II. LABOR POTENTIAL: FORMATION, DEVELOPMENT, USING

VALUATION OF LABOR LOSSES

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Summary. The article proposes an economic-mathematical model for determining lost profits for the regional economic system, associated with the premature losses of the average statistical demographic element. Unlike previous works, this work takes into account the real distribution of the density of demographic elements by ages. This approach can significantly improve the accuracy of taking into account the age factor and demographic dynamics, when calculating the valuation of labor losses. Numerical calculations are carried out on the example of the Udmurt Republic.
Keywords: labor potential; economic losses; lost profits of the region.

In practice, we encounter the problem of economic evaluation of the cost of living quite often [1–2, 4–5]. In particular, the need for such an analysis arises when it is necessary to determine the economic losses from premature mortality of the working-age population.

We estimate the loss of profit from the state associated with the loss of the demographic element. By loss of profit for the economic system of a region, we mean the economic potential of the average worker, unrealized due to his premature death, minus the estimated subsequent wages, as well as the estimated subsequent payments and benefits from public consumption funds.

Consider the amounts laid $B_N(t)$ down in the regional budget for a particular article N, which in the corresponding periods of a person's life we will evenly distribute by the number of demographic units in these periods. As a result, we obtain the distribution of specific total budget expenditures by age:

Consider the amounts $B_N(t)$, laid down in the regional budget for a particular article N, which in the corresponding periods of a person's $[\tau_{1N}, \tau_{2N}]$ will be distributed evenly by the number of demographic units in these periods. As a result, we obtain the distribution of specific total budget expenditures by age $q(t, \tau)$.

$$q(t,\tau)=\sum_N \frac{B_N(t,\tau)}{\int\limits_{\tau_{1N}}^{\tau_{2N}} \rho(t,\tau)d\tau}, \qquad B_N(t,\tau)=\begin{cases} B_N(t), & \tau\in[\tau_{1N},\tau_{2N}], \\ 0, & \tau\notin[\tau_{1N},\tau_{2N}]. \end{cases} \tag{1}$$

At formula (1) $\rho(t,\tau)-$ distribution function of population density by age τ per year t.

The lost profit of the regional economic system associated with the loss of a non-statistical demographic element at an age in time, taking into account the probabilistic nature of the survival of demographic units, can be determined by the formula:

$$u(t,\tau)=\frac{1}{1-\mu(t,\tau)}\int_{\tau}^{\tau_m}[1-\mu(t,\xi)]\{\varepsilon(t,\xi)k(t,\xi)-q(t,\xi)\}d\xi. \tag{2}$$

Here $\mu(t,\tau)-$ is the function of the power of mortality (accept $\mu(t,0)=0$); τ_m – maximum period of human life; $\varepsilon(t,\tau)-$ share of demographic elements of the age τ, participating in social production per year t.

At formula (2) there is an expression $k(t,\xi)=\left[\overline{w}(t)f_w(t,\xi)-\overline{g}(t)f_g(t,\xi)\right]$, the construction of which is possible as follows. Construct a vector-function $\varphi(t,\tau)=\{y(t,\tau), g(t,\tau), w(t,\tau)\}$, the components of which are the functions of the specific labor productivity, unit wage, and surplus product produced by one average worker of age τ per year t. These functions are highly dependent on age.

The average values of the corresponding values for the maximum period of a person's life τ_m are determined by the formula:

$$\overline{\varphi}(t)=\frac{1}{\tau_m}\int_0^{\tau_m}\varphi(t,\tau)d\tau, \qquad \overline{\varphi}(t)=\{\overline{y}(t), \overline{g}(t), \overline{w}(t)\}. \tag{3}$$

Let $f_\varphi(t,\tau)$ – the normalized distribution scales of the functions under consideration $\varphi(t,\tau)=\{y(t,\tau), g(t,\tau), w(t,\tau)\}$ constructed from statistical data. Then we can write:

$$\frac{1}{\tau_m}\int_0^{\tau_m} f_\varphi(t,\tau)d\tau=1, \quad \varphi(t,\tau)=f_\varphi(t,\tau)\overline{\varphi}(t). \tag{4}$$

As a result, we get

$$\Phi(t)=\int_0^{\tau_m}\varphi(t,\tau)\varepsilon_\varphi(t,\tau)\rho(t,\tau)d\tau=\overline{\varphi}(t)\int_0^{\tau_m} f_\varphi(t,\tau)\varepsilon_\varphi(t,\tau)\rho(t,\tau)d\tau, \tag{5}$$

$$\overline{\varphi}(t)=\frac{\Phi(t)}{\int\limits_0^{\tau_m} f_\varphi(t,\tau)\varepsilon_\varphi(t,\tau)\rho(t,\tau)d\tau}, \qquad \Phi(t)=\{Y(t), G(t), W(t)\}. \tag{6}$$

The components of the vector-function $\Phi(t)$ are the total annual volumes of the gross regional product (GRP), wages and surplus product, respectively; $\varepsilon_\varphi(t,\tau)-$ the proportion of demographic elements of age τ participating in the

formation of the corresponding indicator $\overline{\varphi}(t)$ or $\Phi(t)$ per year t. In our case $\varepsilon_y(t,\tau)=\varepsilon_g(t,\tau)=\varepsilon_w(t,\tau)=\varepsilon(t,\tau)$.

The surplus product, produced by all employees per year t is equal to:

$$W(t)=\int_0^{\tau_m} w(t,\tau)\varepsilon(t,\tau)\rho(t,\tau)d\tau=\overline{w}(t)\int_0^{\tau_m} f_w(t,\tau)\varepsilon(t,\tau)\rho(t,\tau)d\tau. \quad (7)$$

On the other hand, the entire annual volume of surplus product is equal to GRP minus depreciation of fixed assets $K(t)$. Therefore, you can write:

$$W(t)=Y(t)-\eta K(t), \quad (8)$$

where $\eta-$ is the depreciation rate.

