"Economic modeling of the GDP gap in Ukraine and worldwide"

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ECONOMIC MODELING OF THE GDP GAP IN UKRAINE AND WORLDWIDE

Abstract

Actuality
The concept of output gap plays an important role in traditional macroeconomic theory, applied research and monetary policy.

Goal
The paper reveals analyses of the potential economic development in Ukraine and in some countries of the world under limited information. Thus, the practical goal is to consider the best modelling approach for the possibility to regulate GDP in Ukraine, as it has been experienced in other countries of the world.

Method
The research is realized with the help of economic-mathematical modelling of GDP gap based on the analysis of the production function, statistical methods of distinguishing the trend component, one-dimensional filtration, multidimensional filtration.

Results
Practical importance of the paper includes implementation of methods for estimating potential GDP and the GDP gap, in particular, the authors proposed to use an approach based on the production function for the potential growth of European countries modelling. The model reveals that for the Eurozone countries, in the short term, it is not expected that the economy will reach its potential level. The negative forecast is explained by the fact that the Eurozone has been severely affected by the debt crisis. There has been a significant increase in the gap in production volumes, which in turn led to deflation. Despite the uncertainty in the assessment of potential GDP and GDP gap for Ukraine the multidimensional method provided the best modelling result. Thus, it is disclosed that Ukraine is under the growing wave of the business cycle, but not in the synergy with the EU dynamics.

INTRODUCTION

The question of economic growth and effective social production is one of the most researched problems. The particular attention is paid to the category of "potential economic growth" that is a key in various areas of economic policy and plays a significant role in studies aimed at the understanding the mechanisms of the functioning of the economy.

Modern economic theory distinguishes between the actual GDP and potential GDP that is most effective for the functioning of the economy. Very often the actual output does not reach its potential value, or, conversely, exceeds it. Such an effect is called the "production gap" or "GDP gap". Potential GDP is the long-term trend of GDP, which differs from actual GDP on the cyclical component (Benes et al., 2010). The gap in production is an important indicator of the economic state and is widely used to determine monetary policy in developed economies.

Also, the assessment of the potential level of growth in production plays an important role in low-income countries.

The existence of GDP gap creates inflationary pressure in economy and shows that some resources in economy are used inefficiently. In case of equalizing factual and potential GDP, the unemployment is at its natural level, and capital resources are used at full capacity, but without overload. At the same time, for the states like Ukraine there is a problem of defining GDP gaps due to statistical observation of the small time series. Therefore, there is a need for an efficient and adequate mathematical apparatus that would allow the estimation of the narrow time series indicators with the lowest level of error.

Long-term economic growth is the main goal of state development policy and is also a key factor in the country's economic stability. However, the handling of standard quantitative methods for assessing the potential output relative to low-income economies is the subject to serious restrictions: in particular, the lack of data set, the lack of quarterly and monthly indicators, the change in the methodology for calculating economic indicators, structural changes at the macro level, such as the economic crisis, etc. The mentioned above complicates the application of standard filtering methods for the topic.

This article is structured in the classical concept of a scientific study. The literature review presented serves as a literary input for examining the issues addressed, followed by the use of scientific methods and evaluation of findings. Once the dynamics and the correlations in GDP gap would be found, a pull of policy recommendations based on insights may be represented to apply in the section Conclusion, disclosing a discussion, a summary of limitations, and proposals for future research.

1. LITERATURE REVIEW

The output gap is considered as a key indicator of the business cycle definition in scientific and practical literature. The contemporary domestic and foreign scientists like Kuttner (1994), Furceri and Mourougane (2012), Zatonatska and Stavytskyy (2009), Hodrick (1997), Mishkin (2007), De Masi (1997), Prescott (1986) and other made significant efforts to assess the potential GDP, some of them like Franceasca et al. (2010), Henroit (1997), De Jager and Smal (1984), William (2002), Hunt and Conway (1997), Koske and Pain (2008), Giorno et al. (1995), Tosetto (2008), Gavin (2012), Dupasquier et al. (1997), and others used the approach of production function for the study. Thus, Kuttner (1994) proposed a new method for estimating potential output in which potential real GDP is modelled as an unobserved stochastic trend and deviations of GDP from potential affect inflation through an aggregate supply relationship. He stated in this way that the procedure yields a measure of potential output and its standard error and an estimate of the quantitative response of inflation to real growth and the output gap. Later, Furceri and Mourougane (2012) assessed the impact of financial crises on potential output by a univariate autoregressive growth equation is estimated on an unbalanced panel of OECD countries over the period 1960–2008. The same approach of Zatonatska and Stavytskyy (2009) resulted that the occurrence of a financial crisis negatively and permanently affects potential output. De Masi (1997) and in the next years Mishkin (2007) researched the concepts of potential output and the output gap as a central to the IMF's analytical work in providing policy recommendations to member governments. This key role has stimulated much more further researches on the IMF to develop and refine estimation techniques, in particular reminding the papers of Hodrick (1997) and Prescott (1986).

The most known contributions to the theory of potential GDP and GDP gaps assessment for the European Union countries were made by Coricelli and Ercolani (2002), Orphanides and Norden (2002), Röger (2006), Rodríguez-Pose and Tselios (2015) and others by means of statistical methods. Modelling using ARMA and ARIMA models for the topic is described in the studies of Andrei and Bugudui (2011), Dritsaki (2015), Nataraja et al. (2012).

Positive GDP is a kind of benchmark to be pursued in the macroeconomic policy of each country. Gokmenoglu et al. (2015) determine that the highest level of production can be potentially sustained over a long period without raising inflation. Benes et al. (2010) consider the potential output, in which unemployment corresponds to its natural level that is called NAILO (Non-Accelerating Inflation Level of Output). Ball and Mankiw (2002) called the natural rate of unemployment as the level of NAIRU (Non-Accelerating Inflation Rate of Unemployment), that is, the unemployment rate, which can be sustained in the long run without a constant increase in inflation. NAIRU represents the unemployment rate that exists in the economy always and corresponds it to the Walrasian equilibrium (Blanchard, 1989). However, this definition of potential GDP is not entirely correct, since NAIRU takes place under any state of the economy, including overheating, when the actual GDP exceeds potential and marginal costs are growing at a high pace. Thus, NAIRU cannot be fully associated with the potential unemployment rate. At the level of output that is less than potential, there is no "overheating" in the economy and marginal costs do not grow too fast. The existence of a positive gap in the output leads to an increase in the pressure on the level of prices in the economy, and the negative – to the lowering. Masi (1997) looks at the potential output as the maximum GDP of the country that can be achieved without causing inflationary pressures.

When considering the GDP, it is necessary to allocate its structural and market components. The structural component of any economic indicator is related to the very nature of the indicator, this is its fundamental part. The most important feature of the structural factor is its slow change over time. This property is usually used in the econometric distribution of the structural component.

