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Output Gap Estimates in the WAEMU Zone

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ABSTRACT

The concepts of potential output and output gap are important tools for central banks and in particular Central Bank of West African States to forecast inflation in pursuit of its priority objective of controlling inflation. In this sense, the choice of a method for their estimation is tricky. This work proposes an estimation of the potential production by the unobservable component methods and proposes a comparison with the production function widely used in the literature and recognized as the best method of estimating the potential production for the WAEMU countries. Two methods with unobservable components are taken into account in this work. This is the approach of Watson (1986) and that of Kuttner (1994). The results indicate that the different approaches as well as the production function explain the various periods of crisis identified within the Union. However, the comparative analysis reveals that only the output gap estimated by the approaches of Watson (1986) and Kuttner (1994) have significant and positive effects on inflation while the output gap obtained by the production function does not explain inflation.

Keywords: Output Gap, Inflation, WAEMU
JEL Classifications: E23, E32, E31, C51, O55

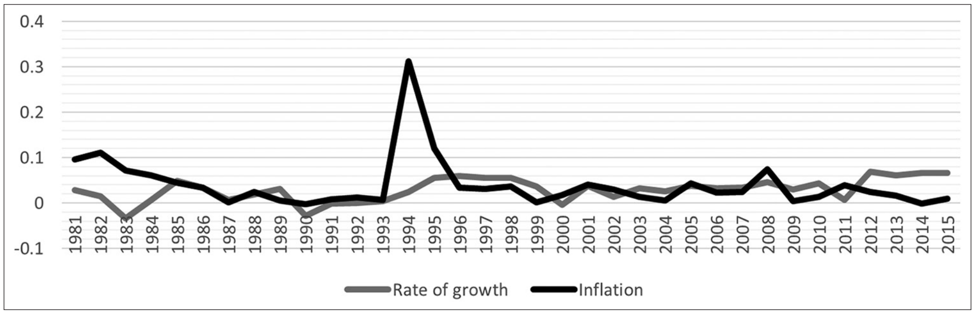
1. INTRODUCTION

In order to ensure the control of inflation, a Central bank uses a key indicator that is the output gap. The latter, which is understood as the difference between the observed production and the potential output, is at the center of many models of forecasting and analysis used by the central banks. Potential output is the maximum level of production that can be generated without an increase in inflation. Then, it is accepted that the output gap is an important reference for assessing inflationary pressures.

In fact, inflation increases the risk premium on long-term interest rates and therefore reduces business investment. It also reduces the purchasing power of households by generating a tax on their cash balances. This creates a climate of mistrust of economic agents who have less and less confidence in their currency. To guard against this, within the West African Economic and Monetary Union (WAEMU), the Central Bank of West African States (CBWAS) has made controlling inflation its priority objective. It is the parent institution responsible for defining the Union's monetary policy and ensuring parity between the CFA Franc and the Euro. In this sense, it must hold enough currency to ensure the convertibility of the CFA Franc. It must therefore follow some key indicators used, especially inflation to prevent any speculative attacks (Figure 1).

The growth rate of the countries of the Union shows a stable trend fluctuating in the band -3.3% and 6.8%. The negative values of the growth rate come from the years 1983 (after the debt crisis), 1990 and 1991 locating the periods before the devaluation. The highest growth rates come mainly from periods after crises: In 1985 with a growth rate of 4.5% and in 1996 with a growth rate of nearly 6%. The other highest values come from the recent period when the economies of the Union are on the rise. Since 2013, the growth rate has been above 6%.

Figure 1: Evolution of the growth rate and inflation of the Union



Source: Author from CBWAS data, 2016

Inflation, on the other hand, has not fluctuated much except for the 1994 devaluation. Since 1996, inflation has not exceeded the 5% mark outside of 2008 corresponding to the banking and financial crisis when it reached 7.4%. Thus, inflation seems essentially controlled within the Union with an average of 3% over the entire period except for 1994.

If until 1985, inflation and the growth rate have moved in the opposite direction, they underwent an almost identical evolution (in terms of rise and fall) until 2010. This is consistent with the assumption that growth goes through a slight inflation. In the end, however, a slight decline is noted.

But the potential output and the output gap being unobservable, their measurement is difficult. A wide range of methods exist in the literature for their estimates. Each of them uses arbitration and none of them is recognized as better than the others (Cotis et al., 2004). Nevertheless, one method is the most common in the literature and is coveted by the major institutions (IMF, World Bank): It is the production function. This method has the advantage of taking into account other additional variables such as capital and labor even if it has the major disadvantage of not highlighting the link between the real economy and inflation. Some studies on WAEMU have shown that this method is better for predicting inflation (Diop, 2000; Abou and Melesse (2012)). However, among the comparison methods highlighted in these two studies, there is no method for models with unobservable components estimated by the Kalman filter while the latter continue to be used in particular by the IMF (Abou and Melesse, 2012) and contain variants taking into account inflation. Moreover, Göran and Kristian (2010) have shown that the methods with unobservable components are better than a variety of other methods for estimating the output gap.

So, how would the use of a model with unobservable components make it possible to better predict inflation for WAEMU countries than the production function? This paper therefore aims to compare the method of the production function with methods with unobservable components in the analysis of the output gap in WAEMU area.

The rest of the paper is structured as follows: The first section presents the literature review in which the different recurrent estimation methods are presented, the second section describes the analysis methodology in which the comparison procedure is described and finally the third section presents the results.

