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ESTIMATION AND ANALYSIS OF THE OUTPUT GAP FOR THE SAUDI ECONOMY; ECONOMETRIC STUDY (1970-2016)

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ABSTRACT

This study highlights the important role plays by the output gap as guidance to the policymakers and macroeconomic decisions. There are two aims for this paper: firstly, it measures and estimates the output gap and secondly, it identifies and analyses the determinants of the economic output gap for the Saudi Arabian economy over the period 1970-2017. This paper uses the HP filter and the new form of production function methods to measure the output gap as the production function method gives more accurate results in calculating the output gap by basing the GDP gap on the sum of production factors gaps. The Autoregressive Distributed Lag (ARDL) cointegration approach and bounds test was applied to determine the factors responsible for this output gap and the Error Correction Model indicated the convergence towards long-run equilibrium. The findings showed the existence of a positive and negative cointegration relationship in the long run between the output gap and its estimated determinants whereby the public sector investment, import expenditure, and higher secondary enrollment have a positive relationship, while the money supply and export earnings have a negative relationship.

Contribution/ Originality: This study is one of few studies that measures and estimates the output gap in the Saudi Arabian economy which is currently undergoing structural transformations to diversify income sources within the Vision 2030 framework. This study has investigated a long-run equilibrium relationship between the output-gap and its estimated determinants.

1. INTRODUCTION

The concepts of potential output and the output gap are useful to the policy makers in providing guidance to macroeconomics decisions for all countries over the world. The output gap is a summary measure of the difference between the economy's output level that would be expected if the economy were at its most efficient – that is, at full capacity (potential GDP) and the actual level of output (real GDP).

The government, public institutions, central banks, and international organizations are all interested in the estimation of the output gap. This is due to several reasons. The first reason is the financial crisis, which started in

2008 in the US and spread to EU and many another countries, causing a great recession, with interest rates nearing zero. Secondly, at the moment many countries are undergoing fiscal consolidation and output gap measures are needed for cyclical estimates for indicators of fiscal policy, Summers (2014). The third reason is that output gap estimates are used in the calculation of structural fiscal balance indicators which are subsequently used for measuring economic growth and stability. Fourthly, the estimation of output gap has an important role in understanding inflationary dynamics and enhancing its measurement, Alvarez and Gómez-Loscos (2018). The fifth reason is that, studying the developments in the output gap can predict two effects: (a) a positive output gap which will create macroeconomic pressures in the form of excess demand in goods and labor markets, eventually generating upward pressure on the inflation rate or (b) a negative output gap which is usually accompanied by falling prices, Alkhareif and Alsadoun (2015).

Saudi Arabia is known as the largest oil producer globally and still continues to rely on oil as the primary source of income. Therefore, it suffers from instability due to world oil price shocks. This requires finding a way to identify and measure these fluctuations. The output gap is the best way to do this.

This paper has two aims: firstly, it measures and estimates the output gap for the Saudi Arabian economy, and secondly, it identifies and analyzes the determinants of the economic output gap.

The paper is organized as follows: an introduction in section one, a summary of the theoretical and empirical literature on the subject in section two, the calculation of the output gap in section three, the methodological framework and data and variables in section four along with the results and approach and a conclusion in section five.

2. A BRIEF REVIEW OF THE THEORETICAL AND EMPIRICAL LITERATURE

Two categories of methodology (See Table 1 below) have been used in economic literature for estimating the potential output and the associated output gap: the non-structural methodologies, which are not based on economic theory but based on statistical procedures; and the structural methodologies, which are based on economic foundations. The most well-known non-structural univariate methods are the linear detrending, the Hodrick-Prescott Filter, the Band-Pass filter, the Beverige-Nelson Decomposition, and the Unobservable Component (UC) method (Shahrier and Lian, 2014).

The structural methods are based on specific economic foundations. The most well-known methods are based on the Okun's Law, the production function approach, the long-run restrictive models, and the NK-DSGE models (Alvarez and Gómez-Loscos (2018)).

Table-1. Various estimation methods.

Estimation Methods and Models		
Non-structural methodology	Univariate Methods	Linear Trend Univariate State Space Hodrick-Prescott (HP)
	Multivariate Methods	Multivariate Kalman Filter (MVKF) Multivariate Filter (MVF)
structural methodology	Structural Methods	Structural Vector Autoregression (SAVR) Cobb-Douglas Production Function (CDPF)

Source: Shahrier and Lian (2014).

The main advantages and disadvantages of each group of methodologies are discussed below. Special attention is given to the production function, which is based on the economic theory approach and adopted by many institutions like the European Commission for the surveillance of the EU member states, Central Bank of Japan and other Central Banks in the rest of world.

Many applied studies have been concerned with estimating and analyzing the output gap as an important tool of economic policy. The following are some of these studies:

By examining and testing methods based on univariate and multivariate statistical filters and principal components analysis and identifying plausible estimates of Ireland's output gap that are relevant for fiscal policy, Casey (2018) finds that the results produce more plausible estimates than the commonly agreed methodology's estimates. The findings of this paper state that the estimates has a similar explanatory power when incorporating price expectations and inflation-targeting or when considering wage inflation instead of price inflation.

Kawamoto *et al.* (2017) explained the new methodology for calculating Japan's output gap and the potential growth rate. This study has revised the method of estimation by accounting for: (1) the time series of Japan's GDP statistics; (2) the newly available capital stock data according to 2008 SNA guidelines; and (3) structural changes taking place in labor and capital markets that should be reflected in these estimated trends.

This study has changed estimation methodology in three ways. Firstly, it revised the estimation method of the "labor force participation rate gap". Secondly, it adjusted the method for calculating the manufacturing "utilization gap" in order to reflect the economic depreciation of equipment and structures more appropriately. Finally it identified the persistent decline in working hours over recent years as more of a structural development possibly due to changes in people's working styles which revised the estimation method of the "hours worked gap,". It also showed that the result of the potential growth rate shows a significant upward revision for the last few years, mainly reflecting a rise in the TFP growth rate associated with the revision of the GDP statistics.

Shahrier and Lian (2014) estimated Malaysia's Output Gap and presented three methods to estimate the output gap for the Malaysian economy: univariate, multivariate and structural. They attempted to also contribute more by providing an evaluation of each model in estimating potential output and the output gap, and the usefulness of each model in terms of assessing the drivers of future potential output, predicting price trends and identifying sources of inflation in the economy. The study's findings show, that by predicting long-term drivers of growth, the CDPF framework which is supported by theory, appears to be a more useful model. The SVAR method can be utilized to identify the source of inflation so that appropriate policies can be implemented to control inflation. In the paper, Shahrier and Lian (2017) find that the diversity in the results produced by the different models offers policymakers different perspectives on the dynamics of growth and the degree of excess capacity and price pressure in the economy. The structural model shows that input driven growth is not sustainable going forward. This study recommended, that Malaysia like other ASEAN economies will need to focus on productivity driven growth.

