THE EU 2020: UNDERSTANDING THE NECESSITY OF MAINTAINING A SUSTAINABLE FISCAL POLICY

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Abstract

Public debt management is perhaps one of the key challenges that has manifested in the aftermath of the 2008 global economic crisis. This article presents key trends in creating fiscal policy in the member-states of the European Union. Using polynomial regressions predictions are made regarding the public debt-to-GDP ratio in 2020. Further analysis of Greece was conducted as the country with the highest projected public debt-to-GDP ratio and Hungary as the country with the lowest projected public debt-to-GDP ratio. Using various quantitative analysis models a statistically significant link between Greek GDP change and public debt-to-GDP change was established, while Hungary displays no such tendencies. Using an output approach to GDP did not reveal any differences in the two economies. An alternative approach clearly indicated that there are significant structural differences between the Greek and Hungarian economy, primarily the fact that Hungary is significantly more dependent upon exports. The article concludes that if substantial changes are not made and the current trends of public debt growth are not reversed, several countries such as Spain, Italy, and Portugal will be faced with the Greek scenario in which they will have a completely unsustainable public debt.

Key words: public debt, the fiscal criteria of Maastricht, EU, PIIGS.

1. Introduction

Public debt is perhaps one of the most significant economic issues that the member-states of the European Union (further in the text: the EU) are facing today. The alarming rise of public debt, despite attempts made by the Commission to enforce the criteria of fiscal convergence from the Maastricht treaty, is causing increasing concern regarding the long-term sustainability of public debt of several EU member-states. Further legislation giving the supranational organs of the EU further mechanisms to act is under constant criticism by experts. Several, such as

Palmstorfer (2014) emphasize that measures such as the ″6 pack″[1] are not completely in line with the founding treaties of the EU. Most of them recognize the necessity of strong actions and that any change that would be implemented through the primary legislation of the EU would not yield the adequate results in the necessary time frame (Palmstorfer, 2014). As the EU has gone through several crisis situations not directly related to economic growth, the question of sustainable fiscal policy and macroeconomic imbalances has once again taken a back seat in light of terrorist threats and the migrant crisis.[2]

Many experts believe that the Greek public debt has become completely unsustainable and further austerity measures are further decreasing the chances of any kind of economic recovery (Robbins, 2015). Scenarios such as the Greek crisis were influenced by many factors, including manipulation of the statistics by the Greek government, but such an alarming rate of public debt-to-GDP ratio should never have passed unnoticed in Brussels (Featherstone, 2009; Loizides, 2013). The main hypothesis of this article is that if significant changes aren't implemented in the fiscal policy of several member-states, their public debt might become unsustainable in the following five years.

2. Methodology

This paper uses simple polynomial regression, with time measured in years as the x variable and the ratio of public debt-to-GDP as the y variable. The first thing this article attempts to achieve is create a simple polynomial function that displays key trends in the public debt-to-GDP ratio percentage change. When an adequate function was identified based upon Eurostat data for 1995-2014, the results the function provided for that period were compared with the actual data. This function should have the following form:

$$f(x)=ax^n+bx^{n-1}+cx^{n-2}+\ldots+dx^2+ex+f \quad (1)$$

[1] A group of 6 measures implemented by the European Commission and the European Council in an attempt to further enhance the standing of legislation that is in line with the Maastricht criteria of fiscal convergence.

[2] These are just several of the situations that are currently given more media and political spotlight than the issue of macroeconomic imbalances. There are also several new situations developing, such as the referendum in the United Kingdom where they might potentially decide to leave the EU.

If the results of the polynomial function correlate with the actual public debt-to-GDP ratio and n<4 then the function will be used to predict results for 2015 and 2020. Functions with an n value higher than 3 will not be considered for predicting results. In order to simplify the function, 1995 was assumed as a base year with the assigned value x=1. For Bulgaria, Croatia and Denmark different base years were used due as there was no available data for the year 1995.

Based upon these projections, which have exclusively a statistical prediction trend[3], further quantitative analysis will be conducted on the countries that have the worst projection of public debt-to-GDP ratio and the country that has the smallest projected public debt-to-GDP ratio. The reason for approaching this issue from such a standpoint is understanding further differences in countries that conform with the Maastricht criteria of fiscal convergence and those that suffer from significant macroeconomic imbalances. These countries will further be analysed using the following quantitative models:

1) A model that views the relationship of GDP as the dependant variable and public debt-to-GDP ratio as the independent variable will be considered. The value of this model will be to provide a simple explanation to the differences of whether a rise in public debt-to-GDP ratio has a statistically significant impact on GDP change. The model will have the following general form:

$$GDP_t = \alpha_0 + \alpha_1 PD_t + \varepsilon_t \quad (2)$$

In this model GDP is the percentage change of GDP, α_0 is the constant, PD_t is the percentage change of the public debt-to-GDP ratio, while ε_t is the error term. The relevance of this model is to understand the impact of public debt-to-GDP ratio change on GDP, taking into account that the possible explanatory value of the model might not be very high due to the fact that there is only one explanatory variable. Before the Ordinary least squares (OLS) model is considered, the

[3] Which is significantly limited as it only projects the continuous values of the current trends, while current econometric models function with the assumption of variable stationarity including using several explanatory variables. The use of this methodology is primarily to provide a simple projection of countries that have significant issues in regards to public debt-to-GDP ratio growth and explain possible differences between countries that have managed to contain such macroeconomic imbalances and countries that still have significant issues in dealing with problems related to long-term unbalanced fiscal policy.

stationarity of the variables will be tested using the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test.