2. REVIEW OF LITERATURE AND EMPIRICAL EVIDENCE ON ESTIMATION METHODS AND DETERMINATION OF POTENTIAL OUTPUT

The choice of the different methods results from an arbitration between availability and reliability of data. In fact, in the absence of additional data or reliability of data, the univariate methods are adequate. The major disadvantage of these methods is that no economic information is taken into account for estimating potential output. Multivariate methods (multivariate filter and econometric modeling) are more appropriate in that they allow an estimate of potential output based on more economic bases. Nevertheless, as noted above, multivariate methods can lead to bias related to measurement errors of additional variables (Table 1).

It should be noted that no method is theoretically better than another for estimating potential output (Kalala and Kimbambu, 2012); (Cotis et al., 2004).

Several studies have focused on the evaluation of potential output. According to the de France (2015), this methodology widely used by international organizations has the advantage of being able to explain the sources of (potential) growth. However, in its analysis, it recommends using several methods to determine potential output. In this sense, Brouwer (1998) estimated potential production in Australia using five methods: The linear trend, the HP filter, the multivariate HP filter, the unobservable component method and the production function method. These results revealed that even if the estimated output gap is not precise because it depends on the method used, the general trend of its evolution is the same regardless of the method used. Heba (2011), proceeding in the same way as Brouwer (1998), but nevertheless, not using exhaustively the same methods, comes to different results for Egypt. For the estimation of potential output, the latter used univariate filters (HP filter and median smoothing) but also a multivariate method which is that of the production function. He finds that the estimation by the production function provides better results and the estimation by the HP filter does not reflect the effects of the financial crisis. Lequien and Montaut, (2014) put forward four methods of estimating the potential production for France, namely the now usual approach of the two-factor production function, capital and labor; its variant to

Table 1: Methods of estimating potential output

Method		Description
Trend	Linear trend	This method consists of OLS regression of the logarithm of real GDP on the constant and the time: Potential GDP is a linear function of time
	Segmented trend	Potential GDP is calculated as a linear function following each cycle. A cycle being defined as a period between peaks of economic growth
Univariate filter	Hodrick prescott filter (HP)	This filter extracts the trend component representing the potential GDP by arbitration between regularity or not using a smoothing parameter
	Baxter and King filter	Linear filter that eliminates the trend and irregular components to retain an intermediate component representing the business cycle
	Beveridge Nelson decomposition	It imposes restrictions on trend and cycle for trend-cycle decomposition
	Kalman Filter	This method performs a recursive estimate of potential output using a filtering algorithm
Multivariate filter	Multivariate Hodrick	Prescott Filter This filter was developed by Laxton and Tetlow (1992). It is an extension of the HP filter by integrating additional variables
	Multivariate Beveridge Nelson decomposition	This method assumes that the trend follows a random walk and assumes that the shocks acting on it are a linear combination of GDP innovations
	Multivariate Kalman filter	This is an extension of the univariate case taking into account some additional equations such as the Philips curve
Economic modeling	The production function	This method provides an approximation of the Cobb-Douglas production function
	Structural VAR	It estimates potential output based on structural assumptions about the nature of economic disruption
	DSGE	This is an estimate of potential output based on the neoclassical approach taking into account the interrelationships between economic variables

Source: Author. VAR: Autoregressive vector, GDP: Gross domestic product

a factor of production, work; the multivariate filter enriched by cyclical indicators and the direct estimation of the output gap by a principal component analysis. Pybus, (2011) refers to the last less common method proposed by the Office for Budget Responsibility, which uses as an estimator of potential output the first factor of a principal component analysis across several indicators of the business cycle. These indicators are selected by diversifying according to their source (business surveys, national accounts), the representativeness of the different markets (goods and services, labor, real estate) and sectors (industry, services and construction)[1].

While the production function is included in the range of methods proposed above, Göran and Kristian, (2010), looking for a better method for estimating the potential production in Sweden, uses methods that do not include the production function. These are the structural autoregressive vector (VAR), the unobservable component methods and the multivariate HP filter. For each of these methods, several specifications have been introduced. To retain the best method, the authors propose a model of production gap and retain the method that better predicts inflation. Their results reveal that the unobservable component method has the best criteria compared to the other models. In the same vein, Daba et al. (2016) are interested in estimating the output gap for CEMAC countries on quarterly data covering 2000-2014 using three methods: The filter HP, an unobserved component model and a structural VAR model. However, they do not obtain conclusive results. The output gap shows a very small impact on inflation in the CEMAC area. Estimates of the output gap allowed them to analyze the timing of cycles and the causality between inflation and output gap within CEMAC. Their results indicate a positive correlation between the cycles of Cameroon and Equatorial Guinea and a general lack of causality between inflation and output gap.

Unlike previous authors estimating potential output by several methods, Kalala and Kimbambu, (2012) propose an estimate of potential production in Congo over the period 1960-2009 using only the HP filter. The peculiarity of their analysis lies in the choice of the smoothing parameter of this filter. Based on 6 economic assumptions, they used as the smoothing parameter of the HP filter, the average of the recommended parameters in the literature.

Using the Hodrick-Prescott filter, the moving average filter, the simple trend, the segmented trend, the VAR model, and the production function, Diop (2000), estimate the potential output of WAEMU countries. His methodology has been to use a method of estimating the output gap that best explains the rate of inflation. Thus, his results reveal that it is the production function method that leads to the "best" estimate of potential output for WAEMU. However, he notes some shortcomings of this method, particularly with regard to the availability of statistical data and the difficulty of evaluating the stock of capital. Abou and Melesse, (2012), using the same methodology as Diop (2000), come to the same result indicating that the production function is the one providing a better estimate of potential output for Benin.

