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Evaluation of Standard of Living in OECD Countries

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Abstract: The present paper focuses on the comparison of wage levels across OECD countries, the research data coming from an official OECD website. The following eight variables are employed in this study – the average wage, minimum wage, GDP per head, tertiary education attainment, employment ratio, trade unions, labour productivity and inflation rate. The average wage represents the main explained variable in regression and correlation analysis, the remaining seven variables being used as potential explanatory ones. In order to compare living standards in different countries, average and minimum wages as well as per capita GDP data were adjusted to relative purchasing power parity. The principal objective was to identify which explanatory variables statistically significantly affect the average wage. The analysis showed that only three of them – namely the employment ratio, GDP per capita and labour productivity – have a significant effect at a 5% statistical level. The regression hyperplane with a forward stepwise selection was applied. Nine clusters of OECD countries were created based on both all the eight variables and four of them selected in regression analysis (the average wage and three explanatory ones) with the aim to identify the countries that coexist in the same cluster. Ward's method and Euclidean distance are utilized in cluster analysis, the number of clusters being determined with the use of the Dunn index. The study also aims at the prediction of the average wage by 2022, which was made via exponential smoothing of time series.

Keywords: average wage; GDP per capita; purchasing power parity; regression analysis; cluster analysis; time-series analysis

JEL Classification: D31; E24; I31

1. Introduction

Recent OECD statistics show that unemployment in member states has fallen to a record level, employment rate exceeding the pre-crisis figures. Employment growth also affects disadvantaged groups of the population such as older workers or mothers with children. A record number of vacancies is registered in Japan, the Eurozone, the United States and Australia. Working poverty, on the other hand, has further increased to 10.6% in the European Union, the poverty threshold being set at a 60% level of the income median of the company. Wage growth, however, is slow, slower than before the recession. At the end of 2017, it was only about half of the growth a decade ago when the average nominal wage grew by 5.8% compared to today’s 3.2%. Wage stagnation affects the income of low-paid workers more than that of high-paid ones.

Although all OECD member states are economically advanced, large wage differentials exist between individual countries. For example, the average nominal gross monthly wage in Iceland is more than 14.3 times higher than in Mexico. In the Czech Republic, it was CZK 31,109 in 2017, nine member countries reporting the average gross monthly wage above CZK 100,000 according to OECD statistics (conversion to CZK corresponding to the current exchange rate) – namely Switzerland (CHF 7,170), Iceland (ISK 741,976), Norway (NOK 48,139), Luxembourg (EUR 4,880), Denmark (DKK 34,459), Australia (AUD 6,962), the Netherlands (EUR 4,242), Germany (EUR 4,121) and Belgium (EUR 3,944). The average gross monthly wage did not reach CZK 25,000 only in six OECD states – Poland (PLN 4,131), Slovakia (EUR 952), Hungary (HUF 298,221), Latvia (EUR 909), Turkey (TRY 3,359) and Mexico (MXN 9,850). However, the average wage figure does not correspond to that of a regular employee in all OECD member countries since it is distorted by the wages of the best-paid employees. In the Czech Republic, only about a third of employees earn average and high income, wage differences being among the lowest in OECD states, the highest ones being recorded in non-European countries in particular.

The standard of living and its measurement has become the point of action and interests of many national and international organizations. The present research focuses on the development of the average annual gross wage in OECD member countries grouped by the location, history and the level of development; see Table 1. The paper aims to describe wage developments in individual OECD countries from the beginning of the century. For this purpose, the analysis of average gross annual wage time series and predictions by 2022 were conducted. Also, the dependence of the explained (dependent) variable (i.e. the average gross annual wage) on other labour market and living standard indicators was verified. The specific objective of the study is to identify which of the seven potentially explanatory (independent) variables influence the average gross annual wage, using regression and correlation methods. Another goal is to create clusters of countries whose living standards are as close as possible to one another in terms of all the eight variables analysed applying the multidimensional method of cluster analysis. The main hypothesis predicts that clusters of countries that are the most similar to each other correspond to the classification of all OECD member countries into individual blocks as displayed in Table 1.

Table 1. Blocks of similar OECD countries (incl. international codes).

Block				
Continental	**Scandinavian**	**Anglo-Saxon**	**South-European**	**Baltic**
1. Austria (AUT)	1. Denmark (DNK)	1. Ireland (IRL)	1. Greece (GRC)	1. Estonia (EST)
2. Belgium (BEL)	2. Finland (FIN)	2. United Kingdom (GBR)	2. Italy (ITA)	2. Latvia (LVA)
3. France (FRA)	3. Norway (NOR)		3. Portugal (PRT)	3. Lithuania (LTU)
4. Germany (DEU)	4. Sweden (SWE)		4. Spain (ESP)	
5. Luxembourg (LUX)				
6. Netherlands (NLD)				
7. Switzerland (CHE)				

Block			
Central-European	**North-Atlantic**	**Advanced non-European**	**Developing non-European**
1. Czech Republic (CZE)	1. Iceland (ISL)	1. Australia (AUS)	1. Chile (CHL)
2. Hungary (HUN)		2. Canada (CAN)	2. Mexico (MEX)
3. Poland (POL)		3. Israel (ISR)	3. Turkey (TUR)
4. Slovak Republic (SVK)		4. Japan (JPN)	
5. Slovenia (SVN)		5. New Zealand (NZL)	
		6. South Korea (KOR)	
		7. United States (USA)	

