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Constructing a Quarterly Measure of Gross Domestic Product and Output Gap for Solomon Islands

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Abstract

The objective of this paper is to estimate an output gap for the Solomon Islands economy using annual data from the years 2002 to 2014. Since the output gap cannot be measured directly, we use various economic indicators to first construct a quarterly real GDP indicator series using two statistical processes, the Chow-Lin procedure and the Fernandez approach. Using the quarterly series, we then estimate a measure of the output gap using two mechanical filtering techniques; the Hodrick-Prescott filter and the BN decomposition filter. We find that the output gap for the Solomon Islands was below zero in 2014, meaning that the economy was producing below its potential output that year. This indicates no inflationary pressures from the demand side in the medium term.

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Contents

1 Introduction

The Central Bank of the Solomon Islands (CBSI) Act 2012 stipulates that the " …primary objective of the Central Bank shall be to achieve and maintain domestic price stability" in the economy. To operationalise this objective, the Bank hopes to keep inflation under control preferably within single digit. In this context, the Bank has been projecting future inflation using the exchange rate along with a range of inflation models. Any change that CBSI makes to the exchange rate takes two quarters before it impacts inflation (Takana, Samani & Especkerman-True, 2014). This is due to the nature of price stickiness in the Solomon Islands. As a result of the lags between these policy actions and inflation outcomes, the bank needs several other economic indicators to guide accurate and appropriate monetary policy making. One of the main factors that can influence inflation in the future is the state of the business cycle or fluctuations in economic activity. Therefore, understanding the nature of the business cycle is of paramount importance as it can infer different inflationary pressures in the economy at different points in time.

The output gap concept is considered to be a useful and frequently used indicator for predicting future price pressures. In fact, this relationship between the output gap and inflation has received extensive attention in the literature. See for example, the work of Claus (1999); Lungu, Jombo & Chuimia (2012); and Citu & Twaddle (2003).

The output gap is defined as the difference between current output and potential or sustainable output of an economy. It is useful in several aspects. First, it acts as an indicator of the balance between aggregate demand and aggregate supply in the economy. A negative output gap suggests aggregate demand is below aggregate supply and resources are underutilized thus, there tends to be less inflationary pressures. Conversely, a positive output gap implies actual output supplied exceeds the sustainable level of the economy, therefore, signalling inflationary threats. Secondly, the output gap is also a useful indicator of volatilities in the economy, whether resources are changing quickly between periods of considerable resource pressures to periods of substantial resource slack or whether the economy is moving smoothly between moderate levels of resource strain and slack (Citu & Twaddle, 2003). Potential output therefore, is a useful assessment of the aggregate supply capabilities of an economy as it gives an indication of the production capacity of the economy.

This working paper can be considered as the first attempt to provide a study on the output gap in the Solomon Islands. Despite the prevalence of output gap studies in the literature, to the authors' knowledge, there has been no published work on output gap in the Solomon Islands. It is believed that findings from this paper will provide additional information to the monetary policy making process of the bank.

Moreover, the annual Gross Domestic Product (GDP) publications Solomon Islands National Statistics Office produced were released with significant time lags though improvements were noted in more recent years. The timeliness issue caused other key stakeholders such as the Ministry of Finance and Treasury, Central Bank of Solomon Islands and other agencies to also compile estimates of GDP for their immediate purposes (economic assessments, budget plans, forecasting and policy formulations). Given that GDP estimates are in yearly frequency, issues often arise when we want to see the impact of short term movements or shocks to the system on GDP. It is difficult for users[1] of the data to analyse short run dynamics of output and to determine whether or not growth is inflationary in the medium term when the frequency of GDP is measured in annual terms.

Thus, three motivations for initiating this paper are; firstly, disaggregating GDP to a higher frequency is of importance for the Central Bank's analysis. Secondly, estimating an output gap of the country is of importance because it indicates the level of economic activity that may be inflationary. This would help the bank to keep an appropriate balance between the price stability mandate of the bank and the need to support economic growth initiatives. Finally, timeliness of data is of paramount importance for short term forecasting in ensuring the bank makes sound policy judgements in a timely manner.

Different countries have different disaggregating methods depending on data availability, the structure of the economy, the political climate and other external factors. In the case of Solomon Islands, we use the methodologies of Chow and Lin (1971) and Fernandez (1981), to convert the annual GDP series to a quarterly real GDP series. Both methods produce similar results; however we choose to use the Fernandez method as it shows less volatility in comparison to the Chow-Lin procedure.

Nominal predictors were used in determining the best indicators of GDP. These nominal series were then deflated by a deflator series which was obtained from Chow-Lin procedure. A quarterly real output series and an output gap measure were then derived which are the key outputs obtained from this study. The results for 2014 suggest that actual output fell by 1.2% in the final quarter and 2% for the whole year, which was slower than the growth rate of potential output of 3.8% in the final quarter of 2014. This was depicted by the negative output gap for final quarter of 2014 indicating no pronounced inflationary pressures from the demand side as the economy is performing below potential output. Meanwhile, the spike in quarterly inflation rate seen in the second quarter of 2014 was transitory due to supply shocks, which were unrelated to aggregate demand and output.

The remaining sections are structured as follows; Section 2 provides a brief overview of the output trends in the Solomon Islands and an overview of the literature on output gaps. Section 3 and 4 outlines the approach and methodology. Section 5 and 6 presents the results and section 7 concludes.

2 Output trends in the Solomon Islands

The GDP in the Solomon Islands has been very volatile over the last twelve years with real annual growth averaging around 5.8%. Sectors that contributed heavily to growth over these years included agriculture, mining, fishing, manufacturing, construction and transport and communication. In line with economic activities during these years, there was a period of

[1] Includes policy analysts, researchers, academics and the general public.

strong economic growth from 2003-2008 owed largely to RAMSI intervention with average annual growth of 7.3%. However, economic growth decelerated with the global financial crisis in 2009 and has averaged 5% since then.

Over the period 2003-2014, inflation eased markedly with the average annual inflation rate falling from 11.3% in 2003 to 5.0%% in 2014. Despite all these developments, it is not easy to figure out whether the Solomon Islands economy operates above or below potential output. It is from this background that this working paper intends to determine the level of the output gap in the Solomon Islands.

2.1 Literature Review

Abundant literature exists covering the procedures used in deriving quarterly GDP as well as various measures of the output gap. This section reviews some of the existing literatures and common indicators and disaggregation methods used. In terms of the output gap literature, it focuses on selected overviews of studies related to the measures of the output gap used in this paper, mainly the Hodrick-Prescott (HP) filter and the Beveridge-Nelson (BN) decomposition filter. The HP filter and the BN decomposition filter are both decomposition and smoothing techniques commonly used in macroeconomics for decomposing time series into its trend component. The HP filter is a model-free based approach to deconstructing a time series into its trend component whilst the BN decomposition is a model based method used for decomposing time series into permanent and transitory components.

