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# Determination of capital accumulation in region using benchmarking tool

## Determinación de la acumulación de capital en la región mediante un instrumento de referencia benchmarking

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**ABSTRACT:**
The article addresses the modeling accumulation parameters of physical and human capital as the forcing drivers of regional development. To achieve this aim we applied tool of regional benchmarking. Different approaches to the interpretation of the definition «regional benchmarking» were considered; as a result we proposed our definition to clarify theoretical foundation in this study area. The model for optimizing the parameters of accumulation physical and human capital based on the Mankiw -Romer-Weil model has been proposed.
**Keywords:** Human capital, regional benchmarking, physical (fixed) capital

**RESUMEN:**
El artículo aborda los parámetros de acumulación de modelos del capital físico y humano como impulsores del desarrollo regional. Para lograr este objetivo aplicamos la herramienta de benchmarking regional. Se consideraron diferentes enfoques para determinar la interpretación de la definición «evaluación comparativa regional»; como resultado, propusimos nuestra definición para aclarar los fundamentos teóricos en esta área de estudio. Se ha propuesto el modelo para optimizar los parámetros de acumulación de capital físico y humano basado en el modelo Mankiw-Romer-Weil.
**Palabras clave**: Capital humano, benchmarking regional, capital físico (fijo).

# 1. Introduction

At present there are a lot of spatial challenges Russian regions are facing. Among key of them are: socio-economical disparities in regional development, the need to reshape technological structure in order to capture innovative pathway, generation new tools of improving social well-being. Therefore in our article we shed some light by adding to emerging body of recent benchmarking studies related to regional level. We propose original approach of capital accumulation using as departure point the Mankiw -Romer-Weil model. Its application facilitates decision-making process and makes possible to

decline spatial heterogeneity.

## 1.1. Literature review

The concept of regional benchmarking has been arising in the regional science for a long time. Initially it was applied in the regional planning thanks to Lisbon strategy aimed on strengthen competiveness of countries EU union.  Benchmarking is considered as the tool that gives vision referring development trends of examined region taking into account economic phenomena and processes in others regions.

There are different definitions of «regional benchmarking» proposed researchers.

For instance, Koellreuter K. (Koellreuter, 2002) defines regional benchmarking as «inter-regional comparisons of activities, processes, practices, policies and usage this information to improve regional development». Clary , G. Grootendorst, K. Nichols (Clary, Grootendorst, Nichols, 2009) reveal the contex of benchmarking as an assessment of the region¢s development using an extensive list of indicators.

Berde A. (Berde, 2008) refers benchmarking to universal tool with which economic entities evaluate their activities in comparison with the best in its class, determine the methods and means of achieving a high level development.

According to the international consulting agency BAK Basel Economics (Eichler, 2007) regional benchmarking is a "process consisting in establishing a list of various indicators and comparing indicators of the region with these ones". On our opinion regional benchmarking  is a systematic activity of collecting, analyzing, choosing the best indicators of the regions and developing tools (programs, schemes, models) to achieve them.

Having analyzed action-oriented researches on regional benchmarking we can highlight involving integral indexes for estimation of territorial development (table 1).

**Table 1**

Integral indexes in benchmarking studies

| Authors | Reseach aim | Directions for measuring |
|---|---|---|
| Atkinson R., Andes S. | Measurement of the regional structure, its  assessment  with regard to the ideal benchmark structure | Jobs requiring high qualification and professional knowledge, globalization, economic dynamism, digital economy,<br>innovative opportunities |
| DeVol R., Bedroussian A., Klowden K., Hynek C. | Identification the most successful cities in terms of creating and maintaining jobs as well as analyzing the quality of jobs and the economic development of urban entities | GDP, average wages, concentration and diversification technological industries |
| Huggins R., Izushi H. | Assessment of the economic competitiveness in the regions and neighborhoods United Kingdom | Cost and production factors |
| Eberts R., Erickcek G., Kleinhenz J. | Understanding regional economic processes and tracking the region¢s economic development | Skilled labor, urban assimilation, race structure population, sustainability territories, income distribution, local territorial particularities, business dynamics, territory structure |

Source: own processing

As above mention table 1 shows there are variety of indicators can be involved for regional benchmarking.  In our opinion benchmarking is a universal tool that can be used in different ways referred to regional development.

Russian scientists have a few studies on benchmarking tools adapted to regional scale. For instance, Ivanov P. (Ivanov, 2017) considers comparative analysis within life cycle of the territory. Klimova N., Krasnoselskaya D.Kh. explore the performance of oil companies using benchmark values (Klimova, Krasnoselskaya, Khamzina, 2018). Yusupov K., Timir'yanova V. (Yusupov, Timir'yanova, 2018) assesses spatial hierarchical impacts on municipal unities. Danilova I., Karetnikova I. (Danilova, Karetnikova, 2016) propose the original methodical approach to evaluate competitive power of companies and industries.

