ON THE MOLDOVAN ECONOMY'S POTENTIAL OUTPUT AND OUTPUT GAP: EVIDENCE FROM THE HODRICK-PRESCOTT FILTER

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SUMMARY

This paper introduces the notion of an economy's potential output, its output gap and its output gap rate, analyses the properties of the Hodrick-Prescott filter drawing from the studies in the literature, and proceeds to estimate and discuss Moldova's potential output, its output gap and its output gap rate utilising a methodology which can be used in other economies. The data for our empirical work comprise annual data on: 1. Moldova's nominal GDP and the annual rate of growth or real GDP over the period 2010-2022; and 2. The latest forecasts of these indicators for the period 2023-2026. Data earlier than 2010 are not comparable as they were compiled under a different methodology. We use this data set to generate a time series of the evolution of Moldova's real GDP in average prices of 2010 over the period 2010-2026. We apply the Hodrick-Prescott filter with the two different values of the filter's smoothing parameter suggested by the studies in the literature for the decomposition of annual data. As it is well-known that the estimates of the filter are sensitive to the value of the smoothing parameter, we use the average of the two estimates in order to calculate the Moldovan economy's potential output, output gap and output gap rate through time. Our calculations suggest that, over the period analysed, Moldova's potential output has grown at a modest rate which is not sufficient for the country to converge to the EU average and attain its EU aspirations. The paper concludes by discussing a number of recent economic developments in Moldova, the required policy response to attain Moldova's EU aspirations and areas for further work.

Keywords: *Potential output, output gap, Hodrick-Prescott filter, Moldova*

INTRODUCTION

An economy's potential output, its output gap and its output gap rate are important indicators for macroeconomic analysis and surveillance and among the economic indicators to be included in the Economic Reform Programme document that all EU candidate countries are obliged to submit annually to the European Commission's Directorate-General for Economic and Financial Affairs. The aim of this paper is to analyse the notion of an economy's potential output and an economy's output gap, discuss the properties of the Hodrick-Prescott filter which is widely used in empirical work in economics in order to decompose an economy's output into a trend component and a cyclical component and provide estimates of Moldova's potential output, its output gap and its output gap rate by utilising primary Moldovan data and forecasts.

The paper Note is organised as follows: Section 2 introduces the notion of an economy's potential output and the concepts of an economy's output gap and its output gap rate. Section 2 discusses also the inter-relationship between an economy's output gap and inflation and notes briefly the various methods used to estimate the output gap in an economy and their relevance to the case of the Moldovan economy. Section 3 introduces the Hodrick-Prescott filter and analyses its properties as well as its advantages and weaknesses drawing from the available studies in the economic literature. Section 4 introduces the primary data for our empirical work which comprise annual National Accounts data on: 1. the evolution of Moldova's nominal GDP and the annual rate of growth or real GDP over the period 2010-2022 as compiled by Moldova's National Bureau of Statistics; and 2. The forecasts of these two economic indicators for the period 2023-2026 produced by the Ministry of Economic Development and Digitalization. It is notable that historical data earlier than 2010 are not comparable as they were compiled under a different compilation methodology. Section 4 uses this data set to generate a time series of the evolution of Moldova's real GDP in average prices of 2010 over the whole period 2010-2026. Section 5 proceeds to use the Hodrick-Prescott filter with the two different values of the filter's smoothing parameter suggested by the studies in the economic literature for the decomposition of annual data. As it is well-known that the estimates derived by the use of the Hodrick-Prescott filter are sensitive to the exact value of the smoothing parameter used, we use the average of the two estimates in order to calculate the Moldovan economy's potential output, output gap and output gap rate through time. Section 6 concludes by discussing briefly a number of recent economic developments in Moldova, the required policy response to attain Moldova's EU aspirations and areas for further work.

ON AN ECONOMY'S POTENTIAL OUTPUT, THE OUTPUT GAP AND THE OUTPUT GAP RATE

By an economy's potential output we refer to the highest sustainable level of an economy's real Gross Domestic Product (GDP).

The concept of an economy's potential output is closely linked to issues of sustainability. In general an economy's output is produced through the combination of the economy's factors of production (such as its land, labour, capital, and entrepreneurial ability). The issue of sustainability arises because of the existence of natural or institutional constraints. There are clearly limits to:

- the number of workers and the total hours that these workers can work efficiently in an economy;
- the quality and sustainability of the capital equipment used through time in an economy; and
- the entrepreneurial and organizational skills that turn the economy's inputs into output.

