Determining the agricultural output gap and its link with food price dynamics in South Africa

by

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ABSTRACT

The objective of the study was to determine the level of output gap for the South African agricultural sector and its link with food inflation. Three different methods, namely the linear trend, the Hodrick-Prescott filter, and the production function approaches were used. The results are inconsistent, with each one showing a different picture. The linear trend results show that the agricultural sector is underutilising the available resources (factors of production and available technology). Meanwhile, the HP method and production function results outline that the agricultural sector is overutilising the available resources (hence high inflationary pressure). The South African agriculture GDP is higher than it can be supported by the existing labour and capital resources.

Keywords: Gross domestic product, agriculture, potential output, output gap

1. INTRODUCTION

South Africa's flexible inflation targeting framework presents a situation where both the output gap and inflation gap are very important inflationary pressure measures making an important contribution in the determination of good policy reactions on interest rates (Ehler *et al*, 2013). There is an existing body of literature on the measurement aspect of the overall output gap in South Africa, however; little work has been done on the agricultural sector output gap. Output gap is defined by Denis *et al* (2002) as the gap/difference (whether negative or positive) between potential output and actual output. Output gap analysis, mainly, is done in order to identify the inflationary or non-inflationary growth, as well as the effect of macroeconomic policies on an economy. Trickier to do, however, is the measurement of the potential output. It is further argued by Smit *et al* (2002) that even the interpretation of potential output can be very confusing, as it does not necessarily mean the maximum attainable output. According to Denis *et al* (2002), estimating the level of an economy's potential output and output gap is essential to identify sustainable non-inflationary growth, as well as to assess macroeconomic policies.

The deviation between the actual output and potential output is commonly known as the output gap (Ehler *et al*, 2013 and Smit *et al*, 2002). This, according to Smit *et al* (2002), assists in measuring the demand and supply situation of an economy over a given time. It is important to note that potential output is not directly observable, as is the case with actual output. Potential output measures, to some degree, the productive capacity of an economy and this should be done with caution as it only refers to the long run (potential output simply measures the sustainable output, as opposed to maximum output subtracting from inflationary pressure).

A number of studies regarding South Africa's overall output gap have been conducted by the South African Reserve Bank and a number of Universities, domestically. From these studies a number of methodologies have been used to evaluate the situation and the methodologies (Linear Trend Method, Hodrick-Prescott Filter Method and the Production Function Method) used in this study have been used in these studies. The results are mixed. The aim of this study was to outline whether or not there were inflationary pressures on South Africa's agricultural products.

2. LITERATURE REVIEW

The literature shows that a number of studies have been conducted on output gaps, with aims of advising governments on appropriate monetary policy measures (de Brouwer 1998; Dupasquier, Guay & St-Amant 1999; Scacciavillani & Swagel 1999; Cerra & Saxena 2000; Laxton & Tetlow 1992; Nelson & Plosser 1982; Smit *et al* , 2002; Ehler *et al* 2013). Smit *et al* (2002) argue an important conceptual interpretation confusion regarding potential output to measure sustainable output as opposed to maximum attainable production, given factors of production and level of technological advancement.

2.1. Output gap argument

In conventional economic literature (macroeconomic), output gap (= Potential Output − Actual Output), as a concept, is important as it is useful in understanding the link between the real economy and inflation. Since actual output is provided (from official statistics), the concept of potential output needs an explanation. Potential output can be viewed in two

ways: from an economic theoretical perspective, it can be viewed as production output level using available factors of production, normally within a given set of technological advancement (supply side). However, from a statistical perspective, potential output is thought to be a trend output (Lungu *et al* 2012).

Denis *et al* (2002) argue that output gap provides a yardstick against which inflationary or non-inflationary pressures are assessed:

- An economy is said to be experiencing excess demand if the actual output is greater than the potential output. Therefore, it can be argued that there are inflationary pressures and appropriate policy responses need to be made by relevant authorities (especially the Central Banks).
- When the actual output is lower than the potential output, inflation reduces (non-inflationary pressure) and governments may be required to design policies that will stimulate demand and ease the monetary policies.

Donders and Kollau (2002) argue that the estimation of potential output and output gap is of direct relevance to government fiscal policies since the cyclical position of the economy affects government expenditures and revenues. Using that same principle, the level of the agricultural sector potential output and output gap should also indicate direct relevance for agricultural policies and fiscal policies. In South Africa, a number of studies have been conducted looking at output gap, but sector-focused studies have not yet been conducted. It is from this background that this study intends to determine the level of the agricultural output gap in South Africa and its link with food inflation.

