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THE PERFORMANCE OF CERTAIN LOGISTICS PROCESSES

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Abstract: *Performance measurement processes are essential for improving their overall effectiveness. In the present contribution addresses the performance measurement of complex logistics processes, which, moreover, not precisely defined structure. Using the methodology of the expert assessment based on an assessment of calibration, and information is shown a possible way of measuring the performance of the aforementioned processes. For concrete examples from practice show a possible implementation of such an approach in terms of the production process.*

Key words: *Production, Process, Performance, Expert evaluation*

1 INTRODUCTION

Measurement and subsequent process performance improvement is the alpha and omega of increasing competitiveness, but also for the overall viability of each organization. Several processes and threads can be measured in exact manner. The results of these measurements are objective and reflect the undoubted merits of the measured reality. For example, if we measure the performance of the mass production line producing one type of product and we know the basic input parameters, we can relatively easily measure its performance. We use the basic parameters of the process and easily find appropriate indicators expressed in some measurable units such as number of products per shift, number of units produced per worker, etc. If you also know the cost of inputs, we can calculate the number of economic indicators characterizing economic performance processes.

The problem occurs in case of processes and threads which structure and linkages are not clearly given. Measuring the performance of such processes and threads is quite difficult due to the fact that they are immeasurable characteristics or unknown structure, respectively process frame, which varies based on the input parameters, so substantially that it is not possible to abstract a common model for all possible options for development.

Logistical processes and threads typically belong to that category. It is usually very difficult in real time on-going logistics processes in incomplete information to find the right logistics process, which allows optimal performance increase of the process.

On the other hand, wrong logistics decision entails additional costs, not all of which are sufficiently well identified. The literature defines these costs as hidden costs, because it is not known for their causes [5].

In order to avoid such costs, both visible and hidden, it is necessary to constantly pay attention to the measurement and subsequent improvement in the performance of logistics processes. In the present contribution we solve the issue of performance measurement wrong structured logistics processes.

2 PROCESSES AND SUBPROCESSES PERFORMANCE EVALUATION IN PRODUCTION LOGISTICS

Production logistics is a system science, which has the subject of research in review material flows (flows of raw materials, semi-finished products, components, spare parts, plant, waste, etc.) as a major integrating link between various elements of business and management in terms of quantity, time, quality to ensure maximum global company profits and customer satisfaction [2].

Within the corporate structure of the logistics we can put production logistics into the following sequence (Fig. 1).

