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Construction of the Dynamic Input – Output Model of Russian Economy with a Human Capital Block and Problems of Its Information Support

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HUMAN CAPITAL: A COMPLICATED CATEGORY

VERSION OF DEFINITION: HUMAN CAPITAL IS AN AMOUNT OF ACCUMULATED KNOWLEDGE AND SKILLS OF THE POPULATION OF A GIVEN COUNTRY, TAKING INTO ACCOUNT THE STATE OF ITS HEALTH.

- Level of education
- Level of population health
- Level of culture
- Level of science
- etc

The *basic idea* of building a block of human capital in a dynamic interindustry model is to model the reproduction of human capital by analogy with the reproduction of fixed capital.

1. Investments in human capital - the costs of education, health care, culture, social expenditures.
2. The human capital put in service is estimated as cost of human capital (students of colleges and universities) who graduated from colleges and universities.
3. The depreciation of human capital is estimated - physical and moral.
4. It's necessary to include human capital in national wealth.

Important parameters of the extended model

I. **Human capital investment:**
   - ✓ Education expenses
   - ✓ Healthcare expenses
   - ✓ Culture expenses
   - ✓ Social expenditures
II. **Human capital put in service**
III. **“Incomplete construction” of human capital - people remaining in the education or medical treatment process.**

Publications

- Zhang H., Chen X.

An Extended Input–Output Model on Education and the Shortfall of Human Capital in China // Economic Systems Research. 2008. - Vol. 20, No. 2. pp. 205-221.

- Chen X., Guo J.E., and Yang C.

Chinese Economic Development and Input-Output Extension // International Journal of Applied Economics and Econometrics. 2004. - Vol. 12, No. 1. pp. 43-88.

Base model

Pavlov V.N., Baranov A.O.

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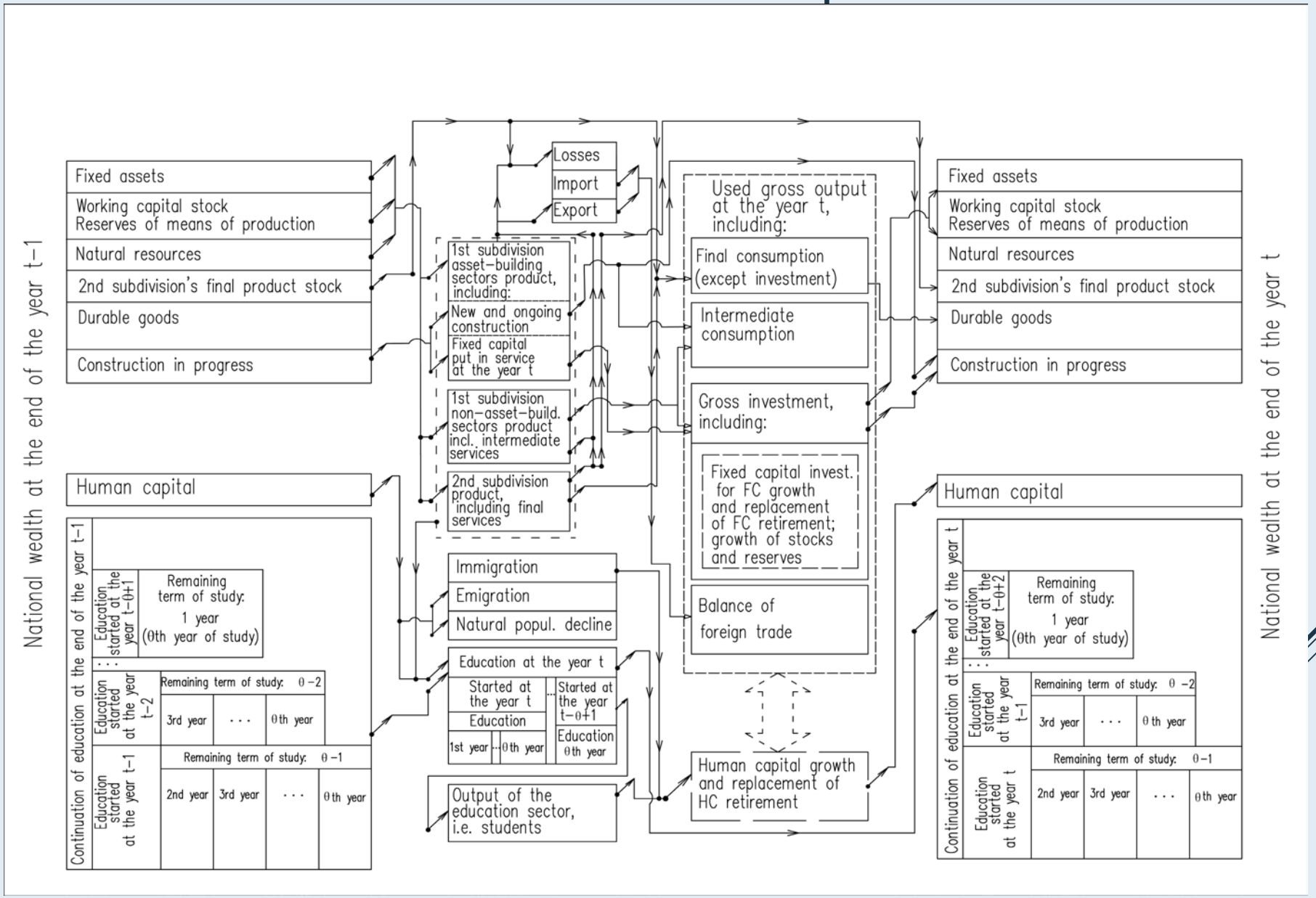
Extended DIOM with a human capital block

