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**Article**

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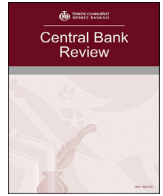
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# Assessing nominal GDP targeting in the South African context



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## ABSTRACT

The main purpose of this research paper is to determine whether Nominal GDP targeting as a monetary policy regime would be superior to Inflation targeting in minimising the South African Reserve Bank's loss function. This is done by algebraically deriving the necessary conditions for Nominal GDP targeting to dominate Inflation targeting using two different forms of loss functions. The first form includes price stability and output stability, while the second form includes both price and output stability and adds currency fluctuation into the loss function, both using data from 1993Q1 to 2014Q1 and uniquely incorporating data from the mining sector due to the sector's key role in the South African economy. Based on these results and practical issues of Nominal GDP targeting, such as the possibility of enhancing the severity of stagflation, this paper does not recommend Nominal GDP targeting as a monetary policy framework for South Africa.

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## 1. Brief outline of topic

Since the first case of implementing Inflation targeting (IT) in New Zealand in 1990, IT has attained the status as the dominant framework for monetary policy in many countries around the globe. Mishkin (1997) described IT as involving “the public announcement of medium-term numerical targets for inflation with a commitment by the monetary authorities to achieve these targets”.

However, the IT regime's status as the most suitable pillar for policy formation is considered by some to be rivalled by Nominal GDP targeting (NGDPT). This is not a new notion because the debate of NGDPT versus IT started in the 1980 and 90's, with important early contributions from Taylor (1985) and Hall and Mankiw (1994). Although it subdued for the larger part of the 1990s–2000s, the debate experienced a revival after the 2008 financial crisis (Frankel, 2012). The crisis highlighted some of the regime's shortcomings, and as a result, gained support for IT to be replaced by NGDPT.

Advocates for NGDPT argue that IT greatly lacks an adequate response to market bubbles and responds inappropriately to supply and terms of trade shocks. The argument is made that NGDPT will lead to a more stable economic environment and therefore

minimise the Central Bank's (CB) loss function (consisting of the output gap and inflation volatility) because it takes into account real GDP growth and inflation compared to IT, which only takes inflation into account. Therefore, some consider NGDPT to be more suitable as a framework for monetary policy, particularly, but not limited to, countries with high vulnerability to exogenous supply shocks. The argument is also made that by strictly targeting inflation, there is extensive negative pressure on economic growth, which may lead to desired inflation but very little or no economic growth.

This is an important topic within Macro Economics and monetary policy theory, and research on this topic contributes to how the field of economics and policymakers consider an appropriate monetary policy framework. Relatively little research has been conducted on this topic in developing countries, especially within a quantitative framework. To begin to fill this gap, this paper conducts a quantitative study on South African monetary policy, aiming to determine which of NGDPT or IT would provide greater stability to the South African economy.

## 2. Literature review

Detailed analyses of the early experiences involved in the implementation of the IT framework were offered by Goodhart and Vinals (1994), Leiderman and Svensson (1995), Haldane (1995), Mccallum (1996) and, with particular reference to South Africa by Aron and Muellbauer (2006). The original idea of NGDPT as a

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monetary rule came from a lecture by James Meade in 1977 (Mccallum, 2011:1). The idea was further developed due to the need to improve monetary policy credibility, combat high inflation, and create a robust system that was adaptable to demand and supply shocks (Bhandari and Frankel, 2015:3).

### 2.1. Brief explanation of how nominal GDP targeting works and its history

The basic logic behind NGDPT is that CBs ought to adjust policy rates in order to achieve predetermined nominal GDP (NGDP) targets. By targeting NGDP, the CB is essentially targeting inflation and the economy's long run average growth of output (real GDP) (Mccallum, 2011:1). Monitoring NGDP gives the CB signals of aggregate nominal spending, and by adjusting policy rates, the CB can influence spending through its influence on aggregate demand (Mccallum, 2011:1).

In the 1980s, CBs followed a money supply targeting regime, but due to supply and demand shocks, they experienced trouble with an unstable money demand (Frankel, 2012). These shocks are one of the reasons why NGDPT was developed; however, NGDPT has not been adopted as the official monetary policy framework of any country (Bhandari and Frankel, 2015:3). The successor was exchange rate targeting, but this regime fell powerless as a result of the speculative "attacks" during the currency crises of the 1990s (Frankel, 2012). At this time, CBs started to turn to IT.

However, the financial crisis in 2008 highlighted some weaknesses of the IT regime, especially the lack or inappropriate response to asset bubbles and supply side shocks (Frankel, 2012). As a result, interest in NGDPT as a replacement for IT has received increased attention from several economists, including Scott Sumner (Bentley University), Professor Jeffrey Frankel (Harvard University), and Christina Romer (former Chair of the Council of Economic Advisors in the Obama administration) among others.

### 2.2. Arguments for (advantages of) nominal GDP targeting

The first argument made in favour of NGDPT is that inflation is not the only figure the CB is concerned about, as it is also, or ought to be, concerned about output, especially for political credibility (Mccallum, 2011:1). Because the CB is concerned about both inflation and output, having only one figure that includes inflation and output is considered to be an advantage, as opposed to considering them separately (Mccallum, 2011:2).

Second, compared to IT, NGDPT has an arguably superior ability to respond to supply and terms of trade shocks (Frankel, 2012). The argument is that IT responds to supply shocks inappropriately. In response to a supply shock, such as an increase in oil prices, an IT regime increases policy rates in order to suppress demand and thus relieves inflationary pressure, but at the same time, this puts further negative pressure on output (Frankel, 2012). This translates into a decrease in employment. In an NGDPT regime, the supply shock is automatically split between inflation and output. In the long run, advocates of NGDPT believe this will result in inflation that is similar to an IT regime but with smaller fluctuations in output (Mccallum, 2011:1), thus resulting in a more stable economy. Considering terms of trade shocks, Frankel (2012) argues that an economy adapts better when the monetary policy responds to changes in the prices of exported goods, as opposed to prices of imported goods, such as in the case of IT. In other words, under different circumstances or during different phases of the business cycle, the economy may be more robust and render smaller output gaps. In the face of an adverse supply shock, only NGDPT allows the currency to depreciate accordingly (Frankel, 2014).