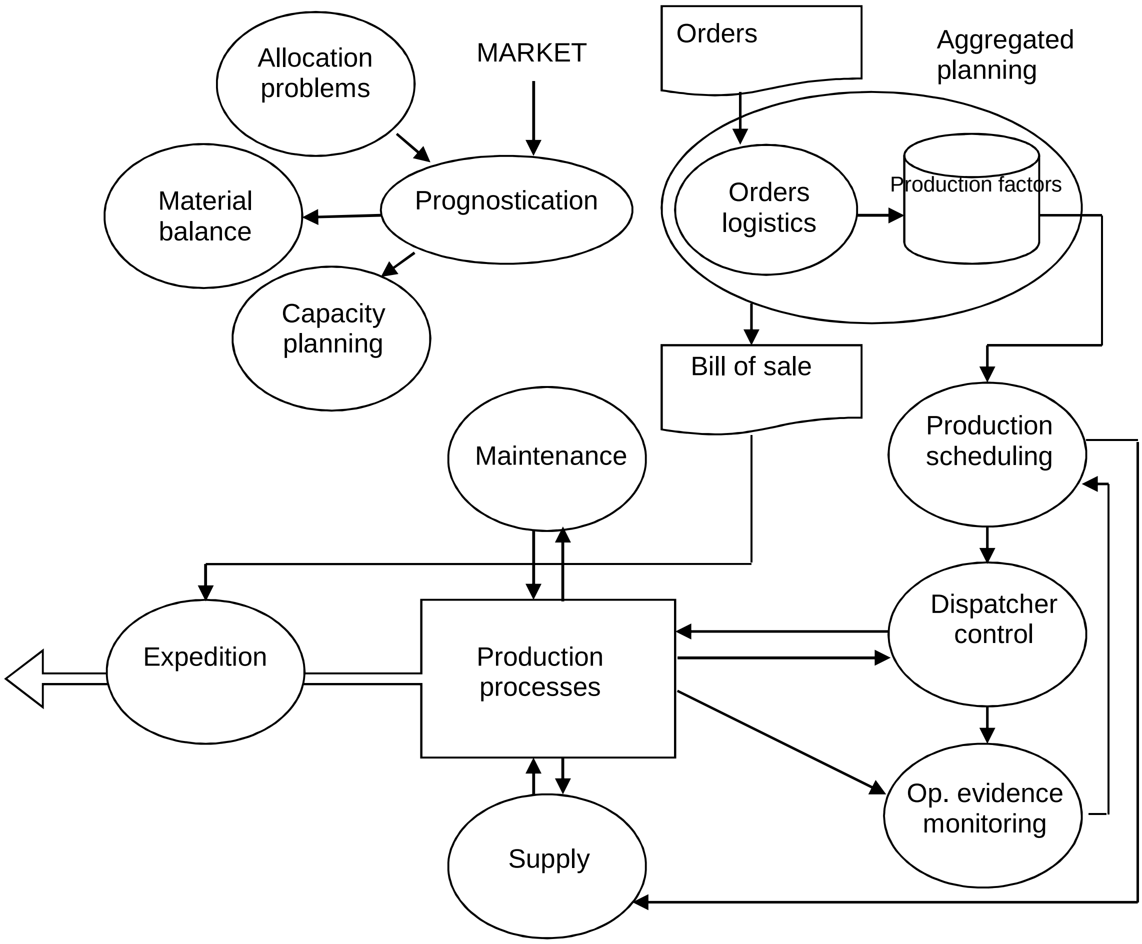

Fig.1 *Production logistics activities structure* [2]

Relative to the segmentation of production logistics processes, it is useful to find some suitable evaluation metric that is able to absorb themselves in the overall heterogeneity of the fundamental aspects of the process.

3 PROBABILISTIC MODELS FOR ASSESSING THE ADEQUACY OF LOGISTICS SOLUTIONS

In production logistics processes it is frequently needed for the various production sites to carry out logistical decision constituting an increased risk of adverse costs. This risk is compounded; moreover, they are referred to decisions made within time constraints. Based on our proposed algorithm in such cases it carries logistical assistance. This is a group of professionals knowledgeable problem designed to assist in the implementation of logistics decision. Assistance consists of the ex-ante stage, namely the part where real-time assistants at the information available, carried out by experts assess the current logistics process in real time using an estimate of total logistics costs by one of the possible alternatives of development. Another part is the ex post evaluation when a group of assistants usually after some time again chooses the best alternative of the logistical decisions but not for its improvements, but due to assess the success of individual assessors. Given the nature of the decision is necessary to determine the extent of assistance occupation groups, but also rules, when, who and how to apply assistive group for assistance. Their communication usually provides intranet, and the experience is a welcome anonymity estimates assistants.

Assigned trained personnel manage and provide assistance in company. Various departments of the companies is planning and implementing logistics decisions, where is an increased risk of adverse costs (based on a subjective estimate of risk), request the assistance on assistance group (so-called professional assistance) or the decision do the department authorized manager without assistance, in terms that assistance assessment ex post may require his superior, irrespective of whether the decision was made ex ante assistance.

The request for assistance except of description of the existing situation determines bookers (in their opinion) the best solution, respectively the best alternative, but in estimating the shape analysis estimates the expected costs associated with the selection of each of the available alternatives. Department responsible person becomes a valid member of the Assistance mind relationship expert assessment of the same status as any judge. Members of the Assistance Group based on present application, respectively after consultation and possible subsequent visit to the terrain, determine an estimate of the expected logistics costs associated with the selection of particular decision alternatives. Based on this data using the method of expert assessment, authorized member of the Assistance Group shall draw up a specific date the draft decision, i.e. realizes assistance. The decision is taken by charge manager.

