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Modelling the trends of the healthcare funding in the EU countries[1]

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Abstract
Healthcare is one of the most important sectors of the public economy in the EU countries. An important task in the analysis and prediction of the values for healthcare funding is the development and application of quantitative models based on different mathematical methods. Three of the most popular indicators used for the macroeconomic description of the funding of healthcare are: (1) total government expenditure on health as a percentage of GDP; (2) total government expenditure on health as a percentage of total general government expenditure; and (3) total government expenditure on health per capita.

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The aim of this research is to study the trends for the main indicators of healthcare funding on the macroeconomic level and to develop models based on time series methods for analysis of the features of the trends and the prediction of the values for the next time period.
Keywords: EU countries, healthcare system, funding, indicator, time series analysis, Holt's model

Modelowanie trendów finansowania ochrony zdrowia w państwach Unii Europejskiej

Streszczenie
System ochrony zdrowia to jeden z najważniejszych sektorów gospodarki w państwach UE. Ważnym zadaniem w analizie i prognozowaniu wielkości finansowania ochrony zdrowia jest opracowanie i zastosowanie modeli ilościowych opartych na różnych metodach matematycznych. Trzy z najpopularniejszych wskaźników wykorzystywanych w makroekonomicznym opisie finansowania ochrony zdrowia to: (1) całkowite wydatki rządowe na zdrowie jako procent PKB; (2) całkowite wydatki rządowe na zdrowie jako odsetek całkowitych wydatków sektora instytucji rządowych i samorządowych; oraz (3) całkowite wydatki rządowe na zdrowie na mieszkańca.
Celem niniejszego artykułu jest zbadanie trendów głównych wskaźników finansowania ochrony zdrowia na poziomie makroekonomicznym oraz opracowanie modeli opartych na metodach szeregów czasowych do analizy cech trendów i prognozowania wartości na kolejny okres.
Słowa kluczowe: kraje UE, system ochrony zdrowia, finansowanie, wskaźnik, analiza szeregów czasowych, model Holta

Healthcare is one of the most important sectors of the public economy in the EU countries. It has been studied in many research and articles provided by scientists as E. Jakubowski, R. Busse, E. Mossialos, A. Dixon, J. Figueras, J. Kutzin, I. Joumard, C. André, M. Kostičová, V. Ozorovský, E. Benova, N. Dubrovina, O. Tulai, and others.[2]

One of the most important tasks of the analysis and prediction of the values for healthcare funding is the development and application of quantitative models based on various mathematical methods.

Three of the most popular indicators are used for the macroeconomic description of the funding of healthcare. Usually, these indicators are: (1) total government expenditure on health as a percentage of GDP; (2) total government expenditure on health as a percentage of total general government expenditure; and (3) total government expenditure on health per capita (Jakubowski, Busse 1998; Docteur, Oxley 2003; Joumard et al. 2010; Kostičová et al. 2011; Benova et al. 2014; Ozorovský et al. 2016; *Highest proportion…* 2020). These indicators are correlated with each other; nevertheless, the application of only one of them is not sufficient for the understanding of government policy in healthcare and the features of its funding. Thus, the first indicator – total government expenditure on health as % of GDP – characterises more the government policy in healthcare. The second indicator – total government expenditure on health as % of total general government

2 See, for example: Jakubowski, Busse 1998; Mossialos et al. 2002; Dixon 2006; Docteur, Oxley 2003; Joumard et al. 2010; Kostičová et al. 2011; Ozorovský et al. 2016; Benova et al. 2014; Dubrovina et al. 2020.

expenditure – describes the budgetary policy and the social policy of the government in its relation to healthcare. The third indicator – total government expenditure on health per capita – demonstrates the level of economic development of the country, well-being and the relative value of the expenditure on health per capita, which are much higher in rich and economically well-developed countries.

Research aim, materials and methods

The aim of this research is to study the trends in the main indicators of healthcare funding on the macroeconomic level and to develop simple models based on time series methods (Harris, Sollis 2003) for the analysis of the features of the trends and the prediction of the values for the next time period.

The comparative and quantitative analyses are based on the database from Eurostat for the main indicators for the period 2000–2017 (Eurostat WWW). For this study we used methods of descriptive statistics and time series analysis (linear trend and exponential smoothing). (see more: Borovikov 2001; Dostal 2008; *Holt's forecasting model* 2000).

Main research results

We studied the features of the dynamics of trends for the main macroeconomic indicators such as: total government expenditure on health as % of GDP ($TGEH_1$), total government expenditure on health as % of total general government expenditure ($TGEH_2$), total government expenditure on health per capita ($TGEH_3$). The graphical analysis of the plots for the dynamics of the indicators $TGEH_1$, $TGEH_2$ and $TGEH_3$ for each country of the EU-28 during the period 2000–2017, as well as the study of the basic descriptive statistics for these indicators, showed that for many countries of the EU-28 there was an increasing trend: in some countries, the values of these indicators fluctuated near the average level; in other countries, more complicated changes in the values of the indicators were revealed, when, for some time the values were growing up to a certain level and then they fell dramatically. These facts proved that a set of social, economic and political factors can have an impact on the dynamics of the main macroeconomic indicators $TGEH_1$, $TGEH_2$ and $TGEH_3$. Of course, for many countries in transition, post-socialist countries, which joined the EU since 2004, the initial values of total government expenditure on health per capita were much lower in comparison with well-developed countries from Western Europe (Dixon 2006; Docteur, Oxley 2003; Jakubowski, Busse 1998; Mossialos et al. 2002; Joumard et al. 2010). Due to crucial reforms in the healthcare sector, structural investment programs from the EU and rapid economic growth in these countries, total government expenditure on health per capita and total government expenditure on health as % of GDP have been seen to display an increasing trend. Nevertheless, in some countries of the EU the change in the political impact of leading political parties, or political or economic crises, have influenced essential changes in national models of funding healthcare (Mossialos et al. 2002; Joumard et al. 2010).

