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Inflation Targeting and Monetary Policy Rules: Further Evidence from the Case of Turkey

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Abstract

In this paper, we attempt to estimate reaction functions of the Central Bank of the Republic of Turkey (CBRT) based on Taylor rule and Hybrid McCallum-Taylor rule. We apply Generalized Methods of Moments (GMM) and Limited Information Maximum Likelihood (LIML) methods for estimating monetary policy reaction functions, over the period when the CBRT has conducted inflation targeting by using nominal interest rate as a monetary policy tool in free floating exchange rate regime. Our efficient and robust empirical findings show that only Taylor rule specifications are able to explain the behaviour of the CBRT.

JEL classification numbers: E52, E58, C36
Keywords: Inflation Targeting, Taylor Rule, Hybrid McCallum-Taylor Rule, Generalized Methods of Moments, Limited Information Maximum Likelihood, Developing Economies, Turkey

1 Introduction

Since early 1990's, many countries have gone through inflation targeting, and studies on monetary policy rules have rapidly been increased. Different definitions of monetary policy rules in inflation targeting framework is not only examined in

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developed countries (McCallum (1988, 1999), Taylor (1993, 1999), Clarida, Gali and Gertler (1998, 1999, 2000), Judd and Rudebusch (1998), Nelson (2000), McCallum and Nelson (1999), Rudebusch and Svensson (1999), Svensson (1999, 2000, 2003), Bekaert and Wang (2010), Wang and Wu (2012)), but also in emerging markets (including Turkey); (Ball and Reyes (2004), Sanchez-Fung (2005), Berument (2007), Yazgan and Yilmazkuday (2007), Yilmazkuday (2007, 2008), Hasanov and Omay (2008), Civcir and Akcaglayan (2010), Mehrotra and Sanchez-Fung (2011), Akyurek, Kutan and Yilmazkuday (2011)).

Interest rate based instrument rule is commonly known as 'Taylor (1993)'s rule' and monetary based instrument rule is commonly described as 'McCallum (1988)'s rule'. McCallum rule targets nominal gross domestic product (GDP) with using monetary base as a policy instrument.

When an emerging market economy disclaims the fixed exchange rate or similar exchange rate regime, the suitable monetary policy alternative is only based on the 'trinity'. This is firstly described by Taylor (1993) and in his definition; he indicates that a flexible exchange rate regime, an inflation targeting and a monetary policy rule in the trinity (Taylor, 2000).

Many developing countries have put into practice an inflation targeting regime and a suitable monetary policy rule. Similarly, Turkey also adopted free floating exchange rate regime in February 2001 and then the implicit inflation targeting carried out from January 2002 to December 2005. The explicit inflation targeting started in January 2006.

In this paper, we try to examine the monetary policy behaviour of the CBRT by estimating combination of reaction functions, and they are derived from the studies by McCallum (1988, 1999) and Taylor (1993, 1999). Following the analysis by McCallum (2000), we also consider this monetary policy feedback rule called 'Hybrid McCallum-Taylor rule', and we examine this rule in Turkey. Consequently, we estimate 'Taylor rule' and 'Hybrid McCallum-Taylor rule' as they are a possible forward-looking monetary policy rules in Turkey. We follow a similar methodology that suggested by Clarida, Gali and Gertler (1998, 1999, 2000).

Clarida, Gali and Gertler (1998, 2000) use GMM estimation for examining monetary policy rules. However, GMM estimators by Hansen (1982) have severely been criticized by the claim that findings based on these GMM estimators could be ineffective. The literature has recently emphasized that 'consequential evidences' can be found from this asymptotic normality approach and findings from this method obtain poor results for the sampling distributions in GMM estimators.

Similarly, Two-stage Least Square (2SLS) estimators may also be biased. In this case, the distribution of 2SLS estimator does not converge into a normal distribution. This problem is defined as 'weak identification' or 'weak instruments' in the literature (Stock and Wright, 2000). This definition comes from the fact that instruments are only and weakly correlated with the included endogenous variables. Stock, Wright and Yogo (2002), and Stock and Yogo

(2005) introduce an extensive contribution in order to solve the 'weak identification' problem in GMM estimators. This problem seems to be solved by their recently developed statistics and methodology in GMM estimation.