In contrast to the structural component, the market component is determined by the current situation in the market that is changing rapidly. As shown by Hodrick and Prescott (1997), Zarnowitz and Ozyildirim (2006), the output series are regarded as the sum of two components: $y_t = g_t + c_t$, where g_t is the structural part, and c_t is the conditional part that is typically cyclic and depends on other rapidly changing parameters.

The most common examples of such decomposition in economic science are the decomposition of GDP of the country into a component of the long-term trend and the cyclical deviations from this trend, called business cycles, the allocation of structural and cyclical deficits of the state budget and the structural component of unemployment, called the level NAIRU. The market component of GDP considers its fluctuations in the path of business cycles. The cyclical behavior of economic indicators is the subject of numerous studies and disputes (Hodrick & Prescott, 1997; Zarnowitz & Ozyildirim, 2006). Consequently, the estimation of potential GDP is reflected in the structural component, while the assessment of the GDP of the gap is market-oriented.

2. AIMS

The reason to choose this topic is to propose the approach of the most effective modelling of economic dynamics of Ukraine under the limited information. The limitation is sourced in the statistics available for the forecasting. Ukraine had a lot of breakpoints in its economic development that are representatively reflected in its statistic data. The most recent breakpoint is the Revolution of Dignity 2014 and the event followed it. The originality and excellence of this article consists of the fact that the modelling approach is tested first on the some world states that had more forecasted and obvious economic development, and then it is tested for Ukraine.

3. METHODS

3.1. Methodological approaches to estimating the potential GDP and output gap

It is believed that potential GDP is not an observable value, and therefore cannot be calculated directly as actual. Nevertheless, potential GDP can be estimated using special tools – economic-theoretical methods (i.e. the method of production function) and statistical ones (Garin et al., 2016). Such a division is traditional and widely used. Both groups of methods have their advantages and disadvantages.

The first approach is an alternative to statistical methods and involves the construction of a production function and the evaluation of its elements (factors of production and the total productivity of production factors). This approach works best in more developed countries, where the statistical base is broader and more detailed in terms of production factors (such as capital, labor employed, labor market segment, hours worked) (Orphanides & Norden, 2002). For example, the US Congress Budget Office and the EU Commission use this method to estimate the potential US growth (Baily & Bosworth, 2014). The potential GDP assessed in this way does not represent a smoothed curve, because structural changes in the economy are taken into account. This method strongly depends on the statistical series and uses short intervals. In the case of Ukraine, it can lead to false results.

One of the disadvantages of the production function method is that it does not use other macroeconomic assumptions, laws and principles of economic theory that may be useful for evaluation. In particular, macroeconomic theory suggests that if the production shocks are temporary, then the potential output should be close to the smoothed trend of sales. In addition, according to the Phillips curve, in terms of the inflation accelerating, the potential output should be less compared to the actual output.

In contrast to the production function, statistical filters take into account the complexities and interconnections of macroeconomic laws. For the application of statistical methods, there is no need in other additional variables, except for actual GDP. This explains why statistical methods are so widespread. On the other hand, some scientists believe that statistical methods have certain disadvantages like low effectiveness of estimation and forecasting (Powers & Xie, 2014). For example, applying the HP filter can minimize the amount of data required for a statistical base due to the use of economic theory constraints. Traditionally, the filtration method is most often used to explain the cyclical fluctuations of output around the trend (to estimate the output gap) and does not provide structural explanations for the sources of long-term growth. The constructed models based on the abovementioned methods can be used to predict potential growth and to be the basis for quantitative growth modeling under different scenarios (Nistor, 2014).

There are the evolution stages of approaches to assessing the potential level of GDP:

- 1960s–early 1970s – potential output was defined as a time-trend approach, derived from business cycles. Potential output was defined as the maximum possible production (peaks of cycles);

- 1970s – a linear trend that "runs" through the middle of the cycle;

- 1980s–present – three main approaches:

1) the contribution of factors – the method of production functions with the evaluation of the various factors contribution:

2) $Y_t = \alpha + \beta K_t + (1 - \beta) L_t$, where Y_t is the potential output, K_t – capital, L_t – labor, β – share of return on capital, α – total factor productivity (TFP – Total factor productivity) (Aigner & Chu, 1968). As a rule, β is evaluated by other sources. Knowing the estimated β, the model can get an estimate for α. An important advantage of the production function method over the trend method is that it can distinguish the influence of individual factors on changes in potential output;

3) structural approach – the development of methods to better assess the structural changes in the economy. This approach considers the application of simultaneous equations system, justifying their legitimacy by the fact that macroeconomic shocks impact on the potential output, the natural rate of unemployment, prices and wages, in particular. It helps to investigate the impact of demographic and political factors on the above indicators;

4) stochastic approach – oscillations of output are considered as a stochastic process. Different constraints are introduced that allow us to distinguish between the effects of demand and supply shocks. It is often assumed that the supply shocks have a permanent effect on output, while demand shocks are temporary.

These and other methods are summarized in Appendix A.

In order to eliminate the cyclical nature of GDP in the development and implementation of state policy in 2002, the Council on Economic and Financial Affairs of the European Union developed a methodology for calculating potential growth and GDP disruptions. The information received was used in the EU countries to combine macroeconomic and structural policies with a vision to substantiating the goals and nature of structural transformations in the country's economy, defining a set of measures to support the development of the elements in the national economic system that provides economic growth and addresses the relevant socio-economic problems. A special "Output Gap Working Group" has been set up to hold regular meetings to discuss the effectiveness and relevance of the existing production function methodology. In general, Kalman filtering is used to obtain GDP trend taking into account the interdependence between aggregate factor productivity and capacity utilization (Grewal, 2011). The GDP gap assessment was of particular interest in developing a crisis exit strategy in the course of an assessment of a cyclically-adjusted budget.

4. RESULTS

Given that there are various alternatives to the formation of a production function, we use the Cobb-Douglas approach. Depending on the initial assumption, the assessment of potential GDP can be made taking into account the constant elasticity of the replacement of production factors or not. A certain number of sources (William, 2002; Röger, 2006) suggests the use of predetermined values of coefficients for the constant return on a scale, with $\beta = 0.33$. However, in this case, the contribution of labor and capital to economic growth can vary greatly depending on the country. We followed this methodology. The statistical base of our study is the data of the statistics of the European Central Bank, statistics of the European Union, the State Statistics Service of Ukraine, the State Treasury Service of Ukraine, the National Bank of Ukraine, the International Monetary Fund, the World Bank. The quarterly data statistics for the period 2000–2015 was used to estimate potential GDP for the EU countries. The study considers the period

till 2015 to have the representative and comparable data and circumstances. Thus, the resulting model can be written as follows:

$$
\ln\left(\frac{GDP_{poten_t}}{GDP_{poten_{t-1}}}\right) = \underset{[0.046]}{0.543} +
$$

$$
+ \underset{[0.025]}{0.345}\ln\left(\frac{Capital_t}{Capital_{t-1}}\right) + \tag{1}
$$

$$
+ \underset{[0.045]}{0.114}\ln\left(\frac{Labor_t}{Labor_{t-1}}\right),
$$

$$
R^2 = 0.81, AIC = -8.816
$$

where

$\dfrac{Capital_t}{Capital_{t-1}}$ – capital growth rate, %,

$\dfrac{Labor_t}{Labor_{t-1}}$ – growth rate of labor force, %.