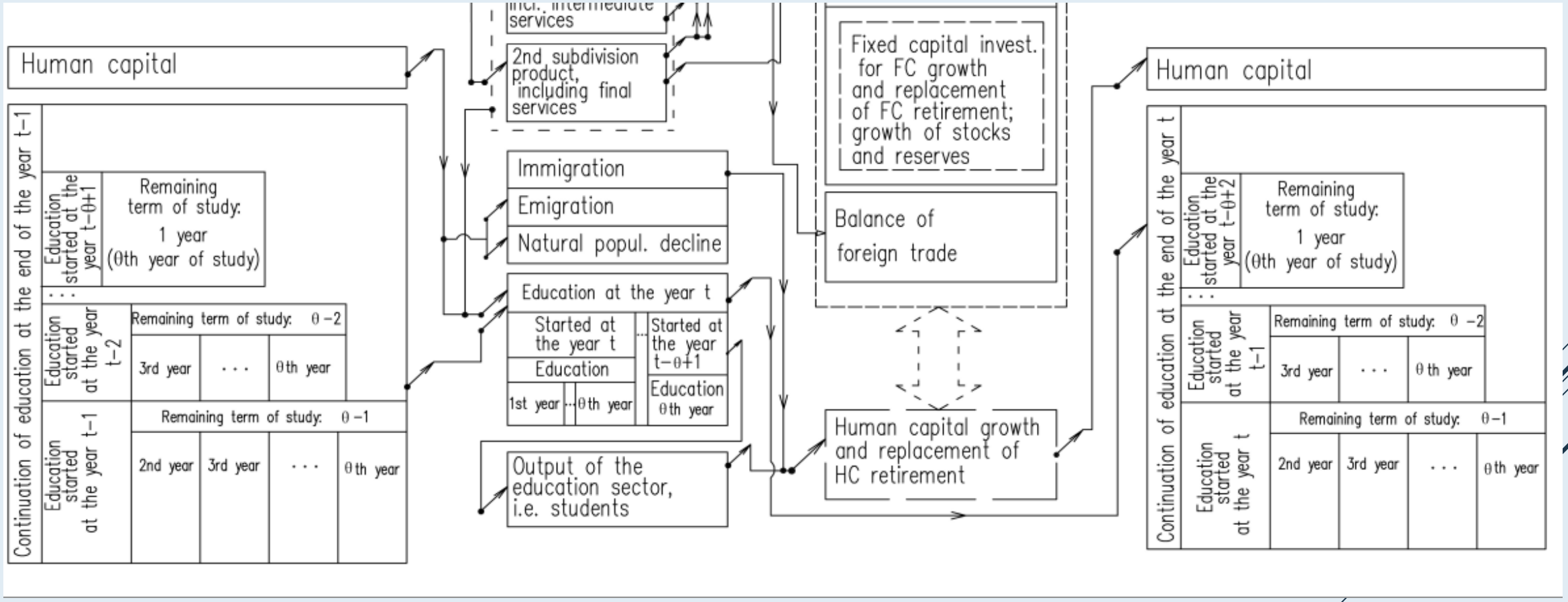
Baranov A.O., Pavlov V.N., Slepenkova Yu. M.

Construction of a dynamic input-output model with a human capital block // World of Economics and Management, 2017, vol. 17, no. 1, p. 14-25. (In Russian).

Scheme of National wealth reproduction



National wealth reproduction: human capital block



The model includes **n** sectors. Among them:

1 ≤ j ≤ k can be defined as asset-building sectors,

k < j ≤ Ĩ as sectors which produce human capital,

Ĩ < j ≤ m as non-asset-building sectors in the first subdivision,

m < j ≤ n as non-asset-building sectors in the second subdivision.

