IMPACT OF POPULATION STRUCTURE ON GDP IN THE REPUBLIC OF MOLDOVA

Ph.D. Associate Professor Researcher, Galina SAVELIEVA
National Institute for Economic Research (CDR NIER),
Academy of Economic Studies of Moldova (AESM), Republic of Moldova
E-mail: savelievagalina@rambler.ru, gts6@mail.ru
Ph.D. Scientific Researcher, Svetlana ZAHAROV
National Institute for Economic Research (CDR NIER),
Academy of Economic Studies of Moldova (AESM), Republic of Moldova
E-mail: zaharov.svetlana@gmail.com, zaharov.svetlana@yahoo.co.uk

Abstract: *The article presents the results of the research of the dependence between changes in population structure and economic development in the Republic of Moldova. The use of econometric method allowed to evaluate the quantitative impact of age changes in population on the value of GDP as the main macroeconomic indicator of sustainable economic development. In the process of the research, the multi-factor regression model was elaborated, which allows to assess the relationship between age groups in population and GDP (age structure of population and economic growth). Based on the results obtained, recommendations for improving public socio-economic policies in the Republic of Moldova were developed.*

Key words*: population by main age groups, GDP, regression model, factors.*
JEL Classification: *C20, E21, J11, O11.*

1. Introduction

The presented article is devoted to the research of the relationship between economic development and population. (economy and population). Population is the main component of any state. The reproduction of labour force, which is one of the main factors of production, depends on the number of population. The labour force is part of the working age population. Therefore, the dynamics of structural changes in population affects the economic development of the country. It characterizes assessments of labour force supply (prospective assessments of labour force are based on demographic forecast.) The supply of labour force reveals the limitations on the part of labour resources, namely the number of working age population, which form and determine the requirements for the formation (elaboration) of certain policies in this area. Age changes, which determine the structure of the population, affect the number of working age population, increasing or decreasing its number. The dynamics of the working-age population affects the number of labour force, limiting or expanding the possibilities of its supply. The classical interpretation of labour as one of the factors of production determines the possibility of influence of the age dynamics of the population on the production of material goods, provision of services and their consumption. That is, the change in the age structure through the number of labour force on labour market can either limit or expand the possibilities of production.

The Gross Domestic Product (GDP) indicator was chosen as the main macroeconomic indicator characterising the country's economy, which most fully reflects the economic development in the country. Being one of the quantitative indicators of macroeconomics, GDP characterises production capabilities, including in the point of view the use of factors of production. In perspective, GDP determines the possibilities of the economy.

2. Purpose of the research, data, methodology and methods applied

The principal purpose of the research is to determine the qualitative assessment of the impact the changes in the age structure of the population on economic development in the Republic of Moldova. Economic development is assessed through the macroeconomic indicator of Gross Domestic Product (GDP).

Source data. Official statistical data of the National Bureau of Statistics of the Republic of Moldova (number of population and GDP indicators), indicators calculated by the authors were used for the analysis. The number of population is represented by average annual data of population statistics. The research used the number of population with usual residence, which characterises the place where a person lived predominantly during the last 12 months independently of temporary absences (for recreation (leasure), leaves, visits to relatives and friends, business, medical treatment, religious pilgrimages, etc.).

The choice of the research period from 2014 to 2023 is justified by the availability of relevant statistical data for this 10-year period and incompatibility with the previous period. The value indicator of GDP in dynamics is adjusted in comparable data on the basis of recalculation in 2014 prices (in the text GDP in 2014 prices), thus GDP indicators are deflated. All calculations were carried out on the basis of NBS RM data, and the results are presented in given article.

Research Methodology. The research of the relationship between the age groups of the population and GDP has several stages:

1. A priori (preceding). It is a pre-model analysis of the economic essence of the phenomena under research, formation of initial assumptions. The research includes the analysis of indicators of the total number of population, age structure of the population, GDP.

2. Econometric research:

2.1 The statement stage includes the definition of the purpose and objectives.

- One of the main tasks of modelling is to substantiate the selection of independent factors the impact.
- Assessment of the connection between the dependent and independent variables on the basis of paired correlation coefficients (R).

2.2 The specification stage includes the selection of regression model. Selection of the type of functional dependence in the regression equation, i.e. the form of the connection between the variables. Determination of the formula of the models.

2.3 Parameterisation stage. Quality assessment of regression model parameters using *evaluation criteria*:

2.3.1 *Quality indicators of regression coefficients*:
- standard errors of coefficients (Std. Error),
- t-statistics (t Student's criterion);

2.3.2 *Quality indicators of the regression model as a whole*:
- coefficient of determination (R^2),
- Fisher's criterion (F),
- autocorrelation of residuals based on the Durbin-Watson (DW) statistic,

2.4 Verification, identification stage. Assessment of the accuracy of the regression models data on the basis of comparison of real and modelled data:

- Determination of the average error of approximation of the regression equation ($\overline{A}$).

Methods. The research was carried out on the basis of the use of complex and systemic approaches, methods of quantitative, qualitative and comparative analysis (including based on time and territorial location), economic and mathematical modelling, authors' calculations and others.