2. Database

Data and variable names come from the official OECD website (see stats.oecd.org), the present analysis covering all the member countries. The eight variables are used, indicated in shortened forms in the text. The average annual gross wage – average wage – in 2017 constant prices in USD after conversion to purchasing power parity (PPP) is the main research variable, the study focusing on its development over the period 2000–2017. The other seven variables based on the 2017 data are as follows: real annual minimum wage in USD after the PPP adjustment – minimum wage; gross domestic product per head in USD PPP (expenditure approach) – GDP per capita; share of the population (in %) between 25 and 64 years of age with completed tertiary education – tertiary education; annual employment ratio (in %) of the population between 15 and 64 years – employment ratio; annual trade union density (in %) – trade unions; labour productivity measured by GDP per hour worked in USD PPP – labour productivity, and consumer price indices (CPI) representing change in 2017 from the previous year (in %) – inflation. (Minimum wage legislation not being enacted in some countries – namely Austria, Denmark, Finland, Italy, Norway, Sweden and Switzerland –, the minimum wage is then considered as zero.)

The data include employees in both business and non-business sectors of the economy. The wage is paid to an employee for work done in the private corporate (business) sphere, while the salary is earned in the state budgetary (non-business) sector. Within the present study, both wages and salaries are under the umbrella term of "wage". Data were processed using SAS and Statgraphics software packages and Microsoft Excel spreadsheet. Table 1 shows the division of all 36 OECD member countries into nine blocks according to their location, history and the level of development. (Country codes are taken from the website of the Ministry of the Interior of the Czech Republic.)

There are the following nine groups of OECD member states: Continental block of advanced Western European countries; Scandinavian block; Anglo-Saxon block containing Ireland and the United Kingdom; South-European block; Baltic block of three OECD countries that were formerly part of the Soviet Union; Central-European block encompassing former socialist countries; North-Atlantic block including only Iceland; Advanced non-European block and Developing non-European block of the so-called newly industrialized countries.

3. Theory and Methodology

3.1 Regression and Correlation Analysis

The regression and correlation analysis of the 2017 data was performed; for details of this approach, see, e.g. (Darlington and Hayes 2017). The average wage represents an explained (dependent) variable, the remaining seven variables being used as potentially explanatory (independent) variables. The normality of the distribution of the variables was verified both visually and by conducting the Kolmogorov-Smirnov goodness-of-fit test, the chi-square test not being run because of too small a number of observations. Figure 1 and Table 2 show the results of normality verification for the average wage. Although the wage variable has mostly a lognormal distribution, i.e. with positive skewness, the average wage variable has a symmetrical distribution, which provides evidence in favour of a normal distribution; see Figure 1. P-value of 0.311443 in Table 2 indicates that the hypothesis assuming the normality of the average wage distribution was not rejected at any (i.e. 5%, 1% or 10%) level of significance. The normality of the other variables was verified analogously.

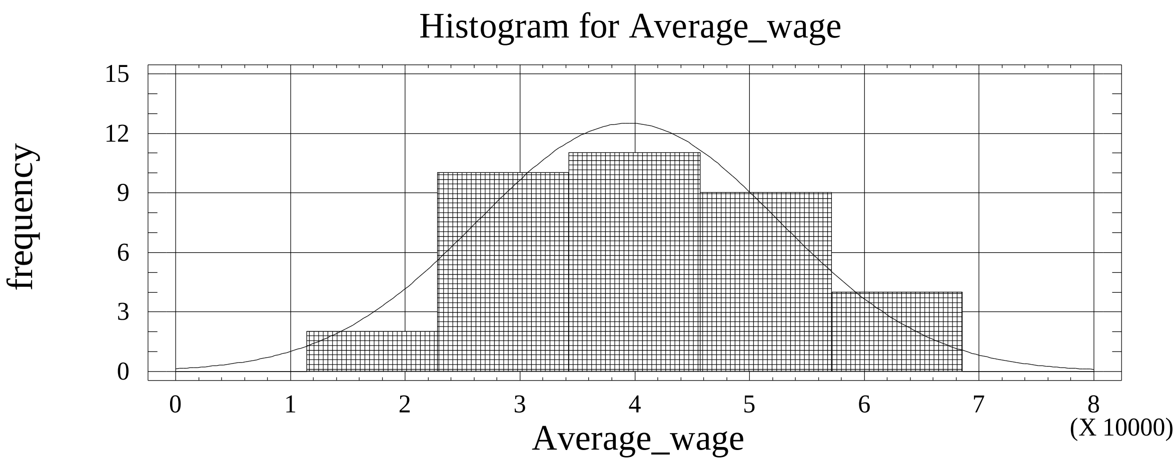
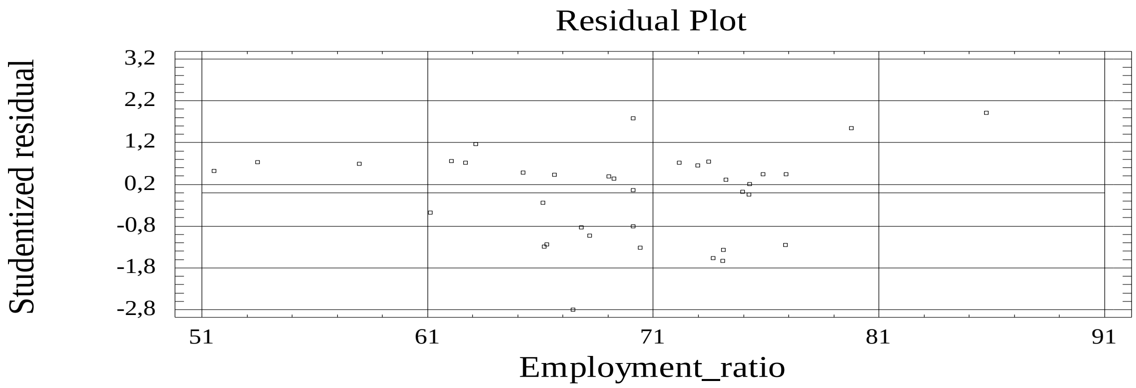