Third, some believe NGDPT may create greater stability in the

financial system, driven by the argument that by implementing NGDPT, financial bubbles will be easier to subdue because of the strong relationship between NGDP and asset bubbles (Mccallum, 2011:2).

Fourth, NGDPT arguably may be more appropriate for nations that seek to gain monetary policy credibility because when choosing a target that is frequently missed, the credibility of the CB is eroded (Bhandari and Frankel, 2015, 4). Due to the compilation of NGDP, freedom exists within one figure. In other words, there is potential for change in real GDP and inflation without changing the NGDP target, making it easier to achieve. This point fuels the argument that NGDPT may potentially have the same benefits as discretionary monetary policy or an IT regime with a target range, while maintaining the same expectations (Bhandari and Frankel, 2015:6).

Fifth, based on the reach of a CB influence, NGDP as a target is arguably more appropriate than inflation as a target. Frankel argues that monetary policy naturally influences the sum of real income growth and inflation, not the breakdown between the two, and therefore should also target the sum of the two variables (Frankel, 2012). Because they cannot influence these two variables separately, CBs cannot make a decision regarding the relative importance of inflation and real output (Frankel, 2012).

### 2.3. Arguments against (disadvantages of) nominal GDP targeting

First, inflation statistics are produced arguably more frequently and more consistently than NGDP figures, which allows an IT regime to respond faster and is arguably based on more accurate information (Hassan and Loewald, 2013:6). Thus, the frequency and revision of NGDP statistics are a major challenge for real-time implementation of NGDPT (Hassan and Loewald, 2013:6). In addition, forecasting nominal income may be more problematic than forecasting inflation (Hassan and Loewald, 2013:6).

Second, within an NGDPT regime, there would be much speculation about how a specific target is compiled between inflation and real output, causing a reduction in the CB's ability to signal expected inflation (Du Plessis and Rietveld, 2014:5). This creates a situation where the CB cannot anchor the public sector's inflation expectations and may ultimately reduce the effectiveness of monetary policy.

Third, targeting NGDP may be difficult because of the two variables that make it up. In response to monetary policy, lags of different length may be experienced because output responds faster than inflation (Rudebusch, 2002).

Fourth, concerns are raised that once the NGDP target is reached, the CB would have to tighten up excessively, which might cause greater welfare loss in comparison to moderate changes in the monetary policy stance. Although this can be avoided if the target is revised, this threatens the credibility of the CB (Hassan and Loewald, 2013:6).

Fifth, because NGDPT combines inflation and real GDP, of which the central bank has no long-term control, joining it with the difference in transmission lags between output and inflation would complicate the extent to which the CB can be held accountable (Du Plessis and Rietveld, 2014:12). Thus, the adoption of NGDPT may reduce accountability and therefore the independence of the CB as well (Du Plessis and Rietveld, 2014:12).

Sixth, choosing an NGDP target may create complications because the potential GDP is prone to be politically sensitive (Du Plessis and Rietveld, 2014:12). This may pose an even larger challenge when the potential or target output that is used by monetary authorities differs from government estimations and might be difficult to articulate publicly (Hassan and Loewald, 2013:6).

#### 2.4. Previous studies within a quantitative framework

- **Clark (1994)**: Using data from 1959 to 1988 to measure the U.S. economy statistically, by way of an atheoretical model and a structural model, this study questioned whether NGDPT would have produced smaller volatilities in both output and inflation compared to monetary aggregates previously used by the Federal Reserve, concluding that it may have reduced volatility in the US economy. The value drawn from this is that NGDPT has stabilising features, but this study is limited because it did not include IT.
- **Hall and Mankiw (1994)** and **Cecchetti (1995)**: This study used counterfactual simulations on the U.S. economy to determine if nominal targets would generally provide lower volatility in nominal variables, such as inflation and output. Further, they considered different nominal targets, concluding that NGDPT would most effectively stabilise these variables.
- **Rudebusch (2002)**: Stating that although NGDPT performs well in theory, after simulations using a VAR model, this study concluded that NGDPT is highly likely to perform poorly in reality, due to model and data uncertainty. This study is based on the context of a developed economy and confirms the operational difficulties of NGDPT.
- **Garin et al. (2015)**: In the context of a new Keynesian model, the researchers undertook a study to evaluate welfare properties of NGDPT in comparison with output gap targeting and IT, using Bayesian methods for parameter estimation and data from the U.S. They concluded that NGDPT performs almost as well as output gap targeting and certainly dominates IT. Although output gap targeting performed best in terms of welfare losses, NGDPT was still preferred because output gap targeting would pose a great challenge when communicating with the public, and practical implementation would not be realistic. Beyond these issues, it was also determined that NGDPT performs best when supply shocks are prominent, and wages are sticky relative to prices.
- **Bhandari and Frankel (2015)**: This study used data about India from June 1996 to December 2013 to estimate the relative importance of supply shocks for the Indian economy, as well as the slope of India's aggregate supply curve. The aim was to determine whether NGDPT would dominate strict IT in its ability to minimise the CB's loss function that comprises output and inflation. Based on theoretical conditions, they concluded that NGDPT dominates IT in its ability to minimise the CB's loss function. The value drawn from this is that India may benefit from an NGDPT regime more than an IT regime due to the relative importance of supply shocks and the slope of India's supply curve.

Based on these studies, it can be concluded with relative certainty that NGDPT may have a stabilising effect on economies, but operational issues remain a large drawback. With the exception of Bhandari and Frankel, all of these studies were conducted in developed countries. This leaves space for research in developing countries, similar to that of Bhandari and Frankel. This research paper will take the form of **Bhandari and Frankel (2015)** but differs not only because of the country in which it is conducted but also because estimation is done based on an IT regime rather than a discretionary regime (India's monetary policy regime). By estimating whether NGDPT might be a superior monetary framework for South Africa, this study will add to the body of knowledge.