2.2. The agricultural output trends in South Africa

Traditionally, agriculture looks at the production processes associated with crops and livestock. In South Africa, agriculture is viewed as including forestry and fisheries, with agriculture contributing a significant share of the gross value of production (more than 70%). The gross value of the agricultural sector (GVA) in South Africa has been in a positive growth trajectory, increasing from R68.3 billion in 2001/02 to about R164.4 billion in 2013 (DAFF, 2013). In absolute terms, the value of agriculture has been on an upward growth, while the relative contribution of agriculture to the economy has been declining. This relative trend is consistent with economic literature which argues that as an economy develops, the relative contribution of primary sectors, such as agriculture, declines. This is argued to come with a structural shift from an economy based on primary industries to one dominated by secondary or tertiary sectors. As a result of this shift, the contributions of secondary and tertiary sectors increase considerably – and these sectors are mostly driven by the primary sector. South Africa's agricultural contribution to the GDP has declined considerably from 1960 to 2012. **Figure 1** shows that agricultural GDP growth is characterised by more or less regular fluctuations or cycles. In addition, the South African agricultural GDP contracted in five distinct periods, that is, in 1995, 1998, 2001, 2006 and 2009-2011.

As noted in **Figure 1**, the food inflation rate is characterised by persistent fluctuations. The highest food inflation rate was observed in 2008, when it was at 16.5%. This high inflation rate was experienced at the same time as the global recession.

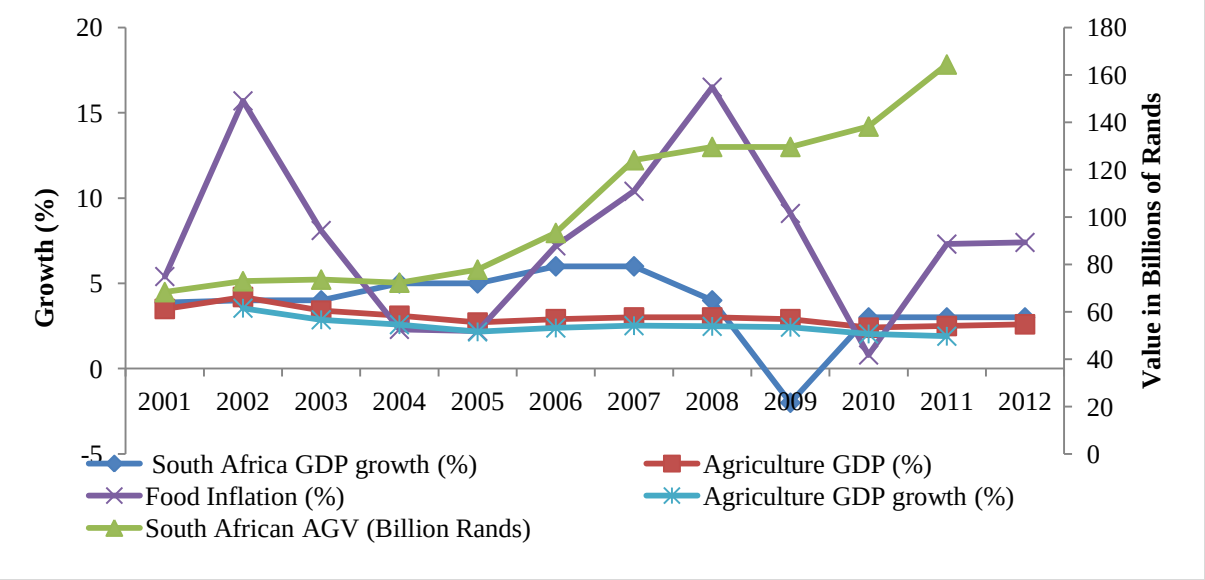

Figure 1: South Africa's GDP, total agricultural gross value of production and, agricultural GDP growth
Source: DAFF, 2013; Statistics South Africa, 2013

Having noted the overall contribution of the agricultural sector to the economy of South Africa, it is important (in absolute and relative terms) to outline the three major categories of performance. According to Liebenberg (2010) and DAFF (2013), livestock contribution to agricultural GDP has always been the biggest of the three, except in a few years where field crops have overtaken it. Field crop contribution has been increasing, depending on the years. The interesting picture of the agricultural story comes from the horticulture sector, the contributions of which have been on an increase for a long period of time, providing an indication that it will ultimately surpass the field crops.