Figure 1. Results of visual verification of average wage variable.

Table 2. Results of Kolmogorov-Smirnov goodness-of-fit test for average wage.

Goodness-of-fit tests for average wage				
Chi-square test				
Lower limit	Upper limit	Observed frequency	Expected frequency	Chi-square
at or below	34,285.7	12	12.51	0.02
34,285.7	45,714.3	11	12.11	0.10
45,714.3	above	13	11.38	0.23
Insufficient data to conduct Chi-square test.				
Estimated Kolmogorov statistic DPLUS = 0.160795				
Estimated Kolmogorov statistic DMINUS = 0.0938418				
Estimated overall statistic DN = 0.160795				
Approximate P-value = 0.311443				

The regression hyperplane with seven potentially explanatory variables having been considered, stepwise regression with the forward selection method was used to determine the set of explanatory variables that have a statistically significant effect on the explained variable; see Table 3. The backward selection approach led to the same result. It is clear from the table that three explanatory variables were inserted into the model, namely the employment ratio, GDP per capita and labour productivity. All individual t-tests and total F-test are significant at the 5% level. The multiple determination coefficient shows that about 80.43% of the variability of the observed average wage values was explained by the selected regression hyperplane and the three explanatory variables. A Durbin-Watson statistic of 2.47733 lies in the interval (1.4; 2.6). Being close to 2, this value indicates that there is no problem with autocorrelation. The matrix of double correlation coefficients for verification of the existence of serious multicollinearity between the explanatory variables suggests that the absolute value of any of the correlation coefficients does not exceed 0.5. This means that there is no problem with multicollinearity. Figure 2 displays the residual plots corresponding to the model with the three selected explanatory variables, the residues being considered as random. In addition to the visual assessment, the Glejser test was undertaken, not showing any problems with heteroscedasticity.