A critical factor for such a management system and assists is the ensuring of continuous assessment of the risks of potentially dangerous logistical decisions by providing services. To avoid underestimated, but neither costly revaluation of the estimated risk of adverse cost model was developed probabilistic risk assessment by expert assessment of adverse logistics costs.

4 EXPERT ESTIMATION OF LOGISTIC PROCESSES PERFORMANCE

There are plenty of models for an assessment of expert judgments. The most common methods are based on the performance weights which are increasingly applied in practice. Experience suggests their greater precision with regard to traditional methods of expert evaluation.

The main goal of these methods is to make a foundation for reaching a rational consensus. In the presented article we will show an example of actual usage of the given method for the verification of a probabilistic model for the assessment of adequacy of logistics assistance service in a large metallurgical complex.

The underlying principle of Cook's method of weighing based on efficiency consists in the fact that the weights used in the combination of distributions of expert judgments are selected by the so-called expert efficiency. It is a numerical assessment of their ability to answer the so-called calibration questions, i.e. the answers to the questions that are known only to the assessors, not to the experts [6].

The inputs for determination of efficiency weights are quantile estimates of experts on requested variability, whereas both the variability of unknown variables and the calibration variability are assessed. Calibration variability is a variability of deviation of estimates from the actual values of the variable, which are known to the assessor (post hoc). The expert estimates are weighted based on their calibration ability and the informativeness of their estimation. Consequently, these values meet the given conditions with an asymptotic strictness. That means that an expert reaches a maximal expected weight in a longer period of assessment, if the estimates long-lastingly correspond to the actual values. The result of evaluation by such system of weighing is subsequently processed by the examiner. The acquired estimation is weighted with respect to calibration and informativeness of the estimation. The examiner determines the so-called inherent range, i.e. the lower and upper bound that is usable for a good approximation of the distribution of an analyzed quantity [3, 4, 6].

4.1 CALIBRATION AND INFORMATIVENESS

The quality of an expert's calibration can be measured based on the differences between the empirical distribution of calibrating variable and the distribution determined by the expert, thus the calibration is a probabilistic characteristic of statistical hypotheses tests that are defined for each expert. Realizations can be understood as independent samples from a distribution corresponding to the quantiles estimated by an expert [6].

The assessor prioritizes those experts, whose statistical hypotheses correspond to the data acquired from an empirical estimation of the distribution of calibrating variable.

Let's assume that we observe a set of N calibrating variables, such as s_1N realizations are from the interval 0-5%, s_2N realizations are from the interval 5-50% etc. Then the empirical density has a form $(s_1,...,s_4)$ and we want to measure its proximity to the hypothetical density $(p_1,...,p_4)$ = (0,05;0,45;0,45;0,05). The way how to measure this proximity is offered by the so-called relative information with respect to p given by the formula:

$$I(s;p)=\sum_{1}^{4} s_i \log\left(\frac{s_i}{p_i}\right) \tag{1}$$

It is a non-negative value that reaches its minimum, i.e. 0 if $s = p$. A good expert should have his empirical density $(s_1,...,s_4)$ close to $(p_1,...,p_4)$ and his relative information should be close to 0. It is a well known fact that for a large N, the distribution of relative information (with the size of $2N$) is well approximated by a χ-square distribution with three degrees of freedom

$$P(2N\, I(s,p) \le x) \approx \chi_3^2(x), \tag{2}$$

where χ_3^2 is a distribution function of a χ-square distribution with three degrees of freedom. The calibration of an expert e is defined as the probability of giving (acquiring) worse information (greater or equal) than they actually acquired information providing that the expert distribution is (p_1,...,p_4). Thus

$$C(e) = 1 - \chi_3^2\ (2N\, I(s, p)), \tag{3}$$

the empirical density *s* equal to the hypothetical density *p* gives us the best possible calibration, which is equal to 1. Informativeness is assessed considering each variable and each expert by the calculation of relative information of an expert's density for this variable with respect to the primary measurement. Inherent range is acquired by adding *k*%, i.e. by increasing the smallest interval containing all quantiles and realizations. *k* is generally determined by the assessor (the most common value is *k* = 10%). Densities of distribution are connected with the assessments of each expert for every requested variable as follows:

– densities correspond to the expert quantile estimates,
– densities are minimally informative with respect to the basis of measurement given by the quantile boundaries.