Because of the different healthcare funding systems in the EU-28 countries in the long term, we studied two basic models: (1) a model based on a linear trend and (2) exponential smoothing with a linear trend (Holt's model) (see: Borovikov 2001; Dostal 2008; *Holt's forecasting model* 2000). The second model was used for the description of a more complicated process than classical linear development, because exponential smoothing has the important that it can adapt recent values based on the changes of previous levels.

In *Table 1.* the characteristics of linear trend models are given for the description of the dynamics for the indicator $TGEH_1$.

Table 1. The characteristics of linear trend models for total government expenditure on health as % of GDP

No.	Country	Estimations of the parameters in linear trend		F- Criterion	Correlation coefficient for model	Std.Error of Estimate
		Intercept (a_0)	Slope (a_1)	F(1,16)	R	σ_ε
1	Belgium	$6,42^{***}$	$0,1^{***}$	25,82	0,79	0,44
2	Bulgaria	$4,36^{***}$	$0,03^{(n.s.)}$	1,54	0,3	0,63
3	Czechia	$7,09^{***}$	$0,03^{**}$	5,04	0,49	0,31
4	Denmark	$7,11^{***}$	$0,1^{***}$	20,52	0,75	0,5
5	Germany	$6,43^{***}$	$0,04^{***}$	17,33	0,72	0,22
6	Estonia	$4,25^{***}$	$0,06^{***}$	16,89	0,72	0,34
7	Ireland	$6,2^{***}$	$0,01^{(n.s.)}$	0,08	0,07	1
8	Greece	$6,28^{***}$	$-0,06^{*}$	4,34	0,46	0,61
9	Spain	$5,36^{***}$	$0,06^{***}$	12,14	0,66	0,41
10	France	$7,28^{***}$	$0,06^{***}$	27,71	0,8	0,24
11	Croatia	$6,54^{***}$	$-0,02^{(n.s.)}$	0,64	0,2	0,51
12	Italy	$6,45^{***}$	$0,05^{***}$	9,41	0,61	0,36
13	Cyprus	$2,84^{***}$	$-0,0045^{(n.s.)}$	0,23	0,12	0,21
14	Latvia	$3,76^{***}$	$0,01^{(n.s.)}$	0,36	0,15	0,4
15	Lithuania	$5,1^{***}$	$0,06^{*}$	4,26	0,46	0,63
16	Luxembourg	$4,38^{***}$	$0,04^{**}$	6,63	0,54	0,33
17	Hungary	$5,44^{***}$	$-0,03^{**}$	6,59	0,54	0,29
18	Malta	$5,31^{***}$	$0,02^{(n.s.)}$	1,28	0,27	0,34
19	Netherlands	$5,31^{***}$	$0,18^{***}$	24,08	0,78	0,82

20	Austria	$7{,}15^{***}$	$0{,}06^{***}$	65,84	0,9	0,17
21	Poland	$4{,}32^{***}$	$0{,}03^{***}$	8,54	0,59	0,24
22	Portugal	$7{,}05^{***}$	$-0{,}03^{(n.s.)}$	1,27	0,27	0,54
23	Romania	$3{,}67^{***}$	$0{,}03^{(n.s.)}$	2,81	0,39	0,34
24	Slovenia	$6{,}56^{***}$	$0{,}01^{(n.s.)}$	0,25	0,12	0,28
25	Slovakia	$5{,}54^{***}$	$0{,}11^{***}$	27,74	0,8	0,48
26	Finland	$6{,}4^{***}$	$0{,}09^{***}$	9,2	0,6	0,67
27	Sweden	$6{,}32^{***}$	$0{,}04^{***}$	14,5	0,69	0,23
28	United Kingdom	$5{,}74^{***}$	$0{,}13^{***}$	30,86	0,81	0,52

Note: ***– estimation is statistically significant at level p<0,01;
**– estimation is statistically significant at level p<0,05;
*– estimation is statistically significant at level p<0,1;
$^{(n.s.)}$ – estimation is not statistically significant.

Source: own elaboration in *Statistica*

It is clearly seen from *Table 1.* that for most countries of the EU-28 the estimates of the parameters of a linear trend model are statistically significant at level p<0,05. For most countries of the EU-28 the estimates of the slope are statistically significant at level p<0,05 and are positive. The relatively high value of the coefficient of correlation for linear trend models for the EU-28 countries means that this kind of model is appropriate for the description of the development of total government expenditure on health as % of GDP. For example, for such countries as: Belgium, Denmark, Germany, Estonia, France, Slovakia and the United Kingdom the values of the coefficient of correlation for linear trend models are more than 0,7. This means that in these countries the linear trend models are valid and have good power for prediction. Nevertheless, some exceptions exist, for example, for such countries as: Bulgaria, Ireland, Croatia, Cyprus, Latvia, Malta, Portugal and Slovenia, the values of the coefficient of correlation for linear trend models are less or equal than 0,3. It means that in these countries the process of total government expenditure on health as % of GDP does not demonstrate a strong linear trend. These features of the dynamics of total government expenditure on health as % of GDP should be taken into account. For this reason we applied another kind of model for analysis and prediction, namely exponential smoothing with linear trend, or Holt's model. This model can be used for the description of more complicated kinds of evolution, it has the property of adapting to the previous levels and it may include different kinds of trend, such as linear trend, exponential trend, etc. (see: *Holt's forecasting model* 2000).