The extended model uses the following parameters:

m = the number of the first division sectors (m<n);

k = the number of asset-building sectors;

Ĩ = the number of human capital investment types;

T = years of the forecast period;

$\widetilde{\boldsymbol{\theta}}_{\boldsymbol{ij}}$ = lag of type *i* human capital formation in sector *j*.

New equations of the extended model

Human capital put in service with *i* level of education ($BH_{ij}(t)$) is determined using investment in human capital of a type *i* in the sector *j*:

$$BH_{ij}(t) = \sum_{\tau=0}^{\widetilde{\theta}_{ij}-1} H_{ij}(t-\tau, \boldsymbol{t}) = \sum_{\tau=0}^{\widetilde{\theta}_{ij}-1} \tilde{\eta}_{ij}(\tau) \cdot H_{ij}(t-\tau) \qquad (1),$$

$$i = 1, \dots, \tilde{l}; \;\; j = 1, \dots, n.$$

where $H_{ij}(t-\tau, \boldsymbol{t})$ is a total amount of human capital investment of type *i* invested in $t-\tau$ time period and provided for type *i* human capital which will be put in service at time period *t* in sector *j*;
$\tilde{\eta}_{ij}$ is a share of previous years $(t-\tau)$ investment providing with putting into operation of a human capital of the same type in sector *j* in *t* time period

A necessary **amount of human capital investment** for human capital output in $t+\tau$ time period is defined as follows:

$$H_{ij}(t) = \sum_{\tau=0}^{\widetilde{\theta}_{ij}-1} \tilde{\mu}_{ij}(\tau) \cdot BH_{ij}(t+\tau) \qquad (2),$$

$$i = 1, \dots, \tilde{l}; \;\; j = 1, \dots, n.$$

where *t* is a year of investment and $(t+\tau)$ is a year of students output, as well as "output" of people who underwent a course of medical treatment and can return to work.

I.e. $(t+\tau)$ is a year of human capital output.

$\tilde{\mu}_{ij}(\tau)$ stands for ratio showing a share of human capital put in service in sector *j* in time period $(t+\tau)$ formed due to investment of type *i* in the *t* time period

The extended model

Recurrent equations for re-computing **construction-in-progress human capital** of type i in sector j (i.e. people remaining in the education or medical treatment process) $NH_{ij}(t)$:

$$NH_{ij}(t) = NH_{ij}(t-1) - \sum_{\tau=1}^{\tilde{\theta}_{ij}-1} H_{ij}(t-\tau, \boldsymbol{t}) + \sum_{\tau=1}^{\tilde{\theta}_{ij}-1} H_{ij}(t, \boldsymbol{t}+\boldsymbol{\tau}) = \qquad (3)$$

$$= NH_{ij}(t-1) - \sum_{\tau=1}^{\tilde{\theta}_{ij}-1} \tilde{\eta}_{ij}(\tau) \cdot H_{ij}(t-\tau) + \sum_{\tau=1}^{\tilde{\theta}_{ij}-1} \tilde{\mu}_{ij}(\tau) \cdot BH_{ij}(t+\tau)$$

$$i = 1, \dots, \tilde{l};\ \ j = 1, \dots, n.$$

The extended model

The **total amount of human capital** of type i in a sector j by the end of the t time period((${HC}_{ij}(t)$):

$$\mathrm{HC}_{ij}(t) = BH_{ij}(t) + \mathrm{HC}_i(t-1) \cdot \left(1 - \tilde{k}_{ij}(t)\right) \quad (4),$$

$$i = 1, \ldots, \tilde{l};\ \ j = 1, \ldots, n.$$

where $\tilde{k}_{ij}(t)$ is a replacement rate of human capital of type i in sector j at time t

The extended model: extra constraints

$x_j(t)$ – produced output in sector j at time t;
$h_{ij}(t)$ – human capital-output ratio, with human capital of type *i* (according to the investment type) and total output in sector;
$c_{ij}(t)$ – labor intensiveness ratios of a sector *j* for the type *k* of labor resources in the *t* time period

