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Modeling the Unemployment Rate at the Eu Level by using Box-Jenkins Methodology

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Abstract

Unemployment, as a measure of market conditions, appears as a crucial economic problem and a phenomenon with considerable negative social consequences, and, as such, requires attention and adequate approach to finding solutions. Enormous unemployment rates are a reality not only in developing and transition countries, but also in some developed countries. Inadequately conducted privatization, unsuccessful transfer of workers from the public to the private sector, inefficiency in attracting foreign direct investment, and the world economic crisis of 2008 have made unemployment a universal disease of modern society. The paper presents economic models in which the unemployment rate is the central analyzed phenomenon. In this context, an important task of European economic policy-makers is to project future unemployment rates. *Box-Jenkins* methodology, i.e. the seasonal ARIMA model, is one approach to the modeling of time series, or, more specifically, for forecasting future values. The subject of this paper is the analysis of the evolution of the unemployment problem on the basis of the values in the period from 2000 to 2015, based on the case of 28 countries of the European Union. Building on the research subject, the purpose of the paper is to create the statistical model for forecasting the values of the monthly unemployment rates in the European Union for the future and establishing its trend.

Keywords: Unemployment, labor market, *Box-Jenkins* methodology, the European Union

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1. Introduction

Unemployment is often seen as a central phenomenon in numerous strategic documents adopted at national or supranational level. The task of economic policy-makers is to recognize the problem of unemployment and define appropriate measures in order to overcome it. A key prerequisite for achieving effective employment policy is an integrated approach to the management of supply and demand factors, which significantly affect the situation on the labor market. Improving employability on the labor market supports further development of comprehensive and cross-sectoral public policies.

In complex business conditions, each national economy, large or small, developed or developing, tends towards full employment. In less developed countries of Europe, the key indicators of the labor market are much poorer, compared to developed countries. Constantly growing problems on the labor markets of most national economies

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are: high unemployment, the emergence of long-term unemployment, and numerous structural mismatches.

Some of the key problems and challenges in the field of employment are: high youth inactivity and unemployment, lack of systemic and continuous cooperation between interested parties, poor coordination among participants on the labor market, implementation of employment policy that is insufficiently based on data, lack of comprehensive and cross-sectoral public policies which include the strengthening of links between the system of education/training and employment, and so on. Particularly worrying is the long-term unemployment, which means looking for job for more than a year. The consequence of these trends is the decreased probability of employment in proportion to the length of unemployment. Strengthening institutional capacities may result in the efficient resolution of previously identified problem. In this regard, it should be borne in mind that there is no universal model for solving the unemployment problem that could be effectively applied in all countries.

Comparison of the labor markets in the group of 28 European countries will point to the main characteristics of the labor market over the last 15 years. Analysis of changes will help in identifying trends in the labor movement and in creating a model of dynamic approach to unemployment, to be used for forecasting labor market trends in the coming period.

2. Overview of Literature

The market economy model implies the establishment and functioning of an integrated market, which, in addition to the market of goods, services, and capital, includes the labor market. The slow recovery of the economy and the absence of economic growth lead to a gap between demand for labor and the needs for new jobs, i.e. employment opportunities. Economic theory states the neoclassical model and the model of imperfect competition as the two basic models of labor market functioning. The first model assumes that the labor market is perfectly competitive, i.e. that the price of labor is freely determined depending on supply and demand for labor, which is a necessary condition for achieving balance. However, on the labor market, equilibrium is achieved with a certain unemployment rate, i.e. voluntary or natural unemployment rate. The model of imperfect competition is closer to actual practice with regard to the labor market being imperfect [?].

A large number of studies have examined whether inflation targeting monetary strategy has contributed to the problem of unemployment, through the reduction of potential output, as well as the issue of empirical testing of key theoretical concepts of Okun's law and the Phillips curve. These concepts explain the relations between gross domestic product (GDP), unemployment, and inflation. Phillips curve reflects the high negative correlation between inflation and unemployment. The lower the unemployment rate of the country, the greater the rate of change in the wages of labor. Deviations from this theoretical approach have been more pronounced since

the 1970s, as a result of pronounced shocks on aggregate supply side (shocks in oil prices on the world market, growth in agricultural product prices at the global level, rapid growth of labor costs).