On the other hand, if there is not enough information to construct the likelihood function, likelihood-based methods can be very difficult to estimate (Kim, 2002). Under these circumstances, Kim (2002) derives the limited information likelihood method. Chernozhukov and Hong (2003) also develop a Laplace-type estimator by obtaining a Markov Chain Monte Carlo (MCMC) approach in GMM estimation. Yin (2009) proposes to sample GMM by using the usual metropolis algorithm in the Bayesian framework, while the convergence of the Markov Chain appears to be slow due to the complexity of the Pseudo-likelihood function. Yin et al. (2011) recently use the special quadratic structure of GMM, called as 'stochastic GMM'. Samples of these model parameters can also be used for statistical inference purposes, although they are not exactly from a MCMC procedure. Their stochastic GMM samples reduce the classical GMM minimization problem to a series of conditional sampling steps. Furthermore, the variances of the estimated parameters can be easily obtained by using empirical variance of a large number of parameter samples.

One can suggest that inflation targeting experiences in developing countries and Turkey have examined in many other studies. However, in this study, we consider GMM technique by Hansen (1982), and LIML method by Bound, Jaeger and Baker (1995). Thus, our main contribution in this study is to examine the monetary policy rules by using different robust and efficient estimation methods. Furthermore, the main objective in this paper is to explain the behaviour of the by using related monetary policy rules.

The rest of the paper is organized as follows: Next section explains data, methodology and empirical findings and the final section is the concluding remarks.

2 Data, Methodology and Empirical Findings

Taylor (1993) explains how the Federal Reserve Board of Governors (FED) sets the nominal interest rate. In his seminal study, nominal interest rate is based on the current inflation rate, the inflation gap, the output gap, and the equilibrium real interest rate. If a central bank (the CBRT in here) follows his similar approach, inflation and the output gap will be right-hand side variables. This is called as the '*symmetric*' model in the literature. Alternatively, the nominal exchange rate or its difference from target exchange rate (that is possibly defined by Purchasing Power Parity) can also be included by a central bank. In this case, this method is known as the '*asymmetric'* model that the real exchange rate is also included in reaction function (Molodtsova, Nikolsko-Rzhevskyy and Papell, 2011).

Furthermore, the interest rate only and partially adjusts to its target within the certain period (Clarida, Gali and Gertler, 1998). In this case, lagged interest rate(s) will also be a right-hand side variable, and this is now called as the '*smoothing*' model. Alternatively, the model of '*no smoothing*' does not include the lagged interest rates. Smoothing or no smoothing models can also be symmetric or asymmetric.

In this study, we consider an asymmetric smoothing Taylor rule model, and we simply define it as follows:

$$R_t = \alpha_T + \varphi_T R_{t-1} + \beta(\overline{\pi} - \pi^*) + \lambda(y_t - \tilde{y}) + \delta_T \Delta e_t$$

In this equation, R_t is the percentage nominal interest rate, and it is controlled by the CBRT. The CBRT has controls over three nominal interest rates, namely, the one-week repo rate, the overnight rate, and the late liquidity window interest rate in related period. $(\overline{\pi} - \pi^*)$ is the inflation gap, and it is defined as the difference between a moving average of percentage annual inflation, and the percentage inflation target that announced by the CBRT. $(y_t - \tilde{y})$ is the output gap, and it is defined as deviations of log output from trend log output and it is calculated by using the Hodrick-Prescott (HP) filter (λ=100). Δe_t is annual change in the log of the nominal United States Dollar/Turkish Lira (USD/TRY) exchange rate.

On the other hand, we simply define a Hybrid McCallum rule as follows:

$$R_t = \alpha_{MT} + \varphi_{MT} R_{t-1} + \rho(\Delta x_t^* - \Delta x_{t-1}) + \delta_{MT} \Delta e_t$$

In this equation, $(\Delta x_t^* - \Delta x_{t-1})$ is the McCallum's nominal income gap measure, and it is calculated as the difference between the annual change in the target nominal income and the annual change in the previous period's annual nominal income. In other words, it is the sum of real output passed through the HP filter and inflation target announced by the CBRT.

