Working Papers
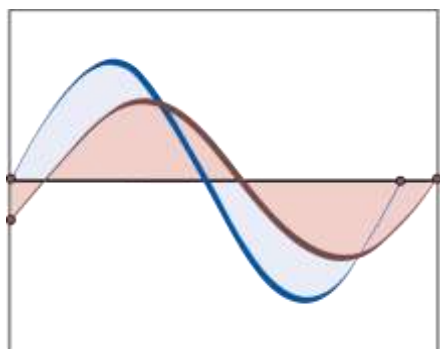
Alternative Monetary Policy Rules in Trinidad and Tobago: An Analysis using a Generalized Methods of Moments (GMM) Approach

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Since Taylor (1993) seminal work on the mechanics of monetary policy, the estimation of a monetary policy reaction function is one of the most researched topics in developed nations and more recently, in emerging economies. This paper estimated Taylor (1993) rule, alongside alternative monetary policy rules such as McCallum (1987) rule and a hybrid McCallum rule using the Generalized Methods of Moments (GMM) technique. The model employed Newey-West estimators that are robust to heteroskedasticity and autocorrelation of an unknown form. Also, the Sargan (1958) test for over-identifying restrictions was used. The estimated results found that policy interest rate was not influenced by inflation. Further, monetary policy in Trinidad and Tobago does not appear to follow either Taylor's rule or McCallum's rule. However, significant support was seen for the hybrid McCallum rule.

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1.   Introduction

The work of Taylor in his 1993 paper on interest rate setting laid the foundation for using a mechanical reaction function to link short term nominal interest rates to inflation and economic activity in an economy. Taylor's Rule analyses how interest rates would have been set previously, and provides a framework and perspective that would be useful for interest rate setting in the future. According to Hofmann and Bogdanova (2012), it is frequently used as a yardstick for the effectiveness of monetary policy. They went further to state that when monetary policy is consistent with Taylor's Rule, it is usually accompanied by low inflation and low macroeconomic volatility. In fact, even in the presence of financial stability, Taylor (2007, 2010, and 2012) and Ahrend et al. (2008) argued that when the policy rate is lower than the mechanical rate suggested by Taylor's Rule, that is monetary policy is too accommodative, it may lead to financial imbalances which may have exacerbated the effects of the global financial crisis.

The aim of this paper is to study the behavior of monetary policy rules in Trinidad and Tobago. Previous work on monetary rules in Trinidad and Tobago is infrequent and as such, it is a useful starting point for further analysis. Econometric analysis in the form of a Generalized Methods of Moments (GMM) model was estimated to determine the influence of macroeconomic variables on the policy tools of the economy. The main findings were that monetary policy was quite accommodative since the policy rate was lower than the rate suggested by Taylor's Rule for most of the dataset. Furthermore, the output gap had a significant impact on the interest rate but the inflation gap had little impact. Additionally, the McCallum rule proves to be insignificant for Trinidad and Tobago. However, the hybrid McCallum rule is highly significant and the policy rate in the economy appears to follow the hybrid McCallum rule

The remainder of the paper is organized as follows: Section two outlines the theoretical and empirical work done on monetary policy rules. Section three highlights the variables used in the estimation as well as descriptive statistics among the variables. Section four puts forward the GMM estimation framework employed by Gozgor (2012) and others to estimate Taylor's rule, McCallum's rule and the hybrid McCallum rule as well as various measures of robustness. Finally, section five concludes the paper, giving its limitations in addition to avenues for further research.

2. Literature Review

Taylor (1993) in his seminal work aimed to explain how the Federal Reserve sets its nominal interest rate between 1987 and 1992. The author found that changes in the federal fund rate react to deviations of inflation from its target level and deviations of output from its potential output. Though Taylor (1993) did not estimate a model, he assumed that both the inflation and output deviations were equally weighted and the real interest rate and targeted rate of inflation was 2 per cent. This study gave rise to what is known as "Taylor's Rule" and has served as a benchmark for many studies since then to evaluate monetary policy. According to Hofmann and Bogdanova (2012), the Taylor Rule "links policy rates mechanically to the deviation of inflation from target and the output gap".

Clarida, Gali and Gertler (1998) estimated a forward looking monetary policy reaction function using a Generalized Methods of Moments (GMM) model for the post-war era. The authors found that the nominal interest rate was less than "expected inflation" pre-1979 (before the Paul Volcker regime) but the opposite for post-1979 (when Paul Volcker took office). Additionally they found that during the pre-Volcker era, monetary policy in the United States (US) was very accommodative but the post-Volcker era was highly proactive . They then examined how the policy rule affected macroeconomic performance. Estimation concluded that pre-1979 was characterized by macroeconomic instability with bursts of inflation and output whilst post-1979 was characterized as anti-inflationary. Given the performance of the economy pre-1979, the monetary policy stance taken was classified as inferior since it did not follow the mechanics of the Taylor Rule.