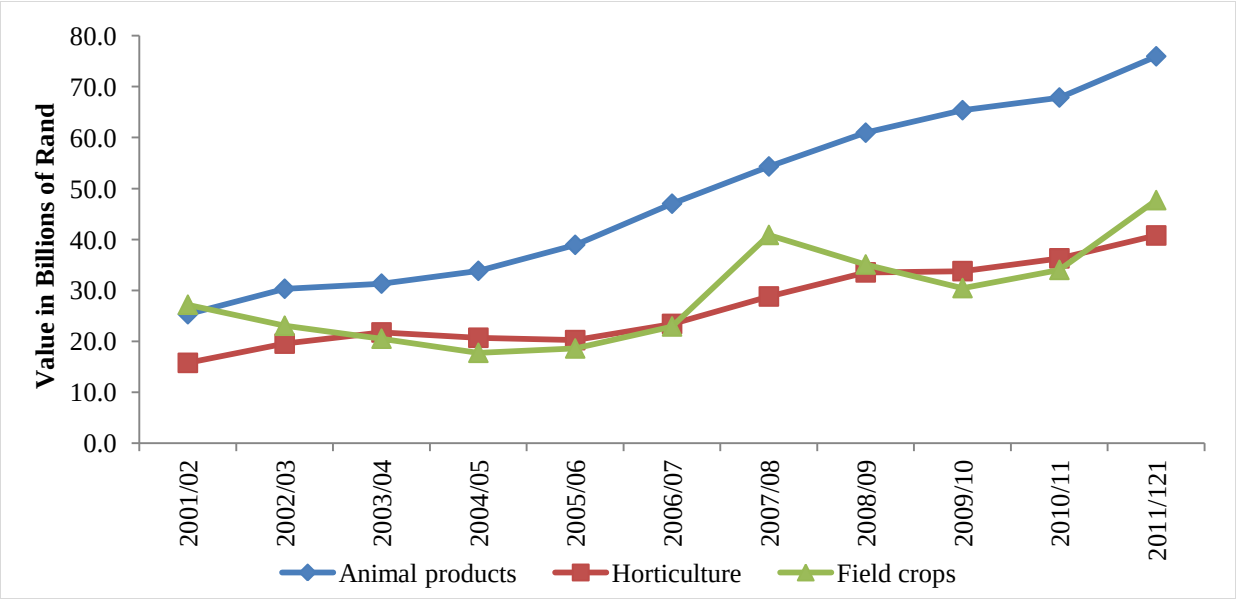

Figure 2: South Africa's agricultural gross value by product categories
Source: DAFF (2013)

3. METHODOLOGY DESCRIPTION

There are three methods used to analyse the output gap of South Africa's agricultural sector from perspectives of both food inflation and the overall inflation of the country. The use of

all the three ensures that the strengths of each are taken into account, while the weaknesses are covered by the results of other methodologies. These methodologies used to estimate the agricultural output gap are the Linear Trend Method, the Hodrick-Prescott Filter Method, and the Production Function Method.

3.1. Linear trend method

The linear trend is the simplest tool for estimating the output gap and potential output. This method presumes that output is at its potential level, on average. The potential output may be estimated as follows:

$$Y_t^* = \hat{a}_0 + \hat{a}_i \text{Trend} \quad (1)$$

- Y_t^* - output trend,
- $\hat{a}_i$, i = 0,1 - estimated coefficients from the regression of the actual output on time trend variable.

Then output gap (C_t) is obtained using:

$$C_t = Y_t - Y_t^* \quad (2)$$

- Y_t - actual output,
- Y_t^* - potential output from (1), and t =1, 2, …,
- t - time index.

It is noteworthy to outline the weaknesses this method suffers from. The time series used is perfectly predictable since it is from a deterministic long-run evolution. Beveridge and Nelson (1981) argue that if the changes in the economic series were to be from a random process, then the deviation of the series from any deterministic path would grow without bound. Furthermore, to impose a deterministic time trend when one is not in fact present may severely distort the apparent statistical properties of the resulting cycle or transitory part of the series (Njuguna *et al*, 2005). Therefore, it is important that the start of the sample period should actually fall at a point where the economy was basically in equilibrium.

There is an assumption that potential output grows at a constant rate (de Brouwer, 1998), which often does not hold. When an economy has undergone considerable structural reform, or when there are major changes in improvements in technology, such an assumption becomes irrelevant. Since this method assumes a trend, and in order to smoothen the results, a detrending method was used, namely the Hodrick-Prescott (HP) filter.

3.2. Hodrick-Prescott (HP) Filter method

The Hodrick-Prescott filter (Hodrick and Prescott, 1997) is argued to be a simple smoothing/detrending procedure. The main assumption of this method is that there is prior knowledge that the growth component varies smoothly over time. It operates on a framework that a given time series, say Y_t (or output), may be expressed as the sum of a growth component or trend Y_t^* (or potential output) and a cyclical component or output gap C_t, expressed as follows:

$$Y_t = Y_t^* + C_t \quad (3)$$

The measure of the smoothness of Y_t^* $(potential\ output)$ is the sum of the squares of its second difference. With the average of the deviations of C_t from Y_t^* is assumed to be near zero over a long period of time. Noteworthy is the fact that these assumptions lead to a

programming problem of finding the growth components by minimising the following expression:

$$\text{Min L} = \{\sum_{t-1}^{T} c_t^2 + \lambda \sum_{t=2}^{T} (\Delta y_t^* - \Delta y_{t-1}^*)^2\}$$
$$= \sum_{t=1}^{T} (y_t - y_t^*)^2 + \lambda \sum_{t-2}^{T} [(y_t^* - y_{t-1}^*) - (y_{t-1}^* - y_{t-2}^*]^2 \quad (4)$$

