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# THE EFFECT OF HUMAN CAPITAL ON ECONOMIC GROWTH: EVIDENCE FROM KAZAKH REGIONS[1]

**Abstract.** The importance of human capital for economic growth is now widely recognised and has been studied extensively. However, the influence of human capital on economic growth of Kazakhstan has not yet been studied fully enough. In particular, to the best of the knowledge, there are no studies that use various approximations of human capital and utilise both direct and indirect approaches. Using educational and health indicators, this paper tests empirically how human capital influences economic growth of Kazakh regions over the period 1994-2019 both as a production function and through total factor productivity (TFP). The analysis revealed that human capital is insignificant as a production factor but has significant indirect effect on the TFP growth rate. The latter is realised through the ability to imitate and introduce new technologies from outside rather than through the domestic innovation. The scientific novelty of this research is as follows. Firstly, it uses both educational and health approximations of human capital. Secondly, it studies how human capital influences economic growth of the Kazakh regions both directly as a production factor and indirectly through TFP. Thirdly, it checks for the presence of spatial dependence in data across Kazakhstan regions. Fourthly, it constructs average years of schooling data across the regions of the country. The results of the study are important for designing policies to increase economic growth of the country and its regions. As a further development of this work, it seems interesting to use other approximations of human capital.

**Keywords:** Kazakhstan, human capital, region, economic growth, total factor productivity, gross regional product, average years of schooling, percentage of population with higher education, infant mortality rate, life expectancy at birth

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ИССЛЕДОВАТЕЛЬСКАЯ СТАТЬЯ

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# Влияние человеческого капитала на экономический рост (на примере регионов Казахстана)

**Аннотация.** В настоящее время значение человеческого капитала для экономического роста становится предметом многих исследований. Однако его влияние на экономический рост Казахстана еще недостаточно исследовано. В частности, отсутствуют работы, в которых использованы различные аппроксимации человеческого капитала, а также прямой и косвенный подходы к изучению данного вопроса. В статье с опорой на показатели в сферах образования и здравоохранения анализируется влияние человеческого капитала на экономический рост регионов Казахстана за 1994-2019 гг. как в качестве фактора производства, так и через совокупную факторную производительность (СФП). Проведенный анализ показал, что человеческий капитал незначим как фактор производства, но оказывает существенное косвенное влияние на темпы роста СФП через способность имитировать и внедрять новые технологии извне, а не за счет внутренних инноваций. Основные результаты данного исследования заключаются в следующем. Во-первых, проанализированы и показатели образования, и показатели здравоохранения человеческого капитала. Во-вторых, изучено влияние человеческого капитала на экономический рост казахстанских регионов как непосредственно в виде фактора производства, так и косвенно через СФП. В-третьих, протестирована пространственная зависимость данных по регионам Казахстана. В-четвертых, представлены данные о средней продолжительности обучения в регионах страны. Результаты исследования могут быть использованы для разработки политики ускорения экономического роста Казахстана и его регионов. В будущих исследованиях предполагается оценить другие аппроксимации человеческого капитала.

**Ключевые слова:** Казахстан, человеческий капитал, регион, экономический рост, совокупная факторная производительность, валовой региональный продукт, средняя продолжительность обучения, процент населения с высшим образованием, младенческая смертность, ожидаемая продолжительность жизни при рождении

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## 1. Introduction

The question on how human capital impacts the process of economic growth has been studied extensively (Alekhin, 2021; Azariadis & Drazen, 1990; Benhabib & Spiegel, 1994; Freire-Serén, 2001; Koritskiy, 2011; Kumar & Chen, 2013; Lucas, 1988; Nelson & Phelps, 1966; Romer, 1990; Temple, 2001; Zhang & Wang, 2021). These studies specify two main approaches. The first is a production function approach, where human capital is treated as one of the production factors and it is assumed that the accumulation of human capital directly increases the growth of output (Coulombe & Tremblay, 2001; Mankiw et al., 1992; Vinod & Kaushik, 2007). This approach is also often related to the studies of economic convergence (Henderson & Russel, 2005; O'Neill, 1995). The second is a total factor productivity (TFP) approach whereby human capital influences economic growth through TFP: specifically, by enhanced technical progress (Benhabib & Spiegel, 1994; Islam, 1995; Männasoo et al., 2018; Nelson & Phelps, 1966). Some studies apply both approaches to the same data sets (Benhabib & Spiegel, 1994; Fleisher et al., 2010; Kumar & Chen, 2013).

