# *ANALYSING AND FORECASTING THE DEBT BURDEN OF THE EU COUNTRIES: IS THERE A NEW EUROPEAN DEBT CRISIS ON THE HORIZON?*[1]

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**Abstract:** The debt crisis which afflicted Europe highlights the weaknesses and instability of the EU member states' financial systems, as well as the inability of their national economies to maintain normal levels of indebtedness. The deteriorating economic environment requires changes in the fiscal policies across Europe. These changes are effected using new financial instruments to raise the necessary funds for implementation of economic reforms in the EU member states. The aim of this study is to analyse the current levels of sovereign debt across the European Union and to forecast their development in the future using specialized econometric software. The results may be used to identify possible future economic shocks in Europe.

**Keywords:** fiscal policy, sovereign debt, debt crisis, European Union, forecasting.

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## I. INTRODUCTION

The Global financial crisis of 2007-2008 and the subsequent debt crisis in Europe highlight the weaknesses and instability of financial systems in the developed and the developing economies around the world as well as the inability of national economies to maintain normal levels of indebtedness. Such crises have occurred many times throughout the years, but for the first time in the economic history they have reached such a scale and affected so many economies in such a short time period.

In the context of a pan-European debt crisis affecting many economies of the European Union (Portugal, Italy, Ireland, Greece, Spain, Cyprus, etc.) it is necessary to analyse the impact of government debt on key macroeconomic indicators (GDP, exports, foreign exchange reserves, etc.) It is the variety of developments on the subject and the existence of many dissenting opinions that raise questions about the causes of the debt crisis, whether the instruments used to combat economic shocks are appropriate and whether the crisis has completely subsided or is still in danger of recurrence.

To find out whether the debt crisis in Europe is over and whether new crises can be expected, we have to analyze the dynamics of sovereign debts of the EU Member States. The results of such an analysis will reveal whether there is a need for changes of the debt policy at national and supranational levels. Due to the dynamics of the world economy today and the interconnectedness of individual countries, a potential new debt crisis in the near future would harm not only businesses and people within Europe, but also around the world.

Considering the relevance of the topic, the **object** of this study is the debt burden of the EU Member States.

The **subject** of the research is the ability to forecast the future value of sovereign debt and to identify possible future economic shocks that could affect the economies of the European countries.

The object and the subject of the study, which were defined above, will be studied in order to corroborate the following **research hypothesis**: We expect an increase of the EU Member States' sovereign debt levels in the short run, which will not only result in new economic shocks but also trigger a new debt crisis in Europe.

An analysis of current debt dynamics and a forecast of its future values require evaluation and selection of an appropriate model and its proper implementation. Only then we can ensure accurate forecasts and research results. Thus, the **aim** of this research is to investigate the sovereign debt of the EU countries and to forecast the future development of the debt burden through the use of specialized econometric software products. Using this forecast, an attempt can be made to identify possible future economic shocks within Europe.

The **tasks** to be carried out in order to achieve the aim are:

- Analysis of the European Union's fiscal policy instruments, providing financial aid to the most indebted European economies;
- Analysis of the dynamics of the government indebtedness of the EU Member States for the period preceding the start of the debt crisis and its current state;
- Selection of an appropriate econometric method for forecasting dynamic time series;
- Approbation of the chosen econometric method and identification of forecast levels of debt within the EU that indicate potential future problems and possible economic shocks.

## II. METHODOLOGY

The study of the dynamics of government indebtedness in the EU Member States is based on analysis of statistical data from reliable sources such as Eurostat, the World Bank, the International Monetary Fund, the European Central Bank, etc. In order to avoid distortions due to the different sizes of the analysed economies, sovereign debt is measured as a percentage of GDP.

Prior to being applied to a future predictive model, the input data must undergo certain transformations. The size of the sovereign debt as a percentage of GDP of each European Union country for the researched period was measured on a quarterly basis, which implies certain seasonality. To avoid model distortion due to seasonality, data is smoothed using the Holt-Winters seasonal additive model and the Holt-Winters seasonal multiplicative model, which are applicable both to time series with constant seasonal variations and to time series with variable seasonal variation (Shopov, 2019, p. 80).

Exponential smoothing methods give larger weights to more recent observations, and the weights decrease exponentially as the observations become more distant. These methods are most effective when the parameters describing the time series are changing slowly over time (Rahman, Salma, Moyazzem, & Khan, 2016, p. 20).

Traditional economic forecasting methods are similar to the regression analysis, where we assign a certain value depending on one or more explanatory variables, searching for the exact parameters of dependence between them. If they are resistant to alterations over time, they can provide aid in predicting the desired value if data about the dimensions of the explanatory variables is available, at the time of the forecast (Костов, 2018, стр. 72-73).

The econometric modeling of time series and their forecasting have certain unique features due to the characteristics which distinguish this type

from other types of data. The difference here is that we can assume that the factors that influence the time series are already reflected in their previous values. In general, this means that if each subsequent value is considered to be equal to the previous one plus a random component, provided that we can determine the parameters of the function obtained and this function can be extrapolated further in time.

When utilizing forecast to predict the future data of the debt levels of the European Union countries, ARMA and ARIMA econometric models should be used. The AutoRegressive Moving Average (ARMA) is a model which describes weakly stationary stochastic processes. It comprises of two polynomial equations – autoregression (AR) and moving average (MA). The second one, the ARIMA or AutoRegressive Moving Integrated Average model, is used mainly when the examined data show evidence of non-stationarity.

The last step of the study is to analyse the forecast results and draw a conclusion about the expected future dynamics of the economies of the EU Member States. Depending on whether the debt levels are expected to increase, decrease or remain the same, we can predict the economic situation in Europe in the coming years. (Недев, 2019, стр. 37). Finally, by making a comparison between the sovereign debt levels prior to the 2008 debt crisis, a resemblance in key economic indicators may be sought to indicate a possible future turmoil.

## III. EMPIRICAL RESEARCH

The study of the debt burden of EU member states and its forecasting goes through several main stages:

- A review of the European Union's fiscal policy instruments intended to provide financial support to heavily indebted European economies;
- An analysis of the sovereign debt levels of EU countries for the period under study and selection of the countries whose debt is to be projected - only the most indebted economies are analysed due to the large number of EU Member States;
- Seasonality test of the empirical data;
- Stationarity test of the data (Augmented Dickey-Fuller Test);
- Selection of appropriate values of the AR and MA coefficients;
- Analysis of all possible ARIMA models based on the AR and AM coefficients obtained and selection of the most suitable model;
- Model approbation – a correlogram of the residuals;
- Forecasting future debt values for selected countries.

## 1. A review of the European Union's fiscal policy instruments for financial support to heavily indebted European economies

The European debt crisis affected a large number of the developed EU economies. During the crisis period, they were not able to cope with the large amounts of public debt accumulated over the last few decades. The resulting collapse of financial institutions and increase of the spreads on sovereign bond yields are only two of the negative effects of the crisis. The crash of the Icelandic banking system in 2008 is considered to be the turning point, which led to the Euro Area debt crisis. A year later, the negative consequences were transposed to the economies of Portugal, Ireland, Greece, Spain, Cyprus and Italy, which became the most affected EU Member States. These six countries are unable to generate enough financial assets through economic growth to pay their investors' bond guarantees (Шопов, 2018, стр. 79).

