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Evaluating the Impact of Socio-Economic Variables on GDP per Capita: A Case Study of Kazakhstan

Abstact

Object: The object of the current article is to build a linear regression model to predict the value of GDP per capita using 9 socio-economic indicators.

Methods: Correlation and regression analysis methods were used for this study. All calculations are performed in MS EXCEL. 1 dependent and 9 independent variables were used as a basis.

Findings: Authors have identified nine variables that can potentially affect the amount of GDP per capita, and collected data according to these variables from 2012 to 2022, from open sources. The model was highly appreciated by generally accepted estimates, including: f value, p value, normalized R square.

Conclusions: Our analysis shows the impact of average wages, human development index, fertility and degree of real interest on GDP per capita, which allows us to build a highly efficient linear regression model. Thanks to our ability to accurately assess and reliably predict, our results shed light on the directions of economic intervention aimed at economic growth and improving the welfare and development of society in Kazakhstan.

Keywords: GDP, regression, dependence, social, economic, factors, statistics, econometrics.

Introduction

In order to understand the size and pace of a country's economy, it is important to distinguish and compare it with the economies of other countries. Many indicators can be used to determine the state of the economy. The most popular indicator is the Gross Domestic Product (GDP) — that is, the volume of all output in dollars in a certain territory for 1 year. However, a more accurate indicator that also takes into account the population of the region is GDP per capita. That is, this indicator shows how much output was produced in dollars per person. This indicator is very significant for any country, so it is important to understand what factors can affect its growth or decline. In this article we decided to identify the statistical relationship between GDP per capita and 9 socio-economic indicators.

Several studies in the scientific literature have examined this issue, but often with different conclusions. For example, while one study identified the fertility rate and population growth as important factors affecting GDP per capita (Çekrezi, 2022), another study showed that the real interest rate is a key factor (Štilić, 2023). Some scholars have examined variables such as compulsory education and population as contributing factors (Ilter, 2016). Moreover, in ASEAN countries, the Human Development Index has shown a particularly strong correlation with GDP per capita (Hussain, 2016), especially in areas where economic growth supports human development (Elistia & Syahzuni, 2018). Koppes (2022) also examined the relationship between fertility and GDP per capita. Another study found that access to credit had a greater impact on GDP per capita than other variables (Vulić, 2021). The differences in the impact of these factors across countries highlight the importance of contextual analysis. In this study, the authors examined open statistics over a 10-year period beginning in 2012 to examine the relationship between Kazakhstan's GDP per capita and nine potentially influential people.

Literature review

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Economists worldwide often measure country's economic growth by growth in productivity, and use measures like gross domestic product (GDP). Technological progress in the socio-economic sphere is an indicator of quality of life, which is mainly determined by the economic well-being of the people (Sadequl, 1995).

There are many studies on this topic in the scientific literature. But their results differ from each other. For example, while fertility rate and population growth were significant factors affecting GDP per capita in one study (Çekrezi, 2022), other studies have identified actual interest rate as this factor (Štilić, 2023). Some authors have investigated indicators such as compulsory education, population size as factors (Ilter, 2016).

Many scientists, including Ciobanu Oana (2015), Swaha Shome et.al (2010) and Mihuţ Loana Sorina (2013), have demonstrated a significant relationship between the Human Development Index (HDI) and GDP per capita. They suggest that economic development is typically measured by the Human Development Index (HDI), an aggregate measure that includes three basic human development areas: (1) health, measured by life expectancy (2) education, knowledge and skills and (3) income, measured by standard of living. (Barro, 2003). Elistia investigated the factors affecting GDP per capita in ASEAN countries, which includes 10 from South East Asia from 2010 to 2016 and found a strong influence of Human Development Index (HDI) on the studied indicator (Elistia & Syahzuni, 2018). A study conducted by Koppes examined the relationship of fertility with gross domestic product per capita (Koppes, 2022).