$c_{kj}(t) = G(HC_{ij}(t))$ depends from the size of human capital

Ω – a trajectory of the economic system development $x_j(t)$;
$f_j(t)$ are weight coefficients of production in sector *j*

$$\sum_{j=1}^{n} h_{ij}(t) \cdot x_j(t) \le HC_i(t) \qquad (5)$$

$$i = 1, \dots, \tilde{l}; \;\; j = 1, \dots, n.$$

$$\sum_{j=1}^{n} c_{kj}(t) \cdot x_j(t) \le L_k(t) \qquad (6)$$

$$k = 1, \dots, l; \;\; j = 1, \dots, n.$$

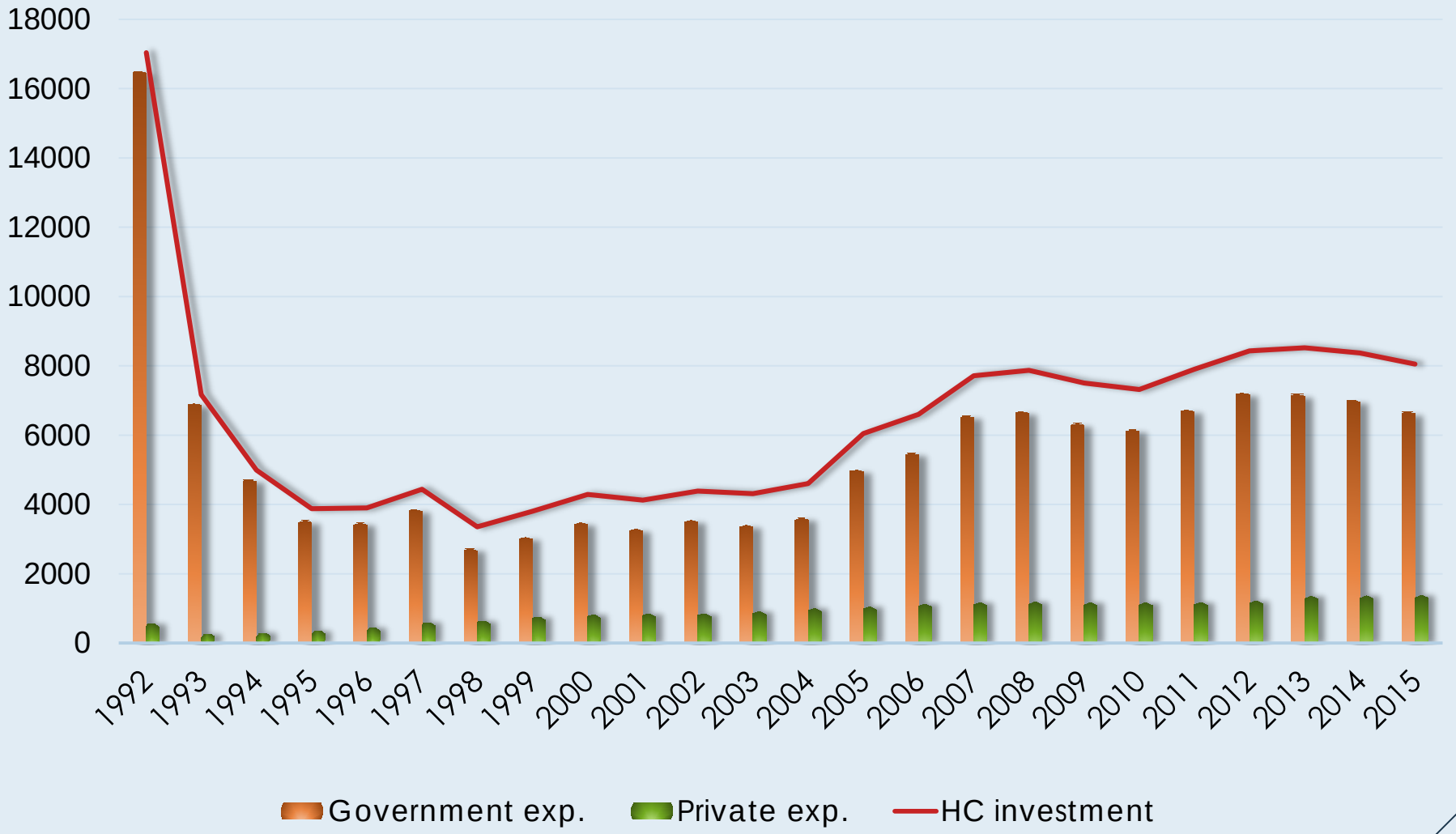
$$\sum_{t=1}^{T} \sum_{j=1}^{n} f_j(t) \cdot x_j(t) \Rightarrow max, \qquad (7)$$