Sene and Thiaw, (2011) provide an estimate of Senegal's potential output by a DSGE model over the period 1980-2008. After recalling the limitations of the production function approach, they justify their approaches by the fact that fluctuations in potential output from DSGE models are larger and by the superiority of DSGE models in predicting certain key macroeconomic variables. The results of the DSGE model indicate that fluctuations in potential output are mainly explained by productivity shocks

1 The author has selected 12 indicators for his study.

and, to a lesser extent, by interest rate shocks and government expenditures.

Soumare (2016) evaluated the WAEMU output gap using the Hodrick and Prescott (HP) filter corrected using the integrated autoregressive moving average (ARIMA). After raising the filter limits HP, he emphasized the end-of-period bias that he corrected by the prediction using the integrated autoregressive moving average method. The author nevertheless specified that his estimation method does not give the specific effects of the cycle on the factors of production. Focusing on the work on WAEMU, we realize that no comparative approach between the production function and the unobserved component methods is provided. All this justifies the choice of this paper.

3. RESEARCH METHODOLOGY

3.1. Method of the Production Function

The production function method provides an estimate of the production function from a Cobb-Douglas equation. The specification found mostly in the literature can be as follows:

$$Y_t = A_t L_t^{\alpha} K_t^{1-\alpha} \quad (1)$$

Where Y_t is the output (gross domestic product [GDP]), L_t and K_t are respectively labor and capital and A_t is the overall factor productivity. An additional assumption is that of constant returns that the sum of the elasticities is 1.

The estimation of the potential production goes through the determination of the potential level of these different components i.e. A_t, L_t et K_t. The level of these components is determined by the Hodrick-Prescott filter often used in the literature[2].

As the capital stock is difficult to measure, we use the same method as Heba (2011) to determine it. The latter started from the dynamic equation of capital accumulation formulated as follows:

$$K_t = I_t + (1-\varphi)K_{t-1}$$

Where I_t is the investment at period t and φ the depreciation rate of capital. The capital stock K_t is then obtained by the formula:

$$K_t = (1-\phi)^t K(0) + \sum_{i=0}^{t-1} I_{t-i} (1-\phi)^i$$

Where $K(0)$ is the initial capital stock. Nehru and Dhareshwar (1993) provide an estimate of this initial stock by the formula:

$$K(0) = \frac{\hat{I}(1)}{g+\phi}$$

Where g is the average growth rate of GDP and $\hat{I}(1)$ the prediction of the initial value of the investment after regression of its logarithm over time. The value retained for ϕ is 0.04. This is the same as the one used by Nehru and Dhareshwar (1993) and also corresponds to the estimate of the depreciation rate of capital estimated by Bu (2006) for Côte d'Ivoire.

As far as our work is concerned, we take as proxy the active population. It should be noted that another approach is to estimate the potential level of the labor force by estimating the potential level of the unemployment rate. However, such an approach cannot be used here because of the bias in estimating the unemployment rate.

The overall productivity of the factors is obtained by retaining the residual of the estimate of equation (1) after log-linearization. Its potential level is then deduced by the HP filter[3].

3.2. Unobserved Component Method Estimated by the Kalman Filter

The unobservable component method breaks down production into two unobservable components. One represents the potential output and the other the output gap. Several variants of these methods exist in the literature. We can distinguish the two following variants.

The first is related to the method of Watson (1986) which makes it possible to obtain the level of the potential production by using a purely statistical approach through the estimation of the following system:

$$\begin{aligned} y_t &= y_t^p + y_t^c \\ y_t^p &= a + y_{t-1}^p + \eta_t^p \\ y_t^c &= \varphi_1 y_{t-1}^c + \varphi_2 y_{t-2}^c + \eta_t^c \end{aligned} \quad (2)$$

Within the previous system falling within the field of space-state models, y_t denotes the production, y_t^p designates the potential, y_t^c the output gap, φ_1 and φ_2 are known constants. The global shape of the space models -state is presented in Annex 1 as well as the Kalman filter, which is the method used to estimate it. Annex 2 gives the maximum likelihood estimates of the parameters φ_1 and φ_2.

Watson's (1986) approach, like that of the HP filter, suffers from not taking into account the behavior of the economy. In fact, no other economic information is involved in the filtering method. In the face of his critics, Kuttner (1994) added to the previous system the relation of the Philips curve between the output gap and inflation.

The second relative to Kuttner's (1994) proposes to use the following system for estimating potential output:

$$\begin{aligned} y_t &= y_t^p + y_t^c \\ \varnothing\pi_t &= u_\pi + \beta y_t^c + \epsilon_t + \delta_1 \epsilon_{t-1} \\ y_t^p &= a + y_{t-1}^p + \eta_t^p \\ y_t^c &= \varphi_1 y_{t-1}^c + \varphi_2 y_{t-2}^c + \eta_t^c \end{aligned} \quad (3)$$

2 Diop (2000) and Abou and Melesse (2012) to name just a few.

3 It should be noted that all filters are applied to the production method function, the smoothing parameter λ retained is 6.5 according to the work of Ravn-Uhlig (2002) and Maraval (2004).

With $\Delta\pi_t$ the variation of the inflation, $\Delta\pi_t$ and ϵ_{t-1} of the terms of errors showing the dynamics of the inflation and u_π a constant. The difference compared to the second system consists in the addition of the second equation of the system (3) representing the Philips curve. The parameters δ_1, φ_1 and φ_2 of the estimated maximum likelihood system (3) are given in Annex 2.