In another study, it was found that the amount of credit is an indicator that has a greater impact on gross domestic product per capita than other factors (Vulić, 2021). The variability of the influence of these factors across countries indicates the need for contextual analysis.

In this study, the authors collected statistical data from open sources for 10 years starting from 2012 and examined the relationship between gross domestic product per capita in Kazakhstan and nine indicators that may have a statistical influence on it. As a result, having developed a regression linear model of this relationship, it is possible to predict the gross domestic product per capita in future years by the values of given variable indicators.

Methods

The methods of correlation and regression analysis were used in the analysis and all calculations were carried out using MS Excel. GDP per capita was selected as the dependent variable and nine socio-economic indicators, which are listed below, were selected as independent factors: tertiary enrolment, dollar exchange rate, inflation, number of doctors of all specialities, average wages, unemployment, human development index (HDI), birth rate in the country and real interest rate. A literature review of these issues was prepared. The model was estimated using generally accepted measures including F value, p value, and adjusted R-squared.

Results

In order to fulfil the purpose of the article, the following steps were followed:

– Identification of socio-economic factors that may affect the change in GDP per capita through scientific literature review and search for statistics on these indicators from 2012 to 2022 in the following documents: Statistics on gross domestic product per capita (2012–2022), Statistics for Human Development Index (HDI) of Kazakhstan (2012–2022), Statistics of the birth rate of Kazakhstan (2012–2022), Statistics of Kazakhstan interest rate (2012–2022).

– Preliminary filtering and processing of data.

– Determination of correlations between independent variables and in case of finding strong relationships between them excluding the least important.

– Modelling the linear regression with GDP per capita and other nine independent variables.

– Making the estimations and adjustments to the model.

Microsoft Excel programme with "data analysis" extension package was used to build the linear regression model.

For this article, the authors chose the following 9 indicators as independent variables:

X1-student enrolment in higher education organisations;

X2- US dollar exchange rate;

X3-inflation;

X4-number of doctors of all specialities;

X5- average salary, in US dollars;

X6-unemployment;

X7-Human Development Index (HDI);
X8-fertility rate;
X9-real interest rate.

Gross Domestic Product (GDP) per capita (in US dollars, labelled Y) was obtained as the dependent variable.

Authors have collected statistical data for nine independent variables and one dependent variable from statistical sources (Table 1): Statistics for X1-X6 were obtained from document, Statistics on gross domestic product per capita (2012), Data for X7 - Human Development Index (HDI), Statistics for Human Development Index (HDI) of Kazakhstan (2012–2022). It was decided that the values of the dependent variable (GDP per capita) were obtained in US dollars. This was done in order to know the real state of the economy taking into account the devaluation of the national currency. The X5 data (average salary) was also translated by authors into US dollars according their corresponding years for this reason (average salary).

Table 1. Statistical data on GDP per capita and 9 independent indicators in the Republic of Kazakhstan for the years 2012–2022

	GDP per capita	Student enrolment in higher education organisations	US dollar rate	Inflation	Number of doctors of all specialities	Average salary	Unemployment	Human Development Index (HDI);	Fertility rate	Real interest rate
year	y	x1	x2	x3	x4	x5	x6	x7	x8	x9
2012	12 386,90	120408	149	6	64 432	67,91	5,3	64	2,62	5,5
2013	13 890,60	119333	152	4,8	66 038	71,74	5,2	59	2,64	5,5
2014	12 807,40	125362	179	7,4	68 864	67,54	5,1	59	2,73	5,5
2015	10 510,70	115195	222	13,6	69 722	56,84	5	59	2,74	16
2016	7 714,80	147692	342	8,5	74 611	41,76	5	59	2,77	12
2017	9 247,60	138378	326	7,1	72 134	46,27	4,1	58	2,75	10,3
2018	9 812,50	163336	345	5,3	72 877	47,19	4,9	59	2,84	9,3
2019	9 812,50	163494	383	5,4	74 046	48,81	4,8	57	2,9	9,3
2020	9 121,70	152789	413	7,5	76 443	51,58	4,9	59	3,13	9
2021	10 370,80	159804	426	20,3	78 227	58,75	4,9	56	3,32	9,8
2022	11 476,60	163472	461	8,4	79 409	67,26	4,9	57	3,05	16,8
Note — compiled by the authors on MS Excel on the basis of the National Bureau of Statistics of the RK Agency for Strategic Planning and Reforms, available at https://stat.gov.kz										