2) The second model will consider GDP growth from an output perspective[4], while not directly taking into account the relevance of the variables to the increase of public debt. The dependant variable is GDP, while the explanatory variables are gross value added and tax profit minus subsidies. [5] The general model is:

$$\Delta \log GDP_t = \alpha_0 + \alpha_1 \Delta \log GVA_t + \alpha_2 \Delta \log TAX_t + \varepsilon_t \quad (3)$$

In this model Δ log GDP is the difference of natural logarithms of the GDP values considered for the model, which for all variables is quarterly data from the first quarter of 1995 to the last quarter of 2015.[6] $\Delta \log GVA_t$ is the difference of logs of gross added value, while $\Delta \log TAX_t$ is the difference of logs of tax profit minus subsidies. α_0 is the constant, $\alpha_{1..2}$ are the coefficients, while ε_t *is the error* term.

3) The final model will consider the GDP change from an alternative perspective, once again taking GDP as the dependent variable. The explanatory variables are export of goods and services in millions of euro, total employment in thousands and primary income in millions of euro.[7] The general model will be as follows[8]:

$$\Delta \log GDP_t = \beta_0 + \beta_1 \Delta \log EXP_t + \beta_2 \Delta \log EMP_t + \beta_3 \Delta \log PI_t + + \varepsilon_t \quad (4)$$

All of the calculations are done using the Gnu Regression, Econometrics and Time-series Library (GRETLE) software.

[4] The output and expenditure models as defined by Eurostat.
[5] By using Eurostat data in millions of euro corrected for inflation with the base year 2010 for both the output and the expenditure approach model.
[6] Meaning that the overall sample that was considered in this model is T=84, which is completely suitable to the methodological requirements of this article.
[7] Investment and human capital were omitted due to lack of data, but they otherwise might have been an integral part of the model.
[8] In order to confront the issue of non-stationarity, the difference of natural logarithm of all of the variables will be calculated. As was the case with the previous model, the stationarity of all of the variables will be confirmed using the KPSS test.

2.1. Research hypothesis[9]

The research hypotheses were set as follows:

Research hypothesis no. 1 – the polynomial functions will display a tendency of rising public debt-to-GDP ratio;

Research hypothesis no. 2 – member states of the EU that currently suffer from macroeconomic disturbances such as Greece, Portugal and Spain will have the most significant growth of public debt-to-GDP;

Null hypothesis – the polynomial function cannot display any significant tendencies in public debt-to-GDP change.

2.2. Methodological constraints

The use of such methodology has several positive effects, while also having significant limitation. The key limitation is that due to the very nature of polynomial functions, this methodology cannot be used to predict long-term results. This methodology is best suited for predicting short-term trends. The size of the sample used is compatible with the aims of the article. In the global economy of the 21st century, trends are constantly changing and there are a multitude of variables that affect economic growth and all relevant macroeconomic indicators. Furthermore, the use of polynomial regression is one possibility while numerous methods may allow predicting trends. This method will clearly display trends in public debt-to-GDP growth and the results can easily be evaluated. Another significant constraint is that two variables[10] were omitted from the expenditure approach GDP model due to lack of data which might decrease the explanatory value of the model.

[9] The research hypothesis concerning the polynomial functions.
[10] Changes in inventories and acquisition less disposal of valuables.

3. Discussion and results

The first relevant results are the polynomial functions for all member-states of the EU based upon their percentage change of public debt-to-GDP ratio, displayed in the Table 1.

Table 1: Polynomial functions for change of public debt-to-GDP ratio

Country	**Function**	**N**	**RSS**
Austria	$y = -4.751377009 \cdot 10^{-3}\, x^3 + 0.2615959219x^2 - 2.630306099x + 71.00598555$	20	169
Belgium	$y = 6.284408223 \cdot 10^{-3}x^3 + 8.171760487 \cdot 10^{-2}x^2 - 5.534916206x + 137.8330237$	20	165.76
Bulgaria	$y = 2.901043458 \cdot 10^{-2}x^3 – 0.3644650843x^2 - 6.723712877x + 97.5620915$	18	334.998
Croatia	$y = 0.530969031x^2 - 3.329170829x + 41.16083916$	13	98.37
Cyprus	$y= 0.05626394515x^3 - 1.547376929x^2 + 12.37984726x + 29.94819401$	20	630.85
Czech Republic	$y = 9.19138892 \cdot 10^{-4}x3 – 0.01494057161x^2 + 1.760935218x + 8.42745098$	20	128.36
Denmark	$y = -0.01288335847x^3 + 0.6265082956x^2 - 7.423795159x + 61.96703297$	15	253.33
Estonia	$y = 0.05496696286x^2 - 1.084381408x + 9.448245614$	20	14.66
France	$y = 5.353712111 \cdot 10^{-3}x^3 – 0.01593060773x^2 + 0.1730249828x + 57.91434469$	20	132.29
Finland	$y = 7.538706489 \cdot 10^{-3}\, x^3 – 0.01207622637x^2 - 2.675224545x + 58.4499484$	20	138.66
Germany	$y= -6.311601681 \cdot 10^{-3}x^3 + 0.2357259109x^2 - 1.188450472\, x + 58.06914345$	20	183.55
Greece	$y = 0.02047667413x^3 -0.1960519178x^2 + 0.2132222558x + 100.2435501$	20	1255.83
Hungary	$y= -0.03908787702x^3 + 1.444300708\, x^2 - 14.25537008x + 95.6130031$	20	75.29
Ireland	$y= -0.01129002282x^4 + 0.4627257142^{x3} - 5.269552713x^2 + 13.38034427x + 62.22278122$	20	1276.334
Italy	$y = 7.225301881 \cdot 10^{-3}x^3 + 0.05720590712x^2 - 3.384487919x + 121.5962848$	20	77.81
Latvia	$y = -8.005074299 \cdot 10^{-3}x^3 + 0.4318704807x^2 - 4.105753223x + 19.43818369$	20	799.91
Lithuania	$y = 0.01663967716x^3 - 0.4268611543x^2 + 3.758179841x + 8.303199174$	20	385.84
Luxemburg	$y=-2.305325431 \cdot 10^{-3}x^3 + 0.1842035337x^2 - 2.059252603x + 11.32218782$	20	48.50
Malta	$y = 0.02199066992x^3 – 0.8762900625x^2 + 11.16806159x + 21.24355005$	20	146.67

