ALTERNATIVE METHODS TO MEASURING THE ROMANIAN ECONOMY'S BUSINESS CYCLE

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Summary

In the following paper we will present a series of mathematical models that have the scope of approximating the business cycle of the Romanian economy for the period between 1995 and 2022 by using quarterly data of the Gross Domestic Product. The main findings of the paper suggest the use of three different methods for approximating the business cycle, with very interesting and varied results. The accuracy of the approximation of the proposed methods is compared to the traditional method of using the Hodrick-Prescott filter. The originality of the paper lays in applying different methods of calculating the business cycle and comparing their effectiveness for the case of the Romanian economy. In this case we observe that when comparing the methods for the Romanian economy, the alternatives to the Hodrick-Prescott filter are viable and useful.

Keywords: *business cycle, Romanian economy, Hodrick-Prescott filter, European Union integration.*

JEL: *E32*

UDC*: 338.12(498)*

Introduction. In the context of macroeconomics, one of the most interesting and studied topics in the scientific literature involves the study of the business cycle. The business cycle is represented by the deviation from the trend of the output of an economy. In most cases the output is represented by the Gross Domestic Product, and it's deviations at a certain period can present insights regarding the evolution of the economy. In the majority of scientific papers that deal with the subject of modelling the business cycle of small open economies, the method used is the one presented by Hodrick-Prescott (1997). We consider that a significant research gap is represented by the lack of familiarisation of the scientific community with alternatives of measuring the business cycle for the case of small open economies. In this context we present several methods of approximating the business cycle in the case of the Romanian economy for the period between 1995 and 2022. By presenting the results we provide an answer to the following research question:

RQ: Are there any efficient alternatives to the Hodrick-Prescott filter for approximating the business cycle of the Romanian economy?

This question is of interest due to the many implications that the business cycle has in modelling the economy. An interesting application is the use of this statistic in the Real Business Cycle and in the Dynamic Stochastic General Equilibrium models. The economic cycle will be determined by using various methods to extract the cyclical component of the Gross Domestic Product time series. The used methods will be the ones described by: Hodrick and Prescott (1997), Hamilton (2018), Baxter and King (1999) and by Kozic and Sever (2014). By analysing the different results, we will be able to conclude what is the best way to approximate the business cycle of the Romanian economy for the period between the 1st quarter of 1995 and the 1st quarter of 2022. Also the results will be compared with results obtained for approximating the business cycle by using the traditional method of the Hordrick-Prescott filter. The usefulness of the present paper is represented by the attempt to extract the business cycle with other methods then the Hodrick-Prescott filter for the Romanian economy. The Romanian economy is a special case because it faced a transition from a command system to a market based economy in the first part of the analysed time interval (1995 – 2007) and later became part of the European Union. The integration in the European Union (E.U.) being a challenge for obtaining real convergence with the economies of the E.U. and to adapt to the competitive European market. In this case we can argue that the results of the current article are interesting in viewing the applicability of mathematical methods developed for Western economies in the case of Romania.

1. Methodology

In order to model the data, we used the following R packages: Quandl, tidyr, neverhpfilter, ggplot2, dplyr, ggthemes and EMD. The following analysis is based on the one made by Mohr (2018) for the case of the U.S. economy. For the Hodrick-Prescott filter we used the following equation:

$$\min_{\tau}(\sum_{t=1}^{T}(y_t - \tau_t)^2 + \lambda * \sum_{t=1}^{T-1}[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2)$$

The Hodrick-Prescott filter was developed in "Postwar U.S. Business Cycles: An Empirical Investigation" by Hodrick and Prescott (1997) by using the data of the U.S. economy. Since its development, the business cycle as described by the equation, is used in the Real Business Cycle (RBC) and Dynamic Stochastic General Equilibrium (DSGE) models. For this article we set the value of λ to 1600 due to the fact that we worked with quarterly data.