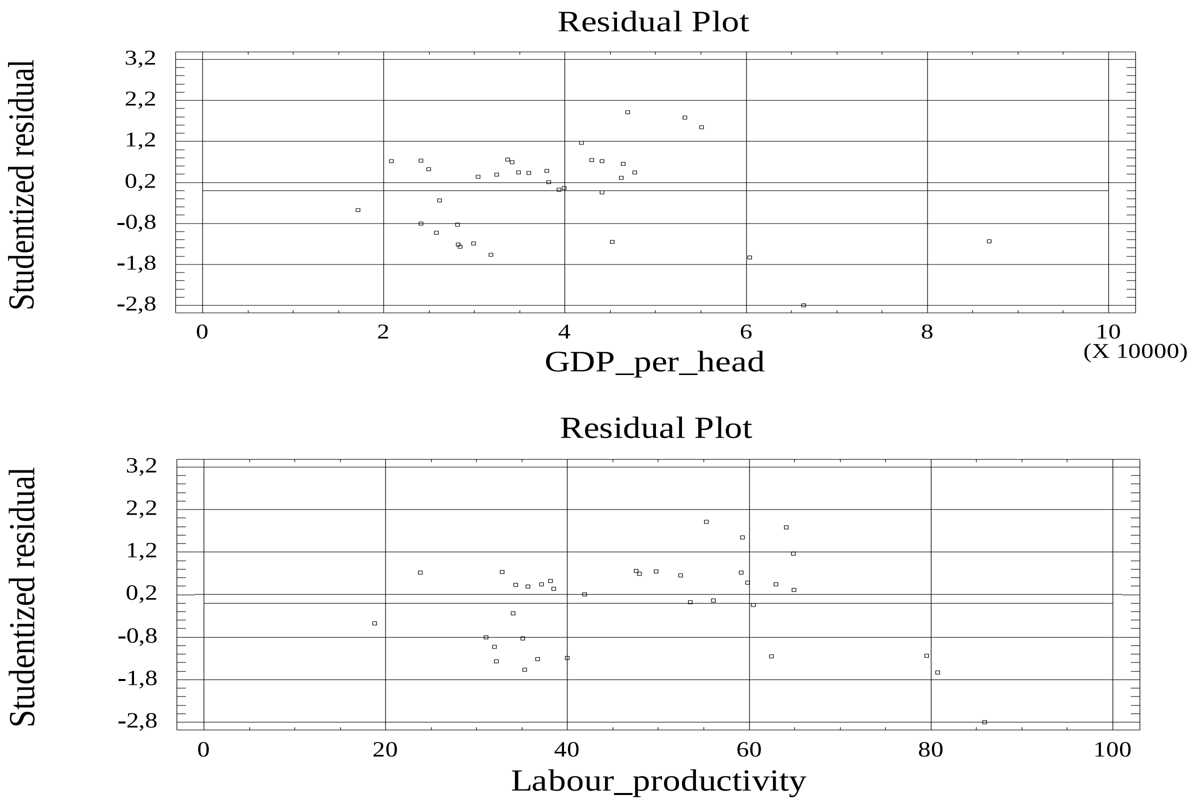


Figure 2. Residual plots.

3.2 Cluster Analysis

The basics of this multidimensional statistical method are explained, for example, by (Rencher and Christensen 2012). Ward's method and the Euclidean distance are the most widely used techniques that are also employed in this cluster analysis of the 2017 data, performed separately for both all the eight variables and only four of them, namely the average wage and the three explanatory variables selected in the regression and correlation analysis.

In the Ward's method, which is one of the hierarchical clustering approaches, the procedure is not based on the optimization of distances between clusters. The minimization of heterogeneity of clusters is carried out according to an increase in the intra-cluster sum of squares of objects' deviations from the centre (centroids) of the clusters. Ward's method tends to remove too small clusters, thus inclining to form those of roughly the same size, which is a welcome feature for the clustering of the OECD countries. As for the measurements of the distance and similarity of objects, the need to reinforce the influence of variables is taken into account. Since there is no such need in this case – points with the same distance from the centre lying on a circle –, the Euclidean distance was chosen.

Table 3. Results of linear regression analysis using stepwise regression and forward selection.

Multiple regression analysis				
Dependent variable: Average wage				
Parameter	Estimate	Standard error	T-statistic	P-value
CONSTANT	–20,402.5	10,420.0	–1.95801	0.0490
Employment ratio	420.915	158.114	2.66209	0.0120
GDP per capita	0.393688	0.178743	2.20254	0.0349
Labour productivity	317.248	148.38	2.13808	0.0402

Analysis of variance

Source	Sum of squares	DF	Mean square	F-ratio	P-value
Model	4.84677E9	3	1.61559E9	43.83	0.0000
Residual	1.17951E9	32	3.68597E7		
Total	6.02628E9	35			

R-squared = 80.4272%
R-squared (adjusted for d.f.) = 78.5923%
Standard error of est. = 6071.22
Mean absolute error = 4770.67
Durbin-Watson statistic = 2.47733

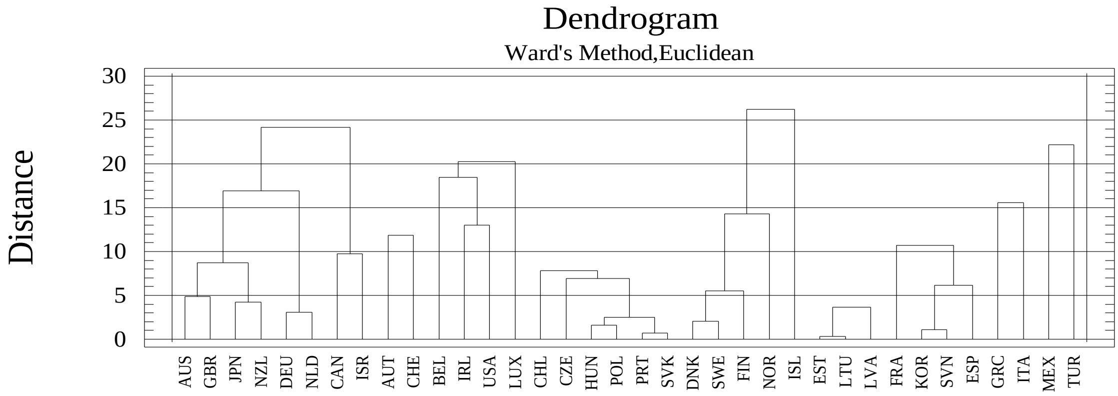


Figure 3. Results of cluster analysis applied to all eight variables.

In cluster analysis, there are different methods and recommendations for determining the optimal number of clusters. However, they do not justify any definitive conclusions because cluster analysis is basically a reconnaissance approach, not a statistical test. Exposition and clarification of the resulting hierarchical structure depend on the context. Theoretically, there are several possible approaches to determining the best number of clusters possible. One of the validation indices is the well-established Dunn index. It represents the ratio of the smallest inter-cluster distance to the largest one, the index values ranging from zero to infinity, high ones indicating the optimal number of clusters. In the present study, the Dunn index was also applied, nine clusters being determined as optimal; see Figures 3 and 4.

