An empirical analysis on the effects of the inflation targeting framework on monetary policy in South Africa

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By

Weiming Chen

Student No: 603566

Supervised by: Dr. Kenneth Creamer

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Declaration

I hereby declare that this is my own unaided work, the substance of or any part of which has not been submitted in the past or will be submitted in the future for a degree to any university and that the information contained herein has not been obtained during my employment, or working under aegis of, any other person or organization other than this university.

Weiming Chen **Signature**

1. Introduction

Prior to the introduction of the inflation targeting monetary policy regime, many countries used alternative methods to dampen increasing prices and to control inflation. The two main monetary policy regimes used were monetary targeting and exchange rate targeting. Monetary targeting is a policy regime wherein the central bank is concentrated on managing the money supply and targeting the growth rate of the money supply in an attempt to stabilise prices (Eatwell et al., 1989). Exchange rate targeting is a monetary policy regime for the central bank to manage the domestic currency in relation to a foreign currency or pegging the domestic currency to some band or value (Fischer, 2001). Both main regimes were deemed ineffective in the fight against increasing prices. Monetary targeting failed due to unstable and erratic demand for money; while the exchange rate targeting constrained the central bank's response to domestic shocks and opened economies up to speculative attacks on their currencies.

Furthermore, the theoretical importance of maintaining low inflation had been well established. Feldstein (1999) found that moderate levels of inflation growth slowed down the growth of the economy when compared to low levels of inflation growth. In theory, the central bank would publicly announce the inflation target it deemed appropriate for the economy and adjusts interest rates accordingly when the inflation rate deviated from the inflation target[1] (Bernanke, 2001).

South Africa embraced the inflation targeting (IT) framework following the Asian Crisis in the late 1990's. During the crisis, the SARB increased interest rates to promote capital inflows and at the same time, borrowed USD 25 billion to purchase Rands in the foreign currency market in a bid to avoid a currency depreciation. The effort was ineffective and resulted in a sharp depreciation of the Rand. After this failed and expensive attempt at targeting the currency, the SARB adopted an IT framework which focused on keeping prices stable and inflation to a level within the published target. Under the IT framework, the SARB explicitly excluded interventions aimed at targeting the exchange rate. (Creamer, 2014)

Casteleijn (1999) and Jonsson (1999) both advocated for the adoption of the newly formed IT framework. The argument for IT was based on the importance to set clear inflation targets to

[1] *The choice of target is between a point target or a range target.*

anchor long-run inflation and expected inflation which helped promote investment for economic growth. Furthermore, the inflationary target selected was in the form of a target range which offered SARB the flexibility in the exchange rate to deal with foreign economic shocks.

This paper deals with the effects of the IT framework on South Africa's monetary policy. The paper will examine whether the implementation of IT in South Africa impacted on the conduct of monetary policy in South Africa. Therefore, it will serve to analyse whether the implementation of the framework in South Africa yielded the expected results as compared to the pre-adoption period and if the implementation of the IT framework provides a more predictable and transparent monetary policy. Finally, the paper will seek to establish the impact of the Great Recession (i.e. the global financial crisis of 2008) on the conduct of monetary policy. The paper will make use of the Taylor rule and term structure of interest rates in an attempt to find out the effects of IT on the conduct of monetary policy.

In section II, the macroeconomic data of South Africa is reviewed with an explanation of the data selection for the empirical analysis. Following the data section, existing literature regarding the Taylor rule is explored with the estimation of the rule conducted in section III, with data analysis and methodology both included. In section IV, the estimation of the term structure for the test of policy transparency is performed followed by an examination of the impact of the Great Recession in section V. The conclusion is to follow in Section VI.

2. Data

The data used for estimation is primarily from the SARB website, with the Consumer Price Index (CPI) data recorded by the Statistics South Africa website. The period under consideration is from 1990-Jan to 2017-Jun.

The economic variables used in the Taylor rule are as follows:

- Short-run interest rate – 3-month treasury bill rate (SARB 1405)
- Output – Manufacturing: total volume of production[2] (SARB 7085)
- Real exchange rate changes – Real effective exchange rate: trade in manufactured goods (SARB 5392)
- Inflation – CPI (STATSA P0141.1)

The economic variables used in the term structure equation are as follows:

- 3-month negotiable certificate of deposits (SARB 1411)
- 6-month negotiable certificate of deposits (SARB 1412)

The method of calculating variables required in the estimation, such as output gap and real exchange rate changes, are included in the Appendix.

SA Macroeconomic Data – Pre IT and IT period

Figures 1-8 shows the macroeconomic performance of South Africa in the period under consideration as well as a closer look into the economy pre-IT and IT periods. Figure 1 and 2 includes two graphical displays for both Pre-IT and IT periods. The notable area in Figure 1 is that after the adoption of IT, where price levels reached an all-time low compared to prior years. Figure 2 displays two substantial peaks in price levels, in 2002 and 2008. The changes in price levels coincides with a slowdown of the economy, with the most extreme gap seen around the 2008 period during the global financial crisis. Potential output refers to the gross domestic product (GDP) when all resources, such as workforce, technology, etc., are fully utilised. Figure 3 and 4 shows that the show movements in the output gap (i.e. when actual output of the economy is above or below potential output[3]. The exact impact of the output gap on the interest rate will be explored in the empirical section.

[2] *The choice to use Manufacturing: total volume of production as a proxy variable for Output is to remain consistent with Woglom (2003)'s study and doing so would facilitate ease of comparison between this study and Woglom's*
[3] *Potential output as measured per deviation from trend output – see Appendix for full explanation*

Figure 1 – Average Monthly Inflation

Pre-IT Period (1990-1999)

Figure 2 – Average Monthly Inflation

IT Period (2000-2017)

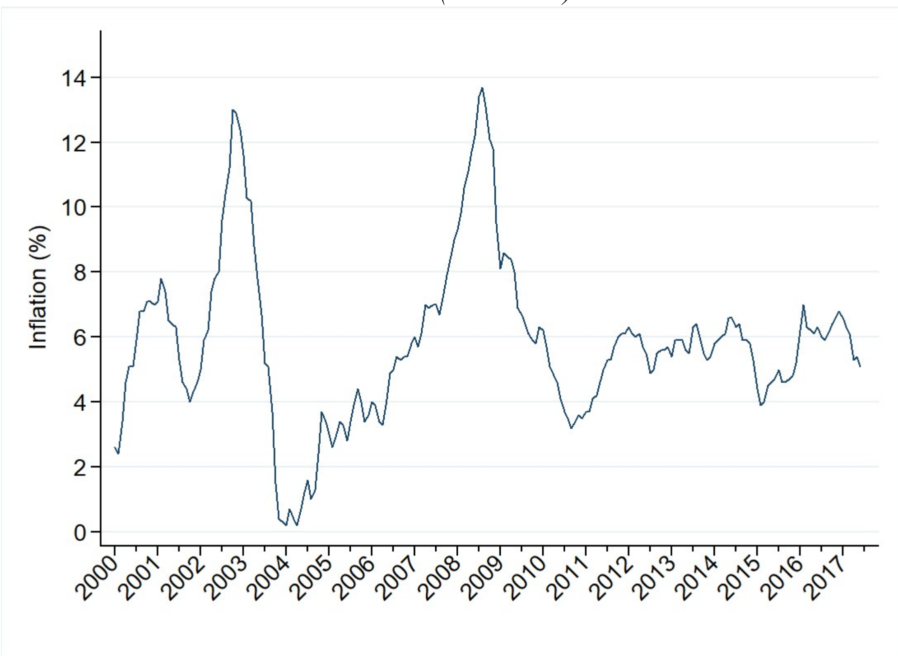


Figure 3 – Average Monthly Output Gap

Pre-IT Period (1990-1999)

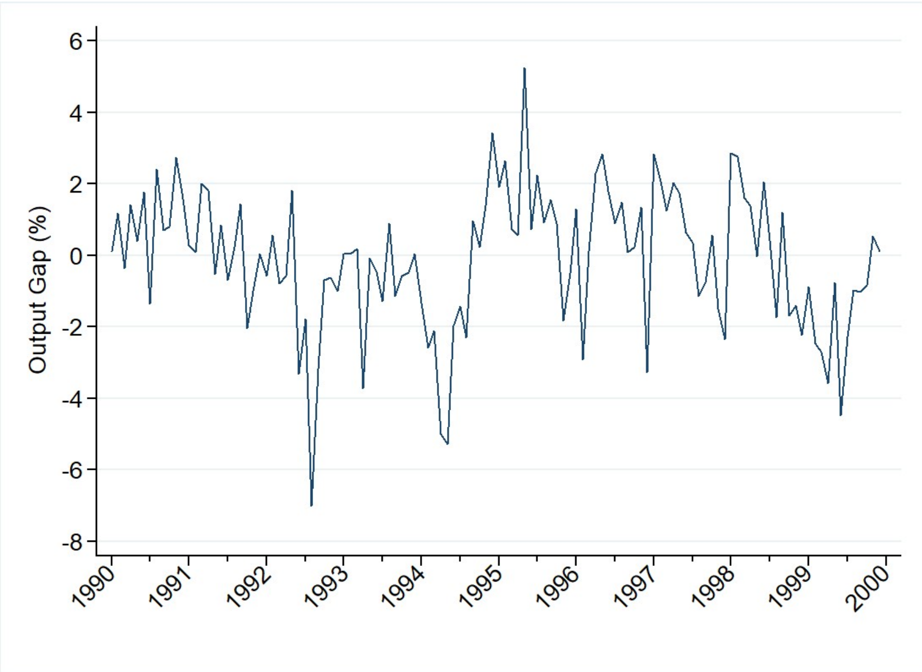
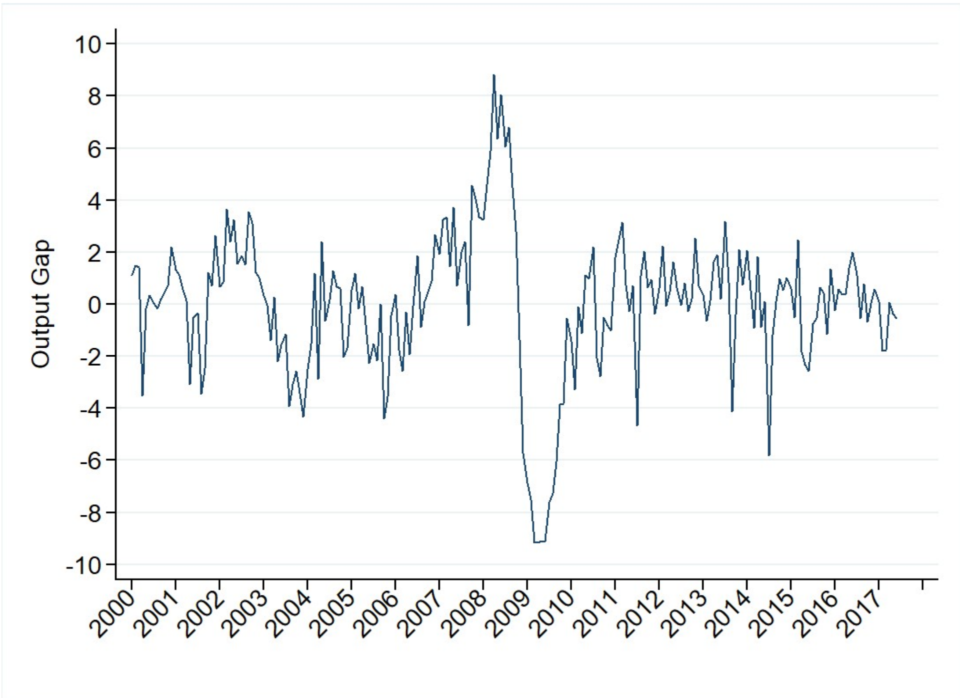


