

Government expenditure on education in the light of the paradigm of sustainable development: Econometric spatial models and models of dynamics

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Abstract. The knowledge economy is a paradigm of the post-industrial stage of the development of society, therefore research on the relationship between the level of the main economic indicators and state spending on education is relevant. The purpose of this article was to assess the impact of the main economic indicators on the state spending on education both in total and per capita. Econometric models based on spatial data as well as dynamics models were constructed, and the Goldfeld-Quandt test was performed. The study was conducted on the example of the most influential countries of the world and the member states of the European Union. It is shown that the growth of the total volume of gross domestic product and purchasing power parity is accompanied by the growth of the total volume of state education deductions and education deductions per capita. For countries with relatively low purchasing power parity, the correlation between these indicators is tight, and the dispersion of empirical data relative to theoretical data derived from the econometric model is not statistically significant. On the contrary, for countries with high purchasing power parity, the dependence between these indicators does exist, but there is a significant dispersion of empirical data relative to theoretical data. The Goldfeld-Quandt test showed that the countries that were selected for the study should be classified according to this feature to different sample populations. It was found that the volume of deductions for education per capita has little effect on the effectiveness of the educational process. Studies of the dynamics of education expenditures have shown that although Ukraine belongs to countries with a relatively low purchasing power parity and during 2015-2022 the growth rate of education expenditures significantly lagged behind the growth rate of economic indicators, the effectiveness of education remains relatively high. The obtained research results should be taken into account in practice in order to optimize the costs of financing the educational sector

Keywords: knowledge economy; gross domestic product; purchasing power parity; effectiveness of learning; multivariate regression; conditions of the Gauss-Markov theorem

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● INTRODUCTION

The integration of Ukraine into the European economic space involves the implementation of a number of reforms aimed at economic growth in all spheres of activity. At the current stage of economic development, which is defined as the knowledge economy, the main factor contributing to the development of science and technology of any country and strengthening its international competitiveness is the level of education of the population. The growth of human potential due to the increase in public spending on education in developed countries allows to create conditions for the long-term economic and social development of these countries, to ensure the implementation of the paradigm of sustainable development, which involves not only meeting the current needs of humanity, but also protecting the interests of future generations. Sustainable Development Strategy for Ukraine by 2030 (2017) is based on the adaptation of sustainable development goals to Ukrainian realities. One of the most important tasks in this direction is the improvement of the educational sector. At the UN Summit on Sustainable Development, 17 global goals were defined, and among them Sustainable Development Goal 4 is quality education and promote lifelong learning opportunities for all (Ensure inclusive..., n.d.).

In the world community of scientists, many studies have been conducted, which testify to the impact of public spending on education on the level of national income of the country. A. Suwandaru *et al.* (2021) when studying the relationship between government allocations to the education sector and economic growth in Indonesia for the period 1986-2018 showed that an increase in budget allocations for education has a positive effect on the development of the country's economy if the government follows a policy aimed at economic growth. K. Efthaltidou *et al.* (2021) presented research on the empirical assessment of the relationship between public spending (on education, health care, and defence) and national income in Greece for the period 1995-2019. It is established that it is investments in education and health care that are considered productive, therefore, their expansion in the long term contributes to the economic growth of the country. The work of E. Appiah (2017) shows that an increase in education spending has a positive effect on GDP (gross domestic product) per capita and there is no significant difference between developing and Sub-Saharan African countries. However, the magnitude of the effect is higher in developing countries, suggesting that annual export growth in Sub-Saharan Africa is relatively higher than in other developing countries. N.M. Salleh *et al.* (2022) investigating the relationship between the accumulation of human potential (health care and education) and the economic growth of Malaysia in 1982-2019 noted that intellectual development as a component of human potential is important for determining the country's key investments capable of ensuring its economic growth. This is especially important in a fast-paced business environment. Investments in people become a decisive factor in maintaining a country's competitive advantage. G.M. Emeru (2023) explains, based on data from 1980 to 2018, how different types of public spending have affected economic growth and proves that public spending on the education sector creates conditions that will help to achieve a higher

level of qualification of the workforce, therefore ensuring and higher rates of economic growth, as they have both short-term and long-term effects. V.D. Chekina & O.A. Vorhach (2020) carried out an analysis of the dependence of the increase in the professional level of the population on the volume of expenditures on higher education in Ukraine and in other countries, and also substantiated the impact of the quality of higher education on economic growth. However, with a direct positive relationship between the increase in state deductions for education and the economic growth of the country, this issue is not so clear-cut. R. Villela & J.J. Paredes (2022) using the example of Honduras for the period from 1990 to 2020 showed that such a relationship can be significant only if the accumulation of human potential in the country occurs in full, which is especially important for poor countries.

Thus, increasing the financing of education in general contributes to the strengthening of the country's economy. But there is both a direct and an inverse relationship between government spending on education and the level of economic development of the country. In accordance, the country's economic growth is able to ensure a further increase in investment in education. However, in most scientific works, only one of the directions of this connection is considered, namely the impact of the amount of public spending on education on the economic growth of the country. The feedback, which reflects the impact of the level of economic development of the country on the state spending on education, is not yet sufficiently worked out. This determines the need to analyse such a connection and the relevance of this study. The purpose of the article was to assess the relationship between macroeconomic indicators and education government expenditure for Ukraine, the countries of the European Union and the most developed countries of the world. The tasks of this study were: analysis of the impact of the total volume of GDP and purchasing power parity (PPP) on the total amount of government expenditure on education and expenditure on education per capita for 63 countries of the world in 2020 using econometric models, based on spatial data; building a dynamic model describing the correlation between education government expenditure and GDP in Ukraine for 2001-2022.

● LITERATURE REVIEW

The study of the factors influencing the government expenditure on education is considered by scientists from different points of view: optimizing the management of educational resources, determining the impact of spending on education on the development of the country's economy, and the effectiveness of education itself. In September 2022, the Summit "Transformation of Education" was held, where reports from 48 countries were presented (Report on the 2022 transforming..., 2023). The leading idea of this Summit is formulated as the need to rethink the purpose and content of education in the 21st century. Development of education, improvement of educational technologies should become priority tasks and determine government policy in the field of education. The transformation of education can ensure quality education for all and the possibility of lifelong learning. It is necessary

to develop scientific approaches to the distribution of educational resources, improve the level of management of educational resources, and expand the scope of technological and innovative education. Education financing is a critically important issue for ensuring the functioning of the country's education system. The list of issues that require constant attention from the government and non-governmental organizations, not only at the local level, but also at the international level, includes issues related to funding sources, the amount of funds and the structure of their distribution, and ensuring the effectiveness of the use of these funds. One of such international organizations is the US Agency for International Development, which provides non-military assistance to other countries, particularly in the field of education. Its activities in this field are aimed at maintaining the stability of the education system functioning (Hurley *et al.*, 2019).