In the paper "Why you should never use the Hodrick-Prescott filter" written by Hamilton (2018), we propose a regression equation, according to which the trend of the Gross Domestic Product can be defined by the equation:

$$y_{t+h} = c(1) + c(2) * y_t + c(3) * y_{t-1} + c(4) * y_{t-2} + c(5) * y_{t-3} + u_{t+h}$$

And the approximated residuals of the equation that represent the business cycle are represented by the following equation:

$$\widehat{u_{t+h}} = y_{t+h} - \widehat{c(0)} - \widehat{c(1)} * y_t + \widehat{c(2)} * y_{t-1} + \widehat{c(3)} * y_{t-2} + \widehat{c(4)} * y_{t-3}$$

The presented residuals represent a fairly accurate way to calculate the transient component for the economic process, according to Hamilton (2018). Also an interesting aspect is that the series is stationary in the case of the fourth differences of y_t are stationary, a fact that according to Hamilton (2018) is not always achieved when using the Hordick-Prescott filter. In the stated equation h represents the number of years of duration for the business cycle that we calculate, in the case of the present paper we set h=8, as recommended in the paper by Hamilton for quarterly data. In order to calculate the trend of the y_{t+h} we used according to the paper written by Hamilton (2018) the following equation, where p=4, and helps to model the deterministic time trend of the analysed series:

$$\delta(1) + \delta(2) * (t + h) + p^{-1} * (u_t + u_{t-1} + \cdots + u_{t-p+1})$$

Another method of approximating the business cycle is the one described in the paper written by Baxter and King (1999). According to this approach the gross domestic product could be described by the following phenomenon:

$$y_t = B(L)x_t$$

Where $B(L)$ is a filter and can be defined in terms of the lag operator L as:

$$B(L) = \sum_{j=-\infty}^{\infty} B_j L^j \ and\ L^k x_t = x_{t-k}$$

According to the paper by Baxter and King (1999) the finite approximation of the filter is the following:

$$y_t = \hat{B}(L)x_t = \sum_{j=-n}^{n} \hat{B}_j x_{t+j} = \hat{B}_0 x_t + \sum_{j=1}^{n} \hat{B}_j (x_{t-j} + x_{t+j})$$

Where $\hat{B}_j = B_j - \frac{1}{2n+1} \sum_{j=-n}^{n} B_j$ and $B_0 = \frac{b-a}{\pi}$ for $a = \frac{2\pi}{p_u}$, $b = \frac{2\pi}{p_l}$. In this way we set p_l to 6 as being the shortest length of an economic cycle (i.e. an economic cycle can last a minimum of 6 months) and p_u to 32 months (i.e. and economic cycle has the maximum length of 32 months). These values being the ones suggested in the scientific literature, in papers such as the one written by Stock and Watson (1998).

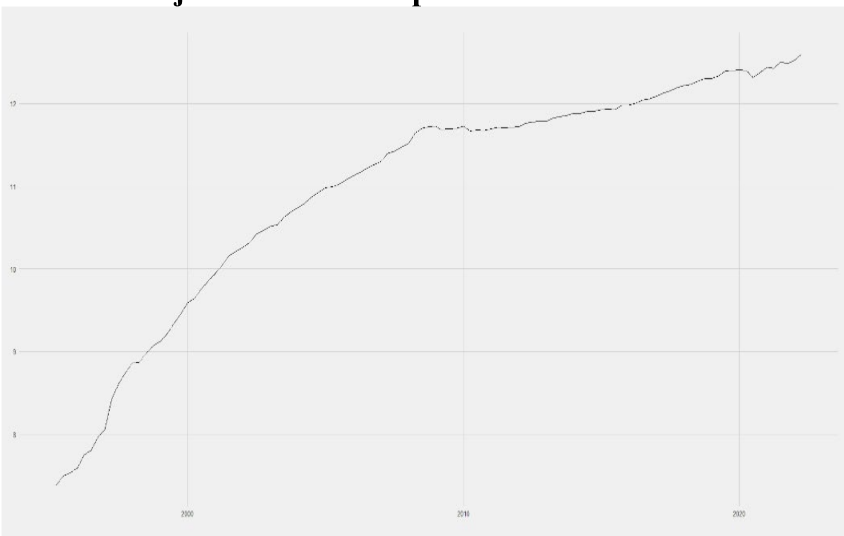
Another way of decomposing the business cycle is the one presented in the paper written by Kozic and Sever (2014). This article proposes an empirical mode decomposition, in this way we present the concept of decomposing the time series into several sub-series that are presented as intrinsic mode functions (IMF). In this way the time series can be mathematically represented with the following formula:

$$y_t = \sum_{j=1}^{n} IMF_j(t) + u_n(t)$$

Where $u_n(t)$ is the residual of the equation and can take the form of the trend of the series (i.e. a monotonic function) or a mathematical constant. In the following part of the paper we will present the results of the computation of the business cycle according to the presented methods.