The next step is to test multicollinearity, that is, the relationship between the independent variables. For this purpose, the authors created a correlation matrix and determined how strong the relationship between each of them is (Table 2). The table is symmetrical on the diagonal, so the top is completely the same as the bottom. From Table 2, we can see how correlated the independent variables are with each other. High values of relationship between variables, exceeding 0.7 or higher, may prevent you from building a regression model. Hence, in such scenario its common practise to remove one of the variables from the model. When you remove variables, the first thing you need to do is to remove those that have a lot of collinearity with others.

Table 2. Correlation matrix

	y	*x1*	*x2*	*x3*	*x4*	*x5*	*x6*	*x7*	*x8*	*x9*
y	1									
x1	-0,55	1								
x2	-0,64	0,92	1							
x3	-0,17	0,10	0,30	1						
x4	-0,59	0,86	0,97	0,42	1					
x5	0,95	-0,48	-0,49	0,01	-0,41	1				
x6	0,53	-0,34	-0,46	-0,03	-0,39	0,58	1			
x7	0,29	-0,60	-0,69	-0,43	-0,75	0,26	0,48	1		
x8	-0,34	0,72	0,83	0,62	0,86	-0,15	-0,19	-0,65	1	
x9	-0,44	0,30	0,54	0,37	0,59	-0,27	-0,29	-0,44	0,31	1
Note — compiled by the authors on MS Excel on the basis of the National Bureau of Statistics of the RK Agency for Strategic Planning and Reforms, available at https://stat.gov.kz										

Having deeply analysed Table 2, the authors decided to remove five indicators in the linear regression model, leaving only four of the originally selected independent variables, X5 (average wage), X7 (human development index), X8 (national fertility) and x9 (actual interest rate), which are listed below in Table 3. Based on Table 3, we can now make linear equation, which can explain the model with Formula 1.

Table 3: Correlation matrix after multicollinearity test

	y	x5	x7	x8	x9
y	1				
x5	0,945908	1			
x7	0,292197	0,258264	1		
x8	-0,34427	-0,15249	-0,64932	1	
x9	-0,43821	-0,27273	-0,43734	0,31224	1
Note — compiled by the authors on MS Excel on the basis of the National Bureau of Statistics of the RK Agency for Strategic Planning and Reforms, available at https://stat.gov.kz					

$$Y=a0+a1x1+\ldots+anxn \quad (1)$$

where:

Y — dependent variable. In our case, GDP per capita in US dollars;

a0, a1, an — regression coefficients;

x1, xn — independent variables.

Table 4: Regression table.

Regression statistics	
Multiple R	0,988041741
R-square	0,976226482
Normalized R-square	0,960377471
Standard error	363,0975004
Observations	11

Analysis of variance					
	df	*SS*	*MS*	*F*	*F significance*
Regression	4	32482908,44	8120727,11	61,59541678	5,2787E-05
Remains	6	791038,7689	131839,7948		
Total	10	33273947,21			