The parameter λ is a positive number, which penalises variability in the growth component series. The larger the value of λ, the smoother the solution series is. Moreover, as λ approaches infinity, the limit of the solutions for equation (4) is the least squares of a linear time trend model. On the other hand, as the smoothing factor approaches zero, the function is minimised by eliminating the difference between actual and potential output that is making potential output equal to actual output. In most empirical work, the value of λ = 1,600 is chosen when using quarterly data. The advantage of using the HP filter is that it renders the output gap stationary over a wide range of smoothing values and it allows the trend to change over time. In most studies for developing countries, this method is preferred because of its considerably lesser data requirements (see De Masi, 1997).

The first weakness of the HP method is that changing the smoothing weight (λ) affects how responsive potential output is to movements in actual output (de Brouwer 1998). Thus, an appropriate smoothing parameter (λ) is difficult to identify. Another weakness of the HP method is the high end-sample biases, which reflect the symmetric trending objective of the method across the whole sample and the different constraints that apply within the sample and its edges. This is especially a problem when one is interested in the most recent observations in the sample for purposes of drawing conclusions for policy implementation and projections for the immediate future. To counter this problem, however, researchers use output projections to augment the observations. Finally, for integrated or nearly integrated series, it has been shown that an arbitrary value of the smoothing parameter could lead to spurious cyclicality and an excessive smoothing of structural breaks (Harvey and Jaeger 1993).

3.3. The Production Function

The aggregate production function is a structural approach that is used to estimate the potential output and the output gap. According to Denis *et al* (2002), the approach relates the potential output to the availability of factors of production and technological change. The Cobb-Douglas production function can be used to characterise the total output as follows:

$$Y = L^{\alpha} K^{-1-\alpha}.\text{TFP} \quad (5)$$

Where Y is the output, L is the labour employed, K is the capital stock, TFP is the total factor productivity and α is the labour share of income. As stated by Denis et al (2002), TFP is defined as equal to:

$$\text{TFP} = (E_L^{\alpha} E_K^{\alpha-1})(U_L^{\alpha} U_K^{1-\alpha}) \quad (6)$$

This summarises both the degree of utilisation (U) of factor inputs, as well as their technological level (E). If inputs are equilibrium values, then equation (1) provides an estimate of the potential output. Given the estimated value of parameter α, the TFP is given:

$$\log(\text{TFP}_t) = \log(Y_t) - \alpha \log(L_t) - (1-\alpha)\log(K_t) \quad (7)$$

where it is computed as a residual. A trend is then fitted to the residual, TFP, in order to obtain an estimate of trend productivity to be used in the estimation of the potential output

where a normal level of efficiency of factor inputs is assumed. The trend efficiency level is usually measured as the HP filtered Solow Residual. The production function approach can provide useful information on the determinants of potential growth. Despite the difficulty in estimation, this approach is intuitively appealing and is widely used (see De Masi 1997 and Denis *et al* 2002). One advantage of the using production function method is that it is capable of highlighting the close relationship between the potential output and the non-accelerating inflation rate of unemployment (NAIRU) concepts, given that the production function approach to calculating potential output requires estimates to be provided of "normal" or equilibrium rates of unemployment. Moreover, the production function approach provides possibility of making forecasts, or at least building scenarios, of possible future growth prospects by making explicit assumptions on the future evolution of demographic, institutional and technological trends. However, given the significant amount of data requirement for this approach and a whole wide range of assumptions to derive variables, this method is difficult to use.

Aside from difficult estimation process, the production function method has also several weaknesses (see Laxton & Tetlow 1992). For example, Laxton and Tetlow (1992) have pointed out that there has been no useful model of estimating the productivity and hence, estimates are based on trend and therefore potential output is essentially exogenous time trends. Moreover, the problems of trend elimination for GDP are shifted to the trend estimates of the inputs. Detrending techniques, such as the HP filter, are used for smoothing the components of the factor inputs.

4. DATA COLLECTION

All the data used in this study is secondary data, as there was no immediate need for primary data in addressing the research question. The study was conducted using official statistics from Statistics South Africa. The data includes annual agriculture GDP at 2005 prices, agricultural capital stock, agricultural employment and inflation rates from 1993 to 2011(all from Statistics South Africa). Such figures were used in the computation of agricultural sector potential output and output gap.