Potential output is linked to the notion of an economy's so-called Non-Accelerating Inflation Rate of Unemployment (NAIRU). If the actual unemployment rate in an economy falls below the NAIRU then inflation tends to accelerate, while if the actual unemployment rate remains above the NAIRU, then inflation tends to drop. If the economy is at its potential output then the unemployment rate is at its NAIRU level.

An economy's output gap is defined as the difference between the economy's actual GDP minus the economy's potential GDP.

If actual GDP > potential GDP then the economy's output gap is positive; the economy operates at a level higher than its sustainable level and, other things being equal, inflationary pressures intensify. A positive output gap is called an "inflationary gap".

If actual GDP < potential GDP then the economy's output gap is negative; the economy operates at a level lower than its sustainable level. A negative output gap is called a "deflationary gap". Inflation, other things being equal, has a tendency to drop.

Finally an economy's output gap rate is defined as the economy's output gap divided by the level of its potential GDP, i.e. by the relationship:

$$\frac{\left(GDP_{actual} - GDP_{potential}\right)}{GDP_{potential}}$$

It should be stressed that an economy's potential output is an unobservable variable which cannot be measured directly. It can only be estimated through the use of various estimation methods. These estimation methods include:

- Production function methods, which link an economy's output to its factor inputs. It should be noted here that, for the case of the Moldovan economy, the use of the production function method to derive estimates of the Moldovan economy's potential output is hampered by the non-availability of reliable data on the Moldovan economy's stock of capital through time.
- Statistical methods, of which the most commonly used in empirical macroeconomic analysis is the Hodrick Prescott filter.

ON THE PROPERTIES OF THE HODRICK-PRESCOTT FILTER

The Hodrick-Prescott (1997, 1981) filter is widely used in empirical macroeconomic analysis to decompose a given time series, yt into:

1. a trend component, τ_t; and
2. a cyclical component c_t.

Formally the Hodrick-Prescott filter fits a trend component to the data so as to minimise the following expression:

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

Where y_t , τ_t are the time series and the fitted trend component respectively, and λ is a positive parameter.
In the above expression:

- The first term is the sum of the squared deviations between the actual series and the trend component.
- The second term penalizes variations in the growth rate of the trend component. The parameter λ controls the smoothness of fitted trend: in particular as the value of λ approaches infinity, the fitted trend component approaches a linear trend.

The Hodrick-Prescott filter is a special case of a smoothing spline Page and Trindale (2010). With regard to the exact value of λ to be used in empirical work, the seminal paper of Hodrick and Prescott (1997) suggested the value of 1600 when working with quarterly data, and the value of 14400 when working with monthly data. Regarding annual data the value of 6.25 is frequently used following the analysis of Ravn and Uhlig (2002). Alternatively the paper by Backus and Kehoe (1992) suggests that the value of 100 should be used for empirical work with annual data.

As Kydland and Prescott (1990) note intuitively the trend fitted by the application of the Hodrick-Prescott filter may be thought of as the trend that a researcher would draw by hand through the data plot.

The main advantage of the Hodrick-Prescott filter is its simplicity, which also explains its wide use in applied empirical work: all that is required is the actual time series itself.

The weaknesses of the Hodrick-Prescott filter include the following:

1. Empirical results critically depend upon the value of the smoothing parameter, λ;
2. Studies in the literature have indicated that the Hodrick-Prescott is sub-optimal at the endpoints of the time series analysed [Baxter and King (1999)]. As Mise, Kim and Newbold (2005) emphasised the Hodrick-Prescott filter is characterized by a high end-sample bias. In order to mitigate this end-of-sample bias in empirical work using the Hodrick-Prescott filter, the researchers frequently include projections along with all the available historical data so as to extend the time series under analysis; and
3. Being a purely statistical method the Hodrick-Prescott filter cannot capture or reflect actual economic processes through time, including the ongoing structural changes in the economy.

The economy's output gap and/or the Hodrick-Prescott filter have been discussed in a number of earlier studies of the Moldovan economy. The study by Pârţachi and Mija (2011) assessed the response of monetary policy to the economy's output gap. The paper by Jaba et al (2014) used the Hodrick-Prescott filter to analyse the impact of the economic crisis on the money transfers remitted through the banking system of Moldova. The paper by Pelipas, Kirchner and Weber (2015) provided an assessment on whether the output gap is a useful indicator for the conduct of monetary policy in Moldova. The article by Mija (2019) analysed the use of a number of econometric methods including the Hodrick-Prescott filter to assess the inflation pressures in the economy.