The time series of model (1) are checked on stationarity; it is adequate. The regression coefficients are significant with a 95% reliability level. The standard error values are given in brackets. The absence of autocorrelation of the residuals was verified using the Breusch-Godfrey test, as well as graph correlation analysis. Converting the received functional form of the model into the initial form of Cobb-Douglas, we obtain:

$$
\frac{GDP_{poten_t}}{GDP_{poten_{t-1}}} = \exp^{0.54}\left(\frac{Capital_t}{Capital_{t-1}}\right)^{0.345} \times
$$

$$
\times \left(\frac{Labor_t}{Labor_{t-1}}\right)^{0.114}. \tag{2}
$$

The Solow's model balance demonstrates a significant contribution of production factors usage to the technological level. The coefficients $\alpha + \beta < 1$ indicate a decreasing return on the scale. The Wald statistical test on $\alpha + \beta = 1$ was fulfilled resulting p-value = 0.00, which indicates that the aboveobtained coefficients α, β are appropriate. According to the simulation results, the contribution of aggregate factor productivity was the most significant, while the contribution of labor force growth to potential growth is not significant.
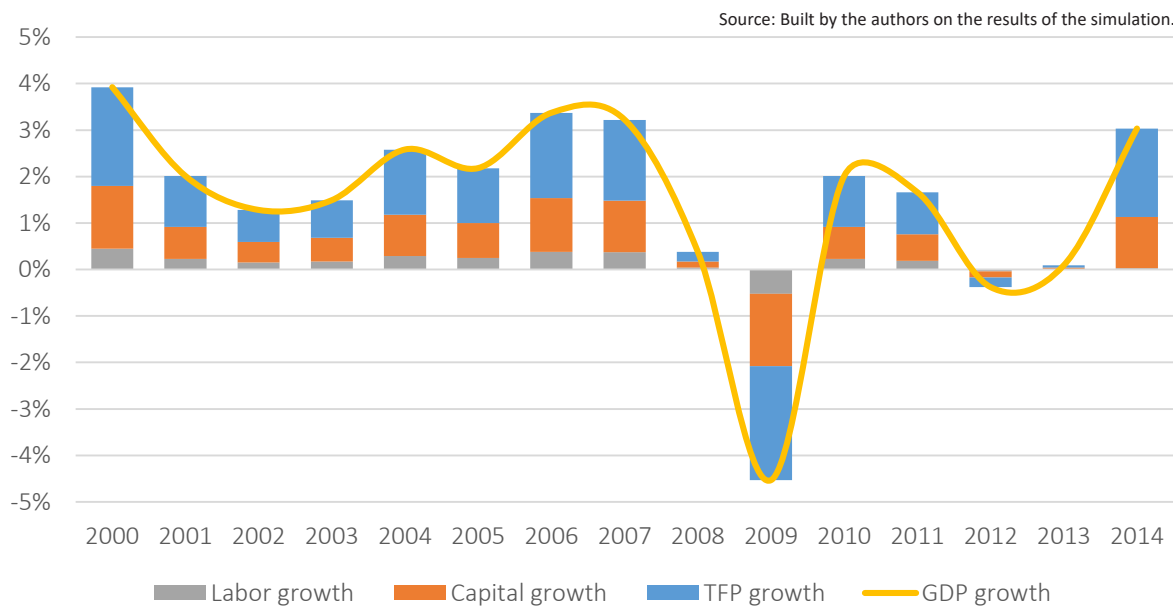
Figure 1. Decomposition of potential GDP growth in capital, labor, aggregate factor productivity

Figure 1 represents a contribution from the growth of capital, labor force, combined factor productivity to the growth rate of potential GDP.

The results are confirmed by practical experience. The crisis growth was determined mainly by the aggregate factor productivity and capital contribution. In the Eurozone and the EU as a whole, post-crisis economic growth was supported only through TFP (European Central Bank, 2011). The dynamics of labor usage is estimated as negative, as well as the contribution of capital to GDP growth. From the point of view of capital accumulation, the share of investments in GDP declined from the second quarter of 2011, which is partly due to lower prices for investment goods and means of production. Nevertheless, we can conclude a more or less balanced structure of potential growth in developed economies. Since today, the contribution of the labor market is increasing in positive dynamics.

Using the descending elasticity of the production factors, we try to compare the results, assuming a constant return on the scale. So, we transform the initial function, assuming that

$$\beta = (1 - \alpha),$$

$$\ln GDP_t = \ln TFP + \alpha \ln Labor_t + (1 - \alpha) \ln Capital_t,$$

$$\ln GDP_t - \ln Capital_t = \ln TFP + \\ + \alpha \ln Labor_t - \alpha \ln Capital_t,$$

$$\ln\left(\frac{GDP_t}{Capital_t}\right) = \ln TFP + \ln\left(\frac{Labor_t}{Capital_t}\right).$$

Seasonally adjusted indicators, normalized to the level of inflation in the 1st quarter of 2000, were used in order not to take into account seasonal fluctuations of GDP and capital as cyclical. In this case, the result of the simulation more accurately illustrates the recession and economic upswing, excluding seasonal recessions as crises. The obtained model is as follows:

$$\ln\left(\frac{GDP_t}{Capital_t}\right) = \underset{[0.023]}{2.24} + \underset{[0.023]}{0.73} \ln\left(\frac{Labor_t}{Capital_t}\right).$$
$$R^2 = 0.927, \ AIC = -5.164$$

The obtained results are significantly different in the share of labor and capital distribution and in the effect of total factor productivity. In the previous model, we used

$$\ln\left(Labor_t / Labor_{t-1}\right) \text{ and}$$
$$\ln\left(Capital_t / Capital_{t-1}\right),$$

as well as the logarithm of the growth rate, which characterizes the intensity of the potential growth of the indicator, or it is defined as a relative acceleration. In this case, we use simply $\ln Labor$ to determine the growth rate of the indicator.

Next, we evaluate the potential GDP with trends and using the NAIRU approach. If we consider the specification of the production function in the form of the Cobb-Douglas function, then for the estimation of the potential output, it is necessary to determine the trends of each of the factors, excluding capital. Since fixed assets are not settled in our case, estimating the potential output reduces the removal of cyclic components of the labor factor and TFP.