In *Table 2.* the results of the exponential smoothing with linear trend are presented for $TGEH_1$.

Table 2. The characteristics of exponential smoothing with linear trend (Holt's model) (as % GDP)

No.	Country	S_0	T_0	Alpha (α)	Gamma (γ)	Mean error (m.e.)	Mean absolute error (m.a.e.)	Mean percent-age error (m.p.e.)	Mean abs. perc. error (m.a.p.e.)
1	Belgium	5,950	0,1000	1,00	0,00	0	0,18	-0,03	2,52
2	Bulgaria	3,768	0,0647	1,00	0,00	0	0,41	-0,62	8,82
3	Czechia	6,779	0,0412	1,00	0,00	0	0,17	-0,06	2,3
4	Denmark	6,650	0,1000	0,840	0,00	0	0,17	-0,06	2,3
5	Germany	6,379	0,0412	0,020	0,00	-0,02	0,16	-0,33	2,35
6	Estonia	4,382	0,0353	0,00	1,00	0,03	0,29	-0,1	6,08
7	Ireland	4,791	0,0176	1,00	0,00	0	0,4	-0,31	6,4
8	Greece	5,612	-0,024	1,00	0,00	0	0,34	-0,26	5,82
9	Spain	5,176	0,0471	1,00	0,00	0	0,16	-0,06	2,59
10	France	6,971	0,0588	0,932	0,00	0	0,13	-0,02	1,65
11	Croatia	6,506	-0,012	0,030	0,00	0,01	0,33	-0,35	4,98
12	Italy	5,874	0,0529	1,00	0,00	0	0,17	-0,01	2,4
13	Cyprus	2,497	0,0059	0,948	0,00	0	0,13	-0,22	4,66
14	Latvia	3,912	-0,024	0,728	0,00	0	0,13	-0,22	4,66
15	Lithuania	4,876	0,0471	1,00	0,00	0	0,39	-0,42	7,17
16	Luxembourg	3,665	0,0706	0,736	0,00	0	0,27	-0,24	5,76
17	Hungary	5,212	-0,024	0,460	0,00	0,01	0,23	-0,14	4,33
18	Malta	4,679	0,0412	1,00	0,00	0	0,17	-0,06	3,13
19	Netherlands	4,512	0,1765	0,929	0,00	0	0,26	-0,02	3,78
20	Austria	7,068	0,0647	1,00	0,00	0	0,11	-0,04	1,42
21	Poland	3,876	0,0471	0,950	0,00	0	0,14	-0,06	3,12
22	Portugal	6,303	-0,006	1,00	0,00	0	0,24	-0,09	3,39
23	Romania	4,197	0,0059	1,00	0,00	0	0,18	-0,24	4,89
24	Slovenia	6,600	0,000	1,00	0,00	0	0,16	-0,06	2,38
25	Slovakia	5,247	0,1059	0,034	0,00	0,14	0,29	1,77	4,67
26	Finland	5,659	0,0824	1,00	0,00	0	0,24	-0,04	3,35
27	Sweden	5,768	0,0647	1,00	0,00	0	0,15	-0,03	2,29
28	United Kingdom	5,032	0,1353	1,00	0,00	0	0,18	0,03	2,53

Note: S_0 – initial smoothed value, T_0 – initial trend, α and γ are parameters for estimation.

Source: own elaboration in *Statistica*

Exponential smoothing is based on the idea that each new smoothed value (forecast) is calculated as the weighted average of the current observation and the previous smoothed observation. Thus, in effect, each smoothed value is the weighted average of the previous observations, where the weights decrease exponentially depending on the value of the parameter α. If α is equal to 1, then the previous observations are ignored entirely; if α is equal to 0, then the current observation is ignored entirely, and the smoothed value consists of the previous smoothed value. Values of α in-between produce intermediate results (Borovikov 2001; *Holt's forecasting model* 2000). When in Holt's model a trend component is included in the exponential smoothing process, an independent trend component is computed for each time and modified as a function of the forecast error and the respective parameter γ. If the parameter γ is 0, it means that the trend component is constant across all values of the time series and for all forecasts. If the parameter γ is 1, then the trend component is modified "maximally" from the observation to observation by the respective forecast error (Borovikov 2001; *Holt's forecasting model* 2000).

In Holt's model with two parameters α and γ the components S_0 (initial smoothed value) and T_0 (initial trend) are calculated according to formulas:

$$S_0 = x_1 - \frac{T_0}{2}, T_0 = \frac{x_{n-x_1}}{n-1},$$

where x_1– the first value of the time series, x_n– the last value of the time series, and *n* – the length of the series.

Concerning the estimation of the parameters α and γ, in practice, the smoothing parameter is often chosen by a grid search of the parameter space. In *Statistica* it is possible to automatically search for the best parameter values via a general function minimisation of mean squared error or other measure of accuracy (Borovikov 2001; *Holt's forecasting model* 2000). To evaluate the accuracy of the forecasts based on exponential smoothing with linear trend we can use such indices as: mean error, mean absolute error, mean percentage error, mean absolute percentage error (*Holt's forecasting model* 2000).

As is seen from *Table 2*, for most countries of the EU-28 the estimate for the parameter α is equal to, or close to 1. Nevertheless, for Germany, Estonia, Croatia and Slovakia the estimate of the parameter α is equal to, or close to 0. For all countries the estimate of the parameter γ is equal to 0, except only for the case of exponential smoothing with linear trend for Estonia.

