MODELLING ROMANIA'S POTENTIAL GDP GROWTH RATE AND OUTPUT GAP

Dan ARMEANU, PhD Professor
The Bucharest University of Economic Studies
E-mail: darmeanu@yahoo.com

Leonard LACHE, PhD Student
The Bucharest University of Economic Studies
E-mail: leonard.lache@gmail.com

Mihaela MITROI, PhD Student
The Bucharest University of Economic Studies
E-mail: mihaela_mitroi@ymail.com

Carmen PASCAL, PhD Student
The Bucharest University of Economic Studies
E-mail: carmen.pascal@yahoo.com

Andreea Cristina DOIA, PhD Student
The Bucharest University of Economic Studies
E-mail: andreea.doia@yahoo.com

Abstract

In today's complex economic decision making environment, the unobservable concepts of potential GDP growth and output gap are paramount to economic policies and have a significant impact on central bank and government actions. Despite being relatively easy to grasp from a conceptual standpoint, the potential output and the output gap are quite difficult to measure and the choice between the many competing models that can be used in practice, as well as the expert opinions imposed to the models may lead to very different results and to radically different policy choices.

Apart from these issues, measuring the output gap in developing economies is further complicated by the lack of reliable statistical data and a short time horizon over which to validate complex macroeconomic relationships that are used by more sophisticated approaches (i.e., multivariate filters). For this reason we propose two straightforward methods of estimating the potential GDP and the *output gap: one based on a simple Hodrick-Prescott filter and one based on an extended Kalman filter with certain restrictions imposed to the cyclical component.*

Keywords: *potential GDP, potential economic growth rate, output gap, extended Kalman filter, trend component, cyclical component*

1. LITERATURE REVIEW. CURRENT STATE OF KNOWLEDGE

In its most abstract definition, potential GDP represents the level of output consistent with the aggregate supply of the economy in the long run after cyclical (short-term) macroeconomic shocks have dissipated. Potential output is fundamental to the Phillips curve, which states the inverse relationship between inflation and unemployment. When actual GDP rises above its potential (equilibrium) level, the economy is overheated and inflationary pressures amplify; when output falls below its equilibrium level, the economy faces the risk of disinflation.

Potential GDP is defined as the level of aggregate supply that attains the optimum balance between output and price stability, given full employment (Hall and Taylor, 1991; Okun, 1962). An alternative definition of potential GDP is the level of output that is achievable given the existing capital stock and labor input if the economy were neither in expansion nor in recession. It is therefore clear that the potential GDP and the output gap are key variables for macroeconomic policies; however, employing them in the decision making process has been troublesome due to both unreliable estimation models and varying intensities of the fluctuations of other macroeconomic variables [Chagny and Dopke, 2001]. Other authors define potential GDP as the maximum output that an economy could sustain without generating inflationary pressures (De Masi, 1997).

In spite of the classical filtering techniques (e.g., the Hodrick–Prescott and Kalman filters – see Chui and Chen, 2009; De Jong and Sakarya, 2013; Hodrick and Prescott, 1997; Kalman, 1961) enjoying great popularity with practitioners and academics alike, these methods have the important limitation of ignoring fundamental macroeconomic relationships, and this is a key fact to consider in the case of emerging economies (Aguiar and Gopinath, 2004). For instance, in many countries, the monetary authorities adopt an inflation-targeting regime of monetary policy (with this also being the case in Romania), a policy stance that leads to overly restrictive policy measures during recessions. This, in turn, generates prolonged periods of negative output gaps. If forecasting models failed to account for inflation during the period, they would produce biased estimates of the potential output and output gap. These issues can lead to inappropriate economic policies (please see the discussion in Benes et al., 2010 for an accurate depiction of the way in which errors in potential output estimation led to ineffective monetary policies in the United States in the 1970s and the 1980s). It is also compulsory to update estimates as new information on macroeconomic time series becomes available, even if the national accounts are not subject to revision themselves.