G. Sart *et al.* (2022) emphasize the importance of identifying factors that influence the level of education. Their article investigated the impact of the use of information and communication technologies on the level of education in individual EU member states during 2000-2018 according to the index of information and communication technologies and the index of globalization. G. Patel & M.S. Annapoorna (2019) attempted to draw attention to and stimulate debate on the role of government in human potential development in India by analysing the relationship between public expenditure on education and levels of human resource development. According to data from 1990-2020 by S. Kousar *et al.* (2023) noted the positive impact of current expenditure on health care, social protection, public expenditure on education and foreign direct investment on human potential formation in Pakistan. N. Mehmetaj & X. Nevila (2022) based on the analysis of the impact of education expenditures found that the causal relationship between the real rates of economic growth and the unemployment rate among the youth of Albania is short-term, namely, if the total state expenditure on education increases by 1%, then the unemployment rate among young people decreases by 10.81%. Similarly, but to a lesser extent, is the long-run causality found between government spending on education and the unemployment rate among young graduates. M.M.A. Mohamed *et al.* (2022) considered the costs of education as one of the components of the knowledge economy and investigated their impact on economic growth in 20 developed countries for the period 1996-2020. M. De Ridder *et al.* (2020) examined how expenditure on Federal Pell Grants for education affects local income levels for various US cities. N. Rambeli *et al.* (2021) showed that there was a long-run equilibrium relationship between government spending on education and economic growth during the post-crisis recovery regime in Malaysia. D.J. Deming (2022) identified that issues of education and its financing are attracting increasing attention from researchers in part because people around the world are spending much more money and time on education than they did half a century ago. Between 1950 and 2010, the share of the world's adult population with at least some secondary education increased from 13% to 51%, and the share of people with tertiary education

increased from 2.2% to 14.6%, nearly sevenfold. During this time, spending on education in the United States rose from 3.1% of GDP in 1950 to 7.1% in 2018, with most of the increase coming from the public sector.

The analysis of scientific works in which the relationship between education government expenditure and indicators of economic growth of different countries is studied, showed that the least researched is the following question: how does the volume of the country's GDP and PPP affect not only the general level of government spending on education, but also the level of expenditure per capita. Studying this issue on the example of the experience of the most developed countries would make it possible to develop recommendations for optimizing the ways of Ukraine's development.

● MATERIALS AND METHODS

When constructing econometric models based on spatial data, statistical data reflecting the main economic indicators of the studied countries for 2020 were used. This is due to the fact that although the World Bank provides information on GDP and PPP of countries for 2022 as well, data on public spending on education for almost all countries is given only as of 2020. Statistical data for Ukraine, which were used in the construction of dynamics models, are presented from 2001 to 2022 inclusive.

The study was conducted on the example of 63 countries. Among them are 57 countries that, according to the rating of the U.S. News, are classified as the most influential countries in the world (Ranked: World's most influential countries, 2021). The ranking is based on the results of a global survey of more than 280,600 experts, including politicians and business leaders. Ukraine is also included in the ranking of the most influential countries in the world, which took 42nd place. In this study, the list of countries was supplemented by EU member states. According to the World Bank, in the countries under study, government expenditure on education ranges from 2.4% (Pakistan, 56th place in the rating) to 7.8% (Saudi Arabia, 12th place in the rating) (Government expenditure..., 2020a). On average, this is 4.86% of GDP. Although in terms of percentages, such dispersion looks insignificant, but the GDP of the specified countries differ tenfold, therefore, in monetary terms, the difference in government expenditure on education is quite large.

The countries considered in this study differ significantly in terms of population size and quality of life, therefore, in the study of economic factors that affect the amount of government expenditure on education, along with the total GDP, the amount of GDP per capita, taking into account the exchange rate, was taken into account the country's currency in relation to the dollar, i.e., purchasing power parity (PPP). The influence of these macroeconomic factors on the per capita government expenditure on education was considered. There are almost no studies examining the latter indicator in such a context. When calculating this indicator, in this research, it is proposed for each country to use the coefficient resulting as the ratio of its PPP to its GDP. Data on the total volume of GDP and PPP for 2020 for the studied countries are shown in Table 1.

Table 1. The total volume of GDP of countries for 2020 (billion USD) and the volume of PPP (thousands of USD)

No.	Country	GDP	PPP	No.	Country	GDP	PPP	No.	Country	GDP	PPP
1	Argentina	385.54	20.76	22	India	2,667.69	6.45	43	Philippines	361.75	8.20
2	Australia	1,326.90	53.07	23	Indonesia	1,058.69	12.19	44	Poland	599.45	35.32
3	Austria	435.22	57.00	24	Iran	239.74	15.22	45	Portugal	229.01	34.88
4	Belarus	62.37	20.28	25	Ireland	425.85	93.95	46	Qatar	144.41	93.89
5	Belgium	525.21	54.20	26	Israel	413.27	39.62	47	Romania	251.36	33.34
6	Brazil	1,114.56	14.79	27	Italy	1,896.76	43.04	48	Saudi Arabia	703.32	45.24
7	Bulgaria	70.24	25.30	28	Japan	5,040.11	41.61	49	Serbia	53.36	19.56
8	Canada	1,645.42	47.13	29	Jordan	44.08	9.71	50	Singapore	345.29	99.68
9	China	1,468.67	17.19	30	Korea, Rep.	1,644.31	44.69	51	Slovak Republic	106.70	32.44
10	Croatia	57.47	29.69	31	Kuwait	105.96	46.33	52	Slovenia	53.71	40.78
11	Cyprus	25.01	41.42	32	Latvia	34.60	32.11	53	South Africa	337.62	13.52
12	Czechia	245.97	42.72	33	Lithuania	56.85	39.92	54	Spain	1,276.96	38.12
13	Denmark	355.22	60.98	34	Luxembourg	76.99	118.97	55	Sweden	547.05	55.57
14	Egypt	365.25	12.00	35	Malta	14.93	44.59	56	Switzerland	739.91	72.00
15	Estonia	31.37	38.54	36	Malaysia	337.34	27.24	57	Thailand	499.68	17.77
16	Finland	271.89	52.29	37	Mexico	1,090.52	18.52	58	Turkey	720.29	27.72
17	France	2,639.01	47.98	38	Netherlands	909.79	60.09	59	Ukraine	156.62	13.09
18	Germany	3,889.67	55.85	39	New Zealand	211.73	45.38	60	Un. Arab Emirates	349.47	71.37
19	Greece	188.93	28.4	40	Norway	362.20	64.17	61	United Kingdom	2,704.61	46.76
20	Hong Kong	344.93	58.95	41	Oman	75.91	34.91	62	United States	21,060.47	63.03
21	Hungary	157.18	34.06	42	Pakistan	300.42	5.28	63	Vietnam	346.63	11.02

Source: developed by the authors based on GDP (current US\$) (2020), GDP per capita, PPP (current international \$) (2020)

Based on the data of Table 1 and the World Bank (Government expenditure..., 2020a), the total amount of government expenditure on education for each coun-

try was determined in monetary terms, as well as the amount of government expenditure per capita was calculated (Table 2).