$$x \in \Omega$$

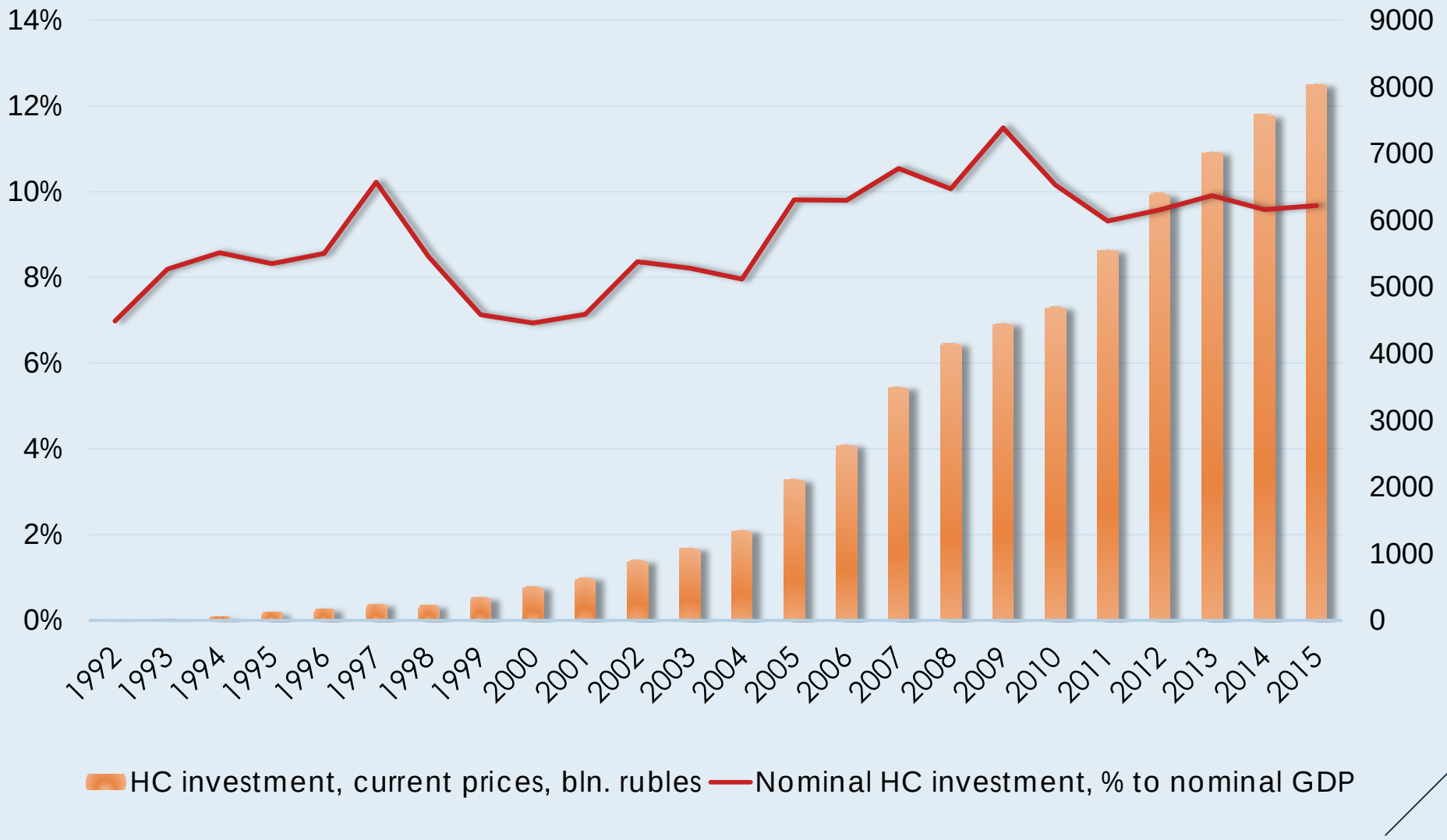
Problems of data formation

- HC investment: education, healthcare, culture expenses.
- Government expenses + private expenses (paid services).
- Price indices:
  - price index for services;
  - price index for paid services of cultural institutions ;
  - price index for healthcare services.