However, it should be noted that in the case of emerging economies it is quite difficult to correctly specify and validate complex economic relationships due to insufficient and unreliable data. In this context, we propose two different approaches to modelling the potential output and the output gap based on filter theory. The first model is a simple Hodrick-Prescott filter, which is often used for the purpose of evaluating the output gap, and the second is an extended Kalman filter as originally designed by Ozbek and Ozlale (2005).

2. TWO FILTERS FOR ESTIMATING THE POTENTIAL OUTPUT

The first model that we shall develop is based on the Hodrick-Prescott (HP) filter as described in Hodrick and Prescott (1997). The authors propose a simple yet intuitive decomposition of economic variables as the sum of a trend and a cyclical component:

$$y_t = g_t + c_t \qquad (1),$$

where y_t is a time series that is directly observable, g_t is the (unobservable) growth or trend component and c_t is the cyclical component. The purpose of the HP filter is to estimate the unobservable trend component g_t based on the observable noisy process y_t, i.e. to „detrend" the observable time series. While it is reasonable to believe that the robustness and the accuracy of the HP filter varies greatly among the broad range of economic variables, it must be noted that the model enjoys a huge popularity and is often the model of choice when it comes to extracting the trend component of macroeconomic variables.

The HP model is based on the idea that the growth component cannot fluctuate significantly in the short-run and that the long-run average of the cyclical component should be very close to zero. As such, Hodrick and Prescott (1997) state the following minimization problem:

$$\min_{\{g_t\}_{t=-1}^{T}} \{\sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=2}^{T-1} [(g_{t+1} - g_t) - (g_t - g_{t-1})]^2\} \qquad (2),$$

in which λ is a smoothing parameter that penalizes the variations in the growth rate of the trend component. Without going too deep in the technical aspects of the model, we note that the authors propose a value of λ = 1,600 for time series with quarterly frequency[1].

Extracting the values of the trend component from the observed values of the variables is not a straightforward task, as De Jong and Sakarya (2013) note. However, it can be proven that the growth component of the HP filter is a weighted average of the observed values of the time series up to the respective moment in time:

$$\hat{g}_t = \sum_{i=1}^{t} w_i y_i \qquad (3)$$

A formal proof of this theorem, as well as the derivation of the actual weights w_i is beyond the scope of this article. However, those interested may find different approaches to this problem in the original work (Hodrick and Prescott, 1980) and in several excellent studies such as McElroy (2008) and De Jong and Sakarya (2013).

Despite the HP filter's immense popularity, which is due to its simplicity and tractability, the model is not without shortcomings. The most important of these is that it is a purely statistical technique that ingores macroeconomic relationships that have been validated throughout business cycles. Another disadvantage is that the model assumes a smooth variation of the trend component and while it may be (somewhat) safe to make this assumption in the case of mature economies, it is clearly an issue with emerging economies which are greatly affected by the different stages of the business cycle. Thirdly, if a one-off permanent macroeconomic shock occurs, the model will record a shift in the growth component that does not exist (French, 2001).

Applying the HP filter to estimate the potential GDP of emerging economies generates unconvincing results, as discussed in Benes and N'Diaye (2004) and Sramkova et al. (2010). This is mainly due to the fact

[1] For the exact derivation of the value of the smoothing parameter at different frequencies please see Hodrick and Prescott (1997) or De Jong and Sakarya (2013).

that emerging economies are subject to significant idiosyncratic shocks (e.g., frequent changes of economic policies) that increase greatly the volatility of the trend (Aguiar and Gopinath, 2004). The HP filter is, of course, less likely to accurately record these shifts in the trend.

The second model that we use in this paper is the extended Kalman filter proposed by Ozbek and Ozlale (OO, 2005). Just as the HP filter, the OO model assumes that the output (Y_k) consists of a trend component (T_k) and a cyclical component (C_k):

$$Y_k = T_k + C_k \qquad (4)$$

The novelty of the OO model is the hypothesis that the trend component follows a random walk process with drift:

$$T_k = T_{k-1} + \omega_k + \varepsilon_k \qquad (5),$$

while the drift itself is generated by a random walk process:

$$\omega_k = \omega_{k-1} + \sigma_k \qquad (6)$$

The cyclical component follows a AR(2) process:

$$C_k = \alpha_{1,k} C_{k-1} + \alpha_{2,k} C_{k-2} + \delta_k \qquad (7),$$

while the parameters $a_{1,k}$ and $a_{2,k}$ also follow random walk processes:

$$\alpha_{1,k} = \alpha_{1,k-1} + \eta_k \qquad (8)$$

$$\alpha_{2,k} = \alpha_{2,k-1} + \vartheta_k \qquad (9)$$

All residuals are i.i.d. with averages of zero and constant variances.