To estimate the output gap for Pakistan economy, Tahir and Ahmad (2017) had a comprehensive review and study conducted to estimate the potential output and the output gap, while avoiding the shortcomings found existing relevant literature. The study's findings indicate a decline in the potential output growth of Pakistan from 2009 to 2013 which has increased the economy's vulnerability by making it more susceptible to demand shocks. Forecasts for the output gap on quarterly and annual frequencies for 2017 is also presented as portraying an upbeat aggregate demand going forward.

Alkhareif *et al.* (2017) aimed to estimate annual potential output growth and the output gap for the Saudi Arabian economy over the period 1980 to 2015, looking at both total output and non-oil output. It also aimed to study the progress of diversifying the economy and measure the possible impact of diversification on potential output. It used three methods for estimating potential output: the Hodrick-Prescott filter, the Kalman filter and the production function approach. The study's findings suggest that the output gap is positive on the average over the entire period; however, the gap has turned negative and has shrunk in recent years. The findings also proved that growth in both potential GDP and total factor productivity has accelerated in the 2011-2015 period. On the other hand, the growth of these factors has declined in many other countries, especially developed economies.

Alichi (2015) estimated the output gap in the United States, by adopting an extension of the methodology developed by Blagrave *et al.* (2015) for the U.S. economy. The study's findings show that the output gap has greatly reduced since the Great Recession but still remains negative. Although this study has achieved better results than its predecessor, there is still considerable uncertainty surrounding the estimates. This study used a methodology consisting of filtering techniques, the use of reduced-form economic relationships, and the use of survey data on growth and inflation expectations. Its findings were more robust than simple SV filtering techniques, as the end-of-sample problems were largely tackled in the MV filtering model used. Alichi (2015) recommended that: "Future work could focus on introducing global and financial imbalances into this MV filtering model, because large and persistent imbalances indeed imply that a closed-economy model could provide gravely incorrect paths of potential output".

To identify the output gap in the Polish economy, Hulej and Grabek (2015) used the indicator of resource utilization (RU) based on survey and labor market data. And it gives a similar picture of the historical developments of the resource strain in the Polish economy to the other gap measures used at the Narodowy Bank Polski. By using a real-time dataset, this paper found that the output gap constructed in this way is revised to a similar or (in recent years) lesser extent than a measure based on the structural approach and Hodrick Prescott filter. This paper also proved that the output gap based on the RU indicator performs comparably to other approaches as a proxy of inflation pressure.

Berger (2011) aimed to estimate potential output, the natural rate of unemployment, the core inflation rate, and the corresponding gaps for the Euro area. The study used an empirical model consisting of a Phillips curve linking inflation to unemployment and to link the output gap to cyclical unemployment in a relationship; it used an Okun-law model. This model is also based on new developments in the models of unobserved components by allowing: (1) the correlation between shocks at normal rates and corresponding gaps and (2) structural restraints in the deviation of potential output and the normal rate of unemployment. The results of the study showed that there is a one-time large shift in the growth rate of potential output in 1974's first quarter. The results presented here are also in line with the production function approach in estimating natural rates.

Economic literature has several theoretical and applied studies dealing with measuring the output gap because of its importance as a tool in economic decision-making. We note from the previous studies on the output gap in many countries that most of the studies were limited to measure the output gap using several methods. Most of those studies preferred the method of the production function, which was used by most recent studies related to measuring the output gap. We also note the paucity of studies that dealt with output gap analysis and research on determinants. Thus, we were interested in running this study to estimate the output gap of Saudi Arabia using production function and to analyze its determinants based on the ARDL approach of co-integration relationships.

3. SAUDI ARABIA'S OUTPUT GAP CALCULATION AND ECONOMETRIC ANALYSIS

In this part, we first calculate the output gap using HP-filter and production function methods, and secondly, we estimate the contributions of the same determinants of the GDP gap.

The output gap ($OutGap_t$) is an economic measure of the difference between the actual output (Y_t) and potential output (Y_t^*). A positive output gap means that growth is above the trend rate and is inflationary. A negative output gap means that there is an economic downturn with unemployment. As considered by Berger (2011) the output gap is modelled according to Watson (1986) and Clark (1987); Berger (2011) as follows:

$$OutGap_t = \frac{Y_t - Y_t^*}{Y_t^*} \quad (1)$$

Adding $\frac{Y_t^*}{Y_t^*}$ in both side of Equation 1 as $1 + OutGup_t = \frac{Y_t}{Y_t^*}$ and applying the logarithm[1] we obtain the Equation 2.

$$OutGap_t = y_t - y_t^* \tag{2}$$

Where $y_t = Ln\, Y_t$, $y_t^* = LnY_t^*$

3.1. Output Gap Calculation by Using H-P Filter and Production Function.

Two categories of the methodology are used in economic literature: the non-structural methodologies, based on statistical procedures and the structural methodologies, based on economic foundations. The main advantages and disadvantages of each group of methodologies are discussed in the economic literature Benes and N'Diaye (2004); Shahrier and Lian (2017). Special attention is given first to the HP filter (Hodrick and Prescott, 1997) than the production function methodologies, which are based on economic theory approach and adopted by many institutions likes the European Commissions for the surveillance of the EU member states, the Central Bank of Japan, and many other institutions (Kawamoto *et al.*, 2017); (Shahrier and Lian, 2017).

3.2. Output Gap Calculation Using the HP Filter

In the economic literature, many studies show that the HP filter method is one of the simple and most widely used methods for detrending macroeconomic time series. In this method, the long-term trend of the desired variable is obtained using actual data. It mainly depends on using a long-run, symmetric, moving average to reduce real output yt (Polycarpou, 2015). The tendency is obtained by reducing the cycle of actual data around the trend, by minimizing the following function:

$$\sum(ln\, y_t - ln\, y_t^*)^2 + \lambda \sum[(ln\, y_{t+1}^* - ln\ \ y_t^*) - (ln\, y_t^* - ln\, y_{t-1}^*)]^2 \tag{3}$$

Where; y^* is the long-run tendency of the variable$y$. The coefficient λ is an exogenous detrending parameter that sets the degree of smoothness of the trend (i.e. how responsive potential output (y_t^*) is to movements of actual output (y_t)). Because the HP filter is used for annual data, λ takes the value 100[2].

These methods of estimation used Saudi Arabian data such as total GDP, oil sector GDP, and non-oil sector GDP, at constant prices (2010=100) (Million Riyals). The result was summarized in Table 1 (in the appendices) and presented in the Figure 1 and Figure 2 below.

[1]Using here, the relationship that ln(1 + x) ≈ x if x is close to zero, to calculate the left-hand side of Equation 1.

[2]The standard in the literature shows that the λ value for the HP filter can often be selected freely depending on the desirable smoothness of the final trend. The λ value equal to 1 600, if the HP filter is used for quarterly data, and from 100 to 10 for annual data.