McCallum (2000) extended the work of Taylor (1993) by investigating how changes in the monetary base were affected by the target growth in nominal Gross Domestic Product (GDP), targeted inflation, the long run average growth in real GDP and average growth of the monetary base velocity for a period of sixteen months. As such, both the work of Taylor and McCallum's differ in instrument variables as well as dependent or target variables. McCallum estimated his model for the US and United Kingdom (UK) (1962 to 1999) and for Japan (1972 to 1998). For the US, monetary policy was too loose in the 1970's but just right between 1987 and 1995. He found that specification rather than the use of the target variable played a more substantive part in the Rules' message. The UK's monetary policy rule followed similar patterns as the US with policy being too loose in the 1970's but on target from 1987. Again, the instruments had a greater impact on the Rule than the target variable. For Japan, the Rule was rarely on point, with some periods being too tight whilst other periods were too loose.

Taylor (2000) extended his seminal work which examined the policy rule in the US to focus on policy rules in emerging markets. Whilst no empirical estimation was undertaken, he argued that the Rule could be applied with minor modifications as long as the country does not operate under a fixed exchange rate regime. Examples of

these adjustments include choice of variables, whether it is monetary aggregates or interest rate, if the exchange rate is to play a greater or lesser role and special considerations for the development of the financial markets.

Using data from 1970 to 1998, Sanchez-Fung (2005) estimated a simple monetary policy reaction function for the Dominican Republic using the monetary base (stating that it was the most used monetary instrument for developing nations) as well as a ceiling placed on interest rate until the 1990's. Furthermore, several changes to the exchange rate regimes were made in the Dominican Republic and are therefore a good proxy for monetary targets. Overall, the author concluded that monetary authorities behaved more systematically between 1985 and 1998 than between 1970 and 1984.

Gerlach-Kristen (2003) estimated the Taylor's Rule in the Euro Area using quarterly data from 1988 to 2002. Even though previous works estimated that the Rule fit well in the past, Gerlach-Kristen (2003) argued that it ignored the presence of non-stationarity in the data and as such, the model was mis-specified. As a result, an examination of two cointegrating equation (unrestricted and restricted) to link interest rate, inflation and the output gap was undertaken. Using the unrestricted equation, the author found that the long-run rate of interest could be seen as an indicator of "expected long-run inflation" and in this sense, it is forward looking. Furthermore, the restricted equation found that the short term interest rate increased in response to the output gap as well as expectations of inflation. Both equations ultimately conformed to the Taylor's Rule.

Mehrotra and Sanchez-Fung (2011) estimated an Ordinary Least Squares (OLS) and GMM model for both the Taylor and McCallum policy reaction functions for twenty emerging market economies using both the short term nominal interest rate as well as the monetary base as dependent variables. The McCallum reaction function was estimated in a variety of ways using different instruments as well as different targets. Whilst the results vary between countries, the overall variations of the McCallum rules used for inflation targeting generally performed better than the Taylor-type rules.

Using GMM and Limited Information Maximum Likelihood (LIML) methods, Gozgor (2012) estimated the Taylor's Rule as well as the hybrid McCallum Rule for Turkey using quarterly data from 2003 to 2012. Over this period, the nominal interest rate was the primary tool of monetary policy used in inflation targeting. The author used a variety of instruments as well as target variables in estimating both specifications of the model. His empirical findings suggest that the Taylor's Rule specification better explains monetary policy for Turkey than the hybrid McCallum specification.