3. Result and Discussions

a. Analysis of GDP and population indicators

The analysis of GDP in the Republic of Moldova for the period 2014-2013 showed that despite the optimistic forecasts of the physical volume of GDP for 2022-2023, the Ministry of Economy (for 2022 - 4.5%, 0.3 (February 2022), for 2023 - 2.5%), international organizations - World Bank (for 2022 - 3.9%, Oct. 2022 - 3.2%, for 2023 - 4.4%, Oct. 2023 2.6%, 2.0%), International Monetary Fund (for 2022 - 0.3%, for 2023 - 2%, World Economic Outlook), and expected the GDP for 2023 at the level of 2.5%, the indicator of the physical volume of GDP after 2019 has no stable growth (unstable). That is, the dynamics of the indicator demonstrates practically about the absence of linear dependence (R^2 = 0.0118, Fig. 1.) between the values for different years of research. The insignificant value and the "minus" sign in the equation indicate a slow continuous decline in the indicators of the physical volume of GDP.

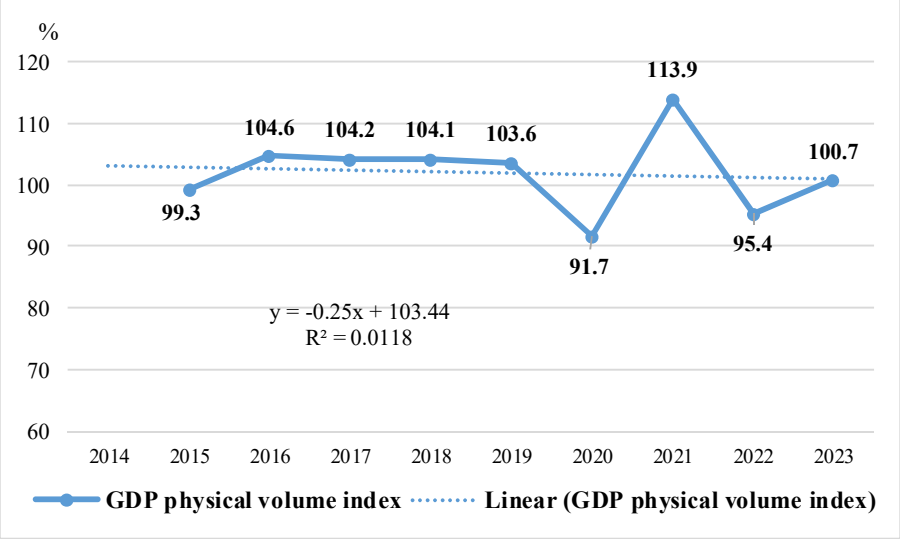


Fig. 1. GDP physical volume index, 2015-2023, %

Source: NBS, www.statistica.md

The analysis of GDP in current prices shows a gradual growth before 2020, and a sharp increase in GDP values over 2020, which correlates with the galloping growth of energy prices and, consequently, the connected subsequent inflation in the country.

Consideration of GDP in 2014 prices shows the real situation with GDP production. The dynamics of the indicator is limited and there is no growth in values. The values of the GDP indicator in 2022-2023 are at the level of 2019, i.e., practically after 2019 there is no GDP growth.

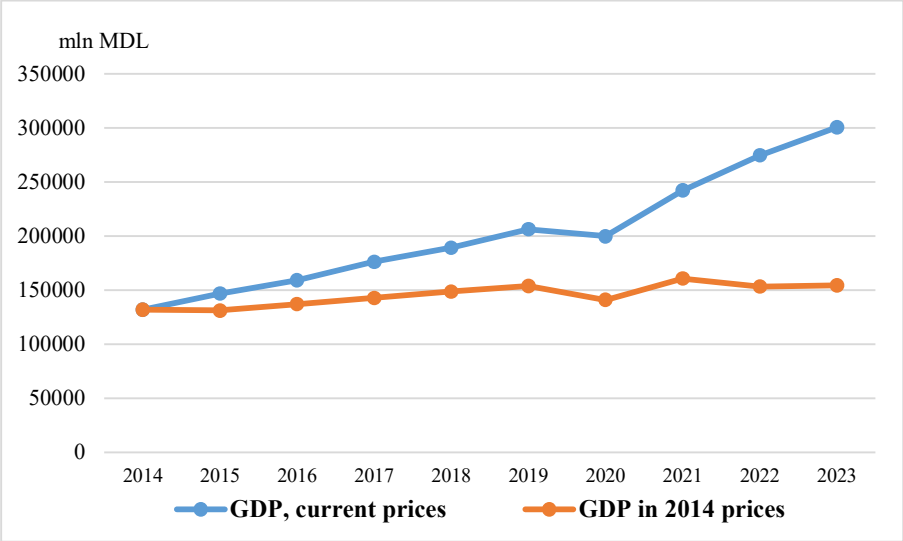
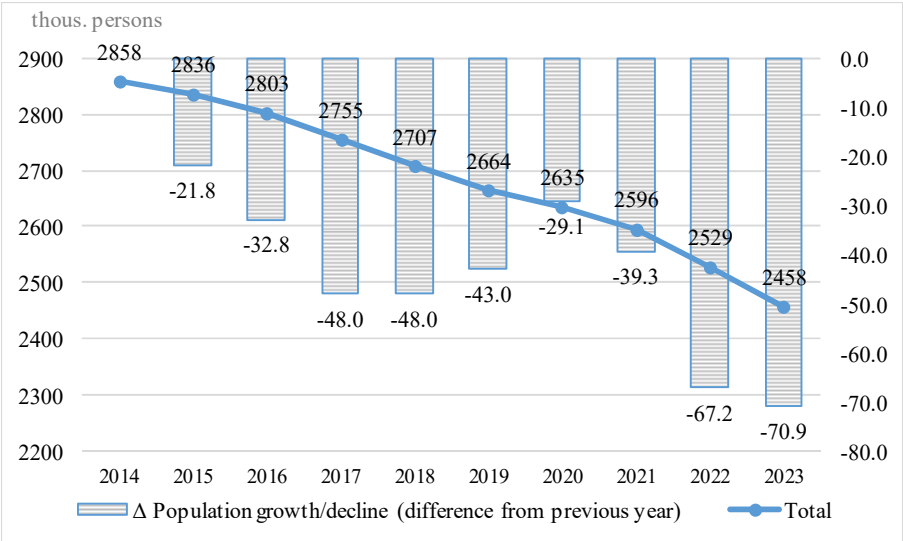


