THE RELATIONSHIP BETWEEN AVERAGE TOTAL MONTHLY SALARY AND GDP/CAPITA - THE ANALISYS ON A PANEL DATA OF THE EU-27 COUNTRIES

NADIA ELENA STOICUȚA [*]

ABSTRACT: *In this article, the econometric analysis of two models is performed. One analyses the evolution of GDP / capita over time for EU-27 member countries over a period of 21 years, and the second model is a panel-type one that analyses the correlation between real GDP per capita and the average gross monthly salary of EU-27 member countries in 2020.*

KEY WORDS: *econometric analysis, data panel, Eviews, least squares method, EU-27 countries.*

JEL CLASSIFICATIONS: *C12, C13, C53, C87.*

1. INTRODUCTION

This article proposes the econometric analysis of two models. The first model refers to the analysis of the correlation between the real GDP per capita and the average real gross monthly salary of the EU-27 member states in 2020. The second model analyses the evolution over time of the real GDP per capita, for EU-27 countries in the period 2000-2020. GDP per capita is a macroeconomic indicator that measures a country's performance. It is calculated by dividing the total output of a state by the total population of that state, thereby comparing the efficiency between different states.

In the European context, according to statistics, ten Member States have a level of GDP per capita above the EU average in 2020. This indicator shows substantial differences between EU Member States. Also in 2020, the GDP per capita expressed in PPS varied between 55% of the EU average in Bulgaria and 266% in Luxembourg. GDP per capita is very high in Luxembourg also due to the fact that a large number of foreign residents are employed in this country and therefore contribute to its GDP, but are not included in the resident population.

[*] *Lecturer, Ph.D., University of Petrosani, Romania, stoicuta_nadia@yahoo.com*

Romania's GDP per capita increased by 3%, reaching 72% of the European Union average compared to 2019. However, Romania is one of the countries with the lowest GDP per capita in the European Union, ranked 25th. According to Eurostat, Romania was overtaken this year by countries such as Poland, which in 2020 had a GDP per capita of 76% of the EU-27 average and Hungary by 74% of the EU average.

The following figure shows the level of real GDP per capita in the EU-27 component countries in 2020.

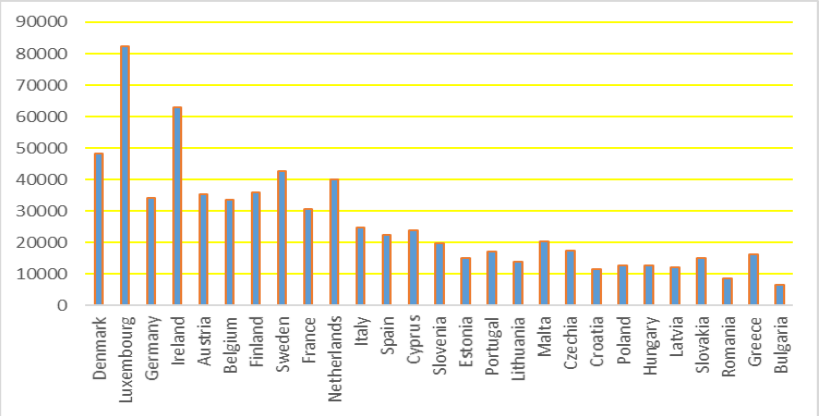

Figure 1. The level of real GDP per capita in the EU component countries in 2020

As shown in the diagram above, the highest level of GDP per capita in the EU-27 in 2020 is that of Luxembourg (EUR 82250 per capita), followed by Ireland (EUR 62980 per capita) and Denmark (EUR 48150 per capita). At the opposite pole, are Croatia (11500 euros per capita), Romania (8780 euros per capita) and last place Bulgaria (6600 euros per capita). In fact, the GDP per capita in Luxembourg, Norway and Ireland is the highest in the world.

In terms of average gross wages, this is one of the most important indicators of an economy, it is one of the main factors considered by investors who want to open different production centres or services in different countries. At the same time, this is an extremely important indicator due to the fact that depending on its evolution, pensions are calculated.

Based on these considerations, Figure 2 shows the level of the average real monthly salary in the EU component countries in 2020. Following the distribution of the chart, it is observed that the highest levels of the average gross salary are those in countries such as Luxembourg (5063 euros) and Denmark (EUR 5027), followed by Germany, Ireland and Austria. The lowest salaries in the EU-27 are in Greece (1076 euros), Romania (1036 euros) and Bulgaria (668 euros). Comparing the richest level of the average gross salary with the lowest, there is a very big difference of 4395 euros. Obviously, this difference is seen in the living standards of the population.