A number of theories regarding the major causes of the crisis have been put forward by various economists. Some of them focus their attention to the private debt incurred due to the crisis in the real estate sector and its transformation into sovereign debt through bank bailouts and inadequate government responses to the subsequent economic slowdowns. (Шопов, 2018, стр. 80). The structure of the European Union, which features monetary but not fiscal union, contributes to the debt crisis, limiting European leaders' ability to response. Another contributing factor to the crisis is the fact that a large number of European banks hold a significant portion of government debt, which only raises additional concerns regarding the solvency of the banking sector (Acharyya & Kar, 2014, pp. 16-17).

To deal with the debt crisis, Member States' economies need aid in the form of a supranational intervention (Европейска комисия, 2012, стр. 3-4). The initial bailout campaign gains institutional outlines by focusing a major part of the financial resources of the European Financial Stability Fund (EFSF). A much smaller role is played by the European Financial Stability Mechanism (EFSM) (Шопов, 2018, стр. 81).

The EFSF was established on 7 June 2010 with headquarters in Luxembourg. Its main objective is to help maintain the financial stability of the Member States of the Union. The main mechanism for achieving this objective is to provide temporary financial assistance to economies that do not have the necessary financial resources to service their debt issues. (Ангелов, 2012, стр. 2). Another similar organization in the Eurozone, the EFSM, plays an important role in maintaining the financial equilibrium. It was established on 9 May 2010, following a decision of the EcoFin Council. A package of measures is being prepared to maintain financial stability in Europe, with a total resource volume of up to half a trillion Euro (Zahariev, 2012, pp. 177-178).

The EFSF is created as a temporary rescue mechanism in response to the first major shocks since the start of the European debt crisis. It is created as a Special-purpose vehicle (SPV). All financial assistance programs of the Fund are aimed towards appropriate economic reforms (Шопов, 2018, стр. 82).

The last EFSF rescue program targeted the Greek economy and expired on 30 June 2015. After that date, the Fund ceased to provide additional financial assistance (Шопов, 2018, стр. 82). Nevertheless, it maintained its operations on (European Financial Stability Facility, 2017, p. 7):

- receiving repayments from the assisted Member States;
- making interest payments and principal payments to bondholders;
- transfer of unpaid debt instruments as the maturity of the loans granted to Ireland, Portugal and Greece is longer than the maturity of the bonds issued by the EFSF.

From 2010 to 2015, the EFSM provided financial assistance for implementation of economic reforms in Ireland and Portugal, as well as short-term bridge loans to Greece. Countries that need financial assistance after 2015 can only apply for support to the European Stabilization Mechanism (ESM) (European Commission, 2015).

In the beginning of 2011, the Council of the European Union established the European Stability Mechanism (ESM) as a permanent framework for crisis management and assistance (European Central Bank, 2011, p. 17).

*Table 1*

***Funds for financial assistance programs allocated to the countries most affected by the crisis (billion EUR)***

| Country/Program | EFSF | EFSM | ESM | Total: |
|---|---|---|---|---|
| **Greece** | 141.8 | - | 61.9 | **203.7** |
| **Ireland** | 17.7 | 22.5 | - | **40.2** |
| **Portugal** | 26 | 24.3 | - | **50.3** |
| **Cyprus** | - | - | 6.3 | **6.3** |
| **Spain** | - | - | 41.3 | **41.3** |
| **Total:** | **185.5** | **46.8** | **109.5** | **341.8** |

**Source:** (Шопов, 2018, стр. 83).

Currently, the ESM is the only mechanism within the EU that is authorized to provide and implement new financial assistance programs to Member States. It is based on the Treaty establishing the European Stabilization Mechanism as an intergovernmental organization with headquarters in Luxembourg. The first bailout program targets the Spanish economy and aims to recapitalize the country's banking sector. Since the start of operations of the three EU organizations in 2010, providing financial assistance programs to

Member States - EFSF, EFSM and ESM, just over € 340 billion has been allocated among the EU Member States most affected by the European debt crisis (see Table 1) (Шопов, 2018, стр. 83).

Overall, the debt crisis in Europe showed that both the governments of the individual Member States and the Council institutions were not prepared to deal with such a large-scale problem caused by various factors. However, the initially limited national set of tools to counteract such economic cataclysms is being significantly improved and upgraded into an integrated fiscal toolbox which aims to provide financial assistance to all member states in need. (Недев, 2014, стр. 43). Despite its proverbial bureaucracy, the EU established three financial mechanisms (EFSF, EFSM and ESM) to bail out the economies of Portugal, Ireland, Greece, Spain and Cyprus and thus proved the importance of certain ways to deal with the debt crisis.

The five countries that received funding under the financial assistance programs of the EU fiscal policy are suitable candidates for further analysis. Their deteriorating economic situation and inability to cope with their debt burdens are serious grounds for an econometric analysis aiming to forecast the expected future levels of their sovereign debt. Despite Italy's absence in the list of economies that received financial aid, it is impossible to overlook the fact that many credible sources (the ECB, IMF, World Bank and several others) suspect that it is the Italian economy that will give impetus to a possible future financial turmoil in Europe, if the necessary preventive measures are not taken. The next part of the study clearly shows the debt levels of Italy and the other five economies in the past and their current indebtedness, which is another reason for choosing them as subjects of the analysis.

## 2. An analysis of the sovereign debt levels of EU countries for the period (2000 – 2018) and selection of the countries whose debt is to be projected

For the purposes of the survey, quarterly data on the consolidated gross national debt of the Member States of the European Union are used. In order to avoid distortions of results, due to the difference in the size of the economies which are surveyed, the values are presented as a percentage of GDP. The sovereign debt/GDP ratio is part of the Maastricht convergence criteria included in the Maastricht Treaty. In order for an economy to join the euro area, the levels of its government debt in the previous fiscal period should not exceed 60% of the country's GDP over the same period (European Central Bank, 2018).

The analysis of Table 2 shows that at the beginning of the study period (2000), only five of the twenty-eight EU member states do not currently meet these convergence criteria. Until the end of 2007, shortly before the Global

Financial Crisis, the debt levels of the economies surveyed remain relatively low.

Since the beginning of the crisis, the economic situation of many countries has deteriorated dramatically. The market is shrinking, income and investment are declining, and the population is running out of savings and starting to accumulate debt. The situation in the public sector is the same. The recession is leading to the European debt crisis, which manifests itself in 2009. As early as next year, the indicators in the table increase significantly. The debt of many European countries no longer covers the Convergence Criteria. As of 2011, fourteen of the surveyed economies have debt over 60% of GDP, and five of them exceed the 90% Debt/GDP threshold above which the economy slows down, contributing to further deterioration in the economic environment (Reinhart & Rogoff, 2010, p. 576).

The last year of the study period (2018) shows that the sovereign debt of seventeen countries was higher than the debt at the end of 2011. This proves that they have not yet managed to cope with the high levels of debt. Six of them (Cyprus, Greece, Ireland, Italy, Portugal and Spain) are suitable for analysing because of the high levels of debt and the risk which they transpose to the other EU Member States. The average values in the last two columns indicate high average levels of debt, both over the entire period and for the recession and crisis periods.

