ESTIMATING POTENTIAL OUTPUT FOR NIGERIA: A STRUCTURAL VAR APPROACH

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ABSTRACT

Potential output and the associated concept of output gap play a key role in macroeconomic policy formulation since a positive output gap is an indicator of excess demand and consequently potential inflationary pressures while a sustained negative output gap is an indicator of deflationary pressures. This is often used as a guide for selecting appropriate monetary policy measures. Yet, obtaining a reliable measure of output gap is difficult since potential output is unobservable. Different techniques sometimes give widely different measures of the output gap. Given the uncertainty surrounding measurement of the output gap, this paper utilizes three of the more popular methodologies to estimate Nigeria's potential output level and output gap. The five techniques used are the linear time trend, the Hodrick-Prescott filter, and the structural vector autoregressive (SVAR) model. Note that the assumption that movements in output are the result of cyclical shocks arising from demand-side developments, and productivity shocks arising from supply-side developments provides the set of identifying restrictions for the SVAR model. A comparison of the empirical results obtained from the methods studied suggests that, apart from the trend model, the measure of output gap obtained from the SVAR model is likely to provide the most reliable predictor for inflation in Nigeria. However, since any assessment of the inflationary pressures of the economy based on one estimate of the output gap is risky and could lead to policy failure, it is recommended that the use of the estimated output gap as an indicator for monetary policy should be supplemented by professional judgment and use of other intermediate indicators.

Key words: potential output, output gap, structural VAR model

I. Introduction

Potential output is the level of output that is consistent with the maximum sustainable level of employment and growth. It is the level of output at which demand and supply in the aggregate economy are balanced so that, all things being equal, inflation tends to gravitate to its long-run expected value. Thus, estimating the path of potential output is central to the conduct of monetary policy. This is because in order to evaluate whether macroeconomic policies will help achieve the maximum sustainable employment and price stability, it is necessary know the level of future output that would be consistent with these objectives.

The output gap, which is the difference between the actual output and the level of potential output, plays an important role in the inflation process. The labour and product markets tend to be very tight when the output gap is positive, that is, when the actual level of output is above potential output. In this case, ceteris paribus, inflation will tend to rise. On the other hand, when the output gap is negative and labour and product markets are slack, inflation will tend to fall. Thus, it becomes imperative to estimate the future path of potential output in order to ascertain whether the projected path of output that is implied by current monetary policy will cause the price level to move in a direction that is consistent with price stability.

However, monetary authorities are faced with the challenge of obtaining an accurate measure of potential output - which is not observable - in order to assess the expected inflation that would emerge eventually, and formulate appropriate policies that will achieve high level of employment and sustainable non-inflationary growth. This accounts for the great interest in obtaining an accurate estimate of potential output in the modern mixed market economies.

There are various approaches to estimating potential output. Some of them are summarized below as a prelude to our own effort to obtain an accurate estimate of potential output for the Nigerian economy.

Aggregate Approaches: These include the univariate and multivariate methods. The univariate statistical methods identify the permanent component of changes in output to be a measure of potential output, Beveridge and Nelson (1981), Clark (1987). Although, the univariate methods have the advantage of simplicity in providing what potential output might be, they are fraught with the following shortcomings: first, a variety of statistical assumptions are made concerning the correlation between permanent and transitory components or whether the permanent component should be modeled as a random walk. These alternative assumptions could lead to different estimates of potential output. Second, these statistical approaches do not indicate whether the measure of the permanent component of output movements provides information about the most important aspect of potential output, which is its association with a stable rate of inflation.

The multivariate approaches include the natural-rate hypothesis or the non-accelerating inflation rate of unemployment (NAIRU). According to the natural-rate hypothesis, there is a natural rate of unemployment at which inflation tends to gravitate to its long-run expected value, Phelps (1967), Friedman (1968). The natural rate of unemployment and NAIRU are frequently used interchangeably, but a subtle distinction exists between them. The natural rate of unemployment is the rate at which inflation would tend to gravitate to its long-run expected value, while NAIRU is the unemployment rate at which inflation will have no tendency to move up or down.

A natural rate of output (potential output) corresponds to the NAIRU. Thus, the natural-rate hypothesis suggests that potential output can be estimated from a multivariate approach in which potential output is an unobserved component in the relationship between inflation and the output gap, Kuttner (1994), Cochrane (1994), Apel and Jansson (1999), Dupasquier et al (1999). Alternatively, NAIRU can be derived directly from estimates of the Phillips curve and then using Okun's law to estimate potential output, Okun (1962). This law relates the output gap to the unemployment gap, that is, the actual unemployment rate minus the NAIRU.