Initially, the works on the role of human capital were focused mostly on across-countries samples. However, because such factors as institutions, geography, and culture are much more similar across regions than across countries, it is easier to identify how human capital affects economic growth of the regions of a country. Therefore, when statistical data became available at the regional level, many studies appeared on the subject (Coulombe & Tremblay, 2001; Fleisher et al., 2010; Martín & Herranz, 2004; Rivera & Currais, 2004; Turner et al., 2007; Kuo & Yang, 2008; Ramos et al., 2010; Fleisher et al., 2011; Kelchevskaya & Shirinkina, 2019). For example, Coulombe and Tremblay (2001) attribute an important part of the growth and convergence across the Canadian provinces to the dynamic accumulation of human capital, which enters directly into the production function. Martín and Herranz (2004) also found a significant effect of human capital as a production factor of Spanish regions. On the other hand, Fleisher, Li and Zhao (Fleisher et al., 2010) revealed a significant and positive spillover effect of human capital on growth of TFP of Chinese provinces.

There are also studies on the role of human capital in economic growth of Kazakhstan. For example, Arabsheibani and Mussurov (2007) study the rates of return to schooling in Kazakhstan and found that they have increased with transition. Azam and Ahmed (2015) studying the role of human capital and foreign direct investment (FDI) in promoting economic growth of ten post-soviet CIS countries, including Kazakhstan, support the hypothesis that human capital development is critical for economic growth. Abdulla (2021) using micro-level Labour Force Survey Data revealed that structural composition, natural resources, physical capital and human capital explain about three quarters of the cross-regional differences in Kazakhstan. Nevertheless, the influence of human capital on the process of economic growth of Kazakhstan has not yet been studied fully enough.

This paper proposes to test empirically both direct and indirect influence of human capital on economic growth of a sample of Kazakhstan regions over the period 1994–2019. The main distinctions of our research from previous ones, apart from a longer and more recent time-period, are as follows. Firstly, it uses both educational and health approximations of human capital. Secondly, it studies how human capital influences economic growth of Kazakh regions both directly as a production factor and indirectly through the total factor productivity. Thirdly, it checks for the presence of spatial dependence in data across regions of Kazakhstan. Fourthly, it constructs average years of schooling data across the regions of the country.

There is still no agreement in the literature on how to measure human capital because of its intangible nature. For example, Le et al. (2003) mention "income-based", "cost-based", "educational stock-based", "health-based", "R&D-based" approaches to the task. Other authors use Human Life Indicator (Ghislandi et al., 2019; Shulgin & Zinkins, 2021). All the proxies have advantages and drawbacks; however, health and education have become the most used measures of human capital in studying its relationship with economic growth. Within the educational stock-based approach, mainly because of the availability of statistical data, the most popular proxies are average years of schooling and educational attainment levels (Barro, 1997; Benhabib & Spiegel, 1994; Islam, 1995; Krueger & Lindahl, 2001; Temple, 1999). However, there are some limitations of this approach related to the diminishing returns to schooling and differences in the quality of education in different countries (Psacharopoulos, 1994; Wößmann, 2003). Nevertheless, since we are considering the regions of the same country and the educational system of Kazakhstan is very much centralised, we assume that the latter does not affect Kazakhstan in the same degree as it would do a set of different countries or regions of a less centralised country. So, in this research, we use average years of schooling and percentage of population with higher education as approximations of human capital of Kazakh regions.

Another strand of research uses health as an important proxy of human capital. The main argument for that is "… Healthier workers are physically and mentally more energetic and robust. They are more productive and earn higher wages" (Bloom et al., 2004, p. 1). Many microeconomic studies also confirm these effects (Bleakley, 2010; Strauss & Thomas, 1998). There are many empirical studies that find a significant positive effect of health capital on both per capita income (Bloom et al., 2004; Knowles & Owen, 1995; McDonald & Roberts, 2002; Narayan et al., 2010) and TFP (Cole & Neumayer, 2006; Kumar & Chen, 2013). Moreover, Kumar & Chen (2013, p. 2) state that "…A number of empirical studies show that the effect of education on per capita income and TFP becomes insignificant, once health capital is included in the regression model in a cross-country setting…". Thus, in this paper, we shall use the educational stock-based and health-based approaches to measure human capital of Kazakh regions.

The rest of the article is organised as follows. Section 2 describes the used models where human capital enters both directly into the production function and indirectly, into the growth rate of TFP. Section 3 describes data. Section 4 introduces methods. Section 5 discusses results and Section 6 concludes the article.

## 2. Model

We use the following model of Mankiw et al. (Bulina et al., 2020; Mankiw et al., 1992) to study the effect of human capital on economic growth of Kazakh regions.

$$Y_{it} = K_{it}^{\alpha_1} H_{it}^{\alpha_2} \left[A_{it} L_{it}\right]^{1-\alpha_1-\alpha_2}, \; 0 < \alpha_1 + \alpha_2 < 1, \quad (1)$$

where $Y_{it}$ is the gross regional product (GRP) of region $i$ at time $t$; $K_{it}$ and $H_{it}$ are physical and human capital respectively; $L_{it}$ is labour, and $A_{it}$ is the technology level; $\alpha_1$ and $\alpha_2$ are output elasticities of physical and human capital respectively. It is assumed that $A_{it}$ grows exogenously at a constant rate $x$, namely $A_{it} = A_{io}e^{xt}$ which is a standard neoclassical assumption.