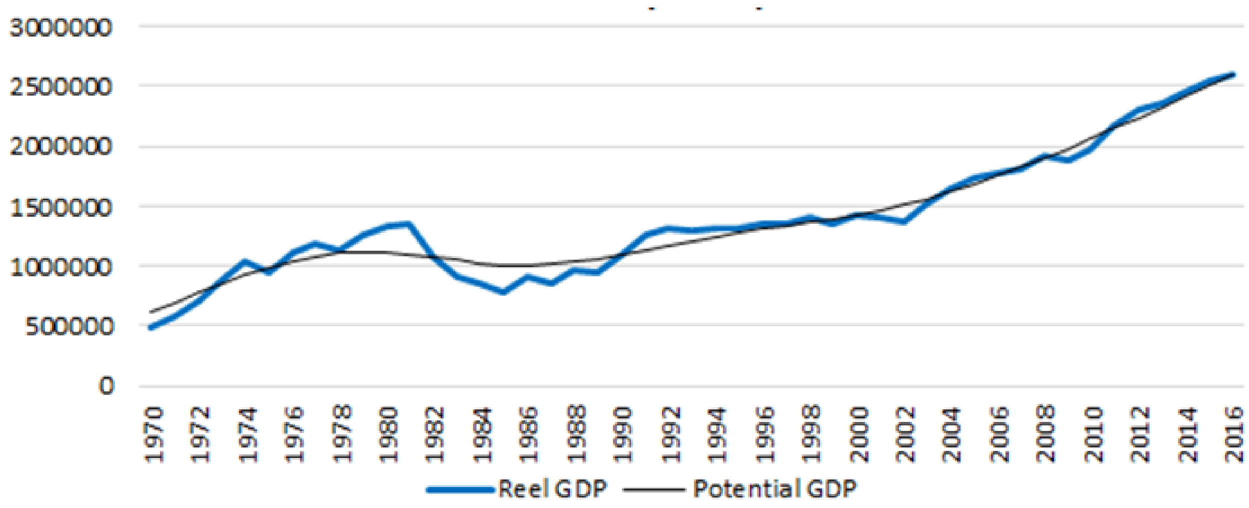

Figure-1a.Total Output Gap.

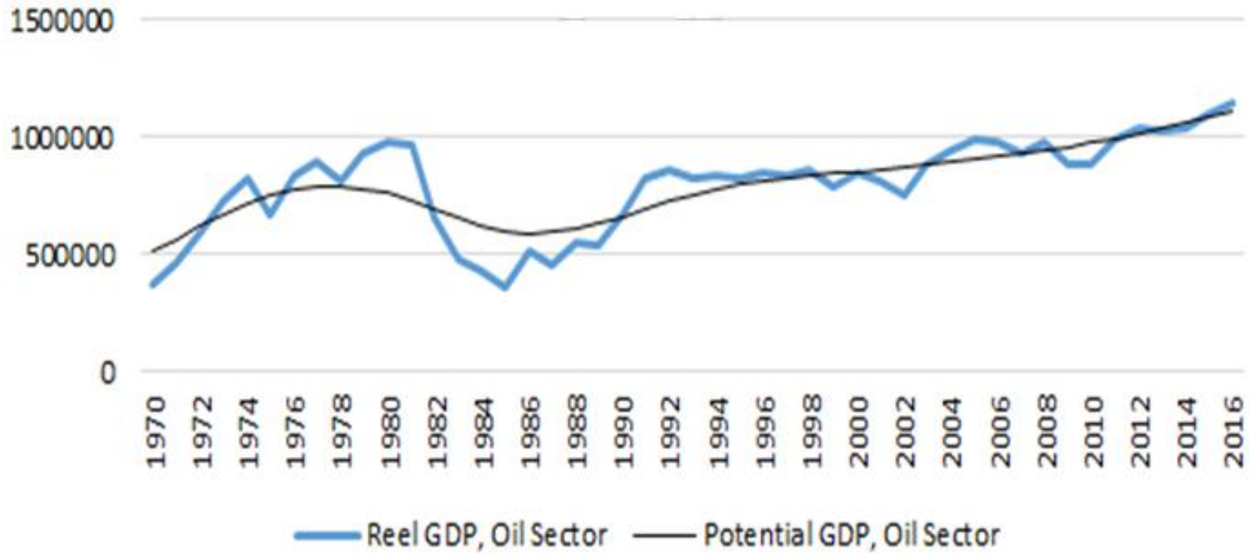

Figure-1b. Output Gap and Oil Sector.

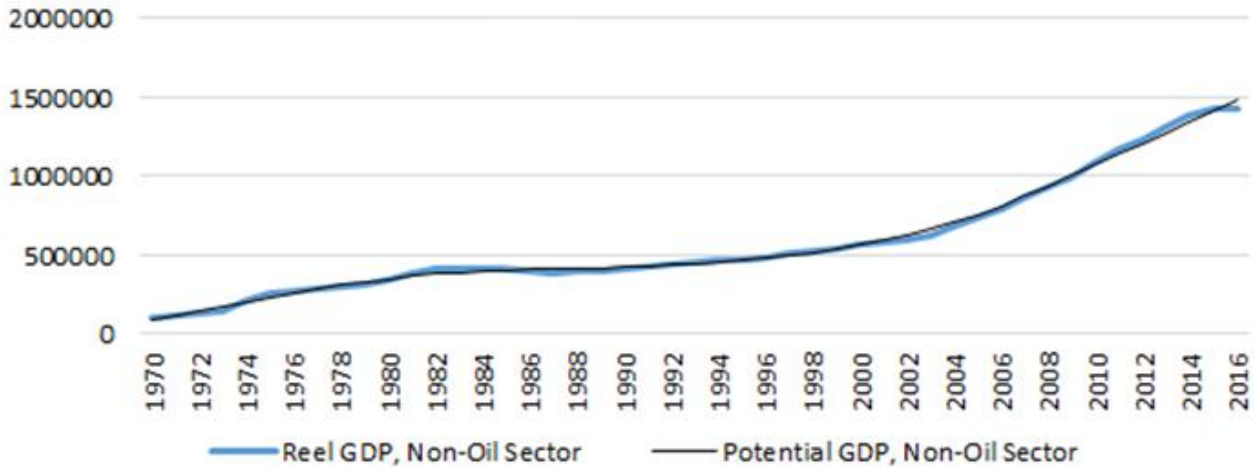

Figure-1c. Output Gap and Non-Oil Sector.

Notes Fig1a to Fig1c: (i.e. Output Gap = Real GDP - Potential GDP) and (Real and potential GDP, at constant prices of 2011, in millions of SAR. Using HP-filter approach, with smoothing parameter $\lambda = 100$.)