### 3. Theoretical framework

The theoretical framework that is followed in this paper is that

of **Frankel (2012)** and **Bhandari and Frankel (2015)**.

The objective is to see which of the two monetary policy formulas, IT or NGDPT, minimise the CB's loss function to the greatest extent, given that the specific nature of the aggregate supply relationship is assumed to be:

$$y = \bar{y} + b(p - p^e) + u \quad (1)$$

$y$  = real output  
 $\bar{y}$  = potential output  
 $p$  = price index  
 $p^e$  = expected price index  
 $u$  = disturbance in supply  
 $b$  = slope of supply curve

In this study, two versions of a CB's loss function are used. The first of the two is in the case of a dual mandate of price and output stability, which is referred to as a “**closed economy**” loss/objective function because the volatility of exchange rates is not included. The second loss function includes the volatility in exchange rates, which will only be given in equation (11). The following is the “closed economy” loss function:

$$L = ap^2 + (y - \hat{y})^2 \quad (2)$$

$a$  = weight assigned to inflation objective  
 $\hat{y}$  = desired output

For simplicity reasons, the assumption is made that the preferred level of inflation is zero. This could be any other number, and zero could also act as a base that is linked to a desired inflation target. Thus, the loss function can be further specified by substituting (1) into (2).

$$L = ap^2 + ((\bar{y} - \hat{y}) + b(p - p^e) + u)^2 \quad (3)$$

#### 3.1. Loss function under NGDPT “closed economy”

In the process of explaining how the loss function will adjust under NGDPT, it is helpful to derive it from a money supply rule. In the money supply rule, money market equilibrium conditions are given by:

$$m = p + y - v \quad (4)$$

$v$  = velocity shocks  
 $m$  = money supply

Under the money supply rule, pursuing the reduction of expected inflation, affecting  $y$  is not plausible. Thus, the optimal growth rate of money is at a level where  $p^e = 0$ , and therefore  $m$  is set at the expected output, which is  $\bar{y}$ . This leads the aggregate demand equation to become:

$$p + y = \bar{y} + v \quad (5)$$

By combining (5) and (1):

$$y = \bar{y} + \frac{u + bv}{1 + b} \quad p = \frac{v - u}{1 + b} \quad (6)$$

Substituting this into (2) gives the expected loss function under the money supply rule:

$$EL = (\bar{y} - \hat{y})^2 + \frac{[(1 + a)var(u) + (a + b^2)var(v)]}{(1 + b)^2} \quad (7)$$

In the case of NGDPT, money supply is adjusted to accommodate for velocity shocks, and  $p + y$  from equation (5) is constant. This implies that the loss function is similar to that of the money supply rule, except for the fact that the velocity disturbance is no longer present.

$$EL = (\bar{y} - \hat{y})^2 + \left[ \frac{1 + a}{(1 + b)^2} \right] var(u) \quad (8)$$

### 3.2. Loss function under IT “closed economy”

Under IT, monetary policy is set so that movement in the price index is zero (note that zero is just a base for the specific target), both in terms of expected price changes and ex post shocks. This implies that the loss function and expected loss function under IT, adjusted from equations (2) and (3), is as follows:

$$L = [(\bar{y} - \hat{y}) + u]^2 \quad (9)$$

$$EL = (\bar{y} - \hat{y})^2 + var(u) \quad (10)$$

Based on this, it is implied that NGDPT will dominate IT in the event that supply shocks  $u$  is prominent in the specific economy, and if:

$$\left[ \frac{1 + a}{(1 + b)^2} \right] < 1 \quad \text{differently put if: } \frac{a}{b} < 2 + b \quad \text{or } a < (2 + b)b \quad (\text{Condition 1})$$

According to this theoretical approach, NGDPT will dominate IT, except in the condition where supply shocks are not present and/or the specific country has an exceptionally steep aggregate supply curve and/or the CB place a very high weight on price stability in their loss function.

This conclusion can be further simplified using a Taylor rule, where both price stability and output stability receive the same weight. This implies that  $c = 1$ , and this transforms condition 1 as follows:

$$b > \sqrt{2} - 1 \quad \text{or differently put: } \frac{1}{b} < 2.414 \quad (\text{Condition 2})$$

### 3.3. Loss function under the NGDPT “open economy”

In this context, the term “open economy” does not refer to the openness of a specific economy. Rather, it indicates that the CB includes exchange rate stability as part of its mandate. Thus, the loss function under the “open economy” condition includes a term for a stable exchange rate.

The loss function then takes the following form:

$$L = ap^2 + (y - \hat{y})^2 + cs^2 \quad (11)$$

$s$  = spot exchange rate measured relative to a target or an equilibrium  
 $c$  = weight placed on exchange rate stability

In this function, it is assumed that the CB wants to minimise exchange rate volatility around a set target or average value. Due to the difficulty of explaining variation in the exchange rate, the largest proportion of the variation will be captured by an error term  $e$ . Other than the addition of  $cs$ , an additional money supply component also exists, enabling authorities to affect the exchange rate. This case  $s$  (spot rate) is to be determined by:

$$s = m - y + e \quad (12)$$

In equation (4), the money market equilibrium is stated as  $m = p + y - v$ . Thus, combining it with equation (12) renders the following:

$$s = p - v + e \quad (13)$$

The loss function can now be derived by combining (13) with the aggregate supply equation (1) and substituting the result into the loss function, which renders the following loss function:

$$L = ap^2 + [\bar{y} - \hat{y} + b(p - p^e) + u]^2 + c(p - v + e)^2 \quad (14)$$

### 3.4. Loss function under NGDPT, the “open economy” condition

The CB is able to vary  $m$  to keep  $p + y$  constant. Therefore, the velocity,  $v$ , is not included in the equation.

$$EL = (\bar{y} - \hat{y})^2 + \left[ \frac{1 + a + c}{(1 + b^2)} \right] var(u) + [c]var(e) \quad (15)$$