Results. In this section of the paper, we will present the results of the paper. In the beginning we will present the results obtained by calculating the Hodrick-Prescott filter for the Romanian economy for the period between 1995 and 2022. In the following Figure we decided to present the evolution of the natural logarithm of the Gross Domestic Product of Romania seasonally adjusted in current prices, in order to observe the evolution of the GDP in the analysed period.

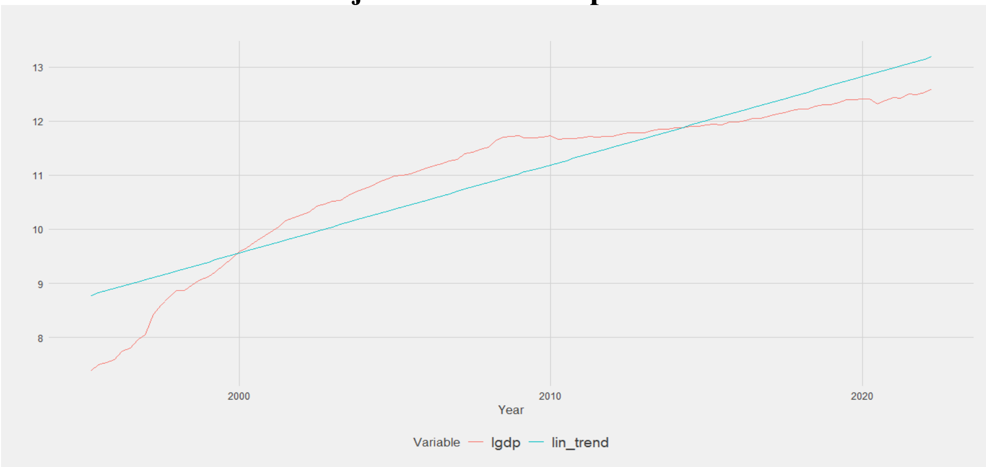
Figure 1. Evolution of natural logarithm of the Romanian GDP seasonally adjusted in current prices



Source: Author's calculation, based on INSSE data

From Figure 1 we can observe the evolution of the Romanian economy in the analysed period, also there is a clear and stable trend of evolution, in order to better isolate the trend of the data from the deviations we decided to extract and present the deviations from the linear trend. In Figure 2, we present the deviations from the trend that were obtained by creating a regression that explains the GDP through the trend and an error term.

Figure 2. Evolution of natural logarithm of the Romanian GDP seasonally adjusted in current prices

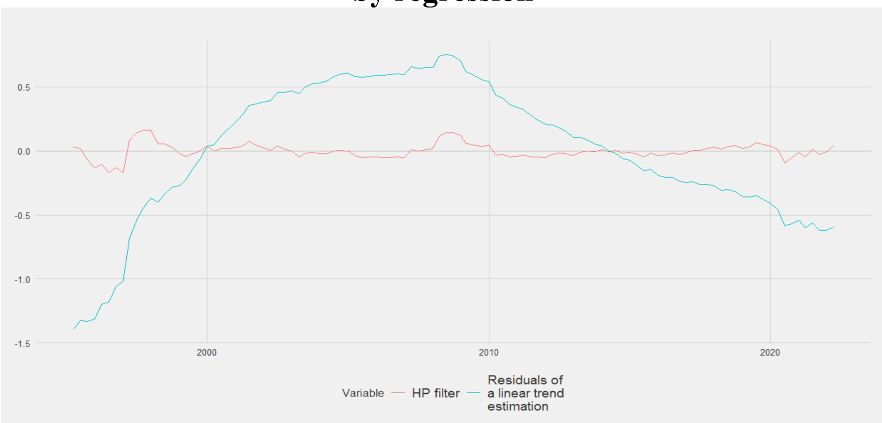


Source: Author's calculation, based on INSSE data

The extraction of the trend by using a simple regression, can be faulty due to the fact that the increase in the GDP is considered to be constant, also this method ignores the white noise, which represent the small fluctuations of the time series.