It is should be noted that one of the popular measures of accuracy is the *mean absolute percentage error* (m.a.p.e.), and for most models of exponential smoothing with linear trend this value does not exceed 5%. It means that such models have relatively high fitness and accuracy for forecasts. For some countries, such as: Bulgaria, Estonia, Ireland, Greece, Lithuania, Luxembourg, the values of the m.a.p.e. exceed 5% but are less than 10%. This means that their accuracy for forecasts is relatively lower, nevertheless such models can be used for predictions.

In the following *Tables 3–6* the results of the linear trend models and Holt's models are presented for indicators $TGEH_2$ and $TGEH_3$.

In *Table 3.* the characteristics of linear trend models are given for the description of the dynamics of the indicator $TGEH_2$.

Table 3. The characteristics of linear trend models for total government expenditure on health as % of total general government expenditure

No.	Country	Estimations of the parameters in linear trend		F- Criterion	Correlation coefficient for model	Std. Error of Estimate
		Intercept (a_0)	Slope (a_1)	F(1,16)	R	σ_ε
1	Belgium	12,79***	0,13***	77,6	0,91	0,31
2	Bulgaria	11,35***	0,12$^{(n.s.)}$	2,66	0,38	1,57
3	Czechia	15,85***	0,17***	57,03	0,88	0,49
4	Denmark	13,14***	0,19***	70,03	0,9	0,5
5	Germany	13,68***	0,15***	120,32	0,94	0,3
6	Estonia	12,01***	0,08***	23,26	0,77	0,36
7	Ireland	16,63***	0,08$^{(n.s.)}$	0,92	0,23	1,84
8	Greece	13,68***	-0,23***	18,7	0,73	1,15
9	Spain	13,71***	0,03$^{(n.s.)}$	1,52	0,29	0,61
10	France	13,88***	0,02**	5,63	0,51	0,22
11	Croatia	13,44***	0,01$^{(n.s.)}$	0,02	0,04	1,01
12	Italy	13,55***	0,06**	5,35	0,5	0,55
13	Cyprus	7,53***	-0,06***	9	0,6	0,42
14	Latvia	10,59***	-0,04$^{(n.s.)}$	0,75	0,21	0,91
15	Lithuania	13,45***	0,21***	33,71	0,82	0,79
16	Luxembourg	10,66***	0,06**	7,01	0,55	0,48
17	Hungary	11,19***	-0,07***	11	0,64	0,47
18	Malta	12,23***	0,12***	12,1	0,66	0,77
19	Netherlands	11,33***	0,44***	146,58	0,95	0,81
20	Austria	13,76***	0,13***	69,03	0,9	0,35
21	Poland	9,45***	0,12***	69,36	0,9	0,32
22	Portugal	15,93***	-0,16***	13,53	0,68	0,95
23	Romania	10***	0,08*	4,1	0,45	0,88
24	Slovenia	13,89***	-0,01$^{(n.s.)}$	0,15	0,1	0,79
25	Slovakia	12,77***	0,33***	27,81	0,8	1,38

26	Finland	13,09***	0,06$^{(n.s.)}$	2,86	0,39	0,8
27	Sweden	11,67***	0,15***	154,17	0,95	0,26
28	United Kingdom	14,27***	0,21***	168,54	0,96	0,36

Note: ***– estimation is statistically significant at level p<0,01;
**– estimation is statistically significant at level p<0,05;
*– estimation is statistically significant at level p<0,1;
$^{(n.s.)}$ – estimation is not statistically significant.

Source: own elaboration in *Statistica*

It is clearly seen from *Table 3.* that for most countries of the EU-28 the estimates of the parameters of the linear trend model are statistically significant at level p<0,05. For most countries of the EU-28 the estimates of the slope are statistically significant at level p<0,05 and are positive. Nevertheless, some statistically significant negative estimates for slope exist in the cases of such countries, as: Greece, Cyprus, Hungary and Portugal. In these countries it is apparent that total government expenditure on health as % of total general government expenditure demonstrates a tendency to decrease.

The relatively high value of the coefficient of correlation for the linear trend models for the EU-28 countries means that this kind of model is appropriate for the description of the development of total government expenditure on health as % of total general government expenditure. For example, for such countries as: Belgium, Czechia, Denmark, Germany, Estonia, Greece, Lithuania, Netherlands, Austria, Poland, Slovakia, Sweden and the United Kingdom the values of the coefficient of correlation for linear trend models are more than 0,7. It means that in these countries the linear trend models are valid and have good power for prediction. Nevertheless, some exceptions exist, for example, for such countries as: Ireland, Spain, Croatia, Cyprus, Latvia and Slovenia the values of the coefficient of correlation for linear trend models are less or equal than 0,3. It means that in these countries the processes of total government expenditure on health as % of total general government expenditure do not exhibit a significant linear trend.

In *Table 4.* the results of the exponential smoothing with linear trend are presented for $TGEH_2$.

Table 4. The characteristics of exponential smoothing with linear trend (Holt's model)

No.	Country	S_0	T_0	Alpha (α)	Gamma (γ)	Mean error (m.e.)	Mean absolute error (m.a.e.)	Mean percent-age error (m.p.e.)	Mean abs. perc. error (m.a.p.e.)
1	Belgium	12,23	0,1418	0,443	0	0	0,24	0	1,75
2	Bulgaria	9,256	0,2671	1	0	-0,01	1,05	-0,55	8,62
3	Czechia	16,52	0,1512	0,447	0	-0,04	0,38	-0,38	2,29