Figure 4 – Average Monthly Output Gap

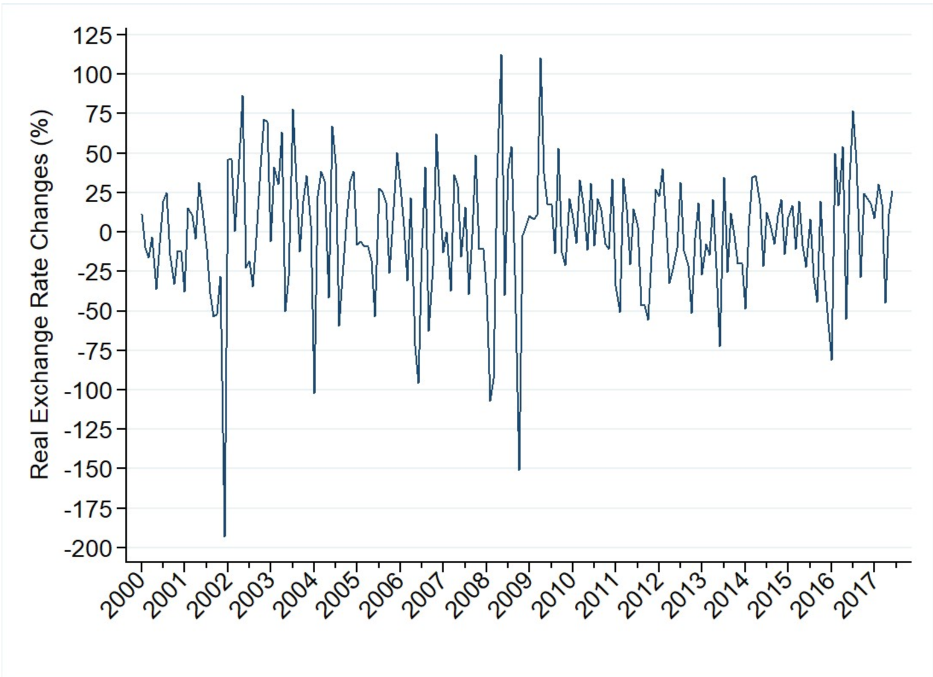


IT Period (2000-2017)

Figure 5 – Average Monthly Real Currency Appreciation

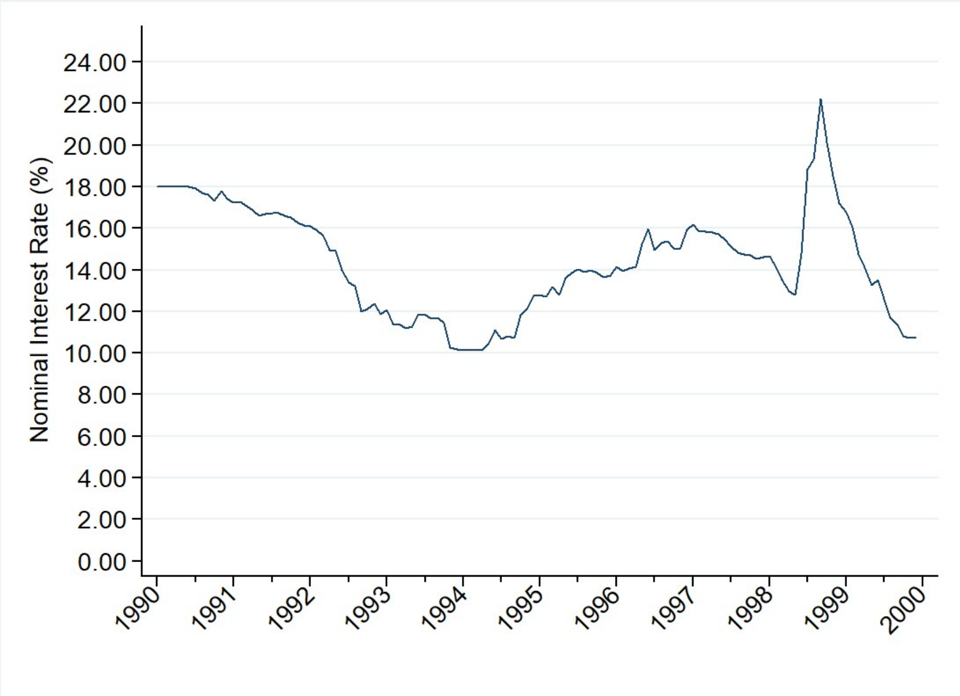
Pre-IT Period (1990-1999)

Figure 6 – Average Monthly Real Currency Appreciation



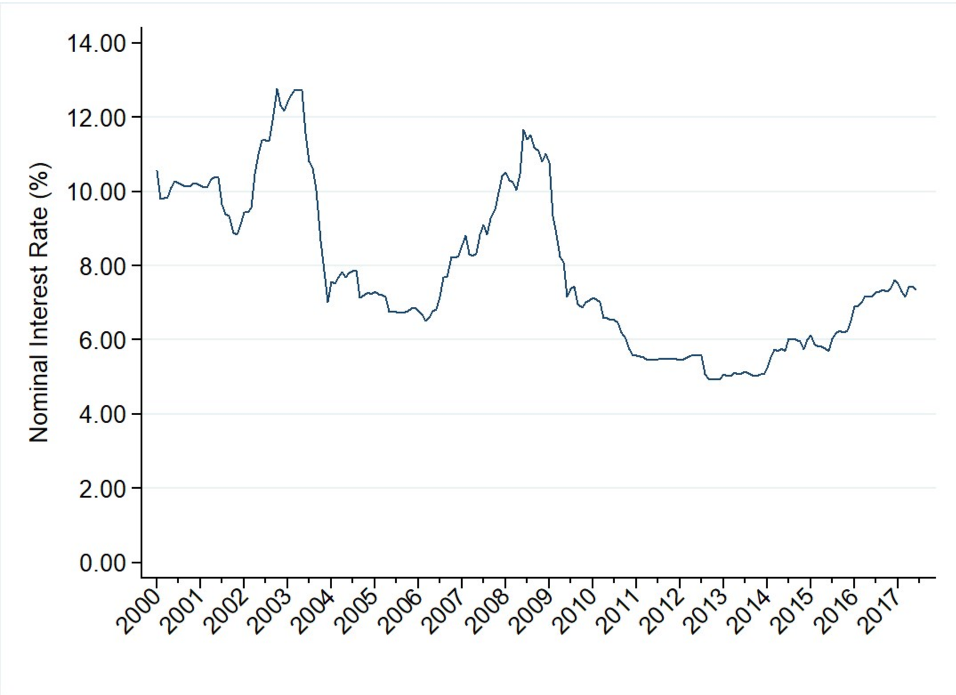
IT Period (2000-2017)

Figure 7 – 3-Month Treasury Bill Rates (First week of the Month)



Pre-IT Period (1990-1999)

Figure 8 – 3-Month Treasury Bill Rates (First week of the Month)



IT Period (2000-2017)

Figure 5 and 6 displays the real exchange rate changes over time. The Pre-IT period displays a time series that is less volatile compared to the IT period. After the adoption of IT, the exchange rate contains more frequent jumps, which fits the economic theory suggested, as the SARB are focused on inflation targeting and allows for the exchange rate to fluctuate. In addition, the notable currency depreciations seen are the Asian crises in 1998, the currency crisis of 2001 and the Global Financial crisis in 2008. The devaluation of the currency coincides with sharp increases in the interest rate. The monetary policy response to the more recent events (i.e. the crises in 2001 and 2008) is moderate with 3-month Treasury-bill rates (a proxy for the repo policy rate) rising to around 12 percent as compared to the 1998 incident where the 3-month Treasury-bill rate rose as high as 22 percent. The time series data are indicative of a difference in monetary policy conduct between the Pre-IT and IT periods.

Table 1 – Macroeconomic Data Performance: Pre-IT and IT

	1990:Jan - 1999:Dec		2000:Jan - 2017:Jun	
Variable	Mean	SD	Mean	SD
Nominal Interest Rate	14.40	2.56	7.80	2.11
Inflation	9.93	3.65	5.82	2.56
Output Gap	-0.11	1.95	-0.02	2.81
Real Exchange Rate Changes	-1.46	26.95	-0.16	40.19

Table 1 further illustrates the differences between the Pre-IT and IT periods. The interest rate volatility in the IT period has reduced as compared to the Pre-IT period, with the inflation levels also following the same trend. As expected, the inflation average is within the inflation target range of 3 to 6 percent set by SARB. The changes in the real exchange rate are now more frequent and volatile but the average of these changes has decreased since the adoption of the IT framework. Furthermore, the evidence would suggest that the output volatility has increased. In the next section, the empirical analyses using the Taylor rule will provide a further insight into the conduct of monetary policy.