Netherlands	$y = -5.839115342 \cdot 10^{-3} x^3 + 0.4767664919x^2 - 7.814460588x + 83.46109391$	20	149.98
Poland	$y = -0.01456957514x^3 + 0.5183515054x^2 - 4.431254063x + 49.82063983$	20	90.95
Portugal	$y = 2.310764123 \cdot 10^{-3} x^3 + 0.346042099x^2 - 4.094570302x + 63.39071207$	20	410.84
Romania	$y = 0.02935873746x^3 – 0.8426061084x^2 + 7.439844088 x – 0.4904024768$	20	351.56
Slovakia	$y = 0.04515949643x^3 - 1.387151615x^2 + 12.23450298x + 10.06728586$	20	384.20
Slovenia	$y = 0.03907292062x^3 - 0.9526015108x^2 + 6.986653742x + 9.782662539$	20	133.31
Spain	$y= 0.04366929491x^3 - 0.9018416187x^2 + 2.893940656x + 61.6871001$	20	341.41
Sweden	$y= 8.175033414 \cdot 10^{-3}x^3 – 0.1191562958x^2 - 2.482483917 x + 73.98906089$	20	130.56
United Kingdom	$y = -8.696467978 \cdot 10^{-3} x^3 + 0.6346131546x^2 - 7.467113494x + 60.01341589$	20	400.26

Source: Authors' calculations based upon Eurostat data

Based upon these results, most functions are capable of producing significant results for estimating the public debt of member-states of the EU. As it was not possible to make a polynomial function with an RSS <2000 with n=3 for Ireland, a function with n=4 was provided. In accordance with the methodology of this article, such a function will not be used to provide any results. Taking into account the lack of data for Bulgaria, Croatia, and Denmark, this paper nevertheless attempts to define future trends regarding public debt using the above mentioned formulas. There have been several examples in which the RSS was significantly high, but it does not compromise the overall value of the results, as can be seen by the value of the Pearson indicator between the actual public debt-to-GDP ratio and the results provided by the function.

Table 2: Pearson indicator and predictions

Country	Pearson indicator between function results and actual public debt to-GDP ratio	P value	Confirmation of the null hypothesis at p=0.01	Prediction of the public debt-to-GDP ratio for 2015 (%)	Prediction of the public debt-to-GDP ratio for 2020 (%)
Austria	0.92	0.00001	Rejected	87.13	95.95
Belgium	0.972	0.00001	Rejected	115.837	159.621
Bulgaria	0.986	0.00001	Rejected	37.22	127.3
Croatia	0.986	0.00001	Rejected	98.62	169.56
Cyprus	0.937	0.00001	Rejected	128.59	294.69
Czech Republic	0.972	0.00001	Rejected	47.33	60.27
Denmark	0.797	0.000374	Rejected	50.8	63.04
Estonia	0.908	0.00001	Rejected	10.92	18.41
France	0.9789	0.00001	Rejected	104.1	145.74
Finland	0.931	0.00001	Rejected	66.76	113.23
Germany	0.932	0.00001	Rejected	78.61	75.59
Greece	0.961	0.00001	Rejected	207.90	333.15
Hungary	0.981	0.00001	Rejected	71.19	14.31
Italy	0.978	0.00001	Rejected	142.66	192.26
Latvia	0.885	0.00001	Rejected	49.54	63.94
Lithuania	0.89	0.00001	Rejected	53.08	109.92
Luxemburg	0.964	0.00001	Rejected	27.96	41.78
Malta	0.967	0.00001	Rejected	72.98	105.75
Netherlands	0.953	0.00001	Rejected	75.54	99.95
Poland	0.924	0.00001	Rejected	50.43	28.94

Portugal	0.986	0.00001	Rejected	151.41	231.47
Romania	0.898	0.00001	Rejected	56.05	139.35
Slovakia	0.92	0.00001	Rejected	73.48	184.17
Slovenia	0.989	0.00001	Rejected	98.26	234.22
Spain	0.97	0.00001	Rejected	129.17	294.82
Sweden	0.976	0.00001	Rejected	45.02	72.58
UK	0.969	0.00001	Rejected	102.53	142.02

Source: Authors' calculation based upon Eurostat data

There is statistically significant and high positive correlation between the results provided by the function and the actual public debt-to-GDP ratio. The median value of the Pearson indicator between the results provided by the function and the actual public debt-to-GDP ratio is 0.964, while the average value of the Pearson indicator is 0.946. Based upon these results the null hypothesis was rejected for all of the functions[11]. As can be seen from the above data, both the United Kingdom and France have negative trends in regards to the increase of the percentage of foreign debt-to-GDP ratio. These trends are perhaps logical in the United Kingdom due to the fact that their economy has a high level of trade and a comparatively high level of financial openness in comparison to other developed countries (Chowla, Quaglietti and Rachel, 2014). Due to these factors it seems that the United Kingdom has yet to adapt to the aftermath of the 2008 crisis.