	Coefficients	*Standard error*	*t-statistics*	*P-value*	*Low 95 %*	*High 95 %*	*Low 95,0 %*	*High 95,0 %*
Y-intersection	20237,61855	6048,89845	3,345670078	0,0155023	5436,497	35038,73	5436,4972	35038,7398
x5	157,498629	11,55653841	13,62852987	9,690E-06	129,2207	185,7764	129,22079	185,776459
x7	-185,9971164	78,56413543	-2,36745577	0,0557138	-378,2366	6,242397	-378,23663	6,24239769
x8	-2342,95561	689,9858529	-3,39565746	0,0145736	-4031,290	-654,6210	-4031,2901	-654,62104
x9	-92,35699018	33,68560955	-2,74173427	0,0336582	-174,7827	-9,931272	-174,78270	-9,9312729
Note — compiled by the authors on MS Excel on the basis of the National Bureau of Statistics of the RK Agency for Strategic Planning and Reforms, available at https://stat.gov.kz								

In this part of the paper a linear regression model will be estimated. Table 4 above shows the main indicators for model estimation used in scientific research. The first one is the normalised coefficient of determination. In this study, the model has a normalised R-square value of 0.98. This indicates a sufficiently high level of explanatory power. From this we can conclude that 98 per cent of the change in GDP per capita (Y) can be explained by the change in average wages (x5), human development index (X7), birth rate in the country (X8) and actual interest rate (X9), and 2 per cent by the change in other random indicators.

The next indicator to look at is the significance level of the F criterion. Many scholars agree that the significance level of the F criterion should be below 0.05. In this model the significance level of F is 5.2787 E-05, this confirms that is statistically significant for this criterion.

n addition, P values were calculated to further assess the significance of the individual coefficients. The P value represents the minimum level of significance at which the null hypothesis can be refuted based on

the calculated test statistics. Typically, p values are compared to standard significance thresholds such as 0.005 or 0.01. For example, a p value of 0.005 indicates that the probability that the null hypothesis is true is only 0.5 %. Hence, smaller p-values indicate strong evidence against the null hypothesis. From the table, we see the P-values of y-intercept, X5, X7, X8 and X9 (0.015, 9.690 E-06, 0.055, 0.014 and 0.033) fulfil these requirements and are statistically significant.

The model is statistically significant on the main characteristics of the estimation, so the formula for the linear equation of the regression model is as follows (Formula 2):

$$1=a0+a1x5+a2x7-a3x8-a4x9, \quad (2)$$

where:

Y1 — GDP per capita in US dollars;

a0, a1, a2, a3, a4 — regression coefficients;

x5 — average salary, in US dollars;

x7 — Human Development Index (HDI);

x8 — fertility rate;

x9 — real interest rate.

The values of the coefficients a0, a1, a2, a3, a4 in the formula can be found in Table 4 in the column of coefficients. Taking into account the found parameters, the equation in its last form a0, a1, a2, a2, a3, a4 takes the following form (Formula 3):

$$Y1=20237,61–157,5x5–186x7+2343x8+92,36x9. \quad (3)$$

To check the correctness of the calculated values of a0, a1, a2, a3, a4, these values are transferred to the initial equations of the system. By comparing the initial equations with the calculated coefficients, we can determine the accuracy of the calculation.

If we add different values of average wages (x5), human development index (X7), fertility (X8) and degree of real interest (X9) to the regression equation, we obtain theoretical values of GDP per capita (Y1) corresponding to these indicators (Table 5).

Table 5: Theoretical values of GDP per capita (Y1) and percentage of model errors.

year	x5	x7	x8	x9	Y	Y1	Error
2012	67,91	64	2,62	5,5	12 386,90	12383,02785	0,03 %
2013	71,74	59	2,64	5,5	13 890,60	13869,37407	0,15 %
2014	67,54	59	2,73	5,5	12 807,40	12997,01382	1,48 %
2015	56,84	59	2,74	16	10 510,70	10318,60054	1,83 %
2016	41,76	59	2,77	12	7 714,80	8242,660508	6,84 %
2017	46,27	58	2,75	10,3	9 247,60	9342,842437	1,03 %
2018	47,19	59	2,84	9,3	9 812,50	9183,235044	6,41 %
2019	48,81	57	2,9	9,3	9 812,50	9669,799719	1,45 %
2020	51,58	59	3,13	9	9 121,70	9222,903996	1,11 %
2021	58,75	56	3,32	9,8	10 370,80	10391,11336	0,20 %
2022	67,26	57	3,05	16,8	11 476,60	11531,52866	0,48 %
						Average error	1,91 %
						Maximal error	6,84 %