3. Taylor Rule

Taylor (1993) described variations of the Fed's interest rate as a regression in the following form:

$$i_t = \pi_t + r_t^* + 0.5(\pi_t - \pi_t^*) + 0.5Gap_t + \epsilon_t \qquad (1)$$

Where

i_t – Interest Rate (Short Run)

π_t – Inflation

Gap_t – Output Gap[4]

r_t^* - Equilibrium or Target Interest Rate

π_t^* - Inflation Target

The original Taylor rule has the following assumption: Taylor assigned weights of 0.5 for both β_π and β_y, implying equal weighting on inflation variations and output gap. Furthermore, it was assumed that the equilibrium interest rate was set at a constant 2 percent for all periods. For the inflation target, the rate announced by the central bank was used and, for central banks that have an inflation target range, the average of the range was calculated and used as the inflation target. The general form of this implicit Taylor rule has been estimated for many countries, although arguments exist for the Taylor rule being an implicit and explicit rule. The general form holds for the variety of monetary policy regimes and the differences between the regimes are shown in different coefficient sizes in the regression equation.

Taylor further developed the Taylor rule and introduced the Taylor principle in 1998. The principle introduced a flexible inflation targeting regime and presented different weights on inflation variation and output gap as compared to the original rule. The Taylor principle stated that the central bank's focus is not solely on inflation, but the weight placed on inflation should be larger than one and the weight placed on the output gap should be larger than zero for a more flexible control on both inflation and output.

The Taylor principle is represented as a regression in the following form:

$$i_t = \pi_t + r_t^* + \beta_\pi(\pi_t - \pi_t^*) + \beta_y Gap_t + v_t \qquad (2)$$

[4] The calculation of the output gap is in the Appendix

Now, rewriting and rearranging the regression by letting: $\beta_0 = r^* + \pi^*$

The new Taylor principle is as follows:

$$i_t = \beta_0 + (1 + \beta_\pi)(\pi_t - \pi_t^*) + \beta_y Gap_t + v_t \qquad (3)$$

Clarida et al. (2000) states that if IT countries yield a β_π value of less than one, the central bank is then unable to control inflation sufficiently using the interest rate. For IT countries, the weight placed on output gap is less restraining as it only requires β_y to be positive. The positive relationship provides stabilising factor as interest rates will increase when the economy is experiencing a positive output gap and reduce the rates when there is a negative output gap. Furthermore, the tendency of central banks is to not implement large increments or reductions to the policy interest rate to avoid shocks to the financial markets. The changes are made in small steps at policy meetings and this process is called interest rate smoothing. Clarida et al. (2000) incorporates the interest rate smoothing parameter into the Taylor principle and the reaction function is of the following form:

$$i_t = \rho(i_{t-1}) + (1 - \rho)i_t^* \qquad (4)$$

Where

ρ – Smoothing Parameter

Rewriting the equation gives:

$$i_t = \rho(i_{t-1}) + (1 - \rho)(\gamma_0 + \gamma_1\pi_t + \gamma_2 Gap_t + \mu_t) \qquad (5)$$

The adoption of different monetary policy frameworks is dependent on economic culture and tradition. The choice between IT or a monetary aggregate no longer hinges on economic principle but rather on the central bank's commitment to ensure stable prices while allowing flexibility to bind its policy to medium-term targets for monetary policy. Ball (2000) critiqued the structure of the Taylor rule equation, proposing that for open economies, the inclusion of the real exchange rate is vital in monetary policy. His suggestion sees the addition of the real exchange rate as an independent variable in the Taylor rule equation. Furthermore, the introduction of the real exchange rate variable would allow for the operation of a monetary conditions index, which could be used for day-to-day operating targets in the conduct of monetary policy. Woglom (2003) introduced an open economy Taylor rule model similar to the one proposed by Ball (2000). The distinct difference between the two was that Woglom brought forward the calculation of the long-run effect of inflation on the short-run interest rate. The long-run response figure is a function of the estimated coefficients of the lagged period's interest rate and inflation. In addition, the figure would give a good indication of the long-run response rate of the interest rate to inflation. The lagged period's interest rate has been included to account for the interest rate smoothing.

The open economy Taylor rule regression equation would be in the form of

$$i_t = \alpha_0 + \alpha_1 i_{t-1} + \alpha_2 \pi_t + \alpha_3 Gap_t + \alpha_4 RER_t + e_t \qquad (6)$$

Where

RER – Real Exchange Rate Changes

The estimation of the Taylor rule regression aims to present an analysis on how the SARB has behaved following the adoption of the inflation targeting framework in South Africa. Svensson (1999) suggested that the weight placed on inflation to increase after the adoption of IT, and the focus on closing the output gap would decrease. Recalling the SARB's objectives, one would expect that α_2 and α_3 to be positive due to the price and output stability commitment. As the RER appreciates, both inflation and interest are expected to decrease so therefore α_4 is negative. In addition, the long-run responses to inflation are theoretically larger with the introduction of the framework due to South Africa's inflation being cost-push in nature.

The empirical results section is organised as follows. The first section will include a graphical representation of the original Taylor rule and the actual interest rate of South Africa. Following the comparison, the Taylor principle and open economy Taylor rule will be estimated using OLS estimation methods. The estimation will make use of the Newey-West[5] procedure to account for autocorrelation within the standard errors.

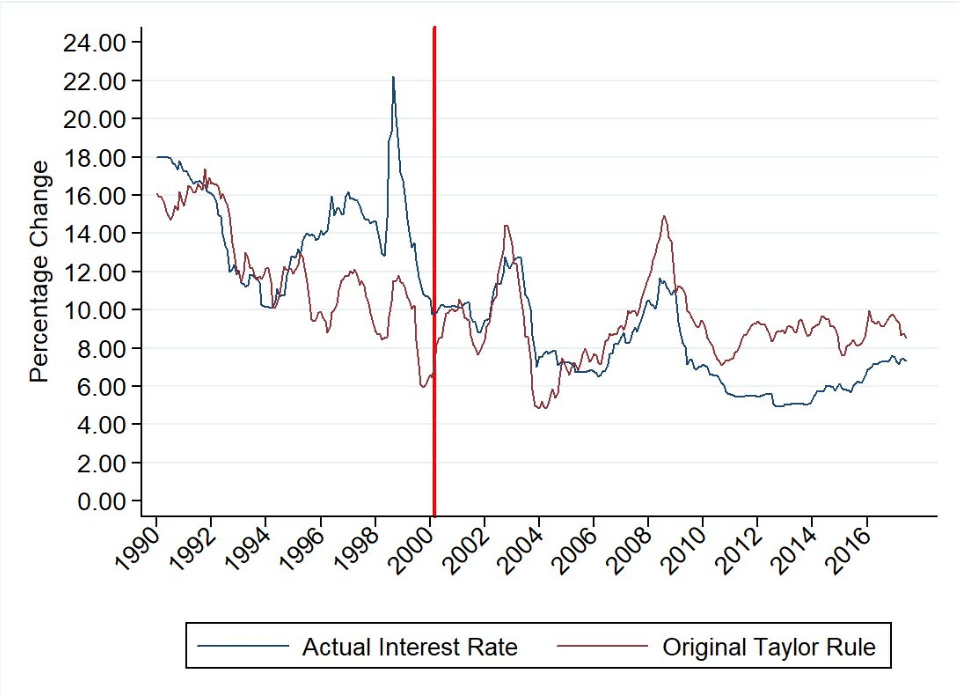
3.1 Original Taylor Rule

For the original Taylor rule, recall Equation one, and that the inflation target range for South Africa as defined by the SARB is between 3 and 6 percent. Therefore the inflation target selected for the estimation equation would be the average of the range (i.e. 4.5 percent). Furthermore, recall Taylor's assumption, the equilibrium interest rate for the estimation is 2

[5] Note: Stata command varsoc used to receive optimal lag order for Newey west procedure.

percent. The results of the estimation will be compared to the actual interest rate of South Africa and a graphical representation is displayed below:

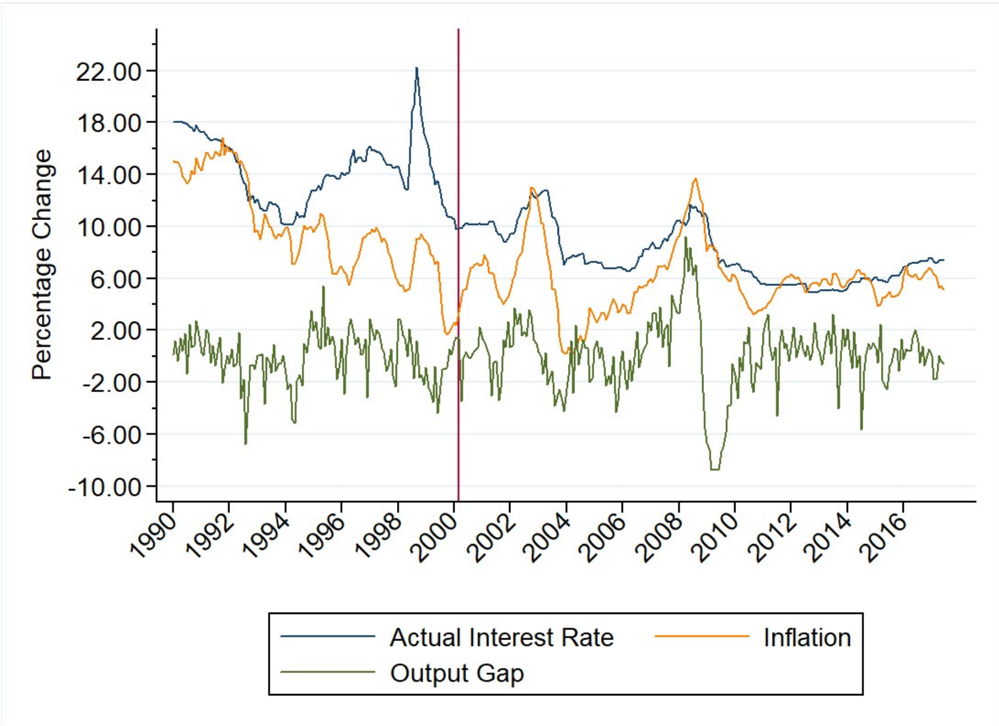
Figure 9 – Actual interest rate vs original Taylor rule interest rate in SA



The SARB announced the intention of switching to IT in August 1999, and the framework was officially introduced in February 2000 with the red vertical line illustrating the introduction date. Since the implementation of IT, the SARB have responded similarly to Taylor's suggested interest rate until 2004. From 2005, the Taylor rule suggested a higher interest rate as compared to the actual interest rate and during this period the SARB have focused more on the output gap and have lowered the weight far more than what the rule suggests. From 2001 to 2007, the commodities market was booming with the boom backed by investor confidence and such is characterised as a strong bull-market. The effects benefitted South Africa's economy, despite the increasing price levels, as the real GDP growth increased with gross fixed capital formation, and capital stock saw significant increases in annual growth rates (IDC, 2013). The increasing inflation was managed within the target range during the period and the rate derived from the Taylor rule was similar to the actual interest rates set by the SARB.