3. Data description and Stylized facts

Taylor (1993) advocated that two variables, namely the deviation of output from its trend and the deviation of inflation from its target would be the main contributors for changes in the interest rate. The most widely used proxy for output is GDP and the measure of inflation is taken by the Retail Price Index. The short term nominal interest rate was represented by the 90 day Treasury bill rate. Similarly, McCallum (2000), using the monetary base as the policy rule, stated that the main determinant of the policy rule was nominal GDP and targeted inflation.
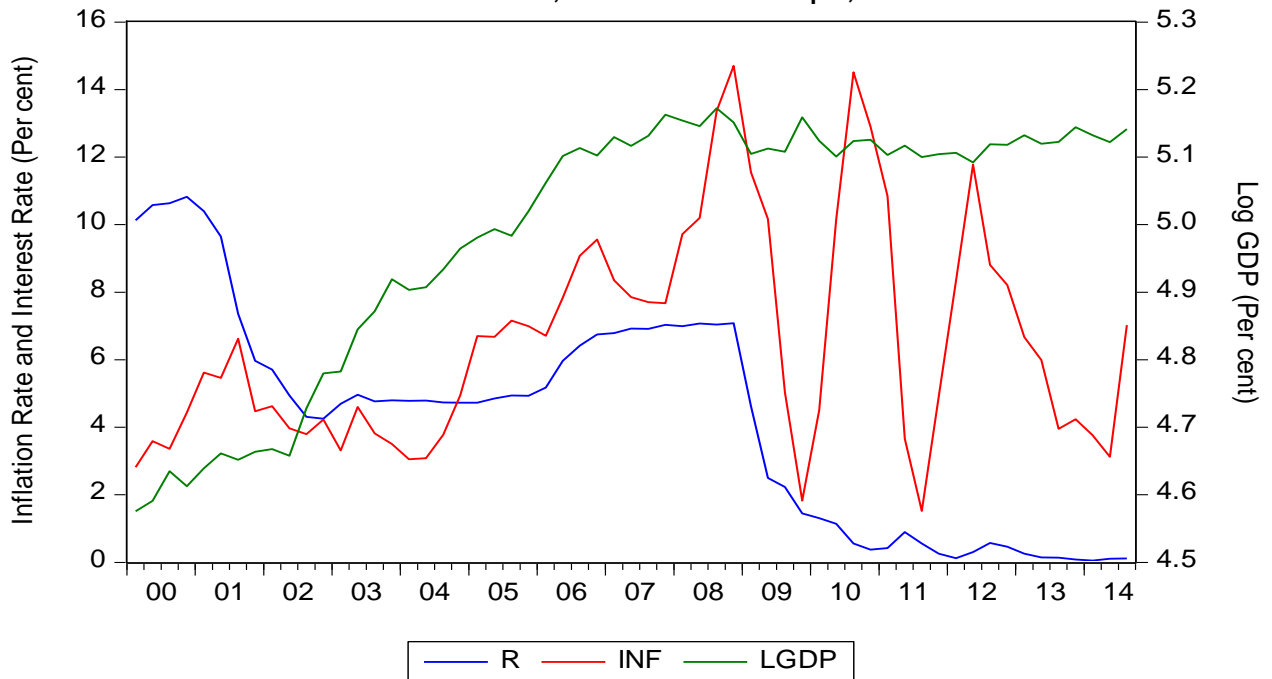
Table 1
Variables and Definition

Variable	Definition
Gross Domestic Product	An aggregate measure of production equal to the sum of gross values added of all resident institutional units engaged in production that are adjusted for price movements with a base year 2000=100. This series is reported as an index in Taylors Rule and nominal in McCallum and hybrid McCallum rule.
Monetary Base	Defined as Currency in Active Circulation plus Commercial Banks' Deposits with the Central Bank.
(Short term nominal interest rate[1])	The interest rate on three month T-bills in Trinidad and Tobago.
Retail Price Index	An index of consumer prices which measures changes in the prices of goods and services bought for household consumption with a base year 2003=100. This series is reported as an index:
	1. Headline Inflation – A measure of change in the overall Index of Retail Prices.
	2. Core Inflation – The component of measured inflation that has no medium to long-run impact on real output. In Trinidad and Tobago, this measure excludes food prices.

Source: Central Bank of Trinidad and Tobago.