In this study, we use quarterly data from March 2003 to March 2012. Nominal interest rates are official policy interest rates of the CBRT. Inflation rates are the percentage annual change of the Consumer Price Index (CPI). The exchange rate is the annual change of the log nominal USD/TRY. The output gap is calculated by using GDP data. All these data are obtained from the CBRT.

We firstly estimate Taylor-type and Hybrid McCallum-Taylor monetary policy reaction functions in Turkey by using GMM, and we report the results in Table 1 and in Table 2, respectively. Secondly, we estimate same Taylor-type and Hybrid McCallum-Taylor monetary policy reaction functions in Turkey by using LIML, and we report results in Table 3 and in Table 4, respectively.

As we can see from all these tables, empirical findings show that the CBRT tends to increase policy interest rate when output gap and inflation gap increase. We also find that the CBRT significantly respond nominal exchange rate deprecation in Taylor rule specifications. Thus, it can be said that when one also consider that the correct signs of the parameters in estimations, findings are

well-fitted with the theoretical background and most previous studies.
We represent all these results as follows:

Table 1: GMM results of Taylor-type reaction function

Country and Analyzing Period Turkey 2003:Q1-2012:Q1	Method GMM-Coefficient
Inflation Gap $(\bar{\pi}-\pi^*)$ (%): β	0.1480* (0.0000)
Output Gap $(y_t-\tilde{y})$ (%): λ	0.0183** (0.0151)
Lagged Policy Rate R_{t-1} (%): φ_T	0.9554* (0.0000)
Change in Nominal Exchange Rate (%): Δe_t	0.0079** (0.0201)
Adjusted R^2	0.989
J-statistic	4.514 (0.2110)

Notes: Dependent variable is R_t (%). Regression includes a constant term. Under null hypothesis of the over-identifying restrictions are valid, the J-statistic tests validity of the over-identifying restrictions in GMM estimation. The instruments are lag 2 and lag 3 of the interest rate, lag 1 and lag 2 of the inflation gap, the output gap, nominal exchange rate, and oil prices. Constant term is also added into the instruments. We use Heteroskedasticity and Autocorrelation Consistent (HAC) estimation weighting matrix by Newey and West (1987), quadratic-spectral Kernel, and bandwidth selection method by Andrews (1991). The optimal number of lag is selected by Newey and West (1994) observation based selection method. The p-values are in parentheses, ** and * denote that rejection of null hypothesis at 5% and at 1% significance level, respectively.

Table 2: GMM results of Hybrid McCallum-Taylor reaction function

Country and Analyzing Period Turkey 2003:Q1-2012:Q1	Method GMM-Coefficient
Nominal Income Gap $(\Delta x_t^*-\Delta x_{t-1})$ (%): ρ	0.1508** (0.0334)
Lagged Policy Rate R_{t-1} (%): φ_{MT}	1.0542* (0.0000)
Change in Nominal Exchange Rate (%): Δet	0.0008 (0.9492)
Adjusted R^2	0.985
J-statistic	2.311 (0.5102)

Notes: Dependent variable is R_t (%). Regression includes a constant term. Under null hypothesis of the over-identifying restrictions are valid, the J-statistic tests validity of the over-identifying restrictions in GMM estimation. The instruments are lag 2 and lag 3 of the interest rate, lag 1 and lag 2 of the inflation gap, the output gap, nominal exchange rate, and oil prices. Constant term is also added into the instruments. We use Heteroskedasticity and Autocorrelation Consistent (HAC) estimation weighting matrix by Newey and West (1987), quadratic-spectral Kernel, and bandwidth selection method by Andrews (1991).

The optimal number of lag is selected by Newey and West (1994) observation based selection method. The p-values are in parentheses, ** and * denote that rejection of null hypothesis at 5% and at 1% significance level, respectively.