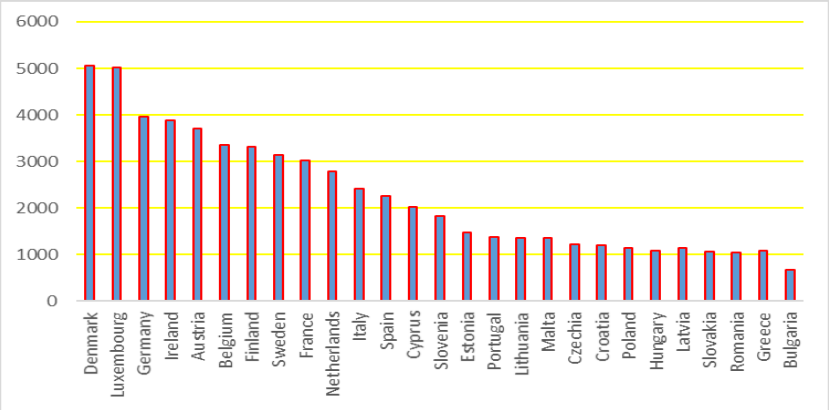

Figure 2. The level of the average real monthly salary in the EU-27 component countries in 2020

Therefore, in order to ensure the optimal functioning of the economy and the labour market, the right decisions must be made on this subject, so that the implications are positive and lasting.

2. LITERATURE REVIEW

Over time, a number of authors have tried to observe, analyse and debate the issue of analysing the correlation between GDP / capita and average gross wage, both at country and European level.

Thus, Wyrzykowski analyses a series of forecasts until 2060, regarding the situation resulting from the increase in the number of people of retirement age. He claims that there will be an increase in the share of pensions in GDP by 2.3 percentage points, but the ratio of the average pension paid in the public system to the average wage in the economy as a whole will be reduced by 19%. Also, in the period 2013-2060, in each country of the European Union, the demographic burden will increase substantially (Wyrzykowski, 2014).

Regarding the use of time series-specific models, the article proposed by Stoical addresses a difficult issue regarding the optimal management of an economic system that describes the dependence between budget expenditures and GDP in Romania. In this order size adjustment system, it is represented by the budget expenditures to be chosen so that the gross domestic product reaches the desired level (Stoical et al., 2009).

Studies on the analysis of the "Europe 2020" strategy were conducted by authors such as Dumitrescu. The paper outlines the economic aspects and social development in the light of this strategy (Dumitrescu, 2010). Kasprzyk and Wojnar also analyse the quantitative measure of the implementation of the Europe 2020 objectives, an assessment of the degree of implementation of the strategic objectives for each EU-27 country and a ranking of countries in terms of achieving the implementation of the strategy objectives (Kasprzyk & Wojnar, 2021).

3. ECONOMETRIC ANALYSIS

In this paragraph, the econometric analysis of two models is performed. The first model refers to the analysis of the dependence between the real GDP per capita and the average real gross monthly salary of the EU-27 member countries in 2020.

Table 1. Data series of the variables analysed in Model 1

The country	Real GDP / per capita in the EU in the year 2020 [euro]	Average real gross monthly salary in the EU in 2020 [euro]
Denmark	48150	5063
Luxembourg	82250	5027
Germany	34310	3971
Ireland	62980	3886
Austria	35390	3707
Belgium	33560	3364
Finland	36070	3324
Sweden	42640	3150
France	30610	3030
Netherlands	40160	2788
Italy	24890	2413
Spain	22350	2254
Cyprus	23770	2022
Slovenia	19720	1831
Estonia	15010	1478
Portugal	17070	1384
Lithuania	13890	1366
Malta	20380	1360
Czechia	17340	1228
Croatia	11500	1209
Poland	12700	1144
Hungary	12680	1092
Latvia	12130	1151
Slovakia	15180	1061
Romania	8780	1036
Greece	16300	1076
Bulgaria	6600	668

The second model analyses the evolution over time of the real GDP / capita per European Union - 27 countries, in the period 2000-2020. The link between the two models is given by the macroeconomic indicator GDP / capita.

Model 1. As specified above, the first model analyses the dependence between real GDP / capita and the average real gross monthly salary of EU-27 member countries. Thus, within the model, the dependent variable is the average gross salary $Y = (y_i)_{i=\overline{1,27}}$, and the independent variable is the GDP / capita $X = (x_i)_{i=\overline{1,27}}$.