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[1] Other measures of the short term interest rate such as the prime lending rate and the Repo rate were statistically insignificant or had little impact on the volatility of output and inflation.
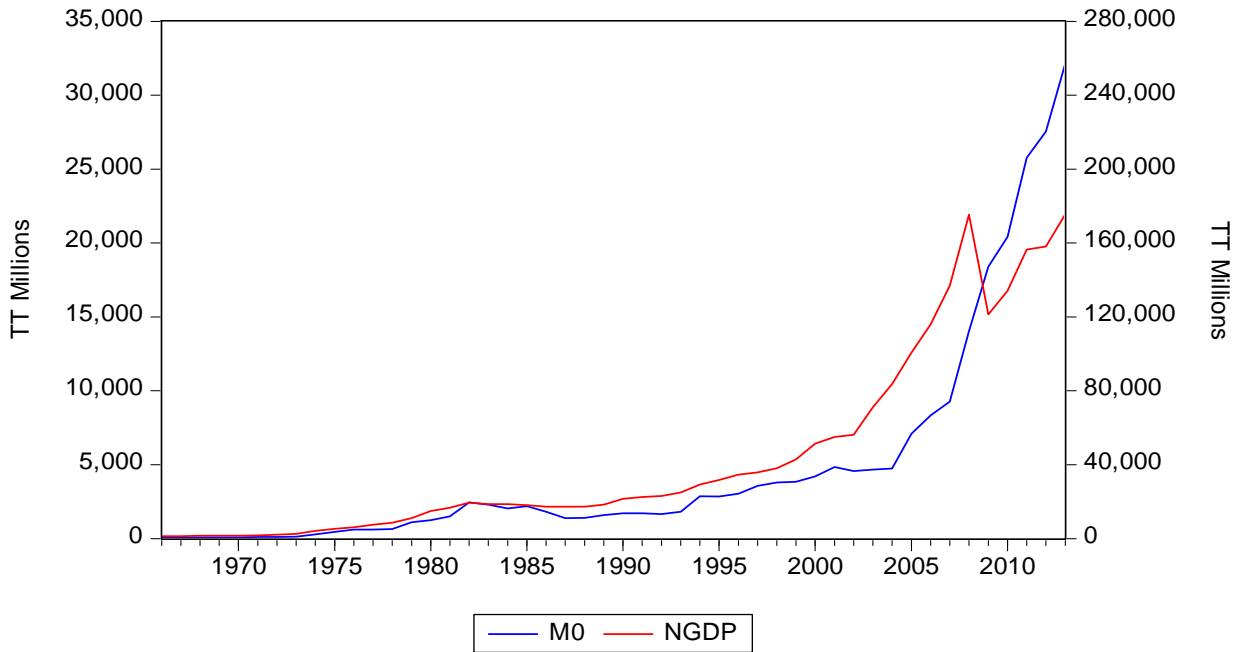
Graph 1
Time Series Plot of Inflation, Interest Rate and Output, 2000-2014

Source: Central Bank of Trinidad and Tobago.

Over the period, the growth rate output increased from 2000 to 2008 but remained relatively unchanged thereafter. Similarly, the Treasury bill rate decline from a high of 10 per cent in 2000 to about 10 basis points in 2014. On the other hand, inflation behaved erratically and exhibited cyclical patterns especially between 2008 and 2014. In an attempt to better understand the relationship among the variables, the Granger Causality test was undertaken. Using two lags, the inference of the test is that inflation does not cause any of the changes in the interest rate. However, output does have some causal impact on the changes in interest rates. Additionally, correlation analysis revealed that there was a fairly high negative relationship between interest rate and output whilst there was little relationship between inflation and the interest rate.

Graph 2
Time Series Plot of the Monetary Base and Nominal GDP

Source: Central Bank of Trinidad and Tobago.

From graph 2, the monetary base and nominal GDP followed a similar trend with a slow and stable growth rate from 1965 to 2005. However, beyond 2005, they both increased rapidly. Along with a booming Trinidad and Tobago economy, the increase in the monetary base may have also contributed to the increase in nominal GDP.

Table 2
Granger Causality Test

Variable	Test Statistics	Interpretation
Inflation	1.0030***	Inflation does not Granger Cause the interest rate
Output	3.6870**	Output does Granger Cause the interest rate
Nominal GDP	9.29*	Nominal GDP does Granger Cause the monetary base

Source: Authors' calculations.

Note: Where *** denotes the non-rejection of the null hypothesis at 10 per cent significance level and ** and * denotes the rejection of the null hypothesis at 5 and 1 per cent significance level respectively

4. Methodology, Estimation and Results

Taylor's Rule

This part of the paper uses quarterly data to estimate a time series Generalized Methods of Moments (GMM) model between March 2000 and September 2014, giving a total of fifty-nine data points. Taylor's (1993) original specification was given as:

$$r = p + 0.5y + 0.5(p - 2) + 2 \qquad (1)$$

Where $'r'$ is the federal fund rate, $'p'$ is the rate of inflation, $'y'$ is the output gap and $'2'$ is the target rate of inflation as well as trend in GDP growth. If inflation and GDP growth increases above its target, the federal funds rate should increase. The converse holds true.

This paper extends previous research by estimating the augmented specification by Gozgor (2012) and this is given as:

$$r_t = a + \beta r_{t-1} + \gamma(\pi_t - \pi^*) + \delta(y_t - \tilde{y}) + \epsilon_t \qquad (2)$$