France faces severe issues in pleasing all of the interest groups present in the country, as well as the issue of the decreasing popularity of the Hollande regime due to his failure in resolving the economic issues of the country (Bowd, 2013:97). France needs to develop a way to surpass its internal divide in order to be able to fully take advantage of its strong position within the EU in comparison to other member-states. Germany is the only highly developed country that has a prediction that indicates that it will have a lower public debt-to-GDP ratio in 5 years. According to Eurostat data (2016), Germany has still managed to achieve a steady growth in its

[11] With the exception of Ireland that, in accordance with the methodology of this article, was not even tested in this phase of the research.

economy despite the 2008 global crisis. The issue for Germany is effectively managing all of the other crises of the EU. Despite the fact that Germany has had significant economic gains from EU membership, it has a significant political responsibility to maintain the EU.[12]

Such a negative trend may be viewed in other developed states, such as the countries of Benelux and Scandinavia. While the trends in Denmark and Sweden indicate low to medium growth, a more significant trend of growth may be observed in Finland. Einhorn and Logue (2010:29) note that the Scandinavian states have managed to maintain a high standard and that the so called Welfare state has survived despite slight disturbances being caused by the 2008 crisis. Luxembourg has a relatively low public debt-to-GDP ratio projection consistent with its economy that is stable and has not had more significant oscillations in the past 20 years. The Netherlands have a recent worrisome trend of increase that might still be combated with adequate measures, but the projection for Belgium is disturbing taking into account the slow and gradual growth of Belgium's public debt-to-GDP ratio throughout the years.

Perhaps the most cause for worry is from the group of countries that already have significant issues with macroeconomic indicators, often referred to by the acronym PIGS. If the trends aren't reversed very soon, the public debt of the countries that have so often been criticised for macroeconomic imbalances will become completely unsustainable. Key policy changes are necessary to reverse these trends and ensure a sustainable fiscal policy. Higher growth of public debt-to-GDP ratio than real GDP growth has been a problem for the PIIGS countries in the last four decades (Ferraz and Duarte, 2015). As the current trends in these countries suggest very high growth, the projections for 2015 and 2020 are alarmingly high. This article does not suggest that the Greek public debt-to-GDP ratio will ever actually amount to 333.15%, but it does claim that if the current trends are not reversed and if the statistical data manipulation was not discovered, that might have been the case.

The results for most of the countries of central Europe show a very different tendency than the rest of the member-states of the EU. Both Hungary and Poland

[12] Germany is often perceived as the driving force behind the EU and is often burdened with crisis management within the EU.

have taken significant steps in decreasing the level of their public debt and therefore the polynomial functions predict further decrease of debt. Rzepka and Bujak (2015) identified the significance of FDI and other elements that have helped the continued growth of the economy of Poland. Hungary was highly dependent on outside funding prior to the 2008 crisis and highly affected by external shocks (Magas, 2012). The decrease of its public debt might be seen as an attempt to decrease its reliance on foreign funding and combat the issue of external shocks. It is unlikely that the trends of lowering of public debt-to-GDP ratio that currently exist in Poland and Hungary will continue, yet they have taken a significant step in reducing macroeconomic disturbances in their economy.

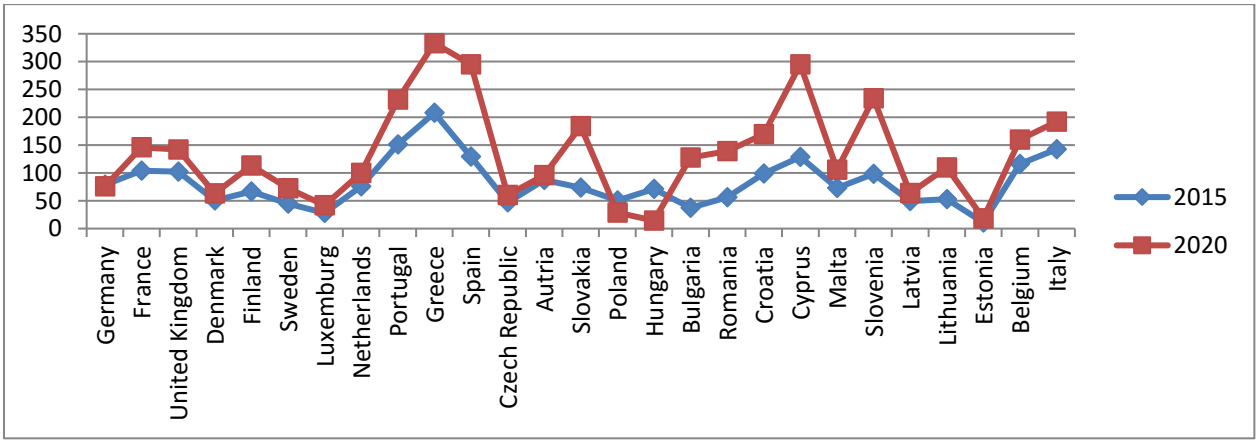
The Baltic countries mostly have a stabilized situation in regards to public-debt-to GDP ratio. Estonia maintains a continuously low public debt and the only country that is displaying tendencies that would place it in with collision with the Maastricht criteria of fiscal convergence is Lithuania. Matysek-Jedrych (2012) identified that the global economic crisis of 2008 caused a dramatic fall of GDP, rise of unemployment and outflow of currency and real wage diminishment in the Baltic States. For a most part these countries have managed to maintain a long-term stable fiscal policy and have accepted the use of austerity measures when it was necessary.