### 3.5. Loss function under IT the “open economy condition”

From the general open economy loss function (24), the inflation targeting (target is 0, as a base) loss function and expected loss function are as follows:

$$L = [(\bar{y} - \hat{y}) + u]^2 + c(-v + e)^2 \quad (16)$$

$$EL = [\bar{y} - \hat{y}]^2 + var(u) + [c]var(e) + [c]var(v) \quad (17)$$

Comparing (17) and (15), at least in theory, the conclusion can be made that NGDPT dominates IT if supply shocks exist and the following condition holds:

$$a + c < b^2 \quad (\text{Condition 3})$$

Further, if the assumption is made that  $c$  is smaller than  $a$  (this is a plausible assumption for South Africa because currency fluctuation is not currently part of the South African Reserve Bank’s (SARB) loss function), a sufficient condition for NGDPT to dominate IT is:

$$a < \frac{b^2}{2} \quad (\text{Condition 4})$$

If a Taylor rule is used, setting  $a = 1$ , the condition is

transformed to:

$$b > \sqrt{2} \text{ or put differently } \frac{1}{b} < \frac{1}{\sqrt{2}} = 0.707 \quad (\text{Condition 5})$$

As above, an exceptionally steep supply curve and/or a high weight on price stability may cause IT to dominate NGDPT.

In this section, we have derived the following conditions:

3.5.1. The “closed economy” condition

NGDPT dominates IT if condition 1 holds, a Taylor rule is used, and condition 1 becomes condition 2. This implies that the slope of the AS curve is the determining factor for NGDPT to dominate IT.

$$\text{Condition 2 : } \frac{1}{b} < 2.414$$

3.5.2. The “open economy” condition

NGDPT dominates IT if condition 3 holds, the assumption is made that  $c < a$ , and condition 3 becomes condition 4. If the Taylor rule is used and  $a = 1$ , condition 4 becomes condition 5.

$$\text{Condition 5 : } \frac{1}{b} < \frac{1}{\sqrt{2}} = 0.707$$

In order to evaluate whether these conditions hold for South Africa, the most important parameter, namely, the slope of the inverse aggregate supply curve, must be estimated. When condition 2 holds, the slope of the inverse short run aggregate supply curve is small enough for NGDPT to dominate IT, as depicted in Fig. 1. In this case, in the event of an adverse supply shock, there would be a movement from A to C under NGDPT, as opposed to the movement from A to B under IT. This would produce a smaller loss for the CB. If condition 2 does not hold, the slope of the inverse short run aggregate supply curve would be steep enough for IT to dominate NGDPT, as depicted in Fig. 2. In such a case, in response to an adverse supply shock, the movement from A to B would render a smaller loss for the CB, as opposed to the movement from A to C under IT.

Based on this and because South Africa is considered to be susceptible to supply shocks, NGDPT ought to perform better in response to supply shocks. Together with the preliminary assumption that South Africa's inverse supply curve is not steep

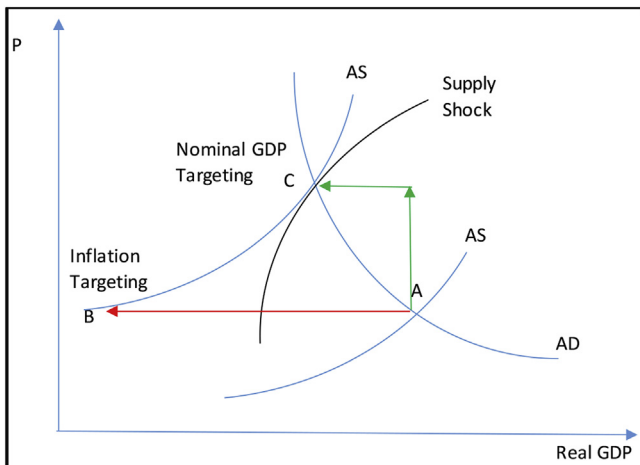


Fig. 1. Response to adverse supply shock in the case of a flat inverted aggregate supply curve.

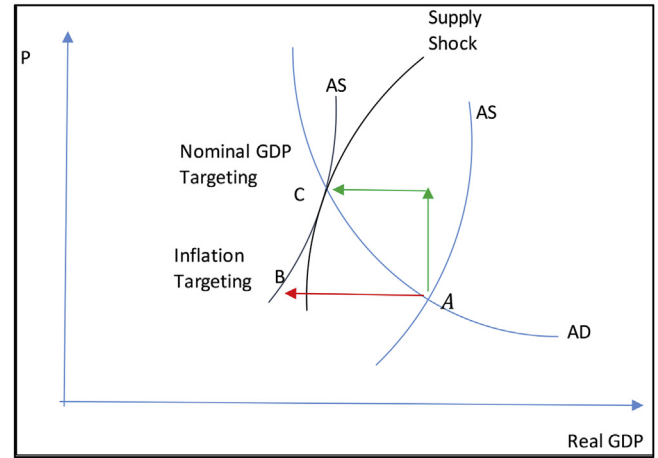


Fig. 2. Response to adverse supply shock in the case of a steep inverted aggregate supply curve.

enough to discredit condition 2 or 5 (which this paper aims to discredit or confirm), the hypothesis is as follows:

In theory, when supply shocks are present, the CB's loss, which is derived from its loss function, will be smaller under NGDPT than it is under IT.