In this augmented specification, a lagged value of the dependent variable (the ninety day Treasury bill rate in the case of Trinidad and Tobago [2]) appears on the right hand side of the equation. This is referred to as the 'smoothing parameter'. This means that current interest rate is influenced in some form by the interest rate from the previous period and the interest rate will adjust slowly to a benchmark level. Changes in the interest rate is also influenced by the deviation of headline inflation[3] (π) from its targeted value (π^*)[4] and the devation of GDP growth (y) from its trend ($\tilde{y}$) and the error term (ϵ_t). The coefficients of the inflation gap and output gap are γ and δ respectively, where Taylor (1993) assumed that $\gamma = 1.5$ and $\delta = 0.5$. The output gap is calculated using the Hodrick-Prescott filter, which is the most recognized way to estimate the long term trend component of a series. Given that the data is quarterly in nature, Hodrick and Prescott (1997) suggested the use of a smoothness parameter of 1600 ($\lambda = 1600$).
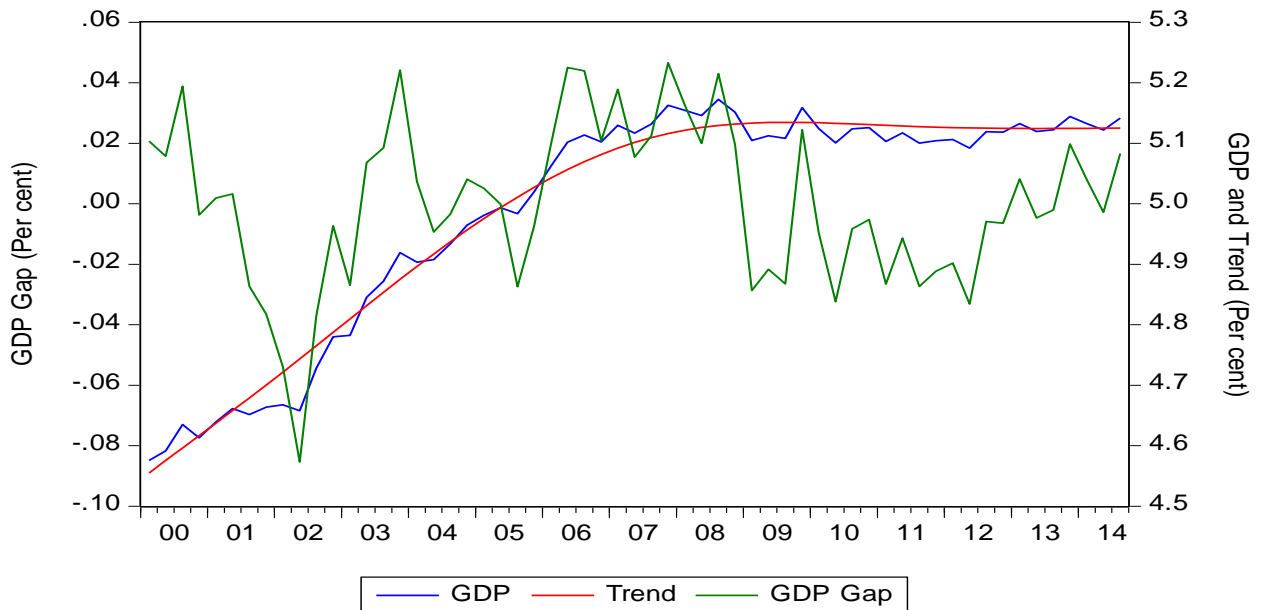
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[2] Similar models were estimated using the Prime Lending Rate.
[3] Headline inflation was used due to insignificance of core inflation in the estimated model at various lag lengths.
[4] This target is not specified for Trinidad and Tobago but is assumed to be 2 per cent in the US. As such, three models will be estimated using two (model one), three (model two) and four (model three) per cent respectively.

Graph 3
Output Gap

Hodrick-Prescott Filter (lambda=1600)

Source: Authors' calculations.

The instruments used in the model include a constant, lagged value of the output gap up to five periods and lagged values of the inflation gap up to nine periods using the principle of parsimony. The model was also estimated using Newey-West estimators where the GMM estimated coefficients are robust to heteroskedasticity and autocorrelation of an unknown form.

Table 3
Taylor Rule estimated results

Variables	Model One	Model Two	Model Three
r_{t-1}	1.01*	1.00*	1.00*
	(86.63)	(91.53)	(96.54)
$\pi_t - \pi^*$	-0.03*	-0.03*	-0.04*
	(-4.59)	(-4.80)	(-4.84)
$y_t - \tilde{y}$	7.96*	8.00*	8.12*
	(5.15)	(5.24)	(5.34)
$\bar{R}^2$	97%	97%	96%
J-Statistic	6.71**	6.70**	6.85**

Source: Authors' calculations.

Note: Where * denotes the significance at the 1 per cent level of significance, ** denotes the non-significance at the 10 per cent level of significance and test statistics are in parentheses.

