Journal of Money and Economy
Vol. 8, No. 1 Winter 2013

Threshold Effects in the Monetary Policy Reaction Function: Evidence from Central Bank of Iran

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Received: 8/22/2013 Approved: 1/27/2014

Abstract

Determining how monetary policy makers react to changes in key economic variables has been of major interest to monetary economists. Estimates of monetary policy rules (reaction functions) are a widely used method for doing this. Behavior differs under different policy regimes, as in rule-based systems or chronic inflation. In practice, estimates of instrument rules have been used to describe how the central bank alters its policy in response to expected macroeconomic events. In this paper we provide linear and non-linear estimates for various instrument rules for Iran. Linear estimates show that monetary policy in Iran tends to accommodate rather than counteract inflationary pressures. More generally, the estimates indicate that Central Bank of I. R. of Iran does not systematically follow any of the well-known instrument rules or hybrid types. Non-linearity tests were performed and the null

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hypothesis of non-linearity of the monetary policy reaction function with respect to inflation was rejected. The narrative that can be read from non-linear rule estimates is that, in the "low inflation" states expansionary policies by CBI tend to support economic activity. However, during "high inflation" periods, CBI does not exercise anti-inflation policy but such a stance cannot accommodate output growth. Monetary policy seems to be ineffective if not inappropriate in this state.

Key words: *Monetary policy, Instrumental rule, Non-linearity, Threshold effect, McCallum Rule, Monetary Policy Reaction Function,*

JEL Classification: *E4, E5*

1. Introduction

Gone, are not only the days of high inflation, but also, at least temporarily, the days of persistent moderate inflation in a large number of developing countries. Monetary policies that accommodated persistent inflation have been replaced in many parts of the world by policies that react to inflation. It is widely held that improvements in monetary policies contributed to a better macroeconomic performance in many parts of the world economy, particularly during the two decades preceding the global financial and economic crisis of 2008-2009. While the evidence regarding the ability of monetary policy to stabilize output, the "natural" level is mixed, the facts regarding its power to control inflation is much stronger. Since the mid-1980s up to the present, the inflation rates in all regions of the world and in economies with different levels of development and per-capita income levels have been trending down. Fluctuations in output gap during 1990-2008, a period referred to as the "great moderation"', also diminished.[1] There seems to have been learning in institution building and monetary policy design in developing countries (Mishkin 2007), as central banks in many developing countries acquired more autonomy in the areas covering their mandates, policies became more systematic or “rule-based”. Over the last three decades average inflation rates have been declining at a faster pace in the developing and emerging economies (Figure 1). The average inflation rate in the Economy of Iran during the 1989-2010 period have not been very high compared to those countries with similar levels of development, considering the negative effects of the Iraqi war on the domestic productive capacity. However, learning in monetary policy design that occurred and the disinflation achieved in other regions of the world economy did not materialize in Iran.

In some oil producing countries, there is evidence of fiscal dominance which affects monetary management. Independence of the central bank from the fiscal authorities is a prerequisite for a successful implementation of any monetary regime. In an economy characterized by fiscal dominance over

1. For more details see Mishkin (2007).

monetary dominance, there is no such independence, and therefore, fiscal dominance impedes the effective implementation of any monetary strategy aimed at controlling inflation. In addition to limit the role of monetary policy through fiscal dominance, oil dominance[1] may also affect the effectiveness of monetary policy if the central bank limits the fluctuations in the nominal exchange rate in response to changes in oil prices. The oil exporting countries with the highest degree of oil dominance, measured by the ratios of oil export to GDP, have chosen to adopt the exchange rate as the nominal anchor [Olivo and Costa (2008)].

Determining how monetary policy makers react to changes in key economic variables has been of major interest to monetary economists. Empirical estimates of monetary policy rules (reaction functions) are the most prevalent method for doing this. For instance, econometric tests of monetary policy reaction function has shown that in a number of countries monetary policy changed from a posture that accommodated inflation to one that resisted inflation during the 1980s and 1990s (Clarida et. al., 2000) and the result was lower and more stable inflation.

Broadly speaking, there are two distinct notions of policy rules: optimal rules and instrumental rules. The former line lies within the optimal monetary policy literature. Optimal policy is derived from an explicit central-bank inter-temporal objective (loss) function. The other line employs a more restrictive notion of a monetary policy reaction function where the rule expresses the monetary authorities' instrument rate (or quantity) as a function of the set of information available to the policy makers (Svensson 2003b). More often, estimated monetary policy reaction functions have been of the simple instrument rule variety—i.e. prescribed rules for setting the instrument rate or quantity as a function of observable current economic variables (Svensson 2005). Simple instrument rules, like Taylor or McCallum rules, recapitulate how the central bank alters its policy in response to (expected) macroeconomic events. In this context, estimates of instrument rules can be utilized to describe central bank's behavior and monetary policy stance, and this is what we plan to do in the case of Iran in this paper.

