Exchange Rate Effects On Monetary Policy: Multinational Evidence

Sunaina Goel[1] and Harshit Agarwal[2]

[1]M.Sc. Economics, Queen Mary College, University of London.

[2]Mphil, University of Portsmouth.

Data Availability Statement

The information that confirms the findings of the study are openly available in OECD at https://data.oecd.org/ and in Bloomberg at https://www.bloomberg.com/professional/product/market-data/.

ABSTRACT

This research paper analysis the Taylor rule in 10 economies, namely UK, USA, Australia, Canada, Poland, Portugal, New Zealand, South Africa, Mexico and Hungary. Specifically, it examines whether the monetary policy framed in these nations can be accurately examined by standard Taylor rule, augmented Taylor rule as well as re-estimating augmented model using Instrument Variable. The results indicate that the rate of exchange rate significant effect, which implies that while taking interest decision central bank considers exchange rate. Overall, augmented Taylor rule captures the behavior of monetary policy more accurately.

Keywords: Exchange Rate, Monetary Policy, Taylor Rule, Inflation, Developed Economies, Emerging Economies.

1. Introduction:

Central banks are responsible for conducting monetary policy by influencing short-term interest rates. The application of the monetary policy is rapidly growing to describe and evaluate the policy actions of the central bank. It has been widely referred by university researchers, central bank staff, and the makers of monetary policy themselves. To teach students about monetary policy, greater emphasis has been placed on economics textbooks. Since then we have observed that several economies have adopted 'inflation targeting' as a significant component of their monetary policy strategy. Inflation targeting focuses on targeting ranges of inflation rate over one or more time- horizons with prior acknowledgement. The rationale behind this approach is stabilizing and maintaining low inflation.

Recently, there has been an increased focus on research for evaluation of monetary and fiscal policy rules using new methods. One of the most extensively used and thoroughly tested models is the Taylor Rule model. John B. Taylor proposed this rule in 1993. Taylor Rule was designed to set guidelines on how central banks should target short-term stability and achieve long-term inflation goal. Empirical work suggested Taylor Rule as a good approximation for the US. The primary enticement for the Taylor Rule comes from the intuitive and straightforward focus on short-term interest rates as an important tool. The main idea is to encourage independence, transparency and time-consistency by emphasizing a rule like behavior in the monetary regime. Macroeconomists agree that a consistent and credible monetary policy gives the best payoff among all the other alternatives. Many economists and policymakers argued that Taylor Rule should be considered as the basis for inflation targeting, i.e., adjusting interest rates. Since then, Taylor Rule became a standard for both small and large macroeconomic models. The discovery of Taylor Rule opened the way to find a consistent method in monetary policy. However, these simple rules came along with problems of estimation, identification and various shortcomings. These rules are very sensitive to data, samples and methods of evaluation, which can cause conflicting results for the same sample data.

However, the original Taylor rule has been modified and emphasizes the importance of non-linearity and threshold effects to inflation and output gap. Empirical studies provided significant evidence. Bae et al. (2012), Murray et al. (2015) estimated Markov switching model to test the presence of non-linearity in central banks reaction function. However, Castro (2011) criticized these changes as they do not allow for a smooth transition between different periods. Tong (1990) and Akdogan (2015) solved this problem by estimating threshold autoregressive (TAR) and smooth transition autoregressive (STAR) model by using previous values of the sample emphasizing the importance of inclusion of other variables in open economies. Mishkin (2007) concluded that this transformation is not required in case of developed economies. However, Ball (1999) provided significant results in the case of Canada. Lubik and Schorfheide (2007) provided evidence of implementing such augmented rule in the conditions of UK and Canada, but not in other developed countries.

The trinity based on inflation rate, the monetary policy and flexible exchange rate rules is the basis of sound monetary policy in economies that does not have a fixed exchange rate as the policy. The question that I addressed in this research: ‘Is exchange rate used in making monetary policy rules in developed and emerging economies?’ To counter this question, the issues we analysed in this research are, examining the usefulness of Taylor Rule in the evolution of the monetary policies, testing the extent to which the economies satisfies this rule and analysing the Taylor Rule model of exchange rate determination.

Recent literature made a comparison in the out-of-sample predictability of a random walk and a model based in the linear fundamental. The predictive ability measure that has been used commonly is mean square prediction error (MSPE). Two non-nested models of equal predictability, which was introduced by Diebold and Mariano in the year 1995 and West in the year 1996, are often being used for evaluating models dependent on MSPE for out-of-sample performance. Several empirical studies by researchers and practitioners regarding exchange rate found beneficial outcomes for both policymakers and central banks. Different models, predictors and method of evaluation have been used which brought contradictory results amongst these studies. Rossi (2013), in her paper (exchange rate predictability), summarize literature related to exchange rate. She states that few paperwork has demonstrated the validity of the Taylor-type rule and foreign assets. These pieces of evidence inspired her to explore the exchange rate by incorporating it, Taylor Rule. Molovtsova and Papell (2008) exploit the symmetric and homogeneous model by employing the fundamentals of Taylor Rule in a linear regression model. Ball (2002) argued that targeting inflation in small, open and emerging economies without exchange rate might be dangerous. However, variables, excluding inflation and output gap should also be considered while estimating reaction function of central bank.

In this paper, we attempt to identify such consistency and credibility of such systematic rules in the decision-making behaviour of national banks of the mentioned countries – USA, UK, Australia, New Zealand, Canada, Mexico, Hungary, Poland, Portugal and South Africa. All these economies have accepted inflation targeting. Any formal mechanism on exchange rate does not bind their monetary policy. Different data sets can check the robustness of Taylor-type Rule; however, I consider its open economy counterparts. I applied this specification on quarterly data (Q1:1991 – Q4:2017). It has many advantages as it illustrates the aftereffects of rate of exchange on nominal interest rates. An important aspect that has been widely missed in the literature is the inclusion of a unit root. Most of the researchers ignored the presence of unit root in inflation and interest rates. They assumed them stationary. By including error correction term in the equation, many economists have proposed a solution to this problem. Siklos and Wohar (2004) concluded that the estimates that address this problem are mostly based on unbalanced regression. My research attempts to fill this gap by considering the presence of unit root in a sample.

Therefore, in this paper, we estimate original Taylor rule, and then we extend our analysis by adding the exchange rate. The estimation method for standard and the augmented rule is Ordinary Least Square (OLS) and then we re-estimate the model using Instrument Variable. Our findings show significant results as 7 out of 10 countries consider the exchange rate effect while modelling optimal monetary policy. The estimation was done using Instrument Variable, which has the advantage of solving the measurement error problem. The only problem faced while estimating the model is finding the appropriate instrument variable.

The paper is divided into different sections: Section 2 outlines the literature review on the Taylor rule and its augmented version, Section 3 highlights the economic model and the data source. Section 4 presents the analysis of the data. Section 5 shows some concluding remarks.

2. Literature review:

From the beginning 1990s, across the world inflation targeting have been opted as a monetary policy framework by various central banks (Bernanke and Mishkin, 1997). Adoption of such a policy rule is believed to have many benefits, namely, formulation of more independent central banks, fall in the inflation and increase in the credibility of the monetary policy, Reduction in the uncertainty revolving around the expected increase in the price level, enhancing the communication between policy-makers and the public (Bernanke and Mishkin, 1997, Svensson, 2000, Gemayel et al., 2011).

However, at the price of a lower output and a higher unemployment rate, a very low inflation rate can be achieved under this framework when compared to other monetary strategy. (Bernanke and Mishkin, 1997).