The estimated models were highly predictive, with the adjusted coefficient of determination being approximately 96 per cent. Furthermore, model robustness was validated through the use of the Sargan (1958) test with $\chi^2_{j,p-k}$ degrees of freedom[5] for over-identifying restrictions[6] (J-Statistics) which confirmed that the restrictions imposed are in fact valid due to the none rejection of the null hypothesis[7]. Based on the results above, both the coefficients of the inflation gap and the output gap are significant. However, the impact that the inflation gap has on interest rate is negligible whilst the impact that the output gap has on interest rate determination is quite significant. When compared to the coefficients set forward by Taylor's Rule; monetary policy in Trinidad and Tobago did not conform. In fact, monetary policy did not support strict inflation targeting (even at varying inflation targets) but appeared to be highly influenced by the deviation of output from its trend[8]. This implies that closer attention should be paid to output fluctuations from its trend to gain a better understanding of the movements in the rate of interest. The results found for Trinidad and Tobago were highly consistent to those found of other economies, especially that of developing nations where the deviations are much more prominent. even though the interest rate smoothing coefficient is usually less than one, a smoothing parameter of greater than one as in the case of South Africa where Mehrotra and Sanchez- Fung (2009) found a coefficient of 1.04. Additionally, a study on the emerging markets found that the inflation gap is usually statistically insignificant and in the cases where the inflation gap was significant, economies such as Peru, Mexico, Hungary, Columbia and Chile had a negative coefficient.

The Taylor rule for Trinidad and Tobago was then calculated using the coefficients from equation two[9]. When the interest rate is compared to the calculated version of Taylors Rule for Trinidad and Tobago, it is seen that the policy rate does not following the mechanics of Taylor's rule.

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[5] Where j is the J- statistic, p is the instrument rank and k is the number of endogenous variables.
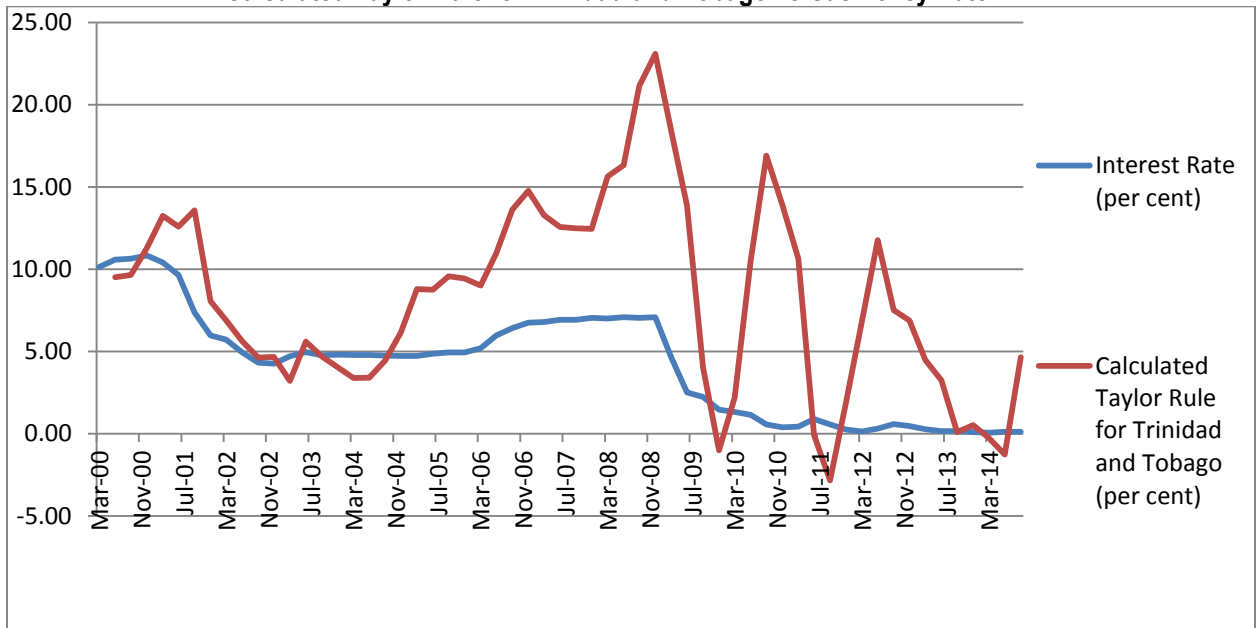[6] Over-identifying restrictions exist when the number of instruments exceeds the number of endogenous variables.
[7] Null hypothesis of over-identifying restrictions being valid.
[8] Alternatively, the estimated modeling using the Prime Lending rate as the dependent variable concluded that the output gap had no impact on its movements as well as the inflation gap have negligible impact on the interest rate.
[9] If alternative coefficients are used, the calculated Taylor rule can be changed.

Graph 4
Calculated Taylor Rule for Trinidad and Tobago versus Policy Rate

Sources: Authors' calculations and the Central Bank of Trinidad and Tobago.