4. Methodology and data

From the theoretical framework in section above, it is clear that the slope of the inverse short run aggregate supply curve must be estimated in order to estimate whether condition 2 and 5 hold true for South Africa. The method is conducted in a similar fashion to the study conducted in India by Bhandari and Frankel (2015) and outlined in Frankel (2014). The following section can be summarised by the general inverted aggregate supply and demand relationship from equations (18) and (19).

$$AD : y = -\left(\frac{1}{d}\right)p + \left(\frac{\delta}{d}\right)y^* + \left(\frac{\gamma}{d}\right)g + v \quad (18)$$

- $y$  = output expressed in relationship to potential output
- $p$  = price level expressed in relationship to expected price level
- $y^*$  = income of trading partners
- $g$  = specific government expenditure
- $v$  = other demand shocks

$$AS : p = \left(\frac{1}{b}\right)y + \left(\frac{\alpha}{b}\right)x + \left(\frac{\beta}{b}\right)w + u \quad (19)$$

- $p$  = price level expressed in relationship to expected price level
- $y$  = output expressed in relationship to potential output
- $x$  = adverse terms of trade shock
- $w$  = adverse weather shock
- $u$  = other adverse supply shocks

The goal is to estimate the slope for the inverted aggregate supply curve for South Africa. This enables us to see if NGDPT will, at least in theory, minimise the CB's loss function, using the derived conditions in the previous section. This is possible by using instrument variables to estimate the equations for the inverted aggregate demand and aggregate supply relationship (Frankel,

2014). In order to derive the system of equations, an approach similar to the New Keynesian Phillips Curve of Roberts (1995) is used, and a two-stage least squares (2SLS) analysis is used for parameter estimation.

For the inverted supply relationship, actual inflation minus expected inflation is regressed on the chosen supply instruments. In order to observe shifts in the supply curve, these instruments must, as far possible, be exogenous and measurable. For instance, this could be natural disasters, such as droughts; it can also be increased world prices of imported goods. For this reason, the first instrument used is a terms of trade shock, which is in the form of changes in world oil prices. Preferably, the second instrument should be a pure supply shock, in the form of a weather condition, such as droughts, making the second instrument an indication of drought in the form of rainfall. Considering that the mining & quarrying sector produces a significant source of exports for SA, both in terms of value and volume, supply in this sector should specifically be included. Data on pure supply shocks for this sector is not readily available, however a production index may serve as a useful indicator as the mining and quarrying sector produces about 8% of SA's GDP. Once the sector's linkages to the sectors is included the contribution to GDP rises to 20% in real terms. Another option is to use capital formation in the mining and quarrying sector. Capital formation as a supply instrument is based, in this case, on the assumption that the decision to increase capital formation increases the sector's supply capacity, which is driven by the expectation that the market will in future allow for greater supply. Therefore the actual instrument when using capital formation is expectations.

The general expectation is that an increase in oil prices will have a positive relationship with inflation, and rainfall will have a negative relationship with inflation. Increased mining production itself is likely to have a positive relationship with inflation, given that increased output translates to increased employment and an increase on the demand side. Two opposing views exist in terms of the relationship between inflation and capital formation. On the one hand there might be a Tobin effect where increased inflation reduces real interest rate which in turn increases the accumulation of capital as opposed to holding money. High and volatile inflation could also create an incentive for capital accumulation channelled through agents' propensity to save as a form of precautionary measures. On the other hand high inflation makes money worth less in the future and as such increases the incentive to consume and discourage savings. Fluctuating inflation also reduces an investor or firm's ability to do long term planning and could create hesitation for long term investment or capital formation. These are all based on how inflation influences capital formation, however it is unlikely that capital formation does not influence inflation as well. One option that could cause a negative relationship is through capital inflows which could have a strengthening effect on the currency, which in turn also reduce pressure on inflation. It could also have a positive relationship if capital formation drives up employment and demand for goods. All of these will only take time to show an impact on the economy, therefore there is a lagged impact. The lag will also reduce the impact inflation might have on capital formation. Which in itself possibly have a lag effect on capital formation (therefore by applying a one period lag on capital formation, effectively there is a two period differences in opposite directions between the influence inflation has on capital formation and influence capital formation has on inflation).

When estimating the inverted aggregate demand relationship, output is expressed in relationship to potential output. Thus, the output gap is regressed against the chosen demand instruments. These instruments can be shocks, such as fluctuation in the income of the country's main trading partners, as well as military spending or specific governmental spending (Frankel, 1995). Considering that

we are including the mining and quarrying sector specifically, mining commodity prices are included.

World economic growth is used as a proxy for the demand for exports. The sum of general government investment and investments from public corporations is used as a domestic demand instrument, and mining commodity prices are used as an instrument for demand for commodities. The general expectation is that all of the instruments will have a positive relationship with the output gap.

This leads to the first stage regression, taking the form of fluctuations in the output gap as the dependent variable, and the independent variables are the general government/public corporation investment, world economic growth, commodity prices and inflation fluctuation, which is instrumented with its appropriate instruments. In the second stage regression, which is central to this study, the dependent variable is the fluctuation in price levels, and the independent variables are the fluctuation in the output gap which is instrumented with its appropriate variables, percentage departure from normal rainfall, changes in the real oil price and either capital formation in the mining sector or actual mining production. This estimation is used to assess whether conditions 2 and 5 hold true for South Africa.

#### 4.1. Data

The data used spans from 1993 Q1 to 2014 Q1, providing us with 85 quarters of data. The limited number of observations may cause the model to lack statistical power.

The output gap is the actual output minus the potential output, which is expressed as a percentage of potential output. This is calculated by using real GDP, which is available from Stats SA (Stats SA, 2015a), and potential GDP, which is calculated by using a Hodrick-Prescott filtering series set on 1600, because quarterly data are used. The variable obtained from this process is labelled as **GDPGAP**.

The first aggregate demand instrument, world economic growth, which acts as a proxy for the demand for South Africa's exports, is represented by the world GDP growth rate. These figures were obtained from the IMF eLibrary database (IMF, 2015) and are available quarterly, covering the entire time span of this study (1993Q1-2014Q1). This variable is labelled as **WorldGDP**.

The second aggregate demand instrument is the percentage change in the sum of government and public corporation investment, both of which is available from the SARB (Sarb, 2015b). This is labelled as **GovPubInv**.

There are two options used for the third aggregate demand instrument, both of which focus specifically on demand for South African commodities. First, is the change in the rand denominated gold price per fine ounce, available from SARB, which gives an indication for demand for Gold, SA single greatest export. This variable is labelled **GoldPriRate**. Second, is the change in Stats SA's commodity export price index, labelled as **ComExpPriRate**.