In the study by Taylor(1993, Taylor, 1999) , any change in actual output and the inflation rate from the target can be defined as an interest rate rule based on the Federal Reserve monetary policy, in a general sense. Economic effectiveness in the US seems to have considerable effect on the economic performance by the acceptance of such policy rule (Bernanke, 2004; Siegfried, 2010; Taylor, 2013a). Clarida et al. (1998) studied the

Taylor rule for two different groups of countries, namely, the G3

Germany, Japa,n and the USA and the E3 (UK, France and Italy). This paper finds the monetary authorities, following a forward-looking model rather by backward looking model in G3, adjust that real interest rate in accordance to the inflationary pressures. In the case of E3, other monetary authorities have meticulously monitored the policies of German Bundesbank. The monetary policy in the Economic and Monetary Union (EMU) area was precisely defined by the Taylor rule as concluded by Gerlach and Schnabel (2000) and supported evidence was provided by Stuart (1996) for the case of UK. Côté et al. (2004) suggested that model ambiguity is not reported by any of the seven modified Taylor rules for the Canadian economy.

According to Svensson (2003) central banks should stick to a standard instrument policy rule. However, Ball (2000), Svensson, 1999, Svensson, 2003, McCallum and Nelson, 1999, Carlson, 2007; and Martin and Milas, 2013 have argued that using algebraic formula is not required in Taylor rule. Similar conditions has been experienced in 1987 when the stock market crashed sharply by the reduction in the Federal Reserve interest rate. Similar economic conditions were faced during the Asian crisis of 1997–98 (Carlson, 2007) and the current global financial crisis. The interest rate fell sharply by The Bank of England from 5% in 2008 to 0.5% in March 2009- considerable cut since its establishment in 1694. (Astley et al., 2009). In the paper by Martin and Milas (2013) to maintain economic stability, the Bank of England started following different monetary policy rule during recent financial crises. These deviations might be due to the number of reasons such as international spillovers. Taylor (2013). The arrival of new information requires amendment in the policy rule by the policy makers (Taylor, 2000; Woodford, 2001).

Also, there are other issues focused by MacCallum and Nelson in the year 1999 related to the precise computation of potential output and Orphanides and Van Norden, 2002, Hatipoglu and Alper, 2008 found the presence of uncertainty in the real time data in comparison with ex-post data. Inappropriate policy action results in either over-forecasting or under-forecasting the gap in output (Orphanides, 2002). The commonly used methods suggested by Cerra and Saxena, (2000) is the Hodrick-Prescott (HP) filter. The filter has many disadvantages. Shortland and Stasavage, 2004 in his paper supports this view by proving that the most recent observations suffer from a lack of accuracy. Also, the possibility that underlying economic structure has been misspecified particularly to US data (Sarikaya et al., 2005). Lastly, the volatility of output affects the valuation of trends for emerging economies (Hatipoglu and Alper, 2008). The standard Taylor rule has been criticized as it does not allow ease in the movements of interest by central bank (Goodfriend, 1991), although smoothing parameter in the reaction function is imperative to achieve credibility by any disruptions in the market. (Clarida et al., 2000).

2.1. The augmented Taylor rule.

According to Svensson, (2000), concerning economic shocks Taylor rule might not be a suitable policy for open economies. In such situation, inclusion of other variables like exchange rate, asset price is required. This inference is not required in case of developed economies (Taylor, 2001, Edwards, 2007 and Mishkin (2007)). Consumer Price Index (CPI) has a little variance when the rate of exchange is included in monetary policy rather when standard Taylor rule is followed Ball (1999). Debelle (1999) considered this as an effective way to reduce the predictability of output and inflation. From 1975 to 2003, similar rule has been followed by Canada, Lubik and Schorfheide (2007) found similar case for UK as well as Canada, but not in Australia and New Zealand. Further arguments was made by Taylor (2000) that the only optimal monetary policy for both developing and emerging economies is a combination of flexible exchange rate and a policy rule based on inflation targeting. According to Masson et al. (1997), low and constant inflation in all these economies can be achieved by a floating exchange regime. According to Svensson, (2000); Goldberg and Campa, (2010) central bank should tighten their monetary policy and which lead to the loss in the competitiveness (Gagnon and Ihrig, (2004); Baily, (2003); Bailliu and Fujii, (2004); Ghosh et al., (2016)) as they start targeting monetary policy.

Further, Daude et al. (2016) highlighted that " central banks in emerging markets with a flexible exchange rate regime frequently intervene in their foreign exchange market: they possess an implicit comfort zone for easing out exchange rate fluctuations, even if they do not specify an exchange rate target".

Gali and Monacelli,(2005) along with Adolfson et al.(2008), and Caglayan et al. (2016) concluded that the performance of major banks is impacted by the change in exchange rate using the Dynamic Stochastic General Equilibrium (DSGE) models. Garcia et al. (2011) reached a conclusion that no major gain is earned from the involvement of the rate of exchange in the linear Taylor rule model for industrialized countries; however, it seems to affect the developing countries. Moreover, Shortland and Stasavage (2004) exhibits that the national bank suggested the foreign exchange policy in consideration with the inflation rate and the gap in output in setting its monetary policy. It has been observed that national banks takes a strong action with regards to the rate of exchange movements in many countries (Filosa, 2001).

Mallick and Sousa (2012) used different method of estimation, B-SVAR model, which includes the exchange rate and came upon the fact that, annual over valuation of domestic currency leads to an interest rate shock. In addition, the involvement of the central bank in the forex market leads to the fall in the degree of persistence and overvaluation of the exchange rate. Mohanty and Klau (2005) and Aizenman et al. (2011) also postulates that national banks, in developing countries with implicit Inflation Targeting takes monetary policy rule into consideration while deciding the rate of exchange movements.

In few a research studies conducted by Calvo and Reinhart (2002), Galimberti and Moura (2013), Catalán-Herrera (2016) discuss that the intervention in the foreign exchange market is not prevented by the adoption of Inflation Targeting in the developing nations. Yilmazkuday (2008) shows that the Poland and Czech Republic are seen to respond to output and inflation deviations from their targets in setting their interest rate whereas Hungarian central bank reacts specifically to exchange rate movements. Further, Granville and Mallick (2010) states that the low inflation target was hard to attain by the Bank of Russia primarily due to its exchange rate targeting policy.

According to Shrestha and Semmler (2015) a standard Taylor rule estimation uses an autoregressive distribution lag (ARDL) model for five East Asian economies and examined that the original Taylor rule fails to explain the monetary policy in developing countries and should be modified in order to take financial instability into consideration. A recent study conducted by Ghosh et al. (2016) found consistent evidence of foreign exchange intervention reaching price stability under inflation targeting in developing countries.

2.2 The Non-Linear Taylor Rule:

Robert-Nobay and Peel, (2003) discussed that the economic structure as an important issue and whether there is correlation between central banks' reaction function and their own asymmetric preference. For instance, policy responses might not be the same based on the phase of the cycle, given that output stabilisation is more important during recessions and inflation is the main concern during expansions (Cukierman and Gerlach,(2003); Ahmad,(2016). Dolado et al. (2000) inferred that the central banks of Spain, France and Germany are relatively less responsive to inflation when it is below as opposed to above target. The empirical findings of Martin and Milas (2013) supported nonlinear Taylor rule in the UK during 2007 financial recession.

There is not enough evidence available for emerging and industrialized economies on augmented version of Taylor rule. Moura and de Carvalho (2010) discovered performance of monetary policy rule in Latin American economies. Asymmetric responses to inflation, output and exchange rate was found in many countries.