4	Denmark	12,58	0,2218	1	0	-0,01	0,22	-0,05	1,49
5	Germany	14,34	0,1041	1	0	0	0,21	-0,05	1,39
6	Estonia	12,13	0,0318	0,022	0	0,22	0,37	1,64	2,87
7	Ireland	15,56	0,2294	0,555	0	-0,04	1,22	-1,3	7,89
8	Greece	12,13	-0,059	0,931	0	0	0,81	-0,52	7,36
9	Spain	13,12	0,08	1	0	0	0,28	-0,06	2,04
10	France	13,5	0,0412	1	0	0	0,11	-0,01	0,79
11	Croatia	14	0	0,09	0	-0,23	0,76	-2,2	5,66
12	Italy	12,57	0,0824	1	0	0	0,25	-0,01	1,75
13	Cyprus	7,137	-0,014	0,089	0	-0,04	0,28	-1,06	4,29
14	Latvia	10,41	-0,065	0,803	0	0,01	0,61	-0,3	5,99
15	Lithuania	12,41	0,2676	0,072	0	0,09	0,65	0,48	4,43
16	Luxem-bourg	9,673	0,0947	0,44	0	0,02	0,41	0,05	3,67
17	Hungary	11,1	-0,049	0,666	0	0	0,35	-0,12	3,34
18	Malta	11,69	0,1947	0,85	0	-0,01	0,52	-0,24	3,99
19	Nether-lands	10,8	0,4041	0,475	0	0	0,47	-0,03	3,01
20	Austria	13,88	0,1571	0,675	0	-0,01	0,26	-0,16	1,72
21	Poland	9,126	0,1276	0,992	0	0	0,19	-0,04	1,82
22	Portugal	14,74	-0,055	1	0	0	0,41	-0,08	2,94
23	Romania	10,81	0,1176	1	0	0	0,42	-0,29	3,96
24	Slovenia	13,91	0,0659	0,74	0	-0,02	0,5	-0,4	3,83
25	Slovakia	10,06	0,4359	0,734	0	-0,01	0,86	0,01	5,54
26	Finland	11,9	0,0659	1	0	0	0,25	-0,02	1,91
27	Sweden	10,86	0,1741	1	0	0	0,16	-0,01	1,29
28	United Kingdom	14,19	0,2294	0,637	0	0	0,28	-0,09	1,74

Note: S_0 – initial smoothed value, T_0 – initial trend, α and γ are parameters for estimation.

Source: own elaboration in *Statistica*

As is seen from *Table 4*, for such countries of the EU-28 as: Bulgaria, Denmark, Germany, Greece, Spain, France, Italy, Latvia, Malta, Poland, Portugal, Romania, Finland and Sweden the estimates for the parameter α are equal to, or close to, 1. Nevertheless, for Estonia, Croatia, Cyprus and Lithuania the estimates of the parameter α are equal to, or close to, 0. For all countries the estimate of the parameter γ is equal to 0.

It is should be noted that for most models of exponential smoothing with linear trend the value of m.a.p.e. does not exceed 5%. It means that such models have relatively high fitness and accuracy for forecasts. For some countries, such as: Bulgaria, Ireland, Greece, Croatia and Slovakia the value of m.a.p.e. exceeds 5% but is less than 10%, it means that their accuracy for forecasts is relatively lower, nevertheless such models can be used for predictions.

In *Table 5.* the characteristics of linear trend models are given for the description of the dynamics of the indicator $TGEH_3$.

Table 5. The characteristics of linear trend models for total government expenditure on health per capita

No.	Country	Estimations of the parameters in linear trend		F- Criterion	Correlation coefficient for model	Std. Error of Estimate
		Intercept (a_0)	Slope (a_1)	F(1,16)	R	σ_ε
1	Belgium	1722,42***	78,17***	49,716	0,87	250,1
2	Bulgaria	88,39***	15,19***	75,040	0,91	39,562
3	Czechia	609,2***	43,88***	40,235	0,85	156,06
4	Denmark	2508,85***	109,32***	49,608	0,87	350,15
5	Germany	1645,47***	63,05***	67,589	0,9	173,01
6	Estonia	230,42***	38,88***	68,130	0,9	106,26
7	Ireland	2050,64***	69,44***	25,484	0,78	310,31
8	Greece	1063,28***	-3,55(n.s.)	0,1103	0,08	241,23
9	Spain	1020,77***	33,28***	21,905	0,76	160,44
10	France	1893,36***	53,41***	56,940	0,88	159,69
11	Croatia	464,21***	16,59***	21,766	0,76	80,23
12	Italy	1555,4***	30,16***	18,393	0,73	158,65
13	Cyprus	533***	6,49*	2,8671	0,39	86,517
14	Latvia	179,67***	19,82***	31,004	0,81	80,311
15	Lithuania	216,67***	35,95***	55,376	0,88	108,98
16	Luxembourg	2496,98***	131,79***	55,617	0,88	398,67
17	Hungary	380,8***	12,94***	26,000	0,79	57,26
18	Malta	561,55***	38,54***	71,020	0,9	103,18

19	Netherlands	1655,08***	108,44***	36,388	0,83	405,55
20	Austria	1992,03***	81,63***	80,236	0,91	205,6
21	Poland	229,2***	20,18***	48,580	0,87	65,33
22	Portugal	976,14***	13,7**	6,2376	0,53	123,72
23	Romania	76,01***	17,67***	75,410	0,91	45,915
24	Slovenia	837,05***	31,26***	43,434	0,85	107,01
25	Slovakia	289,03***	51,52***	53,845	0,88	158,39
26	Finland	1842,64***	76,58***	27,186	0,79	331,32
27	Sweden	2007,99***	76,43***	41,108	0,85	268,93
28	United Kingdom	1745,92***	61,85***	41,574	0,85	216,42

Note: ***– estimation is statistically significant at level p<0,01;
**– estimation is statistically significant at level p<0,05;
*– estimation is statistically significant at level p<0,1;
$^{(n.s.)}$ – estimation is not statistically significant.