These multivariate methods though simple and intuitively sensible, have some drawbacks. First, they require that the specification of the Phillips curve is correct by correctly characterizing the relationship between the unemployment rate gap and inflation dynamics, as well as, taking into account how inflation expectations are formed, Gordon (1982). Second, the use of Okun's law to estimate potential output has not been very reliable due to cyclical fluctuations in productivity and labour supply which can complicate the relationship between output and unemployment gaps, Altig et al (1997), Rudebusch (2000), Groshen and Potters (2003). Therefore, the estimation of the NAIRU in isolation, will provide policymakers a rather myopic insight for evaluating the effect of labour markets on inflation pressures, Staigner et al (1997a and b).

Production Function (Growth-accounting) Approaches: Production function approaches otherwise known as "growth accounting", estimate the potential output as the level of output where all factors of production are fully utilized. The merit of this approach is that it focuses on the various factors that drive growth in potential output, rather than simply on the historical behaviour of output growth or on the historical relationship between output and labour inputs as in Okun's law. The disaggregated nature of this approach implies that more data can be used to estimate potential output, which would be valuable when an economy is experiencing major structural changes such as productivity growth or slowdown, the surge and subsequent slowdown in population growth, and upsurge in labour participation of females.

The growth-accounting method is not without its setbacks. One of such difficulties is that there is a large degree of uncertainty surrounding the estimates of the components that go into the growth-accounting formulas. Added to this is the fact that this approach requires a lot of data, some of which are not reliable for example, capital services, and others like labour composition and multifactor productivity are not readily available for all the sectors, Mishkin, (2007).

Proietti, Musso and Watermann (2002) appraised unobserved component models based on production function approach for estimating the output gap and potential output for the Euro Area, and concluded that the models could be valuable for growth accounting and for reducing the uncertainty surrounding the output gap estimates.

Araujo et al (2004) calculated different measures of potential output and output gap for the Brazilian economy, and found that the potential output estimated by the different models exhibited low and high variance trend, and that the forecasts from the unobserved components models were more inaccurate than those generated by the simple univariate models. In addition, their findings indicated that the deterministic trend, moving average, Hodrick-Prescott, Beveridge-Nelson and production function models have strong short-term co-movements, appearing to be moving upward and downward at roughly the same time. Finally, they also found that the Beverage-Nelson methodology out performed all the models at the forecast horizons.

Dynamic Stochastic General Equilibrium (DSGE) Approaches: DSGE also referred to as New Keynesian Models, provide more realistic and theoretically elegant representatives of the economy because they allow for rigidities and imperfections in the markets. These models view potential output as the level of output that an economy could attain if the inefficiencies resulting from nominal wage and price rigidities were removed, that is, if wages and prices were fully flexible, Goodfriend and King (1997), Woodford (2003).

The DSGE view of potential output is different from conventional measures due to the differences in the properties of potential output and output gap, Neiss and Nelson (2005), Edge et al (2007). For example, in many DSGE models, potential output can undergo swings over the business cycle. In addition, fiscal policy shocks, changes in households' preferences with regard to saving and consumption, as well as, changes in preferences about leisure that affect labour supply, and terms-of-trade shocks can all cause potential output to fluctuate. This is contrary to what obtains in growth-accounting models where such shocks have little effects on potential output at business-cycle frequencies. As such, their estimates have smaller fluctuations than those obtained from DSGE models. Thus, the output gaps generated from DSGE models tend to be less variable than conventional measures, Mishkin (2007).

The DSGE approaches depend so much on models and their estimates. Hence, DSGE Models with different characterizations of the economy's underlying structure can produce substantially different estimates of potential output. The large disparities between the potential output measures in the DSGE models of Neiss and Nelson (2005) and Edge et al (2007) attest to this fact. Finally, the smaller and less persistent output gaps obtained from DSGE models imply that inefficiencies other than price rigidities, such as real wage rigidities are important for output fluctuations, and would likely show output gap estimates that are more similar to traditional gaps, Blanchard and Gali (2007).

Different measures of the output gaps could be evaluated based on how well they actually predict inflationary pressures. Coe and McDermott (1997) test the output gap model for a group of thirteen developing countries, new industrialized and the industrial Asian economies including New Zealand, and using annual data, found that for New Zealand, the change in inflation is closely related to the change in the output gap, where the output gap is based on non-parametric estimation procedure.

On their part, Cerra and Saxena (2000) reviewed a number of different methods that can be used to estimate potential output gap for Sweden, and found evidences of large negative output gap.