Hasanov and Omay (2008) used Generalized Method of Moment to examine data over the economic cycles to check for asymmetries during the period and they reached the conclusion that at a threshold Taylor rule the Central Bank reacts relatively stronger to output movements during financial period. Akyürek et al. (2011) posited that inflation targeting in Turkey by estimating both standard and augmented Taylor rules during the period 1999–2008. They evaluated that the variables included in the Taylor rule foreign inflation rate and exchange rate accurately considers the monetary policy of the Central Bank.

Whereas, Miles and Schreyer (2012) examined the central banks' reaction functions of the central banks of four Asian countries, namely Thailand, Malaysia, Korea and Indonesia using quantile regression analysis. They arrived at the conclusion that there exists variations in cross-country analyses evidence for nonlinearities. For example, monetary authorities of Indonesia do not respond to the gap in output in the lower quantiles, but the national bank of Korea responds to it in both the lower and upper quantiles. Changes in the rate of exchange have been influenced by the national banks of Malaysia and Indonesia.

Jawadi et al. (2014) postulated "a smooth transition regression (STR) model to analyze for nonlinearity of monetary policy rules in China and Brazil. They derived that the real effective exchange rate is one of the main drivers of the adjustments in the interest rate in both countries. Lastly, Akdoğan (2015) arrived at evidence of asymmetric behaviour of monetary policy in nineteen inflation-targeting countries including Thailand, Turkey and Israel using an Asymmetric Exponential Smooth Transition Autoregressive (AESTAR) model. The estimated nonlinear Taylor rule was found to predict well out of sample".

2.3 Taylor Rule and Exchange Rate:

After the abandonment of Bretton wood system and the adoption of floating exchange rate by major developed countries, testing the importance of exchange rate in the model became important. Some empirical studies used data on independently floating exchange rate. They found results that satisfy diagnostic test, significant coefficients and models that fit the sample to provide evidence that supports exchange rate models.

However, in the beginning of 1980s the empirical results changes drastically. These authors concluded that random walk model are at least better than the flexible and sticky price monetary model by Hooper and Martin (1982) of that time. A large number of studies followed work by Muse and Rogoff's (1983). Mark (1995) in his paper used innovative bootstrapping techniques and exchange rate data relative to US from 1973 to 1991. He reversed result of no predictability by finding supporting evidence for forecasting monetary model in Canada, Switzerland, Japan and Germany.

However, this evidence did not exist for so long and was criticized by Kilian (1999) by demonstrating that they were not so robust to the modifications of sample and were crucially dependent on the assumption of data generating process. Some researchers criticized Mark (1995) for assuming the cointegration between exchange rate and monetary fundamentals.

Argument by Berkawith and Giorgianni (2001) showed biasedness of test towards no predictability by rejecting null hypothesis, if the assumption of cointegration is not valid. Cheung et al. (2005) used wide variety of models and tested the US Dollar based exchange rate predictability. He found inconclusive results and summarized that the combination of different model currency that works well in a particular time period does not necessarily mean that they will also work well in another time. Surprisingly, a large number of evidences supported the out-of-sample performance of exchange rate in the second half of 2000s (Engel et al 2008). They provide hope for predicting exchange rates using panel data, expected present values of fundamentals and longer data spans. Old monetary models of 1970s and 1980s were used for a set of similar countries.

3. Data:

While making interest rate setting decision majority of research uses real-time data which is present at that time. Our Dataset consists of a time series data for developed (UK, USA, Australia, Canada and New Zealand) and other emerging economies (Poland, Portugal, Hungary, South Africa and Mexico). The sample covers the period from the first quarter of 1999 to the last quarter of 2017. All the time series are on a quarterly basis, producing a sample of 72 observations.

Before analysing the data, it is essential to know the meaning and acronym used for the research and the sources they were taken from:

Υt: Gdp is the total of all final goods and services manufactured in an economy during a period minus the value of imports. It is measured as the percentage change from the previous quarter and is seasonally adjusted.

rt: Short-term interest rates at which the short-term government paper are issued and short-term borrowing are affected.

πt: Inflation is explained as an increment in the price level of goods and services.

The data for all the variables used in the research was collected from OECD excluding the real exchange rate, that was collected from Bloomberg. An exchange rate is explained as the price of one country with respect to the dollar. Therefore, an increment in the rate of exchange of a particular country means decrement of the currency. The presence of trends justifies the removal of bias before estimation. The differencing of variables helps to remove this trend in relevant variable thus delivers stationarity in variables.

These countries and the sample size were chosen, as all the economies during this period had to adopt or adopted an independent floating exchange rate regime and inflation targeting as the monetary policy framework. Table 1 provides a detailed description of the size of the sample and the structure adopted by each country. It can be clearly seen that the majority of countries adopted this regime during the late 1990s and the remainder in the early 2000s, which makes sense of grouping these countries in a time series data. In addition, countries are homogenous in terms of a target level of inflation, exchange rate regime and inflation target indicator.

Table 1.
Structure adopted by each country.

Country	Start date of inflation targeting regime	Target Inflation	Target indicator Inflation
UK	Oct-92	2%	Headline CPI
USA	1991	2%	Core CPI
Canada	1991	2%	Headline CPI
Australia	1993	2%-3%	Headline CPI
New Zealand	1990	1%-3%	Headline CPI
Mexico	2001	3%	Headline CPI
Poland	Oct-98	2.50%	Headline CPI
Portugal	19988	Below, but close to 2%	HICP
Hungary	2001	3%	CPI
South Africa	2000	3%-6%	Core CPI

Notes: CPI = Consumer Price Index
HICP = Harmonised Index of Consumer Prices

Many theoretical papers focused on the variables that should be used while estimating the Taylor rule equation in generic terms. As different papers have used different measures of a particular variable. It is still skeptical which measure should be used. As the choice of appropriate variables brings the best results. It is very important to choose the right measure to get the best result.

So, Inflation was constructed as the year-over-year change in CPI. However, this measure of inflation has been refined over time. However, CPI has been the most preferred measure of inflation. Throughout 1988, an implicit deflator of a gross national product is used to forecast inflation then it was switched to CPI. Then the CPI was replaced by Personal Consumption Expenditure (PCE) and from 2004 core PCE deflator has been employed that excludes both energy and food prices.

Similarly, Different methods are used to estimate the output gap. Two alternative approaches that are very popular are: Hodrick -Prescott filter (HP) and Quadratic Time Trend (QTT). To construct output, we use Hodrick Prescott (HP). The output gap is explained as the variability of actual output from its potential level. To detrend the data we use real-time detrending, i.e. Hodrick Prescott. It separates the trend component from the raw data of the time series. The sensitivity adjustment of the trend is reached by making modifications λ=1600 for date of a quarter. The advantage of using this is that it increases the sensitivity to short-term trend.

Before heading towards the model, the important part is to check whether the variables are consistent or not?

The table 2 presents the descriptive statistics of all the variables of 10 countries from 1999-2017. To check the skewness and kurtosis of variables Jarque-Bera is used with a Null hypothesis of zero skewness and zero kurtosis. Similarly, In order to examine the stochastic properties of each of the variable under consideration, we use Augmented Dickey-Fuller (1981) test and the Philips-Perron (1988) test. The difference between ADF (Augmented Dickey-Fuller) and PP (Phillips and Perron) is that ADF uses additional lags of variables while PP accounts for serial correlation using Newey West standard errors. The results obtained from DF and PP tests are very similar. However, in our case, the results from ADF proved better to test unit root process. The only disadvantage of using this is the selection of appropriate lagged values.