It is empirically determined that the best indicator of measuring physical labor costs is the hours worked. As a capital, it is recommended to use a complex indicator that includes equipment and reconstruction costs in the private and public sectors. The estimation of the normal level (trend) of the labor factor costs includes several stages:

1) the maximum possible level is the population of the productive age. It helps to determine the proportion of the economically active population in the total working age;

2) separating the trend component from the resulting fraction in the previous step;

3) estimation of the trend of the natural level of employment based on the assessment of structural unemployment, $L_t = 1 - NAIRU_t$;

4) the calculation of the potential supply of labor as a trend of the number of hours worked, which is the product of the natural level of employment and the trend of the average level of hours worked by one employee:

$$LP_t = WAP_t \cdot T\left[\frac{EAP}{WAP}\right]_t \times$$
$$\times (1 - NAIRU_t) \cdot T[HOURS]_t,$$

where WAP_t – the number of working age population, $T[EAP/WAP]_t$ – the trend of the share of the economically active population in the total population of working age, $NAIRU_t$ – the natural rate of unemployment, $T[HOURS]_t$ – the trend of the average level of hours worked. The trend of aggregate factor productivity is estimated on the basis of the isolation of Solow residuals. We rate $NAIRU$ using a one-dimensional Hodrick-Prescott filter or similar multidimensional filtering; coefficient β = 0.33. The way how the average is smoothed in 20-30 years ($NAIRU$ presented as a constant for the entire observation period) we use multidimensional filtering. It is necessary to determine the value of the parameter β. The $NAIRU$ estimate will be based on the Elmeskov method (IMF, 2000; Elmeskov, 1993), the methodology recommended by the OECD. $NAIRU$ is identified on the basis of the Philips curve supplemented by expectations-augmented Phillips curve. Phillips curve has a reciprocal relationship between unemployment and the growth rate of wages, with a level of unemployment (6-7%), in which wage levels are constant (Bollard, 2016). When unemployment is lower than $NAIRU$, there is a rapid increase in wages:

$$\Delta w_t - E_t\{\pi_{t+1}\} = -\beta(u_t - NAIRU_t) + \varepsilon_t^w,$$

where Δw_t – the growth of real wages; $E_t\{\pi_{t+1}\}$ – expected inflation rate in the future period; u_t – the unemployment rate in the current period; $NAIRU_t$ – the level of unemployment, which does not accelerate inflation (natural).

We consider inflation expectations to be static (that is, they are equal to the actual inflation of the previous period) $E_t\{\pi_{t+1}\} = \pi_{t-1} = \Delta w_{t-1}$. (3)

Then, substituting Δw_{t-1} into (3), the Phillips curve has the form:

$$\Delta w_t - \Delta w_{t-1} = -\beta(u_t - NAIRU_t) + \varepsilon_t^w,$$

$$\Delta^2 w_t = -\beta(u_t - NAIRU_t) + \varepsilon_t^w.$$

Assuming that this fluctuation is equal to zero and the $NAIRU$ level is constant between two consecutive periods: $NAIRU$ is the constant in the following subsequent periods:

$$\Delta \log w_t = -\beta(u_t - NAIRU), \quad \beta > 0,$$

$$\Delta^2 \log w_t = -\beta \Delta u_t + \beta \Delta(NAIRU_t),'$$

$$\beta \Delta \left(NAIRU_t \right) = 0,$$

$$\Delta^2 \log w_t = -\beta \Delta u_t.$$

Thus, the coefficient $\beta = \dfrac{-\Delta^2 \log w_t}{\Delta u_t}.$

We obtain:

$$\Delta \log w = \frac{\Delta^2 \log w}{\Delta u}\left(u_t - NAIRU_t \right),$$

$$\Delta \log w_t \frac{\Delta u_t}{\Delta^2 \log w_t} = u_t - NAIRU_t,$$

$$\frac{\Delta u}{\Delta \log w} = u_t - NAIRU_t, \text{ and so}$$

$$NAIRU = u_t - \frac{\Delta u_t}{\Delta \log w_t}.$$

Figure 2 graphically illustrates the unemployment rate, which does not accelerate inflation, assessed on the basis of the resulting calculation formula. For clarity, annual data are displayed. The quarterly statistics of the European Central Bank for Eurozone countries was used for evaluation. The average natural unemployment rate is 8.9%, as opposed to actual unemployment with an average of 9.5% over the period under study.

Analyzing Figure 3 we consider the sharply negative trend that emerged from the second half of 2008.

As can be seen, the natural rate of employment, which is estimated by the formula, is rather high compared to the actual employment rate among the working age population. Average values for the period under study amounted to 90% and 65%, respectively.

After evaluating the potential GDP of the EU using the production method, we separately focus on modeling using the Hodrick-Prescott filter. With the help of the expanded Dickey-Fuller test (Dickey & Fuller, 1981), we checked the stationarity of the GDP gap series. For example, checking the GDP gaps of the Eurozone edges that the trend is turned off and the constant shows that $prob = 0.0002$, ADF test statistic is less critical, so the series are stationary.

To identify the model ARMA (p, q), as a lag p we choose a lag, after which the partial auto-correlation function (PACF) begins to decrease, as the lag q we take a lag, after which the autocorrelation function (ACF) decreases. Modelling the process of autoregressive moving average should apply the functional form of the model AR (2). The coefficient of autocorrelation decreases steadily after the first lag. As a rule, Lung-Box's Q-statistics for all lags are zero, and therefore the zero hypothesis about the absence of a correlation between the levels of the series deviates for all lags.