Unemployment, as the burning problem of modern economies, is inextricably linked with the problem of insufficient economic growth. In fact, it is widely accepted that high growth rates of gross domestic product increase employment and decrease unemployment. This is one of the strongest links in macroeconomic theory, also known as Okun's law. In 1962, Arthur Okun showed that changes in output by 3% were linked with inverse changes in unemployment rates by 1 percentage point. Okun's law implies that real output must grow as fast as the potential output, if it does not want to increase the unemployment rate [?]. According to the estimates of econometric analysis of the European Central Bank for the period 1996-2011, Okun's coefficient takes the value of -0.29% and shows that the decline in GDP by 1 percentage point at the same time leads to an increase in the unemployment rate by 0.3 percentage points. Empirical tests have shown that there are large deviations from Okun's law and Phillips curve during the crisis periods, but also that there are significant differences between countries [?].

The high level and the persistence of unemployment rate in Europe, especially after the first oil shock, was the motive behind a large number of theoretical and empirical studies focused on understanding unemployment. Economists suggest that the main macroeconomic disturbances, such as a slowdown in productivity, the rapid growth of oil prices in 1970, and shifts in global interest rates, could explain the rise and persistence of unemployment [?]. Phelps (1972) suggests that the natural unemployment rate cannot be unique, and that it moves along the path determined by the effect of negative shocks. This author explains the rise in European unemployment rate as adjusting the basic equilibrium unemployment rate, which increased from one to another period of time in response to structural factors in the economy. Most unemployment shocks are temporary with few but significant variations, leading to changes in the natural rate of unemployment.

Basile and Benedicts analyze the relationship between regional unemployment and labor productivity in Europe. Using semiparametric and dynamic panel data estimators, they give evidence of a nonlinear relationship between productivity and regional unemployment in Europe: with a level of productivity smaller than a certain threshold, this relationship is negative, while no relation occurs in the case of higher productivity regions. This evidence proves an important role of a wage-floor (induced by efficiency wages and exacerbated by institutional factors) under which the productivity gap cannot be compensated by a wage gap [?]. "Within the context of economic integration, unemployment is a key variable facilitating the adjustment process through macroeconomic equilibrium in the presence of large structural shocks, such as those associated with opening economies to trade at world prices. Employing a nonlinear logistic smooth transition autoregression system and comovement analysis, some authors find that the German business cycle has acted as a common driver affecting the cyclical behavior of unemployment rates in Central and Eastern European countries. In addition, they

identify convergence clubs in unemployment dynamics. The first comprises the Baltic States, Hungary, and Poland, and the second group of countries is composed of the Czech Republic and Slovakia. Interestingly, this classification matches the labor market policies and institutional divergences observed among these countries" [?].

It is clear that there is a long list of factors that determine the level of unemployment. One factor is certainly the lack of jobs, with the excess of labor supply over demand, producing insufficient employment. The level of the minimum wage can also have a substantial impact on the unemployment rate. Gorry notes that the increase in the minimum wage may cause an increase in the unemployment rate for workers with secondary education between 15 and 24 years of age by 2.8 percentage points [?]. Fiscal and overall macroeconomic policies of the country are responsible for the formation of the general labor market conditions. Regulations governing the market indirectly determine labor demand and supply. Increased production of goods and services in the economy creates a greater need for labor in production, *ceteris paribus*. In this regard, stimulating or non-stimulating tax system also plays a role in the functioning of the companies, and thus indirectly creates or diminishes the need for labor [?].

As regards the categories of the unemployed, empirical and theoretical studies record negative trends, particularly in the framework of the unemployment of young people. This issue took on considerable dimensions after the global economic crisis in 2008. According to the International Labor Organization, youth unemployment reached its highest point in 2009 [?]. Other studies have also shown that the crisis encourages youth unemployment, and that this effect on unemployment is stronger than the effect of crisis in general. The results indicate that the negative effects of the financial crisis on youth unemployment manifest themselves five years after the crisis, while the most negative effects manifest themselves in the second and third year [?].

The phenomenon of unemployment is indirectly associated with the phenomenon of self-employment, so that the relationship between these two variables is often the subject of economic debates. The origin of this debate has been associated with the so-called *refugee effect* that consists of two opposing hypotheses. According to the theory of revenue selection, with rising unemployment levels, it is expected that the level of self-employment also begins to rise. As far as the counter-arguments, increase in the level of unemployment leads to a depreciation of human capital and skills, which, in turn, further encourages unemployment. The first argument is known as "unemployment push", which states that high unemployment may reduce the possibility of finding well-paid jobs, which has positive effects on self-employment. The second hypothesis is known in the literature as "unemployment pull". It suggests that the unemployed tend to focus less on human capital and entrepreneurial talent, as significant factors for the initiation and maintenance of a new business [?].