Table: 2

Descriptive Statistics

Variables	Countries	Mean	Maximum	Minimum	St. Dev	Jarque Bera
	Australia	0.03	0.06	0.01	0.01	30.56
	Canada	0.02	0.04	-0.01	0.01	6.08
	Hungary	0.04	0.10	-0.01	0.03	1.85
	Mexico	0.05	0.16	0.02	0.03	320.86
	New Zealand	0.02	0.05	-0.01	0.01	1.27
CPI	Poland	0.03	0.10	-0.01	0.03	13.09
	Portugal	0.02	0.05	-0.02	0.01	3.38
	South Africa	0.05	0.13	-0.02	0.03	3.45
	United Kingdom	0.02	0.04	0.00	0.01	2.93
	United States	0.02	0.05	-0.02	0.01	5.00
	Australia	-0.01	0.19	-0.41	0.09	230.19
	Canada	-0.02	0.46	-0.78	0.19	85.80
	Hungary	-0.08	3.52	-1.67	0.53	2500.29
	Mexico	-0.02	0.18	-0.32	0.11	11.01
Interest Rate	New Zealand	-0.01	0.15	-0.54	0.10	500.58

	Poland	-0.03	0.25	-0.35	0.10	8.54
	Portugal	-0.07	0.26	-0.74	0.24	25.32
	South Africa	-0.01	0.00	0.14	-0.27	26.05
	United Kingdom	-0.04	0.32	-0.81	0.17	201.10
	United States	-0.02	0.72	-0.96	0.25	26.23
	Australia	5.5E-14	9.3E-01	-1.2E+00	4.5E-01	1.6E+00
	Canada	2.8E-14	9.1E-01	-2.6E+00	5.7E-01	7.8E+01
	Hungary	2.3E-14	1.0E+00	-3.9E+00	7.9E-01	3.7E+02
	Mexico	3.5E-14	2.8E+00	-5.4E+00	9.7E-01	5.2E+02
	New Zealand	4.7E-14	1.6E+00	-1.4E+00	5.7E-01	1.2E-01
Output Gap	Poland	8.1E-14	3.2E+00	-2.6E+00	8.4E-01	1.9E+01
	Portugal	1.3E-14	1.5E+00	-2.2E+00	6.8E-01	2.9E+00
	South Africa	6.1E-14	8.4E-01	-2.2E+00	5.0E-01	6.2E+01
	United Kingdom	3.6E-14	1.0E+00	-2.2E+00	5.4E-01	7.5E+01
	United States	4.1E-14	1.1E+00	-2.3E+00	5.5E-01	4.6E+01
	Australia	4.47	4.70	4.18	0.15	5.19
	Canada	4.48	4.65	4.29	0.11	5.74
	Hungary	4.52	4.71	4.28	0.10	9.29
	Mexico	4.63	4.87	4.33	0.12	4.30
Exchange Rate	New Zealand	4.58	4.75	4.27	0.13	12.38
	Poland	4.57	4.81	4.40	0.08	8.89
	Portugal	4.60	4.65	4.53	0.03	4.96
	South Africa	4.48	4.69	4.16	0.13	4.76
	United Kingdom	4.74	4.89	4.56	0.10	8.32
	United States	4.72	4.91	4.54	0.11	4.65

AIC criterion was used to choose the ADF test lag length. The PP test was based on Bartlett- Kernel, using Newey –West Bandwidth. Null hypothesis is that the series has unit root against the alternative hypothesis of stationary series. ***, ** and * indicates the statistical significance at the 1%, 5%, and 10% level, respectively. The test suggests that interest rate and the output gap remain constant at a level as the p value<α, i.e. level of significance. One can unaccept the null hypothesis of unit root except in cases of the rate of exchange and inflation, which are unchanged at first difference also. It can be clearly seen from table 3 and table 4. That Interest rate and the output gap remained unaltered in levels in both the cases. While CPI of UK, New Zealand is analysed in the first distinction also. Exchange rate for most of the countries is discussed on the first difference. There had been controversial results while deciding the integration order of interest rate. Clarida et al. (2000) considered nominal interest rate as stationary. As they could accept the null hypothesis of non-stationarity. However, Nelson and Plosser (1982) considered interest rate as non-stationary. Castro (2011) decided to treat them as stationary. He found that both interest rate and inflation has an ambiguous order of integration.

3.1. Augmented Dickey-Fuller Test:

Table: 3

Augmented Dickey-Fuller Test

Australia				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-1.908	-2.324	-1.880*
	First difference	-7.011***	-6.985***	-6.785***
Interest rate	Level	-5.314***	-5.547***	-5.198***
Output gap	Level	-6.168***	-6.123***	-6.214***
Exchange rate	Level	-1.058	-2.402	-0.867
	First difference	-7.147***	-7.137***	-7.137***
Canada				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-1.555	-3.495**	-0.643
	First difference	-4.315***	-4.278***	-4.322***
Interest rate	Level	-7.137***	-4.647***	-4.657***
Output gap	Level	-5.555***	-5.515***	-5.595***
Exchange rate	Level	-0.79	-1.659	-0.576
	First difference	-5.915***	-6.240***	-5.939***
Hungary				

Variables		Intercept	Trend and Intercept	None
CPI	Level	-1.763	-2.723	-1.612*
	First difference	-2.499	-2.553	-2.386**
Interest rate	Level	-6.419***	-6.517***	-5.750***
Output gap	Level	-6.429***	-6.384***	-6.474***
Exchange rate	Level	-0.452	0.072	-0.724
	First difference	-1.507	-3.592**	-1.355
Mexico				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-2.990**	-2.813	-0.746
	First difference	-4.094***	-4.048**	-4.201***
Interest rate	Level	-4.554***	-5.176***	-4.654***
Output gap	Level	-6.647***	-6.600***	-4.169***
Exchange rate	Level	-2.202	-3.191*	0.544
New Zealand				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-1.309	-2.124	-0.715
	First Difference	-3.611*	-3.588**	-3.629***
Interest rate	Level	-4.402***	-4.488***	-4.378***
Output gap	Level	-7.971***	-7.916***	-8.025***
Exchange rate	Level	-1.53	-2.535	-0.678
	First difference	-6.881***	-6.831***	-6.882***

Poland				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-2.368	-4.113***	-1.976**
	First difference	-4.374***	-4.402***	-4.329***
Interest rate	Level	-4.822***	-4.786***	-4.542***
Output gap	Level	-4.182***	-4.083**	-4.212***
Exchange rate	Level	-3.239**	-3.596**	0.178
	First difference	-6.881***	-6.831***	-6.882***
United States				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-2.427	-2.949	-0.7
	First difference	-3.481	-3.451*	-3.534***
Interest rate	Level	-4.214***	-4.195***	-4.532***
Output gap	Level	-5.524***	-5.483***	-5.564***
Exchange rate	Level	-1.102	-2.007	0.314
	First difference	-6.203***	-6.363***	-6.243***
Portugal				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-1.888	-4.306***	-1.36
	First difference	-5.400***	-5.362***	-5.422***
Interest rate	Level	-4.283***	-3.092	-3.700***

Output gap	Level	-7.332***	-7.281***	-7.382***
Exchange rate	Level	-1.989	-1.949	-0.169
South Africa				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-3.088**	-0.938	-0.938
	First difference	-3.530***	-3.504**	-3.561***
Interest rate	Level	-4.121***	-4.401***	-4.041***
Output gap	Level	-5.786***	-5.747***	-5.825***
Exchange rate	Level	-2.631*	-3.112	0.263
United Kingdom				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-2.265	-2.382	-0.241
	First difference	-4.359***	-4.324***	-4.386***
Interest rate	Level	-5.157***	-5.202***	-5.169***
Output gap	Level	-6.960***	-6.912***	-7.007***
Exchange rate	Level	-1.783	-2.315*	0.768