If the primary measurement is uniform, it means that an expert interpolating distribution with respect to the inquired question is uniform between 0-5% and 5-50%, etc. Relative information of an expert e for a given requested variable is

$$I(e) = \sum_{i=1}^{4} p_i \log\left(\frac{p_i}{r_i}\right), \tag{4}$$

where *p* = (0,05;0,45;0,45;0,05) is the expert probability and values r_i are the primary measurements of corresponding intervals. The general informativeness of each expert is a mean of all the information over all the variables. This mean is proportional with respect to the relative information with expert continuous distribution over all the variables considering the fact that these variables are independent.

4.2 DETERMINATION OF WEIGHTS

For determination of a weight that is based on the efficiency of each individual expert, the information about his informativeness and calibration will be used [6].
When enumerating the above-mentioned weights, the examiner will set a definite basic success level α. Each expert, whose calibration will be lower than the α level, will automatically be assigned the weight of 0. Weighing rule R for determining an unknown variable that reaches values 1,....,*n* is a function in a form of *R*(*p*,*i*) for a probabilistic prediction *p* during the realization of *i*. The expected value for the subjective probability *p*, when an expert believes that the actual value has a distribution of *q*, is *Eq R*(*p/i*) = *R*(*p,i*). We say that the evaluation rule is suitable, if for every *p* and *q*, there is one maximized *Eq R*(*p/i*) and *q* = *p*. That means that if there is used a suitable evaluating rule, an expert minimizes his weight by determining a probability that he believes is right.

An example of such a suitable evaluation rule is *R*(*q,i*) = *log* q_i. Then the expected value assigned to the subjective probability *p* is $\sum_i p_i \log(q_i)$, which is known as the relative information. In the model we will use more than one calibrating quantity. Thus the generalization of an idea of a suitable evaluation rule is used in a way that gives us an assessment based on a group of estimations and realizations. Supposing that an expert believes that a set *M* of unknown values X_1,....,X_m reaches values 1,.....,*n* and has a Q distribution. Expected relative frequency of the result i is

$$q_i = E\frac{\#\{X_j = i\}}{m} = \frac{1}{m}E\left(\sum_j 1_{X_j = i}\right) = \frac{1}{m}\sum_j Q(X_j = i). \tag{5}$$

Supposing that we have the evaluation rule *R(p, M, s)*. If the expert determines the expected relative results with frequency *p* in the set of *M* variables, whereas the observational relative output frequency is *s*, then the result expected by the expert is

$$E_Q(R(p,M,s)). \tag{6}$$

4.3 APPROXIMATION OF EXPERT DISTRIBUTIONS

During model implementation we ask experts to determine the number of border quantiles (usually 5%, 50% and 95%) for any desired variable. The evaluator will decide the scale for each variable (logarithmic or uniform).

If we use logarithmic scale, then the quantiles must be logarithmed before use. Otherwise, we proceed similar as with uniform distribution within demanded variable. In the following we assume that the scale is uniform.

Since we have 5%, 50% and 95% quantiles, we must interpolate the rest of the distribution for each queried variable. Let q_i(e) is *I* % fractile of expert *e*. Indoor range is obtained as follows *k* % excess rate. Firstly, we find the maximum and minimum values based on relationships

$$l = \min\{q_5(e), r|e\},\ h = \max\{q_{95}(e), r|e\}, \tag{7}$$

where *r* is a value of realisation. Then

$$q_l = l - 0{,}1 \text{ x } [h\text{-}l] \tag{8}$$
$$q_h = h + 0{,}1 \text{ x } [h\text{-}l].$$

Natural (own) range is $[q_i, q_h]$. Distribution function of the expert *e* is then obtained by approximating using linear interpolation quantile information (q_i, 0), (q_5; 0,5), (q_{50}; 0,5) (q_{95}; 0,95), (q_h, 1). It is a distribution with minimal information regarding the uniform distribution of the natural range, which corporate all experts quantiles (Fig. 2).