Table 2. Total education government expenditure for 2020 (billion USD) and per capita government expenditure for education (thousands of USD)

No.	Country	General costs	Specific costs	No.	Country	General costs	Specific costs	No.	Country	General costs	Specific costs
1	Argentina	19.28	1.04	22	India	120.05	0.29	43	Philippines	13.38	0.30
2	Australia	80.94	3.24	23	Indonesia	37.05	0.43	44	Poland	35.32	1.84
3	Austria	22.20	2.91	24	Iran	8.63	0.55	45	Portugal	11.45	1.74
4	Belarus	2.88	0.95	25	Ireland	13.20	2.91	46	Qatar	4.62	3.00
5	Belgium	35.19	3.63	26	Israel	29.34	2.81	47	Romania	9.30	1.23
6	Brazil	86.91	0.89	27	Italy	81.56	1.85	48	Saudi Arabia	54.86	3.53
7	Bulgaria	2.81	1.01	28	Japan	171.36	1.41	49	Serbia	1.92	0.70
8	Canada	85.56	2.45	29	Jordan	1.41	0.31	50	Singapore	9.67	2.76
9	China	528.76	0.62	30	Korea, Rep.	77.28	2.10	51	Slovak Republic	4.91	1.49
10	Croatia	3.16	1.63	31	Kuwait	6.99	3.06	52	Slovenia	3.12	2.37
11	Cyprus	1.53	2.53	32	Latvia	2.08	1.93	53	South Africa	22.28	0.89
12	Czechia	12.54	2.18	33	Lithuania	2.27	1.60	54	Spain	58.74	1.75
13	Denmark	23.73	3.90	34	Luxembourg	3.85	5.95	55	Sweden	39.39	4.00
14	Egypt	9.13	0.30	35	Malta	0.88	2.63	56	Switzerland	38.48	3.74
15	Estonia	2.07	2.54	36	Malaysia	13.16	1.06	57	Thailand	15.49	0.55
16	Finland	16.04	3.09	37	Mexico	46.89	0.80	58	Turkey	24.49	0.94
17	France	145.15	2.64	38	Netherlands	48.22	3.18	59	Ukraine	8.46	0.71
18	Germany	182.81	2.62	39	New Zealand	12.70	2.72	60	Un. Arab Emirates	13.63	2.78
19	Greece	8.32	1.25	40	Norway	21.37	3.79	61	United Kingdom	148.75	2.57
20	Hong Kong	13.80	2.36	41	Oman	34.91	1.89	62	United States	1,284.69	3.84
21	Hungary	7.54	1.63	42	Pakistan	7.21	0.13	63	Vietnam	14.21	0.45

Note: the serial number of the country from Table 1 remains in Table 2

Source: developed by the authors based on GDP (current US\$) (2020), GDP per capita, PPP (current international \$) (2020), Government expenditure on education, total (% of GDP) (2020a)

More detailed studies of the relationship between indicators of the level of economic development of the country and government expenditure for education were carried out on the example of Ukraine. To build an

econometric model of dynamics, the time period from 2001 to 2022 was chosen. Data on the total volume of GDP, PPP and population for this period are shown in Table 3.

Table 3. Nominal GDP of Ukraine (billion USD), PPP (current international \$) and population (million people) for 2001-2022

No.	Year	GDP	PPP	Population size	No.	Year	GDP	PPP	Population size
1	2001	39.31	4,789.7	48.66	12	2012	182.59	9,705.4	45.58
2	2002	43.96	5,173.0	48.23	13	2013	190.50	11,111.1	45.48
3	2003	52.01	5,824.1	47.80	14	2014	133.50	10,743.6	43.72
4	2004	67.22	6,736.8	47.45	15	2015	91.03	10,164.3	42.84
5	2005	89.24	7,214.1	47.09	16	2016	93.36	11,148.2	42.67
6	2006	111.88	8,054.0	46.77	17	2017	112.09	11,860.6	42.48
7	2007	148.73	9,004.9	46.50	18	2018	130.89	12,633.5	42.27
8	2008	188.11	9,434.4	46.24	19	2019	153.88	13,348.0	42.02
9	2009	121.55	8,093.6	46.04	20	2020	156.62	13,102.8	41.76
10	2010	141.21	8,559.9	45.86	21	2021	199.77	14,289.0	41.39
11	2011	169.33	9,246.8	45.69	22	2022	160.50	12,671.2	41.15

Source: developed by the authors based on Gross domestic product (GDP) in Ukraine (2023); GDP per capita, PPP (current international \$) – Ukraine (2022); Population, total – Ukraine (2022)

Data on government expenditure on education as a percentage of GDP and in monetary terms for the period

from 2001 to 2022, as well as the results of calculating education deductions per capita are given in Table 4.

Table 4. Government expenditure on education in Ukraine for 2001-2022 (% of GDP)

No.	Year	General costs, % GDP	General costs, billion USD	Specific costs, USD	No.	Year	General costs, % GDP	General costs, billion USD	Specific costs, USD
1	2001	4.5	1.77	170.41	12	2012	6.4	11.69	621.15
2	2002	5.2	2.29	215.54	13	2013	6.4	12.19	711.11
3	2003	5.4	2.81	269.00	14	2014	5.9	7.88	633.87
4	2004	5.1	3.43	314.50	15	2015	5.7	5.19	579.37
5	2005	5.8	5.18	343.58	16	2016	5.0	4.67	557.41
6	2006	6.0	6.71	418.42	17	2017	5.4	6.05	640.47
7	2007	5.9	8.78	483.24	18	2018	5.3	6.94	669.48
8	2008	6.2	11.66	531.29	19	2019	5.4	8.63	720.65
9	2009	7.1	8.63	584.93	20	2020	5.4	8.46	706.71
10	2010	7.4	10.45	574.65	21	2021	5.4	10.81	767.87
11	2011	5.9	9.99	545.56	22	2022	4.8	7.40	584.21

Source: developed by the authors based on Government expenditure on education, total (% of GDP) – Ukraine (2020b), Expenses by function (2022), Gross domestic product (GDP) in Ukraine (2023), GDP per capita, PPP (current international \$) – Ukraine (2022)

The data from the tables was used in the course of the study to build econometric models. The least squares method (LSM) was used to build the models, the basis of which is the requirement to minimize the sum of squares of random errors. The application of LSM requires the fulfilment of certain conditions, which are formulated in the form of the Gauss-Markov theorem. According to this theorem, one of the requirements for building multivariate regression models is the absence of a tight correlation between exogenous (external) factors. To verify the fulfilment of this condition and to assess the significance of the influence of external factors on the internal (endogenous) factor, the Pearson pair correlation coefficients were calculated between all factors that were included in the model. When constructing all regression models, variables were defined in the units of measurement in which they are listed in the corresponding tables.