Similarly, Dupasquier, Guay and St. Amant (1997) used different methodologies to estimate the spectra of output gaps in the United States. They found that only a structural vector autoregression (VAR) methodology with long-run restrictions generates an output gap with a peak at business cycle frequencies, lasting between 6 and 32 quarters.

Claus (1999) used quarterly data from 1970 to 1998 on real production Gross Domestic Product (GDP), full-time employment and a survey measure of capacity utilization to estimate potential output for New Zealand employing a structural VAR methodology. He obtained good results, finding that prior to the economic reforms, the New Zealand economy was in excess demand with generally poor productivity growth and high inflation.

In order to determine the effectiveness of a variety of output gap estimators to accurately measure the output gap, Rennison (2003) used a Monte Carlo experiment on a model economy, and discovered that an estimator that combines Hodrick-Prescott fitter with a Blanchard-Quah structural VAR yields an accurate estimate.

Serju (2006) also found that the best model for estimating the output gap for the Jamaican economy is the structural VAR because of its relatively good predictive power and its consistency with economic theory when compared to the other models.

Still on the best method of obtaining estimates of the potential output, core inflation and the NAIRU as latent variables, Domenech and Gomez (2003) proposed a new method that uses a combination of a standard Okun's law, a forward-looking Phillips curve and an investment equation. Also, Ehrmann and Smets (2003) used a small forward-looking model of the euro-area economy to examine the implications of incomplete information about potential output for the conduct of monetary policy, under optimal monetary policy. Their study established that output gap uncertainty leads to persistent deviations between the actual and the perceived output gap in response to supply and cost-push shocks.

Osman (2008) estimated the potential output and output gap of four East Africa countries, namely, Kenya, Ethiopia, Tanzania and Uganda, using different statistical methodology with annual data from 1975 – 2004. The results show that the estimations of the output gaps of these countries are generally in agreement about the historical boom bust cycles of the countries, and demonstrate that the business cycles display sharp turning points rather than exhibiting smooth patterns that are typical for the advanced economies. They are of the view that estimates of the output gap should not be based on one measure as this could lead to policy failure.

II. Estimating Potential Output for the Nigerian Economy

This paper focuses on methods of estimating potential output for the Nigerian economy. The methods/techniques of estimation presented in the paper are few because of data limitation. The basic aim was to use quarterly data. This could only be done for the univariate statistical techniques of linear time trend and Hodrick-Prescott filter. Unavailability of quarterly data for capacity utilization prevented the use of quarterly data for the structural vector autoregression (VAR) method and the estimation of a production function. We had to make do with using annual data for the VAR estimation. We hope to make amends when quarterly data series become available for the appropriate variables.

2.1 Univariate Estimation Techniques

Two univariate statistical estimation techniques were used in this study for comparison with the structural VAR methodology. They are: (i) the linear trend technique and (ii) the Hodrick-Prescott filter. Quarterly data for real gross domestic product from 1980 Q1 to 2008 Q4 were utilized. The data were obtained from the Golden Jubilee edition of the CBN’s Statistical Bulletin.

2.11 Linear Trend Method

This method is simple, straightforward and intuitively appealing. Potential output is obtained using a deterministic (linear) time trend. Basically, potential output is computed from a linear equation of output or log of output on a time trend. The fitted line is taken as potential output while the difference between the fitted line and actual output is considered to be the estimate of the output gap. The drawback of this method is that it is mechanical and not based on theory.

2.12 The Hodrick-Prescott Filter

The Hodrick-Prescott (HP) filter is another univariate technique for obtaining an estimate of potential output from actual output data. The HP filter minimizes a combination of the size of the actual output fluctuations around its trend and the rate of change in the trend output for the sample period. Thus, in essence, the Hodrick-Prescott filter selects the potential output sequence which minimizes the squared difference between actual and potential output subject to the constraint that there is no undue fluctuation in potential output. One advantage of the HP filter over the linear trend method is that it makes the output gap stationary over a wide range of smoothing values in addition to allowing the output trend to change over time. However, it suffers from the same criticism as the linear trend method -- that it is mechanical and not based on economic theory.

2.2 The Structural Vector Autoregression Methodology

The structural vector autoregression (SVAR) method is adjudged superior to univariate techniques because it combines economic theory with statistical techniques to make a distinction between permanent and temporary movements in output. In particular, we shall adopt the structural vector autoregression methodology with long-run restrictions first proposed by Blanchard and Quah (1989) and popularized by King, Plosser, Stock and Watson (1991). The method has since been used by many researchers including Claus (1999) and Serju (2006). Using the SVAR framework, the assumption that movements in output are the result of cyclical shocks arising from demand-side developments and productivity shocks emanating from supply-side developments gives a set of identifying restrictions. Using the selected identification rule, the structural shocks are separated into demand and supply shocks. Next, the effects of demand shocks on output are classified as temporary while the effects of aggregate supply shocks are assumed to be permanent. Therefore, potential output is obtained by aggregating the supply shocks while the output gap is calculated from a combination of the demand shocks. The main advantage of this methodology is that the approach is clearly based on theory while it also allows the data to determine the short-run dynamics.