However, in 2008, the South African economy experienced the effects of the Global Financial crisis and the effects of the crisis forced the SARB to run a tight monetary policy to help stabilise the economy. Following the crisis, the inflation level continued to fluctuate in and out of the target range. Although the SARB have been increasing the interest rate in an attempt to control inflation, it wasn't adequate enough to consistently sustain the inflation level within the target range. Figure 9 confirms this in that the actual interest rate was below the Taylor rule interest rate. The evidence may suggest that the performance of the South African economy forced the SARB to shift focus from controlling inflation to output stabilisation, and could also possibly be explained by a tendency for interest rate smoothing.

Figure 10 – Actual interest rate, CPI and output gap in SA



3.2 *Taylor Rule Estimation*

Table 2 includes the estimation results of both the Taylor principle and the open economy Taylor rule. The results have been divided into Pre-IT and IT periods to show the change in the conduct of monetary policy. Across the table, the estimated coefficient of last period's interest rate is positive and statistically significant at a 0.1 percent significance level and the impact on the interest rate increased after the adoption of the IT framework. The impact of inflation is found to be positive but insignificant for all periods under the OLS estimation with Newey-West standard errors. The estimation with general robust standard errors suggest that inflation during the IT era has a positive and significant impact at a 5 percent significance level while the impact prior to adoption is insignificant. Overall, the adoption of the IT framework increased the size of the estimated coefficient of inflation for all estimations.

Prior to the adoption of IT, the impact of the output gap is found to be positive and statistically significant for all estimations indicating the expected positive relationship between above trend output and the policy interest rate. While still positive and significant, the estimated coefficient of output decreases with the adoption of the IT framework with the reduced impact likely due to the shift in focus of monetary policy towards explicitly targeting the inflation rate. Real exchange rate changes are found to have a negative relationship with the interest rate, but the variable is found to be statistically insignificant at a 5 percent significance level with the interest rate responses to real exchange rate changes decreasing post implementation.

All coefficient signs fit the *a priori* expectation. The increasing F-Statistic displays the increased explanatory power after the adoption of IT which fits the economy theory and *a priori* expectations. However, the long run response to inflation are all below unity which suggest that monetary policy is unable to stabilise and control long-run inflation effectively. Despite that, the long-run response to inflation did increase with the introduction of IT especially in the open economy Taylor rule case. This further illustrates the importance of the IT framework and how it influences the conduct of monetary policy. Mishkin (2002) argues that the less than unity error could be the fact that central banks make use of inflation expectation in place of past inflation for the calculations of the long-run responses.

The adoption of the IT framework was announced on August 1999 and the monetary policy regime was formally implemented in February 2000. The estimation results in Table 2 does not account for whether the SARB changed the conduct of monetary policy prior to the formal implementation in 2000.

Table 2 – Estimation of the Taylor equation

	OLS Newey West Std. Errors				OLS Robust Std. Errors			
	1990:Jan – 1999:Dec		*2000:Jan – 2017:Jun*		*1990:Jan – 1999:Dec*		*2000:Jan – 2017:Jun*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Simple	Open Economy	Simple	Open Economy	Simple	Open Economy	Simple	Open Economy
i_{t-1}	0.944	0.951	0.961	0.961	0.944	0.951	0.961	0.961
	(24.26)***	(22.74)***	(55.10)***	(59.20)***	(22.71)***	(24.16)***	(68.69)***	(68.50)***
π_t	0.00258	0.0117	0.0291	0.0294	0.00258	0.0117	0.0291	0.0294
	(0.09)	(0.57)	(1.88)	(1.87)	(0.12)	(0.61)	(2.08)*	(2.09)*
Gap_t	0.108	0.111	0.0362	0.0359	0.108	0.111	0.0362	0.0359
	(3.31)**	(3.62)***	(3.49)***	(3.47)***	(3.68)***	(3.55)***	(3.31)**	(3.24)**
RER_t		-0.0103		-0.000128		-0.0103		-0.000128
		(-1.86)		(-0.25)		(-1.98)*		(-0.24)
Adjusted R^2	0.929	0.940	0.981	0.981	0.929	0.940	0.981	0.981
LR Response to Inflation	0.046	0.24	0.74	0.75	0.046	0.24	0.74	0.75
AIC	249.4	229.7	79.89	81.83	249.4	229.7	79.89	81.83
BIC	260.5	243.6	93.26	98.54	260.5	243.6	93.26	98.54
Durbin's H	2.851	1.687	2.657	2.707	2.851	1.687	2.657	2.707
F-Statistic	681.6	546.5	2150.5	1617.0	578.2	493.7	2460.7	1835.1
Newey West Lag Order	3	2	4	2				

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

3.3 Testing for Structural Breaks

Furthermore, the estimation of the Taylor rule in Table 2 suggests a consistency in the conduct of monetary policy and suggests that no changes occurred following the adoption of IT. Brown et al. (1975) established a test to find unknown structural breaks in given sample periods, the test is called the CUSUM test and will be performed to find such structural breaks and check for parameter stability.

Pesaran and Pesaran (1997) argues that the CUSUM and CUSUMSQ tests have a distinct advantage against alternative tests such as the Chow test due to the test not requiring knowledge of the specific dates of the structural breaks. The null hypothesis of the CUSUM and CUSUMSQ test is that all the estimated coefficients are stable and if the plot of the test figures stay within the 95 percent confidence interval then the null hypothesis cannot be rejected. The results of the tests are shown in Figure 11 and 12 with the results of the test for simple and open economy similar so therefore the open economy have been chosen for illustration. The CUSUM test results suggest that all estimated coefficients are stable within the sample period. However, in 1998, there is a discrete jump and the CUSUMSQ test results confirm the structural break as it exceeds the confidence interval. The other notable decrease in the CUSUM test is during 2008.

Figure 11 – Cumulative Sum Statistic Plot

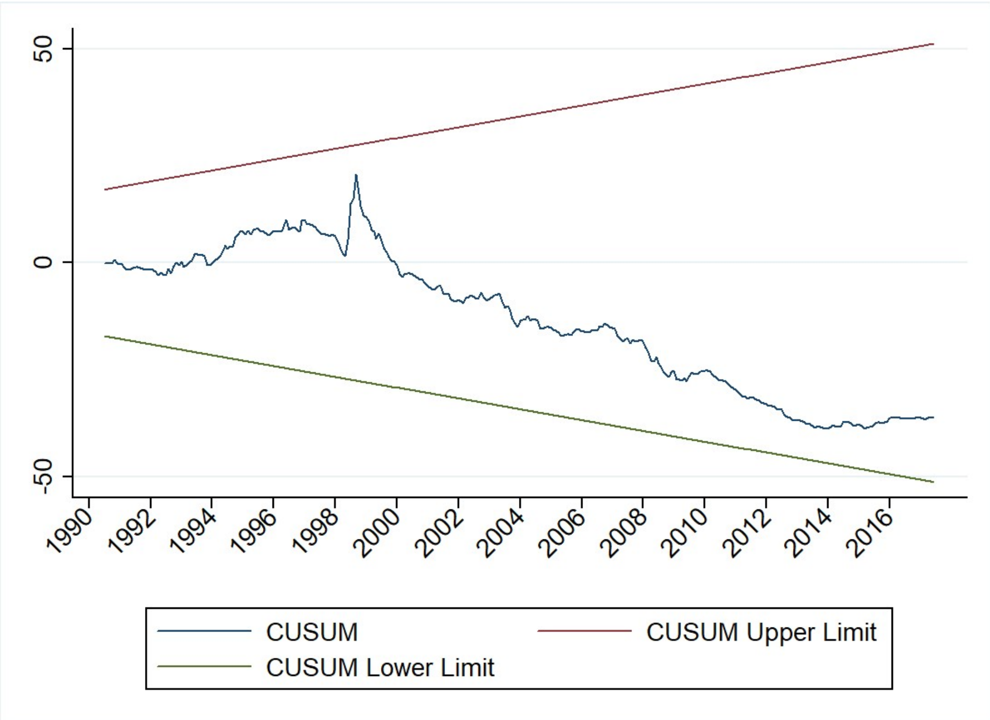
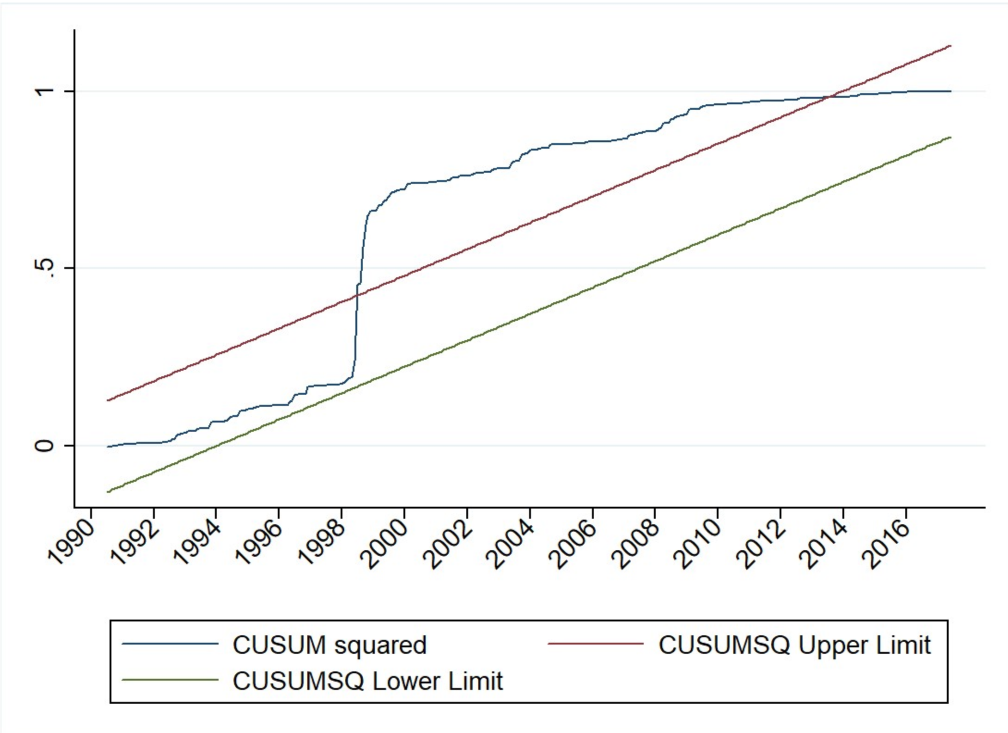