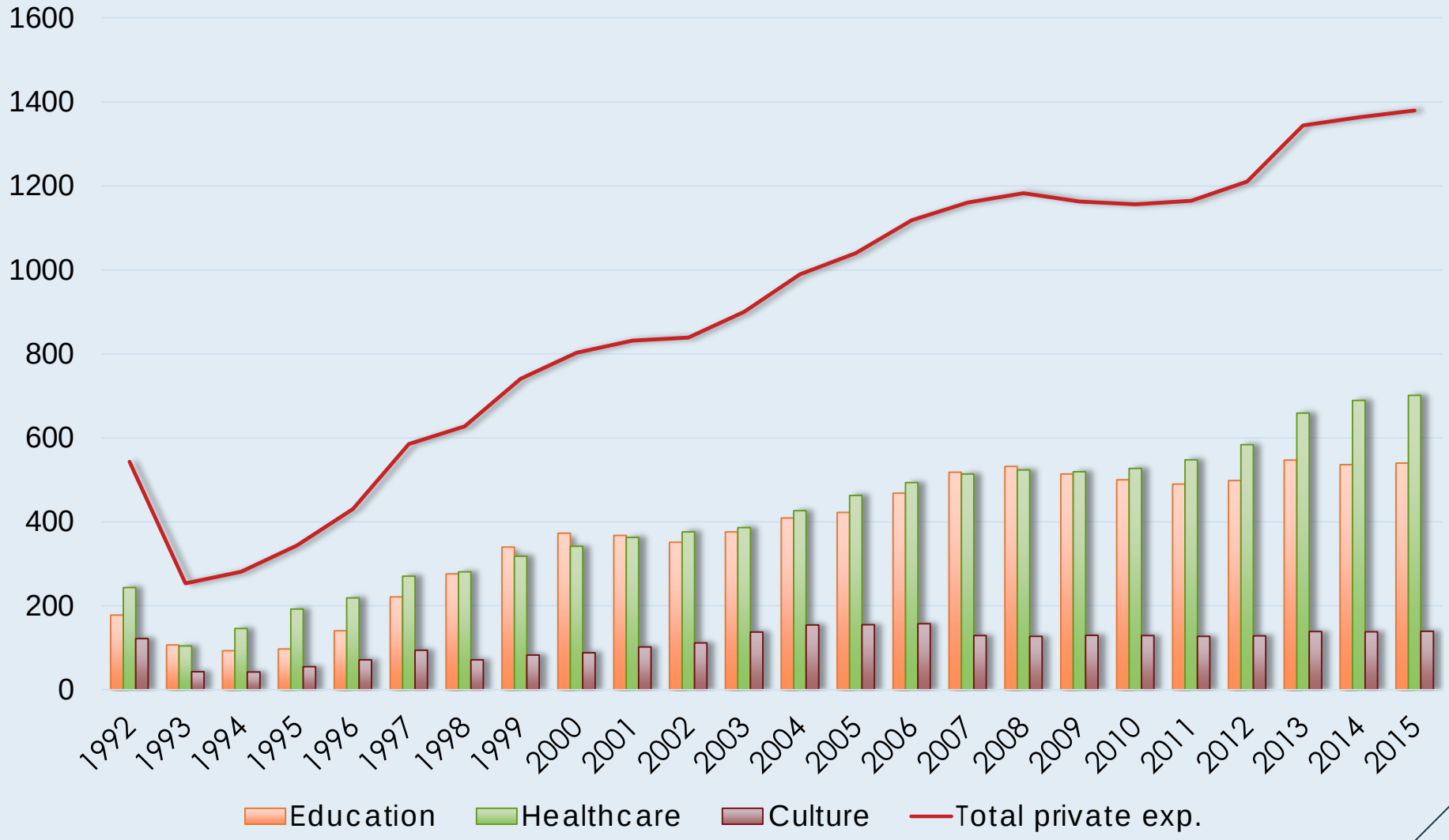
Human capital investment (prices of 2015), bln. rubles



