5 Chapter

McCallum and Taylor Monetary Policy Reaction Function in India

5.1 Introduction

This chapter emphases on data interpretation, prediction & investigation to study the McCallum and Taylor rule's backward-looking for the Indian economy. The analysis starts with some facts about monetary policy behavior of Indian economy and then the analysis of study with econometrics tools. First, the econometric analysis depicted results of the unit root test (ADF test) & the Johansen co-integration test for to check regression is spurious or not and long run equilibrium relationship among the variables. Second, the analysis of OLS is used for backward-looking monetary policy reaction function.

The data for this empirical analysis was obtained through the Reserve Bank of India (RBI) Handbook 2014-15 and CSO covering the period from 1992 to 2015 for the variables such as real GVA at basic price, nominal GVA at basic price, interest rate on the basis of call money rate, inflation calculated on the basis of GVA Deflator and Real Effective Exchange Rate at 36 countries with trade weight.

5.2 Unit Root test

The unit root test using for the time series variables under samples are stationary and spurious or not. Different techniques (test) are often considered to test for stationary of the variable such as Dickey-fuller (1979 & 1981), Augment Dickey-fuller (1979), Kwiatkowski-Phillips-Schmidt-Shin (KPPS, 1992), GLS Detrended Dickey-fuller (1996), Phillips-Perron (1998), Ng-Perron (2001) etc. this study will use the Augment Dickey-fuller (1979). Rejection of null hypothesis i.e. there is Unit root among the variable has been decided on the following assumption[1]:

1. Absolute value of test statistics and critical value.

[1] For an accessible discussion, see Gujrati .D. Econometrics by Example, chapter 13, pp.211.

Table 5.1: ADF Test at Level						
Variable	**ADF Model**	**test-statistics**	**P-value**	**critical value**		
				1%	**5%**	**10%**
Real output gap	Intercept	-2.366	0.259	-3.752	-2.998	-2.638
	Trend & Intercept	-1.892	0.626	-4.416	-3.622	-3.248
	None	-2.034	0.042	-2.669	-1.956	-1.608
Interest Rate	Intercept	-4.248	0.003	-3.753	-2.998	-2.639
	Trend & Intercept	-4.132	0.019	-4.416	-3.622	-3248
	None	-2.111	0.036	-2.669	-1.956	-1.608
Reserve Money	Intercept	-3.62	0.006	-3.752	-2.998	-2.638
	Trend & Intercept	-3.855	0.031	-4.416	-3.622	-3.248
	None	-0.964	0.288	-2.679	-1.958	-1.6078
Exchange rate	Intercept	-5.133	0.0005	-3.769	-3.004	-2.6422
	Trend & Intercept	-5.316	0.001	-4.44	-3.632	-3.254
	None	-5.355	0.000	-2.674	-1.957	-1.608
Nominal output gap	Intercept	-1.934	0.311	-3.769	-3.004	-2.642
	Trend & Intercept	-1.923	0.608	-4.44	-3.632	-3.254
	None	-1.989	0.046	-2.674	-1.957	-1.608
Velocity of Money	Intercept	-4.305	0.002	-3.752	-2.998	-2.638
	Trend & Intercept	-4.224	0.015	-4.416	-3.622	-3.248
	None	-4.409	0.000	-2.669	-1.956	-1.608
Inflation rate	Intercept	-2.894	0.061	-3.752	-2.998	-2.638
	Trend & Intercept	-2.781	0.217	-2.781	-3.622	-3.248
	None	-2.016	0.044	-2.669	-1.956	-1.608

Note: A variable is non-stationary when the ADF t-statistics is less than the critical values and p-value is less than 5%.

Table 5.2 ADF Test at First Difference						
Variable	**ADF Model**	**test statistics**	**P-value**	**critical value**		
				1%	**5%**	**10%**
Real output gap	Intercept	-4.11	0.0047	-3.769	-3.004	-2.642
	Trend & Intercept	-4.028	0.023	-4.44	-3.632	-3.254
	None	-4.227	0.0002	-2.674	-1.957	-1.608
Nominal output gap	Intercept	-4.837	0.001	-3.788	-3.012	-2.646
	Trend & Intercept	-4.7	0.0062	-4.467	-3.644	-3.261
	None	-4.894	0	-2.679	-1.958	-1.607
Inflation rate	Intercept	-7.066	0	-3.769	-3.004	-2.642
	Trend & Intercept	-6.727	0.0001	-4.44	-3.632	-3.254
	None	-6988	0	-2.674	-1.957	-1.608

Note: A variable is non-stationary when the ADF t-statistics is less than the critical values and p-value is less than 5%.

From the table 5.1 and 5.2 above, it is seen that some variables (Interest Rate, Money stock, Exchange rate, and Velocity of Money) are stationary at level and other variables (i.e. Real output gap, Nominal output gap, and Inflation rate) are stationary at first difference. If the variables are not stationary at level as known not spurious and the variables are stationary at first difference to go to co-integration test. After co-integration it proved that there is significant relationship among the variable by the Trace value and Max eigen value.