5. RESULTS AND ANALYSIS - EMPIRICAL ESTIMATES OF POTENTIAL OUTPUT AND OUTPUT GAP

In this study, the estimation of agricultural sector potential output and output gap for South Africa uses data from Statistics South Africa (Stats SA). The data includes annual agriculture GDP at 2005 prices, agricultural capital stock, agricultural employment and inflation rate from 1993 to 2011. As mentioned earlier, positive output gap indicates demand pressures, hence signalling that inflationary pressures are increasing and the implication is that policy needs to be tightened. On the other hand, for a negative output gap, the opposite is true. The following subsections present the estimation results from the methodologies discussed in section 2.

5.1. Linear trend method

The linear trend method used for the trend cycle decomposition yielded the following equation for estimating the South African agricultural output growth:

$$Y_t^* = 28724 + 668.55\ \text{trend} \qquad (8)$$

$R^2 = 0.8123$

The coefficients obtained are highly significant and the regression line is closer to a perfect fit. **Figure 3** presents the estimates of the potential output growth based on the linear trend. The results indicate that the actual output is found to be variable around the potential output. This implies that there are instances where the actual output is found to be above and below the potential output. The results from this methodology reveal that the South African agricultural sector is operating both below and above capacity. The output growth gap is presented. Sustained negative output growth rate gaps are observed in 1995, 1997, 1998, 2001, 2003–2004, 2006, 2009–2011, with the lowest points at −22.3%, −1.3%, −7.6%, −5.5%, −1.5%, −1.3%, −7.7%, −3,9%, −1.8% and −2.3% respectively. This means there is excess capacity (or underutilisation of resources), which translates into low inflationary pressure. The linear trend method shows that in 10 periods out of the 18, South African agriculture was operating below potential. This method shows that the sector is underutilising the available resources.

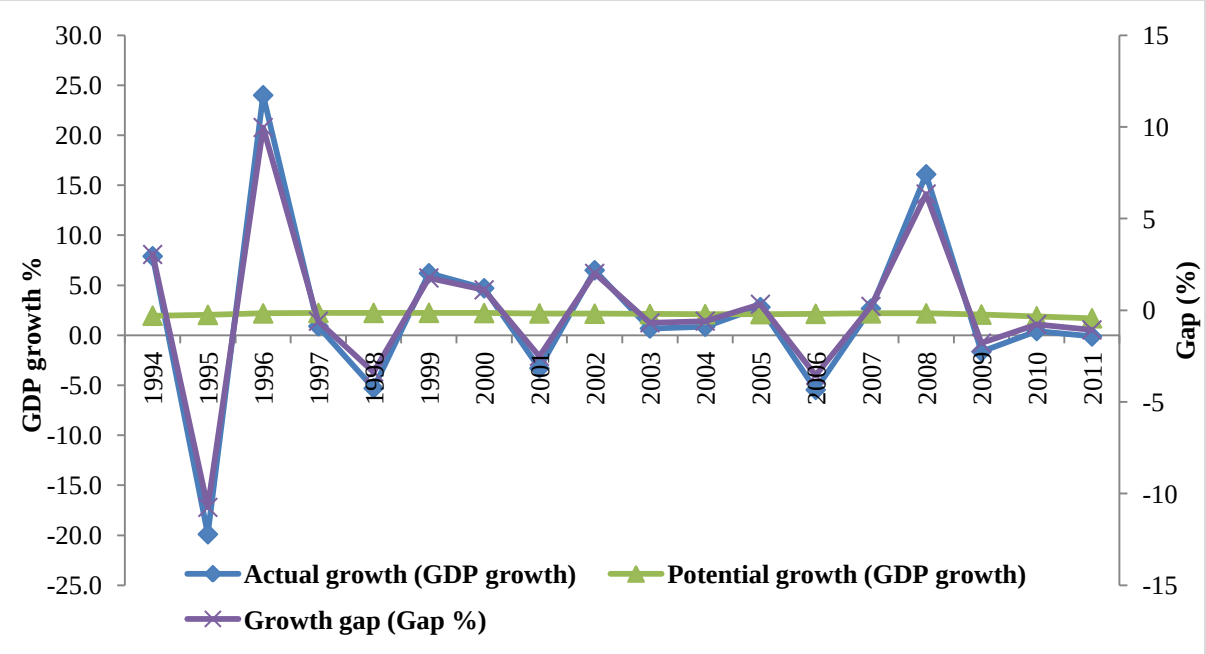

Figure 3: Actual and potential GDP growth rate and output gap from the linear trend method

5.2. HP Filter Method

Given the fact that the data used was on an annual basis, the parameter λ was smoothened using both λ=100 and 1600. The results from the analysis show that in 1994, 1996–1997, 2000 and 2008–2010, the actual output was marginally above the potential output, while in 1995, 1998, 2006–2007 output was below potential level. The results indicate that 1994, 1996–1997 and 2000 and 2008–2010, the output gap was positive. Overall, the results for this methodology show that in 11 periods out of the 18 the South African agriculture has been operating above potential. The sector is overutilising the available resources.