A review of the literature on constructing quarterly GDP from annual data showed three common features. Firstly, most researchers, for example, Abeysinghe and Rajaguru (2003), Lahari et.al (2009), used the Chow-Lin procedure in deriving quarterly GDP. Similarly, other authors used both the Chow-Lin and Fernandez procedures in disaggregating annual GDP to quarterly series. Vellodi and Aba (2012) did use both procedures to generate quarterly series for Papua New Guinea; likewise, Karan (2013) applied both methods for constructing Fiji's quarterly GDP.

Secondly, the choice of variables to obtain quarterly GDP estimates was determined such that the variables cover all aspects of the economy that are believed to have a predictive effect on GDP. Only the variables which were trending along GDP were used in disaggregating GDP. Therefore, the condition of co-integration as applied by Lahari et.al (2008) and Abeysinghe et.al (2004) is not only important, but substantiated the use of the Chow-Lin procedures. Cointegration is when two or more variables share a common trend in the long run. In this paper monetary, fiscal, external, and production indicators were included.

Thirdly, most developed economies have GDP at a quarterly frequency and only a few studies were found on the quarterly disaggregation of GDP for these countries. Most of the literature on constructing quarterly GDP from annual data is for developing countries that have other economic data of higher frequency except for GDP. As Velodi et.al (2012) pointed out, other macroeconomic series that are reported at a higher frequency than GDP can be used to construct a quarterly GDP series.

Furthermore, research on the output gap started as early as 1962 with Okun and has gained popularity since then. Lungu, Jombo, & Chiumia (2012) estimated an output gap for the Malawian economy using three methodologies namely; a linear time trend, a Hodrick-Prescott filter and a structural vector autoregressive (SVAR) model. They find a weak link between business cycle developments, measured by the output gap, and inflation developments.

Razzak and Dennis (1999) estimated an output gap for New Zealand using a modified Hodrick-Prescott filter; they find that the modification produced consistent estimates with theory and improved forecast of inflation.

Claus et al (2000) compared different measures of the output gap for New Zealand including a multivariate (MV) filter and the Hodrick-Prescott filter. They argued that measuring an economy's potential output and output gap is essential in identifying sustainable non-inflationary growth and assessing appropriate macroeconomic policies. They find the performance of the output gap using the HP filter to be basically supportive in terms of its measurement qualities compared to other measures

3 Methodology

This section covers the methods used to disaggregate annual GDP into a quarterly series by using the two different models formulated by Chow and Lin (1971) and Fernandez (1981). Some common features and differences of the two models will be discussed for the purposes of this paper.

3.1 Chow and Lin (1971)

The methodology used in this paper follows the conceptual framework initiated by Chow and Lin (1971) and developed further by Fernandez (1981) and Litterman (1983). The main idea is to use quarterly series, converted into annual form and to choose series that closely link with the annual GDP movement. Quarterly series that are in nominal terms are deflated to reflect real variables and are used to predict the quarterly real GDP series. The Chow-Lin disaggregation of *n* annual GDP figures to *4n* quarterly figures is based on the main equation;

$$\hat{\gamma}=X\hat{\beta}_a + VC'(CVC')^{-1}\,\hat{u}_a \qquad (1)$$

Where

$$\hat{\beta}_a=[X'C'(CVC')^{-1}CX]^{-1}X'C'(CVC')^{-1}\,\gamma_a$$

$$C = \begin{bmatrix} \mathbf{11110000} \dots\dots\dots & \mathbf{0} \\ \mathbf{00001111} \dots\dots\dots & \mathbf{0} \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots & \\ \mathbf{0} \dots\dots\dots\dots\dots\dots. & \mathbf{1111} \end{bmatrix} \qquad (2)$$

$\hat{\gamma}$ denotes vector of disaggregated quarterly GDP estimates

X is a 4n X k matrix of k predictors, GDP related quarterly related variables

B is a k x 1 vector of generalised least squares

V denotes a covariance matrix (4nx4n) of the quarterly regression errors

$\hat{u}_a$ denotes a vector of residuals from an annual regression of GDP

C is an n x 4n averaging matrix as represented in equation (2).

γ_a *represent the observed n x 1vector of annual GDP*

3.2 Fernandez (1981)

The Fernandez framework is an extension to Chow and Lin (1971) and slightly differs in its treatment in the classification of the disturbance term. Whilst Chow and Lin do not allow for a random walk, that is, they use stationary series, Fernandez (1981) and Litterman (1983) do account for non-stationary data in their framework. If GDP and the indicators for disaggregation are non-stationary as is expected for most time series economic data, the appropriateness of using Chow-Lin therefore requires that the variables are co-integrated to ensure that the residuals do not follow a random walk and are therefore stationary.

4 Estimating a Quarterly GDP and a GDP Deflator Indicator Series

4.1 Data

The time series data used in this paper covers 13 years from 2002 to 2014. The choice of series time span was to avoid structural breaks prior to 2002. The first step was to select indicators from the four sectors, namely the external sector, the monetary, fiscal and real sectors that may be used as proxies for GDP. These indicators were then analysed and those that do not track GDP are eliminated. The remaining variables are used as potential predictors of GDP.

4.2 Selection of variables

A visual inspection was undertaken on potential indicators to determine the variables for further analysis and inclusion in the GDP disaggregation. Quarterly data from the four key sectors were used as a crude proxy to indicate movements in GDP. All quarterly and annual nominal indicators are presented in Figure 1 and Figure 2 respectively. They are nominal gross domestic product (NGDP), money supply (M2), consumer price index (CPI), nominal effective exchange rate (NEER), private sector credit (PSC), government spending (GS), government revenue (GR) and pay as you earn (PAYE). All variables selected are sourced from the CBSI database and transformed into an index (2002Q1=100) for ease of comparison of the trends.

The next step is to conduct an eyeballing exercise by comparing the real variables against the real GDP. This involves deflating the above nominal series with additional real variables; electricity production (elect) and visitors arrivals added to the list. This is covered in the next sub section.