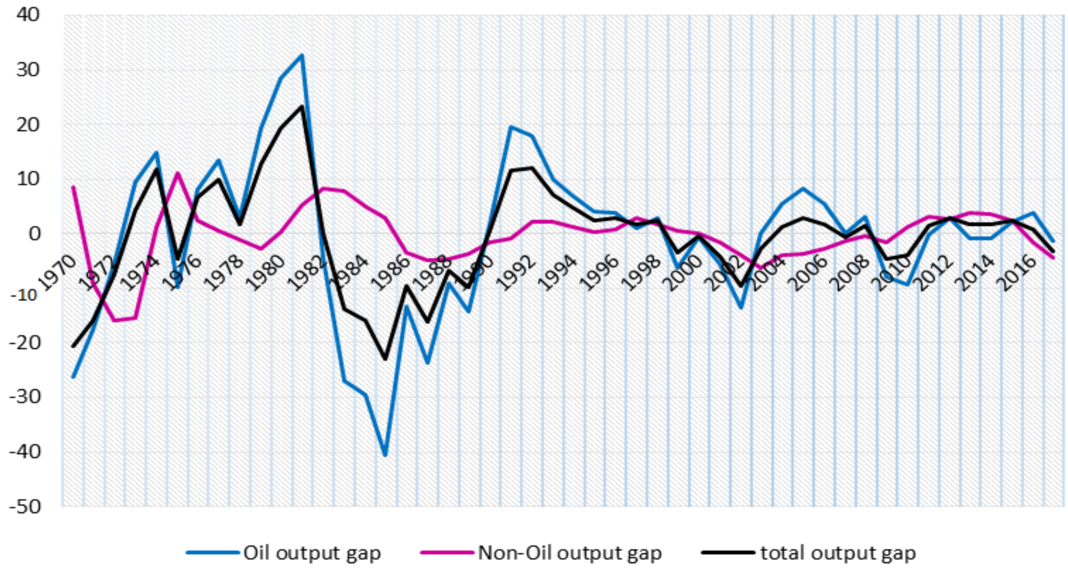

Figure-2. KSA Output Gaps 1970 – 2017.

The result obtained by using HP method and showed in Table 1 (in the appendix) and presented in Figure 1 a, b, c agrees with the main hypothesis of the study: that there are negative and positive output gaps in Saudi Arabia during the period (1980-2017). These gaps are more clearly present in the oil sector Figure 1 b than the non-oil sector Figure 1 c. This result can be explained by the volatility in the oil price.

In the last decades, the widening of the gap between potential and actual output especially for the non-oil sector has been increased due to volatility in oil prices. Lower oil prices cause less government oil revenue and consequently lower levels of capital investment and infrastructure development. Ultimately, this leads to a reduction in the rate of growth. For more details and precise calculations about output gap measurement, we use the second method of estimation mentioned before (production function approach).

3.3: Output gap for the Saudi Arabian economy: a model-based production function approach

The calculation of the output gap in Saudi Arabia is based on the production factors as used by Danielsen *et al.* (2017). The two classic production factors used are capital stock and labor. The capital stock is the buildings, machines and other equipment used in production, while labor is the number of people in employment (Fox and Zurlinden, 2006).

According to the production function in macroeconomics, GDP is obtained from the interrelations of three variables: (i) labor input (L); (ii) capital input (K); and (iii) the efficiency with which these factors are used, namely TFP (A). We assume the following relationship for convenience:

$$Y_t = A_t L_t^{\propto} K_t^{\beta} \quad (4)$$

Taking the logarithm of both sides of the equation provides the following relationship:

$$y_t = tfp_t + \alpha l_t + \beta k_t \quad (5)$$

Under the assumption of the Cobb–Douglas production function, it is known that elasticity α of labor input to GDP equals labor share in equilibrium[3]. Therefore, using Equation 5, it is easy to calculate the change in α_t, TFP

[3] The notation is standard: Y_t is output, L_t labour, K_t capital, A_t characterizes Total Factor Productivity, and α, β are the elasticities of labour and capital, respectively. Given that, typically, the sum of the values of α and β are set equal to unity, Billmeier (2004).

growth or the growth rate of total factors productivity, from the observed change in y_t, l_t, k_t, which is the growth rate of Y_t, L_t, K_t.

- As already mentioned, the physical capital stock (K_t) is calculated using the investment data available through the permanent Inventory Method as follow:

$$K_t = I_t + (1-\delta)K_{t-1} \quad (6)$$

Where δ is the annual capital stock depreciation rate. In this study (δ= 0.05) similar in many other studies[4] .

The initial capital stock (K_0) is calculated for the first year, for which gross fixed capital formation data is available (I_0) (Sallam and Neffati, 2016). We used the hypothesis that capital stock at time zero is positively correlated with investments in the following year and inversely related to the average annual growth rate of GDP and depreciation rate. It was calculated in the same way as in formula:

$$K_0 = \frac{I_0}{(g+\delta)} \quad (7)$$

Where g is the average annual growth rate of the aggregate product and δ the depreciation rate.

- The Human capital stock term was constructed following Barro and Lee (1994) methodology based on educational attainment, then used by Senhadji (1999) to estimate Sources of Economic Growth. According to these researches, H_t is written as follows:

$$H_t = L_t P_t e^{r*s} \quad (8)$$

Where; H_t: human stock, L_t: labor force (persons employed, in thousands of persons), P_t: participation rate, r: average years of schooling, and s: schooling rate (education index).

Table-2. Output estimation of the classical production function.

Dependent Variable: LOG(GDP)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	12.26772***	0.781952	15.68858	0.0000
LOG(L)	0.451402***	0.019234	23.46904	0.0000
LOG(K)	0.283176***	0.028317	10.00030	0.0000
R-squared	0.934764			
F-statistic	322.4015	Durbin-Watson stat		0.610103
Prob(F-statistic)	0.000000			
Included observations: 48				

According to Table 2, the output estimation indicates that the elasticity of labor factors (L) of productions is α = 0.4514.

The same formulation of the production function can be applied to the potential GDP, i.e., the aggregate average supply capacity obtained by smoothing out the business cycle.

$$Y_t^* = TFP_t^* \, L_t^{*\alpha} K_t^{*\beta} \quad (9)$$

Taking the logarithm of both sides of the equation provides the following relationship:

[4] Sherbaz, Amjad and Khan (2009).

$$y_t^* = tfp_t^* + \alpha l_t^* + \beta k_t^* \quad (10)$$

Here, a change in Equation 5 gives the potential growth rate and then subtracting Equation 10 from 5, we obtain:

$$y_t - y_t^* = (tfp_t - tfp_t^*) + \alpha(l_t - l_t^*) + \beta(k_t - k_t^*) \quad (11)$$

Combining Equations 2 and 11, we arrive at the output gap time series as follows[5]:

$$OutGap_t = (tfp_t - tfp_t^*) + \alpha(l_t - l_t^*) + \beta(k_t - k_t^*) \quad (12)$$

$$mean\ that: OutGap_t = TFP_{gap} + L_{gap} + K_{gap} \quad (13)$$

The result of the Equation 13 was given in Table 2 (in the appendix). The different gaps which compound the total output gap are presented in Figure 3 and Figure 4.