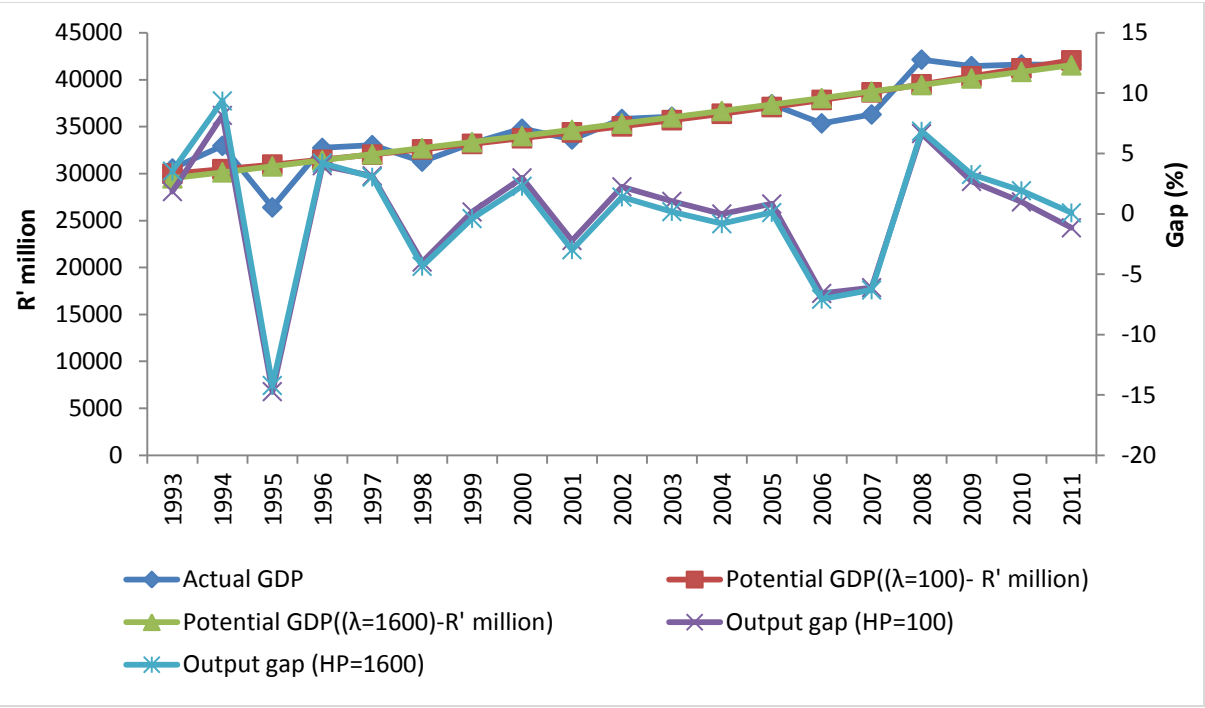

Figure 4: Actual agricultural GDP and potential GDP and output gap for South Africa (1993-2011)

5.3. Production Function Method

In the estimation of the potential output using the production function approach, several variables are needed. The most important ones are the total factor productivity for agriculture (TFP), total agricultural employment (L) and the agricultural capital stock (K). The TFP was derived and the K and L were obtained from the Stats SA database on agricultural statistics. The TFP is the calculated residual from the regression of the log of the output on the log of capital stock and log total employment in agriculture. From the regression, the coefficients below were obtained.

$$\log(Y_t) = 7.215 + 0.289 * \log(K_t) - 0.0165 * \log(L_t) \quad (9)$$

$$\log(TFP_{t)} = \log(Y_t) - 7.215 - 0.289 * \log(K_t) + 0.0165 * \log(L_t) \quad (10)$$

The HP filter was then applied to the calculated residual to obtain the estimate of trend productivity. **Figure 8** shows the estimated series of the potential output from the production function approach, plotted against the actual output. As in the HP method, the results indicate that in 1994, 1996–1997, and 2000 and 2008–2010 the actual output is above the potential output. However, the overall results from this method show that in 10 periods out 18, the agricultural sector is operating above potential. This is consistent with the results obtained from the HP filter.