The analysis is conducted for 2020 and aims the influence of GDP / capita on the level of the average gross salary in EU-27 member states**.**

The following table shows the data series of real GDP / capita, respectively of the average real gross monthly salary, in 2020, of the EU member states. The real values of the average gross monthly salary (https://www.reinisfischer.com) were calculated on the basis of the CPI Consumer Price Index (2010 = 100) in EURO, and those of GDP / capita (2010 = 100) were calculated on the basis of the percentage values of the GDP deflator (https://data.worldbank.org).

Taking into account the above, Figure 3 shows the diagram of the data cloud describing the link between the average gross monthly salary and the real GDP / capita, in the EU-27 member countries, for the year 2020.

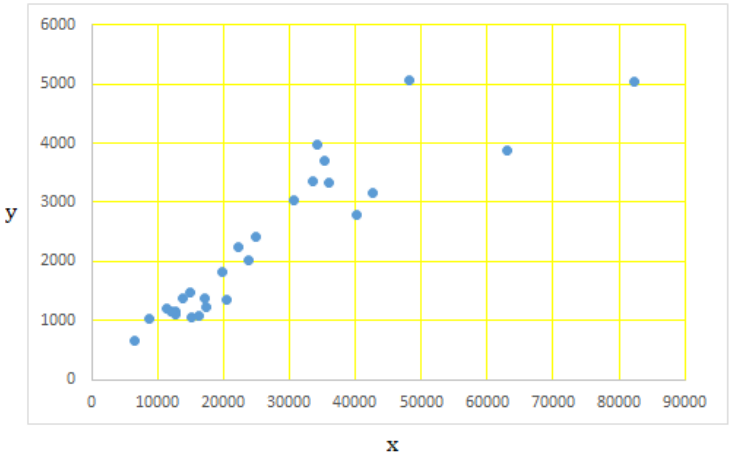

Figure 3. Diagram of the data cloud describing the link between the average real gross monthly salary and the real GDP / capita in the EU in 2020

Model 2. The second model analyses the evolution over time of real GDP / capita per EU-27. The analysis is performed over a period of 21 years (2000-2020). The real-time GDP / capita values are entered in the following table. Data were taken from the Eurostat website (https://www.statista.com).

Table 2. Values of the dependent variable Model 2

Years	2000	2001	2002	2003	2004	2005	2006	2007	2008
GDP/capita EU- 27 [euro]	22460	22900	23090	23210	23710	24060	24820	25510	25580
Years	2009	2010	2011	2012	2013	2014	2015	2016	2017
GDP/capita EU- 27 [euro]	24410	24900	25320	25100	25060	25420	25950	26410	27110
Years	2018	2019	2020						
GDP/capita EU- 27 [euro]	27620	28060	26380						

Following the evolution over time of GDP / capita it can be seen that it was an upward trend until the years affected by the global economic crisis (2009-2010), and then return to an upward trend.

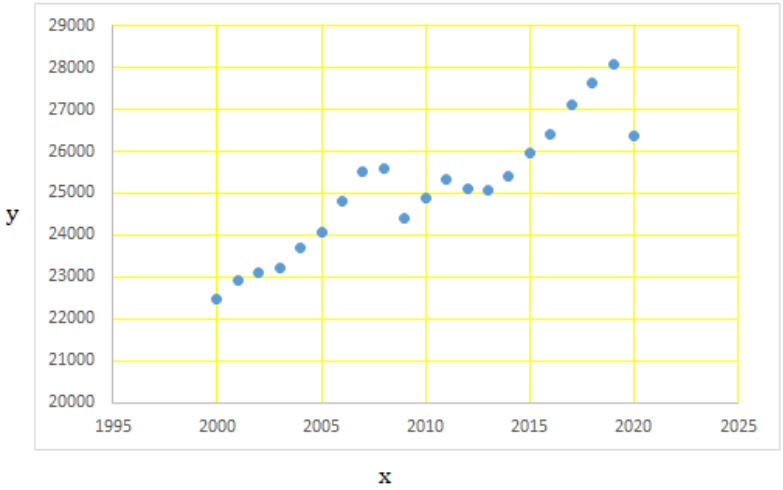

Figure 4. Evolution over time of real GDP / capita, European Union - 27 countries, from 2000-2020

However, in 2020 we notice again a rather large decrease in the value of GDP / capita, this decrease being mainly motivated by the pandemic that affected the whole world, the one with COVID19.