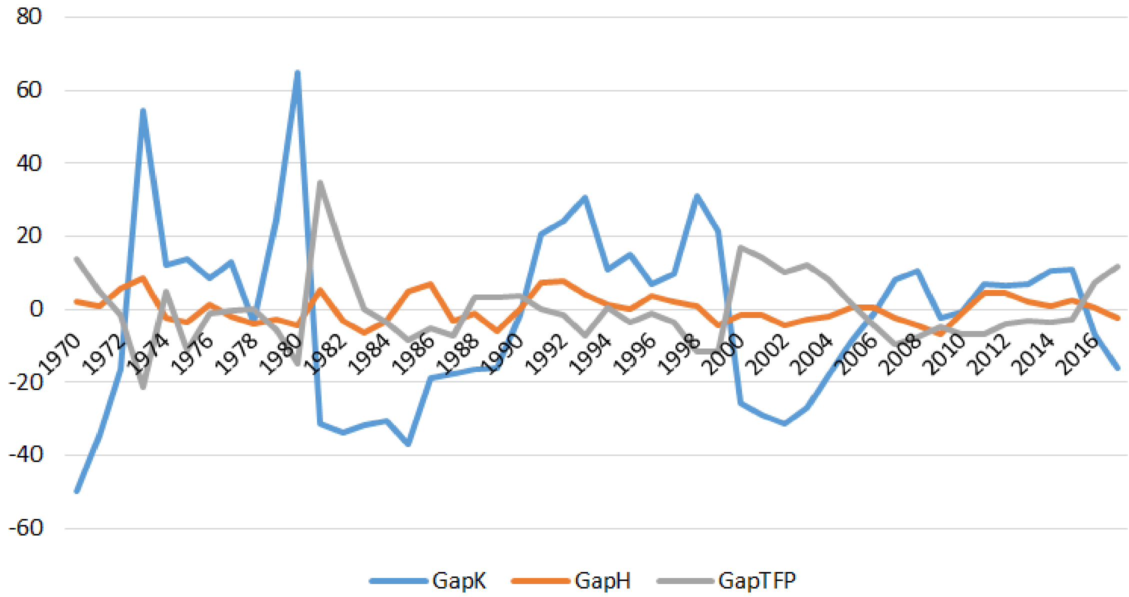

Figure-3. Gaps Component Total Output Gap.

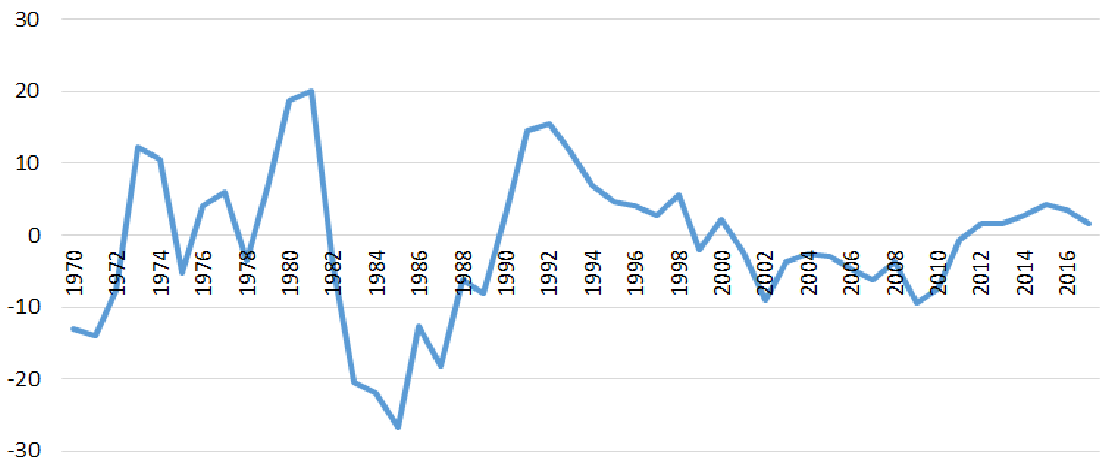

Figure-4. Saudi Arabian Output Gaps, Cobb-Douglas Production Function (1970-2017).

[5] Because of the lack of data, the Labor input gap could not be calculated in the following manner: Labor input gap ($l_t - l_t*$) can be calculated as the sum of labor force input gap ($pt - pt*$), employment rate gap ($e_t - e_t*$) and hours worked gap ($h_t - h_t*$). For more details look Kawamoto, Ozaki, Kato and Maehashi (2017)..

The result obtained by using Cobb-Douglas method and showed in Table 2 (in the appendix) and presented in Figures 3, 4, and 5 agrees with the main hypothesis of the study and also emphasizes the results obtained by HP-filter method.

Figures 3 and 4 shows that the Saudi Arabian economy achieved positive gaps which mean that there was inflation throughout the study period (1970-2017) except for two years of 1975 and 1978 respectively and two periods 1982-1989 and 2001-2011 that have negative gaps due to an economic downturn.

To explain these positive and negative gaps we need to test the relationship between the output gap and some macroeconomic variables that may be influencing those gaps. This is the objective for the next section of this paper.

4. ESTIMATION AND ANALYSIS OF OUTPUT GAP IN KSA

This part of the study is interested in estimating macroeconomic variables that theoretically affect the output gap in Saudi Arabia using macroeconomics time series data covering the period, 1970 – 2017. The data used are obtained from the World Bank and the Saudi Arabian Monetary Authority (SAMA) statistics.

There are many studies which attempt to find the main determinant of the output gap (i.e. Sherbaz *et al.* (2009)). To determine which variables have an effect on the output gap, we will use the equation below:

$$\mathrm{OutGap}_t = \propto_i + \beta_{it} \sum_{i=1}^{k} X_{it} + \mathrm{u}_t \tag{14}$$

Where, OutGap_t is the output gap given by Equation 13 using production function method, X_i represents the determinants variables of output gap. Such as;

i. PI_t= public sector investment

ii. EX_t= export earnings

iii. IM_t= import expenditure

iv. HSE_t= higher secondary enrollment

v. MS_t= money supply

vi. μ_t = stochastic error term

Equation 14 can be written easily as follows:

$$OG_t = \alpha_0 + \alpha_1 PI_t + \alpha_2 EX_t + \alpha_3 IM_t + \alpha_4 HSE_t + \alpha_5 MS_t + \mu_t \tag{15}$$

To analyze the determinants of output gaps (OG_t), many methods have been suggested in the econometric literature for investigating the long-run equilibrium relationship between variables. To choose the suitable methods of estimation, we first do a unit root test for all variables to choose the suitable model for estimation based on the variable's integration degrees.

4.1 Methodology: Tests and Estimations

a- Unit Root Test

These are the stationarity analysis results of variables.

Table-3. Stationarity test.