Both Cyprus and Slovenia have significant negative tendencies in regards to public debt-to-GDP ratio. As such they are the only countries that have so far displayed potential future instability that is at the level of the PIGS countries. Such a high prediction for Cyprus is mostly due to the fact that their current public debt-to-GDP ratio growth is very high. Based upon the research of Neck, Blueschke and Weyerstrass (2013:379) Slovenia should adhere to a strict austerity policy and an expansion policy might further cause a rise in public debt. Such a situation would lead to further economic instability for Slovenia. As the elements most significant for the Slovenian budget are taxes and the contribution of business subjects, it is logical that Slovenia is struggling in the aftermath of the 2008 crisis (Lesnik, Kracun and Jagric, 2014:137). On the other hand, as both the case of Slovenia and Cyprus considered economies both small and open in comparison to other EU member-states, the fact that austerity measures were implemented in a very concise time frame will hopefully curb the increasingly high public debt.

The data for the newest member-states of the EU suggests highly dangerous trends regarding the public debt-to-GDP ratio. Several issues may be seen in these countries. In the case of Romania, Stanica (2014) emphasizes the problems of the informal economy and tax evasion. Croatia is striving to find a balance between fiscal consolidation and achieving economic growth with no defined answer from either the experts or the political elite. These countries are still struggling to assert themselves as full member-states of the EU. They struggle with this issue both on a political level in asserting their authority in Brussels during policy negotiations, but even more significant are their economic issues. This can mostly be seen from a relatively low use of EU funds in comparison to the other member-states of the EU, as well as the continued growth of negative macroeconomic indicators in these 3 countries since the 2008 crisis.

A projection of the public debt-to-GDP ratio for all countries may be seen in Chart 1. Based upon that data, it is possible to confirm both research hypothesis no. 1 and research hypothesis no.2. The only limitation that should be added to research hypothesis no. 1 is that Hungary, Poland and to an extent Germany have trends that indicate that the public debt-to-GDP ratio will decrease. Research hypothesis no. 2 can clearly be confirmed as Portugal, Greece and Spain have the worst projections of the countries considered.

Chart 1: Projections for 2015 and 2020



Source: Authors' calculation based on Eurostat data

4. Discussion and further quantitative analysis of Greece and Hungary

In accordance with the previously mentioned methodology further analysis is conducted for Hungary, which has the lowest predicted ratio of public debt-to-GDP ratio based upon the results of the polynomial function and Greece, which had the highest predicted results. The quantitative analysis first considers the stationarity of the variables before running the OLS regression. The results are summarized in Table 3 in which the KPSS test confirms the stationarity of both GDP and public debt-to-GDP ratio percentage change for Hungary and Greece.

Table 3: KPSS test for variables in public debt-to-GDP ratio model

Greece	
KPSS test for PD T = 35 Lag truncation parameter = 3 Test statistic = 0,253869 10% 5% 1% Critical values: 0,353 0,462 0,716 P-value > .10	KPSS test for GDP T = 36 Lag truncation parameter = 3 Test statistic = 0,223451 10% 5% 1% Critical values: 0,353 0,462 0,717 P-value > .10
Hungary	
KPSS test for GDP1 T = 19 Lag truncation parameter = 2 Test statistic = 0,282333 10% 5% 1% Critical values: 0,358 0,462 0,692 P-value > .10	KPSS test for d_PD T = 19 Lag truncation parameter = 2 Test statistic = 0,391642 10% 5% 1% Critical values: 0,358 0,462 0,692 Interpolated p-value 0,084

Source: GRETL output and Authors' calculations

As the null hypothesis of the KPSS test is stationarity, at p=0,05 we are able to confirm the null hypothesis of stationarity (Kwiatkowsky et al., 1992:160). After considering an OLS model, such a methodological approach suggested autocorrelation issues based upon the value of the Durbin-Watson statistic[13] and the LM test. Therefore in order to resolve the issue of autocorrelation, the Prais-Winsten estimation method is used.

[13] The data is available in the Appendix where it is clearly demonstrated that the OLS model has the issue of autocorrelation.

Model 1: Prais-Winsten, using observations 1980-2015 (T = 35)

Dependent variable: GDP
rho = 0,680066

	coefficient	std. error	t-ratio	p-value	
const	1,11165	1,24121	0,8956	0,3769	
PD	−0,0981389	0,0412130	−2,381	0,0232	**

Statistics based on the rho-differenced data:

Mean dependent var	0,844000	S.D. dependent var	3,643682
Sum squared resid	196,7671	S.E. of regression	2,441852
R-squared	0,566283	Adjusted R-squared	0,553140
F(1, 33)	5,539016	P-value(F)	0,024705
rho	0,044661	Durbin-Watson	1,888177

Source: GRETL output and Authors' calculations

Based upon these results it can be confirmed that there is a statistically significant link between the percentage change of GDP and the growth rate of the public debt-to-GDP ratio. Although the explanatory value of the value is not very high, such an outcome is expected as there is only one explanatory variable. These results report similar results such as studies conducted by Feraz and Duarte (2015) which suggest a statistically significant link between public debt-to-GDP ratio and GDP change. The results of the study suggest an overall higher importance of public debt-to-GDP ratio on GDP in average in PIIGS countries, but the reported results for Portugal are similar to the estimates made by this model.

The results for Hungary display significant differences in comparison to the Greek model. As no autocorrelation errors were encountered, the standard OLS regression model was used.