Since unemployment is the macroeconomic indicator of utmost importance for the functioning of the economy as a whole, most of the countries continuously measure it and forecast it. In this regard, forecasting the unemployment rate stands out as one of the important tasks of economic policy-makers. Despite decades of research on this

topic, policy makers, when forecasting unemployment, often refer to Okun's curve and simple time series models, such as autoregressive moving average models.

Literature abounds in studies dealing with forecasting unemployment by using ARIMA models, i.e. Box-Jenkins methodology. In early 1980s, Ashenfelter and Card explored reciprocity of problems of unemployment, nominal wages, consumer prices and the nominal interest rate, by using autoregressive moving average model [?]. This model was used to overcome the simultaneous problems of high rates of inflation and unemployment, which was, in early 1970s, a new phenomenon that sparked the attention of theoreticians and practitioners. Nlandu, De'nelle and Rudolph looked for the best approach to forecasting unemployment in Barbados, using the criteria of accuracy in forecasting, root mean square error (RMSE), mean absolute percentage error (MAPE), and Theil's inequality coefficient (U-STATISTICS). The used competitive models included seasonal autoregressive integrated moving average (SARIMA) model, basic structural time series (BSTS), and general structural time series (GSTS) model. The obtained results of the comparison of the mentioned models for forecasting unemployment suggest that SARIMA model gives the best results when forecasting unemployment, especially in the long term, which is why this model is recommended for creating policies to fight unemployment [?]. Gagea and Balan (2008) also dealt with forecasting the unemployment rate in the European Union using the Box-Jenkins methodology.

Following the case of inflation, unemployment, exchange rates, and gross domestic product, Bratu compared the accuracy of the forecasts provided by the Institute of Economic Forecasting and National Prognosis Commission of Romania with forecasts provided by the analysis of time series based on ARIMA methodology. It was found that only in respect of unemployment rate, the combined forecast gives better results in relation to the use of initial forecasts obtained by these institutions [?]. This and many other studies show the importance of the practical use of ARIMA models, i.e. Box-Jenkins methodology, in forecasting the unemployment rate.

3. Methodology

The subject of analysis in this paper is the evolution of the unemployment problem on the basis of the values in the period from 2000 to 2015, with reference to 28 countries of the European Union. Building on the research subject, the purpose of the paper is to create statistical model for forecasting the value of the monthly unemployment rate in the European Union for the future and establishing its trend. In other words, the model chosen as the most favorable should point to the unemployment rate at the EU level that should be expected in the next six months, based on actual values in the period January 2000 – December 2015. On the basis of the phenomenon that will be examined, the following hypothesis is set:

The overall unemployment rate in the European Union will have a downward trend in the first half of 2016.

Information base of research will consist of data provided by the Statistical Office of the European Union – Eurostat on the unemployment rate in the selected European group during the analyzed period. Given that the selected data makes the time series, the statistical models that can describe the principles in the behavior of time series and forecast future trends based on the known past situation will be used. The work will rely on the seasonal ARIMA model (SARIMA).

Special emphasis is on the Box-Jenkins methodology for forecasting the unemployment rate for the next six months (January 2016 – June 2016). Box-Jenkins methodology is a powerful method of determination of mathematical models of different stochastic variables. In essence, it is a methodology of systematic multi-phase modeling for the identification and estimation of models that include and combine autoregressive (AR) and moving average (MA) models, with the aim of finding the best adjusted time series of original data and making forecasts. The main advantage of the Box-Jenkins methodology involves obtaining big empirical data for the analyzed time series using a small number of parameters. Further, it can be used for modeling stationary and non-stationary time series with and without seasonal component. The disadvantage of usage the Box-Jenkins methodology for modeling the unemployment rate in this paper is related to the period of forecast. Namely, the chosen forecast period of six months is relatively short. Although analysis, technically, can be conducted for longer forecast period, accuracy of forecast will be smaller in that case. Choosing forecast period of six months, we chose accuracy instead of forecast period length.

ARIMA model was developed in 1970 by Box and Jenkins for identifying, estimating, and diagnosing dynamic time series models in which time is a key variable. ARIMA model itself is used for modeling and forecasting of non-stationary time series, after the process of differentiation. Using the ARIMA model is limited to the long time series of "high frequency" (years, months, weeks, days...), is useful for short-term forecasting, but not for structural understanding of the phenomenon or simulation of scenarios.