Fig. 2. GDP, RM, 2014-2023, current prices and in 2014 prices, mln MDL
Source: NBS, www.statistica.md, authors' calculations

The analysis of the population of the Republic of Moldova showed that the number of population in the Republic of Moldova decreased annually (for 2014-2023 fluctuations of the indicator of annual population growth/decline per year in the range [-70.9; -21.8]), Fig. 2.



Note: calculation data are rounded automatically

Fig. 3. Population, 2014-2023, thousand persons
Source: authors' calculations based on NBS RM data

There were *two waves* in the total population decline over the period since 2014: from 2014 to 2020 and from 2021 to 2023(further). In 2019, the total population declined by about 10% and in 2020 compared to 2019, the drop was compressed (by 32.3%), i.e. the *first wave* ended by 2020, with the beginning of the COVID - 19 pandemic. One of the consequences of

the pandemic in Moldova was a decrease in population migration (abroad), which caused the end of the first wave. The temporary tightness of the number of migrating citizens reduced the drop in the country's population during the COVID-19 pandemic in 2020-2021, despite the increase in the number of deaths in these years. In 2022 and 2023, the declining trend in the number of births in the country that was observed after 2014 continued, coinciding with an increase in poverty in the country. That is, the subsequent wave of population decline continued from 2021 to 2023.

Fertility and mortality (vital statistics) do not have an essential impact on the change of the total population in the country (Table 1.). Population migration determines today the change in the number of population in the Republic of Moldova. Migration processes in the country cannot be considered in isolation from the national economy, without taking into account changes in the world economy and international distribution of labour. Since the transfer of surplus qualified labour force from one sector to another can be difficult, as narrowly qualified labour force has low mobility (Ryazantsev S.V. et al, 2024, p. 43).

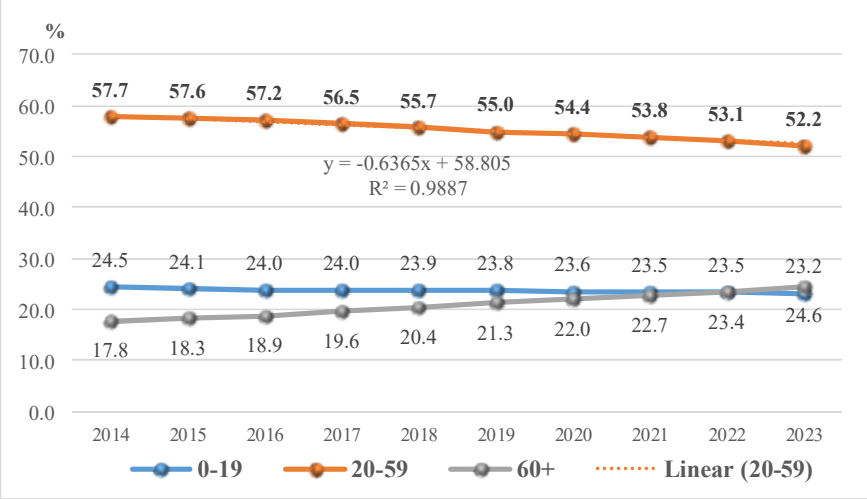
If consider the population in the view of age structure (Table 1.), the total population decline correlates with the population loss of the 20-59 age group compared to the 15-64 age group.

Table 1. Population, 2014-2023, thousand persons

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Population, total										
Population growth/decline, thousand persons		-21.837	-32.792	-47.997	-47.986	-42.979	-29.094	-39.321	-67.155	-70.871
Vital statistics, thousand persons	1.187	0.747	1.228	-0.416	-2.726	-3.988	-9.883	-16.144	-9.178	-9.700
Population migration, thousand persons		-22.584	-34.020	-47.581	-45.260	-38.991	-19.211	-23.177	-57.977	-61.171
15-64										
Population growth/decline, thousand persons		-34.1	-45.2	-57.8	-51.4	-42.7	-29.1	-35.1	-58.0	-62.7
20-59										
Population growth/decline, thousand persons		-16.8	-30.6	-47.3	-48.1	-43.3	-31.7	-35.7	-55.2	-58.7

Note: data of calculations are rounded automatically
Source: authors' calculations based on NBS RM data

The analysis of the population structure showed that the change in the population structure is connected with an annual decrease in the number of the country's population with a usual place of residence. This essentially impacts the change in the age structure of the population. The share of the 0-19 age group is slowly decreasing, while the number of the 60+ age group is rapidly increasing. The share of the 20-59 age group, where the majority of the working age population is found, is decreasing. Thus for the period 2019-2023 the decrease is almost 3 p.p. The negative coefficient of the linear function of change in the values of given age group is increasing.