3.3. Comparison of Methods of Estimating Potential Output

For the comparison of methods of estimating the production function, several approaches exist in the literature. Göran and Kristian (2010) have grouped together qualitative and quantitative criteria. As for the qualitative criteria, the one coming back most in the literature[4] is the consistency between the results of the Output Gap and the realities experienced by the economy (the ability of the output gap to coincide with the periods of known shocks or recoveries in the economy). In the rest of this work it is the latter that will be selected as qualitative criteria.

With regard to the quantitative criteria, contrary to the works of Diop (2000) and Abu and Melesse (2012) which chose as method the one that best explains inflation, the work of Camba-Menez and Rodriguez-Palenzuela (2003) show as main criterion the ability of the method to predict inflation. Drawing on the works of Göran and Kristian (2010), the comparison according to the quantitative criterion will follow the following steps:

Step 1: The inflation benchmark model

At this stage, we will start from a Benchmark model for estimating inflation.

The Benchmark model of inflation can be written as follows:

$$\pi_t = \beta_0 + \beta_1 D_{1,t} + \sum_{j=1}^{p} \gamma_j \pi_{t-j} + \epsilon_t + \sum_{i=1}^{q} \theta_i \epsilon_{t-i} \qquad (4)$$

Where π_t denotes the annual inflation, $D_{1,t}$ an indicator taking 1 in 1994 and 0 otherwise allowing to capture the effect of the devaluation. Equation (4) is simply an inflation process followed by ARIMA. After estimating equation (4) over the period 1980-2009 (i.e., 30 years[5]), we will forecast over the last 6 years (2010-2015). In order to ensure the stability of the coefficients before the forecast, the CUSUM structural change test will be performed. As a result of the forecast, the root mean square error (RMSE) will be calculated between the six predicted values and the current values of inflation. Note this RMSE: $RMSE_{benchmark}$.

Step 2: Adding the Output gap to the Benchmark model

This step consists in estimating an alternative model by adding the delayed output gap as an explanatory variable in the benchmark model (4). The new equation can be as follows:

$$\pi_t = \beta_0 + \beta_1 D_{1,t} + \sum_{j=1}^{p} \gamma_j \pi_{t-j} + \epsilon_t + \sum_{i=1}^{q} \theta_i \epsilon_{t-i} + gap_{t-1} \qquad (5)$$

Where gap_{t-1} designates the delayed output gap. The latter is preferred at the moment because of the assumption that it is the output gap of period t–1 that allows the authorities to predict the inflation of the period t. In fact, we are looking for a model allowing the Central Bank to stabilize inflation. Thus, the output gap of the previous year could be a signal for inflation in the next period[6].

As in step 1, the RMSE will be calculated on the six predicted values from equation (5). Thus, three RMSE will be calculated according to the use of the output gap of the production function, Watson (1986) and Kuttner (1994). We will designate them respectively by $RMSE_{fp}$, $RMSE_{watson}$ and $RMSE_{kuttner}$.

Step 3: Calculation of the relative RMSE

The third and last step will consist in calculating a relative RMSE designating the ratio between the RMSE obtained in the second step and the $RMSE_{benchmark}$. We will have a relative RMSE for the production function method, Watson (1986) and Kuttner (1994). The relative RMSE is obtained as follows:

$$RMSE_{r:fp,watson,kuttner} = \frac{RMSE_{fp,watson,kuttner}}{RMSE_{benchmark}}$$

A relative RMSE of <1 indicates that the method allows a better forecast of inflation than the benchmark model. On the other hand, when it is >1, the benchmark model prevails; otherwise, the addition of the output gap considered does not improve the forecast of inflation.

3.4. Analysis of the Robustness of the Results

In order to ensure the robustness of the results, this study proposes the construction of two statistical tests: The first to compare each model to the benchmark and the second to compare the different methods between them. The first test will consist in testing the superiority of each RMSE relative to 1. It can be written as follows:

$$\begin{cases} H_0 : RMSE_{r:fp,watson,kuttner} \geq 1 \\ H_1 : RMSE_{r:fp,watson,kuttner} < 1 \end{cases}$$

Because the law followed by the relative RMSEs is not known, their distribution will be obtained through a bootstrap with 10000 replications. Following this, a comparison will be made between the computed statistics and that observed at the threshold of 5%. The test being unilateral left[7], the null hypothesis will be rejected when the computed statistic is lower than the one observed. In case of rejection of the null hypothesis, we can conclude that the output gap estimated by one of the methods (Production Function, Watson (1986) or Kuttner (1994)) improves the forecast of inflation that the model benchmark.

The second test concerns the successive comparison of the relative RMSEs of the different methods. Thus, three tests of differences will be made. The pattern of assumptions can be as follows:

$$\begin{cases} H_0 : RMSE_{r:m_i} \geq RMSE_{r:m_j} \\ H_1 : RMSE_{r:m_i} < RMSE_{r:m_j} \end{cases} i, j \in \{1,2,3\}$$

4 For more criteria, confère Cotis et al (2005).

5 This period is chosen because we consider it sufficient to make a good forecast.

6 It must be said that this analysis would be more adequate on monthly data. However, in the absence of such data and due to biases related to quarterly methods, annual data are used in this study.

7 The choice of the left unilateral test is guided by the result that one wishes to obtain appearing in alternative hypothesis.

Where m_i designates the method i and i=1,2 *et* 3 respectively the function of production, the approach of Watson (1986) and that of Kuttner (1994). As before, the distribution of the test statistics will be obtained by bootstrap. In the case of a left unilateral test, the null hypothesis will be rejected when the calculated statistic is lower than the one observed.

It should be noted that in case of no rejection of the null hypothesis, we cannot conclude as to the superiority of one method over another.