1. A situation in which oil exports largely affect the main macroeconomic indicators

The structure of the paper is as follows: Section two discusses the framework for monetary policy making in Iran during 1968-2010 and includes discussions on the stated mandates of the central bank and the choice of the nominal anchor. Section three reviews a number of policy rules that will be subject to empirical test in subsequent sections and provides backward and forward looking estimates for a variety of linear reaction functions. The objective is to find out how CBI[1] behaves and how it reacts to the usual economic variables of interest such as inflation, the level of economic activity, and the exchange rate. In this connection we also test for the existence of threshold effects in the monetary policy reaction function. Section four is the concluding part.

2. Monetary Policy in Iran

The central bank of Iran (CBI) is a multiple mandate central bank in charge of formulating and implementing monetary policy in conjunction with Five-year Development Plans and the government's annual budget. The mission of CBI is "to ensure the economic growth of the country by enforcing monetary policies, and to support the government in implementing various economic stability and development plans."[2] The main objectives of CBI as specified by its charter are: maintaining the value of national currency, enhancing the economic growth potential, and keeping equilibrium in the balance of payments.[3]

CBI has, over time, changed the way it implements monetary policies. From 1980s until early 1990s direct administrative controls were predominant. During the early post-revolution years that coincided with the Iran-Iraq war (1980-88), money supply growth was mainly driven by government debt.[4] The ongoing military conflict required financing, given limited fiscal resources; debt monetization was the viable option. CBI monetized budget deficits and government credit was the main factor contributing to the growth of monetary-base in this period. In this period, CBI pursued a policy of low and

1.CBI stands for Bank Markazi (the Central Bank of the Islamic Republic of Iran).

2. http://www.cbi.ir/page/GeneralInformation.aspx

3. For more details see, http://www.cbi.ir/page/GeneralInformation.aspx

4. Pesaran, (1995)

administratively set profit (“interest”) rates on deposits and loan rates. Given the above backdrop and prevailing conditions, imposition of credit ceiling on the banking system was the main instrument for monetary policy to control the growth rate of money supply. Moreover, in the absence of market mechanisms for allocation of credit, directed credit as well as administratively determined rates on facilities (loans) became the main means of regulating sectoral flows of credit.

After the war, the approach to monetary policy changed gradually, reflecting a different set of priorities and economic management style. Authorities allowed variations of profit rates on deposits and loans within the limits allowed by CBI. After mid-1990s utilization authorities gradually reduced or phased-out some of the direct controls and, to a very limited extent, there was a move toward more market-based monetary policy.[1] With private banks having permission to enter the market for deposits and loans, profit rates became a bit more flexible to be more reflective of the market conditions. Moreover, fixed official exchange rates were substituted with a "managed floating" framework.

Notwithstanding the above developments, CBI's official policy framework has been based on control of monetary aggregates, and more specifically M_2, as its intermediate target.[2]Annual target growth rates for broad money and inflation, until the Fifth Plan (2010-2015) were set within five-year plans which upon approval by the parliament became the policy-benchmark for formulating monetary targets.[3] “With the monetary policy aimed at controlling monetary aggregates, attempts are made to prevent monetary expansion, incompatible with liquidity and inflation targets set in the development plans, and to finance productive and investment sectors." As well-known, the influence of monetary policy on the goals of policy is uncertain and indirect and it comes with a lag. The effect of policy depends on the strength of the relationship between the nominal anchor (the intermediate target) and the final goals. The choice of money supply as the intermediate target for monetary policy in Iran seems to be an appropriate one based on several factors. Firstly, the interbank market is not well developed and due to usury-free laws CBI is not allowed to set short-term

1. For more details see Jbili, Kramarenko, Bailen (2007), chapter three.
2. http://www.cbi.ir/section/1370.aspx.
3. At the level of operations, the Monetary and Credit Council oversees monetary policy formulations and implementations. The Plan targets have at times been subject to revision by MCC in the annual monetary policy reviews. For more details see Kramarenko (2004).

interest rates as policy rates. The “sukuk market’ in Iran is not yet well-developed hence CBI does not have a mechanism to discover short-term prices in the Islamic finance market as, for instance, in Malaysia. Secondly, monetary aggregates (in particular M_1) pass the test of being a “tight” instrument with respect to inflation--but not output. “Money growth drives inflation even in the short-run…there is no evidence of a structural change in the relationship between money and inflation”.[1]Thirdly, components of aggregate expenditures are more volatile relative to demand for money, hence, money supply seems to be a reasonable instrument choice for stabilizing output (Poole 1970).