In this paper, the vector autoregression methodology with long-run restrictions is employed to estimate potential output for Nigeria. It is worth stressing that this technique does not impose restrictions on the short-run dynamics of the permanent component of output but employs a process for permanent shocks that is more general than a random walk.

Following the approach used by Claus (1999), we obtain an estimate of potential output for Nigeria by the instrumentality of a three-variable structural vector autoregression model. Since quarterly data was not available for all the variables, annual data for real gross domestic product, employment and capacity utilization were utilized. Data for real gross domestic product and employment (proxied by the labour force) were sourced from the World Bank's World Development indicators while data for capacity utilization were obtained from the CBN's Statistical Bulletin (Golden Jubilee edition).

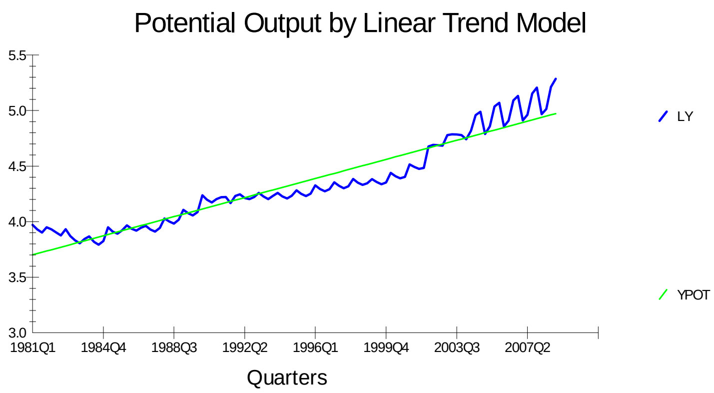
III. Econometric Estimation Results

Econometric estimation was carried out using the Microfit 4.1 econometric software.

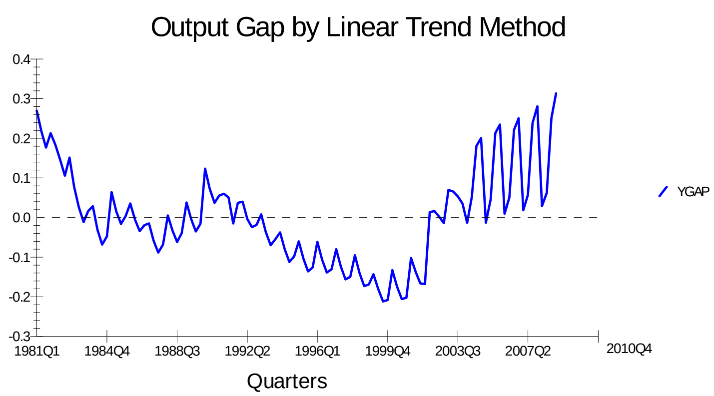
3.1 Linear Trend Model

Figure 1 gives us the relationship between actual and potential output during the entire period. An examination of the graph shows that it agrees with what we already know, namely, that the 1990s were years of recession while there was a boom during the first decade of the 21st century. These results can of course also be obtained from an examination of the output gap in Fig 2. All in all, the simple, univariate trend model gives pretty good results.

Fig. 1: Potential Output



<u>Fig 2: Output Gap</u>



3.2 Hodrick-Prescott Filter

Figures 3 and 4 give us the results of the Hodrick-Prescott filter. Unfortunately, the results are not as impressive as those obtained from the linear trend model. Notice that the results do not accurately capture the deep recession of the 1990s though they show the boom in the new millennium.