Note — compiled by the authors on MS Excel on the basis of the National Bureau of Statistics of the RK Agency for Strategic Planning and Reforms, available at https://stat.gov.kz

The coefficients of the regression equation designated as a0, a1, a2, a3, and a4 are called the regression coefficients and are the key indicators of the equation These coefficients show the change in the dependent variable Y for each unit change in the independent variable variables.

Based on the results, the following conclusions can be drawn.

$1 increase in average wages is predicted to increase GDP per capita by $157.

1 point increase in the Human Development Index is expected to decrease per capita GDP by about $186.

1 point increase in the national fertility rate would decrease per capita GDP by about $2,343.

1 % increase in the real interest rate is estimated to reduce per capita GDP by $92.

The blocked term, a0 (equal to 20,237.62), provides a constant initial value to be considered when using regression coefficients.

We can use Y1 to measure the accuracy of the model. Column 8 of Table 5 shows the error percentages of the 8 models, with an average error rate of 1.91 % and a maximum error of 6.84 %. Given these figures, and other key metrics such as R-squared (over 98 %), P-values (0.015, 9.690E-06, 0.055, 0.014, and 0.033 for Y and X5, X7, X8, X9), its f F-squared value does not exceed 0.05, the model exhibits strong reliability. Confidence can be used to forecast per capita GDP based on average wages, the Human Development Index, fertility rates and real interest rates.

Discussions

In this study, the regression analysis applied to Kazakhstan data from 2012 to 2022 revealed specific socioeconomic variables that significantly affect per capita GDP Notably, wages a supply, human development index, fertility rate and real interest rate as key factors. The results of the model show that an increase in average wages has a positive effect on GDP per capita, which is consistent with the hypothesis that higher incomes can lead to economic growth but which increases in the human development index and the fertility rate have been found to have a negative effect on GDP per capita is unexpected Yitum It can, where rapid changes in these indicators can disturb or hide financial resources underlying inefficiencies revealed.

The negative effect of real interest rates on GDP per capita is consistent with existing economic theory, where higher interest rates can dampen investment and economic activity Strong statistical understanding the presence in the model and the low error rate (average error rate 1.91 % and maximum value 6.84 %) indicate that these relationships are stronger in the case of Kazakhstan.

These findings emphasize the importance of country-specific analysis when examining the factors affecting GDP per capita. Variation in outcomes across studies and regions suggests that a one-size-fits-all approach is inappropriate. The context-specific relevance of these variables needs to be considered when designing policies aimed at economic development. For Kazakhstan, the model developed in this study provides a useful tool to predict per capita GDP based on socio-economic variables, and provides valuable insights for policy-making.

Conclusions

The aim of this study is to assess the impact of various socio-economic variables on GDP per capita in Kazakhstan, using data collected from the National Bureau of Statistics of the Republic of Kazakhstan from 2012 to 2022 capita. After careful preprocessing of the data, including the conversion of average wages from tenge to U.S. dollars. in dollars to ensure accuracy, and after rigorous testing for multicollinearity, the study focused on four key independent variables: average salary, Human Development Index (HDI), country birth rate, and real interest rates.

The results of the linear regression model were checked on widely accepted statistical parameters such as F-value, P-value, and normalized R-squar. The model showed following results:

A $1 increase in average wages is associated with a $157 increase in GDP per capita.

A 1-unit increase in the Human Development Index corresponds to a $186 per capita decrease in GDP.

A 1-unit increase in the national fertility rate produces a whopping $2,343 decrease in per capita GDP.

A 1 % increase in the real interest rate reduces per capita GDP by $92.