Seasonal character of the time series is commonly found in economic studies where the number of time periods S repeats over time. In this case, $S = 12$, and represents the number of months. In order to solve the problem of seasonal character of the observed phenomenon, ARIMA process is generalized and SARIMA model formulated. Seasonal autoregressive integrated moving average (SARIMA) model is designed as a model that includes the trend, seasonal component, and short-time adjustment.

4. Results and Discussion

Modeling of future unemployment rates at the level of the European Union was performed by applying the seasonal ARIMA model. The model was derived from the standard Box and Jenkins model (1970), and includes both seasonal autoregressive factors

```
Null Hypothesis: UNEMPLOYMENT has a unit root
Exogenous: Constant
Lag Length: 2 (Automatic - based on SIC, maxlag=14)
```

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.838763	0.3609
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

*MacKinnon (1996) one-sided p-values.

Figure 1: ADF test for Unemployment. Source: Authors' presentation by using the EViews7 program.

and moving average factors in the modeling process. Seasonal ARIMA (SARIMA) models include non-seasonal and seasonal character factors in the multiplicative model, according to the following formula:

$ARIMA(p,d,q) \times (P,D,Q)_s$

where:

p – non-seasonal component of autoregressive model (AR),

d – non-seasonal differentiation,

q – non-seasonal component of moving average model (MA),

P – seasonal component of autoregressive model (AR),

Q – seasonal component of moving average model (MA),

S – number of periods during the year.

Box-Jenkins methodology was developed through three successive phases, (1) model identification, (2) model estimation, and (3) model diagnostics and forecasting. During the first phase of identification, stationarity of time series is checked, since the basic prerequisite when creating the ARIMA model is the stationary time series. This means that the observed time series must have constant variance and mean value in time.

Determining the stationarity of the original time series of the unemployment rate at the level of EU28 was performed through correlogram and the Augmented Dickey-Fuller Unit Root Test (ADF), which confirmed non-stationarity of the selected time series. The downward trend of the coefficient of autocorrelation and partial correlation after the first lag points to the non-stationarity of the selected time series. In respect of ADF tests, null and alternative hypotheses are set. The null hypothesis confirms the existence of unit roots, i.e. non-stationarity of time series. The obtained value of the ADF test statistic is -1.838763, and is less than the critical value at the error level of 5%, which confirms the null hypothesis and the existence of the non-stationary time series (Figure ??).

To achieve the necessary stationarity, transformation of time series was performed first, i.e. logarythming, followed by first-order differentiation. Stationarity is confirmed by correlogram and ADF test, whose value is 3.633493, which is greater than the value at 5% level, thus accepting the alternative hypothesis of the absence of unit root, i.e. stationarity of the selected time series (Figure ??).

```
Null Hypothesis: D(LOGUNEMPLOYMENT) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=14)
```

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.633493	0.0059
Test critical values:	1% level	-3.465014	
	5% level	-2.876677	
	10% level	-2.574917	

*MacKinnon (1996) one-sided p-values.

Figure 2: ADF test for Logunemployment. Source: Authors' presentation by using the EViews7 program.

Estimation phase is the second, most extensive phase in which the model is created, which will, after diagnostics, be reduced to a single model, to be used to forecast future values of the unemployment rate for the EU28. In order to obtain more efficient ARIMA model, special attention is paid to the selection of autoregressive variables (lags of the dependent variable) and moving average (lags of residual value). During the research, 100 models with different combinations of AR and MA variables were tested, where plots for filtering the season confirmed the existence of seasonal effect. According to the values of the Akaike and Schwarz tests, the most acceptable model was AR(2) SAR(12) MA(1) SMA(12), i.e. $(2,1,1)\times(12,1,12)_{12}$.

Diagnostics model is the stage for estimating the justifiability of accepting the model chosen on the basis of its compatibility with the basic data and predictive power. The first model estimation can be done on the basis of inverted AR and MA roots. When their values are less than one, such as in the case of the chosen model, it is confirmed that the model is stationary and invertible. Justification of the accepted model is also proven by the key parameters obtained during the model diagnostics phase – adjusted coefficient of determination (R^2=55.18%), the value of Durbin-Watson statistic (2.077), and significance of F statistic (0.000000).