Source: Authors' compilation.
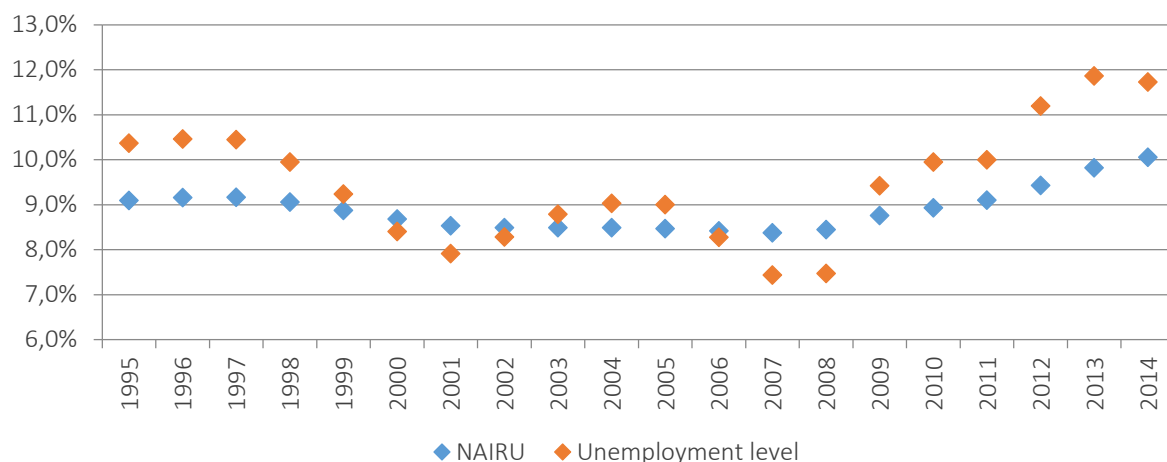
Figure 2. The unemployment rate in the Eurozone countries and the rate of unemployment that does not accelerate inflation (NAIRU)
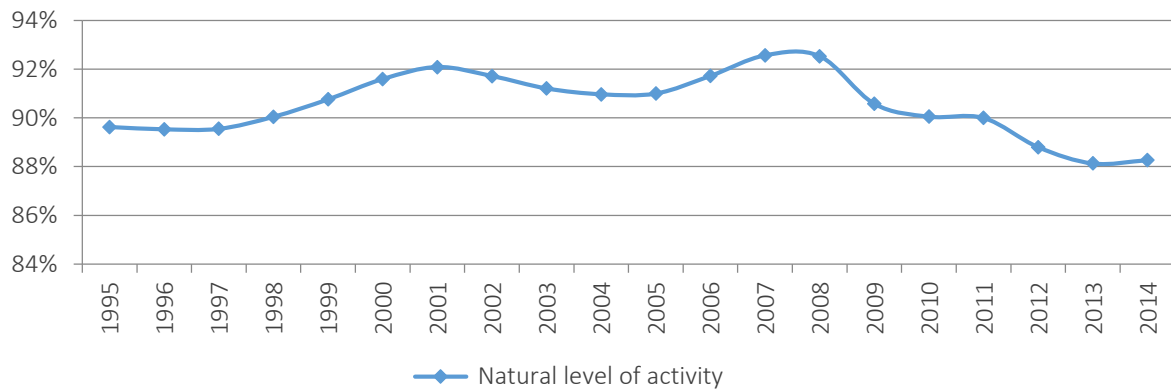
Figure 3. The natural level of employment for the countries of the Eurozone

ARMA (2.0)

$$GAP_t = 1.56_{[0.01]} GAP_{t-1} - 0.72_{[0.01]} GAP_{t-2},$$

$$R^2 = 0.917, AIC = -8.163.$$

The model is adequate, the coefficients are significant with a confidence level of 99.9%. The determination coefficient is rather high, indicating a significant relationship between the dependent variable and the factors. Information criterion AIC = −8.163. The standard error values are given in brackets. The absence of autocorrelation of the residuals was verified using the Breusch-Godfrey test. The process described above is stationary.

Testing the AR structure of the model for stationary with the help of a pulsed function showed that the output value of the external shock is equal to the standard error of the regression coefficient of the factor lag variable that is S.E. = 0.095935. In this case, in the first step, under the absence of external shock, the magnitude of the impulse response is equal to the standard error of the regression equation (0.004011). The magnitude of the predicted impulse is a measure of the deviation of the GDP gap. By default we use one standard deviation as a impulse value, the duration of the test is limited to 12 periods. The magnitude of the standard error of the impulse response function allows us to assess how our model responds to a one-off sharp change in the volume of GDP gap. Figure 4 demonstrates a gradual increase in sampling periods, impulse response and the level of innovation uncertainty (standard error of impulse response) that is approaching zero. That testifies to the stabil-

ity of the stationary process to external shocks. In this case, the asymptotic estimates are zero.

Since the shape of the GDP gap correlogram can not be interpreted in our case uniquely, especially the autocorrelation function, which does not show a sharp decrease for the first three lags, we try to apply other functional forms for modeling for other states.

Model of GDP gap forecasting in Japan – ARMA(1,1)

$$GAP_t = 0.858_{[0.07]} GAP_{t-1} + 0.615_{[0.11]} \varepsilon_{t-1},$$

$$R^2 = 0.89, \ AIC = -7.9.$$

Model for forecasting US GDP gap

ARMA (1,2)

$$GAP_t = 0.789_{[0.097]} GAP_{t-1} + 0.858_{[0.141]} \varepsilon_{t-1} + 0.373_{[0.141]} \varepsilon_{t-2},$$

$$R^2 = 0.90, \ AIC = -7.99.$$

The models are adequate and meet the basic econometric requirements.

According to estimates obtained in 2015, GDP gaps remain negative for G7 countries, an average of −1.9% of GDP. Gradually, the gap in production volumes is decreasing and countries are approaching their potential levels of economy. Negative estimates are projected until 2020. The GDP gap for the G7 countries is projected at 0.07% in 2020. It will fall by 1.8 points in comparison with 2014. On average, one should expect

Impulse response ±2S.E.

Accumulated response ±2S.E.
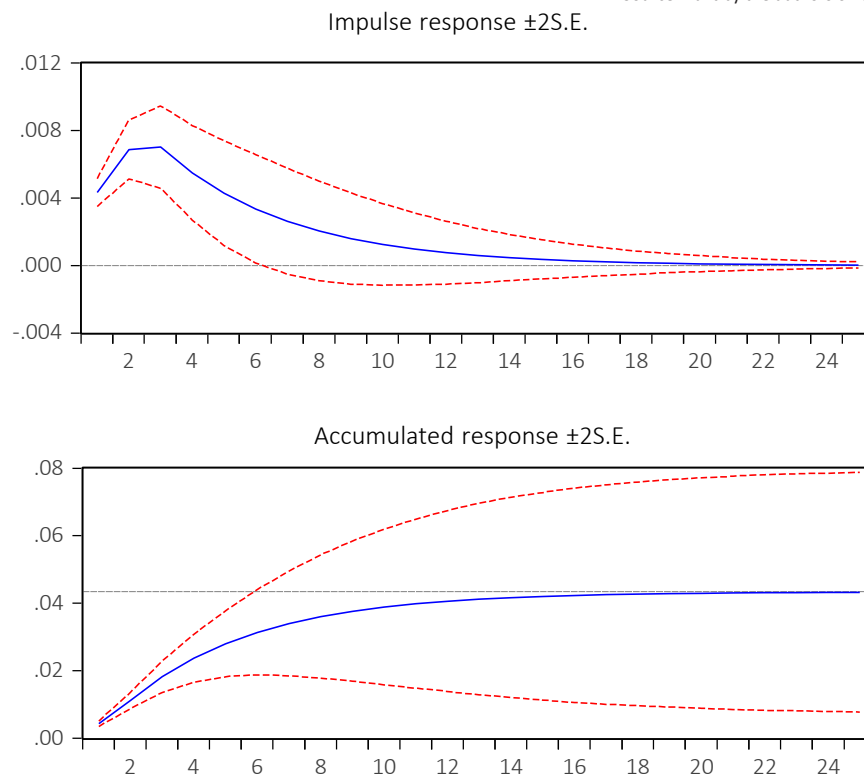
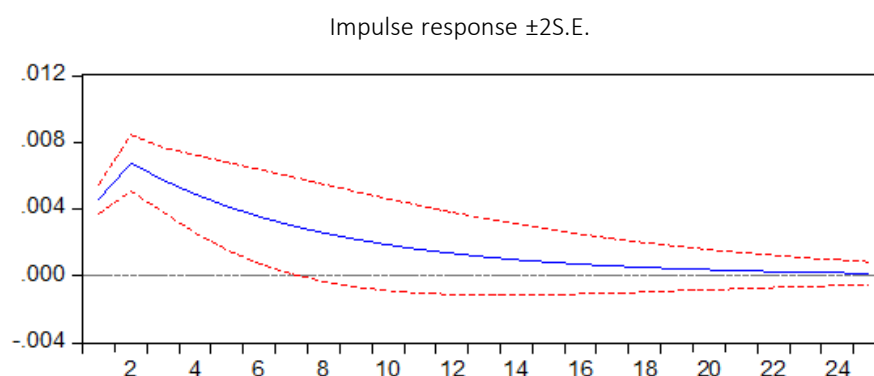**Figure 4.** The impulse response of the model AR (2)