The two most common inflation measurements in South Africa are the consumer price index (CPI) and the producer price index (PPI). For the purpose of this model the PPI is the most suitable, because as mentioned in Bhandari and Frankel (2015) the model focusses on the inflation that will influence domestic producers, therefore PPI is appropriate, whereas CPI also includes greater amounts of imported inflation. PPI is available from the Statistic South Africa (Stats SA, 2015) database. For the supply relationship, the actual ex-post inflation rate (PPI rates) minus ex-ante expected inflation rates are used. The ex-ante expected inflation rates are calculated using an ARIMA (1 1 1) model and PPI values starting from quarter 1 of 1992 (actual study range from 1993 Q1-2014 Q1) are used so that values are not lost as a result of the ARIMA model.

All values used were tested for stationarity by using the Augmented Dickey Fuller test. The lag structure was chosen using the Akaike Information criteria (AIC) and the Bayesian Information criteria (BIC). The residuals from the ARIMA model were also tested for stationarity using the Augmented Dickey Fuller test. The variable from this process is labelled **ARPP1**.

The change in world oil prices, which is the first supply instrument, was obtained by taking the Brent crude oil price per barrel in dollars, converted to the South African rand spot rate (ZAR), and then deflated in order to obtain real oil prices. Changes in real oil prices were calculated based on each consecutive quarter (q-o-q). All of these figures are available from the SARB (Sarab, 2015). The variable from this process is labelled as **Oil**.

The second supply instrument, rainfall levels, is used as an indication of drought. Drought is used because it is considered to be a major natural disaster in South Africa in terms of economic loss and the number of people affected by droughts. Among other things, droughts influence pure agricultural output and significantly reduce the number of livestock (Ngaka, 2012). The variable used as an instrument for drought is obtained from the percentage departures from normal rainfall during each. There was also a 4-period lag assigned to this figure. The motivation behind the lag is that some crops are only harvested once a year, and once harvested, time is required to go through all of the relevant supply chains to reach markets and influence price levels. After a major drought it also takes time for soil to recover and for water levels in dams to reach normal levels. The data used for this was obtained from Weather SA, and the variable from this process is labelled as **Rain4**.

For the third demand instrument there are two options, the first is the change in actual production in the mining sector, measured by the mining sector production index compiled by Statistics SA. The variable from this process is lagged by one period, given that the sector's full effect originates from its multiplier. This variable is labelled **ComProd1**. The second option is the change in capital formation in the mining sector, which was obtained from data available from the SARB. Given that the capital formation does not immediately translate into increased production, but rather over a period of time a three period lag has been assigned (a two period lag was also tested). The variable from this process is labelled as **CapFormMining3**.

## 5. Results

The results for estimating the inverted short run aggregate supply curve, by way of 2SLS regression, are shown in Tables 1 and 2, calculated using STATA 13 (both regressions obtained 85 observations):

Table 1 shows the result for the first regression, using the combination of commodity production (lagged by one period) and change in gold prices. As expected **GDPGAP**, **Oil** and **ComProd1** have positive relationships with inflation fluctuation, and **Rain4** has a negative relationship. **GDPGAP** is statistically significant at a

**Table 1**  
Result for regression using the combination of commodity production and the change in gold prices.

ARPP1	Coef.	Std. Err	z	P > z	[95% Conf.Interval]	
GDPGAP	1.076	0.396	2.71	0.007	0.298	1.854
Oil	0.051	0.016	3.11	0.002	0.018	0.083
Rain4	-0.015	0.007	-2.09	0.037	-0.029	-0.001
ComProd1	0.357	0.171	2.09	0.037	-0.022	0.692
cons	-0.151	0.204	-0.74	0.458	-0.552	0.248

Instrumented: GDPGAP.

Instruments: Oil Rain4 ComProd1 GovPubInv WorldGDP GoldPriRate.

**Table 2**

Result for regression using the combination of commodity production and the change in commodity export prices.

ARPP1	Coef.	Std. Err	z	P > z	[95% Conf.Interval]	
GDPGAP	0.935	0.354	2.64	0.008	0.240	1.630
Oil	0.051	0.015	3.26	0.001	0.020	0.083
Rain4	-0.014	0.006	-2.04	0.042	-0.027	-0.001
ComProd1	0.348	0.164	2.11	0.034	-0.025	0.671
cons	-0.152	0.197	-0.77	0.439	-0.539	0.233

Instrumented: GDPGAP.

Instruments: Oil Rain4 ComProd1 GovPubInv WorldGDP ComExpPriRate.

99.3% confidence level ( $P = 0.007$ ). **Oil** is statistically significantly at a 99.8% confidence level ( $P = 0.002$ ). Both **Rain4** and **ComProd1** are statistically significant at a 96.3% confidence level. According to the results in Table 1, the inverse short run supply curve of South Africa has a slope ( $\frac{1}{b}$ ) of 1.076, which implies condition 2 holds, but condition 5 is not met.

Table 2 shows the result for the second regression, using the combination of commodity production (lagged by one period) and change in South African commodity export prices. Similar to the first regression **GDPGAP**, **Oil** and **ComProd1** have positive relationships with inflation fluctuation, and **Rain4** has a negative relationship. **GDPGAP** is statistically significant at a 99.2% confidence level ( $P = 0.008$ ). **Oil** is statistically significantly at a 99.9% confidence level ( $P = 0.001$ ). **Rain4** was statistically significantly at a 95.8% confidence level ( $P = 0.042$ ) and **ComProd1** was statistically significant at a 96.6% confidence level. According to the results in Table 2, the inverse short run supply curve of South Africa has a slope ( $\frac{1}{b}$ ) of 0.935, which implies similar to Table 1 that condition 2 holds, but condition 5 is not met. A possible motivation for Table 2 to reflect a slightly flatter supply curve is that due to the fact that the South African Commodity Export index (ComExpPriRate) includes a broader range of commodities as opposed to just gold, one could expect the supply curve flatter and more robust.