Monetary base has been the main instrument or the operating target for CBI. Monetary policy instruments are presumed not to have direct influence on monetary policy objectives and transmit their effect via intermediate objectives. Due to the very significant weight of oil revenues and the impact of government expenditures on base-money, fiscal dominance of monetary policy have always been present and a factor that tend to undermine the degree of control by CBI over its instrument. Note, however, that, the relationship between fiscal factor and monetary base growth is complicated and it is difficult to empirically establish link.[2] Prior to the Third-Plan, the fiscal authority could finance the deficits through credit from CBI and fiscal imbalances directly spilled-over to influence the growth rate of monetary base. Since the Third Plan, direct financing of fiscal deficits by CBI is not allowed and the deficits must either be financed through selling of foreign currency to the CBI or raising revenue through public issuance of "Participation Shares".[3] Note that selling of foreign currency (obtained from oil export receipts) to CBI to finance government expenditure, even with no budget-deficit results in money-base expansion. Thus, to control its operating target, CBI must resort to other measures in order to limit the expansion of its balance sheet. CBI has leeway and has had a framework to deal with these issues (such as variations in velocity and unexpected changes in base-money growth) in order to control growth rate of

1. Bonato, 2007, p. 3. Note, however, that money growth rate and output growth have little positive correlation.
2. See section 3.12 for more details.
3. Participation shares are an Islamic instrument of financing where the issuer shares profits made in project with the purchaser of the security in proportion to the amount of capital invested.

M_2.[1] Adherence to the announced targets for the growth of M_2 has been low (Bonato 2007) as CBI does not have the independence and political muscle to withstand pressure from different interest groups (industrialist, farmers, and the public sector) to curtail the growth rate of credit. We shall discuss these and related issues in conjunction with evaluation of the results from the tests of policy instrument rules.

3. Identifying Monetary Policy Behavior and Empirical Policy Rules

Empirical estimates of monetary policy reaction functions have been an active area since the early 1990s. The continued interest in empirical policy rules primarily stems from the ability of Taylor (1993) type rules ability to track real data in a number of countries, initially in the developed economies.[2] On a general level, there are two distinct conceptions of policy rules: optimal rules (including optimal interest rules) and instrument rules. The former line lies within rule-based monetary policy literature. At the center is an optimizing central bank that has (or mandated to have) specific targets for certain economic variables appearing its inter-temporal loss function—usually a quadratic loss in output and inflation gap with a linear constraint. By minimization of the loss, subject to the economic structure as its constraint[3], the optimal policy rule is obtained (Woodford 2004).[4] A variant of this approach is the optimal targeting rules literature (Svensson 2003b).[5]

The other approach, instrument rules, is based on a more restrictive notion of a monetary policy rule. They have been widely used to describe policy behavior and work as a standard for assessing the actual policy conducted by

1. For more details see Mahdavian (2005).
2. See for example, Clarida et al. (1998, 2000), de Brouwer and Gilbert (2005), Sutherland (2010).
3. For instance, forward looking Phillips curve and IS in the New Keynesian system.
4. Policy rule does not have a uniform connotation in the monetary policy literature. In one part of the literature "rule" is to limit the central bank's description. There is also a notion of policy rule based on outcomes (Blinder 1999). A targeting rule stipulates a condition to be satisfied by the central bank's target variables or their forecasts. Friedman’s' k% rule is a target rule on the instrument that fits the above description. Svensson (2005) interprets Freidman's k% rule as a targeting rule.
5. Target variables are variables that are included in the central bank's loss functions. In the case of forecast targeting, forecasts of the target variable (an "intermediate target") enter the loss function.

the central bank. Much of the empirical policy rules focus on simple instrument rules. Taylor (1993) and McCallum (1988) have formulas for setting controllable instrument variable in response to current economic conditions (McCallum and Nelson 2005). An operational rule restricts discretion of the monetary authority, however, in contrast to the rigid monetarist k% rule, Taylor and McCallum rules allow active response to the changing macroeconomic condition—that is, they do not disallow discretion. Since the publication of Taylor (1993) article, economists have extensively relied on simple interest rate reaction functions to describe the endogenous response of monetary policymakers to economic fluctuations. Investigation of simple rules does not presume the existence of a formal commitment framework that forces the policy maker to follow a stringent policy rule. In practice, simple instrument rules serve as transparent and non-rigid policy guide-posts, and even under discretion, for a large number of central-banks monetary-policy decisions maybe well characterized by a simple instrument rule.