For this analysis, we make the following assumptions:
- The output gap obtained by the unobservable component method has a positive and significant effect on inflation.
- The unobservable component methods can better predict inflation.
- The unobservable component methods are better than the production function.

The first hypothesis follows the theory of the Philips curve stating that a period of expansion (positive output gap) should go hand in hand with inflation.

The data used (real GDP and inflation for WAEMU) come from the CBWAS database and cover the period 1980-2015.

4. RESULTS AND DISCUSSION

4.1. Results of the Estimation of Potential Production by the Production Function Method and Comparison According to the Qualitative Criterion

Figure 2 shows, on the one hand, the joint evolution of GDP and potential output estimated by the production function method and, on the other hand, the evolution of the output gap deduced. The analysis of the evolution of the output gap makes it possible to compare the episodes of recessions[8] (negative output gap) with the various shocks actually suffered by the countries of the Union.

8 The concept of recession used in this study is that of the OECD. According to them, on an annual reasoning, a recession can be defined as a period of at least two years during which the cumulative production gap reaches at least 2% of gross domestic product (GDP) and the production becomes lower by minus 1% to potential output in at least one year (OECD Economic Outlook, Volume 2008, Number 2, page 31).

The output gap obtained by the production function method makes it possible to distinguish two periods of recessions mainly: The 82-84 period and the 89-94 period. The first period corresponds to the debt crisis of 1982. In fact, after Mexico's decision in 1982 to suspend the payment of interest due on debt service, many developing countries became insolvent in 1982 because of rising interest rates combined with lower export earnings. This crisis then led to the scarcity of credits leading to a limitation of capital flows. Thus, the output gap obtained by the production function is a good reflection of this crisis.

The 89-94 period reflects the pre-crisis period before the 1994 devaluation. During this period, the countries of the Union were experiencing an economic slump characterized by a lack of competitiveness and a low purchasing power of consumers. Production capacity was then limited. In comparison with the previous crisis (82-84), the output gap estimated by the production function suggests that the potential level of production is higher in 1982 than in 1994.

The lowest level of the output gap is obtained in 2011. The slight recovery in 2012 suggests that this period is a shock. This year coincides with the post-election crisis period in Côte d'Ivoire, the locomotive of the Union. According to the production function approach, the countries of the Union expanded over the periods 88-89, 98-99 and the recent period 2014-2015.

Despite the explanation of certain periods in the lived experience of the countries of the Union, the output gap estimated by the production function does not seem to account for the structural post-adjustment effects of 1980, when the level of employment decreased.

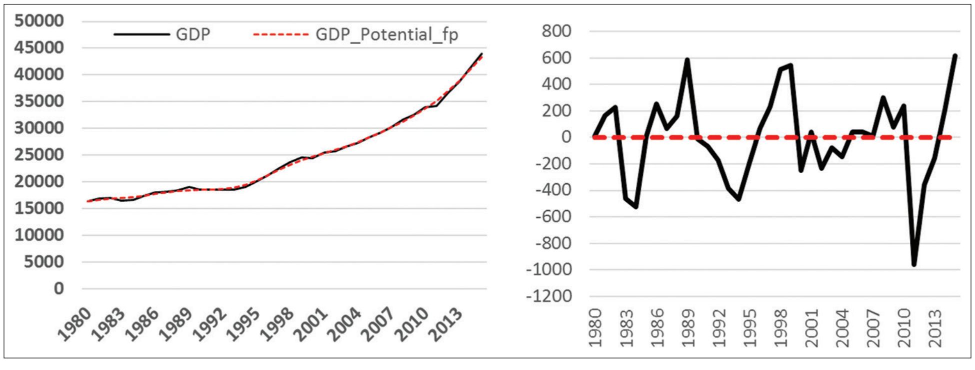
4.2. Results of Estimating Potential Production by the Unobservable Component Method

As presented at the methodological level, two methods of estimating potential output by unobservable components are presented in this paper: The Watson (1986) and Kuttner (1994) methods.

4.2.1. Watson's method (1986)

Figure 3 shows the joint evolution of actual and potential production estimated by the Watson method (1986) and the

Figure 2: Gross domestic product (GDP), potential GDP and output gap estimated by the production function approach



Source: Author from CBWAS data, 2016

corresponding output gap. It must be said that the methods of the unobservable components suffer from an initialization problem. In fact, the initialization value is arbitrary and the series adjusts afterwards gradually. Thus, the method does not allow to capture the effects of the debt crisis of 82, since the output gap remained positive. Nevertheless, it gives a good account of the pre-crisis period before the 1994 devaluation. The periods of expansion noted are the same as those obtained by the production function. However, the expansion period corresponding to 2014-2015 seems more accentuated according to the method of Watson (1986) (Figure 4).

4.2.2. The Kuttner method (1994)

The estimation of potential production by the Kuttner method (1994) reveals a great similarity with that of Watson (1986). The main difference comes from the smaller expansion effect observed for the Kuttner (1994) method compared to that of Watson (1986) at the end of the 2014-2015 period.

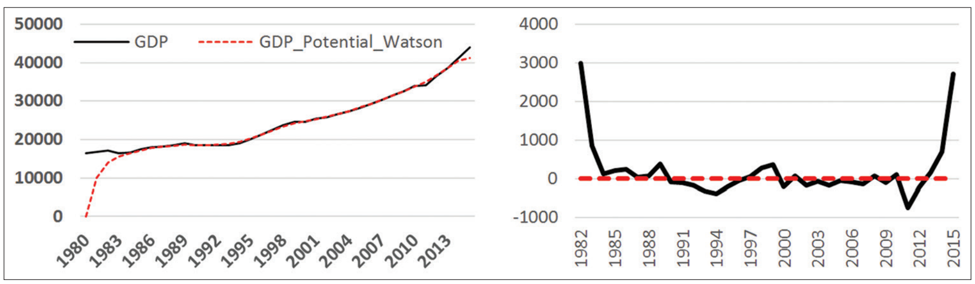
The analysis according to the qualitative criterion shows that the different methods are similar, even if the intensities differ in terms of reproduction of the different phases of the economic cycle of the WAEMU countries. In the next section, we turn to an analysis based on the quantitative criterion.