It is inherent in the specification of the model that certain macroeconomic shocks can have a permanent effect on trend GDP, argument that is consistent with the evolution of most emerging economies in the recent economic crisis. At the same time, by allowing the coefficients of the cyclical component to vary in time (see eq. 8 and 9), Ozbek and Ozlale (2005) ensure that the inappropriate restriction of a smooth variation (i.e., such as the one in the HP filter) in the trend component is eliminated. The model is estimated using an extended Kalman filter (see Chui and Chen, 2009).

3. ESTIMATING THE POTENTIAL GDP AND THE OUTPUT GAP FOR ROMANIA

The HP and the OO filters presented in the previous section have been applied to the time series of quarterly real GDP of Romania in order to capture the trend and evaluate the output gap. The input variable spans over the Q1 2002 – Q4 2015 time horizon and is sourced from Eurostat. The models have been implemented using the WinRATS software application. The smoothing parameter in the HP filter was set to 1,600.

For the OO model, it is important to note that the augmented Dickey-Fuller test reveals the existence of a unit root in the quarterly GDP series, which justifies the option to model the trend as a random walk with drift. At the same time, the AR(2) model used for the cyclical component yields the highest values of the Schwartz and Akaike information criteria (against the alternative specifications AR(1) and random walk with drift). It is also the only specification for which the Durbin-Watson test concludes that the residuals are not autocorrelated.

The option to allow the coefficients of the cyclical component to vary in time appears to be justified from an empirical standpoint. The stability of the model is demonstrated by the fact that the absolute value of the sum of the two coefficients is always less than one (Ozbek and Ozlale, 2005).

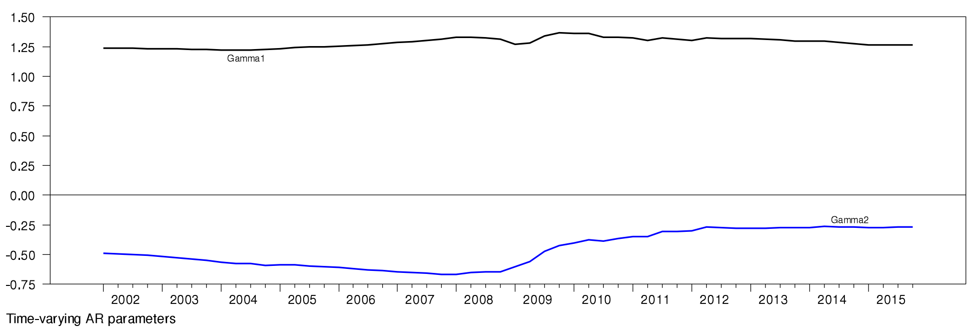

Figure 1. *The coefficients of the cyclical component in the extended Kalman filter*
Source: own calculations.

The table below summarizes the results of the two models:

%

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Gap HP	**-1.4**	**0.0**	**-1.9**	**0.2**	**2.2**	**7.9**	**-1.1**	**-2.3**	**-1.9**	**-2.2**	**-0.6**	**0.2**	**1.5**
Gap OO	**-0.7**	**0.3**	**-1.9**	**-0.4**	**1.1**	**6.5**	**-1.5**	**-1.9**	**-1.0**	**-1.3**	**-0.1**	**0.0**	**0.4**
Pot. GDP yoy (HP)	**6.7**	**6.7**	**6.4**	**5.8**	**4.6**	**3.0**	**1.4**	**0.6**	**0.5**	**1.0**	**1.7**	**2.2**	**2.5**
Pot. GDP yoy (OO)	**7.1**	**7.0**	**6.7**	**6.4**	**5.3**	**3.2**	**0.4**	**-0.3**	**0.1**	**1.0**	**2.1**	**2.9**	**3.4**
Actual GDP yoy	**5.6**	**8.1**	**4.4**	**8.0**	**6.8**	**8.7**	**-7.1**	**-0.7**	**1.0**	**0.7**	**3.3**	**3.1**	**3.8**

Table 1. *Estimates of potential GDP growth and output gap*
Source: own calculations. Note: Output gaps are expressed as % of potential GDP.