Nominal HC investment, bln. rubles



Private human capital expenses, bln. rubles



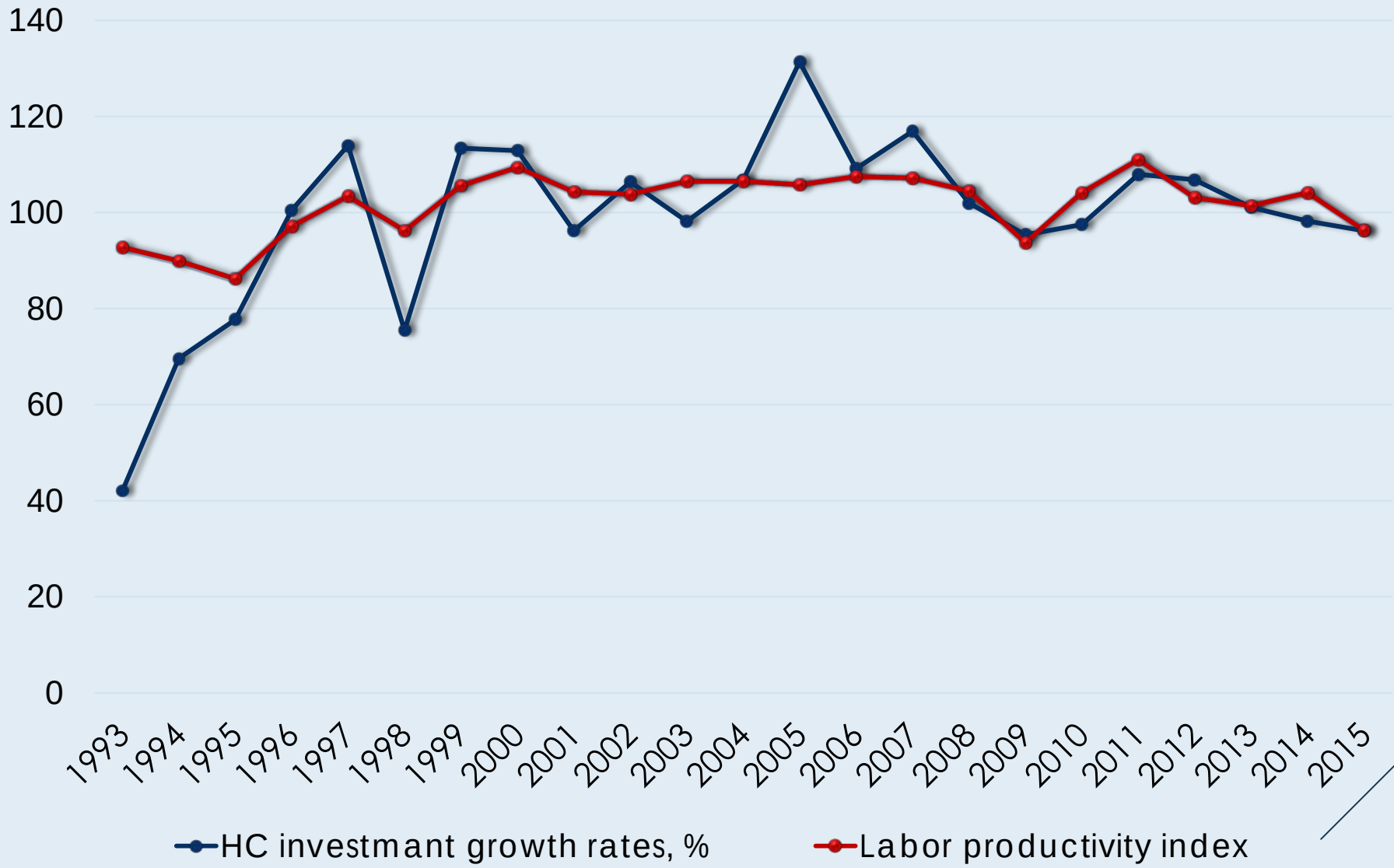
Labor productivity and human capital investment growth rates regression

Productiv = 2.1 + 0.22*Inv_HC + 0.13*HC1.

```
 Source |       SS       df       MS              Number of obs =      23
-------------+------------------------------       F(  2,    20) =   20.62
       Model |  626.401422     2  313.200711         Prob > F      =  0.0000
    Residual |  303.753793    20  15.1876897         R-squared     =  0.6734
-------------+------------------------------       Adj R-squared =  0.6408
       Total |  930.155215    22  42.2797825         Root MSE      =  3.8971

------------------------------------------------------------------------------
   productiv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      inv_hc |   .2188765   .0478079     4.58   0.000     .1191509    .3186021
         hc1 |   .1281257   .0478306     2.68   0.014     .0283528    .2278985
       _cons |    2.09592   .8144132     2.57   0.018     .3970835    3.794756
------------------------------------------------------------------------------
Durbin-Watson d-statistic(  3,    23) =  1.840692
```

Labor productivity and human capital investment growth rates dynamic (%)



Output of human capital in value terms

$$h_t = \frac{\sum_{\tau=t-\tilde{\theta}_{ij}+1}^{t} H(\tau) \Big/ t}{\sum_{\tau=t-\tilde{\theta}_{ij}+1}^{t} BB^H(\tau) \Big/ t} = \frac{\sum_{\tau=t-\tilde{\theta}_{ij}+1}^{t} H(\tau)}{\sum_{\tau=t-\tilde{\theta}_{ij}+1}^{t} BB^H(\tau)} \qquad (8)$$

$$BH(t) = h_t \cdot BB^H(t) \qquad (9)$$

where $H(\tau)$ is human capital investment at the year *t* in mlrd. rubles;
$BB^H(\tau)$ is the output of students (number of persons, in thousands);
h_t are the average expenses for one graduate;
$BH(t)$ is the output of human capital in value terms;
$BB^H(t)$ is the number of students