4.3. Results of Benchmark and Alternative Model Estimates and Comparison

After the specification tests (determination of the ARIMA specification) that made it possible to retain an ARIMA model (1,0,0) and the validation of the post-estimation tests (homoscedasticity, autocorrelation and normality), the results of the benchmark model and alternative models are presented in the Table 2.

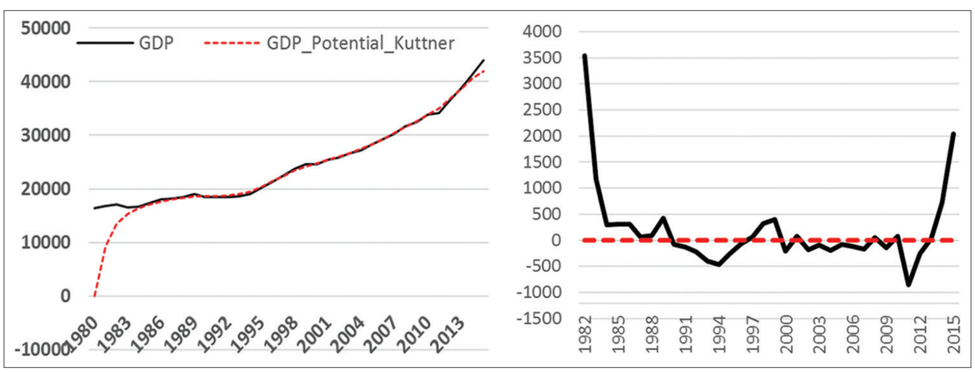
We note that compared to the benchmark model, the one with the output gap of the production function does not seem to improve the forecast of inflation since the R^2 has decreased relative to the benchmark model. In fact, the delayed output gap of the production function is insignificant but also has a negative sign. This negative sign goes against the expected results in that, an increase in the output gap (reflecting a period of expansion) should generate inflationary pressures. This result contradicts those of DIOP (2000) for the WAEMU countries and Abou and Melesse (2012) in Benin.

Figure 3: Gross domestic product (GDP), potential GDP and output gap estimated by the Watson approach (1986)



Source: Author from CBWAS data, 2016

Figure 4: Gross domestic product (GDP), potential GDP and output gap estimated by Kuttner's approach (1994)



Source: Author from CBWAS data, 2016

Table 2: Results of estimates

Variables	Benchmark	Fonction of production output gap	Watson output gap (1986)	Kuttner output gap (1994)
Inflation (−1)	0.84***	0.357***	0.333***	0.330***
Dummy (1994)	0.294***	0.286***	0.296***	0.297***
Output_gap(−1)	-	$-1.688\ 10^{-5}$	$3.603\ 10^{-6}$**	$3.666\ 10^{-6}$**
Constant	0.015*	0.017**	0.014**	0.014**
Adjusted R^2	0.852	0.851	0.884	0.887

Source: Author from CBWAS data, 2016. *,**,***: Significant respectively at the threshold of 10%, 5% and 1%

Estimates by both methods of unobservable components provide more conclusive results. In fact, the delayed output gap is significant at the threshold of 5% and is positive. This sign conforms to the expected theoretical sign. There is also an improvement of the R^2 compared to the benchmark model (0.884 and 0.887 compared to 0.852 for the benchmark model). In order to refine the comparison between the methods, relative RMSEs[9] were calculated on the basis of the forecast on the period (2010-2015). In order to ensure the quality of the forecasts, the CUSUM tests were carried out. The results reveal as much for the benchmark model as for the different alternative models a structural stability of the coefficients. The results are given in Annex 3.

Table 3 presents the relative RMSEs obtained by the different approaches. Estimates show that the output gap obtained by the production function predicts less inflation than the benchmark model. In contrast, the Watson (1986) and Kuttner (1994) approaches have relative RMSEs of <1; which means that the output gap resulting from these methods predicts better inflation than the benchmark model.

En plus, de la comparaison par rapport au modèle benchmark, le RMSE relatif permet également une comparaison entre les méthodes (le dénominateur étant le même). Ainsi, nous retrouvons en tête la méthode de Kuttner (1994) suivi de celle de Watson (1986) puis de la fonction de production. La méthode de Kuttner (1994) semble donc être la meilleure méthode d'estimation de l'output gap permettant de mieux prédire l'inflation.

In addition, from the comparison with the benchmark model, the relative RMSE also allows a comparison between the methods (the denominator being the same). Thus, we find in the first place the Kuttner method (1994) followed by that of Watson (1986) and then the production function. Kuttner's (1994) method therefore seems to be the best method of estimating the output gap, making it possible to better predict inflation.

The next section is devoted to a robustness analysis in order to verify whether the Kuttner (1994) method is actually better than Watson's (1986) and the production function, but also to refine the comparison of the previous methods with respect to benchmark.

As described in the methodology, the results of the comparison test of the different methods to the benchmark model appear in Table 4.