Variables	Test equations	In level: I(0)	In First difference: I(1)
OG	Intercept Intercept and trend non	Stationary ,, ,,	
PI	Intercept Intercept and trend non	Non-stationary Non-stationary Non-stationary	Stationary
EX	Intercept Intercept and trend non	Non-stationary Non-stationary Non-stationary	Stationary
IM	Intercept Intercept and trend non	Non-stationary Non-stationary Non-stationary	Stationary
HSE	Intercept Intercept and trend non	Non-stationary Non-stationary Non-stationary	Stationary
MS	Intercept Intercept and trend non	Non-stationary Stationary ,,	

According to the stationarity analysis results of variables in Table 3 the ARDL approach is the appropriate method for output gap estimation.

The autoregressive distributed lag (ARDL) modeling approach, was originally proposed by Pesaran and Shin (1998). The main advantage of ARDL modeling lies in its flexibility when the variables are of a different order of integration. The ARDL model used in this study is expressed as:

$$\Delta \ln OG_t = C + \alpha T + \beta_1 \ln PI_{t-i} + \beta_2 \ln EX_{t-\mathrm{i}} + \beta_3 \ln IM_{t-\mathrm{i}} + \beta_4 \ln HSE_{t-\mathrm{i}} + \beta_5 \ln MS_{t-\mathrm{i}} + \sum_{i=1}^{n-1} \gamma_{1i} \Delta \ln PI_{t-\mathrm{i}} + \sum_{i=1}^{n-1} \gamma_2 \Delta \ln EX_{t-\mathrm{i}} + \sum_{i=1}^{n-1} \gamma_3 \Delta \ln IM_{t-\mathrm{i}} + \sum_{i=1}^{n-1} \gamma_4 \Delta \ln HSE_{t-\mathrm{i}} + \sum_{i=1}^{n-1} \gamma_5 \Delta \ln MS_{t-\mathrm{i}} + \mu_t . \quad (16)$$

Where; the dependent variable (OG_t) is explained by exogenous variables through the short and long run relationship. β, represent the long-run parameters, while, γ, are the short run parameters. T is a time trend and (μ) refers to random error.

Based on the original papers of Engle and Granger (1987) and Johansen and Juselius (1990) the ARDL model has some advantages over other cointegration approaches (Afzal *et al.*, 2013; Sallam, 2016) as:

- the ARDL model is suitable for small or finite samples consisting of 30 to 80 observations,
- if the variables are being stationary of I(0) or I(1), there is still a prerequisite that none of the explanatory variables is off I(2) or higher order,
- The ARDL Model uses a general-to-specific modeling framework by taking a sufficient number of lags to capture the data generating process. It estimates (p+1) k number of regressions to get an optimal lag length for each variable, and
- The ARDL method can distinguish between dependent and explanatory variables and eradicate the problems that may arise due to the presence of autocorrelation and endogeneity.

b- Determination of Lags Number

Before estimating with the ARDL model and testing the existence of a cointegration relationship in the long and short run between the dependent variable and the independent variables it is necessary to know the optimal lags of all studied variables.

According to the standard AIC following lagged values (2, 2, 4, 4, 3, 0) were chosen as shown in Figure 5.

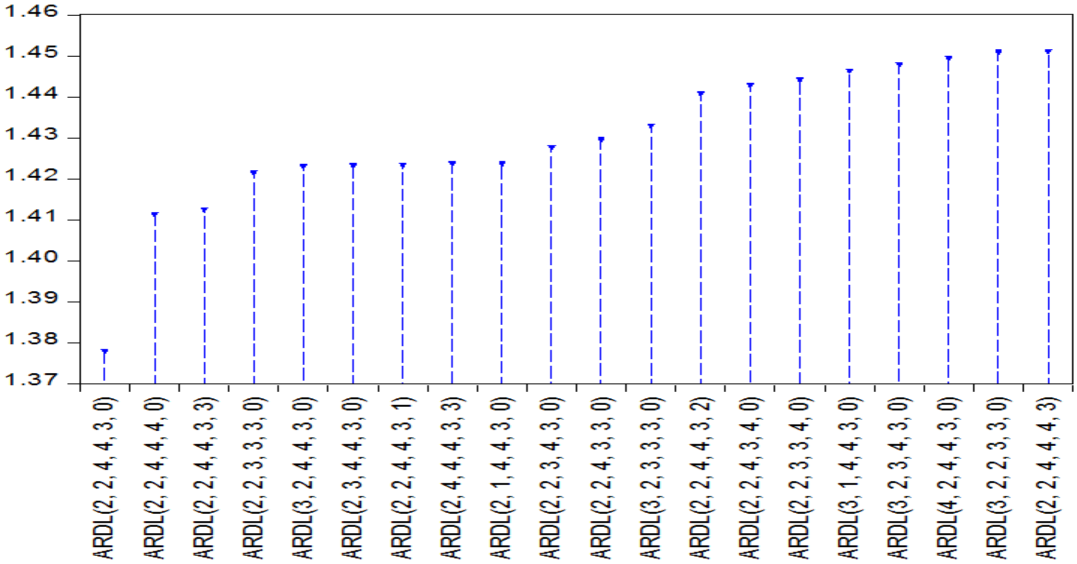

Figure-5. Akaike Information Criteria (top 20 models).

c- Bounds Tests for Cointegration

The results of the bounds test procedure for co-integration analysis between the output gap (OG) and independent variables model are presented in Table 4.

Table-4. Bounds test.

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	**Value**	**Sig.**	**I(0)**	**I(1)**
F-statistic	7.842966	10%	2.08	3
k	5	5%	2.39	3.38
		2.5%	2.7	3.73
		1%	3.06	4.15

*p-value incompatible with t-Bounds distribution.

The empirical results in Table 4 refer to a long standing relationship between OG and the other variables of the model and because the F-statistic for the Bounds Test is 7.842966, it clearly exceeds even the 1% critical value for the upper bound I(1). So, we reject the hypothesis of "no long-run relationship" or agree on the hypothesis that there is a long-run relationship.

After selecting the appropriate number of lags using Akaike's Information Criterion (AIC) and it was confirmed, by the bound test, that they have a cointegration relationship between variables of the study. We moved on to estimation with the ARDL model.

4.2. Estimation with ARDL Model

The results from the ARDL and Error Correction models (ECM) proved the existence of a long standing relationship between the output gap and the independent variables. The optimal lag length for the selected error correction representation of the ARDL (2, 2, 4, 4, 3, 0) model is determined by the Akaike Information Criterion (AIC).

Table-5a- ARDL Error Correction Regression.