Table 3 shows the result for the third regression, using the combination of capital formation in the mining sector (lagged by three periods) and the change in gold prices. Similar to the first regression **GDPGAP** and **Oil** have positive relationships with inflation rates fluctuation. However **CapFormMining3** has a negative relationship with inflation. As expected **Rain4** has a negative relationship. **GDPGAP** is statistically significant at a 99.6% confidence level ( $P = 0.004$ ). **Oil** is statistically significantly at a 99.3% confidence level ( $P = 0.007$ ). **Rain4** was statistically significantly at a 93.5% confidence level ( $P = 0.065$ ) and **CapFormMining3** was statistically significant at a 97.7% confidence level. According to the results in Table 3, the inverse short run supply curve of South Africa has a slope ( $\frac{1}{b}$ ) of 1.296, which implies similar to Tables 1 and 2 that condition 2 holds, but condition 5 is not met.

Table 4 shows the result for the fourth regression, using the combination of capital formation in the mining sector (lagged by three periods) and change in South African commodity export prices. Similar to the regression three **GDPGAP** and **Oil** have positive relationships with inflation rates fluctuation. **CapFormMining3** has a negative relationship with inflation and as expected and **Rain4** has a negative relationship. **GDPGAP** is statistically significant at a 99.5% confidence level ( $P = 0.005$ ). **Oil** is statistically significantly at a 99.7% confidence level ( $P = 0.003$ ). **Rain4** was statistically significantly at a 92.4% confidence level ( $P = 0.065$ ) and **CapFormMining3** was statistically significant at a 97.4% confidence level. According to the results in Table 3, the inverse short run supply curve of South Africa has a slope ( $\frac{1}{b}$ ) of 1.055, which implies similar to Tables 1–3 that condition 2 holds, but condition 5 is not



**Table 3**  
Result for regression using the combination capital formation and change in gold prices.

ARPP1	Coef.	Std. Err	z	P > z	[95% Conf.Interval]	
GDPGAP	1.296	0.446	2.90	0.004	0.420	2.172
Oil	0.048	0.017	2.71	0.007	0.013	0.082
Rain4	-0.014	0.007	-1.85	0.065	-0.029	0.000
CapFormMining3	-0.081	0.035	-2.28	0.023	-0.151	-0.011
cons	-0.012	0.228	-0.05	0.957	-0.459	0.434

Instrumented: GDPGAP.  
Instruments: Oil Rain4 CapFormMining3 GovPubInv WorldGDP GoldPriRate.

**Table 4**  
Result for regression using the combination of capital formation and the change in commodity export prices.

ARPP1	Coef.	Std. Err	z	P > z	[95% Conf.Interval]	
GDPGAP	1.055	0.378	2.79	0.005	0.314	1.797
Oil	0.048	0.016	2.97	0.003	0.016	0.081
Rain4	-0.012	0.007	-1.78	0.076	-0.026	0.001
CapFormMining3	-0.073	0.329	-2.22	0.026	-0.137	-0.008
cons	-0.026	0.213	-0.13	0.899	-0.445	0.391

Instrumented: GDPGAP.  
Instruments: Oil Rain4 CapFormMining3 GovPubInv WorldGDP ComExpPriRate.

met. Similar to the comparison between Tables 1 and 2, the comparison between Tables 3 and 4 also reflects that the use of the South African commodity export prices produce a flatter supply curve as opposed to using gold prices.

From this section, it is evident that whether the hypothesis stated in section 5, which was tested in a theoretical framework with data from South Africa with the assumption that the weight placed on inflation stability ( $a=1$ ) is equal to one, is rejected, depending on which loss function is used. Regarding the closed economy loss function (condition 2), the results lead to a failure to reject the hypothesis that NGDPT will reduce the loss, as specified via the loss function of the CB. However, if the “open economy” loss function is used (condition 5), then the hypothesis is rejected.

**6. Implications of the results**

The results in all four tables imply that condition 2 ( $\frac{1}{b} < 2.414$ ) holds true in the case of South Africa. This means that in the presence of adverse supply shocks, NGDPT will minimise the CB’s “closed economy” loss function to a greater extent than IT. In other words, by meeting condition 2, the result implies that the slope ( $\frac{1}{b}$ ) of the South African short-run inverted supply curve which is between 0.936 and 1.296, former from Table 2 and the latter from Table 3 (Tables 1 and 4 is give slopes between 0.936 and 1.296) is not steep enough for IT to dominate NGDPT. This is similar to Fig. 1, where as a result of the slope of the inverted short-run supply curve, the response action of IT to an adverse supply shock, which leads to a movement from A to B, represents a greater loss to the CB, unlike the response action of NGDPT, which leads to a movement from A to C.

When considering condition 5 ( $\frac{1}{b} < 0.707$ ), the results from none of the tables comply. This means that in the presence of adverse supply shocks, NGDPT would not minimise the CB’s “open economy” loss function to a greater extent than IT. Thus, the slope of the South African inverted short run supply curve is steep enough for IT to dominate NGDPT when condition 5 is used.

Up to this point, we have used the assumption that  $a = 1$ , assigned from the Taylor rule; however, this assumption must be relaxed by considering different weights on price stability. There is no need to apply different levels of weights on price stability ( $a$ )

individually because the slope of the inverse short run supply curve is known  $\frac{1}{b} = 0.935 - 1.296$ . Thus,  $b$  is 0.77 based on Table 3 and 1.068 based on Table 2 ( $b$  for the other two tables are between these values). From this, we can return to condition 1 and relax the assumption that  $a = 1$ , from which condition 2 (closed economy) is derived, and substitute the value of  $b$  into condition 1.

$$\left[ \frac{1+a}{(1+b)^2} \right] < 1 \text{ differently put if : } \frac{a}{b} < 2 + b \text{ or } a < (2+b)b$$

Based on Table 2 :  $a < (2 + 0.77)(0.77)$   
 $a < 2.133$

Based on Table 3 :  $a < (2 + 1.068)(1.068)$   
 $a < 3.276$

This implies that NGDPT will dominate IT with the slope of the inverse supply curve, as long as the weight placed on price stability ( $a$ ) is below 2.133 based on Table 2 and 3.276 based on Table 3 (results of the other two tables imply weight limits between within the range of 2.133–3.276. This implies an exceptionally large weight must be placed on price stability in order for IT to minimise the CB’s “closed economy” loss function more than NGDPT.