The results indicate that we cannot reject at the 5% threshold the null hypothesis in any of the cases (all calculated statistics are higher than those observed). Thus, there is not enough statistical evidence to conclude that the output gap estimated by the production function method, by Watson (1986) or Kuttner (1994), improves the forecast of inflation relating to the benchmark model. Thus, we cannot conclude significantly that one of these methods is better in terms of forecasting inflation.

Table 5 presents the results of the tests on the comparison of the methods of estimating the potential production between them.

9 Confère's methodology.

Table 3: Relative RMSE results

	Production function	Watson (1986)	Kuttner (1994)
RMSE Relative	1.404	0.957	0.946

Source: Author from CBWAS data, 2016

Table 4: Hypothesis test results for benchmark comparison

Alternative hypothesis	Stat. cal.	Stat. obs.
Output gap obtained by the production function does not improve the inflation forecast as the benchmark	0.404	−0.097
Output gap obtained by Watson (1986) does not improve the inflation forecast as the benchmark	−0.043	−0.123
Output gap obtained by Kuttner (1994) does not improve the inflation forecast as the benchmark	−0.054	−0.139

Source: Auteur from CBWAS data, 2016

Table 5: Results of hypothesis tests relating to the comparison of the different methods between them

Alternative hypothesis stat. obs.	Stat. cal.	Stat. obs.
Watson (1986) strictly better than production function −0.447−1.126	−0.447	−1.126
Kuttner (1994) strictly better than the production function −0.458−1.141	−0.458	−1.141
Kuttner (1994) strictly better than Watson (1986) −0.011−0.209	−0.011	−0.209

Source: Auteur from CBWAS data, 2016

As previously, for the three tests, the calculated statistics are higher than those observed at the 5% threshold. Thus, we cannot conclude as to the superiority of one method over the other in terms of forecasting inflation.

Thus, the robustness analysis contrasts with the results of the previous section and shows that no unobservable component method used for this study (Watson, 1986 and Kuttner, 1994) used to estimate the output gap is better than the production function.

5. CONCLUSION

This work provides an estimate of potential output for WAEMU countries using unobservable component methods but also offers a comparison with the production function. Potential production was estimated by the production function but also by two methods with unobservable components: The method of Watson (1986) and that of Kuttner (1994). Two criteria are used for the comparison: A qualitative criterion and a quantitative one. The qualitative criterion chosen is to choose the method whose output gap makes it possible to reproduce the economic cycle of the Union: The ability of the output gap to coincide with the periods of known shocks or recovery in the economy. The quantitative criterion is to retain the method that most improves the forecast of inflation based on a model of production gap. To ensure the robustness of the results obtained, additional statistical tests are proposed.

The results show that the different methods used to estimate potential output similarly reproduce the economic cycle of the

Union, even though with different magnitudes. The qualitative criterion was therefore inconclusive. The comparison according to the quantitative criterion reveals that it is the estimated output gap with Kuttner's approach (1994) that makes it possible to better predict inflation. It is followed by the method of Watson (1986) and that of the production function. It also reveals the non-significance of the output gap obtained by the production function on inflation. This result is contrary to that of Diop (2000) and Abou and Melesse (2012) and challenges the use of this method as the one producing an output gap to better explain inflation. However, the robustness analysis reveals that there is not enough statistical evidence at the 5% threshold to conclude that the output gap obtained by any of the methods proposed in this study would improve the forecast of the inflation and indicate the superiority of one method over the other.

Considering the previous results, we propose to the Central Bank of the Union an estimate of the output gap using Kuttner's (1994) approach which not only explains inflation best, but also improves its prediction with respect to benchmark model.

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ANNEX

Annex 1: The State-space Models and the Kalman Filter

As introduced by Durbin and Koopman (2012) in their book "Time Series Analysis by State Space Methods," state space modeling provides a comprehensive methodology for dealing with several kinds of problems encountered in estimating time series. In this model, it is assumed that the evolution in time of the studied system, is determined by a series $\alpha_1,\ldots,\alpha_n$ with which is associated a series of observations $y_1,\ldots,y_n$; the relation between α_t and y_t being specified by a state space model. The main purpose of the state-space model is to dynamically determine the unknown vector α_t through the knowledge of y_t.

The general Gaussian state space model can be written as follows:

$$\begin{aligned} y_t &= Z_t\alpha_t + \epsilon_t, \epsilon_t \sim N(0, H_t) \\ \alpha_{t+1} &= T_t\alpha_t + R_t\eta_t, \eta_t \sim N\left(0, Q_t\right) \end{aligned} \quad (6)$$

t=1,…,n where, y_t is the vector of the observations, α_t the unobservable component called the state vector. The first equation of (6) is called the equation of observations and the second is the equation of state. Z_t, T_t, R_t, H_t and Q_t are matrices whose initial values are assumed to be known. The errors ϵ_t and η_t are assumed to be iid and not autocorrelated with each other.

The estimation of the model (6) is done recursively. Everything starts from the assumption that α_t~$N(a_1, P_1)$ with a_1 and P_1 known. The Q_t and H_t parameters are also assumed to be known. On this basis, it is sought the distributions of α_t and α_{t+1} knowing Y_t où $Y_t = \left(y_1^{'}, \ldots, y_t^{'}\right)^{'}$ the distribution of α_t conditional on Y_{t-1} being $N(\alpha_t, P_t)$. By putting $a_{t|t}=E(\alpha_t|Y_t)$, $a_{t+1}= E(a_{t+1}|Y_t)$, $P_{t|t}=Var(\alpha_t|Y_t)$, et $P_{t+1}=Var(\alpha_{t+1}|Y_t)$ the respective conditional distributions of α_t and α_{t+1} are given by $N(a_{t|t},P_{t|t})$ and $N(a_{t+t},P_{t+t})$. By putting $v_t=y_t-E(y_t|Y_{t-1})$, we et $v_t=y_t-Z_t\, a_t$ because:

$$E(y_t \mid Y_{t-1}) = E(Z_t\, \alpha_t + \epsilon_t \mid Y_{t-1}) = Z_t\, a_t \quad (7)$$