3.1. Results and discussion

This paragraph will present on the one hand, the results obtained from the processing of data series for the two models analysed, and on the other hand will be interpreted from an econometric point of view the results obtained. The two analyses are performed following the application of the Eviews program.

Model 1. Regarding the analysis of the correlation between the real GDP per capita and the average real gross monthly salary in the EU-27 Member States, for the year 2020, following the distribution of the pairs $(x_i, y_i), i = \overline{1,27}$ in the plan, it is observed that they can be approximated by a polynomial model. The polynomial function by which this model is represented is a third degree one and is represented in Table 3 (Model 1). It is noted with c_1, c_2 and c_3 are the parameters of the model, and ε is the residual variable.

In the panel data series, each value is located by two indices, one to specify the time dimension and the other to identify the statistical unit. Thus, the indicator i represents the number of countries analysed, and t represents the year in which the analysis is performed. In polynomial-type models, it must be taken into account that

the exogenous variable is not affected by the multicollinear phenomenon (the determinant of the matrix $\det\left(\mathbf{X^T X}\right) \neq 0$).

The polynomial model defined in Table 3 can be written in the following matrix form (it has been taken into account that the reporting time $t = 1$ is 2020):

$$\mathbf{y} = \mathbf{XA} + \boldsymbol{\varepsilon}, \tag{1}$$

where

$$\mathbf{y} = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ \dots \\ y_{27} \end{bmatrix}_{(27\times 1)}; \mathbf{X} = \begin{bmatrix} x_1 & x_1^2 & x_1^3 \\ x_2 & x_2^2 & x_2^3 \\ \dots & \dots & \dots \\ x_{27} & x_{25}^2 & x_{25}^3 \end{bmatrix}_{(27\times 3)}; \mathbf{A} = \begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix}_{(3\times 1)}; \boldsymbol{\varepsilon} = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \dots \\ \varepsilon_{27} \end{bmatrix}_{(27\times 1)} \tag{2}$$

The least squares method was used to estimate the parameters c_1, c_2, c_3 of the polynomial model. The normal (Gaussian) system obtained by applying the least squares method has the following matrix form:

$$\mathbf{X^T X \hat{A}} = \mathbf{X^T y} \tag{3}$$

where the matrix $\mathbf{X^T}$ is transposed to the matrix $\mathbf{X}$.

As specified above, from the non-collinearity assumption of the input variable, the matrix $\mathbf{X^T X}$ it must be non-singular ($\det\left(\mathbf{X^T X}\right) \neq 0$).

The solution of the system given by relation (1), is calculated with relation:

$$\mathbf{\hat{A}} = \left(\mathbf{X^T X}\right)^{-1} \mathbf{X^T y}. \tag{4}$$

where $\left(\mathbf{X^T X}\right)^{-1}$ is the inverse of the matrix $\mathbf{X^T X}$.

Model 2. The second model addressed in the article is related to the time analysis $T = (t_i)_{i=\overline{1,21}}$ of the GDP per capita $Y = (y_i)_{i=\overline{1,21}}$ of the EU-27. The analyzed period is 21 years (2000-2020). Following the analysis of the distribution of the analyzed data, it was found that the best model that approximates these data is an Autoregressive Moving Average Model **ARMA (3,3)** (see Table 3-**Model 2**).

In this model, the parameters $c_1, ..., c_8$ of the **ARMA(3,3)** model were denoted, and the residual variable was denoted. The parameters of the Autoregressive Moving Average Model were estimated using the least squares method. The values obtained by using the Eviews software package can also be found in Table 3.