Table 3: LIML results of Taylor-type reaction function

Country and Analyzing Period Turkey 2003:Q1-2012:Q1	Method LIML-Coefficient
Inflation Gap $(\bar{\pi}-\pi^*)$ (%): β	0.1466* (0.0005)
Output Gap $(y_t-\tilde{y})$ (%): λ	0.0324* (0.0074)
Lagged Policy Rate R_{t-1} (%): φ_T	0.9449* (0.0000)
Change in Nominal Exchange Rate (%): Δe_t	0.0051** (0.0431)
Adjusted R^2	0.988
LIML Minimum Eigenvalue	1.145
Cragg-Donald F-statistics	15.679
White Heteroskedasticity Test	2.866 (0.2942)

Notes: Dependent variable is R_t (%). Regression includes a constant term. LIML Minimum Eigenvalue shows that the Eigenvalue of matrix analogue in F-statistics by Cragg and Donald (1993). Cragg-Donald F-statistics denotes that the approach by Stock, Wright and Yogo (2002) under null hypothesis of the under-identification in Cragg-Donald test. Stock and Yogo (2005)'s relative bias critical values at 5% significance level: 12.20, at 10% significance level: 7.77, at 20% significance level: 5.35, at 30% significance level: 4.40. The instruments are lag 2 and lag 3 of the interest rate, lag 1 and lag 2 of the inflation gap, the output gap, nominal exchange rate, and oil prices. Constant term is also added into the instruments. We use covariance estimation method by Hansen, Hausman and Newey (2008). This method is consistent with many instruments, and it assumes that the non-normal disturbances with degree of freedom adjustment. Wald-heteroskedasticity test by White (1980) uses null hypothesis of the variance in the disturbance term is homoskedastic. The p-values are in parentheses, ** and * denote that the rejection of null hypothesis at 5% and at 1% significance level, respectively.

Table 4: LIML results of Hybrid McCallum-Taylor reaction function

Country and Analyzing Period Turkey 2003:Q1-2012:Q1	Method LIML-Coefficient
Nominal Income Gap $(\Delta x_t^*-\Delta x_{t-1})$ (%): ρ	0.1964** (0.0249)
Lagged Policy Rate R_{t-1} (%): φ_{MT}	1.0687* (0.0000)
Change in Nominal Exchange Rate (%): Δet	0.0031 (0.8148)
Adjusted R^2	0.934

LIML Minimum Eigenvalue	1.022
Cragg-Donald F-statistics	0.928
White Heteroskedasticity Test	11.573 (0.00)

Notes: Dependent variable is R_t (%). Regression includes a constant term. LIML Minimum Eigenvalue shows that the Eigenvalue of matrix analogue in F-statistics by Cragg and Donald (1993). Cragg-Donald F-statistics denotes that the approach by Stock, Wright and Yogo (2002) under null hypothesis of the under-identification in Cragg-Donald test. Stock and Yogo (2005)'s relative bias critical values at 5% significance level: 12.20, at 10% significance level: 7.77, at 20% significance level: 5.35, at 30% significance level: 4.40. The instruments are lag 2 and lag 3 of the interest rate, lag 1 and lag 2 of the inflation gap, the output gap, nominal exchange rate, and oil prices. Constant term is also added into the instruments. We use covariance estimation method by Hansen, Hausman and Newey (2008). This method is consistent with many instruments, and it assumes that the non-normal disturbances with degree of freedom adjustment. Wald-heteroskedasticity test by White (1980) uses null hypothesis of the variance in the disturbance term is homoskedastic. The p-values are in parentheses, ** and * denote that the rejection of null hypothesis at 5% and at 1% significance level, respectively.

3 Concluding Remarks

In this paper, we investigate monetary policy behaviour in Turkey due to it is an emerging economy in inflation targeting. We estimate reaction functions of the CBRT based on Taylor and Hybrid McCallum-Taylor rules, and we use mixed instruments and targets of these two classical monetary policy frameworks. We suggest that our findings are robust and efficient just because they are based upon the both results of GMM and LIML estimations. Our empirical findings show that the monetary policy behaviour of the CBRT can significantly be captured and be explained by Taylor rule specification.