Following numerous studies (Islam, 1995; Mankiw et al., 1992; Soukiazis & Cravo, 2008), we express equation (1) in per capita GRP terms and rewrite it in a difference form. This helps us to remove a potential stochastic trend like the common technology component. Using a difference form also allows us to exclude the influence of such factors as oil and other commodities prices, which are important factors for economic growth of Kazakhstan and its regions.

$$\tilde{y}_{it} = \gamma_1 \tilde{y}_{i,t-\tau} + \beta_1 \tilde{x}_{1i,t-\tau} + \beta_2 \tilde{x}_{2i,t-\tau} + \beta_3 \tilde{x}_{3i,t-\tau} + \mu_i + \varepsilon_{it}, \quad (2)$$

where $\tilde{y}_{it} = y_{it} - \bar{y}_t$, $\tilde{x}_{it} = x_{it} - \bar{x}_t$; $\bar{y}_t$ and $\bar{x}_t$ are the averages across the regions at time $t$;

$$y_{it} = \ln \frac{Y_{it}}{L_{it}},\ y_{i,t-\tau} = \ln \frac{Y_{it-\tau}}{L_{it-\tau}},\ \gamma_1 = 1 + \gamma = e^{-\beta\tau},$$

$$\beta_1 = \left(1 - e^{-\beta\tau}\right)\frac{\alpha_1}{1-\alpha_1},\ \beta_2 = -\left(1 - e^{-\beta\tau}\right)\frac{\alpha_1}{1-\alpha_1},$$

$$\beta_3 = \left(1 - e^{-\beta\tau}\right)\frac{\alpha_2}{1-\alpha_1},\ x_{1i,t} = \ln s_{k,it},$$

$$x_{2i,t} = \ln\left(n_{it} + x + \delta\right),\ x_{3i,t} = \ln h_{it},$$

$\mu_i = \left(1 - e^{-\beta\tau}\right)\ln A_{i0}$, $s_k$ is the physical capital saving rate, $h$ is the stock of human capital, $n$ is the population growth rate, $\delta$ is a rate of depreciation which is assumed to be equal for both physical and human types of capital, $\varepsilon_{it}$ is an error term that varies across regions and over time and has zero mean.

Equation (2) is also called in the literature a convergence equation (Turganbayev, 2016) because it relates the current GRP with its initial level. The countries or regions are said to demonstrate β-convergence if the poorer economies grow faster than richer ones where $\beta = \left(1 - \alpha_1 - \alpha_2\right)\left(x + n + \delta\right)$ is called the rate of convergence.

To study how human capital affects the TFP growth of the Kazakhstan regions, we use the following model (Benhabib & Spiegel, 1994; Fleisher et al., 2010):

$$\log TFP_{i,t} - \log TFP_{i,t-1} = = \varphi_1 h_{i,t-1} + \varphi_2 h_{i,t-1}\left[\frac{Y_{\max,t-1} - Y_{i,t-1}}{Y_{i,t-1}}\right] + u_{i,t}. \quad (3)$$

Here, the growth rate of TFP depends on human capital, which is assumed to affect it both directly and indirectly. The term $\varphi_1 h_{i,\,t-1}$ simulates the direct effect which acts through domestic innovation. The term $\varphi_2 h_{i,t-1}\left[\frac{Y_{\max,t-1} - Y_{i,t-1}}{Y_{i,t-1}}\right]$ simulates the indirect or catch-up effect which is an economy's capability to imitate and implement new technologies from outside (Nelson & Phelps, 1966). The variable $Y_{\max,\,t}$ is the output level in the most developed region, which the city of Almaty in the case of Kazakhstan. The term $\frac{Y_{\max,t-1} - Y_{i,t-1}}{Y_{i,t-1}}$ approximates the technology difference, and the factor $\varphi_2 h_{i,\,t-1}$ reflects the ability to take over and accommodate new technology.

## 3. Data

We take the per capita GRP data of Kazakh regions since 1994 from the statistical issue Regions of Kazakhstan available on the website of the Bureau of National Statistics. To exclude the influence of short-run effects, we consider data with three-year time span.

We approximate the saving rate $s_{k,\,it}$ by the ratio of a region's investment to its GRP. The term $x_{2i,\,t}$ is the log of the sum $n_{it} + x + \delta$ of the rates of growth of population $n_{it}$, and technology $x$, as well as the rate of depreciation, δ. Following the reasoning of Turganbayev (2016), in the case of Kazakh regions, we take $x + \delta = 0.065$, although in the literature (Di Liberto et al., 2007; Islam, 1995; Mankiw et al., 1992), $x + \delta$ is usually taken equal to 0.05.

For the human capital term $h_{i,\,t}$, we use four different proxies. Two of them are educational, namely, average years of schooling of the population and the percentage of the population with higher education. Another two proxies relate to health — infant mortality rate and life expectancy at birth.