An argument for utilizing simple rules is that their performance might be nearly as good as optimal rules (Galí 2002, Schmitt-Grohe and Uribe 2007, Taylor and Williams 2010). But this is not the context in which we want to discuss instrument rules in this paper. Rather we have a descriptive take on the subject, that is, to what extent instrument rules empirically describe the behavior of the monetary authority? To this end, we estimate a variety of reaction functions that appear in the relevant literature for Iran in an attempt to evaluate the conduct of monetary policy. Monetary policy reaction functions have been estimated for a large number of developed and developing economies to get insight into the factors that influence policy and changes in the stance of monetary policy. For instance, it has been shown that a simple Taylor rule provides a fairly good description of the behavior of the US and German central banks during certain periods, particularly when simple rules can capture threshold effects in conducting monetary policy.[1] Instrument of various type have been tested for a number of developing countries (Patra and Kapur 2012,

1. Even when the rules do not accurately predict movements in policy, they can serve as reference points for understanding the current policy stance.

Mehrotra and Sanchez-Fung 2011, Jácome and Parrado 2007) and the result indicate that in a number of emerging economies monetary authority responds to higher inflationary pressures by adjusting its instrument to offset such pressures.

3.1. Reaction Function Estimates for Linear Policy Rules

In this section, we estimate a group of backward and forward linear reaction functions for Iran. The literature on empirical policy rules focuses mainly on two types of simple instrument rules that mainly differ in the choice of the policy instrument: interest rate (Taylor, 1993) and monetary (McCallum 1988) based rules.[1] Taking into account the limitations regarding the range of policy instruments in Iran, we estimate McCallum and Taylor monetary policy reaction functions and hybrids forms with a mix of instruments and targets. Data for our linear estimates are quarterly time series for 1990:2- 2010:1[2].[3] Quarterly series for estimation are seasonally adjusted if needed. The rate of inflation is measured by year-on-year (y-o-y) variations in the consumer price index (CPI). The descriptions and notations for the variables used in the estimations of linear policy rules are given in table (1).

3.1.1. Contemporaneous Backward Looking Reaction Functions

Generally, we can specify a contemporaneous/backward looking reaction function as in the following:

$$x_1 = c + \sum_{i=0}^{j} \alpha_i (\Pi_{t-i}) + \sum_{i=0}^{j} \beta_i (y_{t-i} - \tilde{y}_{t-i}) + \sum_{i=1}^{j} \psi_i x_{t-i} + e_\tau \qquad (1)$$

x_t stands for the instrument rate (interest rate) or instrument quantity (money) depending on the type of policy rule. Π_t is the inflation gap, $y_t - \tilde{y}_t$ is the output gap; ψ_i is the coefficient of the lagged values of the instrument that

1. Taylor (2000) argues that utilization of policy rules in the developing economies have similar benefits as in the developed economies.
2. Since in the Fifth Development Plan (2010-2015) quantitative target for inflation was not announced, there is no information on this variable after 2010:1, the end of Fourth Plan. For estimating nonlinear rule we use data for the period 1990:2-2011:3.
3. The data used in our estimates are from CBI website and publications.

reflects the effect of instrument smoothing when the policy maker observes the policy rule. The long-run coefficients of inflation and output gap, respectively, are:

$$\lambda_1 \equiv (\sum_{i=1}^{j} \alpha_i)/(1-\sum_{i=1}^{j} \psi_i) \qquad \lambda_2 \equiv (\sum_{i=1}^{j} \beta_i)/(1-\sum_{i=1}^{j} \psi_i) \tag{2}$$

In a Taylor rule the policy instrument (x_t) is the short-term interest rate. The Taylor rule prescribes the adjustment of interest rate in a systematic manner in response to developments in inflation rate and macroeconomic activity. Ball (1999) argues that adding the exchange rate, either through a monetary conditions index (weighted average of exchange rate and inflation rate) to replace the interest rate as the policy instrument or by adding the exchange rate to the right hand side variables of the simple Taylor rule (extended Taylor rule) may improve macroeconomic performance. We present results of the estimates of Taylor and extended Taylor rules in tables (2) and (3).

The McCallum rule (McCallum, 1988) specifies the growth rate of the instrument, monetary base, in a non-discretionary feedback rule for nominal GDP, the target variable (equation 3).

$$\Delta m_t^b = \alpha + \beta \Delta m_{t-1}^b - \Delta v^a{}_t + \gamma(\Delta x^* - \Delta x_{t-1}) \tag{3}$$

where Δm_t^b is the rate of growth of the monetary base (y-o-y), $\Delta v^a{}_t$ is the rate of growth of base velocity averaged over previous 16 quarters, Δx is the rate of growth of nominal output, and Δx^* is the targeted rate of growth of nominal income.