In short, from 2000 to 2007 there was an improvement in the levels of government debt and the debt/GDP ratio in accordance with the requirements of the Maastricht criteria. However, this economic recovery has proved too fragile and has been hampered by the onset of the Global Financial Crisis. The slowdown of the economic growth rate and the negative change in the debt/GDP ratio are observed not only in the first years of the crisis, but remain clearly visible until the last year of the study period for the six most affected EU economies. This is what makes it necessary to study Cyprus, Greece, Ireland, Italy, Portugal and Spain as potential instigators of a future debt crisis.

*Table 2*

***Change and average values of the Debt/GDP ratio of the EU countries over the study period (2000-2018)***

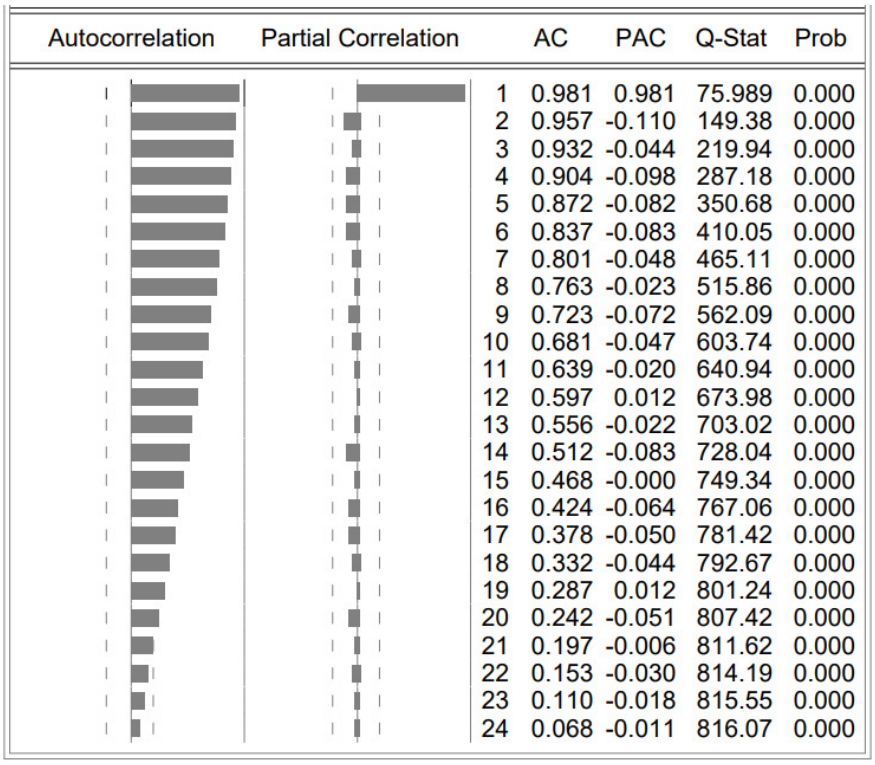
| GEO/TIME | 2000 | 2007 | 2008 | 2009 | 2010 | 2011 | 2018 | AVG(00-18) | AVG(07-11) |
|---|---|---|---|---|---|---|---|---|---|
| EU28 | 61.9 | 59.0 | 59.0 | 69.6 | 77.3 | 80.3 | 80.9 | 71.6 | 69.0 |
| EA19 | 69.7 | 66.7 | 66.8 | 76.5 | 82.6 | 86.3 | 86.3 | 78.5 | 75.8 |
| Austria | 69.6 | 71.3 | 67.0 | 75.2 | 82.5 | 82.2 | 75.6 | 75.9 | 75.6 |
| Belgium | 113.3 | 91.0 | 90.6 | 99.8 | 102.3 | 102.6 | 104.9 | 103.7 | 97.2 |
| Bulgaria | 75.0 | 17.7 | 13.8 | 13.2 | 14.6 | 14.5 | 23.5 | 30.2 | 14.7 |
| Croatia | 34.0 | 38.1 | 37.0 | 44.6 | 53.5 | 62.6 | 75.5 | 55.3 | 47.2 |
| Cyprus | 54.3 | 56.6 | 46.8 | 58.5 | 56.9 | 62.3 | **102.1** | **73.9** | **56.2** |
| Czechia | 16.0 | 27.5 | 27.7 | 31.6 | 36.4 | 38.8 | 34.4 | 32.7 | 32.4 |
| Denmark | 55.4 | 29.1 | 28.0 | 38.1 | 43.4 | 46.3 | 35.0 | 42.0 | 37.0 |
| Estonia | 5.5 | 3.7 | 4.1 | 6.0 | 6.8 | 6.3 | 8.7 | 6.7 | 5.4 |
| Finland | 44.2 | 34.6 | 31.6 | 37.6 | 45.6 | 46.8 | 59.8 | 47.0 | 39.2 |
| France | 59.2 | 65.8 | 67.0 | 79.2 | 85.8 | 87.4 | 99.1 | 78.8 | 77.0 |
| Germany | 59.5 | 64.8 | 64.5 | 70.7 | 75.4 | 80.0 | 62.1 | 68.3 | 71.1 |
| Greece | 104.7 | 103.5 | 106.1 | 122.8 | 138.2 | 162.4 | **179.7** | **135.2** | **126.6** |
| Hungary | 57.1 | 65.3 | 66.7 | 78.4 | 81.2 | 80.5 | 72.8 | 69.5 | 74.4 |
| Ireland | 41.1 | 24.7 | 34.2 | 56.6 | 79.3 | 102.0 | **67.0** | **61.6** | **59.3** |
| Italy | 107.9 | 102.0 | 101.8 | 111.3 | 115.4 | 116.4 | **133.1** | **115.6** | **109.4** |
| Latvia | 12.5 | 8.4 | 11.9 | 28.0 | 44.1 | 45.3 | 36.3 | 26.3 | 27.5 |
| Lithuania | 24.1 | 15.8 | 14.0 | 22.5 | 34.7 | 36.7 | 35.1 | 28.6 | 24.7 |
| Luxembourg | 7.2 | 7.8 | 9.9 | 15.3 | 19.3 | 19.2 | 21.9 | 14.7 | 14.3 |
| Malta | 58.8 | 62.6 | 61.8 | 65.8 | 67.7 | 68.8 | 47.7 | 64.0 | 65.3 |
| Netherlands | 55.9 | 44.6 | 46.6 | 57.0 | 58.8 | 60.7 | 53.6 | 56.0 | 53.5 |
| Poland | 38.6 | 45.1 | 43.5 | 48.6 | 52.4 | 54.1 | 50.0 | 48.1 | 48.7 |
| Portugal | 51.0 | 67.6 | 69.4 | 79.7 | 91.5 | 107.9 | **124.2** | **90.6** | **83.2** |
| Romania | 22.4 | 12.0 | 11.3 | 18.1 | 27.1 | 32.6 | 34.5 | 26.5 | 20.2 |
| Slovakia | 49.6 | 30.4 | 27.2 | 33.7 | 39.1 | 43.2 | 50.8 | 44.2 | 34.7 |
| Slovenia | 25.1 | 24.7 | 22.5 | 31.0 | 37.9 | 45.2 | 72.3 | 44.8 | 32.2 |
| Spain | 58.8 | 37.4 | 36.5 | 47.8 | 57.1 | 66.5 | **98.1** | **66.3** | **49.1** |
| Sweden | 53.1 | 40.2 | 36.6 | 38.2 | 38.5 | 36.6 | 38.5 | 43.3 | 38.0 |
| UK | 37.5 | 40.9 | 44.5 | 58.1 | 72.7 | 78.7 | 86.2 | 60.6 | 59.0 |