Table 3. Results of estimating the parameters of the two models

Model 1. $y_i = c_1 \cdot x_i + c_2 \cdot x_i^2 + c_3 \cdot x_i^3 + \varepsilon_i, i = \overline{1,27}$				
	Coefficient	Std. Error	t-Statistic	Prob.
c_1	0.090381	0.014989	6.029884	0.0000
c_2	2.80E-07	6.54E-07	0.427937	0.6725
c_3	-8.16E-12	6.18E-12	-1.320503	0.1991
R-squared	0.888221	Mean dependent var		2262.333
Adjusted R-squared	0.878906	S.D. dependent var		1290.891
S.E. of regression	449.2118	Akaike info criterion		15.15731
Sum squared resid	4842989.	Schwarz criterion		15.30129
Log likelihood	-201.6236	Hannan-Quinn criter.		15.20012
Durbin-Watson stat	2.297910			
Model 2. $y_t = c_1 + c_2 \cdot t + c_3 \cdot y_{t-1} + c_4 \cdot y_{t-2} + c_5 \cdot y_{t-3} + c_6 \cdot u_{t-1} + c_7 \cdot u_{t-2} + c_8 \cdot u_{t-3} + \varepsilon_t$				
	Coefficient	Std. Error	t-Statistic	Prob.
C	-397900.0	37510.98	-10.60756	0.0000
X	210.4388	18.66588	11.27398	0.0000
AR(1)	0.063524	0.395305	0.160696	0.8750
AR(2)	0.273719	0.823616	0.332338	0.7454
AR(3)	-0.218145	0.528229	-0.412975	0.6869
MA(1)	0.678488	174.7583	0.003882	0.9970
MA(2)	-0.682537	296.4951	-0.002302	0.9982
MA(3)	-0.994826	178.6538	-0.005568	0.9956
SIGMASQ	130322.4	23392351	0.005571	0.9956
R-squared	0.941534	Mean dependent var		25099.05
Adjusted R-squared	0.902557	S.D. dependent var		1529.869
S.E. of regression	477.5608	Akaike info criterion		15.80034
Sum squared resid	2736771.	Schwarz criterion		16.24799
Log likelihood	-156.9036	Hannan-Quinn criter.		15.89749
F-statistic	24.15613	Durbin-Watson stat		1.846190
Inverted AR Roots	.40-.38i	.40+.38i		-.73
Inverted MA Roots	1.00	-.84+.54i		-.84-.54i

To show that the ARMA model applied here is a valid one, it is enough to show that this model is a stationary (stable) one, ie it has all the modules of the roots of the polynomial equation of the model are inside the unit circle of the complex plane. As can be seen in the last two lines of Table 3, the polynomials of the poles of the ARMA model have the subunit modulus, which indicates that the model is stable input-output. On the other hand, it is observed that the roots of the polynomial equation are inside the circle of unit radius.

Following the analysis of the statistical tests of the two models, the following information can be deduced:

- The value of the determination report R^2, shows that for the both analysed models, the approximation of the data series is a good one, this ensuring the

matching of the models to the available data, the intensity of the connection of the variables being a strong one;
- For both models, all the hypotheses specific to the least squares method were verified (zero average of the values of the residual variable, satisfied homoscedasticity, residues not correlated with each other and normally distributed);
- The values of the three indicators based on information theory are small enough to say that the two models analysed give very good results (Akaike criterion, Schwarz criterion, Hannan-Quinn criterion);
- The high value of the Durbin-Whatson statistics shows that for the two models the residues are not correlated with each other;
- The statistical tests that were applied to verify the statistical assumptions applied in the case of both models were applied for a significance threshold of 5%.

Table 4. Values of the descriptive indicators for the two models

	Model 1.		**Model 2**	
	X	Y	T	Y
Mean	26533.70	2262.333	2010.000	25099.05
Median	20380.00	1831.000	2010.000	25100.00
Maximum	82250.00	5063.000	2020.000	28060.00
Minimum	6600.000	668.0000	2000.000	22460.00
Std. Dev.	17522.14	1290.891	6.204837	1529.869
Skewness	1.508540	0.738985	4.97E-18	0.104244
Kurtosis	5.193324	2.387788	1.794545	2.356769
Jarque-Bera	15.65262	2.879097	1.271481	0.400062
Probability	0.000399	0.237035	0.529543	0.818706

Table 4 introduces the values of the main descriptive indicators of the variables X and Y for the first model, respectively T and Y for the second model. The values of these indicators were calculated using the Eviews program. The statistical results obtained show that there is a strong link between the analysed variables of the two models.

4. CONCLUSIONS

Following the two analyses carried out in this article, a direct relationship can be seen both between GDP per capita and the average real gross monthly wage for all EU-27 member states, and in terms of the variation over time of the GDP per capita for the EU-27. Thus, at the level of 2020, it was observed that countries that have a high level of GDP per capita also have a high level of average gross salary. On the other hand, comparing the richest level of the average gross wage with the lowest for the EU-27 member states, there is a very large difference of 4395 euros between the country with the highest GDP per capita and the country with the highest low level of this indicator. Obviously, this difference is seen in the living standards of the population.

At the same time, in 2020 there is a rather large decrease in the value of GDP / capita, this decrease being mainly motivated by the pandemic that affected the whole world, the one with COVID19.

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