PRIMARY DATA FOR THE EMPIRICAL WORK

The primary data for our empirical work comprise annual National Accounts data on:

1. The evolution of Moldova's nominal GDP and the annual rate of growth or real GDP over the period 2010-2022 as compiled by Moldova's National Bureau of Statistics. These indicators are compiled following the 2008 System of National Accounts methodology and exclude the Transnistrian region. It is notable that historical data earlier than 2010 are not comparable with this series as they were compiled under a different compilation methodology; and
2. The forecasts of the above-mentioned two economic indicators for the period 2024-2026 produced by the Ministry of Economic Development and Digitalization. This Ministry is the institution responsible for the macroeconomic forecast underpinning Moldova's Annual Budget and Moldova's Medium-Term Budget Framework.

The historical data are augmented by the forecasts in order to extend our sample of observations for our analysis and also in order to mitigate the end-sample bias of the Hodrick-Prescott filter.

The above-mentioned data are presented in the first two columns of Table 1 below. Column 3 of Table 1 uses the data in the first two columns to calculate estimates rounded to the first decimal of the evolution of Moldova's real GDP in average prices of 2010.

Table 1

Estimates and forecasts of the evolution of nominal GDP, the annual growth of real GDP and real GDP in average prices of 2010

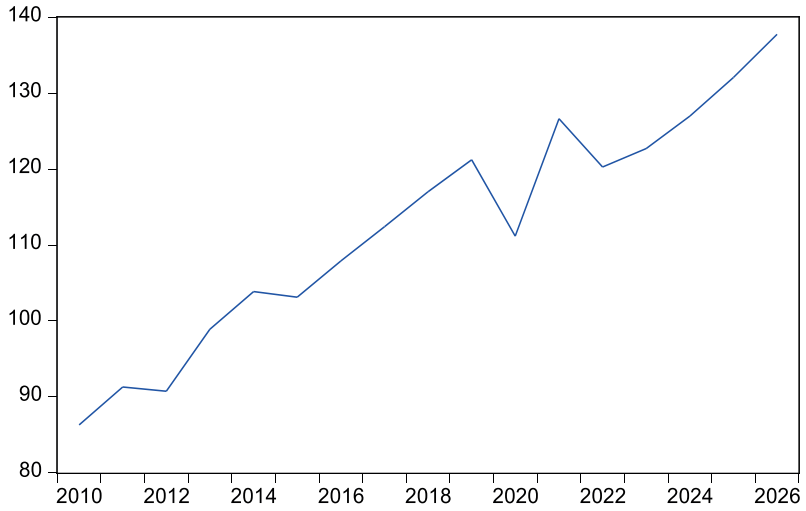
	GDP nominal *MDL billion, current prices*	**Annual growth rate of real GDP** *%*	**GDP real** *MDL billion in prices of 2010*
2010	86,3	7,1	86,3
2011	98,8	5,8	91,3
2012	105,5	-0,6	90,8
2013	119,5	9,0	98,9
2014	132	5,0	103,9
2015	146,7	-0,7	103,1
2016	159	4,6	107,9
2017	176	4,2	112,4
2018	189,1	4,1	117,0
2019	206,3	3,6	121,2
2020	199,7	-8,3	111,2
2021	242,1	13,9	126,6
2022	274,2	-5,0	120,3
2023	312,4	2,0	122,7
2024	342,1	3,5	127,0
2025	378,3	4,0	132,1
2026	418,4	4,3	137,8

Source: National Bureau of Statistics, Ministry of Economic Development and Digitalization and own calculations.