**Source:** Евростат (Eurostat, 2019).

## 3. Seasonality test of the empirical data

The presence of seasonality can most easily be determined by an analysis of the correlograms of the examined data. Figure 1 shows the correlogram of Portugal's Debt/GDP ratio data. The autocorrelation coefficients (ACF) for the twenty-four studied lags do not suggest seasonality. As each lag represents a separate observation and in this case the data are on a quarterly basis, i.e. each lag is equal to three months, the lags from 1 to 4 form one year. Seasonality is a component of the time series that implies a repeated change on

an annual basis, which is not the case here. An example of seasonality are the peaks in sales of products consumed in warm weather (ice cream, sodas, etc.) during the summer months and the downturns in the winter. If these peaks and recessions have been repeated over the years, then we are talking about seasonality (Montgomery, Jennings, & Kulahci, 2008, p. 13).



| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | 0.981 | 0.981 | 75.989 | 0.000 |
| | | 2 | 0.957 | -0.110 | 149.38 | 0.000 |
| | | 3 | 0.932 | -0.044 | 219.94 | 0.000 |
| | | 4 | 0.904 | -0.098 | 287.18 | 0.000 |
| | | 5 | 0.872 | -0.082 | 350.68 | 0.000 |
| | | 6 | 0.837 | -0.083 | 410.05 | 0.000 |
| | | 7 | 0.801 | -0.048 | 465.11 | 0.000 |
| | | 8 | 0.763 | -0.023 | 515.86 | 0.000 |
| | | 9 | 0.723 | -0.072 | 562.09 | 0.000 |
| | | 10 | 0.681 | -0.047 | 603.74 | 0.000 |
| | | 11 | 0.639 | -0.020 | 640.94 | 0.000 |
| | | 12 | 0.597 | 0.012 | 673.98 | 0.000 |
| | | 13 | 0.556 | -0.022 | 703.02 | 0.000 |
| | | 14 | 0.512 | -0.083 | 728.04 | 0.000 |
| | | 15 | 0.468 | -0.000 | 749.34 | 0.000 |
| | | 16 | 0.424 | -0.064 | 767.06 | 0.000 |
| | | 17 | 0.378 | -0.050 | 781.42 | 0.000 |
| | | 18 | 0.332 | -0.044 | 792.67 | 0.000 |
| | | 19 | 0.287 | 0.012 | 801.24 | 0.000 |
| | | 20 | 0.242 | -0.051 | 807.42 | 0.000 |
| | | 21 | 0.197 | -0.006 | 811.62 | 0.000 |
| | | 22 | 0.153 | -0.030 | 814.19 | 0.000 |
| | | 23 | 0.110 | -0.018 | 815.55 | 0.000 |
| | | 24 | 0.068 | -0.011 | 816.07 | 0.000 |

*Figure 1.* ***Correlogram of Portugal's Debt/GDP ratio for the period 2000 – 2018 (24 lags)***

The correlograms of the other five economies (Italy, Spain, Greece, Cyprus, and Ireland) have a similar structure to that of Portugal. This is an evidence of a lack of seasonality in debt data as a percentage of GDP. Along with the autocorrelation coefficients (AFC), the partial autocorrelation study (PACF) can also provide seasonality information. The high value of the first lag and the sudden drop thereafter is a signal for the instability of the data.

The seasonality test applied to the set of historical values of the Debt/GDP indicator of the EU countries and the resulting correlograms for the six countries are a key stage in the process of analysing debt burdens and

forecasting future crises. The results obtained (in this case the lack of seasonality) allow us to move on to the next stage of the econometric research.

## 4. Stationarity test of the empirical data – *Augmented Dickey-Fuller Test*

Having determined whether there is seasonality in the empirical data, we have to test it for stationarity. An essential condition for using time series is that they should be stationary. The presence of non-stationarity in the series makes them difficult to model successfully and they must be made stationary through appropriate transformations (Костов, 2018, стр. 61-62).

Table 3 presents the results of the stationarity test. When analysing the results of the Augmented Dickey-Fuller test, it is important to compare the t-Statistics with the critical values of the given confidence interval. If the former has a greater absolute value than the latter, then the data is stationary. As with many other econometric tests, it is important here that the p-value, or Probability coefficient, to be significant, i.e. its value should be less than 5% (or 0.05).

If both conditions are fulfilled, then we reject the null hypothesis, which assumes the presence of Unit Root, or that the data is non-stationary, and we accept the alternative hypothesis. If one of the conditions is not fulfilled, then we need to modify the data using their first or second difference. When re-testing, we use the same stationarity criteria again.

The results from the test show that Ireland, Italy and Portugal are non-stationary, and we need to use their first differences. Only then the significance of p-value is achieved, and the values of t-Statistics exceed the critical values for the test. The values for Spain, Greece and Cyprus are non-stationary even after the first transformation, which imposes a second one. The second differences already show stationarity. Along with the things listed here, the ADF test examines the trend and the constant. The Exogenous column indicates that all six dynamic series show the presence of a constant.

The stationarity of a time series is a basic prerequisite for its successful modelling. Since it cannot be achieved by using the original data, which requires the use of their first or second differences. In other words, during the first stage of this procedure, the null hypothesis cannot be rejected until the next differences of the selected values are checked. Only then could the null hypothesis be rejected and its alternative accepted.