Note: calculations data are rounded automatically

Fig. 4. Population, age groups, 2014-2023, %

Source: authors' calculations based on NBS RM data.

Analysis the number of the population by age groups showed the dynamics of changes in the ratio of age groups in the composition of the country's population. We can note a significant decrease in the share of the age group of population 20-59 years old with working age population (Fig. 4.). Since the number of working age population inseparably connects to the reproduction of the principal factor of production - labour force, the reduction in the share of working age population will affect to the country's economy, including such an indicator of economic development of the country as GDP.

b. Building and analysing regression models

The above analysis showed that there is a change in the ratio of age groups of the population: the age group 20-59 is slowly declining, while 60+ is increasing, the share of the age group 0-19 is slowly decreasing.

As it was mentioned above, for a quantitative assessment the impact of age changes in the population' composition on the GDP value, it is necessary to use the method of econometric modelling. The main objective of building regression models is to base the choice of influence factors, determine their changes and assess the impact of these changes on GDP.

Gross Domestic Product (GDP) is taken in the quality of the dependent variable (resultant sign) $\boldsymbol{Y_t}$, and independent, explanatory variables (sign - factors) $\boldsymbol{X_{it}}$ shares of age groups 0-19, 20-59, 60+ of the country's population. The value indicators of GDP adjusted into comparable (in 2014 prices) by the deflation method. The research period was from 2014 to 2023, i.e. the number of observations in the regression models is 10.

The principal characteristics and evaluation criteria of the calculated regression models presented below in the form of formulas, graphical and tabular form (Fig. 5., Table 3.).

Estimation of paired correlation

Correlation coefficients are used for primary analyses of the interrelation between GDP and age groups in the population (stochastic or random variables $\boldsymbol{X}$ and $\boldsymbol{Y}$). Given

coefficient presents a relative measure of interrelation. The *correlation coefficient* (R_{xy}) is a measure of linearity of interrelation of variables, the degree of closeness to linear dependence. It is important to note, firstly, for any random variables X and Y the correlation coefficient will be $-1 \leq R_{xy} \leq 1$, secondly, if random variables X and Y are independent, that is the *correlation coefficient* can be equal to zero ($R_{xy}=0$), the reverse is incorrect, as at equality **0** of the correlation coefficient random variables X and Y may be dependent (Ibragimov M., p. 4). The meaning of the correlation coefficient is the location of the sampled population on the Cartesian coordinate axis depending on the value of the correlation coefficient itself: at $R_{xy} \approx 0$ the population is located inside the entire ordinate system, at $R_{xy} > 0$ the sample is located in the 1st and 3rd parts of the coordinates and at $R_{xy} < 0$ in the 2nd and 4th parts of the coordinates (Ibragimov M., p. 8). According to the location of the sample can estimate the value of the correlation coefficient (R_{xy}).

To assess pair correlation, Scatter Plot were constructed, which most rightly reflect the intensity of the connection between variables X and Y (Fig. 5.). Let consider graphically the pair correlation between GDP indicators and relative shares of age groups 0-19, 20-59 and 60+ and their corresponding sampled correlation coefficients, respectively. The pair correlation between GDP indicators and relative shares of population age groups is characterised by the corresponding pair correlation coefficients R_{xy}, which are negative values for the age groups 0-19 and 20-59 respectively -0.813 and -0.860 and the "minus" sign means the *inverse nature of the connection*. The positive correlation coefficient between GDP and relative shares of the age group 60+ (R_{xy} = 0.859) indicates the *direct nature of the connection*. So pair correlation explains the connection between GDP and age groups 0-19, 20-59 and age group 60+. All values of pair correlation coefficients characterise the connection as high according to the Cheddock scale[2].

At the same time, it should be noted that there is an inverse connection between indicators of age group 60+ and age groups 0-19 and 20-59 (-0.960 and -0.999 respectively).

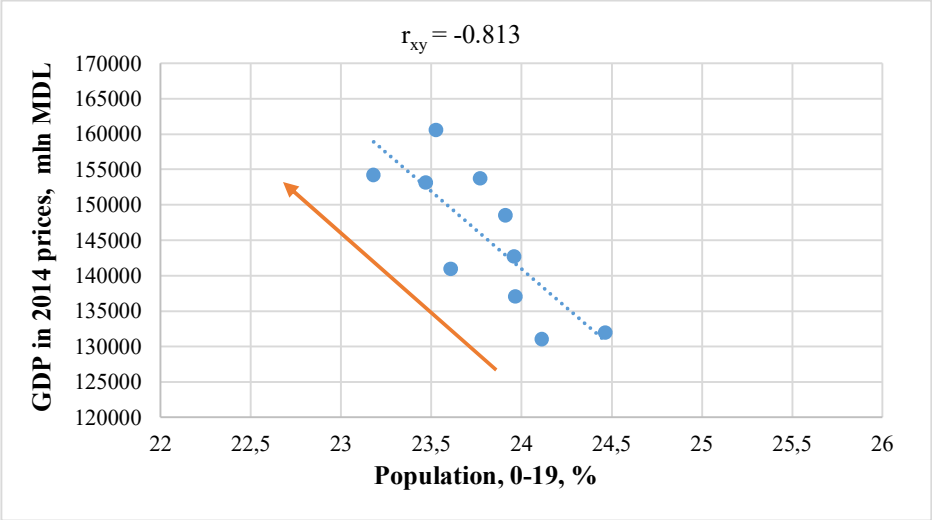
R_{xy} = -0.813

[2] Criteria for assessing the tightness of the relationship between independent factors and GDP on the Cheddock scale.