Prior to mid-2005, the policy rate was similar to the calculated Taylor rule but post 2006, the calculated Taylor rule was higher than the policy rate which suggest that monetary policy was accommodative. This could have been as a result of expansionary policies being implemented during the construction boom between 2004 and 2007 and remained low during the global financial crisis in an attempt to stimulate growth in the economy.

McCallum's Rule

McCallum (1987, 2000) proposed an alternative specification where the target instrument is now the monetary base. He argued that the monetary base was the operational tool used by the central bank and it can be accurately set if the economy operates under a floating exchange rate regime. The author argued that any change in the monetary base is influenced by changes in the velocity of circulation and the deviation of nominal GDP from its target. The specification is given as:

$$\Delta b_t = \Delta x^* - \Delta v_t^a + 0.5(\Delta x^* - \Delta x_{t-1}) \tag{3}$$

Where b is the monetary base, x^* is the target growth rate of nominal GDP (which comprises of real GDP and targeted inflation), x is nominal GDP, v is the average velocity over a sixteen month period and 0.5 is the adjustment coefficient put forth by McCallum (1987). The idea behind the adjustment coefficient is that if the growth in nominal GDP falls short of its target, then monetary policy will be expansionary in nature, that is, it will loosen.

Mehrotra and Sanchez-Fung (2009) argued that if an economy does not engage in inflation targeting, then a modification to the initial McCullum's rule is needed. Their specification is given as:

$$\Delta b_t = \Delta b_{t-1} + \rho(\Delta x^* - \Delta x_{t-1}) \tag{4}$$

The lagged monetary base as a dependent variable act as a smoothing parameter, much like the Taylor rule specification used by Gozgor (2012). McCallum (1987) rule was estimated using a GMM model with annual data from 1965 to 2014[10]. The target of the nominal GDP was taken as a target real GDP growth of two per cent per annual and core inflation[11] of three and seven percent respectively[12]. The estimated model was highly insignificant. Additionally, the Mehrotra and Sanchez- Fung (2009) model was estimated using the smoothing monetary base parameter and this model was also found to be insignificant as well when applied to Trinidad and Tobago. These results may be due to the unstable relationship between money supply and GDP growth. This may have been one factor which led to the diminished role of the monetary base in the conduct of monetary policy in Trinidad and Tobago

Hybrid McCallum Rule

The hybrid McCallum rule, utilized by many authors such as Gozgor (2012) and Mehrotra and Sanchez- Fung (2009), puts forth the view that the target policy variable is adjusted based on the changes in the deviations of nominal GDP from its target. A smoothing parameter is also included to indicate the gradual adjustment of the policy variable. The estimated specification is given as:

$$R_t = \alpha + R_{t-1} + \rho(\Delta x^* - \Delta x_{t-1}) \tag{5}$$

Similar to the estimation of the Taylor rule and the McCallum rule, the hybrid McCallum rule will be estimated using a GMM model over the same period as the initial McCallum. The instruments include constant and lagged values of the independent variables using the principle of parsimony. Furthermore, Newey-West estimators were used meaning that the GMM estimated coefficients are robust to heteroskedasticity and autocorrelation of an unknown form. The following results were estimated:

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[10] Nominal GDP is not collected quarterly and as such, the McCallum rule will be estimated using annual data.
[11] Core inflation was used since it gives a more representative measure of inflation in the domestic economy and is does not take into account the volatility of food prices.
[12] The Hodrick-Prescott filer was also used to estimate the nominal GDP target and this model was statistically insignificant as well.