To calculate educational proxies of human capital stock, we use statistical data on different levels of education adopted in Kazakhstan's educational system: higher education, incomplete higher education, vocational secondary education, general secondary education, basic secondary education and primary general education. The data on the population with corresponding levels of education are available from censuses of 1989, 1999, and 2009. To calculate a region's average years of schooling in other years, we use a linear interpolation technique. However, for higher and vocational secondary levels of education, where reliable yearly data on the number of graduates are available, for the years after 2009, we use a method like the perpetual inventory method that is used for the calculation of the capital stock. For example, if we have the quantity ($H_{it}$) and percentage ($h_{it}$) of the population with higher education in region $i$ in year $t$, then we can calculate the data in other years using the following equation:

$$H_{i,t+1} = H_{it} + HEGraduates_{i,t+1} + +NetMigration_{i,t+1} \cdot h_{it} - NumberOfDied_{i,t+1} \cdot h_{it-20}$$

$$h_{i,t+1} = \frac{H_{i,t+1}}{Totalpopulation_{i,t+1}}, \quad (4)$$

where $HEGraduates_{i,t+1}$ is the number of graduates of higher education institutions in region $i$ at year $t$; $NetMigration_{it}$ is the difference between immigration and emigration in region $i$ at year $t$; $NumberOfDied_{it}$ is the number of people who died in region $i$ at year $t$; $Totalpopulation_{i,t}$ is the number of population in region $i$ at year $t$. We also take into account that the city of Almaty is an educational capital of Kazakhstan and, in 2019, out of 125 higher education institutions 41 were located in Almaty city. Therefore, we assume that only 50 % of the graduates stay in Almaty. Other 50 % we distribute among other regions proportionally to their population and inversely to the distances of a region's capital to Almaty. In addition, we multiply the number of people who died in a region by a percentage of people with higher education with a 20-year lag assuming that the majority of those who died are old, retired people and their level of education was important for the economy 20 years ago.

Another reason that we use this method only for higher and vocational secondary education is that in the last twenty years these two levels experienced fast growth because of opening of many private universities and vocational colleges. We start the technique only from 2009 to be consistent with 2009 census data. For other levels of education, we still use the linear interpolation technique. The calculated data on the percentage of population with higher education is used as a second proxy for the human capital variable.

As the first proxy of health capital of Kazakh regions, following (Kumar & Chen, 2013; McDonald & Roberts, 2002), we take the infant mortality rate defined as the number of infant deaths before 1 year of age per 1000 live births. Sen (1998) strongly supports this proxy in the context of developing countries. As the second proxy of health capital we take life expectancy at birth (Bloom et al., 2004; Knowles & Owen, 1995; Kumar & Chen, 2013; McDonald & Roberts, 2002). However, data on life expectancy across Kazakh regions is available only starting from 1999.

We use lagged values $\tilde{x}_{1i,t-\tau}$, $\tilde{x}_{2i,t-\tau}$, $\tilde{x}_{3i,t-\tau}$ assuming that investments, population growth and human capital influence growth with some lag (Di Liberto et al., 2007). The speed of convergence β can be estimated after we estimate the lagged dependent variable coefficient from the equation: $\gamma_1 = e^{-\beta\tau}$. The heterogeneity degree of the TFP is approximated by the fixed effects, $\mu_i$.

To calculate the TFP series for the regions of Kazakhstan we use the growth accounting methodology (Mitsek, 2021; Turganbayev, 2017). For that, regional economies are assumed to submit to the following production function in which, based on the results of Section 5, we do not include human capital variable as one of the production factors.

$$Y_{it} = K_{it}^{\alpha_{it}} \left(A_{it} L_{it}\right)^{1-\alpha_{it}}, \quad (5)$$

where $Y_{it}(t)$ is the output in real prices, $K_{it}(t)$ is the capital stock, $L_{it}(t)$ is labour force stock of region $i$ at time $t$. $A_{it}(t)$ is the technology term, which is assumed to serve as a proxy of TFP. Then the TFP values at time $t$ for region $i$ can be calculated as follows:

$$A_{it} = TFP_{it} = \left(\frac{Y_{it}}{L_{it}}\right)^{\frac{1}{1-\alpha_{it}}} / \left(\frac{K_{it}}{Y_{it}}\right)^{\frac{\alpha_{it}}{1-\alpha_{it}}}. \quad (6)$$

To assess the capital stock, we use the perpetual inventory method (PIM) based on the equation:

$$K_{it} = (1-\delta) K_{i,t-1} + I_{it}, \quad (7)$$

where $K_{it}$ is the $i$-th region's capital at time $t$, $I_{it}$ is the fixed assets investment, δ is the rate of depreciation. We assume it to be 5 percent per year, which is common in the literature (Miyamoto & Liu, 2005). The 1993 book cost of fixed assets is taken as an initial stock of capital.