an annual narrowing of the gap by 0.2% per year. The forecast error strongly depends on the current levels of production capacity, provided that the initial assumptions and development trends are unchanged.

For the Eurozone countries, in the short term, it is not expected that the economy will reach its potential level. The negative forecast is explained by the fact that the Eurozone has been severely affected by the debt crisis. There has been a significant increase in the gap of production volumes, which in turn led to deflation.

The current inflation rate for Eurozone countries is on average 0%. According to the IMF estimates, alignment with the target level will be gradually jumping up to 2020 and will amount to about 1.7%. In 2015, the gap in production was –2% and, according to estimates, it is expected to decrease. The expected GDP gap will remain negative at –0.2% by 2020. The gap in production volumes is

Impulse response ±2S.E.

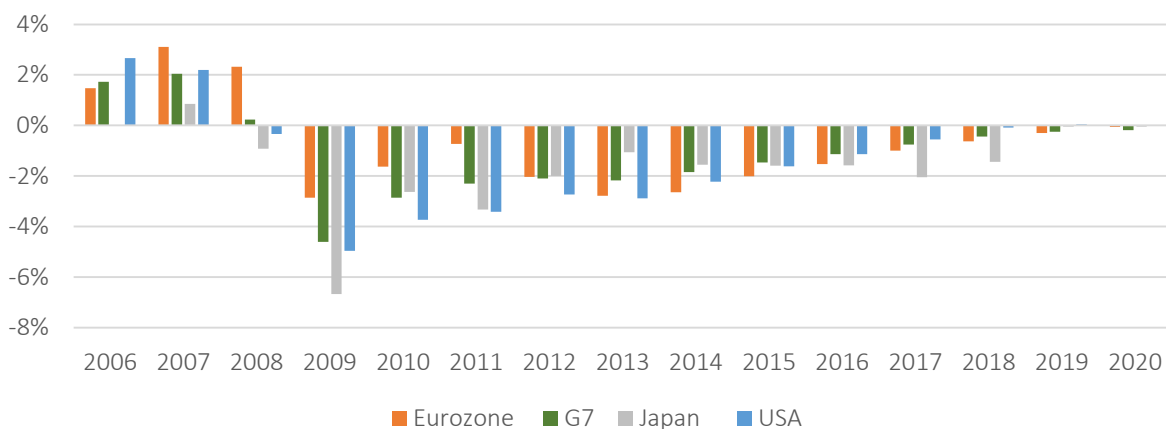**Figure 5.** The impulse response of the model ARMA (1,1)

Impulse response ±2S.E.
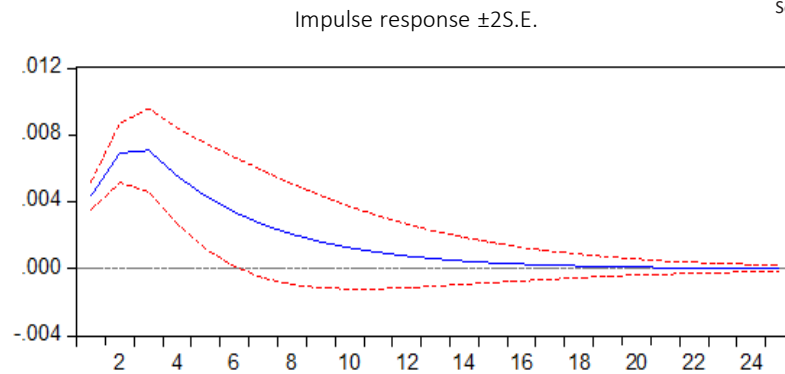
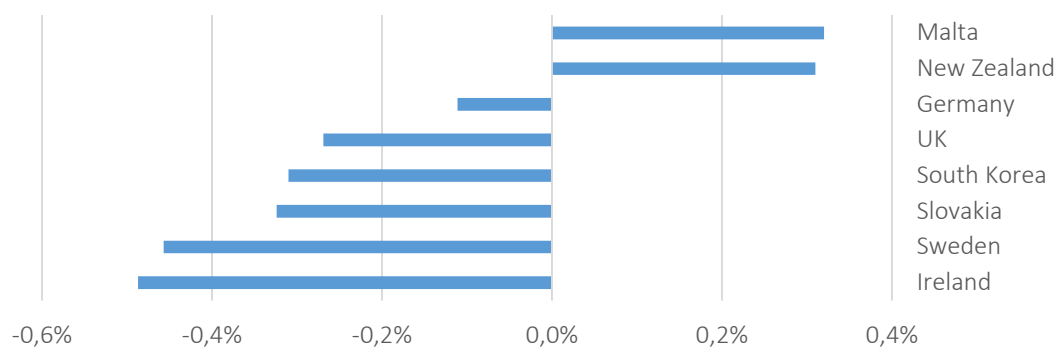
Figure 6. The impulse response of the model ARMA (1,2)

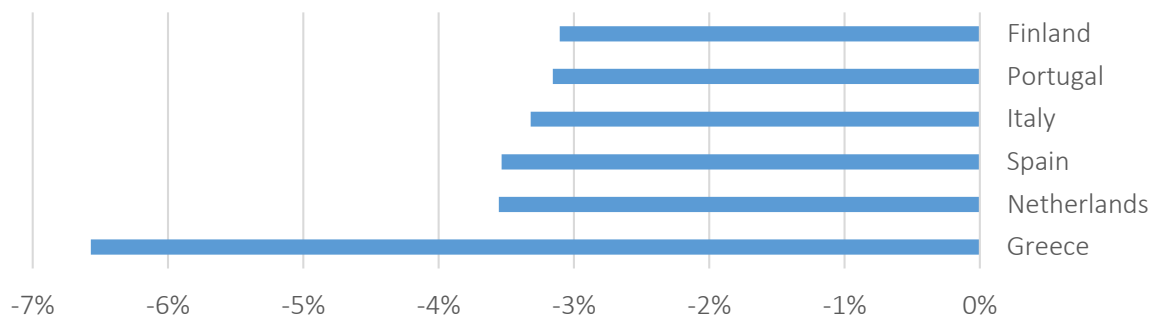**Figure 7.** Estimation of breaks of GDP gaps for the countries of the world

not be completely closed within the next five years. Achieving a potential level makes it impossible to reach an unemployment rate of 10% throughout Europe, as well as the inability to destabilize fiscal imbalances. However, the pace of GDP reduction in the model will be faster than for the G7 countries. Thus, higher growth rates can be expected in the Eurozone than for the G7 countries.