Dependent Variable: D(OG)				
Selected Model: ARDL(2, 2, 4, 4, 3, 0)				
Case 2: Restricted Constant and No Trend				
ECM Regression				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(OG(-1))	-0.573682	0.083048	-6.907871	0.0000
DLOG(PI)	1.822256	0.325149	5.604365	0.0000
DLOG(PI(-1))	0.723044	0.354454	2.039879	0.0530
DLOG(EX)	0.884259	0.381736	2.316417	0.0298
DLOG(EX(-1))	4.164373	0.471277	8.836363	0.0000
DLOG(EX(-2))	1.898881	0.427993	4.436705	0.0002
DLOG(EX(-3))	0.822158	0.411032	2.000228	0.0574
DLOG(IMP)	3.062231	0.491096	6.235504	0.0000
DLOG(IMP(-1))	-2.556432	0.496811	-5.145684	0.0000
DLOG(IMP(-2))	-2.561068	0.471120	-5.436129	0.0000
DLOG(IMP(-3))	-1.060067	0.453777	-2.336098	0.0286
DLOG(HSE)	3.801281	2.551891	1.489594	0.1499
DLOG(HSE(-1))	-8.393751	2.709867	-3.097477	0.0051
DLOG(HSE(-2))	7.666898	2.277805	3.365915	0.0027
CointEq(-1)*	**-0.479658**	**0.057651**	**-8.320018**	**0.0000**

R-squared	0.894931	Mean dependent var	-0.020649
Adjusted R-squared	0.844208	S.D. dependent var	0.933153
S.E. of regression	0.368320	Akaike info criterion	1.105193
Sum squared resid.	3.934122	Schwarz criterion	1.713440
Log likelihood	-9.314255	Hannan-Quinn criter.	1.330761
Durbin-Watson stat	2.167833		
Included observations: 44			

Table-5b- ARDL Long Run Form.

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Ln(PI)	5.344638	1.414304	3.778987	0.0010
Ln(EX)	-5.823766	1.941610	-2.999452	0.0064
Ln(IMP)	8.839340	2.166054	4.080849	0.0005
Ln(HSE)	2.602675	1.136689	2.289698	0.0315
Ln(MS)	-3.691670	1.916827	-1.925928	0.0666
C	-191.6788	50.47416	-3.797562	0.0009
EC = OG - (5.3446*Ln(GFCF) -5.8238*Ln(EX) + 8.8393*Ln(IMP) + 2.6027*Ln(HSE) -3.6917*Ln(MS) -191.6788)				

According to Table 5 a,b which illustrate the results of ARDL Error Correction Regression, the value of the coefficient of the error correction model is negative and significant (-0.479658). It confirms the existence of a long-run equilibrium relationship at a significant level of 5%. This means that 0.4796 short-term errors are corrected automatically over time to achieve long-term equilibrium, and that the output gap requires approximately two years and one month (1/ 0.4796= 2.08 years) to be adjusted and corrected so that the gap between real and potential GDP will reach equilibrium.

The Regression for the underlying ARDL equation fits very well at $R^2 = 0.895$, meaning that over 89% of the output gap is explained by exogenous variables considered in the model.

The estimations result shown in Table 5b indicates the existence of a positive and negative cointegration relationship in the long run between the output gap and its estimated determinants. The public sector investment, import expenditure, and higher secondary enrollment have a positive relationship, while the money supply and export earnings have a negative relationship.

$$OG = 191.6788 + 5.3446 * Ln(PI) + 5.8238 * Ln(EX) - 8.8393 * Ln(IMP) - 2.6027 * Ln(HSE) + 3.6917 * Ln(MS)$$

4.3. Robustness Test for the Estimated Model

To be sure of the quality and the stability of the model used in estimating the determinants of the output gap, the following tests were performed (Serial Correlation LM Test, ARCH, Ramsey RESET Test, Normality test and CUSUM test) as presented in Table 6 and Figure 6 below:

Table-6. Diagnostic test for the ARDL Models.

-Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	5.546340	Prob. F(2,21)	0.0116	
Obs*R-squared	15.20839	Prob. Chi-Square(2)	0.0005	
Heteroskedasticity Test: ARCH				
F-statistic	0.002270	Prob. F(1,41)	0.9622	
Obs*R-squared	0.002380	Prob. Chi-Square(1)	0.9611	
Ramsey RESET Test				
	Value	**df**	**Probability**	
t-statistic	3.185682	22	0.0043	
F-statistic	10.14857	(1, 22)	0.0043	
Normality test				
Jarque- bera	0.765910			
Probability	0.681843			

Source: Eviews output, Authors estimation.

The diagnostic test results, from the Table 6 show that the models pass the tests for functional form and normality (Jarque-Bera=0.765910& Prob.= 0.681843). However, the results indicate that no serial correlation (F-statistic=5.546340 & Prob.= 0.0116) and heteroscedasticity (F-statistic=0.00227 & Prob.=0.9622) exists.

To determine whether the model is stable or not, we used the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUM) tests. The testing results as shown in (Fig 6) prove the stability of long-run coefficients over the sample period because the graphs of the cumulative sum of squares (CUSUM) and (CUSUMsq) do not exceed the critical boundaries of both the figures at 5% level of significance. These results indicate that all the coefficients of the estimated model are stable during the period of study.

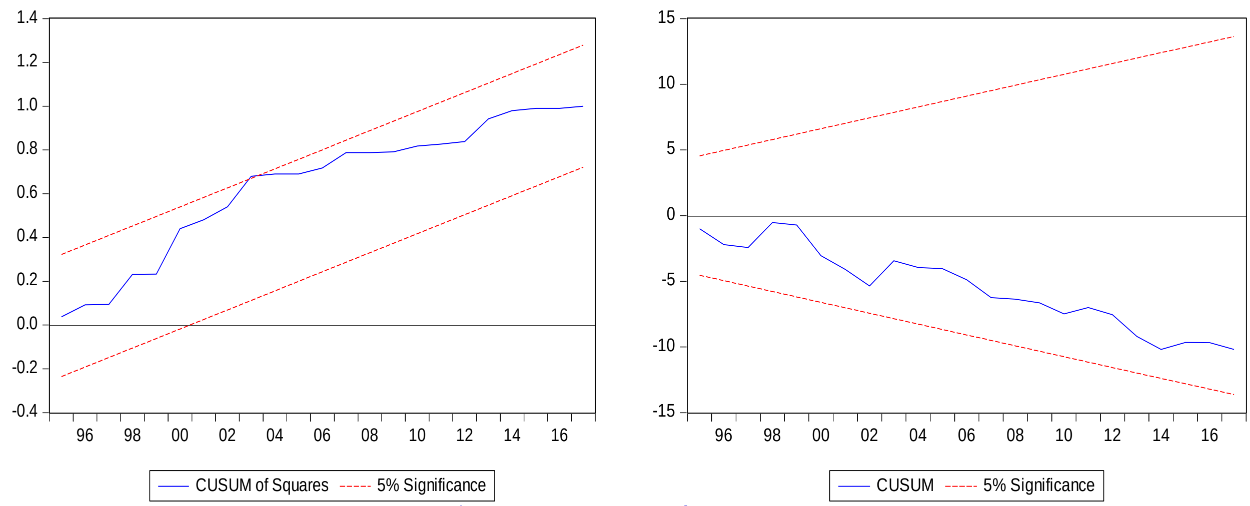

Figure-6. CUSUM test and CUSUM squares test.