*** p<0.01, ** p<0.05, * p<0.1

3.2. Phillips and Perron Test:

Table: 4

Phillips and Perron Test:

Australia

Variables		Intercept	Trend and Intercept	None
CPI	Level	-3.444**	-4.296***	-1.107
Interest rate	Level	-3.958***	-3.914**	-3.969***
Output gap	Level	-10.311***	-10.211***	-10.411***
Exchange rate	Level	-0.798	-2.278	-0.825
	First difference	-6.955***	-6.944***	-6.937***

Canada

Variables		Intercept	Trend and Intercept	None
CPI	Level	-3.625***	-4.409***	-1.292
Interest rate	Level	-4.431***	-4.408***	-4.438***
Output gap	Level	-5.172***	-5.123***	-5.219***
Exchange rate	Level	-0.573	-1.609	-0.551
	First difference	-7.214***	-7.319***	-7.231***

Hungary

Variables		Intercept	Trend and Intercept	None
CPI	Level	-1.584	-2.562	-1.594
	First difference	-5.384***	-5.367***	-5.441***
Interest rate	Level	-11.384***	-11.761***	-10.704***
Output gap	Level	-6.458***	-6.413***	-6.502***
Exchange rate	Level	-0.381	-0.832	0.323
	First difference	-6.713***	-12.496***	-6.719***

Mexico

Variables		Intercept	Trend and Intercept	None
CPI	Level	-6.492***	-5.266***	-3.619***
Interest rate	Level	-4.801***	-5.155***	-4.679***

Output gap	Level	-5.606***	-5.525***	-5.679***
Exchange rate	Level	-2.244	-1.98	0.515
	First difference	-7.822***	-7.890***	-7.869***
New Zealand				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-3.286**	-3.622**	-1.396
Interest rate	Level	-4.352***	-4.355***	-4.338***
Output gap	Level	-7.977***	-7.923***	-8.031***
Exchange rate	Level	-1.293	-2.445	-0.578
	First difference	-6.898***	-6.849***	-6.899***
Poland				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-2.368	-4.113***	-1.976**
Interest rate	Level	-4.804***	-4.768***	-4.502***
Output gap	Level	-10.150***	-10.085***	-10.216***
Exchange rate	Level	-2.698*	-2.964	0.143
United States				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-3.319**	-3.741**	-1.524
Interest rate	Level	-5.111***	-5.164***	-5.123***
Output gap	Level	-7.002***	-6.955***	-7.048***
Exchange rate	Level	-0.745	-1.854	0.338
	First difference	-6.424***	-6.400***	-6.458***
Portugal				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-2.264	-3.003	-1.522
	First difference	-5.843***	-5.809***	-5.879***

Interest rate	Level	-3.865***	-3.815***	-3.799***
Output gap	Level	-7.355**	-7.305***	-7.405***
Exchange rate	Level	-1.249	-1.309	-0.371
	First difference	-7.444***	-7.390***	-7.476***
South Africa				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-3.097**	-3.11	-1.547
Interest rate	Level	-3.989***	-4.166***	-3.911***
Output gap	Level	-5.821***	-5.782***	-5.860***
Exchange rate	Level	-2.229	-2.517	0.366
	First difference	-6.529***	-6.482***	-6.563***
United Kingdom				
Variables		Intercept	Trend and Intercept	None
CPI	Level	-1.913	-2.279	-0.721
	First difference	-5.936***	-5.888***	-5.975***
Interest rate	Level	-4.879***	-4.878***	-4.532***
Output gap	Level	-4.889***	-4.857***	-4.921***
Exchange rate	Level	-1.444	-2.066	0.83
	First difference	-6.123***	-6.087***	-6.120***

*** p<0.01, ** p<0.05, * p<0.1

4. Methodology:

In recent years, the performance of simple policy rules has been examined in theoretical as well as in practical terms. Such rules received considerable attention because of their simplicity and transparency. These rules reflect real activity conditions of the economy and help in setting policy instruments as a function of one or more dependent variable. However, these rules are based on an unrealistic assumption and require subsequent revisions. I focus my attention on a linear function that sets the relationship between the interest rate as a function of output gap and inflation.

Stuart (1996) expressed the behavior of the national bank of the United Kingdom using the same kind of rule. Clarida et al. (1999) use a forward-looking model. Further studies by Weynark (1999), Christiano and Gust (1999) characterises model with limited participation. Studies by Ball (1999) other rules were compared with Taylor type rule. Svensson (1998) showed first order condition could be used to obtain backward looking Taylor-type rule. The purpose was to compare the performance of these rules chosen according to the preferences of the author with the simple Taylor type rule. The problems arise from the infinity of possible methods allow us to choose a simplified version of the rule.

In our study, we focused on both backward and forward-looking version of Taylor rule. Firstly, we will discuss the simple Taylor- type rule i.e. backward looking version and then will explain how it is different from forward looking version of the Taylor rule. In my study, I present how the estimates from the simple Taylor rule equation changes when I incorporate the exchange rate in our Taylor rule equation.

4.1 Linear Taylor Rule:

The linear relationship between the short-term nominal interest rate, output gap and the inflation rate as suggested by Taylor in the year 1993 is given by the following equation:

Model 1: $rt = \pi t +$ m $gdpt +$ h $cpiit + rn$ (4.1.1)

Where,

$\pi *$ = Target inflation rate

$gdpt$ = Deviation of output from its potential level for every quarter t, i.e. output gap

$cpiit$ = (πt-$\pi *$), i.e. the inflation rate over the last four quarters measured as a difference in the logarithm of CPI over four previous quarters.

rn= equilibrium level of interest

Taylor postulated equal weights of 0.5 to output, and inflation gap and the target level of inflation and equilibrium level of real interest rate equals to 2% producing the following equation.

rt = 1.0 + 1.5πt + 0.5$gdpt$ (4.1.2)

For our simplicity, we assume that the target inflation rate and equilibrium level of interest equals to zero. To start, we evaluate the original Taylor rule:

rt= m $gdpt$+ h πt (4.1.3)

To test if the explanatory variables in our model are significant or not we run Wald test. By using the Wald test, we test the null that coefficients of inflation and output gap (m and h) are equal to 0.5 or not. It shows if variables are not significant you can remove that variable from the model. As suggested by the original Taylor rule equation we test it for 0.5 for both output gap and inflation coefficient.

Null hypothesis: Ho: c (2) =0.5, c (3) =0.5

4.2 Augmented Taylor Rule:

Now, we consider how the effectiveness of the original rule affects the addition of real exchange rate with the standard rule. The modified version of the Taylor rule becomes:

Model 2: rt= m $gdpt$+ h πt + lqt + $\varepsilon\varepsilon t$ (4.2.1)

We again run the Wald test and check if l is set at 0.50. so, now the null hypothesis is: Ho = c(2)=0.5, c(3)=0.5,c(4)=0.5.

Then we test for serial correlation that shows the relationship between a particular variable and its lagged version over various time intervals. The presence of serial correlation shows that the future level is affected by the particular level of the variable. We are using the Breusch-Godfrey Serial Correlation LM test to check for serial correlation. A number of lags taken is equal to 1 as suggested by AIC in ADF test. We test it for the null of no serial correlation at up to 1 lag. Zero correlation implies that the variables are uncorrelated.

Then we check for the presence of heteroscedasticity in our data and to test that, we do the white test. The advantage of using this test as it does not rely on the assumption of normality and it is very simple to implement. It allows inflation, output gap and exchange rate (independent variable) to have a nonlinear effect on the variance of error. The null hypothesis, in this case, is Ho: Homoscedasticity. If the p value<.05, i.e. significance level then we have to accept our null hypothesis of Homoscedasticity.