We know that inflation targeting economies are able to put into mixed monetary instruments and exchange rate targets in practice. However, differences for the policy reaction in the output gap, the inflation gap, nominal income target or nominal exchange rate may also be eventuated in practice.

Furthermore, we suggest that future papers about this topic shall focus on more numbers of emerging market economies in inflation targeting. On the other hand, researchers can also use monetary policy rules in real-time data panel framework, and this kind of approaches can lead to a better understanding on the behaviour of central banks in developing economies.

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References

[1] C. Akyurek, A.M. Kutan and H. Yilmazkuday, Can inflation targeting regimes be effective in developing countries? The Turkish experience, *Journal of Asian Economics*, **22**(5), (2011), 343-355.

[2] D.W.K. Andrews, Heteroskedasticity and autocorrelation consistent covariance matrix estimation, *Econometrica*, **59**(3), (1991), 817-858.

[3] C. Ball and J. Reyes, Inflation targeting or fear of floating in disguise: The case of Mexico, *International Journal of Finance and Economics*, **9**(1), (2004), 49-69.

[4] G. Bekaert and X. Wang, Inflation risk and the inflation risk premium, *Economic Policy*, **10**(64), (2010), 756-806.

[5] H. Berument, Measuring monetary policy for a small open economy: Turkey, *Journal of Macroeconomics*, **29**(2), (2007), 411-430.

[6] J. Bound, D.A. Jaeger and R. Baker, Problems with instrumental variables estimation when the correlation between the instruments and the endogenous explanatory variables is weak, *Journal of the American Statistical Association*, **90**(430), (1995), 443-450.

[7] V. Chernozhukov and H. Hong, An MCMC approach to classical estimation, *Journal of Econometrics*, **115(**1-2**)**, (2003), 293-346.

[8] I. Civcir and A. Akcaglayan, Inflation targeting and the exchange rate: Does it matter in Turkey?, Journal *of Policy Modeling*, **32**(3), (2010), 339-354.

[9] R. Clarida, J. Gali and M. Gertler, Monetary policy rules and macroeconomic stability: Evidence and some theory, *Quarterly Journal of Economics*, **115**(1), (2000), 147-180.

[10] R. Clarida, J. Gali and M. Gertler, Monetary policy rules in practice: Some international evidence, *European Economic Review*, **42**(6), (1998), 1033-1067.

[11] R. Clarida, J. Gali and M. Gertler, The science of monetary policy: A new Keynesian perspective, *Journal of Economic Literature*, **37**(4), (1999), 1661-1707.

[12] J.G. Cragg and S.G. Donald, Testing identifiability and specification in instrumental variable models, *Econometric Theory*, **9**(2), (1993), 222-240.

[13] C. Hansen, J. Hausman and W. Newey, Estimation with many instrumental variables, *Journal of Business and Economic Statistics*, **26**(4), (2008), 398-422.

[14] L. Hansen, Large sample properties of generalized method of moments estimators, *Econometrica*, **50**(4), (1982), 1029-1054.

[15] M. Hasanov and T. Omay, Monetary policy rules in practice: Re-examining the case of Turkey, *Physica A: Statistical Mechanics and Its Applications*, **387**(16-17), (2008), 4309-4318.

[16] J.P. Judd and G.D. Rudebusch, Taylor's rule and the FED: 1970-1997, *Federal Reserve Bank of San Francisco Economic Review*, **16**(3), (1998), 1-16.

