Economic and Organizational Problem Research
Accompanying the Processes of Replacing Labor Resources in the Condition of Incomplete Information

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Abstract. One of the most characteristic features of modern theory and practice of production is a systematic approach used in considering a wide variety of economic and organizational problems. To a large extent, this relates to optimization problems and this is the reason why a number of authors single out the principle of optimization among the principles of the system approach. The article deals with the cost optimization for the reservation of labor resources and provides an algorithm for finding the costs of reservation.

1. Introduction
The system approach does not exclude the study of optimization problems at the local level, in a separate production unit that is part of a complex system. It should be noted that, in accordance with the principle of dual consideration, not a single production element (link, site, enterprise) is an isolated object, as it is included in the higher-level economic system. In models of complex systems, sufficiently integrable subsystems with given properties and relations between them should be considered as initial elements. Without taking into account the correlation of the system elements, local optimization results may not only be inconsistent with global extremum, but even contradict it. Therefore, the study of the system technological features and its production structure plays an important role in the system approach. Their description allows us to clarify the qualitative relationships that unite the individual links in the system, and also characterize them with the help of some quantitative relationships.

Among the problems in the study of which the principles of systemacy play a decisive role are the problems of cost optimization on creating and using labor reserves in economic systems of various levels. You can consider the principle of reservation as one of the laws of production organization, aptly noting that the labor reserves objectively exist regardless of whether they were planned to be created in advance or not.

2. Cost Optimization For The Reservation Of Labor Resources With Account For Fines
Optimization tasks for redundancy, as a rule, are quite complex, the reason for which is the fact that system accounting objectively complicates the mathematical models of production systems and
complicates their study with the usual analytical methods. At the same time, the intuitive approach often does not allow even develop an indicative costing strategy associated with the production reservation.

The object of our research is the labor resources of the production site (Figure 1), in which the processing processes are carried out (links A and B), as well as the assembly process (link C).

![Figure 1. The structure of the site with duplication](image)

In the figure, horizontal arrows indicate the progress of the technological process of labor resources production; \( S_i \) denotes the cost of production at the exit of the I system link; \( Z_i \) is the cost created in the i link; \( u_i \) is the option of using labor resources by the i link; \( O_i \) is the average delay time with the delivery of planned production by the i link to its consumer \( i + 1 \) link; \( \eta_i \) is the inherent instability of the i link; \( W(S_i, O_i) \) is the amount of losses from the instability of the system.

While the cost optimization of labor resource reservation in the considering site, the following circumstances should be taken into account: for link C, in which, in addition to generating new value, costs are accumulated created in supply chains that receive separate semi-finished products from links A and B. In link C, unequal cost of labor resources for the manufacture of output product by sections A and B; non-delivery of a semifinished product manufactured by one of the links A or B may cause a delay in the formation of an assembly kit, the cost of which is higher than the cost of this semifinished product.

### 3. Optimization Of Costs For The Labor Resources Reservation

To simplify further reasoning, we will assume that each of the links A and B produces only one type of semi-finished product, and the output of these semi-finished products is carried out with the same workforce intensity for different links.

Combining the planned moments of production, we introduce into consideration the statistical characteristics of the production process. Let \( g(t) \) denote the specific output intensity function: \( g(t) = 1/V_0 * dv/dt = const \). In this case, it is meant that the function \( g(t) \) is defined only on the time interval when production is carried out. Define a number of distribution functions of random variables: \( F_1(t), F_2(t), F_3(t) \) are the proportion of the planned tasks for the semi-finished products manufacturing and the formation of assembly sets made by links A, B, C respectively, to the time \( t \). \( R_1(t), R_2(t), R_3(t) \) are the probabilities of the start of semi-finished products and assembly sets manufacturing by A, B и C links by the time \( t \). Let \( f_1(t), f_2(t), f_3(t), r_1(t), r_2(t) \) denote the distribution density of the corresponding random variables.

Therefore, the equation is

\[
R_3(t) = R_1(t) * R_2(t)
\]  

(1)

after differentiation we get
\[ r_i(t) = r_i(t)R_i(t) + r_2(t)R_2(t) \]  

We now determine the form of the functions \( f_i(t), i = 1 + 3 \). To do this, we fix some time point \( t \) and give it an increment \( \Delta t \). The proportion of the planned task, completed over a period of time \( \Delta t \), is \( F_i(t^* \Delta t) - F_i(t) \). It is obvious that if products are manufactured by labor resources in the time interval \([t, t^* \Delta t]\), then the process of its implementation began no earlier than \( t - 1/g \) and no later than \( t + \Delta t \). We calculate the probability \( (p_i) \) of the fact that the semi-finished products or sets manufacturing (depending on the considered function \( F_i \)) is carried out from the moment \( t \) to \( t + \Delta t \).