Figure 1: Quarterly Nominal Indicators

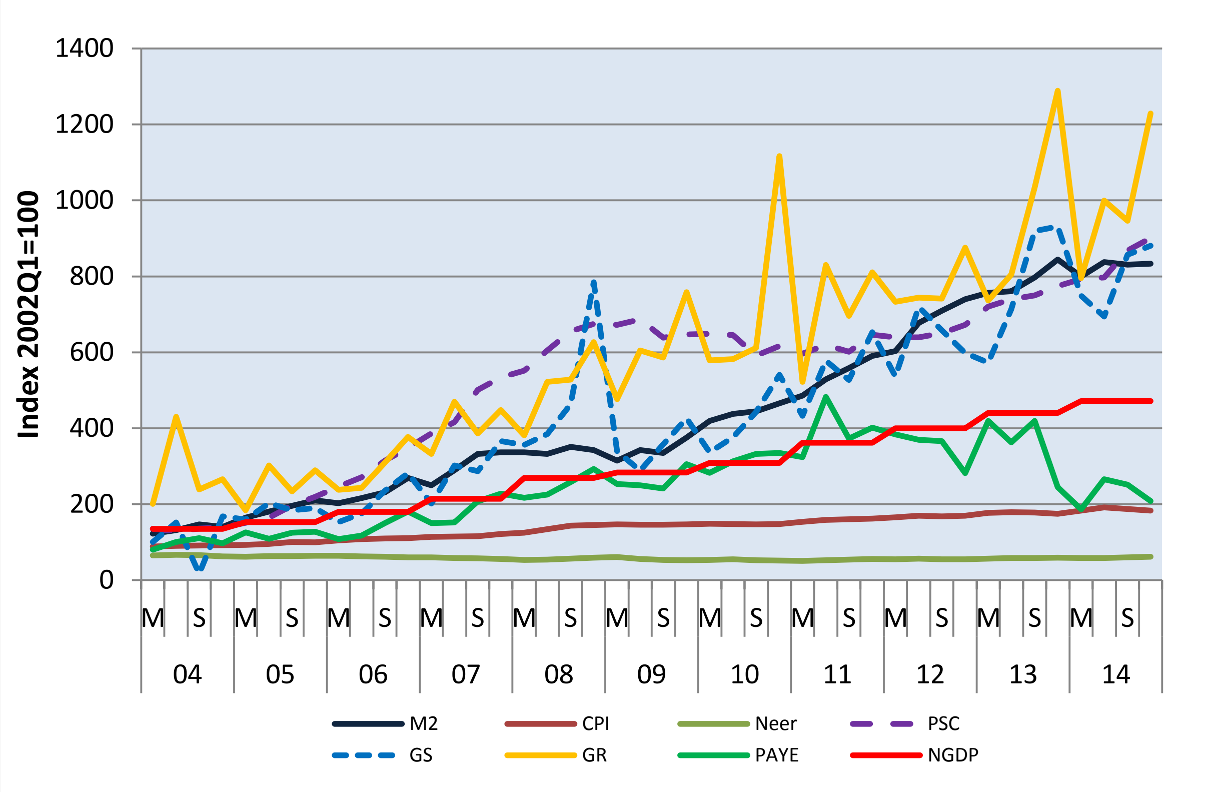
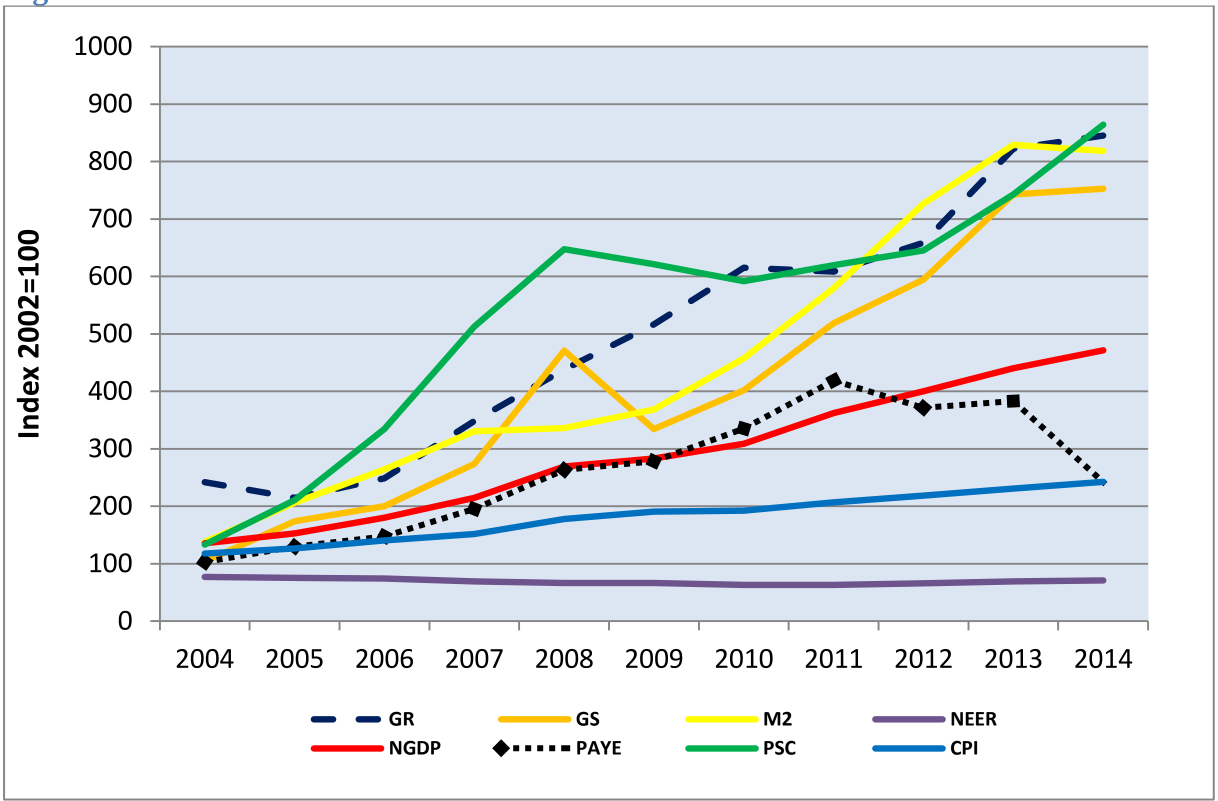


Figure 2: Annual Nominal Indicators

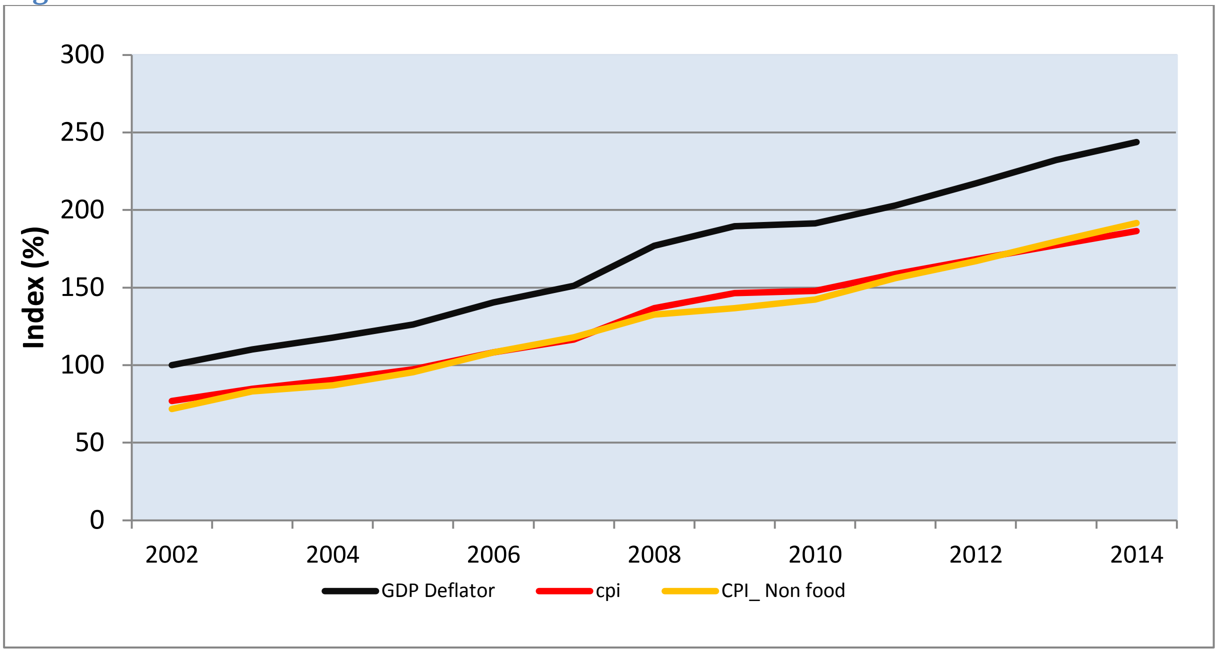


4.3 Estimating a Quarterly GDP Deflator Series

The GDP deflators were estimated to deflate nominal series to real variables. The annual GDP deflator was computed using equation (3) with the potential deflators plotted against each other in Figure 3.