According to the results of the assessment, high economic growth is projected in the United States, Japan and the Eurozone. The gap in GDP in developed countries will be reduced by increasing investment. The level of inflation is expected to be higher than in the previous year, but it will remain at a much lower level than the target benchmarks of central banks. The posi-

Figure 8. Estimated values of GDP gaps for the countries of the world

Figure 9. Predicted values of GDP gaps for the countries of the world

tive development of the United States and Japan may cause positive side effects for emerging market countries, as the strengthening of the United States and Japan implies an increase in demand in country-oriented imports.

Despite the fact that the disruption of the GDP in most developed economies has been negative in 2015, some countries, such as Germany, New Zealand, have reached their potential GDP by the end of 2015, according to the most appraised countries such as South Korea, Luxembourg, Estonia and Sweden have to reach a potential level in 2016. Greece, Italy, Spain are the most distant from their potential output, since they have been most affected by the debt crisis.

The improvement of the world economy is possible on condition of stabilization of prices for oil, natural gas and other basic commodity goods. In emerging economies, the level of economic growth is projected at 4.5%, while in 2015, the corresponding figure was less than 4%.

With regard to the Eurozone countries in 2020, the nominal GDP in the Eurozone will increase to USD 11.9 trillion. The real GDP growth in 2020 is expected at 1.6%, while growth in 2015 was 1.5%. According to the results of the simulation, despite a slight improvement in 2016, the economy in the Eurozone is expected to remain below its potential. Estimates of the GDP gap will remain negative.

It is important to understand the consequences of reducing the GDP gap in developed countries. There are two main transmission effects possible. The first effect is positive and is due to the growth of imports from other countries, and, thus, the export opportu-

nities of developing countries, as well as other major exporters, will increase. The latter is confirmed by IMF forecasts, according to which growth in imports of goods in the Eurozone, G7 and other advanced economies will be between 4% and 5%, compared with an average annual growth rate of less than 2% over the past years.

The second consequence of the increase in economic activity is related to international capital flows. Growth in production in developed economies is expected to be accompanied by an increase in interest rates and the rate of the national currency. This development, in turn, may lead to an increase in capital outflows from emerging markets.

While assessing potential GDP for the Ukrainian economy, there are several problems. Unlike other countries of the world, the results of empirical studies of the rate of potential GDP growth are available to a lesser extent for Ukraine. First, the main problem is the size of the sample for evaluation, as opposed to other countries in the world. This leads to the need for simulation under the limited information when the available data do not cover the full cycle of business activity in the country. Secondly, the statistics are published with a certain delay and then can be reviewed. All this creates conditions for uncertainty in the assessment of potential GDP and GDP gap.

The potential production level is proposed to be evaluated by a one-dimensional Hodrick-Prescott filter and similar multidimensional filtering. In addition, we apply trend methods to estimate potential GDP, but despite the simplicity and widespread use of trend models, the results appeared worse than the results of other methods.
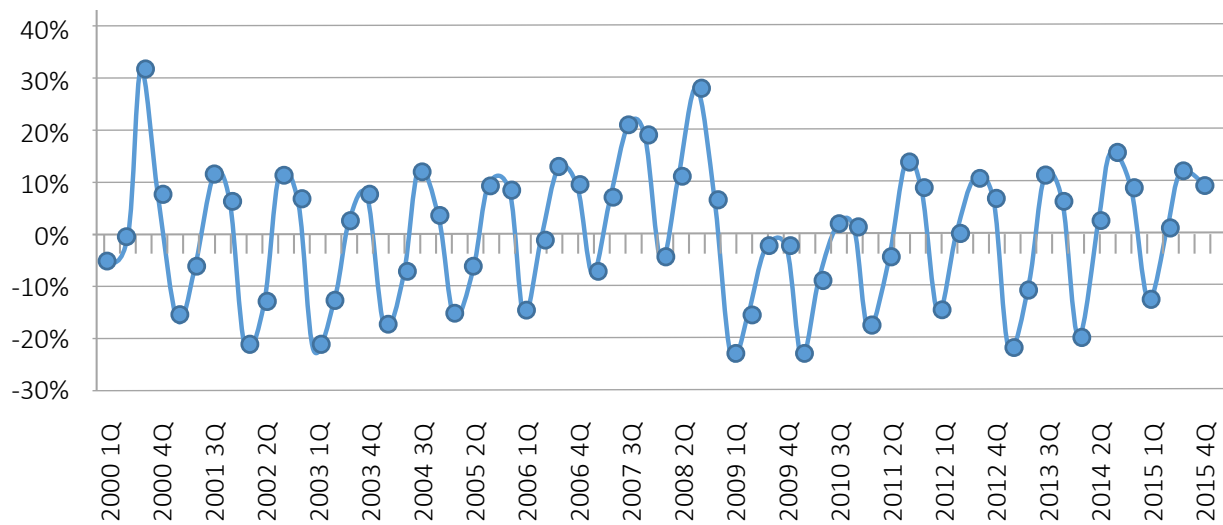
Figure 10. Quarterly GDP gap estimated by HP filter

Figure 10 shows the dynamics of GDP gap obtained by separating the trend component of the GDP as a result of the Hodrick-Prescott filtration. Prior to the crisis, positive gaps are observed mainly in 3 and 4 quarters. The cyclical nature of GDP and GDP gap are associated with business activity cycles. The main share of GDP in Ukraine is the volume of products produced by the Ukrainian agribusiness. Ukraine is an industrial and agricultural country, one of the leading exporters. In the autumn, there is a peak in the production and sale of agricultural products, which increases the export of goods and services. It reaches the maximum in the 3rd quarter of each year. An increase in the volume of export of industrial products leads to a positive break. The