The following approach used to see the business cycle was the method of the Hodrick-Prescott filter, for which we set λ=1600, due to the use of quarterly data. In Figure 3, we present the comparative analysis of the cyclical component of the GDP (i.e. the business cycle) as extracted by the Hodrick-Prescott filter and as expressed by the residuals of the linear trend estimation.

Figure 3. Comparison between the business cycle as identified by HP filter and by regression



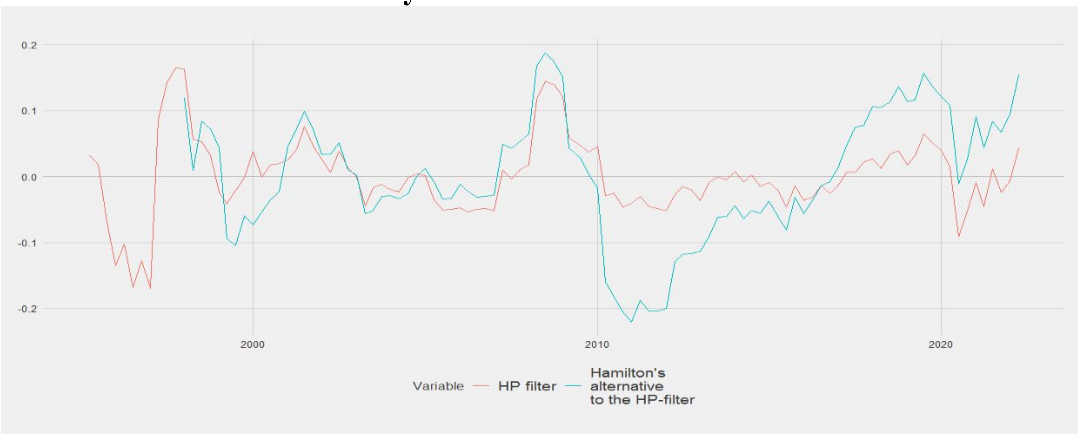
Source: Author's calculation, based on INSSE data

As we can observe the Hodrick-Prescott filter offers a more balanced view of the deviations from the trend of the Gross Domestic Product. According the to the

Hodrick-Prescott filter the deviations from the trend in the case of the Romanian economy have been of a smaller magnitude, comparable to the ones experienced by the US economy in the period between 1970 and 2016 (between -0.5 and 0.5) as observed by Mohr (2018).

Other methods of calculating the business cycle have been developed lately as a response to the criticism of the Hodrick-Prescott filter, one such approach is the one developed by Hamilton (2018). As recommended by the paper, and by using the methods described in the Methodology of this paper, we set the parameters h=8 and p=4. In order to calculate the results, we used the package neverhpfilter for R. In Figure 4, we present the comparison between the Hodrick-Prescott filter and the alternative offered by Hamilton (2018).

Figure 4. Comparison between the business cycle as identified by HP filter and by Hamilton's method



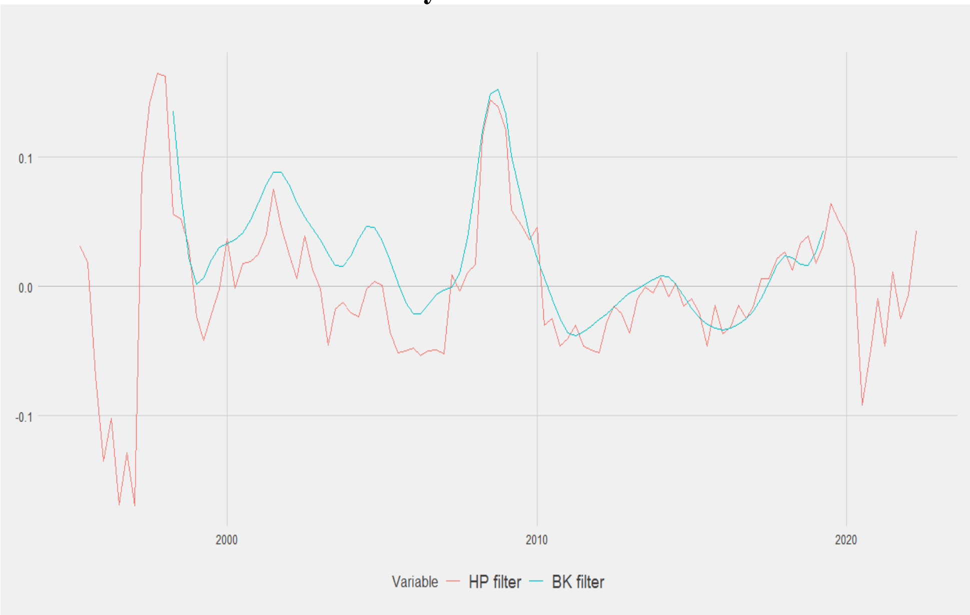
Source: Author's calculation, based on INSSE data.