$$\textit{GDP deflator} = (\textit{nominal gdp/real gdp})*100 \qquad (3)$$

Figure 3: Potential deflators



Two other deflators were plotted against the GDP deflator, the consumer price index and the core consumer price index excluding food. We use the core cpi (seasonally adjusted) as the quarterly indicator series and run it in the Chow-Lin model together with the GDP Deflator obtained from equation 3 to derive the final quarterly deflator. Note that the deflator obtained from equation 3 was at annual frequency therefore, to obtain a quarterly deflator; the core-CPI was used to generate the result shown in Figure 4. The quarterly deflator was then used to deflate the nominal quarterly indicators to become real variables.

From Figure 5, majority of indicators showed high volatility and diverged from RGDP except paye, electricity production and production index which are closely trending and tracking RDGP. *Electricity* production as a measure of demand conditions trended positively with RGDP. *Pay as you earn*, an indicator of employment in the country moved in line with real gross domestic product. Likewise *production index* (a proxy to measure domestic economic activities in the economy) although hovered and diverged in some periods, has recently moved in line with RGDP with a positive relationship.

Figure 4: Quarterly Deflator

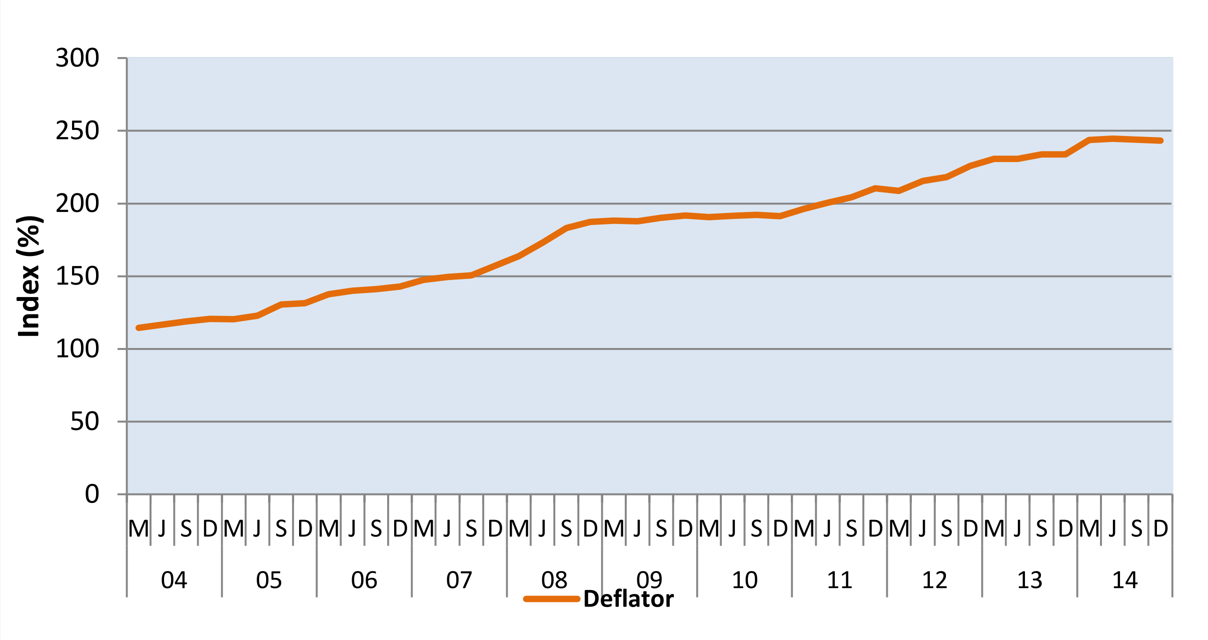
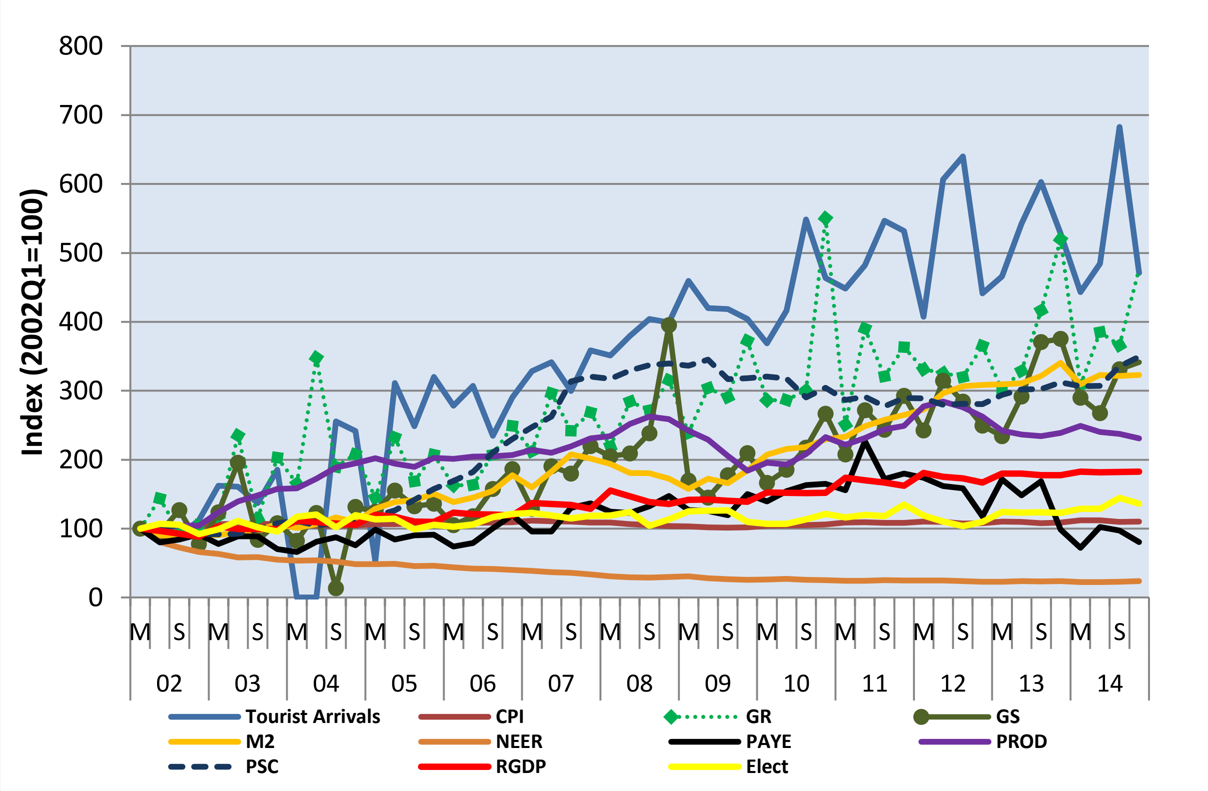