Fig 3: Potential Output

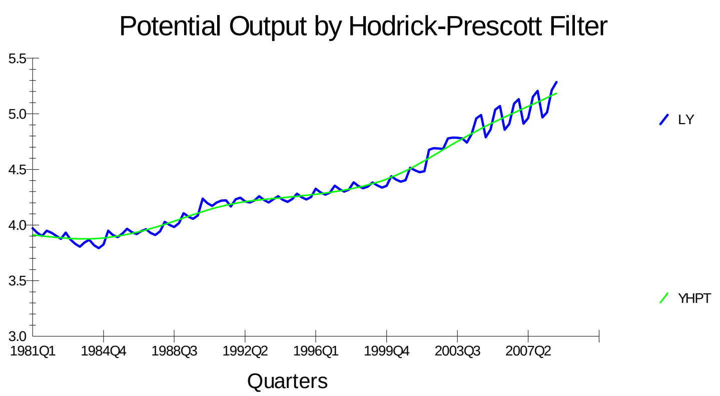
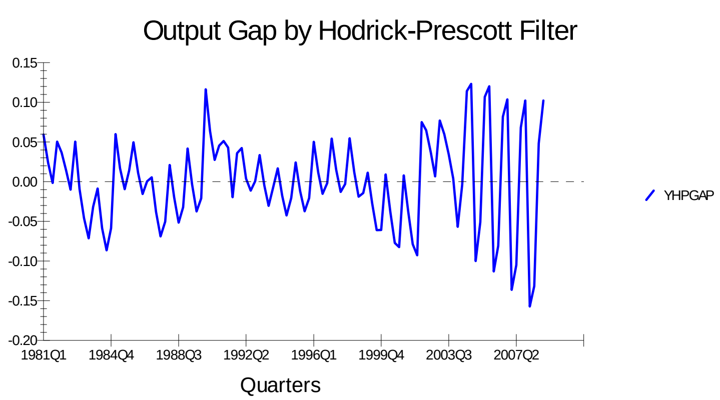


Fig 4: Output Gap



3.3 Econometric results from Annual data

3.31 Linear Trend Method

For purposes of comparison, we also estimated the trend model using annual detail. Figures 5 and 6 give the graphs for potential output and output gap respectively. A comparison of Figures 1 and 5 shows that the quarterly estimate does a better job in reflecting the recession of the 1990s. Also, the annual estimate erroneously shows a deep recession, instead of a minor one in the 1980s. All in all, the estimates using quarterly data are preferred.

Fig 5 Potential Output (annual data)

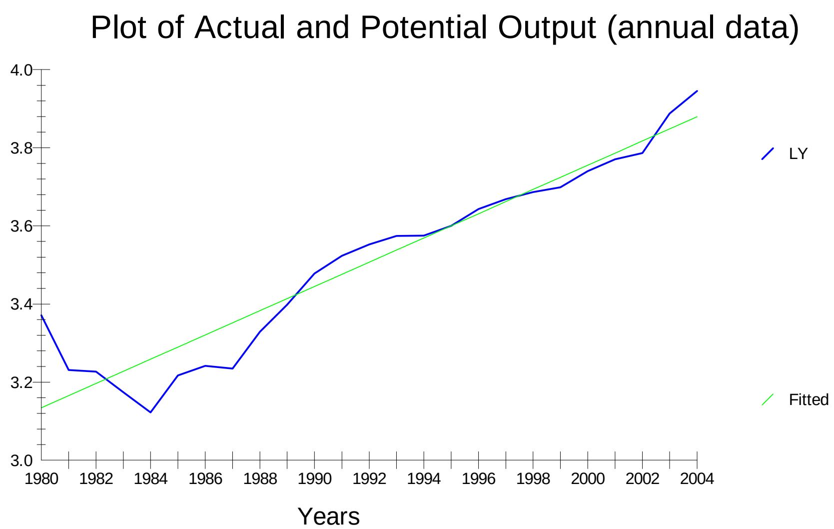
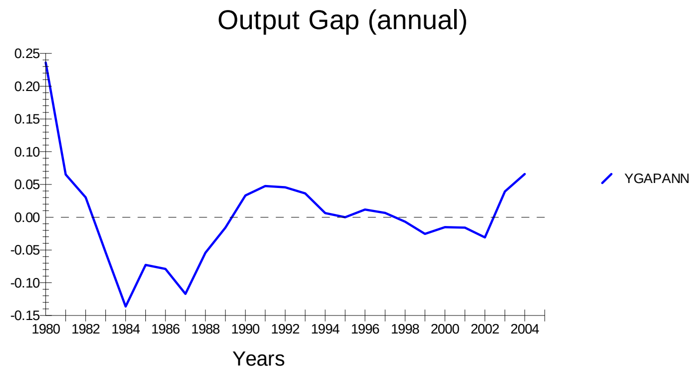


Fig 6: Output Gap (annual)



3.32 Structural Vector Autoregression model results

Figures 7 and 8 give the graphical results of the structural autoregression model. Fig 7 provides us a graphical comparison of actual output and the estimate of potential output obtained using the SVAR methodology. Fig 8 gives the output gap. A close examination of Fig 7 shows that the SVAR estimate of potential output using annual data does not properly capture the deep recession of the 1990s. However, it correctly captures the boom of the new millennium. It remains to be seen whether use of quarterly data will improve the performance of the SVAR methodology. We may expect this since the quarterly estimates of the linear trend model was superior to its annual counterpart.