Because $E(\epsilon_t|Y_{t-1})$=0 and $E(\alpha_t|Y_{t-1})=a_t$. And by putting $F_t=Var(v_t|Y_{t-1})$, we get by some calculations the following recursive algorithm:

$$\begin{aligned} v_t &= y_t - Z_t a_t; F_t = Z_t P_t Z_t^{'} + H_t; a_{t|t} = a_t + P_t Z_t^{'} F_t^{-1} y_t \\ P_{t|t} &= P_t - P_t Z_t^{'} F_t^{-1} Z_t P_t; a_{t+1} = T_t a_t + K_t v_t; P_{t+1} = T_t P_t \left(T_t + K_t Z_t\right)^{'} + R_t Q_t R_t^{'} \end{aligned}$$

For = 1,…,n and $K_t = T_t P_t Z_t^{'} F_t^{-1}$ with a_1 and P_1 the average and variance of the initial parameter α_1. It is this recursive algorithm that we call the Kalman filter.

Annex 2: Estimated Values for the Parameters of Unobservable Component Models

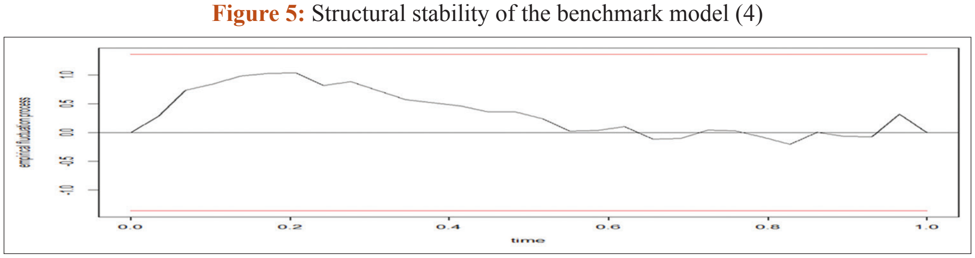
Table 6: Maximum likelihood estimate coefficients of the Watson (1986) and Kuttner (1994) approaches

Coefficient	Watson (1986)	Kuttner (1994)
δ_1	-	116.6
φ_1	−1.33	55.54
φ_2	1.78	−57.12

Source: Author from CBWAS data, 2016

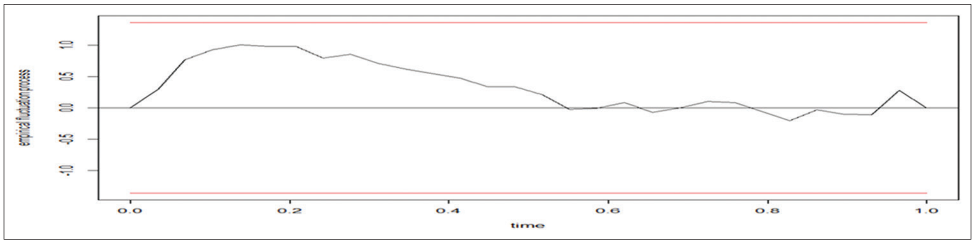
Annex 3: Structural Stability Test Results on Inflation Models

Figure 5: Structural stability of the benchmark model (4)



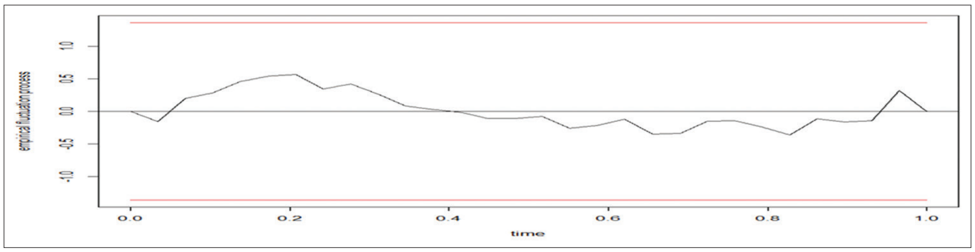
Source: Author from CBWAS data, 2016

Figure 6: Structural stability of the model (5) with the output gap of the production function



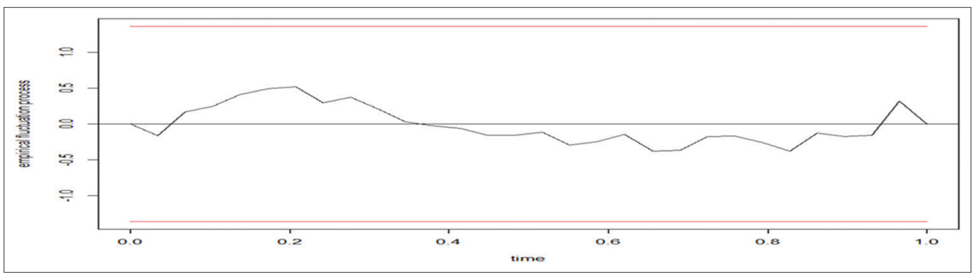
Source: Author from CBWAS data, 2016

Figure 7: Structural stability of the model (5) with Watson's output gap (1986)



Source: Author from CBWAS data, 2016

Figure 8: Structural stability of the model (5) with Kuttner's output gap (1994)



Source: Author from CBWAS data, 2016