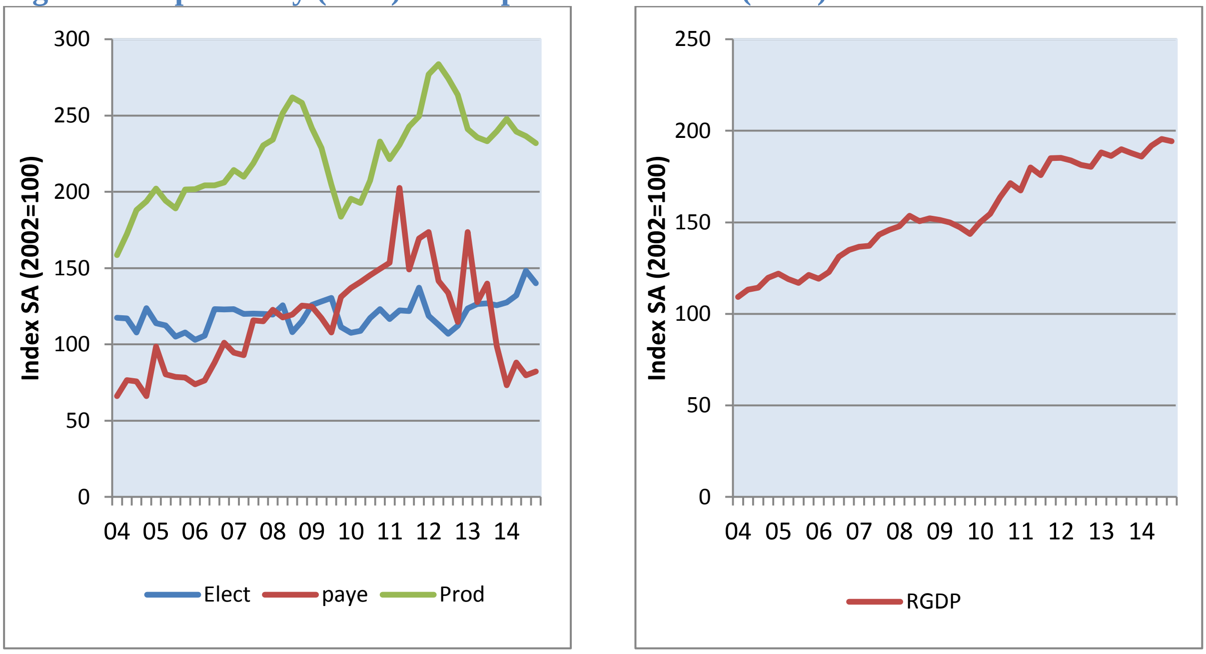
Figure 5: Real Indicators of GDP



It is expected that production index and paye move closely in the same direction, depicting the close correlation between these two series. A higher level of production is associated with higher tax revenue. Money supply (narrow money plus savings) was also positively correlated with RGDP, however money supply has been growing faster than GDP since 2009.

To further test the nature of the three possible selected indicators of RGDP, the next sub section covers the unit root tests.

Figure 6: Explanatory (LHS) and dependant variable (RHS)



4.4 Unit Root Tests

Unit root tests were conducted according to Dicky and Fuller (1979) to determine the nature of the data, that is, whether or not the variables are stationary or non-stationary. This was a prerequisite step for co-integration analysis. The tests were conducted with a constant. Both the ADF and KPSS tests were used to overcome the shortfall of the low power of the ADF test in deciding if the process is stationary but with a root close to the non-stationary boundary. For example, the test is poor at deciding if Ø=1 or Ø=0.95 especially with small sample sizes. If the true data generating process is given by equation (4);

$$y_t = 0.95y_{t-1} + u_t \tag{4}$$

Then the null hypothesis of a unit root should be rejected. One way to get around this was to use a stationary test introduced by Kwiatkowski, Phillips, Schmidt and Sims (1992). The KPSS test was such that

$$H_0: y_t \ is \ stationary$$

$$H_1: y_t \ is \ non-stationary$$

.

With ADF, the test was such that:

$H_0: y_t \text{ has unit root } (Non\ stationary)$

$H_1: y_t \text{ has no unit root } (stationary).$

The results of the tests were tabulated in Table 1.

Table 1: Unit Root Test

Variables	ADF Test With a Constant (Level)	KPSS Test With a Constant (Level)
	t-stat	LM-stat
lnrgdp	-1.4496	0.9509
lnpaye	-2.1185	0.5528
lnelect	-3.4079	0.8002
lnprod	-3.2961	0.7123

Note: The critical values for the ADF test were -3.5777, -2.9252 and -2.6007 for one, five and ten percent levels, whilst the critical values for KPSS were 0.739, 0.463, and 0.347 for one, five and ten percent respectively.

Source: Authors' own calculations

From the results, both the ADF and KPSS tests showed that PAYE and RGDP are stationary in differenced form as we cannot reject the null hypothesis of unit root under ADF while we can reject null of stationarity under KPSS. Therefore, both results were consistent to conclude that PAYE and RGDP were non stationary or *I(1),* integrated order 1. The other two variables, electricity production and production index showed conflicting results as they are stationary under ADF test while non-stationary under KPSS test. Therefore we could not conclude the stationarity of the variables. The next step was to conduct a co-integration analysis to test if the variables share a common stochastic trend in the long run.

4.5 Co-integration Test.

Following results from the ADF test, we have ascertained that all variables in levels were non-stationary but stationary in first differences, and we proceeded with a co-integration test. The co-integration analysis was used to give an indication of the suitability of the three indicators to predict quarterly GDP and to determine whether to use the Chow-Lin or the Fernandez methodology. This was done by regressing the logarithm of all indicator variables namely PAYE, the production index (prod) and electricity production (elect) against RGDP. A co-integration relationship is said to exist where a number of linear combinations of non-stationary I(1) series would yield a stationary series or I(0). It was found that there were more than one co-integration relationships between all three variable indicators and RGDP; refer to Table 2 and Table 3.

Table 2: Co-integration

Johansen's test for co-integration

$H_0(r)$	$H_1(r)$	Trace statistic	5% CV
0	1	116.0545***	47.8561
≤1	2	59.0386***	29.7971
≤2	3	24.0967***	15.4947
≤3	4	8.9377***	3.8415
$H_0(r)$	$H_1(r)$	Max eigenvalue statistic	5% CV
0	1	57.0160***	27.5843
≤1	2	34.9420***	21.1316
≤2	3	15.1589***	14.2646
≤3	4	8.9378***	3.8415

Source: Authors' own calculations

*Notes: **denotes statistical significance at 1%.*

Table 3: Long -run elasticities

lnrgdp	=	*c*	+	*lnpaye*	+	*lnelect*	+	*lnprod*
Coefficient		*-2.8520*		*0.2066*		*0.6843*		*0.4137*
t-Stat		-1.6808		3.5805		3.5489		5.1862
p-value		0.0993		0.0008		0.0009		0.0000
SE		1.6968		0.0577		0.1928		0.0798
R2		0.7789						

A simple ordinary least square (OLS) regression between the explanatory and the dependant variable further confirmed that there is a long run relationship between the variables and real gross domestic product.