Source: own elaboration in *Statistica*

It is clearly seen from *Table 5*, that for most countries of the EU-28 the estimates of the parameters of the linear trend model are statistically significant at level p<0,05 and are positive. A negative, statistically insignificant, estimate for the slope was obtained for Greece. For some countries of the EU-28, such as: Denmark, Luxembourg and Netherlands the estimate of the slope is relatively high; this means that the annual increase in the total government expenditure on health is more than 100 euro per capita. On the other hand, in such countries as: Bulgaria, Croatia, Cyprus, Latvia, Hungary, Portugal, Poland and Romania the estimate of the slope is low. The annual increase in total government expenditure on health is less than or equal to 20 euro per capita.

High values of the coefficient of correlation for linear trend models were obtained for 25 of the EU-28 countries. It means that this kind of model is appropriate for the description of the development of total government expenditure on health per capita. For example, for such countries as: Bulgaria, Germany, Estonia, Maltha and Austria the value of the coefficient of correlation for the linear trend model was equal to 0,9 or more; it means that in these countries the linear trend models are valid and have high predictive power. Nevertheless, some exceptions exist; for example, for Greece the value of the coefficient of correlation for the linear trend model is close to 0. It means that in Greece the process of total government expenditure on health per capita is not linear in nature.

In *Table 6.* the results of the exponential smoothing with linear trend are presented for $TGEH_3$.

Table 6. The characteristics of exponential smoothing with linear trend (Holt's model)

No	Country	S_0	T_0	Alpha (α)	Gamma (γ)	Mean error (m.e.)	Mean absolute error (m.a.e.)	Mean per-cent-age error (m.p.e.)	Mean abs. perc. error (m.a.p.e.)
1	Belgium	1479	85,05	0,909	0,00	-2,56	48,02	-0,05	2,14
2	Bulgaria	58,76	17,14	0,275	0,00	-1,92	15,19	-2,9	8,57
3	Czechia	415,6	53,58	1,00	0,00	-1,49	39,38	-0,05	4,28
4	Denmark	2174	119,6	1,00	0,00	-3,32	62,42	-0,05	1,84
5	Germany	1624	68,34	1,00	0,00	-1,9	27,72	-0,28	1,36
6	Estonia	173,9	41,63	1,00	0,00	-1,16	29	-1,33	6,03
7	Ireland	1336	104,3	1,00	0,00	-2,9	100,83	0,28	4,23
8	Greece	741,5	7,803	1,00	0,00	-0,22	81,91	-0,34	7,91
9	Spain	803,6	39,34	1,00	0,00	-1,09	48,53	0,09	3,68
10	France	1674	61,73	1,00	0,00	-1,72	20,08	0	0,91
11	Croatia	359,6	21,90	0,384	0,00	-1,03	35,24	-0,25	5,73
12	Italy	1260	39,08	1,00	0,00	-1,09	44,85	0,11	2,54
13	Cyprus	378,2	12,23	1,00	0,00	-0,34	31,19	0,06	5,48
14	Latvia	129,7	20,36	1,00	0,00	-0,57	32,7	-1,44	11,13
15	Lithuania	156,3	38,93	1,00	0,00	-1,08	30,79	-1,59	7,86
16	Luxembourg	1879	153,8	0,974	0,00	-4,43	134,73	0,07	4,02
17	Hungary	252,1	20,38	0,907	0,00	-0,78	27,5	0,02	5,74
18	Malta	512,9	46,26	1,00	0,00	-1,29	35	-0,67	4,17
19	Netherlands	1264	115,1	1,00	0,00	-3,2	86,65	-0,05	3,5
20	Austria	1856	90,95	1,00	0,00	-2,53	32,78	-0,19	1,3
21	Poland	176,9	22,83	0,652	0,00	-1,64	27,99	-1,16	7,98
22	Portugal	774,3	23,60	1,00	0,00	-0,66	48,16	-0,01	4,36
23	Romania	65,76	19,86	1,00	0,00	-0,55	19,03	-3,36	10,72
24	Slovenia	709,7	38,37	1,00	0,00	-1,07	31,07	-0,1	2,74
25	Slovakia	195,2	52,27	1,00	0,00	-1,45	35,38	-1,27	6,7
26	Finland	1469,	80,50	1,00	0,00	-2,24	64,52	0,12	2,61
27	Sweden	1827	83,53	1,00	0,00	-2,32	81,95	-0,18	3,24
28	United Kingdom	1508	64,57	1,00	0,00	-1,79	132,84	-0,13	5,64

Note: S_0 – initial smoothed value, T_0 – initial trend, α and γ are parameters for estimation.

Source: own elaboration in *Statistica*

As is seen from *Table 6*, for most countries of the EU-28 the estimate of the parameter α is equal to, or close to, 1. Nevertheless, for Bulgaria and Croatia the estimate of the parameter α is less than 0,5. For all countries the estimate of the parameter γ is equal to 0.

It is should be noted that for more than half the models of exponential smoothing with linear trend the value of the m.a.p.e. does not exceed 5%. It means that such models have relatively high fitness and accuracy for forecasts. For some countries, such as: Bulgaria, Estonia, Greece, Croatia, Cyprus, Lithuania, Hungary, Poland, Slovakia and the United Kingdom the values of m.a.p.e. exceed 5% and less than 10%, it means that their accuracy for forecasts is relatively lower, nevertheless such models can be used for predictions. For such countries, as: Latvia and Romania the values of m.a.p.e. more than 10%, but less than 11,5%, thus the accuracy for forecasts of these models is relatively low and not so convenient.

In *Tables 7–9* the predicted values of total government expenditure on health as % of GDP, total government expenditure on health as % of total general government expenditure, total government expenditure on health per capita are given for period of 2020–2021.