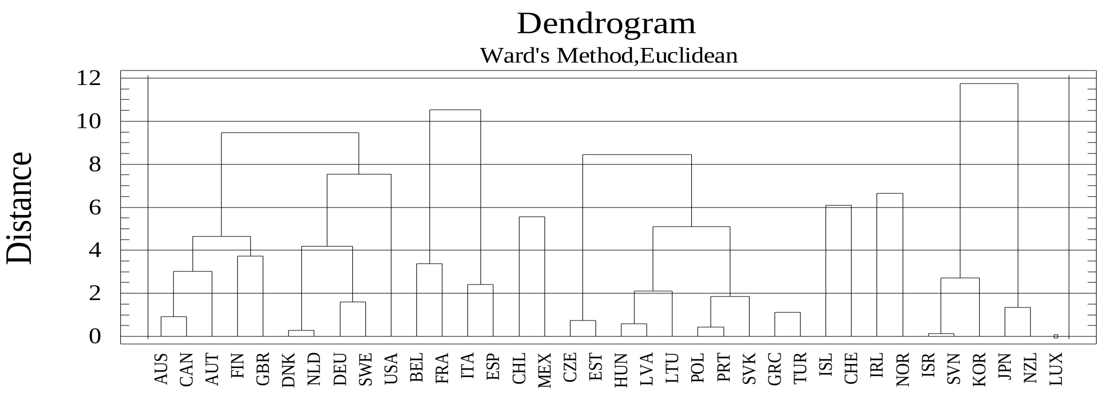


Figure 4. Results of cluster analysis applied to four selected variables.

3.3 Time Series Analysis

The essence of time series analysis is described in detail in, e.g. (Brockwell and Davis 2002). In the context of the trend development, exponential smoothing was done within the analysis of average wage time series to predict the average wage over the next five years. Exponential smoothing is one of the adaptive approaches to modelling time series, using the weighted least squares method, with scales exponentially decreasing towards the past. Its advantage lies in the fact that the latest observations have the highest weights. Appropriate exponential smoothing was selected applying interpolation criteria. Figures 5 and 8 present the results of Brown's and Holt's linear exponential smoothing, respectively, as the most suitable approaches to the time series of the United States and Lithuania. In the case of Holt's exponential smoothing, the statistical software automatically evaluates the most advantageous combinations of equalization constants α and β.

Figures 6 and 9 plot corresponding sample residual autocorrelation functions, Figures 7 and 10 illustrating sample residual partial autocorrelation functions. Brown's and Holt's linear exponential smoothing is satisfactory, a non-systematic component not exhibiting autocorrelation. Durbin-Watson statistics are close to 2, i.e. within the interval (1.4, 2.6). Random failures can be therefore considered as independent.

Table 4 shows the quality of models created for the average wage in the United States and Lithuania, based on which the prediction for the next five years was made. Annual time series for the period 2000–2017 were shortened by $m = 5$ observations, i.e. for the 2013–2017 period, predictions for these five years being constructed using the appropriate exponential smoothing. Deviations between the predicted and actual values were calculated as

$$\Delta_t(i) = P_t(i) - y_{t+i}, \quad (1)$$

where $P_t(i)$ is the forecast of the monitored indicator at time t of i time units forward (prediction horizon) and y_{t+i} is the real value of the predicted indicator at time $t + i$. These deviations are called predictive errors for a given time t and the prediction horizon i; see Table 4. If $\Delta_t(i) < 0$, this is the so-called undervalued prediction, and if, on the other hand, $\Delta t(i) > 0$, an overvalued prediction occurs.

The Theil mismatch coefficient (Theil index II) is a frequently used measure of the variability of relative predictive errors

$$T_H^2 = \frac{\sum_{t=1}^{m} [P_t(i) - y_{t+i}]^2}{\sum_{t=1}^{m} y_{t+i}^2}. \quad (2)$$

This mismatch index can be only non-negative. It gets the lower zero boundary only in the case of a flawless prognosis, where $P_t(i) = y_{t+i}$. The more the Theil coefficient deviates from zero, the more the prediction differs from an ideal prognosis. The root of the index can be interpreted as a relative predictive error.

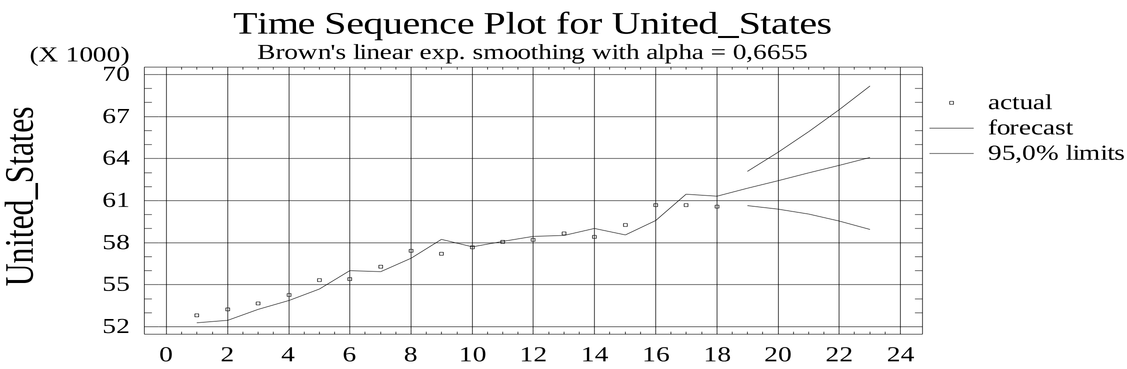


Figure 5. Brown's linear exponential smoothing (α = 0.6655) for time series of average wage in the United States.