Another of the provisions of the Gauss-Markov theorem regarding the possibility of using LSM to build a regression model is the homoskedasticity of model residuals. This means that all observations must have the same variance, that is, the dispersion associated with random errors must be the same for all values of the external factor. Since among the data selected for the construction of the econometric model, there is a significant range in the GDP values of different countries, the data were checked for the presence of heteroskedasticity. To check the Goldfeld-Quandt statistical test was applied. The quality check of the model as a whole was carried out according to Fisher's criterion, to evaluate the significance of each of the parameters of the model, the Student's criterion was applied separately. All calculations that were carried out when building econometric models, checking the quality of these models and

evaluating the significance of their parameters were carried out using the MS Excel spreadsheet processor.

● **RESULTS AND DISCUSSION**

The construction of a mathematical model based on empirical data, which describes the dependence of the level of education costs on GDP both in total and per capita, allows to determine the effectiveness of investing funds in the development of the educational sector and to identify possible ways of its optimization. To determine the influence of economic factors on the total volume of education government expenditure, a multivariate regression model was built, based on the data of Tables 1 and 2. Since education government expenditure per capita were calculated as a share of total expenditures on education taking into account the proportionality coefficient, and the ratio of GDP per capita to the total volume of GDP was chosen as this coefficient, then these four indicators are functionally related, so one of them had to be excluded from the model. The primary model included the following factors: the total volume of government expenditure on education (y_0), which is an internal (exogenous) factor, and also the total volume of GDP (x_1) and the volume of GDP per capita (x_2) were chosen as endogenous (external) factors. A preliminary check of the pairwise correlation coefficient between external factors showed that it is equal to 0.035, therefore, there is no multicollinearity between these factors, they can be simultaneously present in the model. A close correlation between total education government expenditure and GDP (pairwise correlation coefficient is 0.975) and a close correlation between GDP per capita and per capita education expenditures (pairwise correlation coefficient is 0.874) were revealed. For the model with two external factors, the regression equation is:

$$y_0 = -16.89 + 0.052x_1 + 0.32x_2 + e, \tag{1}$$

where e is random model error. For the regression model (1), the following value of the coefficient of determination was obtained: $R^2 = 0.9477$, i.e., 94.77% of the variability of the total amount of government expenditure on education is related to the influence of the factors present in the model. The empirical value of Fisher’s test is 543.5, which is much higher than the critical one, thus at the significance level $\alpha = 0.05$ the critical value of Fisher’s test is $F_{0.05}(2;60) = 3.15$. It follows that the model is significant in general. Checking the significance of each of the parameters of the model according to the Student’s test showed that only the regression coefficient for the variable (x_1) corresponding to GDP is significant. The empirical value of the Student’s criterion was $t_{em} = 32.86$. For the free term of the equation, $t_{em} = 1.65$, and for the regression coefficient for the variable (x_2), which corresponds to GDP per capita, $t_{em} = 1.47$. But for the significance level $\alpha = 0.05$, the critical value of the Student’s test is $t_{0.05}(df_e = 60) = 2.00$. Therefore, the model can be provided as:

$$y_0 = 0.052x_1 + e. \tag{2}$$

As a result, the coefficient of determination increased to 0.9513. It should be noted that the regression coefficient in model (2) exceeds the population mean of share of GDP allocated to education. For the sample population as a whole, its value is 0.048. Such a difference means that the law of distribution in this population is not normal, but has a significant positive asymmetry, i.e., there are some countries for which the total volume of GDP is significantly larger than for other countries. This is also confirmed by the graph of the dependence of the general level of education government expenditure on the GDP of the country (Fig. 1).

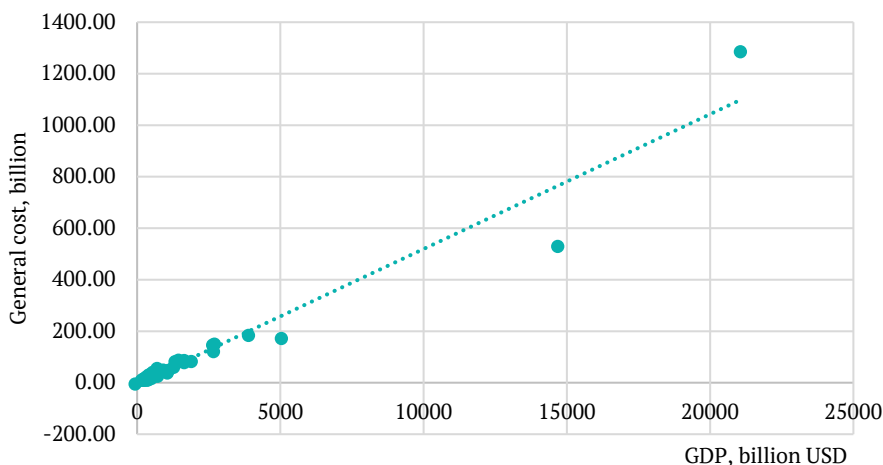


Figure 1. Dependence of the total amount of education government expenditure on the country’s GDP

Source: developed by the authors based on the data presented in the Table 1 and Table 2

However, state financing of education involves spending on the creation and development of the education system as a whole and on ensuring the opportunity to receive education for each citizen of the country separately. The countries under consideration have a sufficiently developed system of educational institutions, so it is appropriate to consider not only the total amount of government

expenditure on education, but also the amount of government expenditure per capita. Therefore, an econometric model was built, for which the volume of education government expenditure per capita (y) was considered as an internal factor, and the volume of GDP per capita (x_2) was considered as an external factor. Such a model is represented by a pairwise regression equation of the form:

$$y = 0.196 + 0.045x_2 + e. \tag{3}$$

$$y = 0.048x_2 + e. \tag{4}$$

For model (3), the coefficient of determination is 0.7644, that is, the model as a whole is significant. The significance check of the model parameters showed that for the free term of the equation, the empirical value of the Student's criterion is $t_{em} = 1.32$, while the critical value of the Student's criterion is $t_{0.05}(df_2 = 61) = 2.00$. The free term of the equation can be excluded from the model, and the regression equation takes the form:

For model (4), the regression coefficient is equal to the mean of the share of GDP allocated on education, and the coefficient of determination of this model is 0.9355, i.e., it has increased compared to model (3). To compare countries by the level of government expenditure on education, it is advisable to consider not the total volume of expenditure, but the volume of expenditure per capita. A graphic illustration of model (4) is shown in Figure 2.