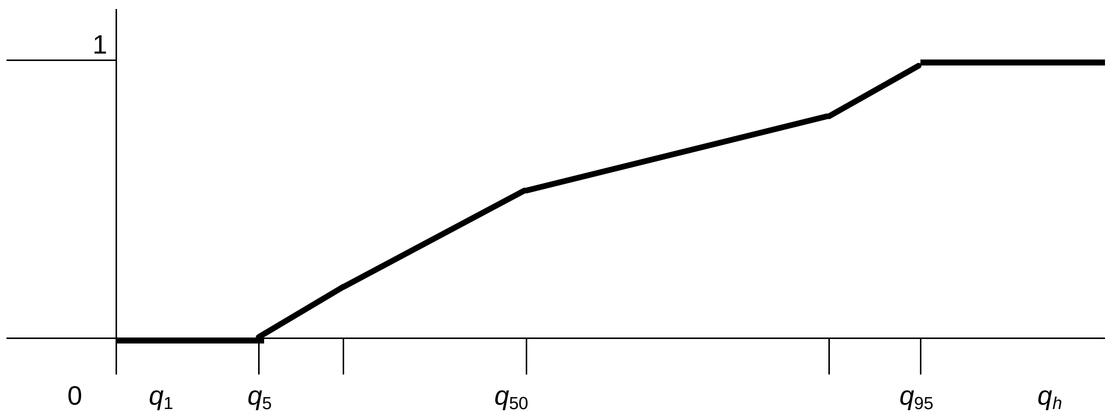

Fig. 2 *Expert quantiles interpretation*

Although the previous method of interpolation expert quantile is executed for any range, in general it makes relatively little difference between the weights that are assigned to experts. This difference came out of the calibration, which usually manages the assignment of weights, depends only on the quantile and not on interpolation. Informativeness depends only on quantile and the choice of q_l a q_h. However, the interpolation makes a difference in the combined - an overall assessment, therefore, to estimate the distribution of the distribution of all experts, called combined expert. Therefore it affects the threshold level for all scales.

Previous procedure determined the distribution function $F_e(t)$ for each expert and each queried variable. An instrument experts W_e combined distribution function has the form

$$\sum_e w_e F_e(t)\ . \tag{9}$$

4.4 CALCULATION OF THE EVALUATOR DISTRIBUTION

Now we have all the elements needed to determine the output distribution of the demanded quantity. Calibration and informativeness are determined for each expert. In order to determine the instrument we choose the threshold of success α. For each choice of threshold the weights are changed (weight is dependent on α because for higher values of α is eliminated more experts, more weights are concentrated on the remaining experts). Therefore, also "combined" expert of combining other experts, also depends on α.

For combined expert, we can also calculate the 5%, 50% and 95% quantiles and hence the calibration and informativeness. The model then we α choice with respect to the weight of the expert in such a way that combined expert should be given to a group of experts.

6 CONCLUSIONS

We can perform logistical assistance in real time by implementation the method of expert assessment. Individual alternatives as the results of decision-making processes within the logistics group valued assistance in such a way that estimates the expected logistics costs for each of the alternatives. Alternative with minimal logistical costs is then recommended as a result of the decision. By ex post analysis we obtain results in almost complete availability of information (usually after some time) to consider the treatment as a guide. Applying for individual evaluators, i.e. assistants to questions with known calibration of the cost determined by consensus within the ex post analysis. With these issues in the long time we determine the individual informativeness and assistant calibration on which assign different weights in accordance with the methodology described in the previous section.

Wrong decision in the logistics process usually entails a number of costs both visible and hidden. The described approach which uses Logistics assistance proposes to continuously monitor the real-world performance of all logistics processes and threads, in addition to creating conditions for improving the performance of logistics processes. Ex post analysis of the logistics processes realized long time ago permit on a case to case uncover various inaccuracies, errors, and also the early decisions leading of unnecessary logistics costs. It describes the way of using the expert assessment of the rational decision-making in uncertainty creates the basic prerequisites for a possible ongoing continuous improvement of logistics processes.

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