Model 2: OLS, using observations 1996-2014 (T = 19)

Dependent variable: GDP1

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	2,14462	0,65794	3,2596	0,0046	***
d_PD	−0,0908841	0,138429	−0,6565	0,5203	

Mean dependent var	2,184319	S.D. dependent var	2,810259
Sum squared resid	138,6408	S.E. of regression	2,855755
R-squared	0,024728	Adjusted R-squared	-0,032641
F(1, 17)	0,431042	P-value(F)	0,520267
Log-likelihood	−45,84058	Akaike criterion	95,68116
Schwarz criterion	97,57004	Hannan-Quinn	96,00083
rho	0,352733	Durbin-Watson	1,212614

LM test for autocorrelation up to order 1 -
Null hypothesis: no autocorrelation
Test statistic: LMF = 2,254
with p-value = P(F(1, 16) > 2,254) = 0,152746

White's test for heteroscedasticity -
Null hypothesis: heteroscedasticity not present
Test statistic: LM = 5,341
with p-value = P(Chi-square(2) > 5,341) = 0,0692175

Source: GRETL output and Authors' calculations

Based upon the results of the OLS regression, there is no statistically significant link between GDP percentage change and the percentage change of the public debt-to-GDP ratio in Hungary. The values of the LM test and the Durbin-Watson statistic imply that the model does not suffer from autocorrelation issues and the p value of White's test statistic is 0,0692175. This leads to the conclusion that at p=0,05 we can confirm the null hypothesis of no heteroscedasticity present. The results from the OLS regression and Prais-Winsten estimation display that the economies of Hungary and Greece are significantly different in regards to public debt management. Further analysis is conducted by reviewing their main GDP components from the output approach. The stationarity of the variables is confirmed using the KPSS test. As the variables were not stationary in the first difference of natural logarithms, the second difference was calculated for the variables for Greece.[14] The variables for Hungary were stationary in the first difference. The results of the KPSS test can be seen in Table 4.

[14] Another thing to note is that the Augmented Dickey-Fuller (ADF) test found the first difference of natural logarithms of taxes less subsidies to be stationary, but the ADF-GLS test and the KPSS test rejected stationarity as the correct hypothesis. Hence the second difference of the variable was calculated and based upon all of the tests the second difference of natural logarithms of taxes less subsidies is stationary.

Table 4: KPSS test for variables used in output approach GDP analysis

Greece		
KPSS test for d_ld_GDP T = 82 Lag truncation parameter = 3 Test statistic = 0,0321758 10% 5% 1% Critical values: 0,350 0,462 0,732 P-value > .10	KPSS test for d_ld_GVA T = 82 Lag truncation parameter = 3 Test statistic = 0,0300829 10% 5% 1% Critical values: 0,350 0,462 0,732 P-value > .10	KPSS test for d_ld_Tax T = 82 Lag truncation parameter = 3 Test statistic = 0,0265509 10% 5% 1% Critical values: 0,350 0,462 0,732 P-value > .10
Hungary		
KPSS test for ld_GDP T = 83 Lag truncation parameter = 3 Test statistic = 0,333542 10% 5% 1% Critical values: 0,350 0,462 0,732 P-value > .10	KPSS test for ld_GVA T = 83 Lag truncation parameter = 3 Test statistic = 0,364737 10% 5% 1% Critical values: 0,350 0,462 0,732 Interpolated p-value 0,093	KPSS test for ld_Tax T = 83 Lag truncation parameter = 3 Test statistic = 0,235682 10% 5% 1% Critical values: 0,350 0,462 0,732 P-value > .10

Source: GRETL output and Authors' calculations

After confirming the stationarity of the variables, an OLS regression was considered, but the issue of autocorrelation was once again encountered in the Greek case[15] so the Prais-Winston estimation method was used. The results for both Hungary and Greece are summarized in Table 5, while full output provided by GRETL may be found in the Appendix. Aside from the full output of the regression models, the correlation matrixes are also provided in the Appendix and they clearly suggest that there is no statistically significant high correlation between the independent variables, meaning that the regression model does not have the issue of multicollinearity.

Table 5: Summary table of results from regression models for output approach for Greece and Hungary

Variable		Coefficient	p value	R-squared		Coefficient	p value	R-squared
constant	Greece	−3,72150e-05	0,8502	0,972661	Hungary	−5,57211e-05	0,7516	0,977747
Gross value added		0,829835	4,04e-047			0,909631	2,98e-064	
Tax less subsidies		0,0929104	1,14e-025			0,0667957	4,31e-09	

Source: GRETL output and Authors' calculations

[15] This can clearly be seen in Model 2 in the Appendix where full output by GRETL is provided.

Surprisingly, the difference in explaining GDP growth using the output approach almost fall in the realm of standard error in regards to the value of the coefficients. Both economies seem to be highly dependent upon gross value added, both the models have a satisfactory R-squared value but based upon the model no structural differences can be detected. The final model considers an alternative approach model to GDP change, with the stationarity of all variables considered confirmed by the KPSS test[16], which may be seen in Table 6.