*Table 3*

***Stationarity test results***

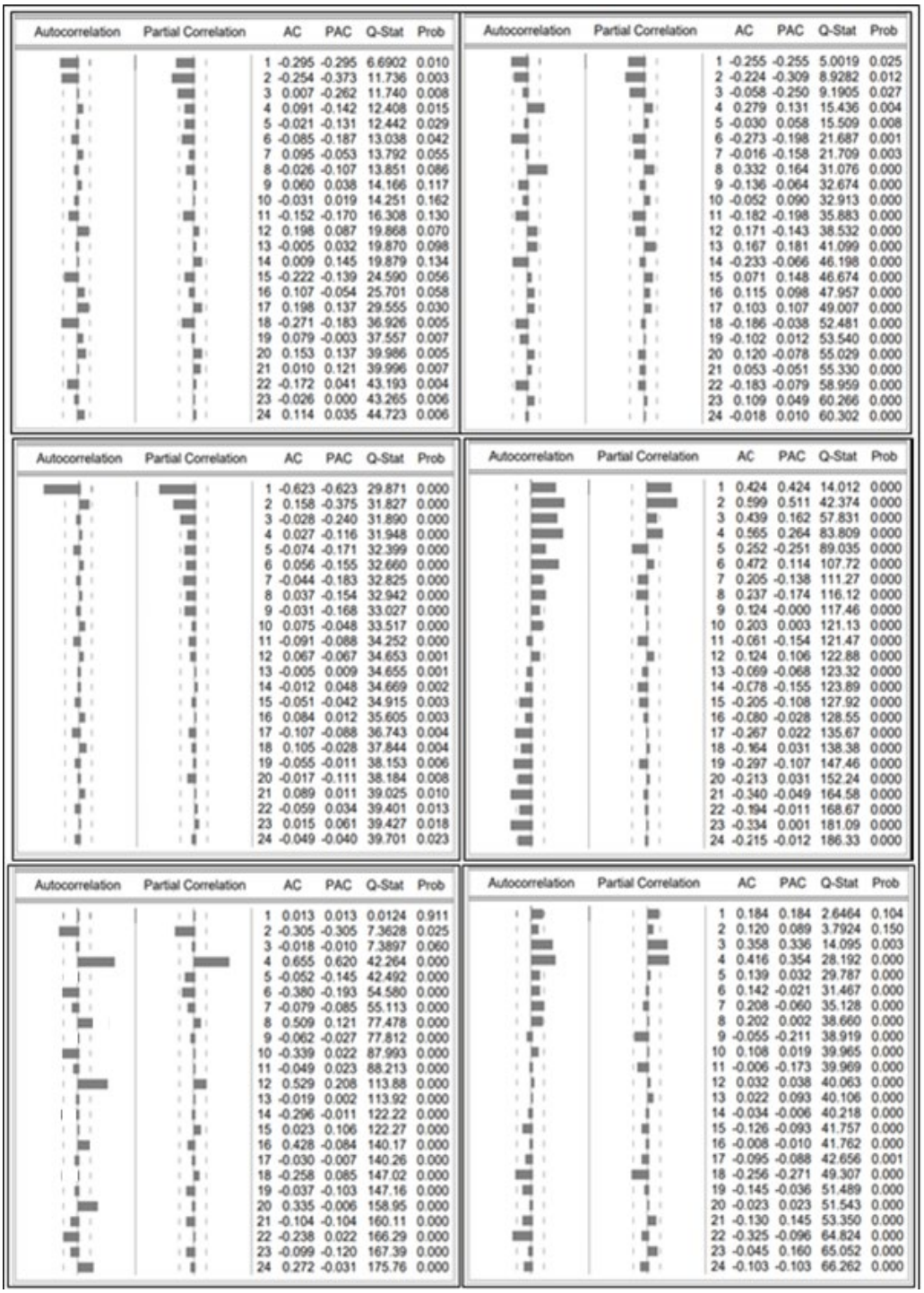
| Augmented Dickey-Fuller Unit Root Test (ADF) | | | | | |
|---|---|---|---|---|---|
| **Country** | **Level of Integration** | **Test critical values (5%)** | **t-Statistic** | **Probability** | **Exogenous** |
| Spain | 2nd Difference | -2.9029 | -7.8109 | 0.0013 | Constant |
| Cyprus | 2nd Difference | -2.9013 | -7.0387 | 0.0084 | Constant |
| Greece | 2nd Difference | -2.9087 | -10.4628 | 0.0001 | Constant |
| Ireland | 1st Difference | -2.9036 | -4.6394 | 0.0003 | Constant |
| Italy | 1st Difference | -2.9042 | -3.1510 | 0.0274 | Constant |
| Portugal | 1st Difference | -2.9030 | -10.8051 | 0.0001 | Constant |

## 5. Selection of appropriate values of the AR and MA coefficient

Time series that change over time (non-stationary) can create a forecast problem. Most of the statistical theories require the time series be stationary (fixed). The standard solution to this problem is to build a model of the first differences of the variable instead of modelling it directly. Given such a differentiated model, then we need to "integrate" the first differences in order to recover the levels. Then we get the ARMA model of the first differences, or the so-called ARIMA model (Startz, 2015, pp. 335-336).

In order to construct an autoregressive model with a moving average, or the AutoRegressive Integrated Moving Average (ARIMA), we need to determine the three variables that define the model - p, d, and q. These coefficients correspond to the three main parts of the model - AR, I and MA. AR(p) shows the autocorrelation component in the model, i.e. it allows the use of previous values. MA(q) is the component of the moving averages, which allows us to set the error of our model as a linear combination of the error values observed in previous moments from the past. The third component - I (d) symbolizes the number of non-seasonal differences required to reach stationarity.

Figure 2 shows the correlograms of the differences of the six studied countries. Cyprus, Greece and Italy are represented in the left column from above the top downwards, and Spain, Ireland and Portugal in the right. In order to determine the values of AR and MA first it is necessary to define the possible combinations. Knowing that Cyprus, Spain and Greece are integrated from second level, i.e. we use their second differences, this automatically means that component I (d) is equal to 2. We will determine the values for the other two components based on the lags that cross the confidence line (95%) of the correlograms.



| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | -0.295 | -0.295 | 6.6902 | 0.010 |
| | | 2 | -0.254 | -0.373 | 11.736 | 0.003 |
| | | 3 | 0.007 | -0.262 | 11.740 | 0.008 |
| | | 4 | 0.091 | -0.142 | 12.408 | 0.015 |
| | | 5 | -0.021 | -0.131 | 12.442 | 0.029 |
| | | 6 | -0.085 | -0.187 | 13.038 | 0.042 |
| | | 7 | 0.095 | -0.053 | 13.792 | 0.055 |
| | | 8 | -0.026 | -0.107 | 13.851 | 0.086 |
| | | 9 | 0.060 | 0.038 | 14.166 | 0.117 |
| | | 10 | -0.031 | 0.019 | 14.251 | 0.162 |
| | | 11 | -0.152 | -0.170 | 16.308 | 0.130 |
| | | 12 | 0.198 | 0.087 | 19.868 | 0.070 |
| | | 13 | -0.005 | 0.032 | 19.870 | 0.098 |
| | | 14 | 0.009 | 0.145 | 19.879 | 0.134 |
| | | 15 | -0.222 | -0.139 | 24.590 | 0.056 |
| | | 16 | 0.107 | -0.054 | 25.701 | 0.058 |
| | | 17 | 0.198 | 0.137 | 29.555 | 0.030 |
| | | 18 | -0.271 | -0.183 | 36.926 | 0.005 |
| | | 19 | 0.079 | -0.003 | 37.557 | 0.007 |
| | | 20 | 0.153 | 0.137 | 39.986 | 0.005 |
| | | 21 | 0.010 | 0.121 | 39.996 | 0.007 |
| | | 22 | -0.172 | 0.041 | 43.193 | 0.004 |
| | | 23 | -0.026 | 0.000 | 43.265 | 0.006 |
| | | 24 | 0.114 | 0.035 | 44.723 | 0.006 |