The above rule can be modified by adding inflation gaps to (3) to give modified McCallum rule (4)-see table (1) for the description of the variables.

$$\Delta m_t^b = \alpha + \beta \Delta m_{t-1}^b - \Delta v^a{}_t + \gamma(\Delta x^* - \Delta x_{t-1}) + \delta(\pi_t^* - \pi_{t-1}) \tag{4}$$

These policy rules allow some discretion in the central bank's response to the changes in the macroeconomic conditions and hence incorporate feedback.

Aside from the above two rules, we also estimate more flexible or hybrid policy rules by allowing target variables not to be restricted by the specification of the two previous rules. In equation (5) the instrument is set to respond to output gap, inflation gap, and also the exchange rate gap (E^g) as target variables. The latter is included since the policy maker may want to keep exchange-rate float within a certain band.[1]

$$\Delta m_t^b = \alpha + \sum_{i=0}^{m} \alpha_i \Delta m_{t-i}^b + \sum_{i=0}^{j} \beta_i (y_{t-i} - \tilde{y}_{t-i}) + \sum_{i=0}^{k} \lambda_i E_{t-i}^g + \sum_{i=0}^{q} \zeta_i (\Pi_{t-i}) + \varepsilon_t \quad (5)$$

For the contemporaneous/backward-looking specifications of the above reaction functions the estimation method is ordinary least squares and their results are shown in table (2). The estimates of the contemporaneous and lagged basic Taylor rules are presented in columns 2 and 3, respectively and the result for the extended Taylor rule with exchange rate deviation as an additional regressor is shown in column 4. The estimates indicate that CBI does not change the administered rates in reaction to the evolving state of the economy as described by inflation and output gap or the deviation of the official exchange rate from the market rate. R^2 for these regressions are very low. Thus changes in the administered rates have little monetary policy implications. Note that, the dependent variable in Taylor rule regressions in tables (2) and (3) are first difference of the weighted loan rate. Since this series has a unit root, its first difference was included in the Taylor rule regressions. We also estimated this rule with the level of loan rate and the loan rate does not respond to inflation and output gap.[2]

The same general conclusions can be said regarding the results of the McCallum rule. In particular, if the central bank conducts an anti-cyclical

1. For instance, one form of hybrid McCallum rules is: $\Delta MB_t = C_{H1} + \theta_{H1} \Delta MB_{t-1} - \gamma_{H1}(\pi_t - \pi_t^*) + \lambda_{H1}(y_t - \tilde{y}_t)$. In this formulation real output gap has been substituted with the nominal GDP gap.

2. $R_t = -0.000187 + 0.997 R_{t-1} + 0.0084(\pi_t - \pi_t^*) + 0.00023 (y_t - \tilde{y}_t)$ the coefficient of R_{t-1} is 0.997, denoting the presence of unit root hence spurious regression. The P-values for the inflation and output gaps are 0.19 and 0.994, respectively, indicating their insignificance. The same equation was estimated with average weighted deposits as the instrument. The results did not change.

monetary policy the expected sign of the coefficient of the nominal output gap ($\Delta x_t^* - \Delta x_{t-1}$) should be positive while the estimated regression coefficients are negative, though statistically insignificant.[1] Moreover, the sign of inflation gap coefficient (reflecting the inflationary stance) is positive and significant at 10% level. A counter-inflationary policy should yield a negative and statistically significant coefficient. In backward looking estimates of the McCallum rule, the inflation gap is defined as the deviation of the actual inflation rate from the "planned inflation rate" as stipulated in the Five-Year Development Plans. In the policy rule literature, the inflation gap has been defined differently. For instance, the inflation target is assumed to be constant over the sample period (for example, a two-percent benchmark) and therefore, we can consider it in intercept term of the regression. Alternatively, the average rate of inflation during the sample period is considered as the inflation target. We estimated hybrid backward rules by using the above alternative definitions. The estimation results using alternative definitions for inflation target indicates that the regressions reported in table (2) are robust with respect to the two alternative definitions.[2]

Table 1: Description of variables in the group of monetary policy reaction functions

Variable	Description
Monetary policy instruments	
ΔR_t	Weighted loan interest rate. Due to the non-stationarity of this series we use the first difference of it.
ΔMB_t	The rate of change of the monetary base (annual and quarterly)
ΔBD_t	The change in central bank claims on banks

1. When actual income growth is declining relative to trends growth, base money should be expanding and vice versa.
2. The sign of inflation and output gap and their P-values for the alternative definitions of the inflation gap are similar to the specification presented in table (2), and the coefficient of inflation gaps are all positive and significant at 5%.