The labour input is approximated by the total number of employed population, which is also available from the Regions of Kazakhstan. To calculate the labour's input share, 1 – α, we presume that factor markets' competition is perfect, and each input's marginal product and factor price are equal. This leads to the following equation for the calculation of the labour share coefficient (Byrne et al., 2009):

$$1-\alpha_{it} = \frac{w_{it} L_{it}}{\tilde{Y}_{it}}, \quad (8)$$

where $w_{it}$ is the wage rate per employee and $\tilde{Y}_{it}$ is a nominal output.

Calculating $K_{it}$, $L_{it}$, and $\alpha_{it}$ and substituting them into equation (6) produces the TFP time series of Kazakh regions. To analyse the catch-up process, which usually takes longer time, and to exclude influence of short-run effects, we consider the calculated data with three-year time span.

## 4. Methods

### *4.1. Human Capital as a Production Factor*

Equation (2) represents a fixed effects dynamic panel data model. Following discussion in the studies by Di Liberto et al. (2007) and Turganbayev (2016), as first candidates we take the Kiviet-corrected Least Squares with Dummy Variables

(LSDVC) estimation procedure (Kiviet, 1995), Arellano and Bond (AB) (Arellano & Bond, 1991) and the Arellano-Bover/Blundell-Bond (BB) linear panel-data estimators (Blundell & Bond, 1998). To choose among them, we use the following three criteria. Firstly, it is well known that in dynamic panels, a consistent estimate of the lagged dependent variable coefficient should lie in between the pooled Ordinary Least Squares (OLS) and the LSDV estimates because the former is upward biased, and the latter is downward biased (Bond et al., 2001; Hsiao, 2014; Nickell, 1981). Secondly, equation (2) implies that the coefficients on the variables $\ln s_{k,i,t-1}$, and $\ln(n_{i,t-1} + x + \delta)$ should be equal in magnitude but have opposite signs. We will check respective hypotheses for each estimator. Thirdly, the speed of convergence calculated based on the estimate of the lagged dependent variable coefficient should be close to what is observed in the literature for studies of conditional convergence across regions of the same country using panel approach which varies from 5 to 20 per cent per year (Badinger et al., 2004; Caselli et al., 1996; de la Fuente, 2002; Turganbayev, 2016; Yao et al., 2019).

To check the above-mentioned conditions, we apply different panel tests to four models based on equation (2). In Model 1, human capital is approximated by average years of schooling of the population; in Model 2 — the percentage of the popula-

Table 1

**Economic growth of Kazakh regions and human capital (human capital — average years of schooling)**

| | Model 1 (human capital — average years of schooling) | | | | |
|---|---|---|---|---|---|
| | **OLS** | **LSDV** | **LSDVC** | **AB** | **BB** |
| $\ln y_{i,t-1}$ | .843*** (.033) | .332*** (.055) | .488*** (.054) | .045 (.205) | .700*** (.130) |
| $\ln s_{k,i,t-1}$ | .149*** (.030) | .111*** (.029) | .131*** (.011) | .116*** (.027) | .140*** (.046) |
| $\ln(n_{it-1} + x + \delta)$ | –.114* (.064) | –.109* (.056) | –.076 (.157) | –.135** (.065) | –.156** (.065) |
| $\ln h_{i,t-1}$ ($h$ — education) | 2.023*** (.675) | 1.922** (.868) | 1.635 (.196) | 2.266 (2.031) | 4.058 (3.448) |
| $\ln h_{i,t-1}$ ($h$ — health) | | | | | |
| Implied β | .057 | .367 | .239 | 1.034 | .119 |
| Number of observations | 128 | 128 | 128 | 112 | 128 |
| Adj $R$ squared | .941 | .967 | | | |
| Arellano-Bond test for AR(1) | | | | .7372 | .0259 |
| Arellano-Bond test for AR(2) | | | | .0809 | .62016 |
| Sargan test $p$-value | | | | .9961 | .9997 |
| $\beta_1 = \beta_2$, $p$-value | .5241 | .9665 | .7074 | .7201 | .4616 |

Notes: 1. The asterisks *, **, and *** mean the level of significance at the 10, 5, and 1 percent, respectively, 2. robust standard errors are in the parentheses, 3. Sargan test is calculated for vce(GMM), 4. bootstrapped SE for Kiviet-corrected estimator.
Source: author's calculations.