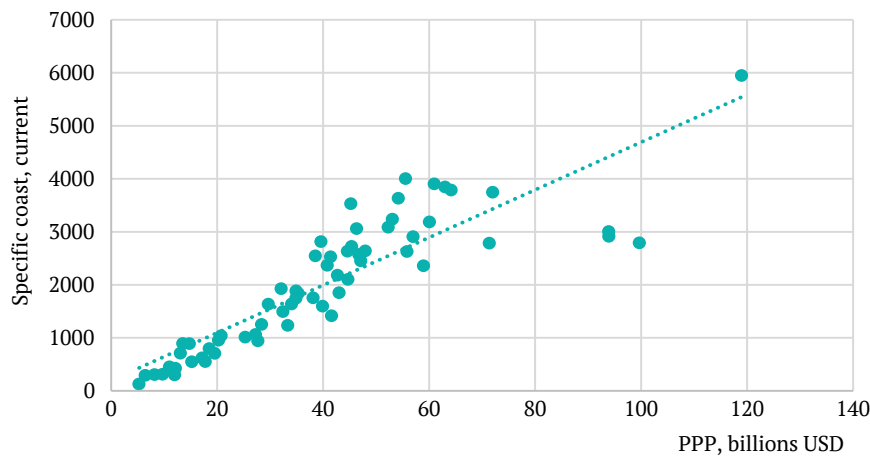


Figure 2. Dependence of education government expenditure per capita on the PPP

Source: developed by the authors based on the data presented in Table 1 and Table 2

The analysis of the dispersion of empirical points relative to the trend line in Figure 2 shows that the random errors of the econometric model increase as the value of the external factor increases. This suggests that heteroscedasticity may be present for this sample population. According to the algorithm of the Goldfeld-Quandt test, to test this

hypothesis, the countries were ordered by the growth of PPP and divided into three parts. The first 21 countries with the lowest PPP values and the last 21 countries with the largest PPP values from the list of countries were selected for the further study. For convenience, Table 5 shows the data for both groups, for which these groups will be compared.

Table 5. Volume of PPP and education government expenditure in calculation per capita for 2020 (current international \$) for countries with the lower and upper values of PPP

Countries with the low GDP per capita				Countries with the upper GDP per capita			
No.	Country	PPP	Specific costs	No.	Country	PPP	Specific costs
42	Pakistan	5,278	127	31	Kuwait	46,328	3,058
22	India	6,449	290	61	United Kingdom	46,759	2,572
43	Philippines	8,199	303	8	Canada	47,127	2,451
29	Jordan	9,707	311	17	France	47,976	2,639
63	Vietnam	11,023	452	16	Finland	52,296	3,085
14	Egypt	12,004	300	2	Australia	53,066	3,237
23	Indonesia	12,146	425	5	Belgium	54,202	3,631
59	Ukraine	13,087	707	55	Sweden	55,569	4,001
53	South Africa	13,518	892	18	Germany	55,854	2,625
6	Brazil	14,790	887	3	Austria	57,000	2,907
24	Iran	15,223	548	20	Hong Kong SAR, China	58,950	2,358
9	China	17,189	619	38	Netherlands	60,091	3,185

Table 5, Continued

Countries with the low GDP per capita				Countries with the upper GDP per capita			
No.	Country	PPP	Specific costs	No.	Country	PPP	Specific costs
57	Thailand	17,771	551	13	Denmark	60,980	3,903
37	Mexico	18,522	796	62	United States	63,028	3,845
49	Serbia	19,558	704	40	Norway	64,167	3,786
4	Belarus	20,278	953	60	United Arab Emirates	71,371	2,783
1	Argentina	20,763	1,038	56	Switzerland	71,991	3,744
7	Bulgaria	25,296	1,012	46	Qatar	93,894	3,004
36	Malaysia	27,246	1,062	25	Ireland	93,951	2,912
58	Turkey	27,724	0,942	50	Singapore	99,681	2,791
19	Greece	28,428	1,250	34	Luxembourg	118,973	5,949

Note: the number of the country in Table 5 coincides with its number in all other tables

Source: developed by the authors based on the data presented in Table 1 and Table 2

Pairwise regression models were constructed for each of the two groups of countries. For countries with lowest values of the PPP, the regression equation describing the dependence of education government expenditure per capita (y_L) on the volume of GDP per capita has the following form:

$$y_L = 0.041x_2 + e. \quad (5)$$

For model (5), the coefficient of determination is 0.9623, and the residual sum of squares of the model is $RSS_L = 0.4356$. For countries with upper values of the PPP, the regression equation describing the dependence of education government expenditure per capita (y_U) on the volume of GDP per capita has the following form:

$$y_U = 0.047x_2 + e. \quad (6)$$

For model (6), the coefficient of determination is 0.9306, and the residual sum of squares of the model is $RSS_U = 16.3636$. Based on the obtained results, an F -statistic was constructed, taking into account the fact that both groups have the same number of countries selected for the study:

$$F = \frac{RSS_U}{RSS_L}. \quad (7)$$

According to the ratio (7), it was obtained that $F = 37.56$, while the critical value of Fisher's test at the significance level $\alpha = 0.05$ is equal to $F_{0.05}(20;20) = 2.12$. Since the empirical value of the F -statistic exceeds the critical one, it can be asserted with 95% confidence that for the studied population of 63 countries, heteroskedasticity is statistically significant. For countries with a low level of PPP, differences in per capita education government expenditure are significantly smaller than for countries with a high level of PPP. For example, both Ireland and Singapore have the PPP, which is almost twice that of Finland or Australia, while education government expenditure per capita for these countries is lower than in Finland and Australia. Such results are debatable and require further investigation.

It can be assumed that the heteroskedasticity that was found in this study is conditional. This means that although

all the proposed econometric models have a large coefficient of determination, there are some factors that were not taken into account when building the model. These can be factors related to the specialization of the economy of this country, or historical traditions, etc. For example, when looking at the education government expenditure in Australia, it is worth paying attention to the work of B. Bentley *et al.* (2022), in which the issue of STEM education (Science, Technology, Engineering and Mathematics) is considered. This country's public policy aligns with future fiscal targets, which suggest that Australia's economic future is tied to the development and use of STEM. That is why significant funds are being directed to education, and with them are growing educational services related to STEM, which is becoming a matter of national priority. The assumption regarding the influence of a certain direction of the national education policy on education government expenditure is consistent with the material of the work of M. Nikšić Radić & H. Paleka (2020), where the cause-and-effect relationship between spending on higher education and GDP in Croatia was investigated using variance analysis. The authors believe that in the future government expenditure on higher education should be increased, which will allow to accelerate economic growth and create conditions for sustainable development. Therefore, the results of this study have important political implications, as they draw the attention of the government to the importance of improving higher education as a way to ensure the country's competitiveness.

Indirect confirmation of the fact that, in addition to financial support, the direction of state policy in this field, as well as the education system itself, the general culture of the population, national traditions, etc., are important for the effectiveness of the educational process, are the results of the international comparative study The Trends in International Mathematics and Science Study (TIMSS), which was carried out by the National Center for Education Statistics under the US Department of Education among 4th-graders and 8th-graders in mathematics and science (International comparisons..., 2021). The results of the study are presented in Figure 3.