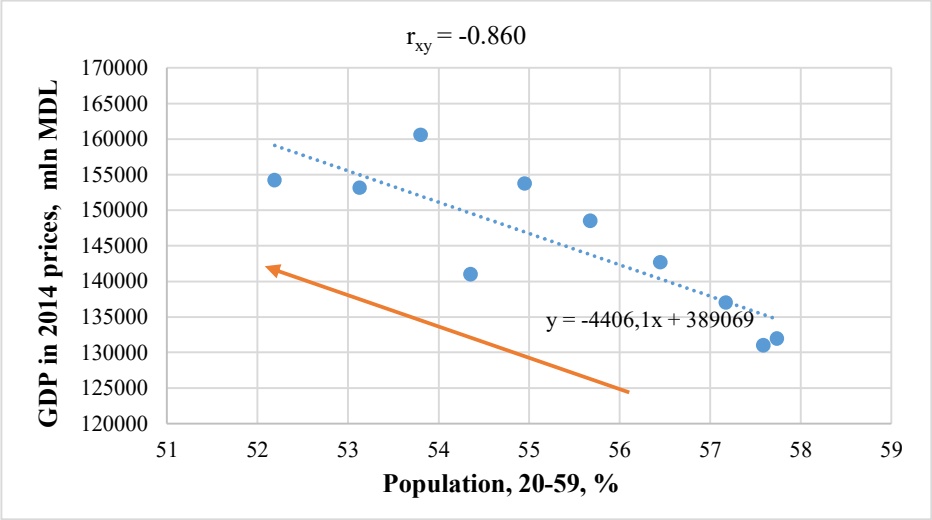
Table. Cheddock scale

Quantitative characteristic of tightness of connection	Qualitative characteristic of tightness of connection
$0,1 < r_{xy} < 0,3$	Weak
$0,3 < r_{xy} < 0,5$	Medium
$0,5 < r_{xy} < 0,7$	Noticeable
$0,7 < r_{xy} < 0,9$	High
$0,9 < r_{xy} < 1$	Very high

***Source**:* Correlation and Regression. https://math.semestr.ru/corel/primer.php (accessed 09.08.2024).



R_{xy} = -0.860



R_{xy} = 0.859

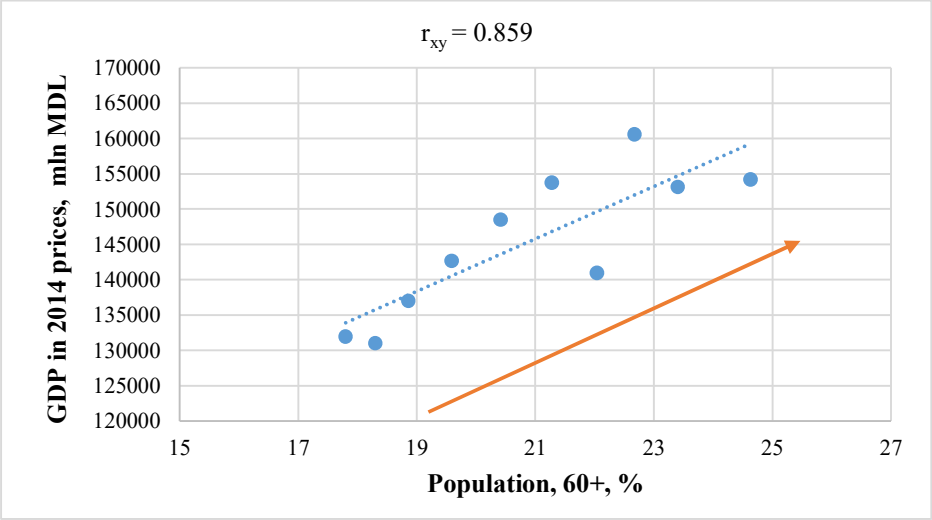


Fig. 5. Scatter diagrams of GDP from the factors of models (pair correlation coefficients)

Source: Authors' calculations

The estimation results should have a sensible economic interpretation and answer the question whether the coefficients showing the directions of influence of these factors are positive or negative and whether the signs of the coefficients correspond to the economic meaning (Ibragimov M., p.12). Considering the economic sense of the *inverse connection* between GDP and relative share of the age group 20-59 years of population (R_{xy} = -0.860, R_{xy}< 0), can note the following: the reduction of relative share of this age group is accompanied by the growth of GDP and its absence in the last years 2022 and 2023 (Fig. 5.). This can be explained by the following: the number of this age group is declining, while GDP was growing, so the decrease in the share of this age group could be compensated by the growth of the age group 60+, as well as by the shift of the centre of gravity due to the deficit of the factor of production - labour force to the factor of capital. It has been observed that the share of capital in GDP production is increasing, while the contribution of labour is dropping according to world tendencies of GDP growth (Motilal O.).

Regression models

For the elaboration the regression models, the following are necessary to take into account:

1. The interrelated between economic variables is analysed by regression equations. The obtained results should have an economic explanation, the semantic adequacy of econometric models is of paramount importance.
2. Regression allows the total influence of factors to be decomposed into its component parts, revealing the marginal contribution of each factor. The coefficients of regressions show the direction of the influence of the explanatory factors.