Table 7. The results of the predicted values of total government expenditure on health as % of GDP for 2020–2021

No.	Country	Real data for 2018	2020				2021			
			Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model
			Lower 95% interval	Prediction for linear trend model	Upper 95% interval		Lower 95% interval	Prediction for linear trend model	Upper 95% interval	
1	Belgium	7,6	7,85	8,39	8,93	8	7,91	8,49	9,07	8,1
2	Bulgaria	5	4,27	5,05	5,82	5,09	4,25	5,08	5,91	5,16
3	Czechia	7,6	7,33	7,72	8,11	7,62	7,33	7,75	8,16	7,66
4	Denmark	8,3	8,5	9,12	9,74	8,74	8,56	9,22	9,88	8,84
5	Germany	7,2	6,96	7,23	7,5	7,24	6,98	7,27	7,56	7,28
6	Estonia	5,1	5,07	5,5	5,93	5,12	5,11	5,56	6,02	5,16
7	Ireland	5	5,21	6,45	7,68	5,15	5,14	6,46	7,78	5,17
8	Greece	5	4,39	5,15	5,9	5,13	4,28	5,09	5,9	5,11
9	Spain	6	6,12	6,62	7,13	6,14	6,14	6,68	7,22	6,19
10	France	8,1	8,1	8,39	8,68	8,19	8,13	8,44	8,76	8,25
11	Croatia	6,6	5,56	6,18	6,81	6,26	5,5	6,17	6,84	6,25
12	Italy	6,8	6,98	7,42	7,86	6,96	6,99	7,47	7,94	7,01
13	Cyprus	2,7	2,48	2,75	3,01	2,62	2,46	2,74	3,02	2,62

14	Latvia	4	3,48	3,97	4,47	3,48	3,45	3,98	4,51	3,46
15	Lithuania	5,9	5,48	6,26	7,05	5,84	5,48	6,32	7,16	5,89
16	Luxembourg	4,7	4,72	5,13	5,55	5,1	4,73	5,17	5,61	5,17
17	Hungary	4,7	4,41	4,77	5,14	4,78	4,35	4,74	5,13	4,75
18	Malta	5,3	5,23	5,65	6,07	5,52	5,22	5,67	6,12	5,56
19	Netherlands	7,6	7,87	8,89	9,91	8,14	7,98	9,07	10,17	8,31
20	Austria	8,2	8,14	8,35	8,56	8,39	8,19	8,41	8,63	8,46
21	Poland	4,8	4,64	4,93	5,23	4,84	4,65	4,97	5,28	4,89
22	Portugal	6,3	5,84	6,51	7,18	6,18	5,77	6,48	7,2	6,18
23	Romania	4,7	3,75	4,17	4,59	4,32	3,75	4,2	4,65	4,32
24	Slovenia	6,6	6,33	6,68	7,03	6,6	6,31	6,69	7,06	6,6
25	Slovakia	7,3	7,18	7,78	8,37	7,56	7,25	7,89	8,53	7,66
26	Finland	7	7,37	8,2	9,03	7,35	7,4	8,29	9,17	7,43
27	Sweden	7	6,81	7,09	7,37	7,09	6,83	7,13	7,43	7,16
28	United Kingdom*	7,5	7,67	8,32	8,97	7,81	7,75	8,45	9,14	7,94

*Since 1 February, 2020 United Kingdom is not the EU Member State
Source: own elaboration in *Statistica*

Table 8. The results of the predicted values of total government expenditure on health as % of total general government expenditure

No.	Country	2020				2021			
		Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model
		Lower 95% interval	Prediction for linear trend model	Upper 95% interval		Lower 95% interval	Prediction for linear trend model	Upper 95% interval	
1	Belgium	14,92	15,31	15,69	15,2	15,02	15,43	15,84	15,34
2	Bulgaria	11,77	13,68	15,59	14,73	11,74	13,79	15,84	15
3	Czechia	18,61	19,2	19,79	19,36	18,73	19,37	20,01	19,51
4	Denmark	16,35	16,96	17,57	17,13	16,5	17,15	17,81	17,35
5	Germany	16,34	16,71	17,08	16,47	16,46	16,86	17,25	16,58
6	Estonia	13,14	13,58	14,01	12,89	13,19	13,66	14,12	12,92
7	Ireland	15,99	18,23	20,46	19,98	15,91	18,31	20,7	20,21
8	Greece	7,75	9,15	10,55	10,84	7,42	8,92	10,43	10,78
9	Spain	13,65	14,39	15,14	14,76	13,63	14,43	15,22	14,84
10	France	14,09	14,36	14,63	14,34	14,09	14,38	14,67	14,38

11	Croatia	12,35	13,58	14,81	13,63	12,27	13,59	14,91	13,63
12	Italy	14,03	14,7	15,36	14,26	14,04	14,76	15,47	14,34
13	Cyprus	5,86	6,38	6,89	6,78	5,77	6,32	6,87	6,77
14	Latvia	8,76	9,87	10,97	9,21	8,65	9,83	11,02	9,15
15	Lithuania	16,66	17,62	18,59	18,15	16,8	17,83	18,86	18,41
16	Luxembourg	11,23	11,8	12,38	11,79	11,24	11,86	12,48	11,88
17	Hungary	9,22	9,79	10,35	10,08	9,11	9,72	10,32	10,03
18	Malta	13,72	14,66	15,59	15,64	13,78	14,78	15,78	15,83
19	Netherlands	19,23	20,21	21,19	19,29	19,61	20,66	21,71	19,7
20	Austria	15,99	16,42	16,85	17,01	16,09	16,55	17,01	17,17
21	Poland	11,49	11,88	12,27	11,74	11,58	12	12,42	11,87
22	Portugal	11,62	12,77	13,92	13,6	11,38	12,61	13,84	13,55
23	Romania	10,55	11,63	12,7	13,22	10,56	11,71	12,86	13,34
24	Slovenia	12,65	13,61	14,57	15,06	12,56	13,59	14,62	15,13
25	Slovakia	17,7	19,38	21,05	19,05	17,91	19,71	21,51	19,49
26	Finland	13,35	14,32	15,29	13,25	13,34	14,38	15,42	13,31
27	Sweden	14,28	14,59	14,9	14,43	14,4	14,74	15,07	14,61
28	United Kingdom*	18,1	18,54	18,98	18,95	18,28	18,75	19,22	19,18