Source: Eviews output, by Authors.

5. CONCLUSIONS

The output gap is defined as the difference between real and potential GDP. It is considered a useful tool for policymakers in providing guidance for macroeconomic decision making in countries across the world. By using annual time series data of Saudi Arabia economy (1970 -2017) based on the SAMA statistics and the World Bank database measuring output gap and using both HP filter and production function of Cobb- Douglas, this paper was able to determine the output gap and relationships between determinants.

The results obtained show there are negative and positive output gaps. This can be explained by the volatility of the oil price because the gaps occur more in the oil sector than in the non-oil sector. Investigations based on the ARDL model and bounds test for a long run co-integration relationship were done to identify the determinants of the output gap. The result of the ECM reveals that public sector investment, export earnings, import expenditure, higher secondary enrolment, and money supply are determinants of the output gap in Saudi Arabia. The significant and negative coefficient of lagged error correction term is an indication of the convergence towards long-run equilibrium. The output gap requires more than two years to be automatically corrected over time in order to achieve long-term equilibrium.

5.1. Highlights

This paper highlights the important role plays by the output gap as a tool for policymakers and macroeconomic decision making. It measures and estimates the output gap for the Saudi Arabian economy, and it identifies and analyses the determinants of the economic output gap. It investigates whether a long-run equilibrium relationship exists between the output gap and the determinants, using the bound testing approach to cointegration and error correction models, developed within an autoregressive distributed lag (ARDL) framework.

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APPENDIX

Table-1. KSA Output Gaps, HP.Filter 1970 – 2017.

years	Real GDP	Potential GDP	Total Output-Gap	years	Real GDP	Potential GDP	Total Output-Gap
1970	484432.8	610420.6	-20.6395	1994	1307485	1247666	4.794395
1971	583800.7	693998.3	-15.8786	1995	1310258	1279175	2.42986
1972	717669.9	776316	-7.5544	1996	1344815	1308444	2.7797
1973	891134.6	855012	4.224802	1997	1359658	1336441	1.737265
1974	1035748	927138	11.7146	1998	1398998	1364500	2.528299
1975	943270.5	990106.8	-4.73043	1999	1346350	1394185	-3.43105
1976	1111370	1042417	6.614718	2000	1422088	1427407	-0.37266
1977	1190204	1082101	9.990128	2001	1404870	1465598	-4.14359
1978	1128079	1107877	1.82348	2002	1365264	1510136	-9.59331
1979	1262539	1119547	12.77237	2003	1518748	1561793	-2.7561
1980	1333904	1117114	19.40626	2004	1639617	1619890	1.217789
1981	1359821	1102011	23.39454	2005	1731006	1683320	2.832873
1982	1077932	1077840	0.008555	2006	1779274	1751173	1.604701
1983	904908.9	1050779	-13.8821	2007	1812139	1823014	-0.59652
1984	862727	1027009	-15.9962	2008	1925394	1898691	1.406378
1985	778227.2	1011251	-23.0431	2009	1885745	1977943	-4.66128
1986	910625.1	1006584	-9.53309	2010	1980776	2060774	-3.88192
1987	850227.9	1013755	-16.1308	2011	2178792	2146269	1.515358
1988	961686.9	1032554	-6.8633	2012	2296697	2232711	2.865848
1989	956849.5	1061135	-9.82769	2013	2358690	2318708	1.724334
1990	1102228	1096941	0.481975	2014	2444841	2403510	1.719612
1991	1267649	1136375	11.55199	2015	2545236	2486765	2.3513
1992	1318197	1175892	12.10189	2016	2587758	2568535	0.748404
1993	1300220	1213259	7.167584	2017	2565591	2649465	-3.16571

Table-2. KSA Output Gaps, C.D Production Function (1970-2017)

years	K-GAP	H-GAP	TFP-GAP	Total Output-GAP	years	K-GAP	H-GAP	TFP-GAP	Total Output-GAP
1970	-50.0192	1.930776	13.6681	-12.9736	1994	10.96218	1.069486	0.477294	6.987764
1971	-34.63	0.955102	4.718515	-13.8982	1995	14.87661	-0.03208	-3.55928	4.608421
1972	-16.3236	5.891076	-1.42989	-7.75688	1996	6.824237	3.580977	-1.30901	4.055762
1973	54.50037	8.382762	-21.4673	12.28018	1997	9.542875	2.122608	-3.47232	2.73144
1974	12.30011	-2.24551	4.857874	10.61246	1998	31.18044	0.771253	-11.7999	5.696428
1975	13.63252	-3.70879	-11.0848	-5.25592	1999	21.50983	-4.2995	-11.7944	-1.89872
1976	8.683337	1.090729	-1.21517	4.051489	2000	-25.6221	-1.65256	16.96182	2.126029
1977	13.07811	-1.8769	-0.26734	6.081021	2001	-28.8574	-1.47057	14.23903	-2.29432
1978	-3.44376	-3.76766	0.033539	-3.55597	2002	-31.2017	-4.18654	9.970371	-9.0745
1979	24.58303	-2.78809	-5.66097	6.605061	2003	-26.886	-2.71667	12.31148	-3.69834
1980	64.82504	-4.29981	-14.9756	18.7433	2004	-18.0263	-2.07856	8.291017	-2.55879
1981	-31.1621	5.342254	34.74888	20.01374	2005	-8.773	0.429572	1.759704	-2.87214
1982	-33.5933	-3.12229	15.38641	-4.49493	2006	-1.01576	0.439189	-4.22113	-4.58216
1983	-31.6643	-6.56643	-0.0687	-20.439	2007	8.040556	-2.17351	-9.5419	-6.09767
1984	-30.7175	-3.00277	-3.68251	-21.9284	2008	10.63196	-4.52746	-7.42437	-3.61415
1985	-37.0536	5.006349	-8.59635	-26.7229	2009	-2.41609	-6.98549	-4.83972	-9.31205
1986	-18.7264	6.856938	-5.36587	-12.5798	2010	-0.70551	-1.04205	-6.60984	-7.4668
1987	-17.5175	-3.32664	-7.00272	-18.1343	2011	7.069519	4.599286	-6.6406	-0.68269
1988	-16.4096	-1.05232	3.325826	-6.17298	2012	6.489115	4.427397	-3.94988	1.611461
1989	-15.8639	-6.0294	3.40421	-8.03419	2013	7.053545	2.167834	-3.30927	1.545706
1990	-1.54198	0.06399	3.575302	2.756007	2014	10.35117	1.03428	-3.4701	2.688469
1991	20.48076	7.298716	0.06545	14.61429	2015	10.8169	2.463892	-2.80261	4.255434
1992	24.39627	7.827455	-1.41232	15.52799	2016	-6.84745	0.348203	7.21371	3.604304
1993	30.719	4.020013	-6.99513	11.70933	2017	-16.0104	-2.43235	11.61728	1.717003