At present one of the most important aims for Russian Federation is to transition to innovative economy accompanied by forming and effective using human capital. Therefore in this paper we formalize model that allows region to choose optimal structure of capital based on indicators leading region.

# 2. Methodology

Originally, Mankiw- Romer-Weil model was created by including the human capital as well a physical capital into classic Solow's model to provide better understanding of differences in income per capita across countries. Authors proved that this model better fits cross-countries data in comparison with the latter one. They use three samples of countries covering data from 1960 to 1985: countries that are not oil producers, countries having average rates of development and OESD countries.

Results showed that human capital is significant for all samples; it gravely increases the quality of examined model. Adding a human capital as explanatory variable allowed to explain the 80% of cross-countries variance in GDP per capita attributed to not oil producing countries and countries with average rates of development.

Our research aims to formalization model of accumulation parameters physical and human capital in region based on Mankiw- Romer-Weil study that assumes Cobb-Douglas production function at the time *t* (eq.1):

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} (A(t)L(t))^{1-\alpha-\beta} \quad (1)$$

where $Y$ - output, $H$ - stock of human capital, $K$ - stock of physical capital, $L$ - labor; $A$ - level of technology; $\alpha, \beta$ - parameters of production function ($0 < \alpha < 1,\ 1 < \beta < 0$). $L, A$ are assumed to grow exogenously at rates *n* and g.

Let $s_k$ be the fraction of income invested in physical capital, $s_h$ - fraction of income invested in human capital.

$y = Y / AL, k = K / AL, h = H / AL -$ are quantities for effective unit of labor.

Then production function (1) can be written (eq.2):

$$y = k^{a} h^{\beta}, \quad (2)$$

Authors assume that firstly, one unit of consumption can be transformed costless into either one unit of physical capital or one unit of human capital; secondly, human capital depreciates at the same rate $\delta$ as physical capital; thirdly, according decreasing returns to all capital $\alpha + \beta < 1$. Let us consider the growth of physical capital per effective unit of labor (eq3).

$$\dot{k}(t) = s_k y(t) - (n + g + \delta)k(t) \quad (3)$$

$\dot{k}(t) = 0$ if $s_k y(t) = (n + g + \delta)k(t)$

$$\text{Therefore, } k = \left( \frac{s_k}{n + g + \delta} \right)^{\frac{1}{1-\alpha}} h^{\frac{\beta}{1-\alpha}} \quad (4)$$

Let us consider the growth of human capital per effective unit of labor (eq5)

$$\dot{h}(t) = s_h y(t) - (n + g + \delta)h(t), \quad (5)$$

Obviously that $\dot{h}(t) = 0$ when $s_h y(t) = (n + g + \delta)h(t)$

From where

$$k = \left( \frac{n + g + \delta}{s_h} \right)^{\frac{1}{\alpha}} h^{\frac{1-\beta}{\alpha}} \quad (6)$$

In the steady state $\dot{k}(t) = \dot{h}(t) = 0$, therefore

$$\overset{*}{k} = \left( \frac{{s_k}^{1-\beta} {s_h}^{\beta}}{n + g + \delta} \right)^{\frac{1}{1-\alpha-\beta}} \quad (7)$$

$$\overset{*}{h} = \left( \frac{{s_k}^{\alpha} {s_h}^{1-\alpha}}{n + g + \delta} \right)^{\frac{1}{1-\alpha-\beta}} \quad (8)$$

Adding $\overset{*}{k}$ и $\overset{*}{h}$ in the equation (2) and taking logarithm we have following result:

$$\ln \frac{Y(t)}{L(t)} = \ln A(0) + gt + \frac{\alpha}{1-\alpha-\beta} \ln(s_k) + \frac{\beta}{1-\alpha-\beta} \ln(s_h) - \frac{\alpha+\beta}{1-\alpha-\beta} (n + g + \delta) \quad (9)$$

The above equation shows dependence of the income per capita on population growth and stock of physical and human capital. The coefficients in equation (9) define the contribution (share) of production factors, i.e. $\alpha$ is the share of physical capital in income and takes a value approximately equal 1/3.

The measurement the proportion of human capital is more difficult task. Developers of the extended model in determining the coefficient $\beta$ and its contribution to the growth of income consider that way: in the US, the minimum wage shows the return on labor without taking into account human capital averaging 30-50% of the average wage in industry. This fact suggests that the remaining 50-70% percent reflects the return on human capital or the $\beta$ value is between $1/3-1/2$. It followed that firstly, a higher level of savings is characterized by a higher income, which in turn leads to a higher level of human capital in a stable equilibrium of the economy, even if the share of income referred into the accumulation of human capital remains unchanged. For example, if $\alpha=\beta=1/3$ then the coefficient at $\ln(s_k)=1$. Secondly, the coefficient at $\ln(n+g+\delta)$ is larger in absolute value than the coefficient at $\ln(s_k)$. For example, if $\alpha=\beta=1/3$ then the coefficient at $\ln(n+g+\delta)$ is -2. Consequently, the growth rate of savings has a positive effect on the $\overset{*}{h}$ value, and the growth rate of the population reduces per capita income.