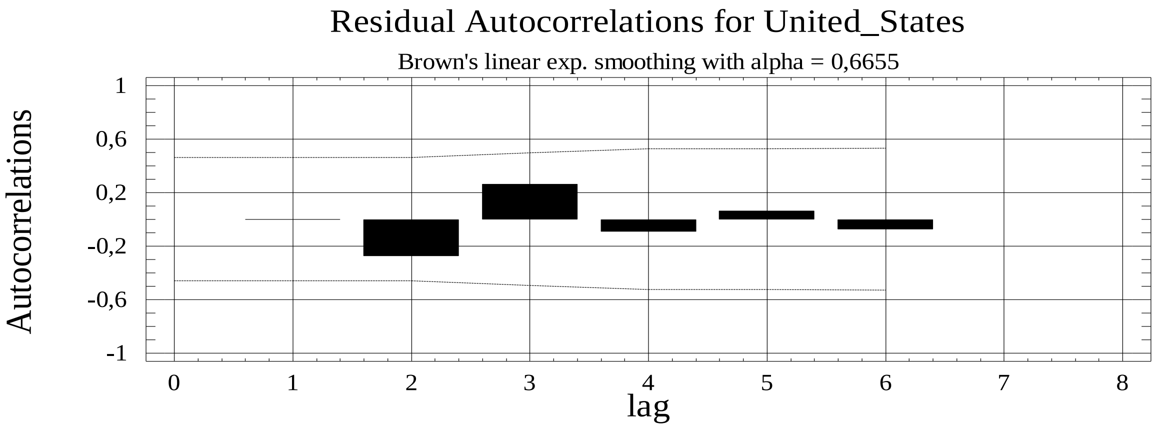


Figure 6. Sample residual autocorrelation function for time series of average wage in the United States.

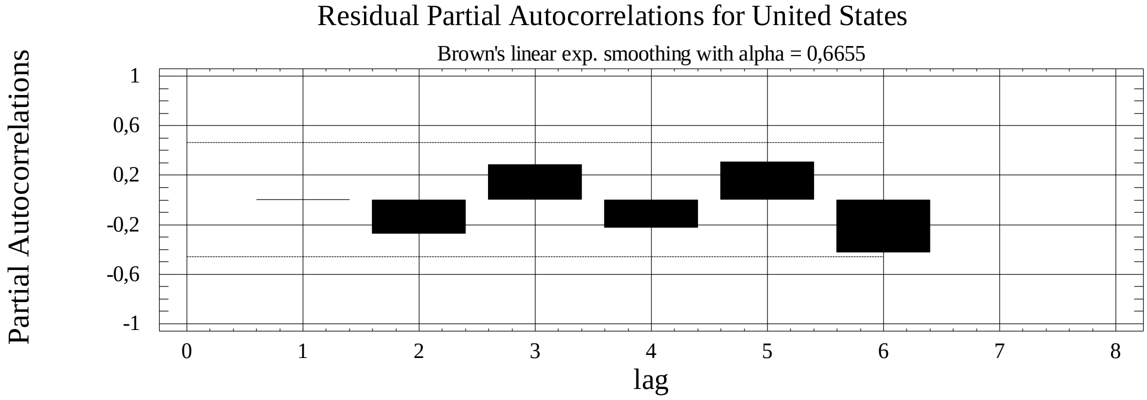


Figure 7. Sample residual partial autocorrelation function for time series of average wage in the United States.

Table 4 shows that when constructing extrapolation predictions of the average wage rate, average errors of 1.543% and 6.571% (for the U.S. and Lithuania, respectively) occurred. The values of the Theil coefficient and the relative predictive error indicate the high quality of exponential smoothing models. A similar verification of the suitability of the chosen smoothing models was also carried out for the other analysed countries.

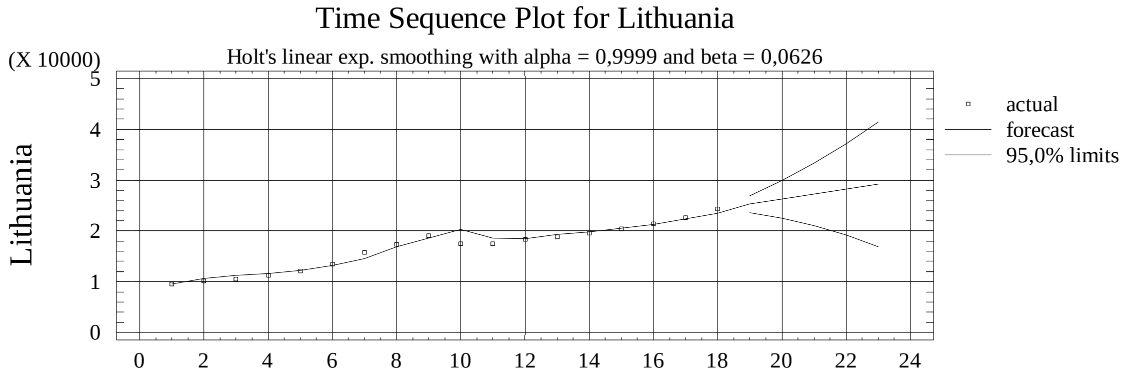


Figure 8. Holt's linear exponential smoothing ($\alpha = 0.9999$ and $\beta = 0.0626$) for time series of average wage in Lithuania.