Variable	Description
Monetary policy targets	
$y_t - \tilde{y}_t$	Real Output gap is defined as deviations of log of output (real GDP) from its trend using two stage Hodrick-Prescott filter with smoothing parameter (lambda=677,1). An alternative measure of the output gap defined as the deviation of log of non-oil GDP from its H-P trend was used for estimation.
$\pi_t - \pi_t^*$	Inflation gap defined as the difference between annual inflation ($logCPI_{\mathrm{t}} - logCPI_{\mathrm{t-4}}$) and the inflation-rate target as specified in the five year development plans.
$\Delta x_t^* - \Delta x_{t-1}$	Nominal output gap, defined as the difference between the target rate of growth of nominal GDP(considered as the sum of inflation and real GDP growth rate targets written in five year development plan) and the annualized rate of change in the previous period's nominal income ($logNGDP_{\mathrm{t-1}} - logNGDP_{\mathrm{t-5}}$).
$\Delta(e_m - e_o)$	Nominal exchange rate gap defined as the difference between market rate and the official exchange rate. Due to the non-stationarity of the series its 4-quarter moving average is used in the estimations.
Δv_t	the rate of growth of base velocity averaged over previous 16 quarters

3.1.2 Forward-looking Reaction Function

In a forward looking framework the instrument rate (quantity), x_t^*, is adjusted with regard to expected state of the economy as described by the dual gaps. Therefore:

$$x_t^* = \rho + \alpha\,[E(\pi_{t+n}|\,\Omega_t) - \pi^*] + \beta\,[E(\tilde{y}_{t+m}|\Omega_t)],\ \tilde{y}_t = (y_t - y^*_t) \quad (6)$$

If the policy maker wants to adjust the instrument variable gradually as in (1)

$$x_t = (1-\lambda)\,x_t^* + \lambda x_{t-1} + \upsilon_t \quad (7)$$

by substituting (7) in (6) we obtain:

$$x_t^* = (1-\lambda)\Phi + (1-\lambda)\alpha[E(\pi_{t+n}|\,\Omega_t)] + \beta[E(\tilde{y}_{t+m}|\Omega_t)] + \lambda x_{t-1} \quad (8)$$

The empirical forward looking reaction function can be estimated with the generalized Method of Moments (GMM) and the result of the estimations are shown in table (3).[1] The results shown in table (3) indicate that in the forward-looking estimate of McCallum rule the sign of income gap coefficient is positive but not significant. Therefore, CBI's policy reactions do not follow this rule. The common feature of the McCallum rule estimates (both backward and forward looking versions) is that much of the variation in the growth rate of the instrument is explained by its own lag. The coefficients on lagged policy instrument are relatively high and statistically significant, indicating that the inertial growth of money base (business as usual) dominates other variables.

The estimation results of hybrid and modified McCallum's rules indicate that CBI had an accommodating stance regarding the inflation gap.[2] This means that even when the rate of inflation is above the target, the growth rate of monetary base is not reduced to dampen inflationary forces.

Due to the potential presence of fiscal dominance and the effects of oil expenditures on the monetary base[3], we also tested the above regressions with one of the components of monetary base which *a priori* CBI should have more control over it and it is not systematically linked to oil revenues.

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1. $E\,[x_t - (1-\lambda)\Phi - (1-\lambda)\,\alpha\pi_{t+n} - (1-\lambda)\beta\, y_{t+m} - \lambda\, x_{t-1} \,|\, \Lambda_t\,] = 0$
where Λ is a set of instrumental variables and a subset of the information set of the policy maker.
2. For instance the regression equation for the hybrid McCallum-Taylor model is of the following form:
$\Delta MB_t = c_{H1} + \theta_{H1}\Delta MB_{t-1} - \gamma_{H1}E_t(\pi_{t+1} - \pi_t^*) + \lambda_{H1}E_t(y_{t+1} - \tilde{y}_t) + \delta_{H1}\Delta(e_m - e_0).$
3. To test the existence of fiscal dominance, a VECM with growth rate of monetary base and government expenditure was estimated. The results showed no evidence of long/short run relationship between these two variables. Estimation of the model with non-oil deficit as the fiscal variable did not change the result. We also extracted the common factor from four fiscal variables (current-government expenditures, development expenditures, tax, and oil revenue) and repeated the estimation using this (fiscal condition) factor. The coefficient of this factor is not statistically significant, hence does not explain variations in growth rate of monetary base.