As a hypothesis in general form for each year (observation), the regression equation is as follows general form for one year and for the total period of observation:

$$y = a_0 + b_1x_1 + b_2x_2 + b_3x_3 + \varepsilon, \quad (1)$$

$$y_t = a_0 + b_1x_{1t} + b_2x_{2t} + b_3x_{3t} + \varepsilon_t, \quad (2)$$

Based on this formula, two linear regression models (Model 1., Model 2.) were calculated in order to assess the impact of given factors on GDP dynamics. The obtained equations of Model 1. and Model 2. belong to the *first order regression equation*.

Model 1.

$$y_t = -68187601.13 + 4718944.073X_{1t} + 4868485.790X_{3t} + \varepsilon_t, \quad (3)$$

Model 2.

$$y_t = 416511690.0 - 4893992.209X_{2t} + \varepsilon_t, \quad (4)$$

where, y_t - GDP, in 2014 prices, thousand MDL;

x_{1t} - share of population in the age group 0-19, %;

x_{2t} - share of population in the age group 20-59, %;

x_{3t} - share of population in the age group 60+, %;

ε_t - random variable, sampling error on unaccounted factors;

t - year of observation.

Model 1. includes two explanatory variables (factors) and Model 2. includes only one variable. Model 2. is a *pair regression*. This econometric model consists of one explanatory variable, and is a regression between two variables ***y*** and ***x***. In a pair regression equation, only one factor will affect the final result *y*. The model has the form ***y(x)=f(x)*** and there is no strict functional dependence between the variables ***y*** and ***x***. Due to this, the value of ***y*** consists of the value of the resultant characteristic based on the pair regression equation and ε - a random variable (Model 2.).

One of the main problems solved through the regression equation is to determine the values of regression coefficients. In conditions when the available sample of observations is limited in volume, it is impossible to obtain the true values of regression coefficients (Ibragimov M.). In this case, it is important to determine statistical assessments ***a*** and ***c*** of the unknown true parameters (coefficients) of the regression. Given statistical assessments and are called regression coefficients (Model 1., Model 2.).

The economic meaning of the *coefficients of the linear regression equation* is to explain how much the result will change when a concrete factor changes by 1 unit. The regression equation itself reflects the general tendence in the change of the variables under consideration.

According to Model 2., used for *quantitative assessment of the factor impact* - the share of population of age group 20-59 years (x_{2t}), reducing it by one unit equal to 1%, GDP in 2014 prices will decrease by 4893992.209 thousand MDL.

Looking at Model 1., it can be observed that the regression coefficients have positive values, while according to the values of pair correlation, the GDP indicator has a negative dependence with the age group 0-19 and positive with the age group 60+. The inverse connection between the GDP indicator and the share of the population of age group 0-19 years is not reflected in the equation of Model 1. This non-conformity in the sign of the

indicator coefficient characterising the age group 0-19 years in Model 1. casts doubt on the significance of given regression coefficient (b_1=**+4718944.073**).

A statistical assessment of the degree of accuracy and reliability of application of the regression parameters is necessary. Reliability is the probability that the value of the parameters is not equal to zero, i.e. connection is absent and the variables are random variables. Accuracy of regression parameters is determined by calculations of criteria of parameters at independent regression variables. Characteristics of conformity the Model 1. and Model 2. parameters with the criteria for assessment the quality of regression models are presented in Table 3.

Table 3. **Criteria for assessments the quality of regression models**
(Comparative characterisation of the quality of regression models)

Indicators		**Characteristics**	
		Model 1.	**Model 2.**
$\mathbf{У_t = -68187601.13 + 4718944.073X_{1t} + 4868485.790X_{3t} + \varepsilon_t}$, **(1)**			$\mathbf{У_t = 416511690.0 - 4893992.209X_{2t} + \varepsilon_t}$ **(2)**
Quality indicators of regression coefficients (a, b)			
Standard errors of coefficients (*Std. Error*) or standard deviations of assessments of coefficients *a* and *b*	S_a, S_{b1}, S_{b2}, S_{b3}	S_a = **588 902 434.3** S_{b1} = **21 892 243.64** S_{b3} = **3 357 483.372**	S_a = **57 001 954.03** S_{b2} = **1 028 456.345**
t statistic (Student's t test)	$\lvert t \rvert > t_{tabl.}$; $t_{tabl.} = t_{1-\alpha;\, n-m-1}$**	$t_{tabl..} = t_{0,95;7} = 2.3646$[1] $\mathbf{t_a = -0.116;}$ $\mathbf{t_{b1} = 0.216;}$ $\mathbf{t_{b3} = =1.450}$ $\mathbf{\lvert t \rvert < t_{0,95;7}}$	$t_{tabl.} = t_{0,95;8} = 2.3060$[1] $\mathbf{t_a = 7.307;\ t_{b2} = -4.759}$ $\mathbf{\lvert t \rvert > t_{0,95;8}}$
Quality indicators of regression model as a whole			
Coefficient of determination (R^2)	$0 \le R^2 \le 1$	R^2=0.739	R^2=0.739
F - Fisher's criterion	F fact. > F tabl., $F_{\alpha;k1;k2}$ α=0.05	F fact.=9.906; F tabl.= F ($\kappa_1;\kappa_2$)*= F(2; 7) = **4.74**[2]**;** F fact. > F(2; 7) at α=0,05.	F fact.=22.644; F tabl.= F ($\kappa_1;\kappa_2$)*= F(1; 8) = =**5.32**[2]; F fact. > F(1; 8) at α=0,05.
Autocorrelation of residuals (Durbin-Watson statistic, *DW*)	If 1,5 ≤ DW ≤ 2,5 no autocorrelation of residuals	DW=2.789 DW ≥ 2,5[3]	DW=2.788 DW ≥ 2,5[3]

* *k1= m; k2=n-m-1*,
where *m* is the number of variables in model, *n* is the number of observations in model.
** *1- α*, where, α is the significance level; *n-m-1* is the number of degrees of freedom.