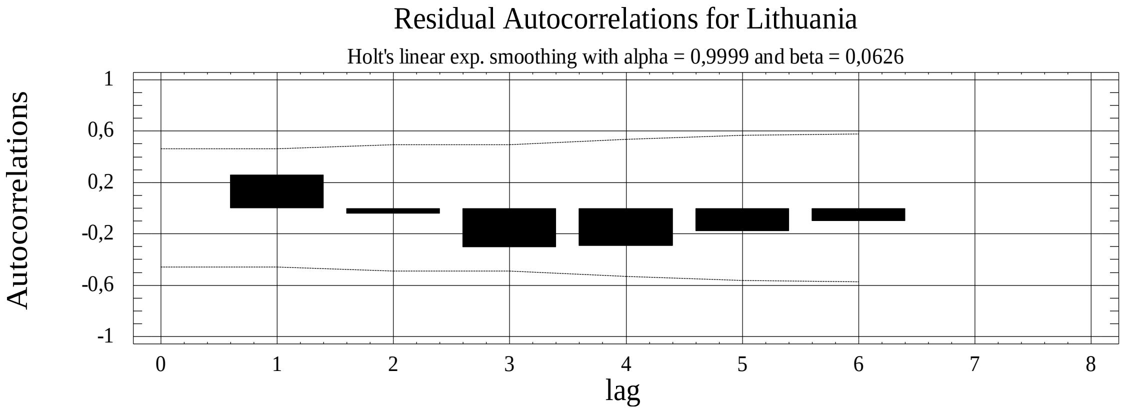


Figure 9. Sample residual autocorrelation function for time series of average wage in Lithuania.

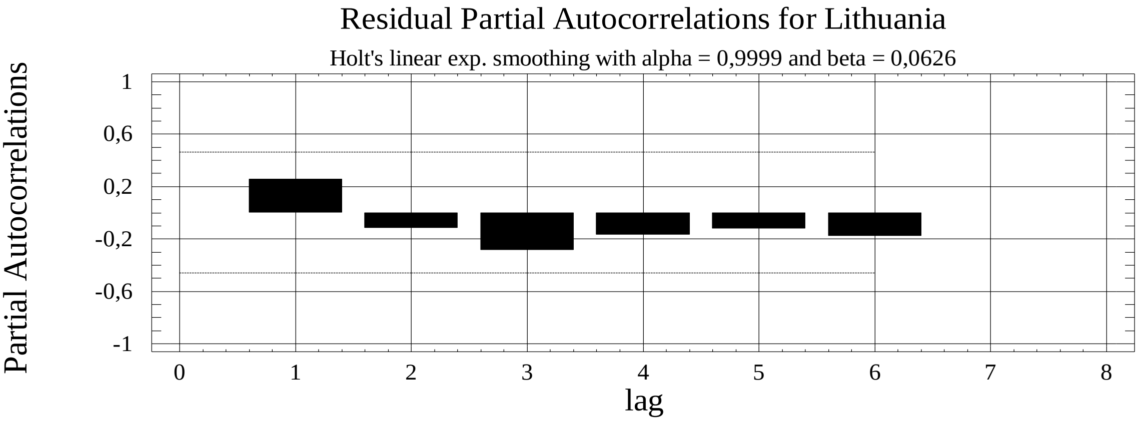


Figure 10. Sample residual partial autocorrelation function for time series of average wage in Lithuania.

4. Results and Conclusion

The world economy has been heading toward a five per cent rate of unemployment, the lowest over the last four decades. A more relaxed budgetary policy has supported the economic growth (its effects are apparent in about three quarters of the OECD countries), tax reliefs (e.g. recent US cuts) also playing their role.

Only three explanatory variables were inserted into the model as statistically significant at a 5% level in a positive direction, namely the employment ratio, GDP per capita and labour productivity. The sample regression hyperplane has the following form (cf. Table 3)

*Average wage = –20,402.5 + 420.915*employment ratio + 0.393688*GDP per head + 317.248*labour productivity.*

Table 4. Time series prediction errors for the United States and Lithuania.