Figure 12 – Cumulative Sum Squared Statistic Plot



Note: CUSUM test used a 95% confidence interval to calculate the CUSUM and CUSUMSQ Statistic.

After the 1998 jump, the negative slope of the CUSUM plot illustrates the below target and continued to decrease with the CUSUMSQ statistic only returning into the confidence interval in 2013. To account for the two identified structural breaks, the Taylor rule will be re-estimated with the exclusion of the 1998 Asian crisis and the 2008 Global Financial crisis. Therefore, the periods are Jun-1998 to Dec-1998 and Jan-2007 to Dec-2008 will be exclude from the sample period.

Table 3 provides a clearer outlook on the impact of IT on the monetary policy conduct and how the crises have affected the conduct. The smoothing parameter reduced following the adoption of IT, and then increased once again after the Global Financial crisis. The smoothing parameter is positive and statistically significant at a 0.1 percent significance level. Economic theory would suggest that with IT, the smoothing parameter would decrease, and it is the case in the estimation results. The more important result is the highly statistically significant coefficient of inflation, the estimated coefficient became statistically significant at a 0.1 percent significance level after the adoption of the IT framework. However, the impact became insignificant once again post-Global Financial crisis. The output gap is still found to have a significant impact but at a 5 percent significance level which is less than the estimation shown in Table 2. The estimated coefficient for the real exchange rate changes appear to have decreased and remains statistically insignificant at a 5 percent level. The increased explanatory power of the independent variables can be seen between 1999 and 2006 where the F-Statistic increased greatly and the short run response to inflation became larger when compared to the estimation in Table 2. Furthermore, the lack of significance post-Global Financial crisis could be explained by the South African economy attempting to recover from the aftermath of the crisis and other, smaller economic shocks during the period.

Table 3 – Stability of the Taylor rule

	1990:Jan – 1998:Jun		*1999:Jan – 2006:Dec*		*2009:Jan – 2017:Jun*	
	(1) Simple	(2) Open Economy	(3) Simple	(4) Open Economy	(5) Simple	(6) Open Economy
i_{t-1}	0.959 (40.95)***	0.959 (40.79)***	0.871 (49.26)***	0.871 (50.40)***	0.915 (20.90)***	0.918 (19.30)***
π_t	-0.00968 (-0.56)	-0.00540 (-0.31)	0.0812 (4.66)***	0.0808 (4.55)***	0.0191 (0.89)	0.0202 (0.99)
Gap_t	0.0653 (2.43)*	0.0707 (2.43)*	0.0449 (2.48)*	0.0452 (2.42)*	0.0247 (2.35)*	0.0243 (2.16)*
RER_t		-0.00341 (-1.36)		0.000172 (0.21)		-0.000438 (-0.52)
Adjusted R^2	0.966	0.966	0.979	0.979	0.956	0.956
LR Response to Inflation	-0.24	-0.13	0.63	0.63	0.22	0.25
AIC	118.0	117.0	54.88	56.83	-34.91	-33.34
BIC	128.5	130.1	65.10	69.60	-24.45	-20.27
Durbin's H	0.291	0.165	0.890	0.867	1.350	1.387
F-Statistic	1300.6	1082.3	1765.1	1271.4	179.5	187.7
Newey West Lag Order	1	1	3	2	2	1

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

For another perspective of the impact of the IT framework, an additional estimation will be performed using quarterly estimates. The conclusions from quarterly estimates are similar to the monthly estimates. The estimated coefficients of the economic variables have increased, compared to the monthly estimates. However, the distinct differences are that the output gap became insignificant post-Global Financial crisis and that the explanatory power of the variables of the open economy after the adoption of IT increased greatly.

Looking at the empirical evidence provided in the estimation tables, the adoption of the IT framework has changed the conduct of monetary policy. The adoption brings forth an increased weighting toward controlling inflation. Furthermore, the weight placed on stabilising output has decreased over time since the adoption, which further suggests there has been a shift in the economic focus. The effect of inflation on the interest rate is larger with the exclusion of structural breaks. In addition, the marginal effect of the real exchange rate changes reduced and the variable remained statistically insignificant after the introduction of IT. The expected result of reduced interest rate smoothing was also achieved, as the estimated coefficient of the lagged interest rate decreased over time post-adoption. The explanatory power of the economic variables increased with the adoption of the IT framework. The evidence is only conclusive within the 1999 to 2006 period, with results significant at the 0.1 percent level, as the Global Financial crisis appears to have distorted the effects and the results of the more recent period. The extent of the Global Financial crisis will be explored later in the paper which will give a better understanding to the conflicting change in the conduct of monetary policy.

Table 4 – Quarterly Estimates

	1990:Jan – 1998:Jun		*1999:Jan – 2006:Dec*		*2009:Jan – 2017:Jun*	
	(1) Simple	(2) Open Economy	(3) Simple	(4) Open Economy	(5) Simple	(6) Open Economy
i_{t-1}	0.821 (9.59)***	0.818 (9.64)***	0.701 (16.91)***	0.696 (16.47)***	0.742 (6.91)***	0.739 (6.31)***
π_t	0.0499 (0.80)	0.0559 (0.92)	0.190 (6.66)***	0.179 (6.81)***	0.0645 (0.81)	0.0647 (0.80)
Gap_t	0.233 (2.95)*	0.244 (3.28)**	0.125 (2.60)*	0.141 (3.47)*	0.0619 (1.70)	0.0621 (1.68)
RER_t		-0.00363 (-0.51)		0.00459 (1.36)		0.000285 (0.06)
Adjusted R^2	0.913	0.911	0.949	0.951	0.808	0.802
LR Response to Inflation	0.28	0.31	0.64	0.60	0.25	0.25
AIC	71.29	73.08	45.95	46.00	35.24	37.24
BIC	77.27	80.57	51.69	53.17	41.23	44.72
Durbin's H	1.483	1.304	0.421	0.734	1.849	1.819
F-Statistic	181.4	156.5	206.5	379.4	16.73	12.20
Newey West Lag Order	3	4	4	4	1	1

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In the next section, the analysis will attempt to answer whether the adoption of the IT framework has made monetary policy more transparent.

4. Transparency

The introduction of the IT framework often brings forth increased monetary policy transparency (IMF, 2005). Although transparency is not a required condition for IT, the benefits of transparency have been widely supported by existing literature.

Ammer and Freeman (1995) developed the expectation hypothesis and applied it to inflation, and they found that a low expected inflation will result in a lower level of actual realised inflation and vice versa. Therefore, if the market is to have a lower level of expected inflation, the government need not to intervene and increase the interest rates to control inflation. The central bank can achieve the desired inflation expectation by regularly announcing their inflation targets and such targets must be attainable for success. Geraats (2001) argued that monetary policy transparency helps reduce inflationary bias and enables the central bank to operate with greater flexibility in dealing with economic shocks. Belke et al. (2005) states that if the central bank can reason justify why the previous target was not achieved and consistently announce planned actions with published minutes from the policy meetings, it would further motivate the actions of the central bank and reinforce its policy credibility.

The increased transparency allows for more accurate prediction of future actions of the central bank. Swanson (2004) found that the United States financial markets and private sector were able to better forecast interest rates under the new and transparent regime, although the Federal Reserve does not pursue explicit IT. For robustness of results, Swanson tested the improvements in GDP and inflation forecasting and the results suggest that the increased transparency only improved interest rate forecasting. Lasaosa (2005) investigated the results of the increased transparency for the Bank of England. In theory, the transparency as (suggested by previous research) would provide a higher predictability of the central bank's actions. The market would focus on the economic data which would reveal the expected inflation level and react accordingly. Contrastingly, the period under the IT framework suggests a low sensitivity to the macroeconomic data upon release. The initial adoption suggested low predictability of the interest rate but, over time, the market learned to adapt to the policy committee and market reactions were stronger as compared to the initial stages. Furthermore, Lasaosa classified transparency into specific categories (i.e. goal transparency; knowledge transparency and operational transparency). The goal transparency refers to the openness of the central bank in the announcement of targets. Knowledge transparency refers to the information regarding the economy and its forecast being released by the central bank. Operational transparency refers to the clarity of policy decisions and openness in the reveal of policy meetings.