According to residual correlogram, it is seen that the selected model has a value of Q statistic less than the critical value $\chi^2_{(0.05;33)}$(44,190 < 47,300) and that the level of significance (p value) is greater than 5%, indicating that there is no residual auto-correlation after the 36th lag and that there is no white noise in the data. Based on the histogram and Jarque-Bera test value, whose value should be less than the critical level with two degrees of freedom $\chi^2_{(0.05;2)}$(1,196 < 5,991), the normal distribution of residuals is confirmed (Figure ??).

Another indication in favor of the model is the heteroskedasticity test (White test), whose value (20.76180) is less than the critical value of $\chi^2_{(0.05;20)}$, which is 31,410. The assumption of homoscedasticity of the model variance is accepted (Figure ??).

In order to forecast future trends in the unemployment rate for the EU28, the original number of observations is modified in relation to the length of the forecast horizon. Given the tendency of forecasting the unemployment rate by June 2016, the following figure is obtained, which shows the current unemployment trends in red, while the blue part of the line on the figure refers to the future values of the observed variable (Figure 1).

```
Dependent Variable: D(LOGUNEMPLOYMENT)
Method: Least Squares
Date: 01/21/16   Time: 20:22
Sample (adjusted): 2001M04 2015M12
Included observations: 177 after adjustments
Failure to improve SSR after 6 iterations
MA Backcast: 2000M03 2001M03
```

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000313	0.000430	0.727962	0.4676
AR(2)	0.663375	0.060160	11.02680	0.0000
SAR(12)	0.379907	0.104509	3.635143	0.0004
MA(1)	0.278838	0.068302	4.082419	0.0001
SMA(12)	-0.775235	0.057335	-13.52106	0.0000

R-squared	0.561972	Mean dependent var		0.000110
Adjusted R-squared	0.551786	S.D. dependent var		0.004446
S.E. of regression	0.002977	Akaike info criterion		-8.768163
Sum squared resid	0.001524	Schwarz criterion		-8.678442
Log likelihood	780.9825	Hannan-Quinn criter.		-8.731776
F-statistic	55.16735	Durbin-Watson stat		2.077107
Prob(F-statistic)	0.000000			

Inverted AR Roots	.92	.81	.80+.46i	.80-.46i
	.46-.80i	.46+.80i	.00+.92i	-.00-.92i
	-.46-.80i	-.46+.80i	-.80-.46i	-.80+.46i
	-.81	-.92		
Inverted MA Roots	.98	.85+.49i	.85-.49i	.49-.85i
	.49+.85i	.00+.98i	-.00-.98i	-.28
	-.49-.85i	-.49+.85i	-.85-.49i	-.85+.49i
	-.98			

Figure 3: AR(2) SAR(12) MA(1) SMA(12) model statistics. Source: Authors' presentation by using the EViews7 program.
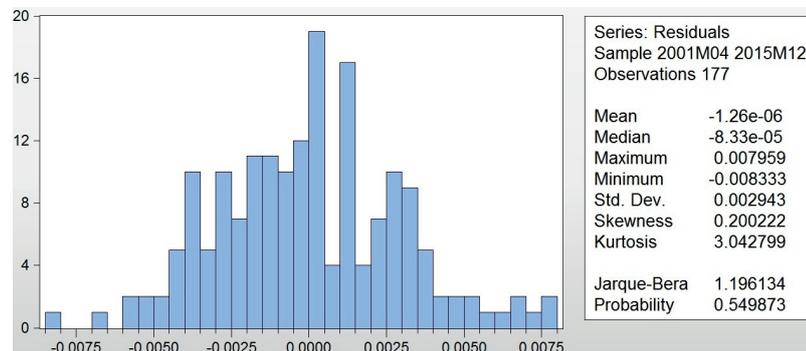
Figure 4: Model histogram. Source: Authors' presentation by using the EViews7 program.

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Heteroskedasticity Test: White
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F-statistic	1.036507	Prob. F(20,156)	0.4233
Obs*R-squared	20.76180	Prob. Chi-Square(20)	0.4113
Scaled explained SS	20.02155	Prob. Chi-Square(20)	0.4566