The results of the unit root tests of the variables are reported in the appendix. As expected real output is difference stationary; employment is I(1) while capacity utilization is I(0).

Fig 7: SVAR Potential Output (annual data)

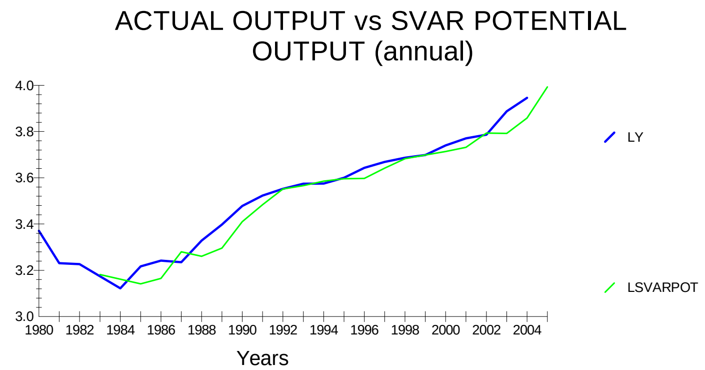
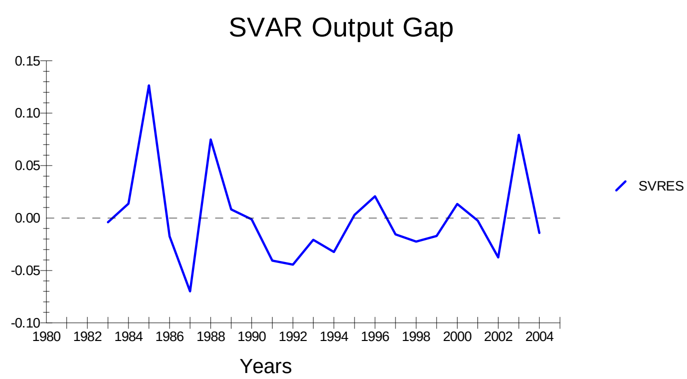


Fig 8: SVAR: Output Gap



IV. Summary and Conclusion

In this paper, an attempt has been made to obtain estimates of potential output and the output gap for Nigeria, using different techniques. The number of techniques or methodologies used was limited, *inter alia*, by data availability. For example, the unavailability of quarterly data for key variables made it impossible to use the production function approach. Three methods, namely, linear trend, Hodrick-Prescott and structural vector autoregression, were utilized. The results were fairly satisfactory and surprisingly, the linear trend method gave good results. We had to be satisfied with estimating the structural autoregression model with annual data because of the unavailability of quarterly data for capacity utilization. Therefore, it would be necessary to estimate the SVAR model with quarterly data before a definitive conclusion can be reached about its superiority over other methods in the Nigerian context. Also, it would be necessary to carry out tests concerning their performance in forecasting inflation.

In conclusion, considering the uncertainty that surrounds the measures of potential output, more work needs to be done in improving its estimate and that of the output gap. Therefore, caution needs to be exercised about taking on board the implication of our current estimates of the output gap. For instance, if inflation is moving away from the direction suggested by the output gap estimation, then it is possible that our output gap measure is not providing us with reliable information. The implication of these uncertainties is that policymakers should not rely on a single measure of estimating potential output.

References

Altig, D., T. Fitzgerald, and P. Rupert. 1997. "Okuns Law Revisited: Should We Worry about Low Unemployment?" *Economic Commentary*, Federal Reserve Bank of Cleveland (May)

Apel, Mikeal, and Per Jansson 1999. "A theory-Consistent System Approach for Estimating Potential Output and the Nairu" *Economic Letters*, vol. 64, pp. 271 – 75.

Araujo, H. V., M. B. M. Areosa and O. T. C. Guillen. 2004. "Estimating Potential Output and Output Gap for Brazil". *Banco do Brazil*, July.

Baxter, M. and R. G. King, 1995. "Measuring business cycles: approximate band-pass filters for economic time series", *NBER Working Paper* No 5022.

Beveridge, Stephen, and Charles R. Nelson. 1981. "A New Approach to Decomposition of Economic Time Series into Permanent and Transitory Components with particular Attention to Measurement of the 'Business Cycle' " *Journal of Monetary Economics*, vol 7 (March), pp. 151-74.

Blanchard, Olivier, and Jordi Gali. 2007. "Real Wage Rigidities and the New Keynesian Model", *Journal of Money, Credit and Banking*, VOL.39 (February), pp. 35 -65.