Carpenter (2004) found that the existing literature explain very little regarding the practical implementation of policy transparency. Furthermore, there exists an asymmetric information problem with both knowledge and operational transparency. Central banks publish reports and forecasts, but the publications are only sets of incomplete information as the public does not know how the conclusions are drawn from these, nor the extensive information behind the decisions. The public would then hold less information and misjudge the associated risk within the revealed information. The empirical section would attempt to investigate how the public, mainly the private sector and financial markets, assess the changes in the interest rate and use the information to forecast future interest rate changes. The market interactions in the financial market will reveal the transparency of the monetary policy as the forecast accuracy is associated with policy transparency.

Carlson et al. (1995) investigated the forecast ability of the interest rate futures to predict the interest rates. They used the Fed fund rates to measure the predictive accuracy in forecasting the effective Fed fund rate. The study found that the standard deviation between the future and actual rate decreased as the contract closed in on the expiration date. Though the predictive accuracy was fair, the accuracy decreased as the time horizon under consideration expanded. Poole et al. (2002) examined the ability of the market to foresee changes in the Fed interest rate using changes in the Fed fund rates as the Fed fund rate represents the market expectation most accurately. By dividing the sample period into Pre-IT and IT periods, the number of unexpected changes in the interest rate reduced greatly due to the improvement in the transparency of monetary policy, which allowed the market to better anticipate the interest rate changes.

Existing research provides the benefits of better transparency from the central bank. Though inflation targeting does not instantaneously increase transparency, over time countries shift toward high transparency upon the adoption of the framework. The empirical analysis up next will test for the transparency of the SARB and will make use of interest rate futures as a proxy variable for the market expectations of the interest rate. The analysis would provide the ability of the market to forecast the interest rate.

4.1 Term Structure Equation

Gürkaynak et al. (2007) used the expectation hypothesis of the yield curve to develop an equation for forecasting the interest rate set by the Federal Reserve. Similarly, by applying the expectation hypothesis of the yield curve and using the negotiable certificate of deposits (CDs) yields an equation of the form:

$$CD_{6,t} = \frac{[CD_{3,t} + E(CD_{3,t+3})]}{2} + \phi_t \tag{7}$$

Where

$CD_{6,t}$ – 6-month negotiable certificate of deposit

$CD_{3,t}$ – 3-month negotiable certificate of deposit

ϕ_t – risk premium between 6-month and 3-month CD

Assume rational expectations, then the expected 3-month negotiable CD at time $t + 3$ is:

$$E(CD_{3,t+3}) = CD_{3,t+3} - 2[\theta_{t+1} + \theta_{t+2} + \theta_{t+3}] \tag{8}$$

Where θ_{t+i} represents uncorrelated shocks from exogenous components and/or unexpected monetary policy changes at time t for $i = 1, 2, \dots$, n

Rewriting Equation 7 with rational expectations yields:

$$CD_{6,t} = \frac{[CD_{3,t} + CD_{3,t+3}]}{2} + \phi_t - \theta_{t+1} - \theta_{t+2} - \theta_{t+3} \tag{9}$$

Subtracting $CD_{3,t}$ from both sides to account for cointegration

$$CD_{6,t} - CD_{3,t} = \frac{[CD_{3,t+3} - CD_{3,t}]}{2} + \phi_t - \theta_{t+1} - \theta_{t+2} - \theta_{t+3} \tag{10}$$

Rearranging the equation and taking the uncorrelated shocks to the other side

$$\frac{[CD_{3,t+3} - CD_{3,t}]}{2} = [CD_{6,t} - CD_{3,t]} - \phi_t + \theta_{t+1} + \theta_{t+2} + \theta_{t+3} \tag{11}$$

Adding and subtracting the average risk premium ϕ from the RHS yields

$$\frac{[CD_{3,t+3} - CD_{3,t}]}{2} = -\phi + [CD_{6,t} - CD_{3,t}] + [\phi - \phi_t] + \theta_{t+1} + \theta_{t+2} + \theta_{t+3} \tag{12}$$

Rewriting the above into a more simplified equation:

$$PFS_t = \psi_0 + \psi_1 yield_t + \epsilon_t \qquad (13)$$

Where

$$perfect\ foresight\ spread, PFS_t = \frac{[CD_{3,t+3} - CD_{3,t}]}{2}$$

$$yield_t = CD_{6,t} - CD_{3,t}$$

$$\epsilon_t = [\phi - \phi_t] + \theta_{t+1} + \theta_{t+2} + \theta_{t+3}$$

The coefficient of the current yield spread ψ_1 displays the market's forecast ability of the interest rate. The larger the coefficient, the better the predictability of the interest rate. The error term ϵ_t has, by construction, residual autocorrelation due to the 3-period moving average component. The autocorrelation can be corrected by estimating the equation using the Newey-West procedure, similar to the Taylor rule.

4.2 Term Structure Estimation

Table 5 – Estimation of the Term Structure

	1990:Jan – 2017:Jun (1)	*1990:Jan – 1999:Dec* (2)	*2000:Jan – 2017:Jun* (3)	*1990:Jan – 2017:Jun* (4)
$Yield\ Spread_t$	0.521 $(2.98)^{**}$	0.353 (1.42)	0.722 $(4.25)^{***}$	0.558 $(3.28)^{**}$
$Risk\ Premium$	-0.136 (-1.90)	-0.106 (-0.89)	-0.208 $(-3.14)^{**}$	-0.102 (-0.85)
$IT\ Dummy$				-0.0628 (-0.50)
Adjusted R^2	0.097	0.015	0.335	0.097
AIC	526.5	287.8	90.95	527.6
BIC	534.0	293.4	97.62	539.0
F-Statistic	8.852	2.004	18.10	5.373
Newey West Lag Order	4	4	4	4

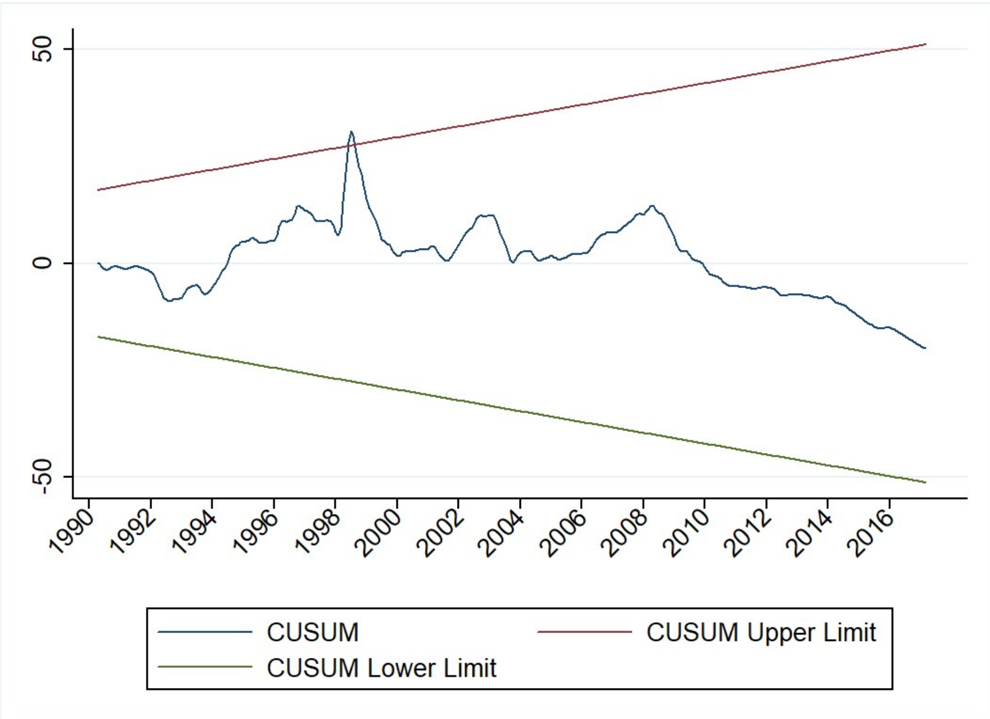
t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5 illustrates how the adoption of the IT framework has made monetary policy more predictable. The estimated coefficient of the yield spread increased from the adoption, going from 0.353 to 0.722 and becoming statistically significant at a 0.1 percent significance level. Furthermore, there is a large increase in the adjust R-squared value from the adoption of IT with the information criterion further confirming the increased predictability. The explanatory power of the yield spread increased greatly with the adoption, which could signify that the market is able to use the economic data released by the SARB to better predict the interest rate. The estimation includes a model with an IT dummy which differentiates periods with and without IT. The estimated coefficient is found to be negative and statistically insignificant at a 5 percent level which makes economic sense, as the interest rate futures play the primary role in determining future changes of the interest rate.

4.3 Testing for Structural Breaks

Similar to the Taylor rule estimation, a test must be performed to determine unknown structural breaks and the stability of the parameters. The CUSUM and CUSUMSQ tests are performed and the plots of the test are below:

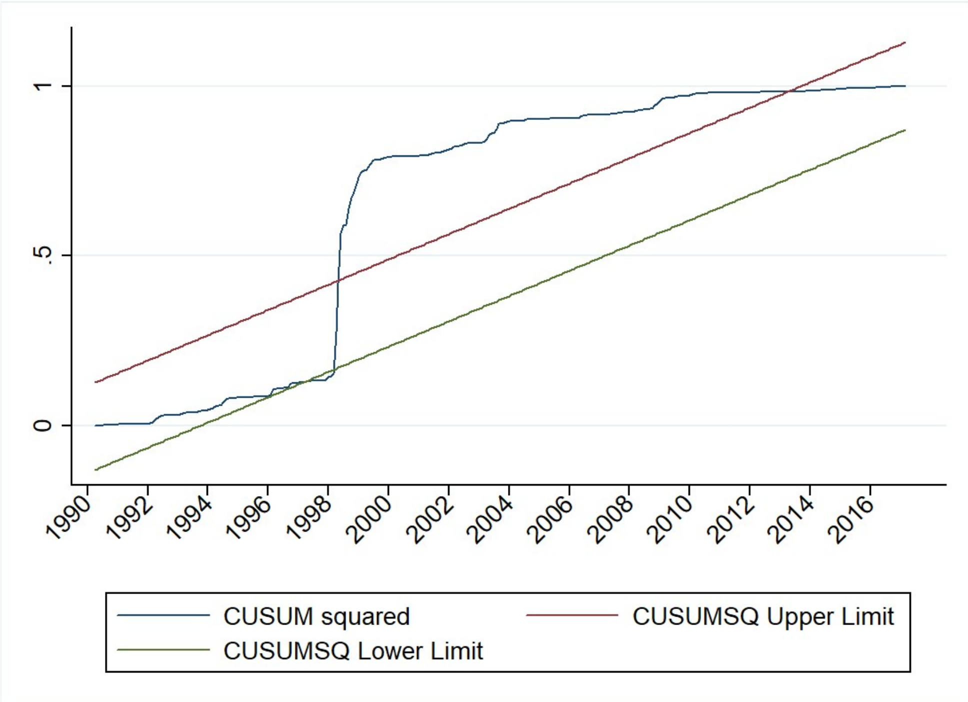
Figure 13 - Cumulative Sum Statistic Plot



Note: CUSUM test used a 95% confidence interval for the estimation.