The same can be done when considering the “open economy” loss function, thus returning to condition 4, and substituting the value for  $b$  into the condition in order to see the level of  $a$  at which NGDPT would dominate IT. Although the assumption that  $a = 1$  is relaxed, the assumption that  $a > c$  holds.

$$a < \frac{b^2}{2}$$

∴ Based on Table 2  $a < \frac{0.77^2}{2}$   
 $a < 0.296$

∴ Based on Table 3  $a < \frac{1.068^2}{2}$   
 $a < 0.570$

This implies that given the current slope of the inverse supply

curve, NGDPT will only dominate IT for a value the weight placed on price fluctuation ( $\alpha$ ), below 0.296 based on Table 2 or below 0.570, based on Table 3. These are very low weight, and not very likely for a CB so relaxed on inflation fluctuation.

At this point, the analysis is stuck in a situation where NGDPT clearly dominates IT, minimising the “closed economy” loss function, where the tides only turn in favour of IT when the weight placed on inflation ( $\alpha$ ) increases to 2.133 based on Table 2 and 3.276 based on Table 3. However, when the “open economy” loss function is considered, IT dominates NGDPT, and the tides only change in favour of NGDPT when the weight placed on inflation ( $\alpha$ ) decreases to 0.296 (Table 2) or 0.570 (Table 3).

It is clear from the results that, at this stage, the key point of the analysis now is to determine which of the two loss functions are most appropriate for South Africa, as well as the appropriate weights to be used by the SARB.

Based on the constitutional role and mission statement of the SARB, the argument can be made that the key purpose of the SARB is to protect the value of the South African currency and to achieve and maintain price stability in the interest of balanced and sustainable economic growth (South African constitution, 1996) (Sarb, 2015). This implies that the SARB should follow a hierarchical mandate with price stability and guard the value of the currency placed at the top of the list, as opposed to a dual mandate, for which both low inflation and output objectives are pursued.

This implies that currency fluctuation ought to be included implicitly or explicitly in the SARB's loss function, and the weight placed on inflation is to be at least equal to that of the output. Thus, from the constitutional role and the mission statement of the SARB the “open economy” loss function and the IT regime are the most appropriate for South Africa at this moment.

Taking the analysis beyond the realm of the constitutional role and the mission statement of the SARB, it is unlikely that NGDPT will be feasible for the South African economy. This is based on the fact that, as a target, NGDP experiences different lags within its components and the low frequency of NGDP figures. In addition, in the event that weak economic growth is the result of structural issues instead of insufficient demand, NGDPT might lead to a weaker currency, higher inflation levels, and increased intensity and proneness for stagflation.

If it is possible to work around or resolve the immediate practical issues around NGDPT, one must consider whether the South African economy will gain in the long run from a more accommodative framework, with longer periods of demand stimulation coupled with higher currency fluctuations, potentially long periods of a weakened currency, and potentially higher inflation under NGDPT, or whether the country benefit from a less accommodative framework, with longer periods of subdued demand, a more stable and strong currency, and lower inflation under IT. The answer to this question is linked to the goals and growth path that South Africa will pursue. In the event of growth driven by exports, NGDPT might be a viable solution in terms of increased competitiveness via potentially longer periods of a weaker currency. However, this gain might be mitigated in the long run by the greater levels of inflation and might thus only provide short-term gains. IT might be more appropriate for an investment and capacity growth path, focusing on long-term benefits and future capacity for growth.

The results support the theories of Clark (1994), Hall and Mankiw (1994) and Cecchetti (1995), indicating that NGDPT has stabilising features, especially when the results are considered using the “closed economy” loss function. However, considering the “open economy” loss function, in the case of South Africa, IT would result in greater stability. Although Bhandari and Frankel (2015) recommend NGDPT for developing countries such as India, it is not clear that NGDPT will suit South Africa's economic needs.

According to Garin et al. (2015), NGDPT has welfare properties that are superior to IT, which can only be supported if the “closed economy” loss function is used and implementation issues are addressed. When considering the “open economy” loss function and long-term welfare, it is highly unlikely that NGDPT will be superior to IT in the South African case.

As raised by Hassan and Loewald (2013) and Du Plessis and Rietveld (2014), the practical challenges of NGDPT and the dangers posed by the fundamentals of NGDPT, such as stagflation, are accepted and further extended in this study. Our results support the argument from Rudebusch (2002), indicating that NGDPT may perform well in theory, but not in practice.

## 7. Conclusion and recommendations

This study attempts to evaluate whether NGDPT will minimise the CB's loss function to a greater extent than IT and evaluates the general feasibility of NGDPT in the case of South Africa.

A key finding of the study is that NGDPT would only minimise the CB's loss function to a greater extent than IT if the “closed economy” loss function is considered. When the “open economy” loss function is chosen, IT minimises loss to a greater extent than NGDPT. This leads to a consideration as to which of the two loss functions would be more appropriate for South Africa, and based on the constitutional role and mission statement of the SARB, an “open economy” loss function is more appropriate. When the weight placed on price stability is lower than the weight placed on output stability, NGDPT can possibly dominate IT; however, based on feasibility factors, IT is still likely to outperform NGDPT. For this reason, the hypothesis is rejected.

Based on this study, NGDPT would not be appropriate for South Africa and may potentially pose great dangers, particularly in the context of stagflation pressure. However, if South Africa's goals change and developments emerge to address the practical issues of NGDPT, there is space for further research using more advanced quantitative frameworks, including more supply and demand instruments. Research on the appropriate level of weights placed on price and output stability may also be of value.

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