Table 2

**Economic growth of Kazakh regions and human capital (human capital — % of the population with higher education)**

| | Model 2 (human capital — higher education) | | | | |
|---|---|---|---|---|---|
| | **OLS** | **LSDV** | **LSDVC** | **AB** | **BB** |
| $\ln y_{i,t-1}$ | .848*** (.031) | .311*** (.055) | .483*** (.031) | .170 (.177) | .661*** (.130) |
| $\ln s_{k,i,t-1}$ | .163*** (.032) | .106*** (.028) | .129*** (.017) | .107*** (.031) | .127*** (.030) |
| $\ln(n_{i,t-1} + x + \delta)$ | –.096 (.064) | –.093* (.053) | –.064 (.161) | –.136** (.057) | –.136* (.081) |
| $\ln h_{i,t-1}$ ($h$ — education) | .316 *** (.101) | .572*** (.179) | .546*** (.036) | .586** (.273) | .544 (.678) |
| $\ln h_{i,t-1}$ ($h$ — health) | | | | | |
| Implied β | .055 | .389 | .243 | .591 | .138 |
| Number of observations | 128 | 128 | 128 | 112 | 128 |
| Adj $R$ squared | .943 | | | | |
| Arellano-Bond test for AR(1) ($p$-value) | | | | .2422 | .0045 |
| Arellano-Bond test for AR(2) (p-value) | | | | .0707 | .5805 |
| Sargan test $p$-value | | | | .9990 | .9998 |
| $\beta_1 = \beta_2$, $p$-value | .218 | .8082 | .6506 | .5136 | .9168 |

Notes: 1. The asterisks *, **, and *** mean the level of significance at the 10, 5, and 1 percent, respectively, 2. robust standard errors are in the parentheses, 3. Sargan test is calculated for vce(GMM).
Source: author's calculations.

tion with higher education; in Model 3 — by the infant mortality rate; in Model 4 — by the life expectancy of the population. We also include results for the pooled OLS and LSDV estimators to be able to choose appropriate estimation results. The results are presented in the Tables 1–4 and show that only BB estimator satisfies all three above-mentioned criteria for all four models: 1) the estimates of the coefficient of the lagged dependent variable lie between pooled OLS and LSDV estimates; 2) we cannot reject the hypothesis that $\beta_1 = \beta_2$; 3) the respective speeds of convergence lie between 5.1 and 13.8 percent per year and are similar to what is observed in the literature.

In addition, many authors argue that the presence of spatial dependence can lead to model misspecification (Anselin, 2009; Arbia, 2006; Celbis & de Crombrugghe, 2018; Pfaffermayr, 2012; Piras & Arbia, 2007; Rey & Janikas, 2005; Timiryanova et al., 2021). This is supposedly based on omitted variables that relate to the connectivity of neighbouring regions as a reason for spatial correlation or dependence in the error terms of regional econometric models. To check whether it is a problem in the current study, we look at the Global Moran's I statistic (Moran, 1950). To do so, we first generate a matrix of weights based on the locations of administrative capitals of regions in Kazakhstan and then use the Stata's spatgsa command to calculate Moran's I. We found that the absolute values of Moran's I statistics never exceed 0.162 and in most cases are less than 0.1. The *p*-values evi-

Table 3

**Economic growth of Kazakh regions and human capital (human capital — infant mortality rate)**

| | Model 3 (human capital — infant mortality rate) | | | | |
|---|---|---|---|---|---|
| | OLS | LSDV | LSDVC | AB | BB |
| $\ln y_{i,t-1}$ | .919*** (.022) | .349*** (.056) | .534*** (.025) | .208 (.207) | .858*** (.156) |
| $\ln s_{k,i,t-1}$ | .113*** (.031) | .097*** (.029) | .122*** (.024) | .106*** (.032) | .135** (.069) |
| $\ln(n_{i,t-1} + x + \delta)$ | .051 (.061) | –.070 (.055) | –.038 (.160) | –.126** (.059) | –.130 (.087) |
| $\ln h_{i,t-1}$ ($h$ — education) | | | | | |
| $\ln h_{i,t-1}$ ($h$ — health) | –.099 (.104) | .087 (.106) | .035 (.081) | .136 (.096) | –.075 (.218) |
| Implied β | .028 | .351 | .209 | .523 | .051 |
| Number of observations | 128 | 128 | 128 | 112 | 128 |
| Adj $R$ squared | .934 | .965 | | | |
| Arellano-Bond test for AR(1) ($p$-value) | | | | .3138 | .0071 |
| Arellano-Bond test for AR(2) ($p$-value) | | | | .3017 | .8634 |
| Sargan test $p$-value | | | | .9982 | .827 |
| $\beta_1 = \beta_2$, $p$-value | .0026 | .6079 | .5355 | .6938 | .9575 |

Notes: 1. The asterisks *, **, and *** mean the level of significance at the 10, 5, and 1 percent, respectively, 2. robust standard errors are in the parentheses, 3. Sargan test is calculated for vce (GMM).
Source: author's calculations.