[1] Special table "The values of Student's t criterion at the significance level of 0.10, 0.05, 0.01". Afanasiev Econometrics Appendix 2, p. 251.
[2] Special table "Values of Fα; k1; k2 -Fisher-Snedekor criterion". Kremer N.S., Putko B.A. (2007). Econometrics. Moscow: UNITI-DANA, Mathematical and Statistical Tables. Table IV., pp. 295-297.
[3] Special table "Values of the Durbin-Watson criterion at the significance level α=0.05" (starts at n equal to 15 observations). Kremer N.S., Putko B.A. (2007). Econometrics. Moscow: UNITI-DANA, p. 298.

Source: Authors' calculations

It should be noted that the parameter *a* does not carry economic meaning, if ***x=0*** shows the value of the resultant sign ***y***.

Table 4. Stage of verification of regression models

Indicators		**Characteristics**	
		Model 1.	**Model 2.**
Average approximation error	$\overline{A} < 10\ \%$	$\overline{A} = 3.127\ \%$ $\overline{A} < 10\ \%$	$\overline{A} = 3.130\ \%$ $\overline{A} < 10\ \%$

Source: Authors' calculations

Detailed explanation of Table 3. Quality assessment criteria for regression models are presented in Table 5.

Table 5. Explanation of the obtained assessments of regression models quality

Indicators	**Explanation of the obtained assessments**
Standard errors of coefficients (*Std. Error*) or standard deviations of assessments of coefficients *a* and *b*	Estimation of statistical significance of coefficients in independent variable regression is performed by determining their random errors. Estimation of the *standard error of the coefficients* is based on the logic of comparison with the values of the free term ***a*** and coefficients ***b***. Model 1. $s_a > a$, $s_{b1} > b_1$, $s_{b3} < b_3$ - the errors are higher than the values of the coefficients, which is not logical. Model 2. $s_a < a$, $s_{b2} < b_2$ - errors are lower the value of the coefficients, logic is observed. The values of the coefficients are presented in the models equation.
t statistic (Student's t test)	A formal method for testing the statistical significance of regression coefficients ***b*** and free term ***a***. *Student's t-criterion* is the ratio of the regression coefficient to its standard error: $t_{bi} = b_i / s_{bi}$, where s_{bi} is the standard error for the coefficient b_i. The coefficients ***b*** and the free term ***a*** have a Student's distribution with **n-m-1** degrees of freedom, which is compared with the tabular at a significance 0.05 and **n-m-1** degrees of freedom. The *null hypothesis* that the **t-statistic** and, consequently, the coefficients ***b*** and the free term ***a*** are equal to zero is tested (H_0: $t=0$, then $a=0$, $b_1=0$, $b_2=0$, Model 1.; H_0: $t=0$, then $a=0$, $b_1=0$, Model 2.). The null hypothesis H_0 is rejected if $\lvert t \rvert > t_{tabl}$ $(t_{1-\alpha;\ n-m-1})$, where t_{tabl} is the boundary of the Student's distribution field for the number of degrees of freedom **n-2** for pair regression Model 2., **n-3** for multiple regression Model 1. and significance level α**=0.05**. **Model 1.** $\lvert t \rvert < t_{0,95;7}$. t Student's t distribution for regression coefficients and free term is less than $t_{tabl.} = 2.3646$. The *null hypothesis* H_0 is accepted and the random nature of the formation of a, b_1, b_2 is recognized, they **are not statistically significant**. **Model 2.** $\lvert t \rvert > t_{0.95;8}$. t Student's t distribution for the free term and regression coefficient is greater than $t_{tabl} = 2.3060$. The null hypothesis H_0 is rejected and parameters a, b_1 are non-random and formed under the influence of factor x. The coefficient on the independent variable and the free term **are statistically significant**. The procedure for testing the significance of the coefficients and free term of multiple regression and pair regression is the same.
Coefficient of determination (R^2)	It is used to test the overall quality of the regression equation. *Coefficient of determination* characterises the tightness of the connection between a set of