The results are similar to the tests performed for the Taylor rule with the majority of the points fluctuating around zero. It is worthwhile to note that there are two significant structural breaks: the 1998 discrete jump and the 2008 fluctuation that caused the CUSUM statistic to fall below target and continue to decrease. Furthermore, the 1998 jump contains an ‘out of control’ point, while the coefficients are stable with the exclusion of the jump. The CUSUMSQ statistic supports the two structural breaks at 1998 and 2008. Therefore, the sample period under consideration will remove the Asian crisis and Global Financial crisis and reperform the term structure estimation. The results are shown in Table 6.

Figure 14 - Cumulative Sum Squared Statistic Plot



Note: CUSUM test used a 95% confidence interval to calculate the CUSUM and CUSUMSQ Statistic

Table 6 – Stability of the term structure

	1990:Jan – 1998:Jun	*1999:Jan – 2006:Dec*	*2009:Jan – 2017:Jun*
	(1)	(2)	(3)
$Yield\ Spread_t$	0.506 (3.45)***	1.298 (7.74)***	0.521 (2.98)**
$Risk\ Premium$	0.0221 (0.19)	-0.241 (-3.68)***	-0.136 (-1.90)
Adjusted R^2	0.033	0.422	0.535
AIC	228.0	96.41	-64.12
BIC	233.2	101.5	-58.93
F-Statistic	11.87	59.93	8.852
Newey West Lag Order	4	4	4

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The elimination of the two crises from the sample period provides a clear understanding of the impact of IT on the transparency of monetary policy. Model 2 in Table 6 displays a great increase in the estimated coefficient of the yield spread. Though Model 3 displays a decrease in the estimated coefficient of the yield spread, this could be due to the uncertainty associated with the economy after the Global Financial crisis which affected the predictability of monetary policy. The improved transparency of the policy can be seen in the increasing adjust R-Squared value with the information criterion further supporting the claim.

Table 7 – Analysis of the residuals

Mean (ϵ_t)	0
Var(ϵ_t)	0.29
White Heteroscedasticity	8.825
p-value	(0.0121)
Durbin-Watson d-statistic	0.385
Breusch-Godfrey	1lag
Skewness	2.65
Kurtosis	23.15

To ensure robustness of the estimation results, an analysis on the residual is performed. Table 7 illustrates the autocorrelation problem and the violation of the basic assumptions of OLS. The confirmation of autocorrelation can be seen from the Breusch-Godfrey test and the White heteroscedasticity test. The Breusch-Godfrey test further suggest the autocorrelation is of order one which can be corrected by the inclusion of a lagged period of the current yield spread. The results are as follows:

Table 8 – Stability of the term structure using an AR(1) model

	1990:Jan – 1998:Jun	*1999:Jan – 2006:Dec*	*2009:Jan – 2017:Jun*
	(1)	(2)	(3)
$Yield\ Spread_t$	0.335 (0.56)	0.879 (3.72)***	0.578 (2.30)*
$Yield\ Spread_{t-1}$	0.203 (0.38)	0.454 (1.51)	-0.00264 (-0.02)
$Risk\ Premium$	0.0210 (0.19)	-0.228 (-4.04)***	-0.260 (-3.60)***
Adjusted R^2	0.025	0.448	0.475
AIC	228.6	83.06	-77.46
BIC	236.4	90.72	-69.70
F-Statistic	13.92	33.72	7.961
Newey West Lag Order	2	1	1
Durbin-Watson d-Statistic	0.286	0.621	0.499

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The AR(1) model gives the same conclusion as the previous model. The adoption of IT increases the predictability of the future changes of the interest rate. The lagged yield spread has no significant impact on the perfect foresight spread in all 3 periods under consideration. The adjusted R-Squared increased over time, which is consistent with the previous estimation. Though the estimation results suggest that monetary policy became more transparent due to the increased predictability, the predictability is also based on the market's ability to use the data released by central banks to better forecast and predict future changes. The change in explanatory power of the economic variables are expected to increase with a more transparent policy. Therefore, an examination of the determinants of the yield spread with the addition of economic variable will provide a better outlook on the transparency of monetary policy.

Table 9 – Predictability of future interest rate changes using economic variables

	1990:Jan – 1999:Dec		*2000:Jan – 2017:Jun*	
	(1)	(2)	(3)	(4)
$Yield\ Spread_t$	-0.00754 (-0.03)		0.637 (7.74)***	
$CD_{3,t}$	-0.102 (-3.34)**	-0.101 (-3.75)***	0.00731 (0.62)	-0.0401 (-3.49)***
π_t	-0.00522 (-0.25)	-0.00522 (-0.25)	-0.0251 (-2.47)*	0.000136 (0.01)
Gap_t	0.127 (3.31)**	0.126 (3.59)***	0.0380 (4.74)***	0.0619 (7.36)***
RER_t	-0.00784 (-3.03)**	-0.00786 (-3.17)**	-0.000742 (-1.50)	-0.000668 (-1.19)
Adjusted R^2	0.204	0.211	0.416	0.246
AIC	264.9	262.9	67.83	119.8
BIC	281.6	276.8	87.83	136.5
F-Statistic	7.055	8.897	30.35	17.78

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9 illustrates the difference in explanatory power in determining the future changes of the interest rate. The difference in explanatory power is greater as the output gap, inflation and the current yield spread have significant impact on determining future changes. Again, the exchange rate has no significant impact post adoption of IT. The improvement in the F-Statistic gives an indication that the recent period's yield spread contains all the information required for the forecasting and prediction of future interest rate changes, with the large increase in the t-statistic of the current yield spread coefficient. Furthermore, the current yield spread had no significant impact prior to IT and the estimated coefficient became statistically significant at a 0.1 percent significance level after the change in monetary policy regime. Although the increase in the F-Statistic signals an increase in predictability, the suggested conclusion is that the market cannot fully utilise the information within the yield curve to better forecast future changes due to the fairly low F-Statistic.

Figure 13 illustrated two peaks post the 1998 Asian crisis, South Africa's currency crisis of 2001 and the peak associated with the Great Recession from 2008. In 2001, the exchange rate fell in the second half of the year, but the response of the monetary policy was significantly different to how the 1998 Asian crisis was dealt with. The SARB opted to maintain monetary policy discipline, with the interest rate not being used to influence the exchange rate but rather to primarily stabilise inflation during the period. The difference in how monetary policy was conducted would have caused the market to misread the information and not fully utilize the information released by the SARB. Similarly, the 2008 Global Financial crisis caused an abrupt increase in inflation and the IT objective was abandoned due to the large decrease in economic growth. The SARB maintained the monetary discipline despite an ursine global financial market and were more consistent at maintaining the conduct of monetary policy. Although IT improved predictability as illustrated in Table 6 and 8, the decrease in the yield curve coefficient supports the notion that market expectations are far from accurate and similar to the forecasting ability prior to IT.

5. Impact of the 2008 Global Financial Crisis

The estimation of both the Taylor rule and term structure will both be examined to better understand the impact of the Global Financial crisis. Table 10 displays the term structure and the Taylor rule estimations with both regression estimated with the Newey-West procedure to account for autocorrelation. In the term structure estimation, the estimated coefficient of the yield spread determines the predictability of monetary policy and is the highest after the adoption of IT and before the crisis. However, the crisis did not change the market expectation of future changes of interest rate and caused the predictability to decrease severely during the crisis. The loss in predictability is clearest after the crisis where the market is less able to forecast as accurately as previous periods with the estimated coefficient decreasing, but still statistically significant. The F-Statistic illustrates a large decrease during the crisis and a slight increase post-crisis. Figure 16 supports the conclusions drawn as the yield spread following a similar trend to the perfect foresight spread until mid-2009. The yield spread struggled to maintain a similar trend post-crisis and is seen to have an upward trend from 2012 onward.

Table 10 – Impact of the 2008 Global Financial crisis

	Term Structure		
	2000:Jan – 2006:Dec	*2007:Jan – 2008:Dec*	*2009:Jan – 2017:Jun*
	(1)	(2)	(3)
$Yield\ Spread_t$	1.194 (6.24)***	1.160 (2.98)**	0.660 (3.58)***
$Risk\ Premium$	-0.153 (-2.60)*	-0.220 (-1.49)	-0.299 (-3.38)**
F-Statistic	38.96	8.861	12.82
	Taylor Rule		
	2000:Jan – 2006:Dec	*2007:Jan – 2008:Dec*	*2009:Jan – 2017:Jun*
	(4)	(5)	(6)
i_{t-1}	0.858 (26.80)***	0.588 (2.00)	0.918 (18.90)***
π_t	0.0927 (3.97)***	0.165 (1.25)	0.0202 (0.91)
Gap_t	0.0452 (2.61)*	-0.0151 (-0.92)	0.0243 (2.32)*
RER_t	-0.000203 (-0.24)	-0.000114 (-0.08)	-0.000438 (-0.53)
$Constant$	0.796 (3.91)***	2.680 (1.54)	0.376 (1.04)
F-Statistic	648.3	60.74	161.6

t statistics in parentheses
$^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

The results of the Taylor rule estimation suggest that inflation played an important role in the period post-IT adoption while the other estimated coefficients signs fit *a priori* expectations and significance. During the crisis, none of the variables are found to be statistically significant and economic theory would suggest the same conclusion as the conduct of monetary policy deviated from IT. Post-crisis period would see the output gap play a role in determining the interest rate as the SARB is attempting to stabilise the economy. The evidence in Figure 15 illustrates smaller fluctuations for output gap and inflation, though inflation is outside the target range for the majority of the post-crisis period. The increase in the F-Statistic suggests that there is a resurgence in the explanatory power of the variables for determining the interest rate.