Table 4
Hybrid McCallum Rule Estimated Results

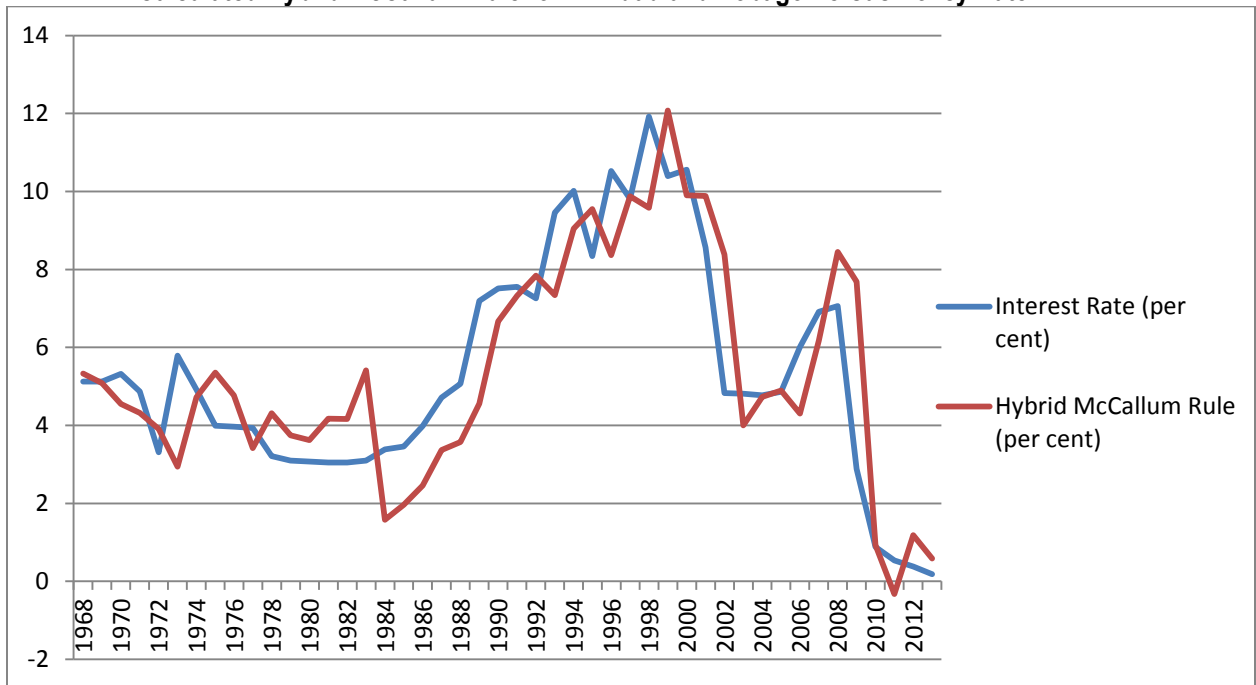| Variable	Coefficient
R_{t-1}	0.96*
$\Delta x^* - \Delta x_{t-1}$	-13.87**
J- Statistic = 1.11***	

Source: Authors' calculations.

Note: Where * and ** represents statistical significance at the 1 per cent and 10 percent level of significance and *** represents the non-significance at the 10 per cent significance level.

The estimated model displayed high predictable power with a goodness of fit coefficient of 71% and the robustness was validated through the use of the J-statistic which indicated that the over-identifying restrictions were indeed valid. The coefficient of the lagged dependent variable is less than unity implying a smooth movement of the target policy rate. The coefficient of ρ is negative implying that as nominal GDP falls short of its target, monetary policy should loosen. Both coefficients were statistically significant.

When the calculated hybrid McCallum rule was compared to the target policy rate, it appears that monetary policy in Trinidad and Tobago follows a hybrid McCallum rule as opposed to Taylor's rule or McCallum's as a stand-alone mechanic for policy determination.

Graph 5
Calculated Hybrid McCallum Rule for Trinidad and Tobago Versus Policy Rate

Source: Authors' calculations and the Central Bank of Trinidad and Tobago

It can be seen that while the target policy rate does not fit perfectly to the hybrid McCallum's rule, it does follow it to a high degree. This implies that the policy interest rate appears to be influenced by the gap in nominal GDP from its target. The results obtained were consistent with that found by Sanchez-Fung (2011) in their study of twenty emerging market economies. Mehrotra and Sanchez- Fung (2009) also found negative coefficients of the nominal income gap for the hybrid McCallum rule for economies such as Chile, Malaysia, Costa Rica and Czech Republic.

5. Conclusion and Policy Recommendation

This paper aimed to estimate monetary policy rules for Trinidad and Tobago using the popular GMM estimation technique in an attempt to determine how interest rates respond real sector variables such as GDP and inflation. A comparison of the calculated monetary policy rules for Trinidad and Tobago to that of the policy rates was undertaken. Taylor's rule found that, like many emerging market economies, the policy rate in Trinidad and Tobago was very accommodative with the output gap having a significant influence but the inflation gap having little influence on the policy rate. Taylor's rule may have limited applicability in Trinidad and Tobago since the economy does not engage in formal inflation targeting. The McCallum rule proved to have little prevalence in policy rates in Trinidad and Tobago and this may have been due to the fact that the monetary base is not the primary policy tool utilized in the economy. The most important finding of the paper is that policy interest rate tends to move in a pattern that follows that which is suggest by the hybrid McCallum rule. Policymakers can now forecast nominal GDP to be used as a guide as one of the factors in setting policy interest rate.

One of the short comings of the model is that it was designed for an advanced economy framework. However, it has been applied to many developing economies in the past by adjusting the estimated equations, for example, in the estimated Taylor rule in this paper, several inflation targets were used as well as different instruments of short term interest rate. Other empirical work suggests the inclusion of changes in the exchange rate as a determinant of the interest rate. However, given the Trinidad and Tobago dollar is a managed float, it may be of limited use in the model.

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