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | -0.255 | -0.255 | 5.0019 | 0.025 |
| | | 2 | -0.224 | -0.309 | 8.9282 | 0.012 |
| | | 3 | -0.058 | -0.250 | 9.1905 | 0.027 |
| | | 4 | 0.279 | 0.131 | 15.436 | 0.004 |
| | | 5 | -0.030 | 0.058 | 15.509 | 0.008 |
| | | 6 | -0.273 | -0.198 | 21.687 | 0.001 |
| | | 7 | -0.016 | -0.158 | 21.709 | 0.003 |
| | | 8 | 0.332 | 0.164 | 31.076 | 0.000 |
| | | 9 | -0.136 | -0.064 | 32.674 | 0.000 |
| | | 10 | -0.052 | 0.090 | 32.913 | 0.000 |
| | | 11 | -0.182 | -0.198 | 35.883 | 0.000 |
| | | 12 | 0.171 | -0.143 | 38.532 | 0.000 |
| | | 13 | 0.167 | 0.181 | 41.099 | 0.000 |
| | | 14 | -0.233 | -0.066 | 46.198 | 0.000 |
| | | 15 | 0.071 | 0.148 | 46.674 | 0.000 |
| | | 16 | 0.115 | 0.098 | 47.957 | 0.000 |
| | | 17 | 0.103 | 0.107 | 49.007 | 0.000 |
| | | 18 | -0.186 | -0.038 | 52.481 | 0.000 |
| | | 19 | -0.102 | 0.012 | 53.540 | 0.000 |
| | | 20 | 0.120 | -0.078 | 55.029 | 0.000 |
| | | 21 | 0.053 | -0.051 | 55.330 | 0.000 |
| | | 22 | -0.183 | -0.079 | 58.959 | 0.000 |
| | | 23 | 0.109 | 0.049 | 60.266 | 0.000 |
| | | 24 | -0.018 | 0.010 | 60.302 | 0.000 |

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | -0.623 | -0.623 | 29.871 | 0.000 |
| | | 2 | 0.158 | -0.375 | 31.827 | 0.000 |
| | | 3 | -0.028 | -0.240 | 31.890 | 0.000 |
| | | 4 | 0.027 | -0.116 | 31.948 | 0.000 |
| | | 5 | -0.074 | -0.171 | 32.399 | 0.000 |
| | | 6 | 0.056 | -0.155 | 32.660 | 0.000 |
| | | 7 | -0.044 | -0.183 | 32.825 | 0.000 |
| | | 8 | 0.037 | -0.154 | 32.942 | 0.000 |
| | | 9 | -0.031 | -0.168 | 33.027 | 0.000 |
| | | 10 | 0.075 | -0.048 | 33.517 | 0.000 |
| | | 11 | -0.091 | -0.088 | 34.252 | 0.000 |
| | | 12 | 0.067 | -0.067 | 34.653 | 0.001 |
| | | 13 | -0.005 | 0.009 | 34.655 | 0.001 |
| | | 14 | -0.012 | 0.048 | 34.669 | 0.002 |
| | | 15 | -0.051 | -0.042 | 34.915 | 0.003 |
| | | 16 | 0.084 | 0.012 | 35.605 | 0.003 |
| | | 17 | -0.107 | -0.088 | 36.743 | 0.004 |
| | | 18 | 0.105 | -0.028 | 37.844 | 0.004 |
| | | 19 | -0.055 | -0.011 | 38.153 | 0.006 |
| | | 20 | -0.017 | -0.111 | 38.184 | 0.008 |
| | | 21 | 0.089 | 0.011 | 39.025 | 0.010 |
| | | 22 | -0.059 | 0.034 | 39.401 | 0.013 |
| | | 23 | 0.015 | 0.061 | 39.427 | 0.018 |
| | | 24 | -0.049 | -0.040 | 39.701 | 0.023 |

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | 0.424 | 0.424 | 14.012 | 0.000 |
| | | 2 | 0.599 | 0.511 | 42.374 | 0.000 |
| | | 3 | 0.439 | 0.162 | 57.831 | 0.000 |
| | | 4 | 0.565 | 0.264 | 83.809 | 0.000 |
| | | 5 | 0.252 | -0.251 | 89.035 | 0.000 |
| | | 6 | 0.472 | 0.114 | 107.72 | 0.000 |
| | | 7 | 0.205 | -0.138 | 111.27 | 0.000 |
| | | 8 | 0.237 | -0.174 | 116.12 | 0.000 |
| | | 9 | 0.124 | -0.000 | 117.46 | 0.000 |
| | | 10 | 0.203 | 0.003 | 121.13 | 0.000 |
| | | 11 | -0.061 | -0.154 | 121.47 | 0.000 |
| | | 12 | 0.124 | 0.106 | 122.88 | 0.000 |
| | | 13 | -0.069 | -0.068 | 123.32 | 0.000 |
| | | 14 | -0.078 | -0.155 | 123.89 | 0.000 |
| | | 15 | -0.205 | -0.108 | 127.92 | 0.000 |
| | | 16 | -0.080 | -0.028 | 128.55 | 0.000 |
| | | 17 | -0.267 | 0.022 | 135.67 | 0.000 |
| | | 18 | -0.164 | 0.031 | 138.38 | 0.000 |
| | | 19 | -0.297 | -0.107 | 147.46 | 0.000 |
| | | 20 | -0.213 | 0.031 | 152.24 | 0.000 |
| | | 21 | -0.340 | -0.049 | 164.58 | 0.000 |
| | | 22 | -0.194 | -0.011 | 168.67 | 0.000 |
| | | 23 | -0.334 | 0.001 | 181.09 | 0.000 |
| | | 24 | -0.215 | -0.012 | 186.33 | 0.000 |

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | 0.013 | 0.013 | 0.0124 | 0.911 |
| | | 2 | -0.305 | -0.305 | 7.3628 | 0.025 |
| | | 3 | -0.018 | -0.010 | 7.3897 | 0.060 |
| | | 4 | 0.655 | 0.620 | 42.264 | 0.000 |
| | | 5 | -0.052 | -0.145 | 42.492 | 0.000 |
| | | 6 | -0.380 | -0.193 | 54.580 | 0.000 |
| | | 7 | -0.079 | -0.085 | 55.113 | 0.000 |
| | | 8 | 0.509 | 0.121 | 77.478 | 0.000 |
| | | 9 | -0.062 | -0.027 | 77.812 | 0.000 |
| | | 10 | -0.339 | 0.022 | 87.993 | 0.000 |
| | | 11 | -0.049 | 0.023 | 88.213 | 0.000 |
| | | 12 | 0.529 | 0.208 | 113.88 | 0.000 |
| | | 13 | -0.019 | 0.002 | 113.92 | 0.000 |
| | | 14 | -0.296 | -0.011 | 122.22 | 0.000 |
| | | 15 | 0.023 | 0.106 | 122.27 | 0.000 |
| | | 16 | 0.428 | -0.084 | 140.17 | 0.000 |
| | | 17 | -0.030 | -0.007 | 140.26 | 0.000 |
| | | 18 | -0.258 | 0.085 | 147.02 | 0.000 |
| | | 19 | -0.037 | -0.103 | 147.16 | 0.000 |
| | | 20 | 0.335 | -0.006 | 158.95 | 0.000 |
| | | 21 | -0.104 | -0.104 | 160.11 | 0.000 |
| | | 22 | -0.238 | 0.022 | 166.29 | 0.000 |
| | | 23 | -0.099 | -0.120 | 167.39 | 0.000 |
| | | 24 | 0.272 | -0.031 | 175.76 | 0.000 |