Blanchard, o. and D. Quah, 1989. "The dynamic effects of aggregate supply and demand disturbances", *American Economic Review*, 79, pages 655-673.

Central Bank of Nigeria 2008. *Statistical Bulletin*, Golden Jubilee Edition. Abuja.

Cerra, V. and S. C. Saxena 2000. "Alternative Methods of Estimating Potential Output and the Output Gap: An Application to Sweden". *International Monetary Fund (IMF) Working paper*, 00/59.

Clark, Peter K. 1987. "The Cyclical Component of the U.S. Economic Activity". *Quarterly Journal of Economics*, vol. 102 (November), pp.797 – 814.

Claus, I. 1999. "Estimating Potential Output for New Zealand: A

Structural VAR Approach". *Reserve Bank of New Zealand*, *Discussion Paper Series.*

Cochrane, John H. 1994. "Permanent and Transitory Components of GNP and Stock Prices", *Quarterly Journal of Economics*, vol. 109 (February), pp. 241 – 65.

Coe, D.T. and McDermott. 1997. "Does the Gap Model Work in Asia?". *IMF Staff Papers* 44, 59 – 80.

Domenech, R. and V. Gomez. 2003. "Estimating Potential Output, Core Inflation and the NAIRU as Latent Variables", *mimeo,* University of Valencia.

Dupasquier, C., A. Guay and P. St. Amant. 1997. "A Comparison of Alternative Methodology for Estimating Potential Output and the Output Gap". *Bank of Canada Working Paper* No. 97 – 5.

Dupasquier, Chantal, Alain Guay, and Pierre St-Amant. 1999. A "Survey of Alternative Methodologies for Estimating Potential Output and the Output Gap," *Journal of Macroeconomics*, vol 21 (summer), pp. 577 – 95.

Edge, Rochelle M., Micheal T. Kiley, and Jean-Pierre Laforte. (2007). "Natural Rate Measures in an Estimated DSGE Model of the U.S. Economy", *Finance and Economics Discussion Series 2007 – 8* (Washington: Board of Governors of the Federal Reserve System, March).

Ehrmann, M. and F. Smets. 2003. "Uncertain Potential Output: Implications for Monetary Policy". *Journal of Economic Dynamics and Control,* 27 1611 – 1638.

Friedman, Milton. 1968. "The Role of Monetary Policy," American *Economic Review,* vol 58 (March0, pp. 1 – 17.

Goodfriend, Marvin, and Robert G. King. 1997. "The New Neoclassical Synthesis and the Role of Monetary Policy," Ben S. Bernanke and Julio J. Rotemberg, eds., *NBER Macroeconomics Annual*, 1997. Cambridge, Mass.: MIT Press, pp. 231 – 83.

Gordon, Robert J. 1982. "Inflation, Flexible Exchange Rates, and the

Natural Rate of Unemployment." In Martin Neil Baily, ed., *Workers, Jobs and Inflation*. Washington, D. C.: Brookings Institution, pp. 89 – 158.

Groshen, Erica L., and Simon Porter. 2003. "Has Structural Change Contributed to a Jobless Recovery?" *Current Issues in Economic and Finance,* Federal Reserve Bank of New York, vol. 10 (December).

Hodrick, R. J. and E. C. Prescott, 1997. "Post-war U S cycles: an empirical investigation". *Journal of Money, Credit and Banking*, 29, 1-16

King, R. G., C. I. Plosser, J. H. Stock and M. W. Watson, 1991. "Stochastic trends and economic fluctuations" *American Economic Review*, 81, 819-840.

Kuttner, Kenneth N. 1994. "Estimating Potential Output as a Latent Variable". *Journal of Business and Economic Studies*, vol. 12 (July), pp.361-68

Mishkin, F.S. 2007. "Estimating Potential Output". *Address at the Conference of Price Measurement for Monetary Policy*, Federal Reserve Bank of Dallas (May).

Neiss, Kathrine S., and Edward Nelson. 2005. "Inflation Dynamics, Marginal cost, and the Output Gap: Evidence from Three Countries," *Journal Of Money, Credit, and Banking*, vol. 37 (December), pp. 1019 – 45.

Okun, Arthur. 1962. "Potential GNP: Its Measurement and Significance," *Proceedings of the Business and Economics Section of the American Statistical Association*, pp. 98 – 104.

Osman, M. 2008. "Estimating Potential Output and Output Gap for East African Countries: An Eclectic Approach". *European Journal of Economics, Finance and Administrative Sciences*. Issue 12.

Phelps, Edmund S. 1967. "Phillips Curves Expectations of Inflation, and Optimal Inflation over Time," *Economica*, vol. 34 (August), pp. 254 – 81.