The data in Column 3 of Table 1 are reproduced in Graph 1:

Graph 1

The evolution of real GDP in average prices of 2010



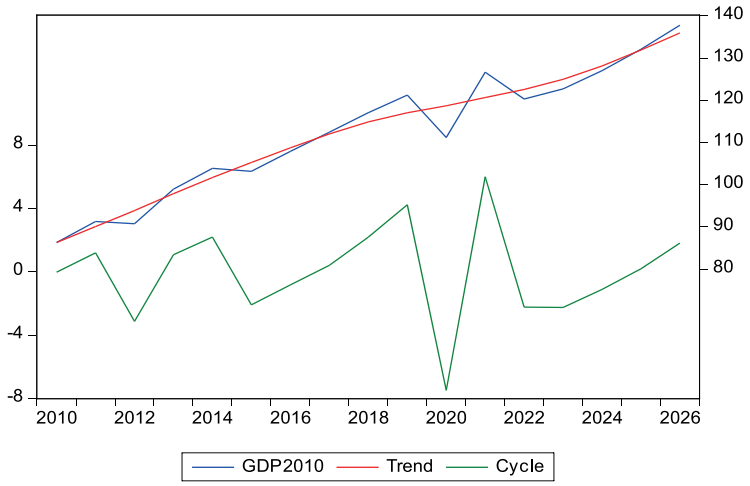
Source: Own calculations on historical data compiled by the National Bureau of Statistics for 2010-2022 and the forecasts of the Ministry of Economic Development and Digitalization for 2023-2026.

EMPIRICAL ESTIMATES

Graphs 2 and 3 below portray graphically the Hodrick-Prescott decomposition of the trend and cyclical component of Moldova's real GDP series presented in column 3 of table 1 with the two values of the smoothing parameter **λ** suggested in the economic literature, namely **λ**=6.25 and λ=100.

Graph 2

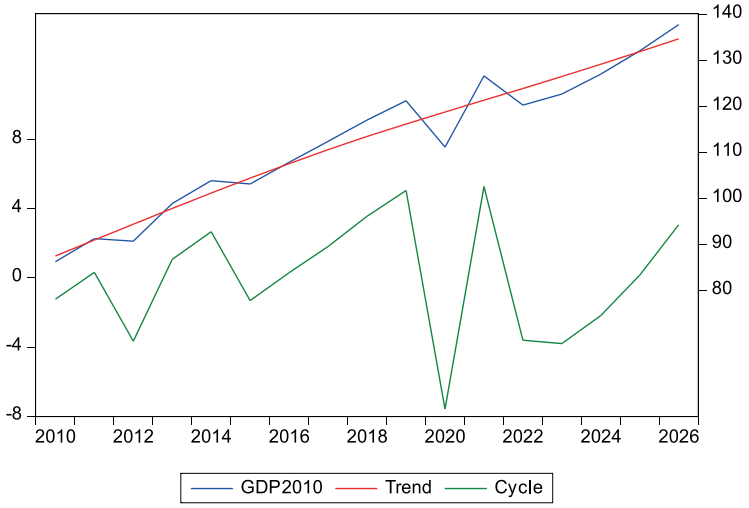
Hodrick-Prescott decomposition of trend and cycle with λ = 6.25



Source: EViews generated estimates and graph

Graph 3

Hodrick-Prescott decomposition of trend and cycle with λ = 100



Source: EViews generated estimates and graph

Since the empirical estimates generated by the Hodrick-Prescott filter are sensitive to the exact value of the smoothing parameter λ we use the average of the two estimates generated by placing λ=6.25 and λ=100 in order to calculate estimates of the Moldovan economy's output gap and its output gap rate.

The results of our empirical work are summarized in Table 2.