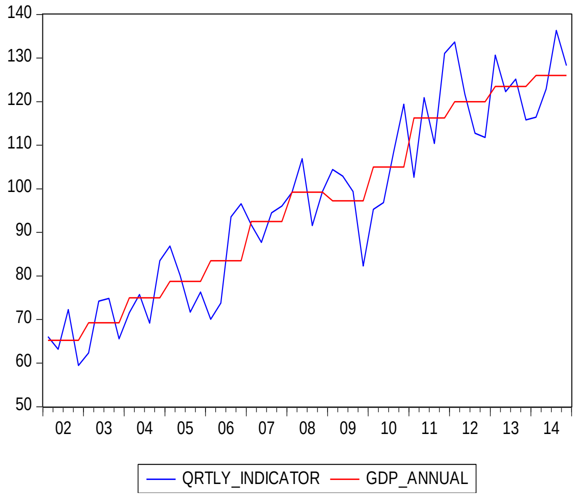
5 Results

This section covers the results obtained from the previous procedures in generating a quarterly real GDP series. Using *PAYE, elect* and *prod* as our best indicators, the output is shown in Figure 7. The findings of unit root and co-integration suggests that the Fernandez methodology is the appropriate approach to use as a quarterly series for RGDP. However, we also report the results from applying the Chow-Lin method for comparison purposes given the low power of the test due to the small sample size.

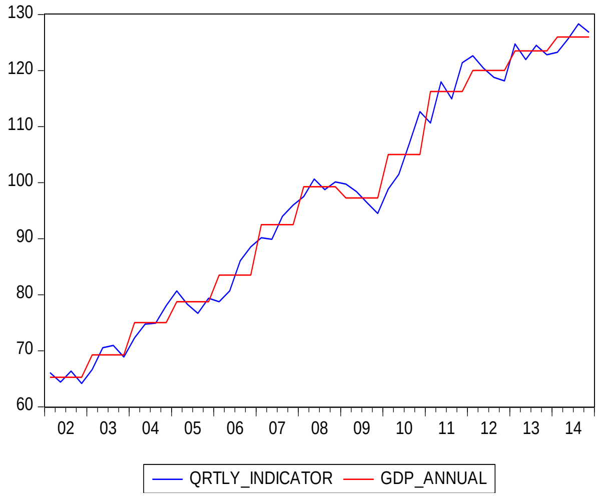
5.1 Real Quarterly GDP series using Chow-Lin and Fernandez Model.

Figure 7: Quarterly Real GDP

A. Chow-Lin Results

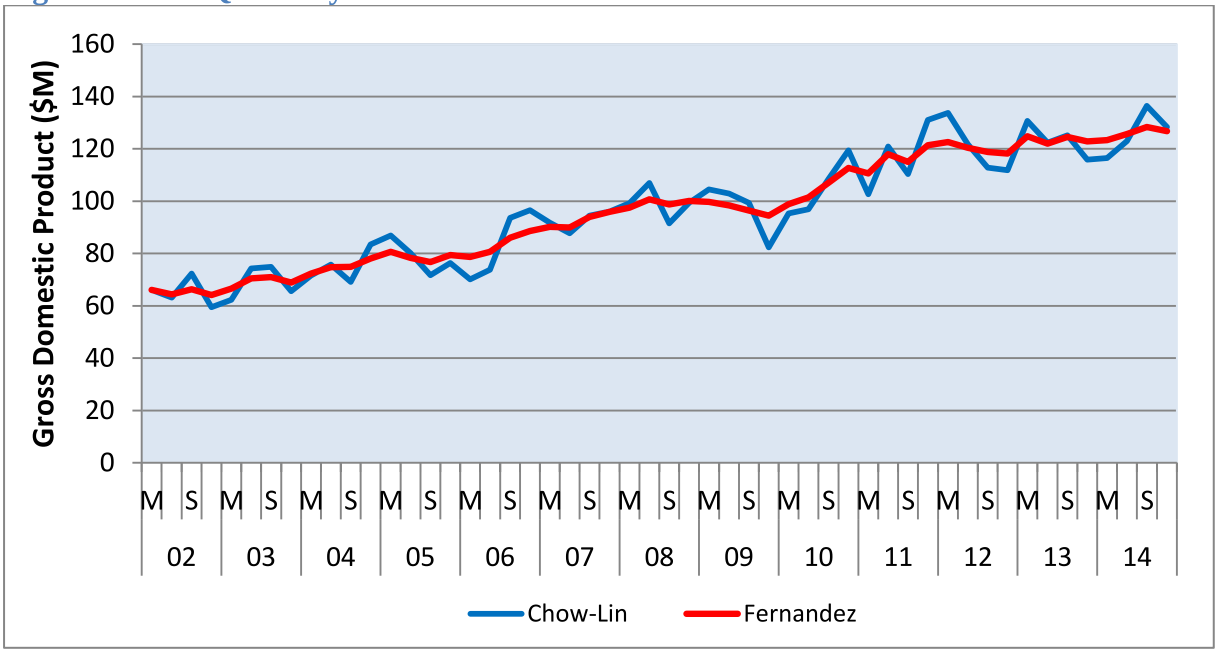


B. Fernandez Results



As depicted in Figure 7, both the Fernandez and Chow-Lin procedures showed similar results, except that the Chow-Lin procedure showed a larger quarterly volatility than the Fernandez methodology. Combining the two procedures, the results are shown in Figure 8.