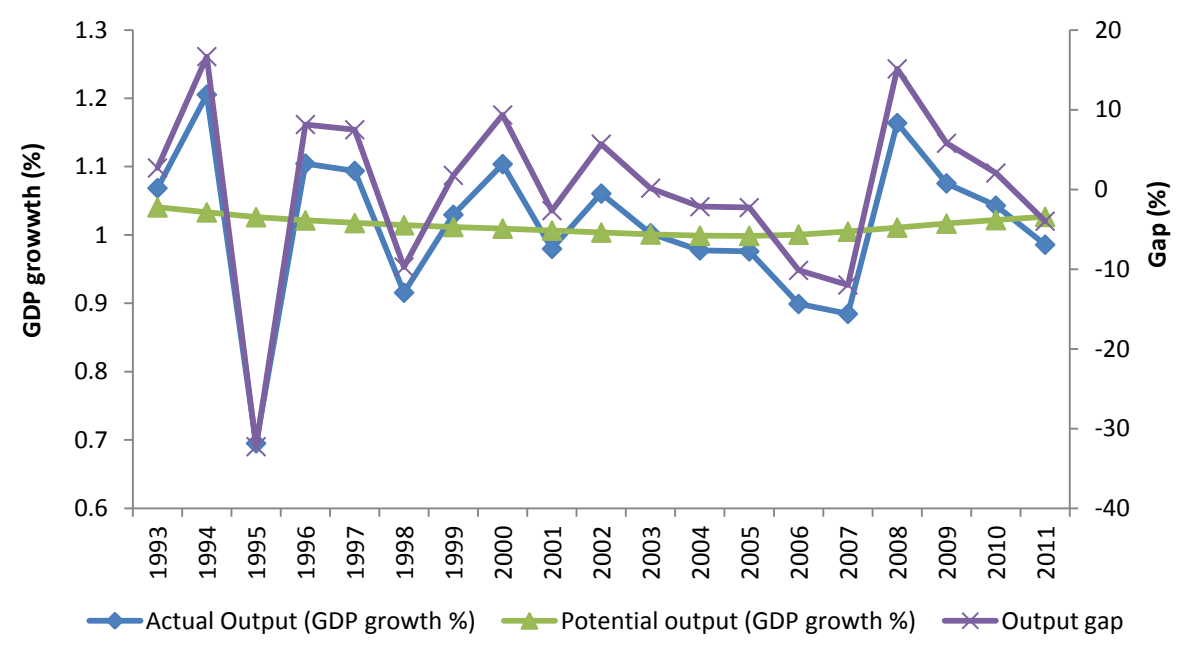

Figure 5: Actual and potential output from the production function approach

5.4. Agricultural output gap versus Inflation

The paper was aimed at determining the South African agricultural output gap and how it relates to the food prices. From the results, it appears that the country's agricultural sector has been experiencing some overutilisation of available resources. **Figure 6** presents the agricultural output gap as it relates to the food inflation in South Africa over the period 1993 to 2011.

5.4.1. Below potential

Figure 6 shows that in 1995, 1998, 2001, 2004–2007 and 2011, the South African agricultural sector was operating below the potential output level. This implies that there was underutilisation of available resources during these time periods. Theoretically speaking, under such circumstances the inflationary pressures tend to ease (theoretically, this was supposed to result in lower food inflation rate – ideally below the South African Reserve Bank's upper bound rate of 6%), allowing policymakers to design policies that will stimulate demand. In spite of the theoretical expectation, food inflation in South Africa during these time periods was more than the Reserve Bank 6%, except for 2001 and 2004, as seen in **Figure 6**. This implies that the excess capacity within the agricultural sector is not attributed solely to the agricultural supply, but other external factors are involved.

5.4.2. Above potential

In 1993, 1994, 1996–1997, 2000, 2002–2003 and 2008–2009, the South African agricultural sector was operating above its potential, implying excess demand that leads to inflationary pressures (Claus, 2000). The inflation during these time periods was above the Reserve Bank rate of 6%. This implies that for these time periods, agricultural supply had an influence on the food inflation rate of the country. This is in line with the fact that the periods 2002, 2008–2009 were the years where there was global recession.