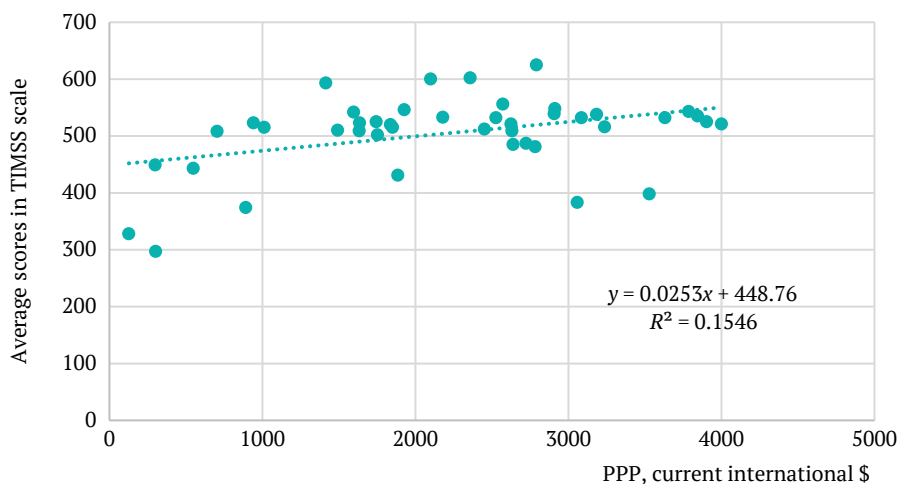


Figure 3. The average score of the mathematics and science skills of 4th-graders and 8th-graders according to the TIMSS scale, depending on the country's PPP

Source: developed by the authors based on GDP per capita, PPP (current international \$) (2020), International comparisons: Mathematics and science achievement at grades 4 and 8 (2021)

Along with the graph, Figure 3 also shows the equation of the trend line and the value of the coefficient of determination. There is a positive correlation between the country's PPP and students' achievements in mathematics and science, but only 15.46% of the variability of the average score is determined by the influence of the PPP. A similar conclusion can be reached based on the analysis of the re-

sults of the Program for International Student Assessment (PISA), which assesses reading, mathematics and science skills among 15-year-old students (Yau, 2022). Figure 4 shows the scores in reading, mathematics, and science obtained by schoolchildren from the country's groups with, respectively, the lower and upper amount of PPP among the studied countries, using the example of several countries.

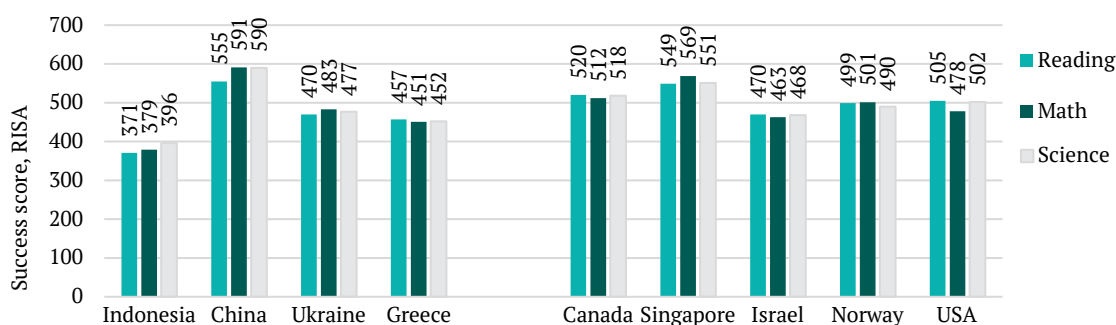


Figure 4. The average score of 15-year-old students in reading, mathematics, and science according to RISA data for the least and most well-off countries by the level of the PPP

Source: developed by the authors based on N. Yau (2022)

Therefore, the conducted studies confirm the existence of a close correlation between the PPP and education government expenditure per capita. However, the significant dispersal of indicators of the quality of education, observed for countries with a high level of PPP, indicates that in the future, an important issue is the analysis of the effectiveness of these costs in the light of comparing the priorities of state policy in the field of education for different countries. Ukraine's economic policy regarding state financing of education needs to be considered in more detail. For this, in addition to spatial regression models, it is necessary to apply dynamics models to investigate this problem.

Ukraine is a country with an average level of economic development, in terms of GDP in different years according to World Bank ratings, it was in the 50-100th place in the world (GDP (current US\$), 2020). For example, in 2022,

Ukraine ranked 57th among 196 countries in the world (GDP by country, 2023). According to the rating of the world's most influential countries, Ukraine took 42nd place (Ranked: World's most influential countries, 2021). Government expenditures on education as a percentage of GDP in Ukraine average 5.4%, which corresponds to the level of similar expenditures in the countries of EU and OECD (Organization for Economic Cooperation and Development) (Government expenditure..., 2020a). However, in monetary terms, per capita or even per student, these indicators are different in different countries. In Ukraine in 2020, government expenditure on education per capita amounted to \$710, while in Poland they were equal to \$1,840, in Latvia – \$1,930, in Estonia – \$2,540 (Table 2). Note that education government expenditure with the same percentage could be larger in monetary terms if there were no shadow

economy in Ukraine, the share of which, according to the National Bank of Ukraine’s assessment in 2019, was 25% (Research on the shadow economy..., 2020). According to

statistic data (GDP per capita..., 2022), such an economic indicator as GDP per capita is growing in Ukraine in the period from 2001 to 2022 (Fig. 5).

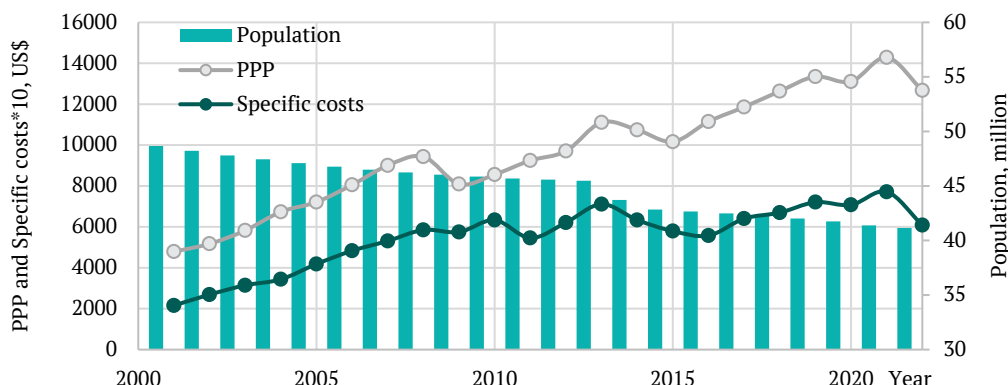


Figure 5. Dynamics of GDP and education government expenditure per capita and population of Ukraine for the period from 2001 to 2022

Source: developed by the authors based on GDP per capita, PPP (current international \$) – Ukraine (2022), Gross domestic product (GDP) in Ukraine (2023)

Such an increase in education government expenditure per capita is due not only to GDP growth, but also to a steady decrease in the population (Population, total – Ukraine, 2022). As evidenced by the results of the calculation of education expenditure per capita, the nature of changes in this indicator during the period from 2001 to 2013 repeats the nature of changes in the PPP, and the growth rate averaged 11% per year. Starting in 2015, PPP continues to grow at about the same rate, while education government expenditure also grows, but at a much slower rate. The average rate of growth of government expenditure on education decreased to 5% per year. Therefore, the data for the period 2001-2022 cannot be considered as a homogeneous population.