Now, we estimate the modified version of the Taylor rule employing more advanced estimator called Instrument Variable (IV) by taking two lags of our independent variable (exchange rate). To answer the problem of heteroscedasticity, we re-estimate our model using Instrument Variable by taking lags of the rate of exchange. We assume for the moment that qt and $\varepsilon\varepsilon t$ are correlated and to isolate uncorrelated part between qt and $\varepsilon\varepsilon t$ we use the additional variable. Two conditions must be satisfied to show how estimated coefficients differs from the modified version of the Taylor rule: (1) Relevance condition and (2) Exogeneity condition.

In general, there are three different methods we can choose from (1) Least Square (LS), (2) Generalised Methods of Moments (GMM) and (3) Instrument Variable (IV). Empirical evidence shows that GMM is more consistent than any other method. Clarida et al., (1998) and Mark, (2009) gave two reasons for that: (1) the endogenous variable and the error term are correlated, and the expectation of explanatory variables (inflation and output gap) are endogenous. In addition, the inflation rate and output gap lagged interest rate, which proves that the estimates from Least Square (LS) are biased, and IV and GMM should be used. Majority of paper uses LS to study the non- linearity of the model. For example, Alcidi etal.(2009) estimated the reaction function of Federal Reserve interest rate using smooth transition regression model (STR) and the same thing was estimated by Kenneth (2007) and Bunzel and Enders (2010) by employing threshold model. The two techniques are different smooth transition model allows for slow adjustment speed which is more probable in reality while threshold model allows for switching of the model between higher and lower regime and the switch between them is instant. However, it is complicated to prove which technique is more appropriate even if nonlinear Taylor model is followed. Sometimes it depends on the preferences of researchers. Up until now few discussions on which method should be used in a particular situation has been demonstrated. These methods have not been fully developed in statistical theory and the related software are very rare. Caner and Hansen (2004) introduced the GMM framework. They developed GMM as the estimator of the slope parameter and for threshold variable; they developed Two-Stage Least Square (TSLS) Estimator. Inflation threshold introduced by Zisimos and Jean- Francois (2009) to estimate forward-looking Taylor rule.

5. Data Analysis:

As the table 5 below present results of an estimated unit root. Newey Width (1994) selected the bandwidth for PP tests, and AIC criterion is used to select the lag order. The results implies that null hypothesis of unit root is unaccepted at 10% critical level. The test indicates that rt, $gdpt$ are I (0) and $qt\ and\ \pi t$ are I (1) in some cases. Then we use these stationary series to construct the theoretical model.

Table 5:
Taylor Rule and Augmented Taylor rule (Linear Models)

Australia				
VARIABLES	C	CPI	OG	Exc
Model 1	0.042**	-2.106	0.033**	
	(-0.107)	(-0.023)	(-0.136)	
Model 2	0.045**	-2.209	0.0356**	0.421
	(-0.081)	(-0.018)	(-0.106)	(-0.085)
Canada				
VARIABLES	C	CPI	OG	Exc
Model 1	0.042**	-2.106	0.033**	
	(-0.107)	(-0.023)	(-0.136)	
Model 2	-0.036**	0.962	0.153	1.042
	(-0.473)	(-0.689)	0	(-0.129)
Hungary				

VARIABLES	C	CPI	OG	Exc
Model 1	-0.047**	-0.652	-0.121	
	(-0.677)	(-0.756)	(-0.126)	
Model 2	-0.077*	0.479	-0.11	-0.322
	(-0.48)	(-0.815)	(-0.143)	(-0.863)
Mexico				
VARIABLES	C	CPI	OG	Exc
Model 1	0.084*	1.282	0.016**	
	(-0.001)	(-0.007)	(-0.181)	
Model 2	1.438	0.25	0.017*	-0.318
	(-0.026)	(-0.689)	(-0.147)	(-0.019)
New Zealand				
VARIABLES	C	CPI	OG	Exc
Model 1	-0.011**	-1.812	0.036**	
	(-0.309)	(-0.251)	(-0.062)	
Model 2	-0.009***	-1.976	0.039**	0.783
	(-0.386)	(-0.191)	(-0.038)	(-0.007)
Poland				
VARIABLES	C	CPI	OG	Exc
Model 1	-0.048**	0.725	0.003***	
	(-0.004)	(-0.099)	(-0.808)	
Model 2	-0.468	0.822	0.005***	0.091*
	(-0.506)	(-0.082)	(-0.709)	(-0.551)
Portugal				
VARIABLES	C	CPI	OG	Exc
Model 1	-0.021**	-2.635	0.072*	
	(-0.649)	(-0.199)	(-0.07)	
Model 2	-0.037**	-1.747	0.076*	-4.439
	(-0.441)	(-0.416)	(-0.058)	(-0.201)
South Africa				
VARIABLES	C	CPI	OG	Exc

Model 1	-0.043**	0.597	0.049**	
	(-0.017)	(-0.052)	(-0.003)	
Model 2	1.158	0.26	0.064*	-0.264
	0	(-0.345)	0	0
United Kingdom				
VARIABLES	C	CPI	OG	Exc
Model 1	-0.042**	4.831	0.104	
	(-0.023)	(-0.03)	(-0.003)	
Model 2	-2.162	4.799	0.093*	0.447
	(-0.01)	(-0.027)	(-0.006)	(-0.011)
United States				
VARIABLES	C	CPI	OG	Exc
Model 1	-0.019**	-0.635	0.115	
	(-0.512)	(-0.863)	(-0.034)	
Model 2	-0.017**	-0.094*	0.11	-2.069
	(-0.562)	(-0.973)	(-0.04)	(-0.066)

Notes: Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

USA: Due to the dominance of dollar throughout the world, our model suggests that the exchange rate coefficient in case of USA is not significant that means Fed is not responsive to the changes in exchange rate. Therefore, all the measures in the table explain only the original Taylor rule. Now, the output gap coefficient is significant in both the case. In addition, the output gap coefficient is not around 0.5, which proves that during the chosen period FED was not following the Taylor rule. It can also be seen that the coefficient of inflation is not significant. Yiding Wan (2012) also estimate the insignificant coefficient of inflation rate using HP- filter.

UK: Taylor rule suggests for the monetary policy to be a stable response of nominal interest rate to inflation rate should be more than unity. This show to control inflation central bank must increase the real interest rate. Our standard and modified version of the Taylor rule satisfies this assumption. Even though the exchange rate effects are added to the model. In addition, the exchange rate and output gap are significant in both the cases. As the p values<0.05. Also, monetary shocks account for 44% of real exchange rate dynamics, it explains only 9% of output gap dynamics in the UK. The fact that capital is flowing freely and free-floating regime without foreign exchange intervention is the main reason of the significant effect on a real exchange rate.

Canada: Major banking crises in Southeast Asia at the end of the 1990s and early 2000s lead to the undervaluation of Canadian dollar. And overvaluation in the early 1990s and mid-2000s.In the late 1990s USA experience substantial external shock which leads to the appreciation of all major currencies relative to the US, Hence temporary overvaluation of the Canadian dollar (Bailliu et al.,2005). The output gap is highly significant which means nominal interest rate in Canada response too much with changes in output gap and highly insignificant for exchange rate, i.e. alterations in the exchange rate do not affect the rate of interest.

Australia: With forward looking orientation introduction of the inflation targeting seems to have had some effect. The table shows the underlying value of coefficient on inflation and the gap in output. Inflation response is negative though significant, and the output response is actually positive. Inflation response then exceeds the unity value for the entire period. The gap coefficient is weak though entirely positive. This is called leaning-against-a-wind approach to inflation showing reaction to the changing circumstances structurally.