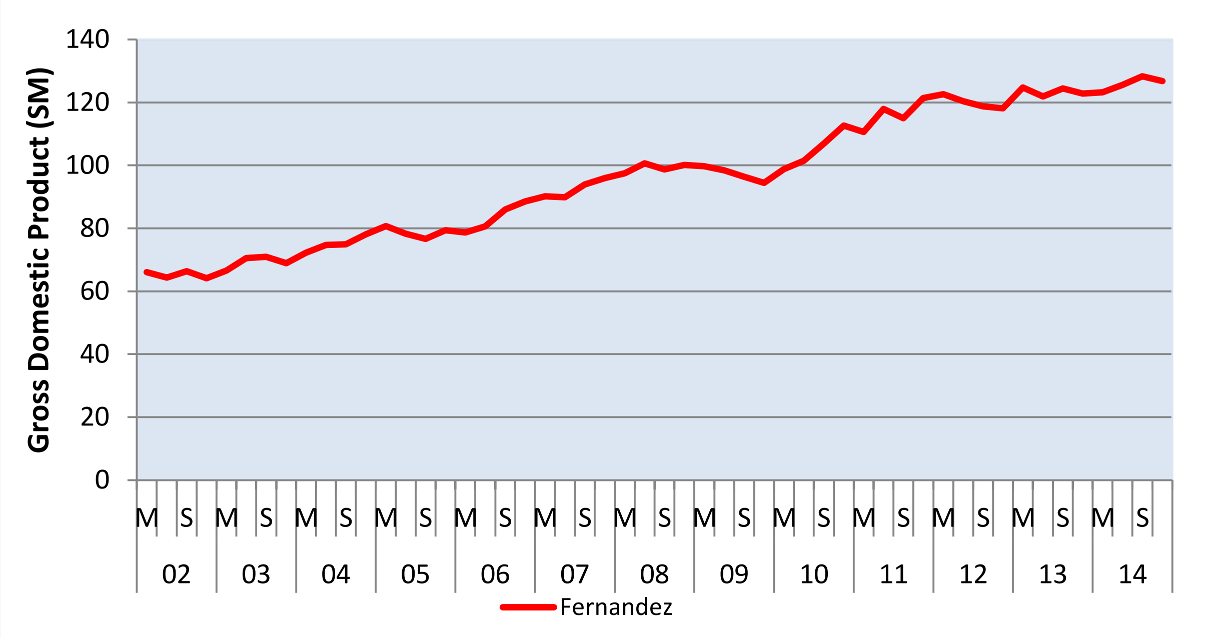
Figure 8: Real Quarterly GDP



5.2 Quarterly Real GDP Series

Deciding on which series to use in determining the output gap measures, we selected the Fernandez model as it is fairly smooth and has less volatility compared to Chow-Lin as shown in Figure 9.

Figure 9: Final quarterly RGDP using Fernandez model



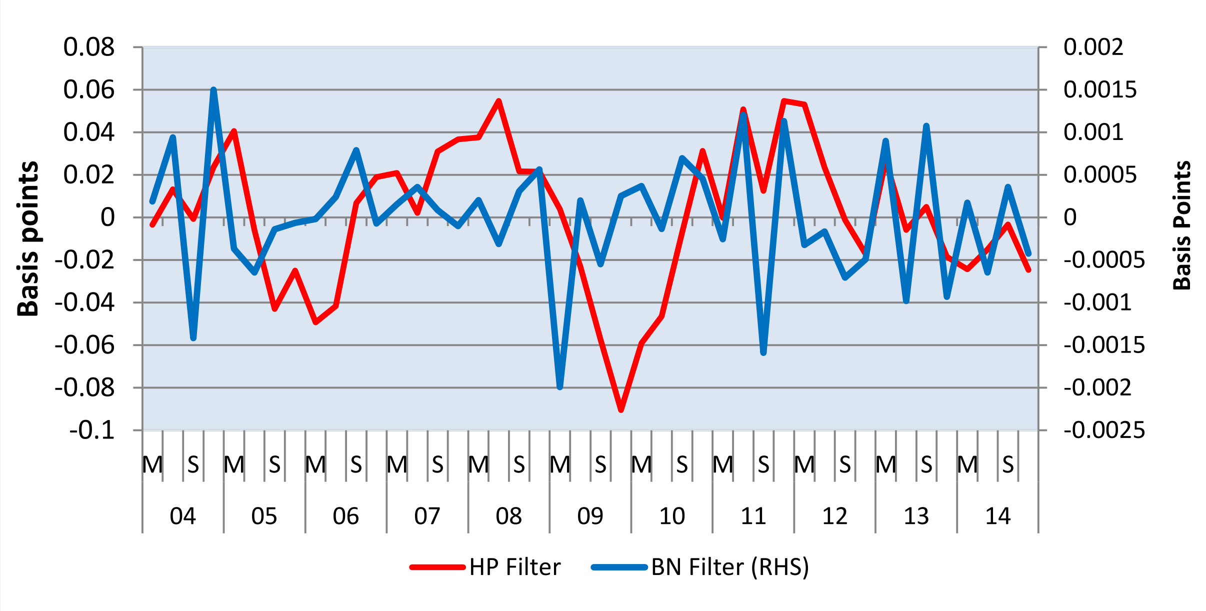
From the quarterly series, we can identify which quarters showed weak movements and which periods showed strong economic performances. Recent quarterly trends showed troughs in December quarters while March quarters showed peaks. This is useful information for policy makers to be able to make informed decisions. Using the quarterly series obtained from Fernandez, the next step was to construct the output gap which is covered in the next section.

6 Generating an Output Gap

6.1 Hodrick–Prescott and BN Decompositions

We have applied two univariate filters namely the Hodrick-Prescott filter (HP filter) and the BN decomposition to estimate an output gap based on the quarterly series of RGDP. As mentioned earlier, the HP filter and the BN decomposition filter are decomposition and smoothing techniques commonly used in macroeconomics for decomposing time series data into its trend component. The BN decomposition was run on a number of ARMA specifications for the autocorrelation structure in the deterministic and trend component. Judging on the basis of volatility, we chose the HP filter as a rule of thumb as it is less volatile compared to BN Filter. Meanwhile BN filter cannot be ruled out as it gives us more information about short term movements compared to HP filter. Results of the output gaps are shown in Figure 10.

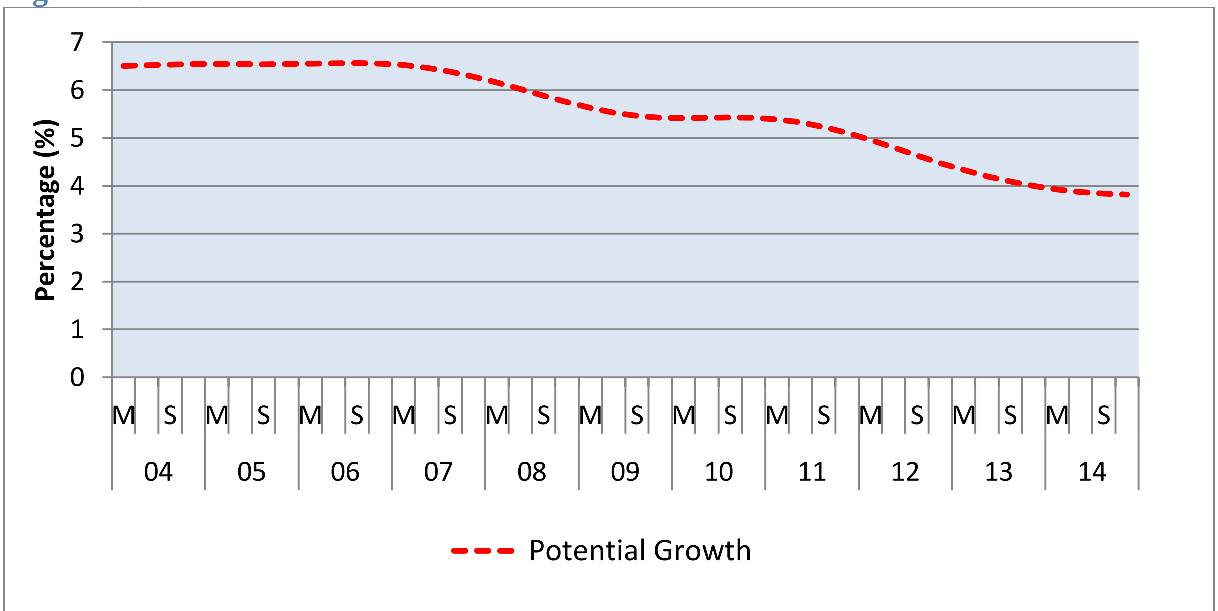
Figure 10: Output Gaps (HP & BN Filters)



Historically the output gap was positive in the first half of 2011 and went to negative output gap towards second half of 2012 then reverted to positive gap again in the first half of 2013 and remained below zero in 2014. This suggests no recent inflationary pressures from aggregate demand in 2014.