Despite the fact that education government expenditure in Ukraine are much smaller than in EU countries, as well as in countries with highly developed economies, the level of education in Ukraine is quite high (Figure 4). Knowledge and skills in science, especially skills in mathematics, adequately reflect a person’s ability to obtain a high-quality higher education, as it forms a person’s logic and consistency of thinking, the ability to justify his judgments and conclusions and further realize himself in a professional activity (Ponomarenko, 2020). For example, Israeli schoolchildren (470, 463 and 468) and Luxembourgish schoolchildren (470, 489 and 477) received approximately the same scores as Ukrainian schoolchildren, although Luxembourg belongs to the countries with a high level of PPP and a high level of education government expenditure per capita. However, schoolchildren from Poland received 512, 516 and 511 scores, from Estonia – 436, 523 and 530 scores, respectively. The highest level according to these indicators belongs to China, whose students received 555, 591 and 590 scores (Yau, 2022). Per capita government expenditure on education in 2020 was \$619 in China and \$707 in Ukraine, the largest per capita government expenditure on education is in Luxembourg, it reaches \$5,949 (Table 5). This once again proves that, in addition to the economic support of the educational process, attention should be

paid to the motivation of students and the education system should be improved.

When calculating education government expenditure per capita, the size of the entire population was taken into account, as well as the purchasing power parity of the national currency. However, education government expenditure is not distributed to the entire population, but mainly to young people aged 5 to 25. This contingent in Ukraine in 2020 was 21.47% of the total population (Age structure..., 2022). In fact, in 2020, \$3,239 were allocated to each Ukrainian studying. To determine the main factors affecting the level of education government expenditure per capita, an econometric model was built, for which the volume of education government expenditure per capita (y) was considered as an internal factor, and as external factors in the model total GDP (x_1) and population size (x_2) were included. Such a model is represented by a multivariate regression equation of the form:

$$y = 1741.99 + 1.85x_1 - 31.73x_2 + e. \quad (8)$$

For model (8), the coefficient of determination is 0.9050, therefore, only 9.5% of the variability of the amount of education government expenditure is determined by the influence of factors, which were not included in the model. The test showed that the model is significant overall by Fisher’s test, and all parameters of this model are significant by Student’s test. The correlation coefficient between external factors, which are GDP per capita and population size, is negative and amounts to -0.4995. Since the correlation between these factors exists, but is not tight, both external factors can be present in the model without violating the conditions of the Gauss–Markov theorem. A model with lagged variables was built to test the effect of GDP of previous years on education government expenditure in the current year. This made it possible to test the assumptions about the existence of a cumulative effect. This model looks like this:

$$y_o = -0.32 + 0.061x_{t-1} - 0.009x_{t-2} + 0.023x_{t-2} + e, \quad (9)$$

where y_t is total government expenditure on education in the current year; x_t is GDP of the current year; x_{t-1} is GDP of the previous year; x_{t-2} is GDP, which was obtained 2 years ago. At the first stage, a model containing information on 5 lag variables was considered, however, starting with the variable x_{t-3} , the regression coefficients were already an order of magnitude smaller than the regression coefficient for the variable x_{t-1} . That is why only 2 lag variables were left in the model. According to Fisher's test, model (9) is significant in general, and the coefficient of determination for it is 0.8758. However, according to Student's test, only the regression coefficient before x_t is significant, that is, only the effect of the current year's GDP is significant. This made it possible to conclude that during the studied period the cumulative effect was not observed, which in turn determines the lack of state planning for the future.

Ensuring the conditions for economic growth in Ukraine requires the accumulation and use of the experience of the leading countries of the world, which determines the importance of analysing the dynamics of government expenditure on education, evaluating efficiency of their use and the dependence of the volume of these expenses on the level of the most important macroeconomic indicators. The term "economic growth" implies an increase in such economic indicators as real national income, gross domestic product, per capita income (Radionov, 2019), although the most common macroeconomic indicator used to obtain objective information about the state of the country's economy, and also allows identifying and measuring reserves to ensure its sustainable development, is GDP. It should be emphasized that this paper considers the approach to financing education at the state level, while in addition to the macro level, this problem can be considered at the meso- or micro-level, that is, at the level of an individual family (Li, 2021; Rahman *et al.*, 2023). This is due to the fact that attention is paid to such an aspect of the problem as the development of human potential at the state level, and the financing of education from the side of the state was considered as the implementation of a policy aimed at accumulating human potential.

Since education is financed not only from the state budget, but also from the local budget, total education expenses can be considered as a percentage of the consolidated budget expenses (Komarova, 2011). However, for Ukraine, there is a significant difference between the values of this indicator for different regions. In 2020, for the country as a whole (i.e., at the macro level), state expenditures on secondary education per student amounted to UAH 24.7 thousand, but in the Kharkiv region (at the meso level) it amounted to only UAH 21.7 thousand, while in Luhansk, it was equal to UAH 30.2 thousand. (Budget expenditures..., 2021). If the average amount of spending on education in Ukraine is considered as a percentage of the consolidated budget, then for the period from 2015 to 2021, in percentage terms, this indicator ranged from 15.49% to 16.97%, although in monetary terms a rather slow growth was observed (Expenditures of the consolidated..., 2023). However, in 2022 this indicator fell to 9.55%, and in 2023 – to 7.84%. Such a significant drop in education expenditure is associated with an increase in defence expenditure. If in 2021 this indicator was 6.91%, then in 2023 it increased to 48.62%. If these results are

compared with the data presented in Figure 5, it can be concluded that at the macro level, the same regularities are observed regarding the dynamics of changes in economic indicators.