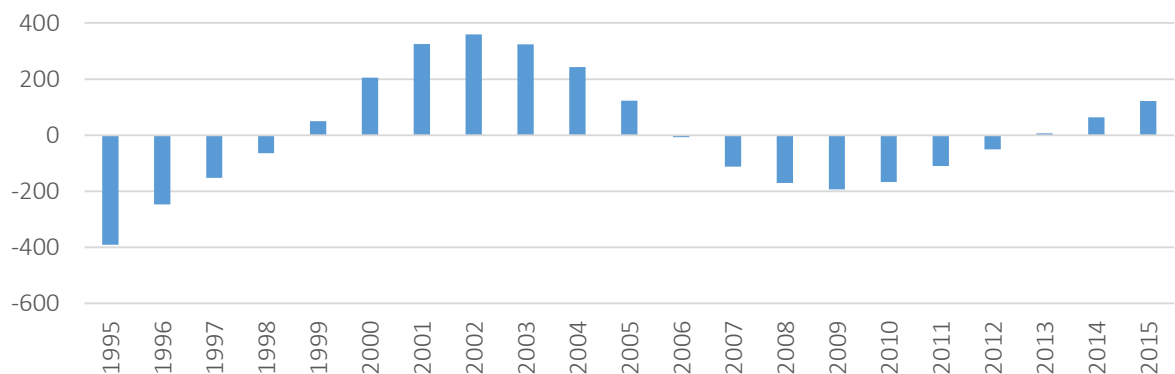winter is the least productive, as a result, the gap in 1 and 2 quarters is negative.

Using the obtained quarterly indicators, a model of GDP gaps is made based on the use of the ARMA model:

$$GAP_t = \underset{(0.025)}{0.06} + \underset{(0.116)}{0.11} GAP_{t-1} +$$

$$+ \underset{(0.105)}{0.41} GAP_{t-2} - \underset{(0.012)}{0.24} q1 -$$

$$- \underset{(0.016)}{0.12} q2 + \underset{(0.012)}{0.04} q3 + \underset{(0.83)}{0.96} \varepsilon_{t-1},$$

$$R^2 = 0.918, AIC = -3.397.$$

Figure 11. Deviation of the results of one-dimensional filtering from the Hodrick-Prescott multidimensional filter, million dollars USA

where $q1$, $q2$, $q3$ – dummy variables that take 1's at the first, second, third quarters of each year respectively and 0's otherwise, such variables are responsible for the seasonality of the GDP gap; GAP_{t-1}, GAP_{t-2} – autoregressive second-order process, ε_{t-1} – the moving average process of the first order.

The model is adequate. The regression coefficients are significant with a 95% reliability level. The prediction error MAPE = 6.08%.

Annual data are used at constant prices for 1995–2015 due to high level of inflation in Ukraine. Preliminary, *NAIRU* potential GDP was estimated using a one-dimensional filter. We evaluate the structural equations using the previously obtained potential GDP by one-dimensional filtering. For example, for a model that takes into account the level of natural unemployment, the following form and the corresponding residual sum is obtained:

$$u_t - NAIRU_t = -0.002\left(GDP_t - GDP_{potential}\right),$$

where $RSS = \sum_{t=1}^{n} \varepsilon_t^u = 5.97$.

If to consider GDP gap in %:

$$\log\left(u_t - NAIRU_t\right) =$$
$$= -0.002\log\left(GDP_t - GDP_{potential}\right),$$

where $RSS = \sum_{t=1}^{n} \varepsilon_t^u = 0.05$.

When comparing multidimensional filtering and one-dimensional, significant deviations between the obtained indicators can be noted. The multidimensional filter takes into account not only the statistical process of trend allocation, but also economic relations.

CONCLUSION

The relevance of the topic is explained with the fact that the existing relationship between the real economy and inflation is the focus of the authorities. Under the equilibrium release, we mean the volume of output of goods and services, which is achieved under the condition of price flexibility (actual inflation is equal to the expected) and which, in turn, does not put pressure on inflation either downward or upward with existing factors of production and technologies. The relevance of this problem is rising. The deviation of the actual production in the country from the potential level is determined by the notion of the GDP gap. The new focus of the article is in the analysis of the potential economic growth of countries under the limited information and in the concept of the natural level of unemployment. The use of different approaches is an advantage of the paper. Based on the identified factors of economic growth, it is proposed to use an approach based on the production function for modeling the potential growth of European countries. The variation of the functional forms of economic and mathematical models that differ in the assumption of return on a scale is presented. The estimation of the potential output volume taking into account the *NAIRU* indicator was conducted.

For the Ukrainian economy, it is suggested to use statistical methods: one-dimensional and multidimensional Hodrick-Prescott filter. The results indicate that both approaches show the same tendency to estimate potential GDP, however, the use of production function takes into account all the ups and downs of the economy, while the Hodrick-Prescott filter allocates a trend that is as close as possible to the linear one.

The results of the work confirmed that the GDP gap and potential output are necessary for developing a state strategy for development. While the gap in production plays a central role in the development of monetary policy, firstly, acting as a factor in inflation, and secondly, being one of the target indicators of monetary politics. The optimum is a policy that stabilizes the price level, and the output gap is zero.

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APPENDIX A

Table A1. Methods to estimate the potential GDP and GDP breakdowns

Source: Own compilation.

Method	Description
Trend	
Linear trend	Trend component of the GDP is a time dependent linear function
Bulk trend	Trend component of GDP is calculated as a linear trend per each cycle, and the cycle is defined as the period between the peaks of economic growth
One-dimensional filters	
Hodrick-Prescott filter	Highlights the trend component by introducing the possibility to choose between the quality of fitting to real data and the degree of trend smoothing
Bandpass filter (Baxter-King filter)	A linear filter that eliminates slow-moving components ("trend") and components with very high frequency ("irregular"), leaving intermediate components ("business cycle")
Beveridge-Nelson decomposition	The method imposes a trend and cycles constraint to decompose the trend/cycle
Kalman filter	Macroeconomic time series consist of a trend, cyclic, and volatile components that are not directly observable. These three components can be restored by imposing sufficient restrictions on the processes of the trend and the cycle
Multidimensional filters	
Hodrick-Prescott filter	The potential output minimizes the GDP weighted average deviations from the potential level, changes in the potential growth rate, and errors in the three constraints: the Phillips curve, the Oaken law, and the ratio between the deviations of productivity and output from potential values
The decomposition of Beveridge-Nelson	The trend is a random walk, but the random shock that shifts this trend is a linear combination of innovations in GDP and other variables that contains core information to determine the long-term GDP
Kalman filter	Extension of a one-dimensional case by taking into account additional equations, for example, Phillips curve
Approaches based on the analysis of the production function	
Complete structural model	All factors in the production function are endogenously listed, for example, by the macroeconomic model
Production function with exogenous variables	All factors of the production function are determined exogenously using single or multidimensional filters
Structural model of vector autoregression (VAR)	The structural model of vector autoregression that evaluates the potential GDP and GDP gap and is based on structural preconditions of the economic fluctuations nature