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | 0.184 | 0.184 | 2.6464 | 0.104 |
| | | 2 | 0.120 | 0.089 | 3.7924 | 0.150 |
| | | 3 | 0.358 | 0.336 | 14.095 | 0.003 |
| | | 4 | 0.416 | 0.354 | 28.192 | 0.000 |
| | | 5 | 0.139 | 0.032 | 29.787 | 0.000 |
| | | 6 | 0.142 | -0.021 | 31.467 | 0.000 |
| | | 7 | 0.208 | -0.060 | 35.128 | 0.000 |
| | | 8 | 0.202 | 0.002 | 38.660 | 0.000 |
| | | 9 | -0.055 | -0.211 | 38.919 | 0.000 |
| | | 10 | 0.108 | 0.019 | 39.965 | 0.000 |
| | | 11 | -0.006 | -0.173 | 39.969 | 0.000 |
| | | 12 | 0.032 | 0.038 | 40.063 | 0.000 |
| | | 13 | 0.022 | 0.093 | 40.106 | 0.000 |
| | | 14 | -0.034 | -0.006 | 40.218 | 0.000 |
| | | 15 | -0.126 | -0.093 | 41.757 | 0.000 |
| | | 16 | -0.008 | -0.010 | 41.762 | 0.000 |
| | | 17 | -0.095 | -0.088 | 42.656 | 0.001 |
| | | 18 | -0.256 | -0.271 | 49.307 | 0.000 |
| | | 19 | -0.145 | -0.036 | 51.489 | 0.000 |
| | | 20 | -0.023 | 0.023 | 51.543 | 0.000 |
| | | 21 | -0.130 | 0.145 | 53.350 | 0.000 |
| | | 22 | -0.325 | -0.096 | 64.824 | 0.000 |
| | | 23 | -0.045 | 0.160 | 65.052 | 0.000 |
| | | 24 | -0.103 | -0.103 | 66.262 | 0.000 |

*Figure 2.* ***Correlograms of the differences for the data of Spain, Cyprus, Greece, Ireland, Italy and Portugal***

In the first correlogram in left column (Cyprus), lag 1, lag 2, lag 3 and lag 18 intersect the dashed line, which means that AR and MA will take one of these values. Below it (Greece), the values are 1, 2 and 3. In the last correlogram from the left column (Italy), the values are 1 and 2. In the left column - Spain, Ireland and Portugal, the values that AR and MA can take are respectively 1, 2, 4 and 13 for Spain, 1, 2, 3, 4, and 6 for Ireland and 3, 4, 18 and 22 for Portugal. Based on the values obtained in the next stage of the model, the variants of the different ARIMA models are prepared and the most appropriate one is selected based on different criteria.

Overall, the selection of appropriate values for the coefficients p (AR), I and q (MA) is essential for the correct construction of the ARIMA model and is based on the previously prepared correlograms for each of the six countries. Thus, the lags exceeding the 95% confidence line are detected and the related values are used to compile variants of the model, between which a choice is subsequently made.

## 6. Analysis of all possible ARIMA models based on the AR and AM coefficients obtained and selection of the most suitable model

Based on the possible AR and MA coefficients obtained in the previous test, all possible ARIMA models are prepared, striving to comply with the "Parsimony principle", which states that model selection methods should value both descriptive accuracy and simplicity (Vandekerckhove, Matzke, & Wagenmakers, 2015).

Table 4 summarizes the test results for selecting the most appropriate ARIMA model. After playing out all the possible options to choose the most suitable one for each country, the obtained results are compared. The important criteria in this case are:

- P-value of AR and MA – it should be below 5% or 0.05 to be significant;
- Sigmasq (volatility) – the lower the value, the more appropriate the model;
- Adjusted R-squared (corrected coefficient of determination) – the higher the value, the better;
- Akaike info и Schwarz info criteria – lower values are more appropriate.

These criteria ensue the correct selection of both the coefficients p and q and the variant of the model for each individual country.

*Table 4*

**Results from the test for selecting the most appropriate ARIMA model**

| ARIMA Models Fitting | | | | | |
|---|---|---|---|---|---|
| **Country** | **Models (AR,I,MA)** | **Best Fit** | **Country** | **Models (AR,I,MA)** | **Best Fit** |
| **Spain** | (1,2,1) | **(2,2,1)** | **Ireland** | (1,1,1) | **(2,1,2)** |
| | (1,2,2) | | | (1,1,2) | |
| | (2,2,1) | | | (2,1,1) | |
| **+AR(13)** | (2,13,2,1) | **(2,2,1,13)** | | (2,1,2) | |
| **+MA(13)** | (2,2,1,13) | | **+AR(3)** | (2,3,1,2) | **(2,1,2,3)** |
| **Portugal** | (3,1,3) | **(4,1,3)** | **+MA(3)** | (2,1,2,3) | |
| | (3,1,4) | | **Greece** | (1,2,1) | **(1,2,2)** |
| | (4,1,3) | | | (2,2,1) | |
| | (4,1,4) | | | (1,2,2) | |
| **Italy** | (2,1,2) | **(4,1,4)** | | (2,2,2) | |
| | (2,1,4) | | **Cyprus** | (1,2,1) | **(2,2,1)** |
| | (4,1,2) | | | (1,2,2) | |
| | (4,1,4) | | | (2,2,1) | |
| | | | | (2,2,2) | |

## 7. Model testing – a correlogram of the residuals

Based on the listed criteria, an assessment of the possible data models for each of the surveyed economies is made. In Figure 3 we can see that in Spain and Ireland it is necessary to add an additional factor of AR and MA. This is due to the residual information after the residual correlogram.

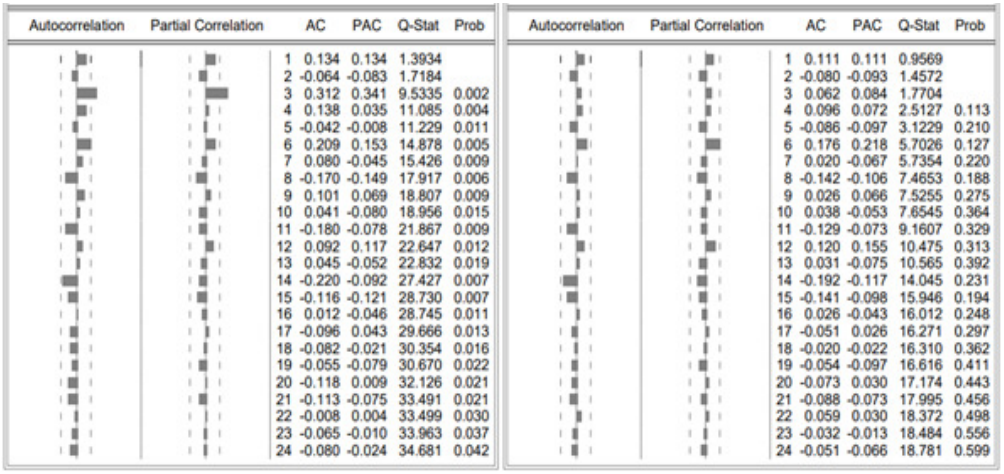



*Figure 3.* ***Resudual information test***

The left side of Figure 3 shows the correlogram of the residuals of the ARIMA model (2,1,2), which was initially selected as the best of the four. However, one of the lags, lag 3, goes beyond the 95% confidence interval which means that it must also be included in the model. The two new models - ARIMA (2,3,1,2) and ARIMA (2,1,2,3) are tested according to the criteria of the previous paragraph and the second one was selected as the most suitable.

The last test to be done is related to the residual correlogram of the new ARIMA (2,1,2,3) model. The figure to the right shows the correlogram of Ireland's most appropriate Debt/GDP ratio data.