Table 6: KPSS test for variables used in expenditure approach GDP analysis

Greece			
KPSS test for d_ld_GDP T = 82 Lag truncation parameter = 3 Test statistic = 0,189802 10% 5% 1% Critical values: 0,350 0,462 0,732 P-value > .10	KPSS test for d_ld_EXP T = 82 Lag truncation parameter = 3 Test statistic = 0,211371 10% 5% 1% Critical values: 0,350 0,462 0,732 P-value > .10	KPSS test for d_ld_EMP T = 82 Lag truncation parameter = 3 Test statistic = 0,0489426 10% 5% 1% Critical values: 0,350 0,462 0,732 P-value > .10	KPSS test for d_ld_PI T = 37 Lag truncation parameter = 3 Test statistic = 0,315351 10% 5% 1% Critical values: 0,353 0,462 0,717 P-value > .10
Hungary			
KPSS test for ld_GDP T = 83 Lag truncation parameter = 3 Test statistic = 0,345566 10% 5% 1% Critical values: 0,350 0,462 0,732 P-value > .10	KPSS test for d_ld_EXP T = 82 Lag truncation parameter = 3 Test statistic = 0,130414 10% 5% 1% Critical values: 0,350 0,462 0,732 P-value > .10	KPSS test for ld_EMP T = 83 Lag truncation parameter = 3 Test statistic = 0,280846 10% 5% 1% Critical values: 0,350 0,462 0,732 P-value > .10	KPSS test for d_ld_PI T = 64 Lag truncation parameter = 3 Test statistic = 0,101229 10% 5% 1% Critical values: 0,351 0,462 0,729 P-value > .10

Source: GRETL output and Authors' calculations

Upon confirming the stationarity of all of the variables, a summary table of the results of the regression models is presented in Table 7, while full output provided by GRETL may be found in the appendix. As results for Greece and Hungary once again displayed autocorrelation issues by using the standard OLS regression, the Prais-Winston estimation method was used.

[16] For Greece, all of the variables were stationary in the second difference of logs, while for Hungary GDP and employment were stationary at the first difference of variables, while export and primary income were stationary at the second difference.

Table 7: Summary results of Prais-Winston estimation

Variable		Coefficient	p value	R-squared		Coefficient	p value	R-squared
constant	Greece	0,00192105	0,6844	0,902149	Hungary	0,000230499	0,9652	0,711932
Export of goods and services		0,146535	2,74e-08			0,471763	3,14e-06	
Total employment		0,250448	0,6297			3,39446	4,37e-07	
Primary income		0,319562	1,72e-012			0,0188056	0,6792	

Source: GRETL output and Authors' calculations

Based upon these results it is possible to conclude that there are significant structural differences between the economies of Greece and Hungary. Of the variables considered, for the Greek model exports and primary income were statistically significant, while in the Hungarian model exports and total employment were statistically significant at p=0,05. Aside from these basic conclusions, it is clear that Hungarian GDP change is more dependent upon export and that the overall value of the model suffers from the exclusion of human capital and investment. The Greek model with an R-squared value of 0,902149 has an acceptable explanatory value.

5. Conclusion

Using simple polynomial regression it was possible to make predictions for future tendencies of the public debt-to-GDP ratio. Based upon these projections, public debt will continue to be one of the most significant economic issues the EU currently faces. Current trends suggest that Poland and Hungary have taken significant steps in reducing their public debt-to-GDP ratio and if such trends persist they should have a stable macroeconomic environment. Of the developed countries only Germany seems to have remain immune to the 2008 crisis, at least when viewing its public debt-to-GDP ratio. The other developed economies of the EU will have significant issues with macroeconomic imbalances if current trends persist. Upon analysing the

economies of Greece and Hungary, significant differences were encountered both in their relation to public debt-to-GDP ratio as well as basic structural differences.

Perhaps the most significant issue are the so called PIGS countries in which the public-debt-to GDP ratio is reaching unsustainably high levels. Their instability is a danger not only to the euro, but to the very stability and regular functioning of the EU as an economic and political integration. Aside from the PIGS countries, the problem of small open economies such as Slovenia and Cyprus has also become apparent in the aftermath of the 2008 crisis. The EU should take a more decisive stance against statistic data manipulation and imbalanced fiscal policies. The existing legislation provides enough legal capacity for the EU to act, but there seems to be a lack of political will. Such indecisiveness cannot persist if the Greek situation is to be avoided in other member-states of the EU.

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Eurostat data, http://ec.europa.eu/eurostat (9.1.2016.)

Appendix

When considering the OLS model for Greece, it is clearly possible to see that the model has autocorrelation problems due to the fact that the LM test rejects the null hypothesis of no autocorrelation and the Durbin-Watson statistic value suggests that autocorrelation is present.

Model 1. OLS, using observations 1981-2015 (T = 35)

Dependent variable: GDP

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	2,01465	0,622202	3,2379	0,0027	***
d_PD	−0,233086	0,0648823	−3,5925	0,0011	***

Mean dependent var	0,844000	S.D. dependent var	3,643682
Sum squared resid	324,4943	S.E. of regression	3,135787
R-squared	0,281135	Adjusted R-squared	0,259351
F(1, 33)	12,90570	P-value(F)	0,001052
Log-likelihood	−88,63395	Akaike criterion	181,2679
Schwarz criterion	184,3786	Hannan-Quinn	182,3417
rho	0,477052	Durbin-Watson	1,024088

LM test for autocorrelation up to order 1 -
Null hypothesis: no autocorrelation
Test statistic: LMF = 10,9534
with p-value = P(F(1, 32) > 10,9534) = 0,00231957

Source: GRETL output and Authors' calculations

When attempting an OLS regression model to display the change of Greek GDP, autocorrelation was once again present which can be seen based upon the value of the Durbin-Watson statistic and the LM test rejects the null hypothesis of no autocorrelation.

