical representations used are diagrams and histograms.

The objectives of the paper call for an approach to diagrams and histograms of the following mathematical functions:

$$(p_{f(t,p)} \text{ and } p_{v(t,p)})=f(L, S, A, P_k)$$
$$(p_{f(v)} \text{ and } p_{v(v)})=f(L, S, A, P_k) \quad (6)$$

These diagrams/histograms are to produce conclusions making reference to: production dynamics (evolution) in time and per products, definition of the states characterizing the manufacturing technical-economic environment (recession, stagnation, production growth), tendencies in the production dynamics.

The main types of resulted diagrams are presented in figure 1.

In the seasonal production the states of nature specific to the manufacturing technical-economic environment assimilated as seasons are: recession – r, stagnation – s, and economic growth – c, resulting the seasons $S_r$, $S_s$ and $S_c$.

In figure 1, a), b), c), d) the dynamics of the seasonal production is presented in Sr, Ss and Sc for a set of products $\{P_k, k=1,2\}=\{P_1, P_2\}$.

The diagrams presented show:

- The lengths of seasons may be equal or different for different $P_k$ products, k=var, that is $T_{rp1}=T_{rp2}$ and $T_{sp1}\neq T_{sp2}$;
- The sum of the lengths of seasons is equal to the reference length τ=3L, 6L, 1A, that is $\sum_{S=r,s,c} T_S = \sum_{i=1}^{n} T_i = \tau$, where n denotes the number of $T_i$ samples comprised in τ;
- The sum of probabilities for monthly (L) or seasonal (S) distribution, for a $P_k$ product, k=ct is equal to 1, that is for L=January, February, March, April, May, June, July, August, September, October, November, December = 1, 2, 3, ..., 12, $\sum_{\substack{L=1 \\ K=ct}}^{12} p_{LK} = 1$, and for S=r, s, c, $\sum_{\substack{S=r,s,c \\ K=ct}} p_{SK} = 1$;
- The length of Ts season is expressed through the determinist set of the months in the season set $S_{L\alpha}=\{L_1, L_2, ..., L_\alpha\}$, $S_{L\beta}=\{L_{\alpha+1}, L_{\alpha+2}, ..., L_\beta\}$, $S_{L\gamma}=\{L_{\beta+1}, L_{\beta+2}, ..., L_\gamma\}$, α+β+γ=12 for τ=1A;
- Any length τ may be sampled in n intervals $T_i$, according to production seasoning so that $\sum_{i=1}^{n} T_i = \tau$;
- The sum of probabilities for a monthly (L), seasonal (S) or annual (A) distribution of the total production in the factory, $\{P_k, 1\leq k\leq r\}$ is equal to 1, that is $\sum_{k=1}^{r} p_{TK} = 1$, or $\sum_{\substack{k=1 \\ S=r,s,c}}^{r} p_{TSK} = 1$.

The diagram in figure 1a is characteristic to a seasonal production ordered in an increasing order whereas the diagram in figure 1b is characteristic of a seasonal production ordered in an decreasing order. The diagram in figure 1c is characteristic of a seasonal manufacturing recording a production down-time during the τ interval whereas the diagram in figure 1,d) is characteristic of a seasonal production recording a τ overloaded manufacturing.

Figure 1, e) presents the diagram of share variation related to time (t, p) and forecasted $p_v$ probabilities. The curve $C_1$ expresses the tendency of slow production growth in τ, C2 – tendency of slow decrease, C3 – tendency of sudden increase and stabilization of a mature product, C4 – tendency of normal increase of a mature product, followed by a sudden decrease under the conditions of elimination from the market due to the strong competition, C5 – tendency of sudden decrease of an immature product, and C6 –

tendency of increase of an immature product, through maturation.