	factors under study and GDP, the share of explained variation of the dependent variable or the share of explained dispersion in the total dispersion of the dependent variable ***Y***. Equal to the square of the correlation coefficient between variables ***X*** and ***Y***. $\mathbf{R^2 = (R_{xy})^2}$ **Model 1.**, **Model 2.** $\mathbf{R^2}$=0.739, is in the interval **[0; 1]**, the connection is high, the change in GDP depends on the factors included in the models.
F - Fisher's criterion	It is used to determine the *statistical significance* of the coefficient of determination. The null hypothesis (H_0) is put forward for the F-statistic: all regression coefficients except the free term are made equal to zero, in this case the coefficient the determination $\mathbf{R^2}$ and the ***F-statistic*** are also equal to zero (H_0: $\mathbf{R^2 = 0}$ is equivalent to the hypothesis H_0: $\mathbf{b_1 = ... = b_n = 0}$). The null hypothesis is rejected if ***F* fact. > *F* tabl**. **F fact. > F tabl.**, Model 1. **9.906 > 4.74**; Model 2. **22.644 > 5.32**. *F - Fisher's criterion* confirms the presence influence of factor variation on the resultant sign: the influence of the change in the age structure of the population on GDP is practically reliable. *For pair regression*, the null hypothesis test for the *t-statistic* of the regression coefficient is equivalent to the null hypothesis test for the *F-statistic*.
Autocorrelation of residuals (Durbin-Watson statistic, *DW*)	The presence of autocorrelation indicates the influence of the result of the previous observation on the subsequent one. The test for the presence of autocorrelation is based on the *hypothesis*: if the autocorrelation of regression errors is not equal to zero, then it is present in the regression residuals ($\boldsymbol{e_t}$) as a result of applying the *least squares method*. The closeness of the test to **0** determines the presence of *positive* correlation, to 4 - *negative* correlation. According to the test of autocorrelation (**DW ≥ 2.5**) - Model 1. and Model 2. enter into the zone of uncertainty - there is **no possibility to affirm** that there is no autocorrelation. It should be noted that the *Durbin-Watson test* does **not represent a statistical criterion**, as it depends on the number of observations ***n***, the number of regressors ***x***. The presence of uncertainty zones does not allow us to reject the hypothesis about the absence of autocorrelation.
Average approximation error	Approximation reproduction of factual data of an economic phenomenon by an analytical function. *The average approximation error* is the deviation of calculations from the factual data. For Model 1. the average deviation ($\overline{A}$) was = 3.127 %, for Model 2. $\overline{A}$ = 3.130 %. The calculated average deviation in both models is within acceptable limits ($\overline{A}$ < 10 %). The constructed equations reflect the dependence between the studied factors.

Source: Authors' calculations

The main task of modelling is to justify the choice of influencing factors, determine their changes and assess the impact of these changes on the value of GDP. The authors have successfully coped with this task.

In the conditions of population decline, reduction in the share of working age population and, as a consequence, reduction in the number of employed population, the role of STP, namely, innovation factors is increasing. The share of capital in the composition of GDP is not decreasing. This indicates that the share of labour in GDP is freezing or decreasing. At the same time, it is necessary to note the increase in the number of the employed population with professional education (Zaharov S., 2020).

4. Conclusions

Based on the analysis of the connection between age groups in the population and GDP as the main macroeconomic indicator, the following conclusions can be formulated:

- The application of econometric method allowed to assess the quantitative impact of age changes in the composition of the population on the value of GDP,
- On the basis of econometric estimation, using calculations based on NBS data, the negative impact on GDP of the decreasing share of the age group 20-59 (on the GDP value) and the positive impact of the increasing share of the age group 60+ was revealed.
- The use of regression analysis made it possible to note the prospectivity of the age group of the elderly population (60+) according to the value of t - Student's criterion (Table 1., Model 1., t_{x3}= 1.450) compared to the tabulated value ($t_{tabl.}$= $t_{0.95;7}$ = 2.3646).

Acknowledgement: *The article was developed within the framework of the institutional project "Demographic transition in the Republic of Moldova: particularities, socioeconomic implications and consolidation of demographic resilience (2024-2027)".*

References:

1. Ibragimov, M., 1959. *Elements of Mathematical Statistics for Economists*.
2. Kremer, N.S. and Putko, B.A., 2007. *Econometrics*. Moscow: Unity-Dana.
3. Motilal, O., 1980. Is labor losing the battle against capital? An analysis of annual survey of industries since 1980s. *The Hindu Business Line*. [pdf] Available at: <https://www.thehindubusinessline.com/multimedia/archive/03172/Motilal_Oswal__Is__3172873a.pdf> [Accessed 20 February 2024].
4. Ryazantsev, S.V., Gnevashev, V.A., Bozhenko, V.V. et al., 2014. *New Model of the Russian Labour Market: The Role of External Factors*. Moscow: Ekoninform.
5. Zaharov, S., 2017. The Impact of the Education Level of the Employed Population on the Dynamics of GDP. In: *Creşterea Economică în Condiţiile Globalizării*, Sesiunea ştiinţifică: *Dinamica populaţiei şi calitatea potenţialului uman*: conferinţa internaţională ştiinţifico-practică, 12-13 octombrie 2017, Chişinău. Ediţia a XII-a. Institutul Naţional de Cercetări Economice. Chişinău, 2017, pp.186-197. [pdf] Available at: <http://ccd.ucoz.com/_ld/0/58_Conferinta-DEMO.pdf> [Accessed 20 February 2024].
6. Zaharov, S., 2020. *Labour market in the conditions of demographic changes*. 128 p. [pdf] Available at: <doi.org/10.36004/nier.monogr.331.2020> [Accessed 20 February 2024].

Annexe 1. Table 1. Calculated data of GDP and population by age groups for calculation

	GDP, 2014 prices, thousand MDL	Population with usual place of residence, %		
		0-19	20-59	60+
2014	131964258	24.5	57.7	17.8
2015	131018040	24.1	57.6	18.3
2016	137040143	24.0	57.2	18.9
2017	142698570	24.0	56.5	19.6
2018	148530262	23.9	55.7	20.4
2019	**153736059**	23.8	55.0	21.3
2020	140979525	23.6	54.4	22.0
2021	160590390	23.5	53.8	22.7
2022	153145666	23.5	53.1	23.4
2023	154199330	23.5	53.1	23.4

Note: calculation data are rounded automatically
Source: Authors' calculations