In 2014, the Central Bank of Solomon Islands estimated an annual real GDP growth rate of 2.0%. Looking at the quarterly outcomes, there was negative growth in the final quarter of 2014 against the third quarter, however in terms of half yearly; a real growth of 2.5% was attained in the second half of 2014 against the first half of the year. Meanwhile the potential growth of 3.8% was still above the quarter-on–quarter and half-yearly outcomes thus creating a negative output gap for 2014 (Figure 11).

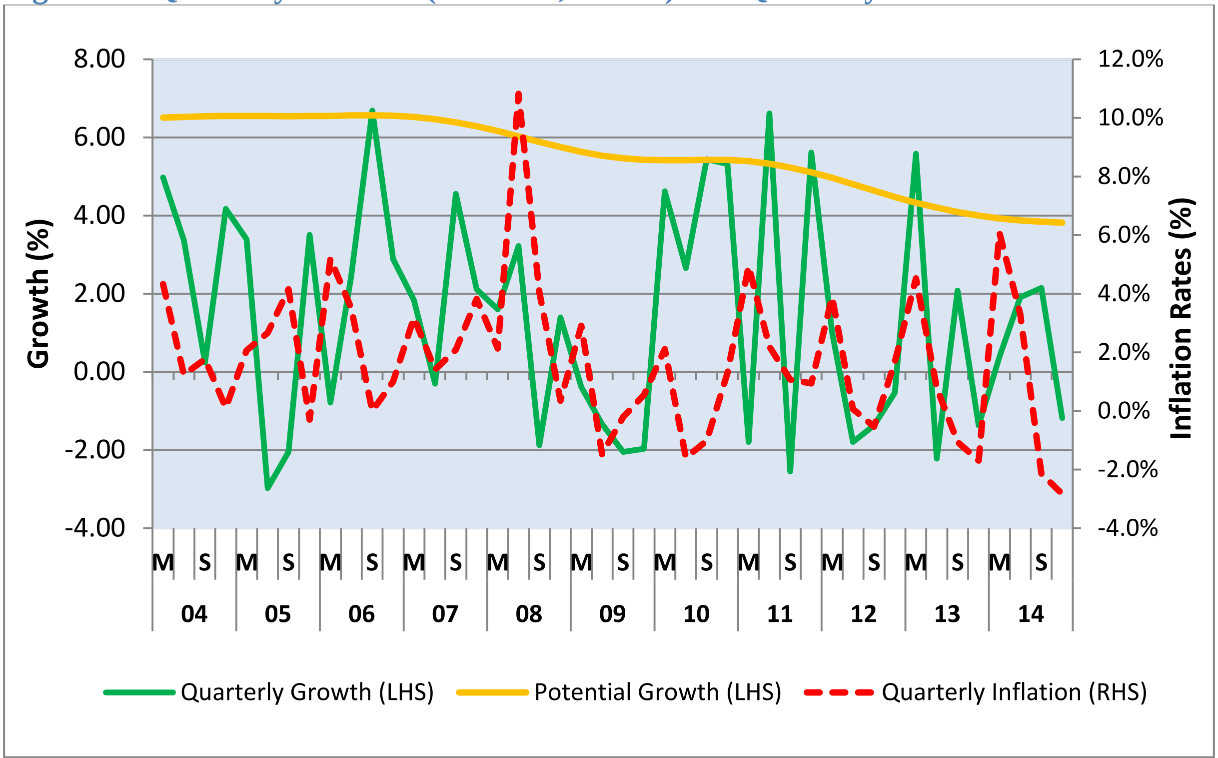
Figure 11: Potential Growth



Both filters showed a negative output gap, however, caution needs to be taken as this negative gap might revert, but currently have no significant signs of inflation overshooting from demand side.

Relating the output gap with the quarterly movement of prices, output for the second half of 2014 outperformed the first half by 2.5%, but fell in the final quarter by 1% and below potential growth of 3.8%. Due to the pronounced lagged nature in inflation as found by Especkerman-True et al (2014), this has not immediately translated through into inflation. However, quarterly measure of inflation[2] showed the increase in inflation rate for the first six months of 2014 was not due to demand but supply shocks associated with the aftermath of the April flood. However, quarterly inflation eased in subsequent periods to negative territory by the end of 2014 (Figure 12).

Figure 12: Quarterly Growths (Potential, Actual) and Quarterly Inflation Rates



7 Conclusion

Temporary disaggregation of low frequency data to a higher frequency can be done by various methods. We have used the Chow and Lin (1971) and Fernandez (1981) methods in this paper to derive quarterly economic output. The procedures involved employing a two-step selection process to obtain a quarterly series. In the first step potential variables were selected based on visual inspection and the second step empirically tested the variables to use as indicators, including whether or not the indicator variables are statistically co-integrated with GDP. We found that PAYE, production index and electricity production moved closely and with positive relations with GDP compared to the other indicators.

[2] Quarter against the immediate preceding quarter, for example, June 2014 against March 2014

Two univariate filters were used to estimate an output gap—the HP filter and the BN decomposition whereby the former appeared to be more reflective of the Solomon Islands output.

We found that the quarterly output was below potential for the whole of 2014 resulting in negative output gap. This is an indication of no demand pressures to inflation in 2014, and that the uptick in quarterly inflation in the first half of 2014 was due to supply shocks. However, our headline inflation of three months moving average (3mma) rates only respond with a lag of about two quarters and therefore demand pressures may not be expected in the first half of 2015. Nonetheless, developments affecting commodity and electricity production and employment must be monitored to capture the moment of reversion from the current negative output gap. Against the potential output, the Solomon Islands economy has ample policy space to grow without causing any inflationary pressures in the medium term.

7.1 Policy Implications

As found in our discussions above, the SI economy has been growing below potential for most of the sample period except for some points where it exceeded the average potential growth rate of 5.3% in the first quarter of 2011, and 4.3% in the first quarter of 2013.

Efforts should be taken to channel investment into areas that can drive growth above the potential level. This will require strong partnership between public and private sector.

Credit growth has weakened in 2015 after lending activities in 2014. While there is still space to accommodate increased lending activities especially at this time when inflation rates are low, lending should be strategically channelled into productive sectors that can support long term growth.

A useful extension to this paper for future researchers would be to use the output gap measures to estimate a Phillips Curve and/or performing univariate and bivariate models (horse racing) for inflation forecasting going forward.

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