Clearly, sometimes an additional coefficient of AR and MA is needed due to residual information obtained from the correlogram of the residues. This ensures that the most accurate version of ARIMA is chosen correctly in order to achieve greater accuracy in forecasting future changes in debt levels, especially in Spain and Ireland.

## 8. Forecasting future debt values for the selected countries

The final stage of the preparation of debt forecast data for the six selected EU member states is to make the following forecasts shown in Figure 4:

- The forecast for Greece's sovereign debt shows a strong upward trend. Based on ARIMA, the outlook for Greece is not optimistic at all. The Debt/GDP indicator is expected to reach 200% by 2021, and even at the end of the forecast (2023) it is approaching 220%;

- The forecast for Ireland is exactly opposite of that for Greece. Strong downward trend, with levels approaching 0% Debt / GDP at the end of the forecast period;

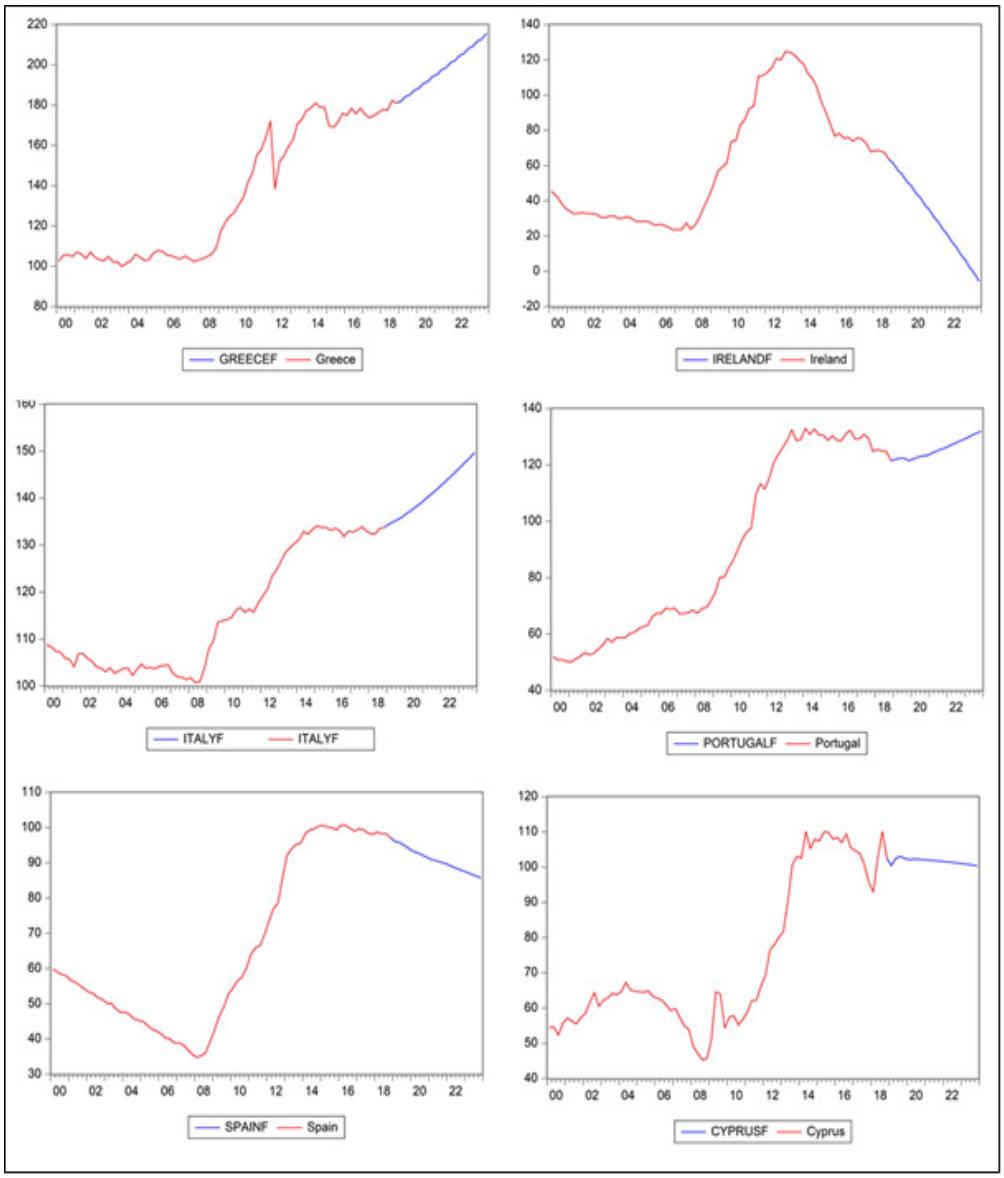



*Figure 4.* ***Graphical representation of the forecasts for the Debt/GDP indicator from the beginning of 2019 to the end of 2023.***

- The outlook for Italy is negative as well. Italy's debt will continue to grow, reaching almost 150% of GDP by 2023;
- Portugal's forecast shows a return to debt levels from 2011-2012, which is also not good news for the country;
- Spain's outlook is positive, with a minor sustained debt reduction to around 85% in 2023;
- The forecast for Cyprus is that the country will continue to maintain high levels of the Debt / GDP ratio. At the end of the forecast debt is about 100% of GDP.

These forecasts clearly show that that only in Ireland and Spain can expect a positive development of their Debt/GDP ratios. The level of indebtedness of the other four countries (Greece, Italy, Portugal and Cyprus) is expected to grow with varying rates, taking into account only the historical data on the levels of the selected indicator and disregarding other variables (such as social and economic shocks), which at the time of making the forecast are extremely difficult to predict.

## IV. CONCLUSION

In conclusion, econometric models such as ARIMA can be very useful in forecasting future levels of country-relevant indicators. Having sufficient and complete historical data and building the model correctly is vital to forecasting. If the modelling steps are followed and deviations from the algorithm are not allowed, it is possible to predict with approximate accuracy, if not certain values, at least the general trend of development of a certain variable.

Since the onset of the Global Financial Crisis and, subsequently, the European Debt Crisis, many authors have focused their efforts on exploring the causes of the emergence of both. For many of them the main causes are the existing debt financing model and the inappropriate national fiscal policies. Others blame the high level of indebtedness in the private sector, where debt levels are even higher than government debt. Despite the varying opinions and research findings, it is still difficult to be 100 percent certain what exactly is the cause of the high debt burden and find a solution to prevent such shocks in the future.

Indeed, it is difficult to accurately predict the future values of economic indicators, even if we rely on the many studies in this field and the huge amount of data that continues to expand its spectrum to this day. But this does not mean that a forecast that is known to accurately give at least the direction of movement of an indicator in the future is extremely valuable and important for

the economic governance of the countries despite the fact that we cannot predict all possible shocks.

These constraints are fully applicable to this study as well. To some extent, the Debt/GDP forecast for the six economies surveyed may indicate the direction of its future development, but we cannot predict the future events that may alter it. However, based on the six projections, we can say that Europe's future in terms of sovereign debt is at least uncertain. With the current levels of indebtedness in many European countries, a possible unforeseen future turmoil can quickly trigger a new crisis, which may entail various adverse economic and social events.

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