Table 4

**Economic growth of Kazakh regions and human capital (human capital — life expectancy at birth)**

| | Model 4 (human capital — life expectancy) | | | | |
|---|---|---|---|---|---|
| | OLS | LSDV | LSDVC | AB | BB |
| $\ln y_{i,t-1}$ | 0.959*** (0.021) | 0.380*** (0.071) | 0.641*** (.105) | 0.226 (0.187) | 0.785*** (0.104) |
| $\ln s_{k,i,t-1}$ | 0.119*** (0.028) | 0.074*** (0.028) | 0.105*** (.033) | 0.111*** (0.024) | 0.113*** (0.030) |
| $\ln(n_{i,t-1} + x + \delta)$ | –0.014 (0.062) | –0.085* (0.047) | –0.086* (.047) | –0.109* (0.061) | –0.057 (0.065) |
| $\ln h_{i,t-1}$ ($h$ — education) | | | | | |
| $\ln h_{i,t-1}$ ($h$ — health) | –0.611 (0.645) | –2.133** (1.030) | –2.460** (1.208) | –0.225 (1.809) | 0.101 (1.073) |
| Implied β | .014 | .323 | .148 | .496 | .081 |
| Number of observations | 112 | 112 | 112 | 96 | 112 |
| Adj $R$ squared | 0.963 | .9781 | | | |
| Arellano-Bond test for AR(1) ($p$-value) | | | | 0.3129 | 0.0077 |
| Arellano-Bond test for AR(2) ($p$-value) | | | | 0.1036 | 0.0830 |
| Sargan test $p$-value | | | | 0.9959 | 0.9994 |
| $\beta_1 = \beta_2$, $p$-value | .0528 | .8161 | .1917 | .9661 | .5004 |

Notes: 1. The asterisks *, **, and *** mean the level of significance at the 10, 5, and 1 percent, respectively, 2. robust standard errors are in the parentheses, 3. Sargan test is calculated for vce (GMM).
Source: Author's calculations.

dence that the null hypothesis on the presence of zero spatial autocorrelation in the variable $\tilde{y}_{it}$ can be rejected only in two years out of nine (in 1995 and 2010), for the variable $x_{1i,\,t}$ — in 2001, $x_{2i,\,t}$ — in 1995, $h_{it}$ (when human capital is approximated by the infant mortality rate) — in 1998, 2001, and 2016. In other years, and for all other approximations of human capital, the p-values testify that we cannot reject hypothesis of zero spatial autocorrelation in our data. Thus, we can conclude that the spatial autocorrelation is not a problem in this regression.

### *4.2. Human capital and TFP*

Since we are trying to find causal relationships between TFP growth and human capital, we should consider that the correlation between them could be caused by the omitted variables, such as institutions, oil abundance, etc. However, since we are studying regions of the same country, the impact of such differences as legislation, institution, culture, openness reduces significantly. In addition, to control for a possible bias due to such factors as natural resources abundance, geography, price on commodities, we will use a two-way fixed effect estimation. We use the same four models with different approximations of human capital described in Subsection 4.1.

Again, we check the presence of spatial dependence in our data using the Global Moran's I statistic. We use the same matrix of weights calculated earlier. Again, the absolute values of Moran's I statistics in most cases are less than 0.1 and never exceed 0.156. We observe spatial autocorrelation for the TFP growth rate variable only in 1998 when p-value is equal to 0.008, and for the infant mortality rate variable in 1998 and 2016. In all other years and for all other variables the p-value is never less than 0.05 that means that we cannot reject the null hypothesis of zero spatial autocorrelation present in our data.

## 5. Results and Discussion

### *5.1. Human Capital as a Production Factor*

Table 5 shows the results of the application of the BB estimator to the four models with different approximation of human capital. The estimates of the lagged dependent variable coefficient are highly significant for all four models and lie between .661 (Model 2) and .858 (Model 3). The coefficients produce respective speeds of convergence lying between 5.1 and 13.8 percent per year. For all four models we cannot reject the hypothesis that $\beta_1 = \beta_2$. The estimates of the coefficients of the saving rate are positive and significant in all four models. However, the estimates of the population growth coefficient although are negative for all four models but significant only for Model 1 at 5 % confidence level and Model 2 at 10 % confidence level. As to the estimates of the coefficient of the human capital, the BB estimator generates insignificant estimates in all four models with positive sign in Models 1,2,4 and negative one in Model 3. The results of the Sargan test show that the instruments of the BB estimator are valid in all four models. The Arellano-Bond test for AR(2) confirms the absence of the second-order serial correlation in disturbances also in all four models. So, all four proxies of human capital prove to have insignificant direct effect on economic growth of the Kazakh regions.

The obtained insignificant estimates of human capital reflect the real picture of Kazakhstan's

Table 5

**Human capital and economic growth of Kazakh regions**

| | **Education** | | **Health** | |
|---|---|---|---|---|
| | **Model 1: human capital — average years of schooling** | **Model 2: human capital — higher education** | **Model 3: human capital — infant mortality rate** | **Model 4: human capital — life expectancy** |
| $\ln y_{i,\,t-1}$ | .700*** (.130) | .661*** (.130) | .858*** (.156) | 0.785*** (0.104) |
| $\ln s_{k,\,i,\,t-1}$ | .140*** (.046) | .127*** (.030) | .135** (.069) | 0.113*** (0.030) |
| $\ln(n_{i,\,t-1} + x + \delta)$ | –.156** (.065) | –.136* (.081) | –.130 (.087) | –0.057 (0.065) |
| $\ln_{i,\,t-1}$ | 4.058 (3.448) | .544 (.678) | –.075 (.218) | 0.101 (1.073) |
| Implied β | .119 | .138 | .051 | .081 |
| Number of observations | 128 | 128 | 128 | 112 |
| Arellano-Bond test for AR(2) | .62016 | .5805 | .8634 | 0.0830 |
| Sargan test *p*-value | .9997 | .9998 | .827 | 0.9994 |
| $\beta_1 = \beta_2$, *p*-value | .4616 | .9168 | .9575 | .5004 |

Notes: 1. The asterisks *, **, and *** mean the level of significance at the 10, 5, and 1 percent, respectively, 2. robust standard errors are in the parentheses, 3. Sargan test is calculated for vce (GMM).
Source: author's calculations.