New Zealand: Taylor rule does not mimic the behavior of closely in this case. However, inflation is greater than unity and output gap is close to significant. In an open economy like this exchange rate can affect price levels and inflationary dynamics directly. This can also be seen from the table, as the variable is highly significant. Undoubtedly, explicitly considering the changes in the rate of exchange is the best way to make policy decisions. The central bank should respond to domestic inflation rather CPI (Conway et al. (1999)). The reason of divergent of interest rate from the Taylor rule is due to the economic slowdown, reduction in the inflation rate, high oil prices, increase in taxes on tobacco and exchange rate depreciation. The risk associated with the decrease in interest rate was sufficiently high but being backward looking Taylor rule made no such judgement. A number of factors can justify these differences, but these variables require cautious about how they evaluate.

Portugal: the table shows the value of the intercept and the coefficients of inflation and output gap respectively. The intercept term is defined as the neutral nominal interest rate. In addition, p-value of inflation shows no statistical significance, meaning one cannot statistically say that the estimation of the rate of interest relies on the inflation. When setting interest rate Portuguese central bank only considers the output gap, not the inflation as shown by the following calculations. Even the rate of exchange does not affect the interest rate decision of the national bank. Geni and Munteanu (2010) found a significant deviation from ECB Taylor rule. Significant deviations were found up until 2003, the gap reduced after 2003, and in 2005, they discover that the interest rate falls below the rate set by Taylor rule.

Hungary: The coefficient estimates and corresponding test statistics of regression are presented in the table. Estimated policy rates overshoot or undershoot the actual policy rates reflecting the importance of other variables than output gap and inflation. Being an emerging economy, the country goes through many changes that affect its structure and organization, these changes lead does not capture a model with empirical regularities. Central banks influence the recurring position of macro variables by regulating current theoretical and empirical knowledge on monetary policies, which have no long-term effect on the country's real economic development.

Mexico: The analysis exhibits that the Taylor rule performs relatively well when the alterations of the nominal rate of exchange are being stimulated. The regression estimation improves the properties of the variables with the involvement of the rate of exchange. According to the Mexican regression model, the obvious statement of the targeted exchange rate created a higher deviation in the interest rate. In addition, it presents a strong connection between the two variables of the interest rate and exchange rate. Past studies show that the simulating monetary policy actions of the Mexican Central Bank's simple norm perform relatively well. However, the impact of is partially captured by the output gap and exchange rate. Therefore, including the exchange rate improves our model by the negligible amount.

South Africa: In comparison to the estimated coefficients, Taylor rule suggests higher optimal value associated with output gap and a lower value with inflation. It also suggests high-interest rate movements as central bank responds more aggressively to output gap and inflation. The coefficient on the output gap is much unexpected. The optimal coefficient on the output gap is just 4.9% which is very low than what is suggested by Taylor rule. The results suggest that while setting policy, central bank should consider exchange rate and output gap as these two variables are highly significant. The involvement of the rate of exchange in our model also improved the regression result.

Poland: One can easily state that based on the estimated result that the coefficients of all the variables are highly insignificant which proves that Poland does not consider Taylor rule while taking policy decisions. However, there might be many reasons why they do not reflect the true preferences of the optimal policy rule. Economic shocks hit the fact the preferences might change over time and period under consideration. Focusing on the final result, this can be clearly seen that the policy setting of the economies are not following Taylor rule, and this is also proved with the help of Wald test with null hypothesis Ho : c(2)=0.5, c(3)=0.5 that shows clearly that we reject our hull in favor of alternative hypothesis(table 6). In addition, in order to test whether or not the variables are homogenous it's important to check that the residuals should not be serially correlated and to check that we conducted Durbin-Watson test (Table 7) and found that the residuals are not serially correlated. Then we conducted the test to check for the heteroscedasticity, and we found that the variables have heteroscedasticity (shown in table 8).

Table: 6

Wald Test

Developed Economies	p-value	Developing Economies	p-value
UK	0.00***	Poland	0.00***
USA	0.00***	Portugal	0.00***
Canada	0.00***	South Africa	0.00***
Australia	0.00***	Hungary	0.00***
New Zealand	0.00***	Mexico	0.00***

Notes: *** p<0.01, ** p<0.05, * p<0.1

Table: 7

Serial Correlation Test

Developed Economies	p-value	Developing Economies	p-value
UK	0.00***	Poland	0.00***
USA	0.0006***	Portugal	0.00***
Canada	0.00***	South Africa	0.0002***
Australia	0.00***	Hungary	0.7734
New Zealand	0.00***	Mexico	0.00***

Notes: *** p<0.01, ** p<0.05, * p<0.1

Table: 8

Heteroscedasticity Test

Developed Economies	p-value	Developing Economies	p-value
UK	0.0004***	Poland	0.6925
USA	0.2854	Portugal	0.0472***
Canada	0.00***	South Africa	0.0136***
Australia	0.00***	Hungary	0.0001***
New Zealand	0.00***	Mexico	0.80

Notes: *** p<0.01, ** p<0.05, * p<0.1

Now we are re-estimating our model using IV as it ensures convergence at a very fast rate. The summary statistics at the bottom of the table can be explained in the following way.

The table 8 provides information regarding the coefficients of the variable. The p-value provides information about the significance of the individual variables. The p value < α means coefficients are significant and should be considered while taking optimal policy decisions. The bottom part can be described as follows:

R-square: how much proportion of change in dependent variable explained by the independent variable. Equals to one if the model fits perfectly. It can be negative also.

Adjusted R-squared: Difference between r-square and adjusted r-square is adjusted r-square penalizes for the additional number of independent variables while r-square will not.

The Durbin Watson Statistics: It measures correlation between residuals. If it is less than 2, then error terms are positively correlated, if it's close to 1 it shows the presence of serial correlation.

F- statistic: It is a test to check whether all the coefficients are zero or not. Even if individual slope coefficient are insignificant, F statistic can be highly significant.

Table: 9

Augmented taylor rule with exchange rate (using VAR model)

Variables	Mexico	Australia	Canada	Hungary	New Zealand	Portugal	United Kingdom	USA	South Africa	Poland
CPI	0.523	-2.841*	0.861	-0.123	-25.299*	16.75	4.8	-2.493	0.251	1.021**
	-0.498	-0.057	-0.738	-0.963	-0.078	-0.788	-0.277	-0.567	-0.37	-0.042
OG	0.017	0.05	0.155***	-0.109	0.008	0.141	0.093***	0.244**	0.066***	0.009
	-0.137	-0.159	0	-0.155	-0.853	-0.589	-0.006	-0.051	0	0.525
EXC_Rate	-0.318**	2.712	0.542	1.8	2.624	-96.897	0.440**	0.756	-0.282***	0.278
	-0.04	-0.162	-0.895	-0.848	-0.262	-0.754	-0.015	-0.886	0	0.138
Constant	1.426*	0.073	-0.041	-0.047	0.002	-0.365	-2.129**	-0.023	1.241	-1.329
	-0.055	-0.108	-0.472	-0.755	-0.923	-0.742	-0.013	-0.497	0	-0.124
No. of observations	75	74	74	74	74	65	75	74	75	75
R-squared	0.192	-0.938	0.255	0.014	-3.069	-10.603	0.196	-0.137	0.341	0.021
Prob(F-statistic)	0.002	0.139	0.0002	0.522	0.248	0.918	0.002	1.388	0.000003	0.188

Notes: *** p<0.01, ** p<0.05, * p<0.1

Table 9 above shows in case of USA only output gap is significant also the probability of F- statistic is not significant showing that the USA does not consider inflation, previous year exchange rate while taking policy decisions. While the Durbin Watson test indicates the presence of correlation in error terms (Table 8). The inclusion of previous year exchange rate does not affect the outcome much. Similar results estimated for Canada with only one difference that joint probability of the coefficients is now significant. In the case of Australia the consideration of past exchange rate values affects the p-value of CPI. In addition, r- square is negative. The Australian bank decisions for monetary policy depends on other variables. The United Kingdom has a significant output gap and exchange rate. CPI is not significant but is greater than unity also; F- statistical probability is significant which shows that Central Bank of United Kingdom considers all the variables while deciding nominal interest rate. The results from New Zealand has changed with the inclusion of one more variable by making all coefficients highly insignificant. Therefore, In the case of developed economies Exchange rate does not play a crucial role while taking the monetary policy decision.