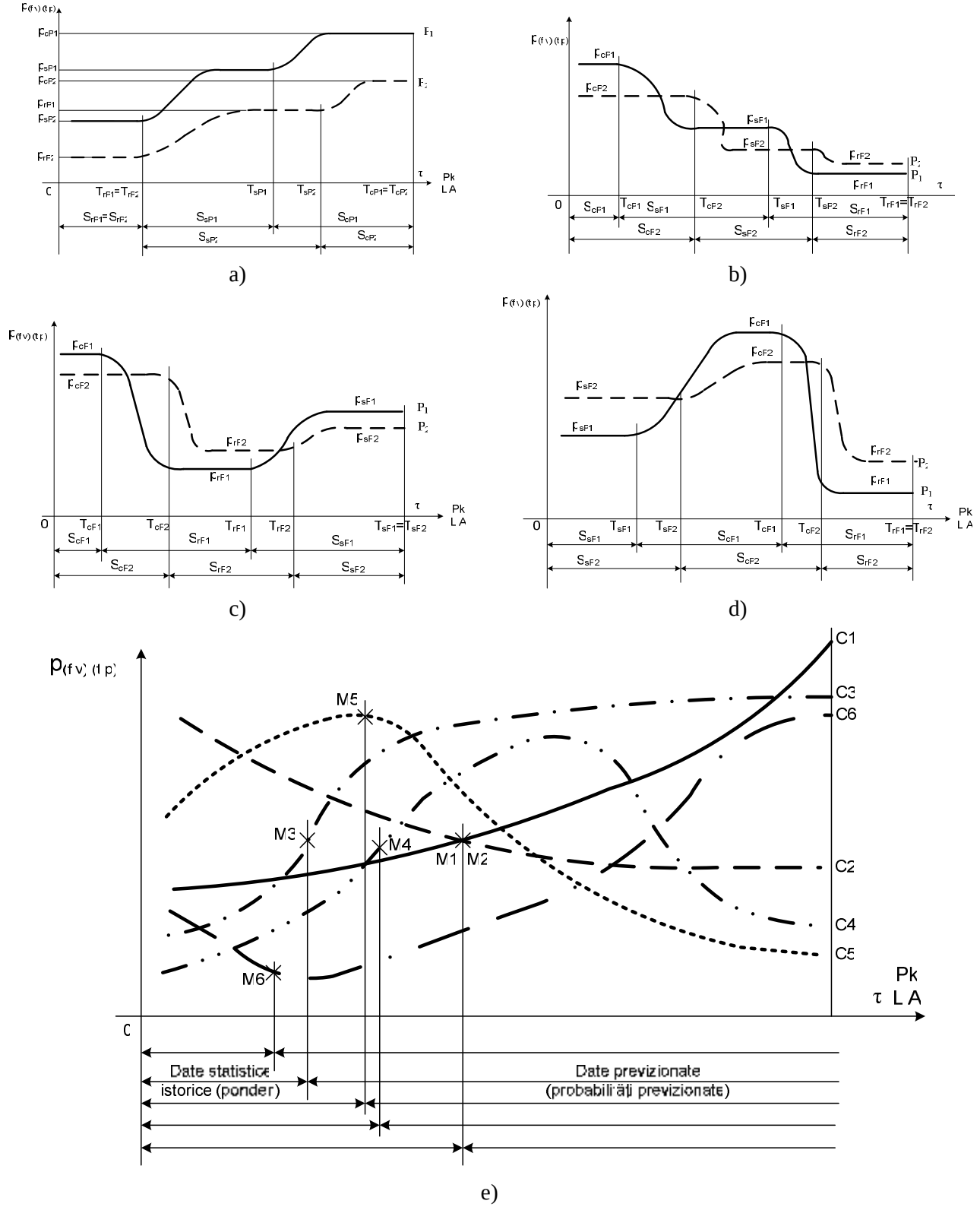


Figure 1. Typical diagrams illustrating the variation of the seasonal production

Figure 2, a) and b) presents the histograms which show the tendencies of manufacturing development and the dynamics of future manufacturing development.