Table 2: OLS estimates of contemporaneous/backward-looking reaction functions

Policy rules	Taylor's rule		Extended Taylor Rule	McCallum rule	Modified McCallum rule	Hybrid rule			
Dependent variable	ΔR_t		ΔR_t	ΔMB_t	ΔMB_t	ΔMB_t		ΔBD_t	
Coefficients									
Intercept	-0.000665 (0.3083)	-0.000632 (0.3413)	-0.0016 (0.3612)	0.0678*** (0.0037)	0.0762*** (0.0014)	0.0602*** (0.0008)	0.0667*** (0.0004)	0.09* (0.0797)	0.096 (0.071)
ΔR_{t-1}	-0.0278 (0.8177)	-0.0303 (0.8031)	-0.0338 (0.7814)						
ΔMB_{t-1}				0.6422*** (0.0000)	0.593*** (0.0000)	0.663*** (0.0000)	0.628*** (0.0000)		
ΔBD_{t-1}								0.713*** (0.0000)	0.756*** (0.0000)
$\Delta x_t^* - \Delta x_{t-1}$				-0.159 (0.1226)	-0.0864 (0.4335)				
Δv_t				-0.0271 (0.3982)	-0.0258 (0.4154)				
$y_t - \tilde{y}_t$	0.00079 (0.9765)		0.0037 (0.8932)			-0.057 (0.8697)		3.818* (0.06)	
$\pi_t - \pi_t^*$	0.00875 (0.1633)		0.0085 (0.1826)		0.174* (0.0987)	0.193** (0.0326)		1.394** (0.0137)	
$y_{t-1} - \tilde{y}_{t-1}$		-0.0099 (0.7142)					-0.153 (0.6596)		2.73 (0.1983)
$\pi_{t-1} - \pi_t^*$		0.0087 (0.1778)					0.2188** (0.0202)		1.209** (0.0478)
$\Delta(e_m - e_o)$			0.00017 (0.5164)			0.00208 (0.6699)	0.00219 (0.6651)	-0.00048 (0.9862)	0.0077 (0.7961)
R^2	0.028	0.029	0.039	0.52	0.54	0.58	0.57	0.56	0.54

Note: *, ** and *** indicate significance at 10, 5 and 1% respectively. Numbers in parentheses are the p-values of the estimates. We consider a dummy variable for 2002 year –in which unification of formal and market rate of exchange rate occurred- in extended Taylor rule regression.

Table 3: GMM estimates of forward looking reaction functions

Policy rules	Taylor's rule	Extended Taylor Rule	McCallum's rule	Modified McCallum's rule	Hybrid rule	
Dependent variable	ΔR_t	ΔR_t	ΔMB_t	ΔMB_t	ΔMB_t	ΔBD_t
Coefficients						
Intercept	-0.00038 (0.2425)	-0.0106 (0.0845)	0.00072 (0.9775)	0.0314 (0.1868)	0.0194 (0.6039)	0.2089** (0.0143)
ΔR_{t-1}	0.402 (0.0138)	0.00805 (0.9275)				
ΔMB_{t-1}			0.917*** (0.0000)	0.759*** (0.0000)	0.745*** (0.0000)	
ΔBD_{t-1}						0.7963* (0.0706)
$\Delta x^*_{t+n} - \Delta x_{t+n-1}$			0.1079 (0.3428)	0.1446 (0.2564)		
Δv_t			0.088** (0.0217)	0.07318* (0.0723)		
$y_{t+m} - \tilde{y}_{t+m}$	0.0199 (0.047)	0.045 (0.6755)			-0.372 (0.2786)	4.962 (0.2954)
$\pi_{t+n} - \pi^*_{t+n}$	0.0018 (0.37)	0.0057 (0.5259)		0.2601*** (0.0017)	0.3968*** (0.002)	2.782** (0.0179)
$\Delta(e_m - e_o)$		0.0015 (0.067)			-0.0151 (0.3239)	-0.0053 (0.9575)
R^2	-0.16	-0.54	0.41	0.46	0.29	0.41
J-statistic	0.058	0.022	0.075	0.0478	0.0371	0.0368

Notes: GMM generalized method of moments. The instruments used in estimations are lags 2 and 3 of the instrument, and lags 1 and 2 of the output gap, inflation, the growth rate of nominal exchange rate and oil revenues. *, ** and *** indicate significant at 10, 5 and 1% respectively. Numbers in parentheses are the p-values of the estimates. The J-statistic tests the validity of the over-identifying restrictions for the GMM estimations.