As we can observe from Figure 4, the business cycle as identified by using Hamilton's method, sees the effects of the 2009 crisis as being more severe for the Romanian economy after 2010, than the Hodrick-Prescott filter. This is of interest due to the significant deviation from the trend being greater than the deviation registered by HP filter before 2000. This can lead us to reconsider the great effects of the 2009 financial crisis on the Romanian economy.

Another interesting approach to extract the cyclical component of the Gross Domestic Product is described by Baxter and King (1999). As described in the methodology, this approach is interesting due to the fact that it takes out the white noise from the time series, making possible an additional smoothing of the cyclical component. In Figure 5 we present the comparison of the filter proposed by Baxter and King (1999) with the Hordick-Prescott filter, in order to compute the Baxter and King filter we set p_l to 6, which represents the shortest length of an economic cycle and p_u to 32 months, the maximum possible length of an economic cycle. By analysing the results presented in Figure 5 we can see that the method proposed by

Baxter and King (1999) offers a smoother approximate of the business cycle than the Hodrick-Prescott filter, fact stated in the paper, also the approximation is closer to the results of the HP filter than the alternative suggested by Hamilton (2018).

Figure 5. Comparison between the business cycle as identified by HP filter and by BK filter



Source: Author's calculation, based on INSSE data

Another interesting method for calculating and extracting the business cycle is described by Kozic and Sever (2014), this is basically a method based on the Empirical Mode Decomposition, and is a continuation of work done by Huang et al (1998). In Figure 6, we present the comparison between the Hodrick-Prescott filter and the Empirical Mode Decomposition (EMD) presented by Kozic and Sever (2014). As we can observe the Empirical Mode Decomposition, offers an even more balanced view regarding the evolution of the business cycle, when compared to the results of the Hodrick-Prescott filter. In this way the positive deviation from the trend that was identified by the HP filter in the period preceding 2010 is smaller, and the economic crisis of 2009 had a smaller effect in deviating the business cycle from the trend. Also an interesting fact is the relative idea that the Romanian economy in the analysed period was closer to the trend than expected, as explained by the EMD decomposition, this suggests an appropriate economic policy that had the right mix of restrictive and expansive economic incentives, in order to maintain a sustainable and responsible economic growth.

Figure 6. Comparison between the business cycle as identified by HP filter and EMD

Source: Author's calculation, based on INSSE data

Conclusions. In conclusion, this paper presents several mathematical methods of identifying the cyclical component of the Gross Domestic Product of the Romanian economy for the period between 1995 and 2022. The idea of decomposing the GDP data series in a cyclical component and a trend is of interest, and is used in building macroeconomic models. In this way the present article shows the results of using other methods then the popular use of the Hodrick-Prescott filter for extracting the business cycle. As we can see results differ from method to method, notable results are obtained by the Baxter and King (1999) filter and the EMD decomposition proposed by Kozic and Sever (2014). Also the method proposed by Hamilton (2018) is useful due to its ease of calculation.

Thus we conclude, that when modelling the economy of Romania the presented methods are useful and could provide an alternative to measuring the business cycle. In our opinion the one which offers the most interesting alternative is the Baxter and King filter (1999) due to the smoothing of the cyclical component. This could provide a new view regarding the effects of the fiscal and monetary policy on the economy, and offer perspectives for using new data for modelling the business cycle (i.e. by implementing the Baxter and King filter in the Real Business Cycle or Dynamic Stochastic General Equilibrium frameworks). In any case, all of the presented methods, provide in our opinion interesting subjects of research, and could be useful in the decision making process.

Further research could be done by testing the implementation of one of the business cycle approximation models in an RBC framework, in this way we could observe and compare the way in which shocks influence the economy when compared to the Hodrick-Prescott filter based approach.

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