Table 2

Selected economic indicators

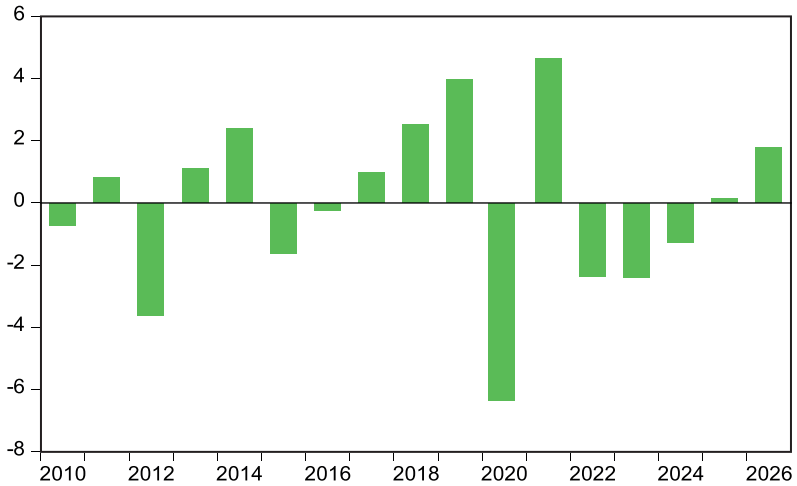
	GDP real *MDL billion*	HP trend $1\lambda = 6.25$	HP trend $2\lambda = 100$	HP trend *average*	Output gap *MDL billion*	Output gap rate %
2010	86,3	86,3	87,5	86,9	-0,6	-0,7
2011	91,3	90,1	91,0	90,5	0,8	0,8
2012	90,8	93,9	94,4	94,2	-3,4	-3,6
2013	98,9	97,9	97,8	97,8	1,1	1,1
2014	103,9	101,7	101,2	101,4	2,4	2,4
2015	103,1	105,2	104,4	104,8	-1,7	-1,6
2016	107,9	108,7	107,6	108,2	-0,3	-0,3
2017	112,4	112,0	110,6	111,3	1,1	1,0
2018	117,0	114,9	113,5	114,2	2,9	2,5
2019	121,2	117,0	116,2	116,6	4,6	4,0
2020	111,2	118,7	118,8	118,7	-7,5	-6,4
2021	126,6	120,6	121,3	121,0	5,6	4,7
2022	120,3	122,5	123,9	123,2	-2,9	-2,4
2023	122,7	125,0	126,5	125,7	-3,0	-2,4
2024	127,0	128,1	129,2	128,7	-1,7	-1,3
2025	132,1	131,9	131,9	131,9	0,2	0,1
2026	137,8	136,0	134,7	135,3	2,4	1,8

Source: Own calculations on historical data compiled by the National Bureau of Statistics for 2010-2022 and the forecasts of the Ministry of Economic Development and Digitalization for 2023-2026

Graph 4 below illustrates the evolution of the output gap rate over the whole period.

Graph 4

The estimated evolution of the output gap rate



Source: Own calculations on historical data compiled by the National Bureau of Statistics for 2010-2022 and the forecasts of the Ministry of Economic Development and Digitalization for 2023-2026

It is notable that our calculations suggest that:

- Over the period Moldova's potential output grew by an average cumulative annual growth rate of slightly over 2,8 %. While this growth record is not insignificant, it is not sufficient for a successful convergence to the EU's average in line with Moldova's European aspirations.
- The largest two deviations in Graph 4 occurred in: (1) the year 2020 when the economy was adversely affected by the COVID-19 pandemic shock (registering an output gap rate estimated at -6,4%); and (2) the year 2021 when the economy rebounded strongly after the significant real GDP drop of 2020 (registering an output gap rate of 4,7 %).
- The current cyclical position of the Moldovan economy is below its potential output. The latest forecast by the Ministry of Economic Development and Digitalization foresees that real GDP will register sustained growth over the period 2023-2026. However, our calculations indicate that the negative output gap of the Moldovan economy will close only in 2025, while in 2026 the output gap rate will be around 1,8 %.

We will examine the reliability of the above estimates in the concluding section below which provides also a brief discussion of recent macroeconomic developments in the Moldovan economy and the required policy response to attain Moldova's EU aspirations.

DISCUSSION AND CONCLUSION

In this paper we have provided estimates of Moldova's potential output, its output gap and its output gap rate utilising a methodology which can be readily used for other countries.

It is notable that over the recent past the Moldovan economy has been subjected to several external shocks. It is well known that these shocks include droughts, the adverse consequences of the COVID-19 pandemic, the significant acceleration of inflation driven by the growth in the international prices of food and energy, the disruptions to the Moldovan economy due to the war in Ukraine and the energy crisis. Given the relatively small sample of the observations we have analysed and the recent volatility in the Moldovan economy, our calculations should be considered indicative and interpreted cautiously. However our analysis provides firm evidence of the need to accelerate the Moldovan economy's potential output growth in order for the country to be able to attain its EU aspirations. This is likely to require structural reform measures aiming at stimulating the Moldovan economy's potential output.

A natural area for further work will be to use the methodology in this paper in order to update the estimates of Moldova's potential output, its output gap and its output gap rate as time passes by and/or the forecasts of real GDP are updated as these three indicators are important variables for macroeconomic analysis and surveillance. Another area for further work is the use of the Hodrick-Prescott filter on the time series comprised of quarterly real GDP estimates.

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