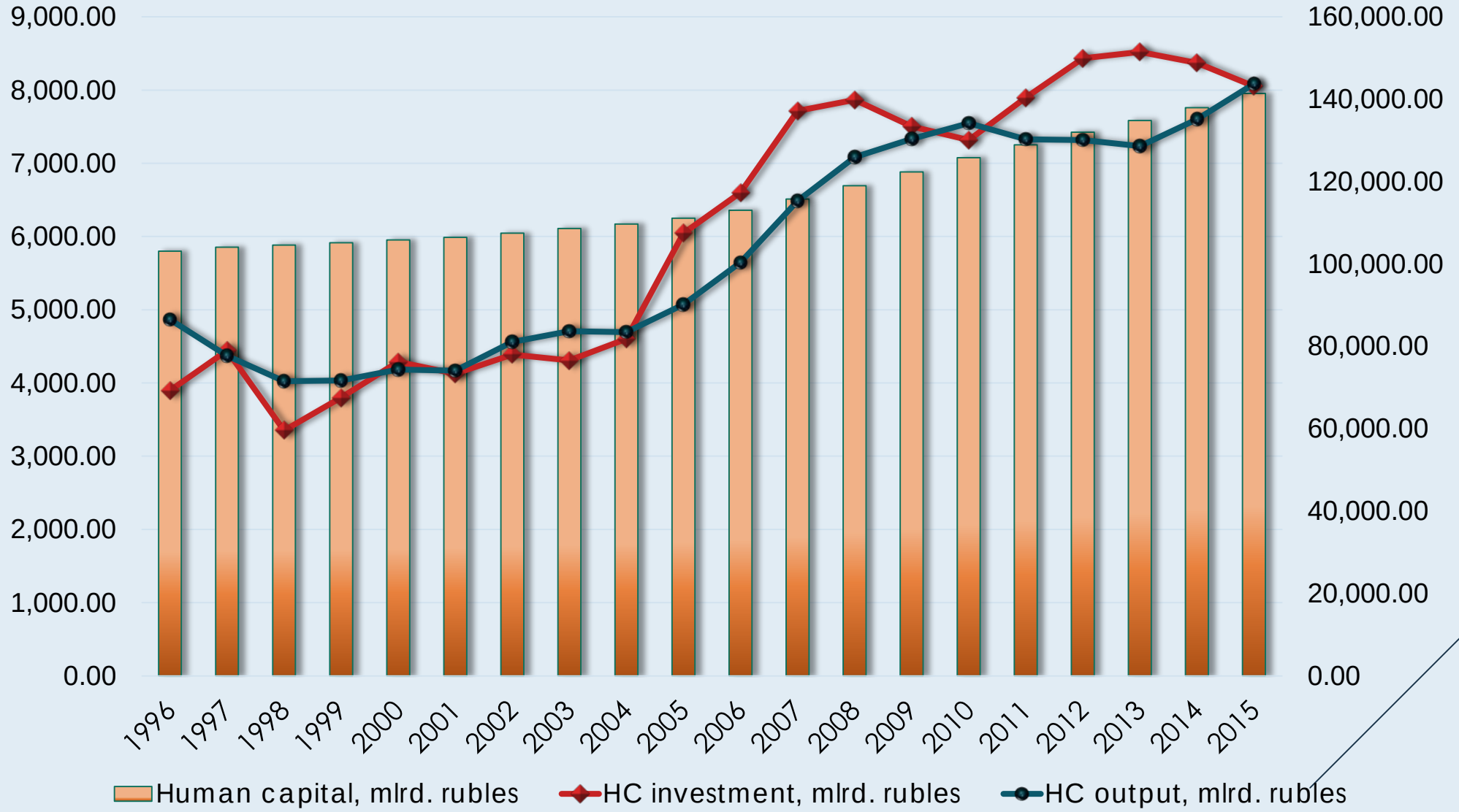
Human capital amount

$$HC(t) = BH(t) + HC(t-1) \cdot \left(1 - \tilde{k}\right) \qquad (10)$$

$$HC(1) = BH(1) \cdot \frac{1 + g_{BH}}{g_{HC} + \tilde{k}} \qquad (11)$$

where $\tilde{\kappa}$ is a replacement rate of human capital;
g_{HC} is the growth rate of the volume of human capital;
g_{BH} is the growth rate of human capital output

Labor productivity and human capital investment growth rates dynamic (%)



Conclusion

- Important influence of human capital and human capital investment on economic growth and development
- Lack of necessary investment and slow growth rates of important economic activities

Future research

- More detailed information, including interindustry information of human capital reproduction;
- Forecasting of Russian economy development;
- Estimation of necessary level of investment and human capital to reach the target growth rate of economy

THANK YOU!