Figure 5: White test – model heteroskedasticity test. Source: Authors' presentation by using the EViews7 program.
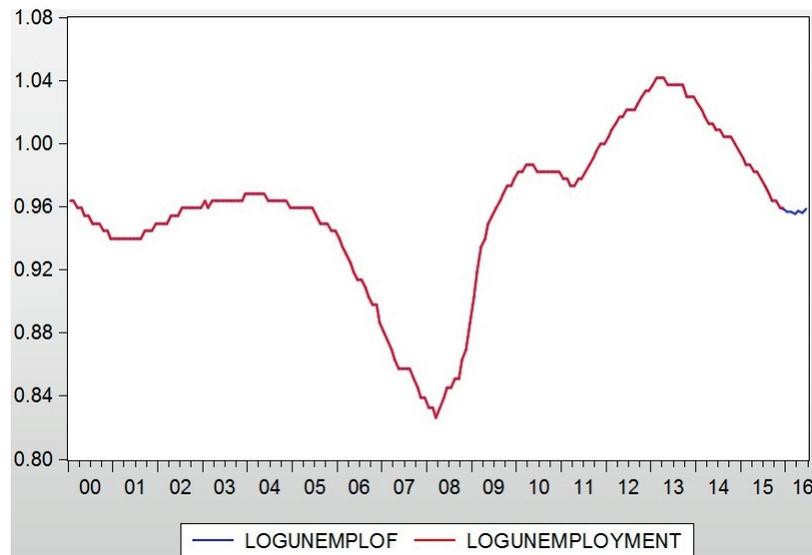
Figure 6: Unemployment rate trend at the European Union level in the period January 2000 – June 2016. Source: Authors' presentation by using the EViews7 program

Month/Year	Projected value
1.2016.	9,050
2.2016.	9,050
3.2016.	9,020
4.2016.	9,066
5.2016.	9,040
6.2016.	9,090

TABLE 1: Projected unemployment rates at the EU28 level for the period January 2016 – June 2016. Source: Authors' independent presentation.

The final figure of the unemployment rate in the European Union shows the actual and projected value for the selected analyzed time period. A drop in unemployment in the coming months can be noticed, compared with the achieved five-year monthly values of this economic phenomenon. Following the oscillatory trend in the unemployment rate in the European Union from 2000 to 2005, upward trend over the years can be observed, while in 2006 and 2007 there is a decrease in the unemployment rate. From March 2008, when the lowest unemployment rate in the European Union of 6.7% was achieved, onwards, there is an increase in the value with several extreme peaks (2010 and 2013).

The forecasted value of the unemployment rate in the EU28 for the coming months is given in Table 1. The expectation is that the unemployment rate in the future will decrease, due to the slow but steady improvement of conditions on the European Union labor market and the rise in economic activity. The unemployment rate is gradually declining, but the differences across member states still remain significant. The recovery of the economies, improving business trust, and expansive growth in earnings will lead to the creation of new jobs and higher employment [?].

The confirmation of results obtained in the developed SARIMA model on the basis of the available data on the unemployment rate in the EU member states is also provided by forecasts of the European Commission, according to which employment in 2016 should increase by 0.9%, while, in the long term, the unemployment rate in 2020 should be about 8.50% [?]. In addition, the speed of economic growth and job creation greatly contribute to reducing the unemployment rate, but it is still above pre-crisis levels.

5. Conclusion

Unemployment is the primary problem of most countries, both underdeveloped and developed countries in the world. It can be seen as the cause, but also as a consequence of the declining phase of the economic cycle. Generally speaking, unemployment is a phenomenon with a strong negative effect on the economy as a whole. Associated with opening economies and within the context of economic integration, unemployment is a key variable facilitating the adjustment process through macroeconomic equilibrium in the presence of large structural shocks. The slow recovery of the economy and the absence of economic growth lead to a gap between demand for labor and the need for new jobs, i.e. employment opportunities.

There is a large number of factors that directly or indirectly affect the unemployment rate. After examining the models in which unemployment is a central phenomenon, it can be concluded that the economies with inflexible labor market in the last 15 years face many difficulties while adapting to changes. The need to solve the unemployment problem stems from the spillover effects of unemployment, considering the existence of convergence clubs in unemployment dynamics.

In early 2000s, over 20 million people were unemployed in the EU28, corresponding to 9.2% of the total labor. During the years before the crisis, the unemployment rate was stagnant, with a pronounced peak in 2004. The rapid growth of this economic indicator of stability of the labor market was evident from the second quarter of 2008 until mid-2010, when it was thought to have achieved a record level of 9.7%. However, the most significant increase in the unemployment rate was typical for the period from mid-2011 until mid-2013, when, in some moments, the rate was as high as 11%. Since then, the unemployment rate has been characterized by declining values, and, based on forecasts, such a situation will continue during the first half of 2016. Reasons for the decrease in the unemployment rate are increasingly better conditions on the labor market, the increase in economic activity, a higher degree of coordination of economic activities with the real needs of society, business trust, as well as increased earnings.

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