[17] J.Y. Kim, Limited information likelihood and Bayesian analysis, *Journal of Econometrics*, **107**(2), (2002), 175-193.
[18] B.T. McCallum, Alternative monetary policy rules: A comparison with historical settings for the United States, the United Kingdom, and Japan, *Federal Reserve Bank of Richmond Economic Quarterly*, **86**(2), (2000), 49-79.
[19] B.T. McCallum, Issues in the design of monetary policy rules, *Handbook of Macroeconomics* **1**, Elsevier, Amsterdam, 1999, 1483-1530.
[20] B.T. McCallum, Robustness properties of a rule for monetary policy, *Carnegie-Rochester Conference Series on Public Policy*, **29**(1), (1988), 53-84.
[21] B.T. McCallum and E. Nelson, Nominal income targeting in an open-economy optimizing model, *Journal of Monetary Economics,* **43**(3), (1999), 553-578.
[22] A. Mehrotra and J.R. Sanchez-Fung, Assessing McCallum and Taylor rules in a cross-section of emerging market economies, *Journal of International Financial Markets, Institutions and Money*, **21**(2), (2011), 207-228.
[23] T. Molodtsova, A. Nikolsko-Rzhevskyy and D.H. Papell, Taylor rules and the Euro, *Journal of Money, Credit and Banking*, **43**(3), (2011), 535-552.
[24] E. Nelson, UK monetary policy 1972-1997: A guide using Taylor rules, *Bank of England Working Paper*, **W120**, (2000).
[25] W. Newey and K. West, A simple positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix, *Econometrica*, **55**(3), (1987), 703-708.
[26] W. Newey and K. West, Automatic lag selection in covariance matrix estimation, *Review of Economic Studies*, **61**(4), (1994), 631-653.
[27] G.D. Rudebusch and L.E.O. Svensson, Policy rules for inflation targeting *Monetary Policy Rules*, University of Chicago Press, Chicago, 1999, 203-262.
[28] J.R. Sanchez-Fung, Estimating a monetary policy reaction function for the Dominican Republic, *International Economic Journal*, **19**(4), (2005), 563-577.
[29] J.H. Stock and J.H. Wright, GMM with weak identification, *Econometrica*, **68**(5), (2000), 1055-1096.
[30] J.H. Stock, J.H. Wright and M. Yogo, A survey of weak instruments and weak identification in generalized method of moments, *Journal of Business and Economic Statistics*, **20**(4), (2002), 518-529.
[31] J.H. Stock and M. Yogo, Testing for weak instruments in linear IV regression, *Identification and Inference for Econometric Models Essays in Honour of Thomas Rothenberg*, Cambridge University Press, Cambridge, 2005, 80-108.
[32] L.E.O. Svensson, Inflation targeting as a monetary policy rule, *Journal of Monetary Economics*, **43**(3), (1999), 607-654.
[33] L.E.O. Svensson, Open-economy inflation targeting, *Journal of International Economics*, **50**(1), (2000), 155-183.
[34] L.E.O. Svensson, What is wrong with Taylor rules? Using judgment in monetary policy through targeting rules, *Journal of Economic Literature*, **41**(2), (2003), 426-477.

[35] J.B. Taylor, A historical analysis of monetary policy rules, *Monetary Policy Rules*, University of Chicago Press, Chicago, 1999, 319-341.
[36] J.B. Taylor, Discretion versus policy rules in practice, *Carnegie-Rochester Conference Series on Public Policy*, **39**(1), (1993), 195-214.
[37] J.B. Taylor, Using monetary policy rules in emerging market economies, *Stanford University*, mimeo, (2000).
[38] J. Wang and J.J. Wu, The Taylor rule and forecast intervals for exchange rates, *Journal of Money, Credit and Banking*, **44**(1), (2012), 103-144.
[39] H. White, A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity, *Econometrica*, **48**(4), (1980), 817-838.
[40] M.E. Yazgan and H. Yilmazkuday, Monetary policy rules in practice: Evidence from Turkey and Israel, *Applied Financial Economics*, **17**(1), (2007), 1-8.
[41] H. Yilmazkuday, Inflation targeting supported by managed exchange rate, *Applied Economics*, **39**(16), (2007), 2011-2026.
[42] H. Yilmazkuday, Structural breaks in monetary policy rules: Evidence from transition countries, *Emerging Markets Finance and Trade*, **44**(6), (2008), 87-97.
[43] G. Yin, Bayesian generalized method of moments, *Bayesian Analysis*, **4**(2), (2009), 191-208.
[44] G. Yin, Y. Ma, F. Liang and Y. Yuan, Stochastic generalized method of moments, *Journal of Computational and Graphical Statistics*, **20**(3), (2011), 714-727.