*Since 1 February, 2020 United Kingdom is not the EU Member State
Source: own elaboration in *Statistica*

Table 9. The results of the predicted values of total government expenditure on health per capita for 2020–2021

No.	Country	2020				2021			
		Predicted values for linear trend model and their confidential intervals			Pre-dicted values for Holt's model	Predicted values for linear trend model and their confidential intervals			Predicted values for Holt's model
		Lower 95% interval	Predic-tion for linear trend model	Upper 95% interval		Lower 95% interval	Predic-tion for linear trend model	Upper 95% interval	
1	Belgium	2976,11	3285,76	3595,42	3223,08	3032,63	3363,93	3695,23	3308,13
2	Bulgaria	343,23	392,21	441,2	409,17	355	407,41	459,81	426,31
3	Czechia	1293,56	1486,78	1680,01	1513,9	1323,93	1530,66	1737,39	1567,48
4	Denmark	4261,71	4695,24	5128,78	4626,53	4340,73	4804,56	5268,4	4746,16
5	Germany	2692,22	2906,43	3120,64	3025,3	2740,3	2969,48	3198,66	3093,65
6	Estonia	876,43	1007,99	1139,56	1027,27	906,11	1046,87	1187,63	1068,9
7	Ireland	3055,16	3439,36	3823,56	3473,9	3097,75	3508,8	3919,85	3578,19

8	Greece	693,57	992,24	1290,91	901,46	669,15	988,69	1308,23	909,26
9	Spain	1487,81	1686,45	1885,09	1610,18	1507,21	1719,74	1932,26	1649,52
10	France	2763,89	2961,61	3159,32	2939,67	2803,49	3015,02	3226,55	3001,4
11	Croatia	696,71	796,05	895,38	812,23	706,36	812,64	918,91	834,12
12	Italy	1962,18	2158,61	2355,04	2061,18	1978,61	2188,77	2398,93	2100,25
13	Cyprus	555,75	662,87	769,99	629	554,76	669,37	783,97	641,23
14	Latvia	476,67	576,11	675,55	547,05	489,55	595,93	702,32	567,41
15	Lithuania	800,69	935,63	1070,56	954,31	827,21	971,58	1115,94	993,24
16	Luxembourg	4639,14	5132,74	5626,35	5030,26	4736,44	5264,53	5792,63	5184,02
17	Hungary	568,75	639,64	710,54	667,31	576,74	652,59	728,44	687,69
18	Malta	1204,68	1332,43	1460,18	1461,18	1234,29	1370,97	1507,65	1507,43
19	Netherlands	3321,76	3823,9	4326,03	3623,86	3395,12	3932,34	4469,56	3738,96
20	Austria	3370,16	3624,72	3879,28	3720,51	3434	3706,36	3978,71	3811,46
21	Poland	551,99	632,87	713,76	637	566,52	653,06	739,6	659,83
22	Portugal	1096,89	1250,07	1403,25	1258,1	1099,88	1263,77	1427,65	1281,7
23	Romania	372,65	429,49	486,34	472,88	386,35	447,17	507,99	492,74
24	Slovenia	1329,77	1462,26	1594,74	1496,24	1351,77	1493,52	1635,26	1534,61
25	Slovakia	1123,28	1319,39	1515,49	1266,7	1161,1	1370,9	1580,71	1318,97
26	Finland	2963,93	3374,15	3784,38	3118,86	3011,84	3450,73	3889,62	3199,36
27	Sweden	3203,63	3536,6	3869,57	3539,11	3256,79	3613,03	3969,27	3622,64
28	United Kingdom*	2715,05	2983,01	3250,96	2831,83	2758,18	3044,86	3331,54	2896,41

*Since 1 February, 2020 United Kingdom is not the EU Member State
Source: own elaboration in *Statistica*

It should be noted that in some countries the policy of financing health systems was quite flexible and changed, while in other countries this policy was stable for a long term period. At the same time, a number of social, economic, political and institutional factors influence the policy of financing health systems, which should also be taken into account and studied in connection with the changing characteristics of financing the health system in the country.

Conclusions

To describe the features of financing national health systems in the EU countries, it is necessary to study a set of indicators, such as: $TGEH_1$ (total government expenditure on health as % of GDP), $TGEH_2$ (total government expenditure on health as % of total general government expenditure) and $TGEH_3$ (total government expenditure on health per capita). For simple models of analysis and forecasts, it is sufficient to use basic models, such as a linear trend and exponential smoothing models, such as Holt's model. At the same time, for more detailed studies and forecasts for individual countries, it is advisable to use other, more advanced models, such as: ARIMA, VAR, etc. Nevertheless, models developed in our research can be used for the prediction on next time periods, and the results of the prediction will be used as upper and lower limits of the values of mentioned indicators in our further study with application more advanced models for optimisation of funding healthcare policy with taking into account the features of national healthcare systems.

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