The Romanian economy was affected by several shocks over the 2003 – 2015 period and while these shocks have certainly reduced the economy's potential output, they have also generated significant fluctuations in output as the different phases of the business cycles unwound. It is our contention that the HP filter treats wrongly these cyclical fluctuations as changes in the trend and as such produces potential GDP estimates that are too volatile, i.e. the exact opposite of the model's assumptions. At the same time, the HP filter suggests potential GDP growth rates that are too low even after accounting for the severe impact of the crisis on the Romanian economy.

In contrast, the OO model produces estimates of the potential GDP and potential growth that appear to be more natural and smooth.

4. CONCLUSIONS

In this paper, we have attempted to apply two simple and widely used concepts to estimate Romania's potential GDP and trend growth rates. The HP filter is very popular due to its simplicity; however, it does fail to account for fundamental macroeconomic relationships and as such is not so relevant for emerging economies. In contrast, the OO model, based on an extended Kalman filter, manages to accommodate the conditionalities of developing markets rather well and therefore provides a reliable tool to measure the output gap and potential growth rates of these economies.

This is also the case of the Romanian economy, for which the HP filter produces estimates that appear to be unusually volatile while also lacking proper economic justification. On the other hand, the OO model generates estimates that are credible from an empirical standpoint and justified if we take into account the volatility of the Romanian economy.

REFERENCES

1. Aguiar, M., Gopinath, G., "Emerging market business cycles: the cycle is the trend", Mimeo, University of Chicago, 2004
2. Benes, J., Clinton, K., Garcia-Saltos, R., Johnson, M., Laxton, D., Manchev, P., Matheson, T., "Estimating Potential Output with a Multivariate Filter", IMF WP/10/285/2010
3. Benes, J., N'Diaye, P., "A Multivariate Filter for Measuring Potential Output and the NAIRU: Application to The Czech Republic", IMF WP/04/45/2004
4. Chui, C.K., Chen, G., "Kalman Filtering with Real-Time Applications", Springer, Berlin, 2009
5. de Jong, R., Sakarya, N., "The Econometrics of the Hodrick-Prescott Filter", Ohio State University, 2013
6. De Masi, P., "IMF Estimates of Potential Output: Theory and Practice", IMF WP/97/177/1997
7. French, M., "Estimating Changes in Trend Growth of Total Factor Productivity: Kalman and H-P Filters versus a Markov-Switching Framework", FEDS WP No. 2001-44, 2001
8. Hall, R.E., Taylor, J.B., "Macroeconomics", New York: Norton, 1991
9. Hodrick, R.J., Prescott, E.C., "Post-War U.S. Business Cycles: An Empirical Investigation", Journal of Money, Credit and Banking, vol. 29(1)/1997
10. Kalman, R.E., Bucy, R.S., "New Results in Linear Filtering and Prediction Theory", Journal of Basic Engineering, 83/1961
11. McElroy, T., "Exact formulas for the Hodrick Prescott filter", The Econometrics Journal 11(1)/2008
12. Okun, A.M., "Potential GDP: Its Measurement and Significations," Cowles Foundation Paper 190/1962
13. Ozbek, L., Ozlale, U, "Employing the extended Kalman filter in measuring the output gap", Journal of Economic Dynamics and Control, 29/2005

14. Sramkova, L., Kobilicova, M., Krajcir, Z., "Output Gap and NAIRU Estimates within State-Space Framework: An Application to Slovakia", Economic Analysis No.2/March 2010, Financial Policy Institute, The Ministry of Finance of the Slovak Republic