5.3 Co-integration Test

The next steps to find out the spurious regression and long run relationship among the variables Real output gap, Nominal output gap, Inflation rate. The purpose of the co-integration test is measure whether a group of non-stationary series is co-integration or not at level.

Table 5.3 Johansson Co-integration Test

Trace statistics

Hypothesized No. of CE(s)	Eigenvalue	Trace statistics	5% critical value	Prob.
None*	0.905	62.9043	29.797	0.000
At most 1	0.340	13.4619	15.494	0.098
At most 2*	0.200	4.710	3.8414	0.030

Table 5.4 Johansson Co-integration Test

Max statistics

Hypothesized No. of CE(s)	Eigen value	Max statistics	5% critical value	Prob.
None*	0.905	49.442	21.13	0.000
At most 1	0.341	8.751	14.264	0.307
At most 2*	0.200	4.711	3.841	0.030

Note: Hypothesized of CE none is must be significant at 5% level. It means trace statistics and max statistics are greater than critical value.

From the table 5.3 and 5.2 above, among the variable are not spurious and exit association ship for long run.

5.4 Taylor rule

Taylor rule (1993) mainly describes how central bank maintains low and stable inflation and to avoids large fluctuation of output, employment and also maintains exchange rate by utilizing the means of nominal short run interest rate. It is a rule that nominal interest rate reacts to the inflation deviation and output gap.

Central banks should be concerned by the output gap and inflation gap in conducting monetary policy or interest rate. The backward-looking Taylor rule in close economy (i.e. exclude exchange rate) is as following:

Closed economy

$$i^*_t = \lambda + \mu\pi_t + \beta y_t + \varepsilon_t$$

Table 5.5 Taylor rule in closed economy				
Dependent variable: Call Money Rate (Interest Rate)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Inflation Rate	0.573	0.652	0.879	0.3897
Real Output Gap	0.796	0.443	1.839	0.081
Constant	4.401	4.157	1.059	0.302
R^2 = 0.15, Adjusted R^2= 0.06, J-Statistic = 0.0000				

Table 5.5 indicates the prediction results. As is evident from this table, the real output gap coefficient is statistically significant at the 10 percent level and its value is positive (0.796 for lag one).On other hand the inflation rate coefficient is predicted to be positive (0.573 for lag one). However, the inflation rate coefficient is not statistically significant.

Open Economy

$$i^*_t = \lambda + \mu\pi_t + \beta y_t + \Delta e_t + \varepsilon_t$$

Table 5.6 Taylor rule in open economy				
Dependent variable: Call Money Rate				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Inflation Rate	0.142	0.197	0.72	0.479
Real Output Gap	0.791	0.205	3.848	0.001
Exchange Rate	-0.328	0.107	-3.066	0.0061
Constant	7.293	1.305	5.588	0.000
R^2 = 0.59, Adjusted R^2= 0.53, J-statistic = 0.0000, DW= 1.89				

Table 5.6 indicates the prediction results. As is evident from this table, the real output coefficient is statistically significant at the 1 percent level and value is positive (0.791).On other hand the inflation rate coefficient is predicted to be positive (0.142). However, the inflation coefficient is not statistically significant. These results those obtained in table 5.5. And the real effective exchange rate's coefficient is predicted to be negative (-0.328) and is statistically significant at this cases at the 1 percent level.

5.5 McCallum rule

Different from Taylor rule, McCallum rule （1988，1993，2000）describes how a central bank to avoid the big fluctuations of output by utilizing the instrument of base money. The seminal McCallum rule (1988) is as follows.

$$\Delta b = b_1^* \Delta x^* + b_2^* \Delta v_t + b_3^* (\Delta x^* - \Delta x_{t-1}) + \varepsilon_t$$

The OLS regression equation is

$$\Delta b = 0.98\Delta x^* - 0.642 \Delta v_t - 1.04(\Delta x^* - \Delta x_{t-1}) + \varepsilon_t$$

Table 5.7 McCallum rule in closed economy

Dependent variable: Reserve Money				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
X*	0.980	0.0317	-30.897	0.000
Nominal Output Gap	-0.642	0.159	-4.223	0.0007
Money velocity	-1.042	0.085	-12.262	0.000
Adjusted R^2 = 0.89, Durbin-Waston = 2.27				

Note: All three variable are statistical significant at 5%.

Table 5.7 indicates the prediction results. As is evident from this table, the nominal output gap coefficient is statistically significant at the 1 percent level and value is negative (-0.642).On other hand the money velocity coefficient is predicted to be negative (-1.042) and Change target nominal GVA at basic price coefficient is also predicted to be positive (0.980). However, both are also statistically significant at the 1 percent level.