Considering developing countries, open economies like South Africa where the exchange rate and output gap plays a very important role in deciding nominal interest rate. In addition, the F-statistical is highly significant CPI affects representing that Nominal interest also. Durbin Watson close to 1 shows the presence of correlation among residuals. While in the case of Poland, only the coefficient of CPI is less than 0.05. On the contrary, Estimation of the interest rate by Central bank of Portugal is dependent on variables other than examined variables. Mexico shows the presence of the exchange rate, but due to the significant f statistic, we can say other variables also have considerable effects.

However, no variable has significant effect in the case of Hungary. We can say that taking the lag of the exchange rate has no significant impact. In the case of Instrument Variable, only the coefficient of South Africa and Mexico has significant results.

6. Conclusion:

Taylor rule plays a crucial role to check the appropriate level of interest rate, though it gives unlikely results under different conditions. The significant difference in the rate of interest from the Taylor suggested rate causes bank to think what factors excluding inflation and output gap justifies this difference. Number of factors such as unexpected alteration in exchange rate, distinctions between current and forecasted output gap, what methods to choose to calculate output gap, selection of appropriate inflation measure, market shocks and economic developments places constraint on the implementation of Taylor rule.

Over past few years, monetary institutions has restructured the policy framework. Economic conditions become the key tools for both short and long-term interest rates. One important key factor of this external shock is exchange rate. Many Central bank emphasizes the importance of these factors while formulating optimal monetary policy of the economy. The major challenge faces by these countries is the trade-off between stabilization of Exchange rate and price. Against this background, we discuss what role does exchange rate plays in the preparation of monetary policy.

Firstly, we model specification of the Taylor rule. This model is associated with the developed country case but we try to change this assumption by inclusion of emerging countries in our dataset. This study aims to contribute to the literature by showing that for the chosen period, variables suggested by Taylor are not sufficient to influence central banks decision for the set of 10 countries (UK, USA, Canada, Australia, New Zealand, Poland, Portugal, South Africa, Mexico and Hungary). It is not strictly operational because while using real time data researchers need to be very careful. Models are built with respect to particular macroeconomic conditions and the conditions that are required to deviate from rule-like behaviour varies. We find that the standard rule for selected countries does not performs well which proves that these rules offer useful baselines for future decisions. Although the magnitude of problem is not discussed in this paper.

Second purpose is to incorporate exchange rate into Taylor rule fundamentals influencing central banks decisions of optimal policy. Inclusion of exchange rate improves our result and shows significant impact on the central banks reaction function. However, estimates of the exchange effects may vary across countries depending upon the economic conditions. In addition, the inclusion of Instrument variable of previous year exchange rate does not have significant effect on interest rate.

Hence, we can conclude that when it is practically difficult to algebraically apply algebraic models, it is important to preserve the concept of policy rules.

7. Limitations of the model:

We did not take into account the effects of unknown structural breaks, the non-linear Taylor model, forecasting of exchange rate, Different measures of output gap and inflation. The estimation of interest rate was based on simple Ordinary Least Square (OLS). More appropriate methods and models can be used in future.

References

Akdoğan, K., 2015. Asymmetric Behaviour of Inflation around the Target in Inflation-Targeting Countries. Scottish Journal of Political Economy, pp. 486-504.

Bailliu, J., Dib, A. & Schembri, L., 2005. Multilateral Adjustment and the Canadian Dollar. Ball, L., 2000. Policy Rules and External Shocks. NBER Working Paper.

Ball, L. M., 1999. Policy Rules for Open Economies. National Bureau of Economics Research, pp. 127-156.

Bernanke, B. S. & Mishkin, F. S., 1997. Inflation Targeting: A New Framework For Monetary Policy. NBER.

Bernanke, B. S., n.d. The Great Moderation. [Online].

Borio, C. & Disyatat, P., 2011. Global imbalances and the financial crisis: Link or no link?. Bank for International Settlements.

Caporalea, G. M. et al., 2018. Monetary policy rules in emerging countries: Is there an augmented nonlinear taylor rule?. Economic Modelling, pp. 306-319.

Castro, V., 2011. Can central banks' monetary policy be described by a linear (augmented) Taylor rule or by a nonlinear rule?. Journal of Financial Stability, pp. 228-246.

Coˆte´, D. et al., 2004. The performance and robustness of simplemonetary policy rules in models of the Canadian economy. Canadian Journal of Economics, p. 978–998 .

Debelle, G., 1999. INFLATION TARGETING AND OUTPUT STABILISATION. Reserve Bank of Australia.

Gerlach, S. & Schnabel, G., 2000. The Taylor rule and interest rates in the EMU area. Economics Letters, p. 165–171.

Goodfriend, M., 1991. Interest rates and the conduct of monetary policy. Carnegie-Rochester Conference Series on Public Policy, pp. 7-30.

Hatipoglu, O. & Alper, C. E., 2007. Estimating Central Bank Behavior in Emerging Markets: The Case of Turkey. Munich Personal RePEc Archive.

Hetzel, R. L., 2017. The Evolution of U. S. Monetary Policy.

Holmberg, A. & Bengtsson, C., 2012. Portugal and the European Monetary Union.

Lubika, T. A. & Schorfheide, F., 2007. Do central banks respond to exchange rate movements? A structural investigation. Journal of Monetary Economics, pp. 1069-1087.

Martina, C. & Milas, C., 2013. Financial crises and monetary policy: Evidence from the UK. Journal of Financial Stability, pp. 654-661.

McCalluma, B. T. & Nelson, E., 1999. Nominal income targeting in an open-economy optimizing model. Journal of Monetary Economics, pp. 553-578.

Mishkin, F. S., 2007. Housing and the Monetary Transmission Mechanism.

Molodtsova, T. & Papell, D. H., 2008. Out-of-Sample Exchange Rate Predictability with Taylor Rule Fundamentals. Journal of International Economics, pp. 167-180.

Murray, C. J., NIikoloso-Rzhevskyy, A. & Papell, D. H., 2015. Markov Switching and the Taylor Principle. Macroeconomic Dynamics, pp. 913-930.

Rossi, B., 2013. Exchange Rate Predictability. Journal of Economic Literarture, pp. 1063-1119.

SATTI, A. U. H. & MALIK, W. S., 2017. The Unreliability of Output-Gap Estimates in Real Time. The Pakistan Development Review, pp. 193-219.

Siklos, P. L. & Wohar, M. E., 2004. Estimating Taylor-Type Rules: An Unbalanced Regression?. SSRN.

Svensson, L. E., 2000. Open-economy inflation targeting. Journal of International Economics, pp. 155-183.

Svensson, L. E., 2003. What Is Wrong with Taylor Rules? Using Judgment in Monetary Policy through Targeting Rules. Journal of Economic Literature.

Üngör, m., n.d. Estimating the output gap for turkey: a simple production function approach. Central bank of the republic of turkey.