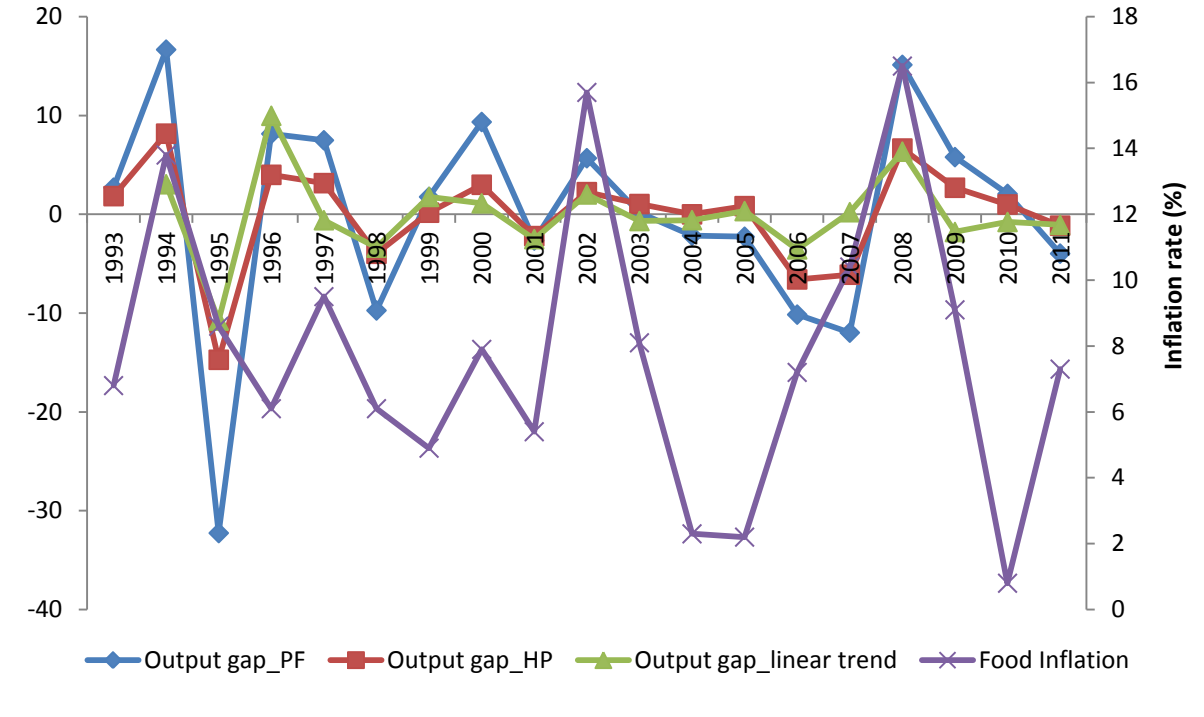

Figure 6: Output gaps and inflation rates

5.4.3 Correlation between food inflation and the output gaps from the three methods

From the analysis of the three methods, the results from HP and the production function method show that there is a positive relationship between agricultural output gap and food inflation. To statically test which of the method proves the presence of a relationship between the two variables (agricultural output gap and food inflation), a correlation test was performed on SPSS. Correlation is a technique which measures the relationship between two variables and how strong the relationship is (Pichika, 2012). **Table 1** shows that the correlation coefficients of all the two of the methods (linear trend and HP filter) are closer to 1.0 and are 0.985 and 0.64, respectively. This implies that there is a stronger relationship between the output gap and inflation. The production function method has a correlation efficient of 0.31, which means that under this method the relationship between food inflation and output gap is weak. The positive signs in the coefficients of the three methods imply that the food inflation and the output gap move in the same direction. In other words, if the output gap increases, the inflation rate increases, and vice versa. The p-values of the correlation coefficients from the linear trend and HP method are less than 0.01. This means that the probability of obtaining the relationship by chance is less than one time out of 100; the results show the presence of a relationship between output gap and inflation. These results prove that there exists a positive relationship between output gap and food inflation.

Table 1: Correlation between food inflation rate and food prices

		Food Inflation	Output gap_linear trend	Output gap_HP	Output gap_PF
Food Inflation	Pearson Correlation	1	.985**	.646**	.310
	Sig. (1-tailed)		.000	.001	.098
	N	19	19	19	19
Output gap_linear trend	Pearson Correlation	.985**	1	.698**	.261
	Sig. (1-tailed)	.000		.000	.140
	N	19	19	19	19
Output gap_HP	Pearson Correlation	.646**	.698**	1	-.485*
	Sig. (1-tailed)	.001	.000		.018
	N	19	19	19	19
Output gap_PF	Pearson Correlation	.310	.261	-.485*	1
	Sig. (1-tailed)	.098	.140	.018	
	N	19	19	19	19

**. Correlation is significant at the 0.01 level (1-tailed).
*. Correlation is significant at the 0.05 level (1-tailed).

6. Conclusions

The study estimated the South African potential output and output gap using three different methods namely; the linear trend filter method, HP filter method and the production function approach. The HP filter and the production function methods established that the agricultural output gap in South Africa has a positive relationship with inflation. This suggests that, according to the findings from this study, the South African agricultural sector is under excessive demand, hence the high food inflation rates. Economic theory suggests that when the output gap is positive, it implies that the production and labour costs are on the rise. The agriculture GDP is higher than can be supported by the existing labour and capital resources. Consequently, policies that will ensure optimal use of available resources are essential. However, in this study the overall agricultural GDP was used. To further inform policy, the agricultural output gaps for the different production regions, subsectors and crops should be done to ascertain which contributes the most to the overall agricultural output gap.

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