# 3. Results

We propose model of setting optimal ratios human and physical capital using benchmarking tool. To formalize this model we introduce the following denotations. The leading region is described by functions and parameters with the "a" index, the examined region is described with the "p" index.

Economic dynamics of the leading region can be described as follows (eq.10-15):

$$Y(t) = K_a(t)^{\alpha} H_a(t)^{\beta} (A_a(t)L_a(t))^{1-\alpha-\beta}, \quad (10)$$

$$K(t)_a' = s_{k,a}K(t)_a, \quad (11)$$

$$H(t)_a' = s_{h,a}H(t)_a, \quad (12)$$

$$A(t)_a' = g_a A(t)_a, \quad (13)$$

$$L(t)_a' = nL(t)_a, \quad (14)$$

$$C(t)_a = Y(t)_a - s_{k,a}Y(t)_a - s_{h,a}Y(t)_a \quad (15)$$

The dynamics of the examined region is described by the same system of differential equations but with different parameters (eq.16-21):

$$Y(t) = K_p(t)^{\alpha} H_p(t)^{\beta} (A_p(t)L_p(t))^{1-\alpha-\beta}, \quad (16)$$

$$K(t)_p' = s_{k,p}K(t)_p \quad (17)$$

$$H(t)_p' = s_{h,p}H(t)_p \quad (18)$$

$$A(t)_p' = g_p A(t)_p \quad (19)$$

$$L(t)_a' = nL(t)_a \quad (20)$$

$$C(t)_p = Y(t)_p - s_{k,p}Y(t)_p - s_{h,p}Y(t)_p \quad (21)$$

The leading region makes decisions to maximize its utility function which depends only on consumption (eq.22):

$$U_a = \int_0^{\infty} e^{-\rho t} \frac{C_a(t)^{1-\sigma}}{1-\sigma} dt \quad (22)$$

Where $\rho$ — is the discount rate;
$\sigma$ — coefficient of intertemporal substitution elasticity.

The system of equations (eq.10-15) allows determining the time dependence of consumption, physical and human capital of the leading region. The condition (eq.22) is used to determine the optimal consumption rate for the leading region. Further, we will assume that the dependence on the time of consumption the leading region is known.

The examined region makes decisions not only to maximize the utility from consumption, but also to minimize the gap in the level of consumption between it and the leading region.

Mathematically it can be written using the utility function for the examined region:

$$U_p = \int_0^{\infty} e^{-\rho t} \frac{\left[C_p(t)^{1-\sigma} - \gamma\left\{\max\left(C_a(t) - C_p(t), 0\right)\right\}^{1-\sigma}\right]}{1-\sigma} dt \quad (23)$$

Where $\gamma$ — coefficient reflecting the measure of preference between the reduction of the gap in the level of consumption of the examined region and the leading region in comparison with the maximization consumption utility examined region.

It is assumed that the examined region will reach the level of consumption of leading region by reducing the current consumption and investing the optimal share of investment in human and physical capital ( $s_{h,p}$ and $s_{k,p}$ ) which lead to a greater stock of human and physical capital in the future by increasing production and consumption.

When the examined region will overtake leading region, the utility function for the examined region will depend only on its consumption (eq. 24):

$$U_p = \int_0^{\infty} e^{-\rho t} \frac{C_p(t)^{1-\sigma}}{1-\sigma} dt \quad (24)$$

Equations (16-21) are sufficient to calculate the time dependence of the consumption for leading region. The maximal condition (24) is used to determine the optimal parameters of the examined region, i.e. parameters $s_{h,p}$ and $s_{k,p}$ .

# 4. Conclusions

The proposed model can be used to predict the development of regional socio-economic systems in the field of capital accumulation, optimization of current consumption bearing in mind sectoral structure, institutional restrictions and business climate. But it is

noteworthy to define some shortcomings of method. Firstly, significant spatial heterogeneity and huge square of Russian Federation require justifying criteria for region's comparison. Secondly, the chosen indicators should be embedded into regional programs to provide data for decision-making process.

The findings of model's application should be useful in the development programs and activities both at federal and regional scales to update fixed assets, create and maintain the necessary conditions for the full reproduction of human capital. The use of benchmarking as a promising tool for solving problems of a spatial planning assumes further elaboration of its organizational and methodological issues and evaluating the economic application effects.

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