Proietti, T. A. Musso and T. Westermann 2002. "Estimating Potential Output and the Output Gap for the Euro Area: A Model – Based Production Function Approach*". EUI Working Paper*, ECO No. 2002/9.

Rennison, A. 2003. "Comparing Alternative Output Gap Estimators: A

Monte Carlo Approach". *Bank of Canada Working Paper*, 03 – 8.

Rudebusch, Glenn D. 2000. "How Fast Can the New Economy Grow?". *FRSBF Economic Letter* 2000-05, Federal Reserve Bank for San Franncisco, February 25

Serju, P. 2006. "Estimating Potential Output for Jamaica: A Structural VAR Approach". *Bank of Jamaica Working Paper* 2006/03.

Staiger, Douglas, James H. Stock, and Mark W. Watson. 1997a. "How Precise Are Estimates of the Natural Rates of Unemployment?" In Christina Romer and David Romer, eds., *Reducing Inflation: Motivation and Strategy*. Chicago: University of Chicago Press, pp. 195-242.

Staiger, Douglas, James H. Stock, and Mark W. Watson. 1997b. "The NAIRU Unemployment, and Monetary Policy" *Journal of Economic Perspectives*, vol. 11 (winter), pp. 195 – 242.

Woodford, Micheal (2003). *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton: Princeton University Press.

World Bank, 2006, *World Development Indicators CD-ROM*. Washington, D.C.

Appendix

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                       Unit root tests for variable DLY
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 20 observations used in the estimation of all ADF regressions.
 Sample period from 1985 to 2004
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF          -5.5189       41.2289      39.2289      38.2332      39.0346
 ADF(1)      -4.9155       41.8407      38.8407      37.3471      38.5491
 ADF(2)      -3.4863       42.6442      38.6442      36.6528      38.2555
 ADF(3)      -3.3145       44.6650      39.6650      37.1757      39.1791
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.0199
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion


                       Unit root tests for variable DLY
     The Dickey-Fuller regressions include an intercept and a linear trend
*******************************************************************************
 20 observations used in the estimation of all ADF regressions.
 Sample period from 1985 to 2004
*******************************************************************************
        Test Statistic      LL          AIC          SBC          HQC
 DF          -5.3659       41.3829      38.3829      36.8893      38.0913
 ADF(1)      -4.7310       41.9555      37.9555      35.9640      37.5667
 ADF(2)      -3.2497       42.9208      37.9208      35.4315      37.4349
 ADF(3)      -3.1778       44.6654      38.6654      35.6782      38.0823
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -3.6592
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
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Unit root tests for variable DEMPL

The Dickey-Fuller regressions include an intercept but not a trend

****

22 observations used in the estimation of all ADF regressions.

Sample period from 1983 to 2004

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	Test Statistic	LL	AIC	SBC	HQC
DF	-5.4664	-4.4098	-6.4098	-7.5008	-6.6668
ADF(1)	-4.4132	-4.1637	-7.1637	-8.8003	-7.5493

****

95% critical value for the augmented Dickey-Fuller statistic = -3.0039

LL = Maximized log-likelihood AIC = Akaike Information Criterion

SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

Unit root tests for variable DEMPL

The Dickey-Fuller regressions include an intercept and a linear trend

****

22 observations used in the estimation of all ADF regressions.

Sample period from 1983 to 2004

****

	Test Statistic	LL	AIC	SBC	HQC
DF	-8.2533	2.9896	-.010424	-1.6470	-.39595
ADF(1)	-7.6603	4.9763	.97634	-1.2057	.46231

****

95% critical value for the augmented Dickey-Fuller statistic = -3.6331

LL = Maximized log-likelihood AIC = Akaike Information Criterion

SBC = Schwarz Bayesian Criterion HQC = Hannan-Quinn Criterion

```
                       Unit root tests for variable CU
      The Dickey-Fuller regressions include an intercept but not a trend
*******************************************************************************
 24 observations used in the estimation of all ADF regressions.
 Sample period from 1982 to 2005
*******************************************************************************
        Test Statistic      LL           AIC           SBC           HQC
 DF         -3.0074      -69.5074      -71.5074      -72.6855      -71.8200
 ADF(1)     -3.8184      -63.9685      -66.9685      -68.7355      -67.4373
*******************************************************************************
 95% critical value for the augmented Dickey-Fuller statistic =  -2.9907
 LL  = Maximized log-likelihood      AIC = Akaike Information Criterion
 SBC = Schwarz Bayesian Criterion    HQC = Hannan-Quinn Criterion
```