Figure 15 – Actual interest rate, CPI and output gap in SA (2000 – 2017)

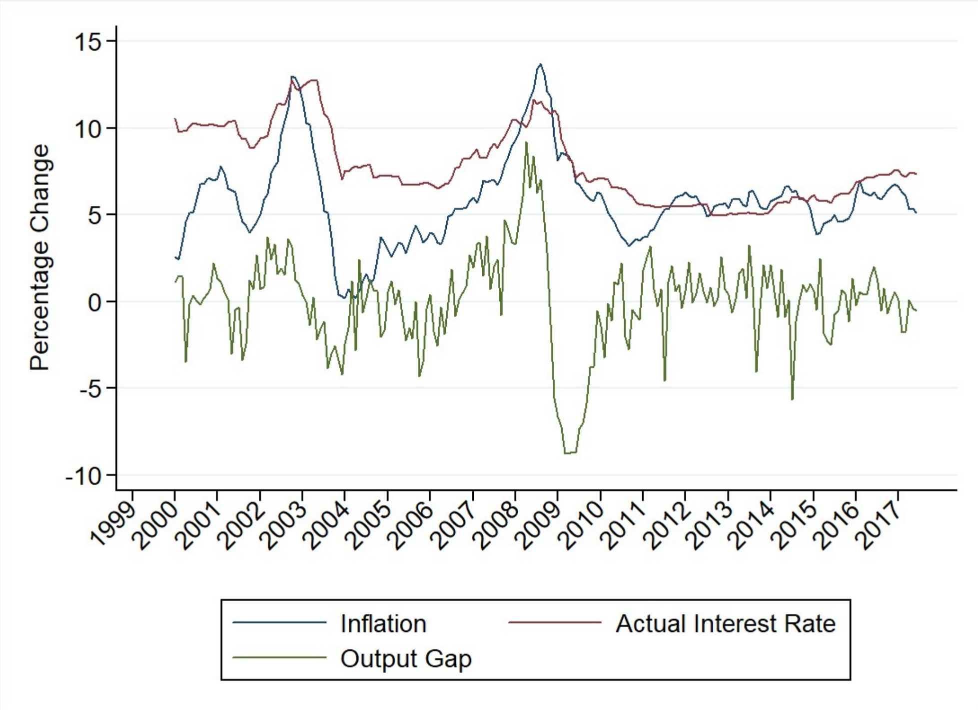
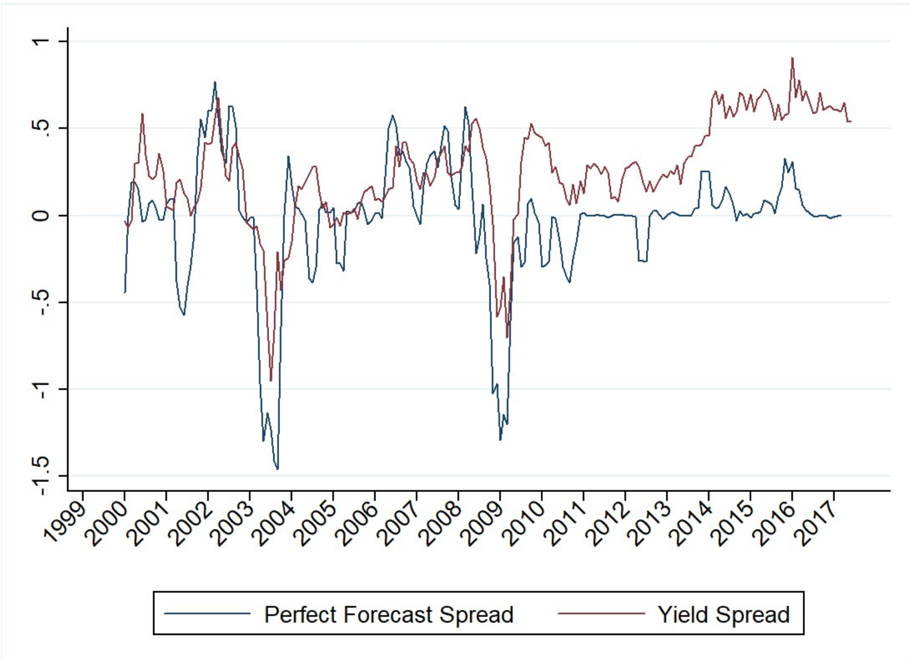


Figure 16 – Perfect foresight spread vs current yield spread (2000 – 2017)



The 2001 inflation peak illustrated the clear lack of transparency in the implemented monetary policy, which lead to the market expectations of the future interest rate changes to be skewed. This lack in communication during the peak, which may have been compounded by market uncertainty as to whether the SARB would adhere strictly to the IT framework and resist pressure to try and strengthen the severely weakened Rand, caused the confusion in the financial market.

An analysis of the impact of the Great Recession indicates that post this crisis, the financial market experienced reduced accuracy in forecasting future interest rate changes and the SARB was unable to keep inflation within target due to the overwhelming effects of the crisis. The financial market's forecasting ability and confidence has been damaged due to the reduced predictability of monetary policy.

6. Conclusion

Unlike a number of other countries, which introduced IT in relatively moderate and benign circumstances, South Africa's introduction of IT was followed by turbulent and harsh macroeconomic circumstances. Such circumstances impacted on South Africa's ability to fully experience the presumed benefits of the IT framework.

Economic shocks, both internal and external, have tested the SARB monetary policy thoroughly. This paper set out to answer whether IT has changed the conduct of monetary policy to the expected conduct (i.e. more credible, transparent and consistent monetary policy). The empirical analysis made use of the Taylor rule and term structure to test for the change in conduct. The empirical evidence showed that despite the economic circumstances, the adoption of IT has changed the conduct of monetary policy and the resultant changes satisfied *a priori* expectations. The reduction of interest rate parameter smoothing, decreases in both the output gap and the real exchange rate's impact on the current interest rate, as well as a more significant role for inflation in determining changes in the interest rate. In addition, a comparison between the original Taylor rule and the actual interest rate showed that South Africa used a relatively tight monetary policy in the context of the economic shocks outlined.

Furthermore, the predictability of monetary policy initially increased greatly with the introduction of IT and the market was better able to forecast monetary policy developments. This predictability was reduced in the aftermath of the Great Recession. The effects of the crisis are seen in the drastic reduction in predictability of the interest rate with the SARB forced to adopt a more flexible approach in the conduct of policy.

Overall, the initial period of IT in South Africa proves that the transparency of monetary policy can be improved as a result of the introduction of the IT framework. To further promote the benefits seen by the initial periods of the adoption of the IT framework, it is would be especially important for policy transparency to prevail during times of economic shocks.

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Appendix

The output trend used for the output gap was calculated using the Hodrick-Prescott (HP) filter. The filter used the smoothing parameter of 14 400 as the estimation made use of monthly data. The output gap was calculated as follows:

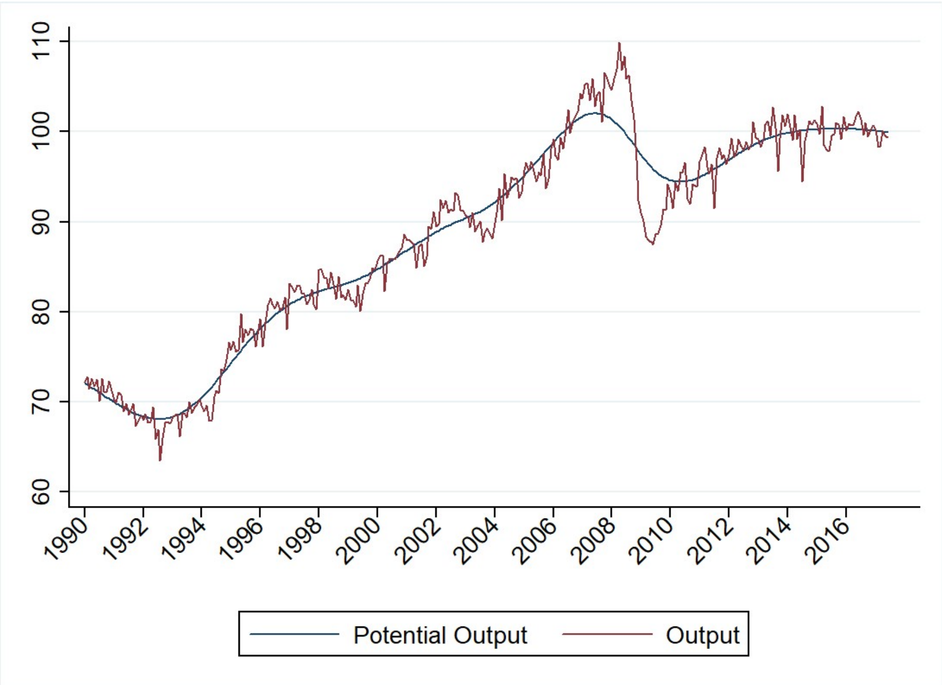
$$Gap_t = \frac{(Y_t - Y_t^*)}{Y_t^*} * 100$$

Where

Y_t – Actual Output

Y_t^* - Potential output calculated using the HP filter

Figure – Actual output vs potential output



Note: Potential output calculated using a HP filter ($\lambda = 14\,400$*)*

The real exchange rates were measured as continuously compounded annual rates so therefore the calculation the calculation for the monthly changes was as follows:

$$RER_t = 12 * \ln\left(\frac{ER_t}{ER_{t-1}}\right) * 100$$

Where

ER_t – Real effective exchange rate