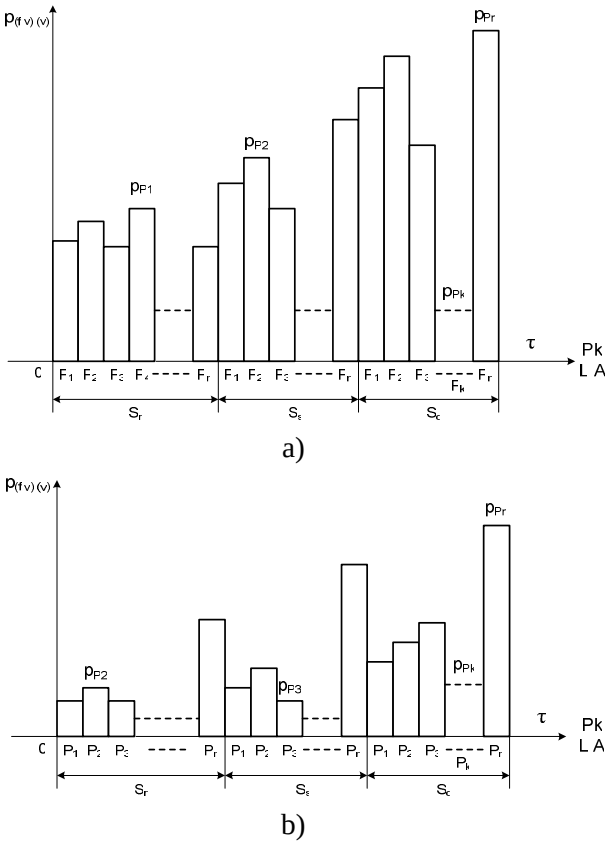


Figure 2. Typical diagrams forecasting the development tendencies

These histograms show that:

- The product with greatest share in each season and in the total production (for example $P_4$ in $S_r$, $P_n$ in $S_s$ and $S_c$;
- The following ratio is defined:

$$R_{CK(S,A)} = \min\left(\frac{p_{P_k,S_c}}{p_{P_k,S_s}}, \frac{p_{P_k,S_s}}{p_{P_k,S_r}}\right) = \min\left(R_{C_k,S_c}, R_{C_k,S_s}\right)$$

and $\frac{R_{C_k,S_c}}{R_{C_k,Ss}} = m$, for $p_{P_k,S_c} > p_{P_k,S_s} > p_{P_k,S_r}$, for $1 \le \forall k \le n$, called the growth rate of product manufacturing $P_k$ per season (S) or per year (A). This varies in the interval $1 < R_{CK} \le N_R, N_R \in R$, and:

- If $R_{CK,S_c} = m * R_{CK,S_s} = m * R_{CK,S_r}$ there results that $P_k$ has a growth rate $R_{CK}$, which varies linearly with the scalar m in all seasons (in the $\tau$ interval);
- m expresses the rate of $R_{CK}$ growth in a $\Delta\tau$ interval.

- The following ratio is defined:

$$\frac{p_{P_n(S,A)}}{p_{P_k(S,A)}} = K_{p_k(S,A)} \quad \text{for} \quad p_{P_n} > \forall p_{P_k},$$

$1 \le k \le (n-1)$ named share coefficient, whose values vary in the $1 < K_{p_k} \le N_k, N_k \in R$ interval, and:

- Provided $K_{pk}$ is lower, tending to 1, $P_k$ has a greater share and, therefore, greater importance in the manufacturing program; provided $K_{pk} \rightarrow N_k$, $P_k$ has a smaller share and, therefore, less importance in the manufacturing program;
- In figure 1, g), $P_1$ has the highest $K_p$ and, therefore, the least importance and $P_n$-$K_{pn}$ is equal to 1, having the greatest importance.

On the basis of the conclusions resulted from $R_{CK}$ and $K_{pk}$ analysis, the strategy of choosing the composition, structure and organization of the manufacturing system is established.

## 4. Conclusions

The authors present a completely developed and new graphical-analytical model to forecast the technical-economic environment in manufacturing heat-insulation carpentry, useful in establishing the development strategy of the manufacturing system.

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