	United States			Lithuania		
Year	**Reality**	**Model**	**Error**	**Reality**	**Model**	**Error**
2000	52,801	–	–	9,544	–	–
2001	53,244	–	–	10,091	–	–
2002	53,652	–	–	10,532	–	–
2003	54,280	–	–	11,232	–	–
2004	55,335	–	–	12,157	–	–
2005	55,391	–	–	13,469	–	–
2006	56,298	–	–	15,788	–	–
2007	57,420	–	–	17,403	–	–

2008	57,192	–	–	19,087	–	–
2009	57,687	–	–	17,519	–	–
2010	58,054	–	–	17,530	–	–
2011	58,200	–	–	18,345	–	–
2012	58,669	–	–	18,854	–	–
2013	58,412	58,734	322	19,608	19,412	–196
2014	59,250	58,991	–259	20,393	19,970	–423
2015	60,692	59,249	–1,443	21,417	20,528	–889
2016	60,686	59,507	–1,179	22,562	21,085	–1,477
2017	60,558	59,764	–794	24,287	21,643	–2,644
	T_H^2	0.000238		T_H^2	0.004317	
	T_H	0.015427		T_H	0.065706	

Table 5. Groups of countries that are always in the same cluster (for both eight and four variables. analysed)

Groups of countries				
Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 5**
1. Australia	1. Israel	1. Denmark	1. Czech Republic	1. Estonia
2. Canada	2. Japan	2. Finland	2. Hungary	2. Latvia
3. Germany	3. New Zealand		3. Poland	3. Lithuania
4. Netherlands			4. Portugal	
			5. Slovak Republic	

The blocks of the OECD countries broken down by their location, history and stage of development do not fully coincide with the groups of countries whose cluster analysis results are similar. However, there are many countries which are always in the same group, whether they are clustered by all eight or selected four variables analysed. These groups of countries are listed in Table 5. The first one comprises four countries, two of them belonging to the block of advanced non-European countries, the other two to the block of continental OECD states. The second group is made up of three countries which are also among the advanced non-European countries. The third group consists of two Scandinavian countries. The fourth one contains four states that belong to the Central European block of post-communist countries plus one southern European country. Finally, the fifth group is made up of the three Baltic states that used to be a part of the Soviet Union. Table 6 gives predictions of the average wage by 2022 for individual OECD member countries, except for Turkey. The highest expected average annual wage growth rates for the period 2018–2022 being predicted for the Baltic states, namely 4.58%, 3.66% and 2.15% for Latvia, Lithuania and Estonia, respectively. A relatively fast average wage growth can be also expected in most Central European countries, namely in the Czech Republic (3.44%), Slovakia (2.75%), Poland (2.58%) and Hungary (2.51%). The rapid annual increase in the average wage is also projected for Iceland (2.38%). The lowest wage growth values, on the other hand, are forecast for South-European countries – Greece, Italy and Portugal.

Table 6. Average wage prediction by 2022 (in USD).

		Prediction for year				
Block of countries	**Country**	**2018**	**2019**	**2020**	**2021**	**2022**
Continental	**1. AUT**	51,219	51,681	52,142	52,604	53,066
	2. BEL	49,721	49,766	49,812	49,857	49,903
	3. FRA	44,179	44,593	45,007	45,421	45,836
	4. DEU	48,613	49,368	50,123	50,878	51,633
	5. LUX	62,917	63,455	63,992	64,530	65,067
	6. NLD	53,089	53,298	53,508	53,717	53,926

	7. CHE	63,651	64,065	64,479	64,892	65,306
Scandinavian	**1. DNK**	51,935	52,404	52,873	53,342	53,811
	2. FIN	43,247	43,531	43,814	44,097	44,381
	3. NOR	51,941	52,669	53,397	54,126	54,854
	4. SWE	43,519	44,202	44,885	45,568	46,250
Anglo-Saxon	**1. IRL**	47,763	48,178	48,593	49,008	49,423
	2. GBR	43,969	44,205	44,442	44,679	44,916
South-European	**1. GRC**	26,226	26,176	26,126	26,076	26,026
	2. ITA	36,635	36,611	36,588	36,564	36,541
	3. PRT	25,369	25,296	25,223	25,150	25,077
	4. ESP	39,452	39,569	39,685	39,802	39,919
Baltic	**1. EST**	24,887	25,439	25,990	26,541	27,093
	2. LVA	25,204	26,441	27,678	28,915	30,152
	3. LTU	25,263	26,238	27,214	28,189	29,165
Central-European	**1. CZE**	26,231	27,181	28,131	29,081	30,031
	2. HUN	23,180	23,785	24,389	24,994	25,598
	3. POL	27,225	27,956	28,687	29,418	30,149
	4. SVK	25,239	25,964	26,688	27,413	28,137
	5. SVN	35,310	35,686	36,063	36,440	36,816
North-Atlantic	**1. ISL**	63,351	64,915	66,479	68,043	69,607
Advanced non-European	**1. AUS**	49,368	49,603	49,839	50,075	50,311
	2. CAN	48,081	48,540	48,998	49,456	49,915
	3. ISR	35,322	35,577	35,831	36,086	36,341
	4. JPN	40,748	40,780	40,811	40,843	40,874
	5. NZL	40,560	41,075	41,591	42,107	42,622
	6. KOR	35,791	36,391	36,990	37,590	38,190
	7. USA	61,871	62,420	62,970	63,519	64,069
Developing non-European	**1. CHL**	18,861	19,077	19,292	19,508	19,724
	2. MEX	15,411	15,421	15,430	15,439	15,448
	3. TUR	–	–	–	–	–

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