The accuracy of the model was further confirmed by error analysis, which showed an average error rate of 1.91 % and a maximum error of 6.84 %. The high R-square value (greater than 98 %) and positive p-value confirm the robustness and reliability of the model in predicting per capita GDP based on a given set of socioeconomic variables

In conclusion, this study provides valuable insights into the socio-economic factors affecting GDP per capita in Kazakhstan. The findings highlight the importance of context-specific research in understanding economic development. The model developed here can be a reliable tool for forecasting GDP per capita based on the use of key socio-economic indicators. However, the negative effects observed by the HDI and higher fertility rates suggest that further research is needed to understand their causal mechanisms and identify policy changes that can mitigate these effects. These results contribute to the wider literature by highlighting the complex and sometimes unexpected relationships between socioeconomic variables and economic growth, especially in the context of emerging economies such as Kazakhstan.

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Әлеуметтік-экономикалық айнымалылардың жан басына шаққандағы ЖІӨ-ге әсерін бағалау: Қазақстан мысалында

Аңдатпа:

Мақсаты: Мақаланың мақсаты — 9 әлеуметтік-экономикалық көрсеткішті қолдана отырып, жан басына шаққандағы ЖІӨ құнын болжау үшін сызықтық регрессия моделін құру.

Әдісі: Зерттеуде корреляциялық және регрессиялық талдау әдістері қолданылды. Барлық есептеулер MS EXCEL бағдарламасында орындалды. Негіз ретінде 1 тәуелді және 9 тәуелсіз айнымалылар пайдаланылды.

Қорытынды: Авторлар жан басына шаққандағы ЖІӨ-нің көлеміне әсер етуі мүмкін 9 айнымалыны анықтады және 2012 жылдан 2022 жылға дейінгі осы айнымалылар туралы деректерді ашық көздерден жинады.

Модель жалпы қабылданған бағалаулармен жоғары бағаланды, соның ішінде: f мәні, p мәні, нормаланған R квадрат.

Тұжырымдама: Біз жүргізген талдау жан басына шаққандағы ЖІӨ-ге орташа жалақының, адам дамуы индексінің, туу коэффициентінің және нақты қызығушылық дәрежесінің әсерін көрсетеді, бұл жоғары тиімді сызықтық регрессия моделін құруға мүмкіндік береді. Дәл бағалау және сенімді болжау мүмкіндігінің арқасында біздің нәтижелеріміз экономикалық өсуге және Қазақстандағы қоғамның әл-ауқаты мен дамуын арттыруға бағытталған экономикалық араласу бағыттарына өзіндік ықпалын тигізеді.

Кілт сөздер: ЖІӨ, регрессия, тәуелділік, әлеуметтік, экономикалық факторлар, статистика, эконометрика.

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Оценка влияния социально-экономических переменных на ВВП на душу населения: на примере Казахстана

Аннотация

Цель: Целью данной статьи является построение линейной регрессионной модели для прогнозирования значения ВВП на душу населения по 9 социально-экономическим показателям.

Методы: Для исследования использовались методы корреляционного и регрессионного анализа. Все расчеты выполнены в MS EXCEL. За основу были взяты 1 зависимая и 9 независимых переменных.

Результаты: Авторы выделили девять переменных, которые потенциально могут влиять на объем ВВП на душу населения, и собрали данные по этим переменным с 2012 по 2022 год из открытых источников. Модель была высоко оценена общепринятыми оценками, включая: значение *f*, значение *p*, нормализованный квадрат *R*.

Выводы: Проведенный нами анализ показывает влияние средней заработной платы, индекса человеческого развития, рождаемости и степени реальной заинтересованности на ВВП на душу населения, что позволяет построить высокоэффективную линейную регрессионную модель. Благодаря возможности точной оценки и надежного прогнозирования наши результаты проливают свет на направления экономического вмешательства, направленного на экономический рост и повышение благосостояния и развития общества в Казахстане.

Ключевые слова: ВВП, регрессия, зависимость, социальные, экономические факторы, статистика, эконометрика.