Then the formula for calculating the average surplus product produced by one average employee of an age τ per year t has the form:

$$\overline{w}(t)=\frac{Y(t)-\eta K(t)}{\int_0^{\tau_m} f_w(t,\tau)\varepsilon(t,\tau)\rho(t,\tau)d\tau}. \quad (9)$$

The average unit salary of an average employee per year t of age τ is calculated by the formula:

$$\overline{g}(t)=\frac{G(t)}{\int_0^{\tau_m} f_g(t,\tau)\varepsilon(t,\tau)\rho(t,\tau)d\tau}. \quad (10)$$

Thus, in accordance with formula (2), the lost profit of the regional economic system associated with the loss of a medium-non-statistical demographic element at a time t in age τ can be calculated.

The lost profit $u_\mu(t,\tau)$ from premature annual losses per year t of all demographic units of age τ is determined from the expression:

$$u_\mu(t,\tau)=u(t,\tau)\mu(t,\tau)\rho(t,\tau). \quad (11)$$

Then the total loss of profits associated with the annual mortality of the population before age τ, can be found by the formula:

$$U_\mu(t,\tau)=\int_0^{\tau} u_\mu(t,\xi)d\xi. \quad (12)$$

In fig. 1 is a graph of lost profits, calculated in rubles per one human, for the Udmurt Republic (UR) during the retirement of the demographic element in age, constructed according to statistical data [3]. As can be seen from the graph, the maximum lost profit is achieved with the loss of a demographic unit at the age $\tau=22$ year. A characteristic point on the chart is the point $\tau=56\div57$ years. Starting from this age, the unit costs of the state, together with the salary of the average worker in the coming period of his life, begin to surpass the surplus product he created in the same period.

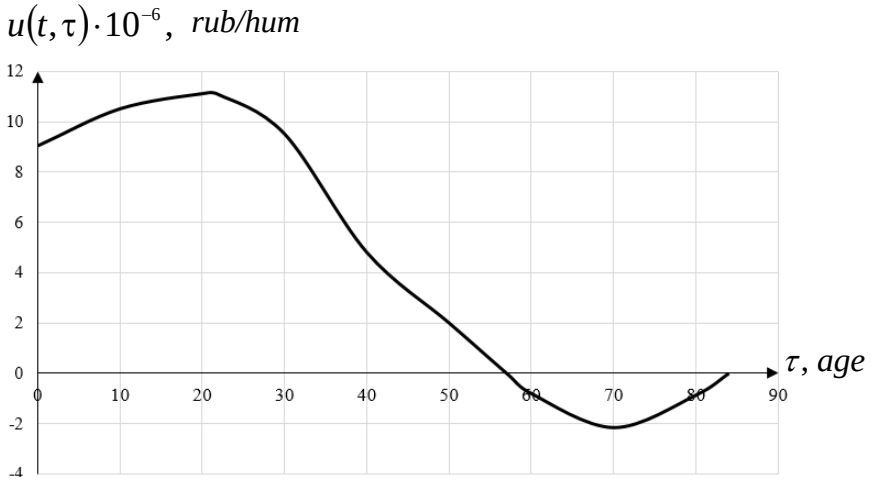

Fig. 1. **Loss of profit for the economy of UR on disposal demographic element in age τ at the time $t = 2018$ year**

Here is an estimate of the total loss of profits associated with the annual mortality of the population before age for the UR region. The graph of the corresponding dependence is presented in Fig. 2. Calculations are carried out in rubles per year.

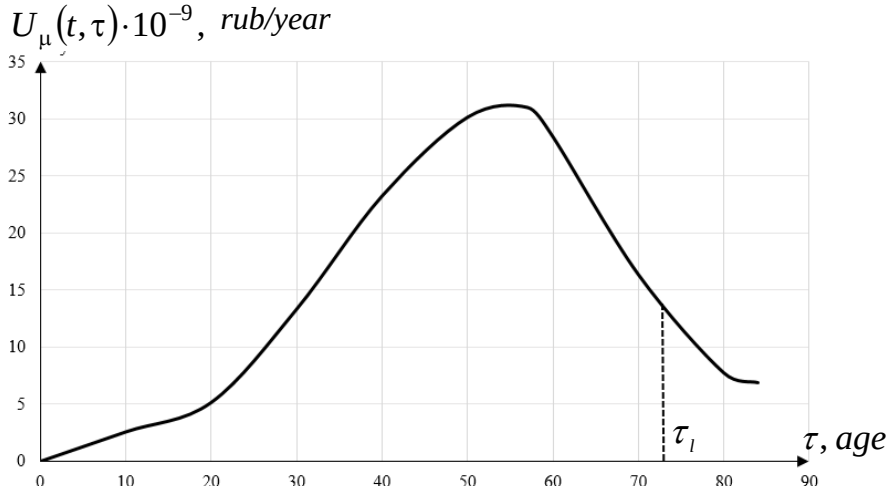

Fig. 2. **Total loss of profit for the economy of UR from loss demographic units before age τ at time point $t = 2018$ year**

Calculations show that the total loss of profits from premature loss of demographic elements up to the age defined as the average life expectancy (τ_l), which turned out to be 73 years in 2018, is 2.3% of the GRP of the Udmurt Republic. The maximum total loss of profits from the premature loss of demographic elements takes place by the age $\tau = 56 \div 57$ year and amounts to 5.2%.

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