Table 6

**TFP growth regressions**

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| $h_{i,\,t-1}$ | .644 (.405) | 6.675 (4.304) | $-.081^{**}$ (.035) | –.112 (.087) |
| $z_{2,\,i,\,t-1}$ | $.023^{***}$ (.005) | $1.513^{***}$ (.427) | $.014^{***}$ (.003) | $.003^{**}$ (.001) |
| Constant | $-8.359^{*}$ (4.372) | –2.006 (.584) | .431 (.967) | $-.853^{**}$ $(.189)^{***}$ |
| Number of obs | 128 | 128 | 128 | 128 |
| *R*-square (within) | .4161 | .3789 | .4283 | .3775 |

Notes: 1. The asterisks $^{*}$, $^{**}$, and $^{***}$ mean the level of significance at the 10, 5, and 1 percent, respectively; 2. Standard errors are in the parenthesis.
Source: author's calculations.

economy. The predominance of extractive industries in the economy leads to the fact that labour and capital are dominant, while education and health, i. e. the quality of the labour force, do not have a direct impact on economic growth. The difference in the economic growth of the regions of Kazakhstan is explained mainly by the quantity of labour force and the rate of capital accumulation.

### *5.2. Human capital and TFP*

Table 6 charts the two-way fixed effects estimation results of the equation (3) using four above-mentioned specifications. The growth rate of the logarithm of TFP is a dependent variable. The independent variables are: $h_{i,\,t-1}$ — human capital variable, which simulates the direct human capital effect on the growth rate of TFP, and $z_{2,it-1} = h_{i,t-1}\left[\frac{Y_{\max,t-1} - Y_{i,t-1}}{Y_{i,t-1}}\right]$ is a variable, which simulates the human capital spillover effect.

The estimated coefficients of the variable representing human capital's direct effect $h_{it}$ is significant at 5 % significance level only for Model 3 and it enters with expected negative sign. When human capital is approximated by the education indicators (Model 1 and Model 2) and life expectancy (Model 4), the estimated coefficients of the variable representing human capital's direct effect are insignificant. As to the catch-up effect of human capital, we see that the estimate of the coefficient of the $z_{2it}$ enters significantly at least at 5 % significance level in all four models. That means the indirect technology spillover effect of human capital on the TFP growth rate is positive and significant in all models.

So, the effect of human capital on economic growth of the Kazakh regions is realised through the growth rate of the total factor productivity. However, out of the two possible channels, namely internal innovation and the ability to imitate and introduce new technologies from outside, the latter is realised. This is also explained by the current state of Kazakhstan's economy, in which the level of innovative activity is still quite low, and technical progress takes place mainly due to the introduction of ready-made technologies.

## 6. Conclusion

It is generally accepted that human capital plays an important role in the economic growth of countries and regions. However, there is no united view about how this influence is realised. In this paper, we have studied the effect of human capital on the economic growth of the Kazakh regions over the period of 1994–2019. The analysis showed that human capital considered as one of the production factors and approximated by both education and health indicators has insignificant effect on the growth rate of Kazakh regions. The estimates of the speed of convergence, as well as coefficients of the population and investment variables, do not change noticeably when compared with the neoclassical model without human capital. The results are also robust to the estimation procedure.

As to the influence of human capital on the TFP growth rate, we found that the direct effect is significant for one of health approximations of human capital, namely infant mortality rate, and insignificant for both education approximations. Another health approximation of human capital, namely life expectancy at birth, also produces insignificant direct effect on the growth rate of TFP. However, the indirect spillover effect is significant for all human capital proxies we used in this study. This means that the growth rate of TFP in Kazakh regions was influenced by human capital not through the domestic innovation but imitation and implementation of new technologies from outside.

The scientific novelty of this research, apart from a longer and more recent time period, is as follows. Firstly, it uses both educational and health approximations of human capital. Secondly, it studies how human capital influences economic growth of the Kazakh regions both directly as a production factor and indirectly through TFP. Thirdly, it checks for the presence of spatial dependence in data across Kazakhstan regions. Fourthly, it constructs average years of schooling data across the regions of the country.

We believe that the results of this research are important for understanding how different forms of human capital affect economic growth of the Kazakh regions. They are also important for designing policies for increasing economic growth of the country.

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