Model 2. OLS, using observations 1995:3-2015:4 (T = 82)

Dependent variable: d_ld_GDP

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−3,67178e-05	0,0003647	−0,1007	0,9201	
d_ld_GVA	0,824889	0,0239843	34,3930	<0,0001	***
d_ld_Tax	0,0958016	0,00521985	18,3533	<0,0001	***

Mean dependent var	−0,000101	S.D. dependent var	0,016442
Sum squared resid	0,000862	S.E. of regression	0,003302
R-squared	0,960654	Adjusted R-squared	0,959658
F(2, 79)	964,4162	P-value(F)	3,15e-56
Log-likelihood	353,6483	Akaike criterion	−701,2966
Schwarz criterion	−694,0764	Hannan-Quinn	−698,3978
rho	−0,550547	Durbin-Watson	3,098997

LM test for autocorrelation up to order 4 -
Null hypothesis: no autocorrelation
Test statistic: LMF = 29,0008
with p-value = P(F(4, 75) > 29,0008) = 1,41869e-014

Source: GRETL output based upon Eurostat data

Full output provided by GRETL using the Prais-Winsten estimation in the GDP growth model for Greece can be seen in Model 3, while the correlation matrix can be seen in Table 1.

Model 3. Prais-Winsten, using observations 1995:3-2015:4 (T = 82)

Dependent variable: d_ld_GDP
rho = -0,554978

	coefficient	std. error	t-ratio	p-value	
const	−3,72150e-05	0,000196375	−0,1895	0,8502	
d_ld_GVA	0,829835	0,0258224	32,14	4,04e-047	***
d_ld_Tax	0,0929104	0,00599463	15,50	1,14e-025	***

Statistics based on the rho-differenced data:

Mean dependent var	−0,000101	S.D. dependent var	0,016442
Sum squared resid	0,000599	S.E. of regression	0,002753
R-squared	0,972661	Adjusted R-squared	0,971969
F(2, 79)	863,7732	P-value(F)	2,05e-54
rho	−0,300170	Durbin-Watson	2,595468

Source: GRETL output based upon Eurostat data

Table 1. Correlation coefficients

d_ld_GDP	d_ld_GVA	d_ld_Tax	
1,0000	0,8904	0,6095	d_ld_GDP
	1,0000	0,2377	d_ld_GVA
		1,0000	d_ld_Tax

Source: Source: GRETL output based upon Eurostat data

Full output by GRETL for the OLS regression model of Hungary using the output approach can be seen in Model 4, as well as the correlation matrix in Table 2.

Model 4. OLS, using observations 1995:2-2015:4 (T = 83)

Dependent variable: ld_GDP

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−5,57211e-05	0,000175408	−0,3177	0,7516	
ld_GVA	0,909631	0,0170748	53,2734	<0,0001	***
ld_Tax	0,0667957	0,0101368	6,5894	<0,0001	***

Mean dependent var	0,005310	S.D. dependent var	0,009063
Sum squared resid	0,000150	S.E. of regression	0,001369
R-squared	0,977747	Adjusted R-squared	0,977190
F(2, 80)	1757,482	P-value(F)	7,87e-67
Log-likelihood	431,0430	Akaike criterion	−856,0861
Schwarz criterion	−848,8295	Hannan-Quinn	−853,1708
rho	−0,002504	Durbin-Watson	1,877788

LM test for autocorrelation up to order 4 -
Null hypothesis: no autocorrelation
Test statistic: LMF = 1,66422
with p-value = P(F(4, 76) > 1,66422) = 0,167064

White's test for heteroscedasticity -
Null hypothesis: heteroscedasticity not present
Test statistic: LM = 8,57466
with p-value = P(Chi-square(5) > 8,57466) = 0,12728

Source: Source: GRETL output based upon Eurostat data

Table 2. Correlation coefficients

ld_GDP	ld_GVA	ld_Tax	
1,0000	0,9827	0,4339	ld_GDP
	1,0000	0,3362	ld_GVA
		1,0000	ld_Tax

Source: Source: GRETL output based upon Eurostat data

Detailed GRETL output regarding the alternative GDP change model is available in Model 5 for Greece and Model 6 for Hungary.

Model 5. Prais-Winsten, using observations 2006:3-2015:3 (T = 37)

Dependent variable: d_ld_GDP
rho = -0,142403

	coefficient	std. error	t-ratio	p-value
const	0,00192105	0,00468417	0,4101	0,6844
d_ld_EXP	0,146535	0,0202720	7,228	2,74e-08 ***
d_ld_EMP	0,250448	0,514623	0,4867	0,6297
d_ld_PI	0,319562	0,0292688	10,92	1,72e-012 ***

Statistics based on the rho-differenced data:

Mean dependent var	−0,000241	S.D. dependent var	0,099079
Sum squared resid	0,034677	S.E. of regression	0,032416
R-squared	0,902149	Adjusted R-squared	0,893253
F(3, 33)	95,43740	P-value(F)	2,42e-16
rho	−0,089386	Durbin-Watson	2,054550

Source: GRETL output based upon Eurostat data

Model 6. Prais-Winsten, using observations 1999:3-2015:2 (T = 64)

Dependent variable: ld_GDP
rho = -0,171024

	coefficient	std. error	t-ratio	p-value
const	0,000230499	0,00526256	0,04380	0,9652
ld_EMP	3,39446	0,598872	5,668	4,37e-07 ***
d_ld_PI	0,0188056	0,0452454	0,4156	0,6792
d_ld_EXP	0,471763	0,0917568	5,141	3,14e-06 ***

Statistics based on the rho-differenced data:

Mean dependent var	0,005144	S.D. dependent var	0,087919
Sum squared resid	0,140558	S.E. of regression	0,048401
R-squared	0,711932	Adjusted R-squared	0,697529
F(3, 60)	40,73726	P-value(F)	1,74e-14
rho	−0,054771	Durbin-Watson	2,098222

Source: GRETL output based upon Eurostat data

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