The required probability \( P_i \) can be calculated by the formula:

\[
P_i = \lim_{\Delta t \to 0} \frac{\Delta F}{\Delta t} = g \int_0^{\frac{1}{g}} r_i(t - \tau) d\tau.
\]

Thus, the proportion of the planned task, released for the period \( \Delta t \), will be: \( F_i(t + \Delta t) - F_i(t) = g\Delta t P_i \).

Now you can determine the form of the function \( f_i(t) \):

\[
f_i(t) = \lim_{\Delta t \to 0} \frac{\Delta F}{\Delta t} = g \int_0^{\frac{1}{g}} r_i(t - \tau) d\tau.
\]

Taking into account the relation (2) we get

\[
f_0(t) = g \int_0^{\frac{1}{g}} r_0(t - \tau) d\tau = g \int_0^{\frac{1}{g}} [r_1(t - \tau)R_1(t - \tau) + r_2(t - \tau)R_2(t - \tau)] d\tau.
\]

Integrating in parts:

\[
f_0(t) = \int_0^{\frac{1}{g}} r_1(t - \tau)R_1(t - \tau) d\tau + \int_0^{\frac{1}{g}} r_2(t - \tau)R_2(t - \tau) d\tau = R_1(t)R_2(t) - R_1(t - g)R_2(t - g).
\]

The average time lag of production output of labor resources relative to the planned dates can be found by the formula \( \theta \int_{t_0}^{\infty} (t - t_0)f_0(t) dt \) or the equation is

\[
\theta = \int_{t_0}^{\infty} (t - t_0)f_0(t) dt = g \int_{t_0}^{\infty} [R_1(t)R_2(t) - R_1(t - g)R_2(t - g)]
\]

where \( \theta \) is the set delay time.

Similarly, we find the average times of semi-finished products undersupply by links A and B:

\[
\theta_A = g \int_{t_0}^{\infty} r_1(t - \tau) d\tau dt = g \int_{t_0}^{\infty} [R_1(t) - R_1(t - g)] dt
\]

\[
\theta_B = g \int_{t_0}^{\infty} r_2(t - \tau) d\tau dt = g \int_{t_0}^{\infty} [R_2(t) - R_2(t - g)] dt
\]

The formulas obtained for finding the quantities \( \theta, \theta_A, \theta_B \) are directly related to finding the penalty coefficients to determine the damage caused by the short supply of products by the A and B links, because for link C, the initial production is assembly kits, the set of links A and B can be considered as a single production, busy with their output. Then, we have:

\[
S_{01}\theta_{01} + S_{02}\theta_{02} = (S_{01} + S_{02} + Z_A + Z_B)\theta
\]
Obviously, the penalty for late delivery of assembly kits to link C must be distributed between suppliers A and B. Therefore, the balance ratio is satisfied

\[ \beta(S_{01} + S_{02} + Z_A + Z_B)\theta - \beta_A(S_{01} + Z_A)\theta_A + \beta_B(S_{02} + Z_B)\theta_B \]  

\[ \beta, \beta_A, \beta_B \] are the corresponding penalty coefficients.

If the values of \( \theta_{01} \) and \( \theta_{02} \) are known in advance, then the penalty coefficients \( \beta_A \) and \( \beta_B \) can be determined from the equations

\[ \begin{align*}
\beta_A(S_{01} + Z_A)\theta_A &= \beta S_{01}\theta_{01} \\
\beta_B(S_{02} + Z_B)\theta_B &= \beta S_{02}\theta_{02}
\end{align*} \]  

(6)

The values of \( \beta_A \) and \( \beta_B \) found from the solution of system (6) will obviously satisfy relations (4) and (5).

Thus, to find the coefficients \( \beta_A \) and \( \beta_B \), it is necessary to know the average delay times with the supply of component parts of the semi-finished products \( \theta_A \) and \( \theta_B \), to be able to calculate the corresponding costs \( Z_A \) and \( Z_B \).

4. Conclusions

A series of numerical experiments showed that if the labour resources cost of link A is higher than the labour resources cost used by link B, then in some important cases the values ratio of \( \beta_A \) and \( \beta_B \) is significantly greater than one. At the same time, the cost is less than the reciprocal of the value relation \( S_{01} + Z_A \) \( S_{02} + Z_B \). It should be noted that the functions connecting the quantities \( \theta_A \) and \( Z_A \), \( \theta_B \) and \( Z_B \), satisfy the condition of constant elasticity of substitution. This condition allows determining the total costs \( Z_A + Z_B \) from the values of \( \theta_A \) and \( \theta_A \).

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