In contrast to the above-mentioned studies (Efthaltidou *et al.*, 2021), the results presented in this article confirm the hypothesis of the presence of the influence of the total volume of GDP and PPP on the total amount of government expenditure on education and per capita expenditure on education. Due to the increase in the number of researched countries and the selection of the most developed countries of the world as research objects, the spatial coverage of the problem was expanded. The substantive characteristics of the influence of GDP on the implementation of educational policy at the state level have been clarified thanks to the consideration of per capita education government expenditure. This approach can be considered a further development of the work of A.C. Coman Nuță *et al.* (2023), which conducted a thorough analysis of the impact of public education spending over the years 1990–2020 on economic growth in 11 former socialist republics of Eastern Europe that acquired EU membership. These researchers noted that education government expenditure as the percentage of GDP is different in the countries of Eastern Europe. The lowest percentage of GDP allocated to education was inherent Romania (3.35% of GDP), followed by Bulgaria (3.72% of GDP), Slovakia (4.11%) and the Czech Republic (4.19%). In other countries of Eastern Europe, a higher percentage of GDP is allocated to education financing (Poland – 4.9%, Hungary – 5.1%, Latvia – 5.36%, Estonia – 5.4%, Slovenia – 5.47%). The analysis of data relative to individual EU member states, including countries whose economy was planned in the past, confirms the presence of a statistically significant relationship between the level of population qualification and spending on higher education, as well as between GDP growth and the level of personnel qualification (Pelinescu, 2015; Agasisti & Bertoletti, 2022; Molchanova & Guliyeva, 2023).

This study has proven the feasibility of separating the analysis of the amounts of PPP and education government expenditure per capita for countries with the smallest and largest values of PPP. The difference between the built models clearly demonstrates the influence of the PPP, which is consistent with the conclusions of the study of M. Marto *et al.* (2022), which measured differences between EU regions in terms of GDP per capita and level of higher education. The econometric models proposed in this paper also complement the study of the evolution of people's well-being depending on GDP per capita (Wu *et al.* 2022), in which the relationship between the indicator of real progress and GDP per capita, and adjustment of social policy was analysed using statistical data of China during 1995–2017. The presence of a positive correlation relationship between human well-being and country's economic growth at the level of planning public spending on education can be explained as a means of ensuring the educational component of well-being through the development of human potential in both quantitative and qualitative terms.

The research, the results of which are presented in this article, complements existing scientific approaches, providing additional comparative information on how the GDP of countries and their PPP effect on education government

expenditure in Ukraine and in the world and also on the effectiveness of education. Determination of the impact of macroeconomic indicators characterizing the level of economic development of the country on education government expenditure, which was carried out on the example of the most influential countries in the world, allowed to clarify the idea of the density of the correlation between these factors. The analysis of the econometric models proposed in this study shows that it is appropriate to consider not so much the relationship between total education expenses and the volume of GDP, as is done in most researches, but the relationship between education expenses per capita and PPP. This result can be explained by the fact that the countries under consideration already have a sufficiently extensive education system and, accordingly, government expenditure are primarily aimed at creating conditions for the realization of the right to education by every citizen of the country.

● CONCLUSIONS

The study of the impact of the PPP on education government expenditure per capita made it possible to conclude that a close correlation between these factors is inherent only in countries with a not very large amount of PPP per capita, which includes Ukraine, but for countries with a high level of PPP per capita, there is a significant discrepancy this indicator for different countries. Although there is a positive correlation between educational effectiveness, as measured by PISA and TIMSS reading, mathematics and science performance, and government expenditure on education, this correlation is not strong. It is reasonable to assume that the effectiveness of education is high in those countries where the state motivates its citizens to achieve results. It is in these countries also the rapid economic growth is observed. Although the research indicates the existence of a close correlation between the volume of education government expenditure per capita and the PPP, in the future, an important issue is the analysis of the effectiveness of these expenditures and the determination of the

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priorities of the state policy in the field of education. The construction of a mathematical models based on empirical data, which describe the dependence of the level of education costs on GDP both in total and per capita, allows to determine the effectiveness of investing funds in the development of the educational sector and to identify possible ways of its optimization. The analysis of econometric models of dynamics shows that in Ukraine during 2015-2022, education funding lags behind the growth of GDP, but even such a small increase in education deductions per capita is largely due to the decrease in the population of Ukraine, but not an increase in funding. However, the effectiveness of education in Ukraine remains at a fairly high level, even if compared with some countries where education government expenditure per capita are much higher. At the stage of formation of the state education policy, the planning of government expenditure on education in Ukraine using the econometric models proposed in this article will contribute to the strengthening of the analytical justification of certain management decisions in the field of financing and the improvement of the evaluation mechanism of measures aimed at economic growth.

In further research, it is advisable to diversify the proposed models by adding new groups of countries and extending time periods. Also, in the future, the analysis of the effectiveness of public spending on education in countries with a high and low level of PPP should be considered an important direction. Supplementing the list of economic factors influencing the amount of education expenses in Ukraine with factors of an intangible nature will allow identifying promising directions for reforming the education sector and, as a result, will contribute to the growth of the country's economy.

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● CONFLICT OF INTEREST

None.

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Державні витрати на освіту в світлі парадигми сталого розвитку: економетричні просторові моделі та моделі динаміки

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Анотація. Економіка знань є парадигмою постіндустріального етапу розвитку суспільства, тому дослідження взаємозв'язку між рівнем основних економічних показників і державними витратами на освіту є актуальними. Метою даної статті було оцінювання впливу основних економічних показників на державні витрати на освіту як у загальному обсязі, так і в розрахунку на душу населення. Економетричні моделі побудовано з використанням просторових даних і моделі динаміки, проведено тест Голдфелда-Квандта. Дослідження проводилося на прикладі найвпливовіших країн світу та країн-членів Євросоюзу. Показано, що зростання загального обсягу валового внутрішнього продукту та паритету купівельної спроможності супроводжується зростанням загального обсягу державних відряджень на освіту та відряджень на освіту в розрахунку на душу населення. Для країн із відносно низьким паритетом купівельної спроможності кореляційний зв'язок між цими показниками є щільним, а розпорощення емпіричних даних відносно теоретичних, що впливають з економетричної моделі, є статистично несуттєвим. Навпаки, для країн з високим паритетом купівельної спроможності залежність між цими показниками хоча й існує, але спостерігається суттєве розпорощення емпіричних даних відносно теоретичних. Перевірка за тестом Голдфелда-Квандта показала, що ці країни не можна об'єднувати в одну вибірку сукупність. Виявлено, що обсяг відряджень на освіту на душу населення мало впливає на ефективність освітнього процесу. Дослідження динаміки витрат на освіту показали, що хоча Україна належить до країн з відносно низьким паритетом купівельної спроможності і протягом 2015-2022 років швидкість зростання витрат на освіту суттєво відставала від швидкості зростання економічних показників, ефективність освіти залишається відносно високою. Отримані результати дослідження на практиці доцільно враховувати з метою оптимізації витрат на фінансування освітньої галузі

Ключові слова: економіка знань; валовий внутрішній продукт; паритет купівельної спроможності; ефективність навчання; багатофакторна регресія; умови теореми Гаусса-Маркова