McCallum rule in open economy

$$\Delta b = b_1^* \Delta x^* + b_2^* \Delta v_t + b_3^* (\Delta x^* \square \Delta x_{t-1}) + b_4^* e_t + \varepsilon_t$$

Table 5.8 McCallum rule in open economy				
Dependent variable: Reserve Money				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Ln ΔX*	0.050	0.001	27.676	0.000
Nominal Output Gap	-0.005	0.001	-2.968	0.007
Money velocity	-1.153	0.119	-9.689	0.000
Exchange Rate	-0.001	0.001	-1.496	0.150
R^2 = 0.88, Adjusted R^2= 0.86, DW=1.49				

Table 5.8 indicates the prediction results. As is evident from this table, the nominal output gap, money velocity and target nominal GVA coefficients are statistically significant at the 1 percent level and value are negative for both (-0.005, -1.153, 0.050), respectively. On other hand the exchange rate coefficient is predicted to be negative (-0.001). However, the exchange rate (REER) coefficient is not statistically significant.

5.6 Hybrid McCallum-Taylor Rule

In hybrid McCallum-Taylor rule, Interest Rate is as instrument variable

Closed Economy

$$i_t = c_1^* \Delta x^* + c_2^* \Delta v_t + c_3^* (\Delta x^* - \Delta x_{t-1}) + \varepsilon_t$$

Table5.9 Hybrid McCallum-Taylor rule in open Economy				
Dependent variable: Call Money Rate				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Ln Δ X*	3.057	0.231	13.217	0.000
Nominal Output Gap	-0.167	0.195	-0.855	0.402
Money velocity	10.274	12.023	-0.855	0.402
R^2 = 0.12, Adjusted R^2= 0.03, DW=1.35				

Table 5.9 indicates the prediction results. As is evident from this table, the nominal output gap coefficient is not significant at the 1%, 5%, 10% level and value is negative (-0.167).On other hand the money velocity coefficient is predicted to be positive (10.274). However, money velocity is also not statistically significant at the 1%, 5%, 10% level. And target nominal GVA is statistically significant at the 1 percent level.

Open Economy

$$i_t = c_1^* \Delta x^* + c_2^* \Delta v_t + c_3^* (\Delta x^* - \Delta x_{t-1}) + c_4^* \Delta e_t + \varepsilon_t$$

Table 5.10 Hybrid McCallum-Taylor rule in open Economy				
Dependent variable: Call Money Rate				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Ln ΔX*	3.031	0.209	14.488	0.000
Nominal Output Gap	-0.389	0.201	-1.944	0.066
Money velocity	-9.449	13.737	-0.687	0.499
Exchange Rate	-0.315	0.134	-2.345	0.030
R^2 = 0.32, Adjusted R^2= 0.21, DW=1.47				

Table 5.10 indicates the prediction results. As is evident from this table, the nominal output gap and exchange rate (REER) coefficients are statistically significant at the 10%, 5% level, respectively, and both values are negative (-1.944, -0.315), respectively and target nominal GVA is also statistically significant at the 1% level. On other hand the money velocity coefficient is predicted to be negative (-9.449). However, the money velocity coefficient is not statistically significant.

In hybrid McCallum-Taylor rule, Reserve Money is as instrument variable

closed Economy

$\Delta b = d_0 + d_1^*(\pi_t - \pi^*_t) + d_2^*(yt) + \varepsilon_t$

Table 5.11 Hybrid McCallum-Taylor rule in closed Economy				
Dependent variable: Reserve Money				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Inflation gap	-0.011	0.004	-2.569	0.0179
Real Output Gap	0.004	0.006	0.68	0.503
Constant	0.13	0.009	14.74	0.000
R^2 = 0.25, Adjusted R^2= 0.17, J-statistic = 0.0000, DW=2.12				

Table 5.10 indicates the prediction results. As is evident from this table, the real output coefficient is not statistically significant at the 10 percent level and value is positive (0.004).On other hand the inflation rate coefficient is predicted to be negative (-0.011). However, the inflation gap coefficient is also statistically significant at the 5% level.

Open Economy

$\Delta b = d_0 + d_1^*(\pi_t - \pi^*_t) + d_2^*(yt) + d_3^* e_t + \varepsilon_t$

Table 5.12 Hybrid McCallum-Taylor rule in closed Economy				
Dependent variable: Reserve Money				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Inflation Gap	-0.011	0.004	-2.849	0.009
Real Output Gap	0.004	0.005	0.900	0.378
Exchange Rate	0.002	0.001	1.695	0.105
Constant	0.132	0.009	13.624	0.000
R^2 = 0.33, Adjusted R^2= 0.23, J-statistic = 0.0000, DW=2.01				

Table 5.11 indicates the prediction results. As is evident from this table, the real output coefficient is not statistically significant at the 1%, 5%, 10% level and value is positive (0.791).On other hand the inflation gap coefficient is predicted to be negative (-0.011). However, the inflation gap coefficient is statistically significant at the 1%. And the real effective exchange rate's coefficient is predicted to be positive (0.002) and is not statistically significant at this cases at the 1%, 5%, 10% level.

5.7 Conclusion

Overall, results of estimated rule based coefficients provide a clear picture of Indian monetary policy conduct. The output gap appears to matter more than inflation rate. The outcomes of above analysis reveals that monetary rules i.e. precisely money rule would be more appropriate. However, exchange rate does not have much role to determine inflation and output through money rule. While interest rate rule influence exchange rate.