Net lending of CBI to the banking system seems to fit this criterion more than any other component of base-money. As indicated in both tables (2) and (3) banking system debt to CBI (DB) is the dependent (instrument) variable. The results indicate that changes in DB are positively related to the inflation gap, indicating an accommodating stance with regards to inflation in both backward and forward-looking estimates of the hybrid McCallum rule. Therefore, we can conclude that in all versions of the McCallum rule, there is no evidence for an inflation-fighting stance. If anything, the results indicate tendency for inflation accommodation.

3.2. Threshold Effects and Non-linear Policy Rules

In the previous section, we tested simple linear instrumental rules to determine if CBI behaves according to a standard reaction function with linear specification in terms of the level of the inflation and output gap. In this part, we revisit the same question but with the conjecture that there might be some degree of asymmetry in CBI’s preferences whenever the inflation rate exceeds a certain threshold, and examine the threshold effects in monetary policy behavior using threshold regressions. Despite the fact that the linear instrumental rules, as developed by McCallum's (1988) and Taylor (1993), have been a useful tool for evaluating monetary policy of central banks, these simple rules may not be suitable if monetary policy decision making process involves asymmetric behavior with respect to the target variable(s). By formulating the policy rule as a threshold process, we allow the central bank to take action more aggressively under some circumstances (e.g. high inflation or a negative output gap) than in others (low inflation and a positive output gap).

There are a number of studies that show non-linearities in the monetary policy rules, especially Taylor rule (Taylor and Davradakis 2006, Bunzel and Enders 2010). Martin and Milas (2004) and Taylor and Davradakis (2006) papers provide evidence that the Bank of England tightens monetary policy in a non-linear fashion if the actual inflation rate goes out of a zone around the target inflation rate. Taylor and Davradakis (2006) find that their estimated Taylor rule exhibits significant non-linearity. During the periods when inflation rate is within a half percent or so below the target rate of 2.5 percent annual rate, the

Taylor rule falls into a random walk mode, that is, interest rate adjustments approximately follow a random walk and seem to be unrelated to expected inflation. In contrast, when the inflation rate exceeds the target by about 0.5 percent, it appears that the Bank of England follows a forward-looking Taylor rule with highly significant coefficients. Bunzel and Enders (2010) examined whether the Federal Reserve would act more aggressively when the rate of inflation is high compared to periods when it is low, by formulating the Taylor rule as a threshold process. They use both the inflation rate and output gap as threshold variables. They make a case that the Federal Reserve responds more to a negative than a positive output gap. They found out that a modified threshold model that is consistent with an "opportunistic monetary policy" (the state of high inflation and negative output gap) could provide a better explanation for Federal Reserve behavior.[1]

3.2.1. Testing for Model Non-linearity

We perform a threshold effect test to determine whether there is a statistically significant non-linearity in the reaction functions estimated in the previous section. In order to test the existence of nonlinearity, we follow the approach proposed by Terasvirta (1994) to test linearity in smooth transition auto-regressive models (STAR)[2]. The linearity test with respect to inflation rate is performed on the following regression:

$$\begin{aligned} \Delta MB_t &= \gamma_0' Z_t + \sum_{j=1}^{3} \gamma_j' Z_t \pi_t^j + \varepsilon_t \\ Z_t &= (1, \Delta MB_{t-1}, \pi_t, (y_t - \tilde{y}_t))' \end{aligned} \tag{9}$$

If the Null hypothesis $H_0 = \gamma_1 = \gamma_2 = \gamma_3 = 0$ is not rejected, then the non-linear regression can be reduced to a linear form ($\Delta MB_t = \gamma_0' Z_t + \varepsilon_t$). We also carried out this test to examine the existence of non–linearity with respect to RGDP gap. The results of these tests are reported in table (4).

1. Mandler (2012) provides evidence of threshold effect with respect to inflation for the Deutsche Bundesbank, based on real time data.
2. Since threshold regression is nested in smooth transition regression (STR), this test of linearity is more general than corresponding test in threshold regression.

Table 4: Results of non-linearity test

	Test Statistics (chi-square)	Probability
π_t	20.2	0.0167
$(y_t - \tilde{y}_t)$	10.68	0.2982

According to results in table (4), the null hypothesis regarding the non-linearity of regression with respect to inflation rate is rejected within the 5% confidence level. The null hypothesis is conducted with a Wald test of restriction on coefficients as: $\gamma_1 = \gamma_2 = \gamma_3 = 0$. The test statistic (20.2) and the P-value of the test (0.0167) indicate that the non-linearity cannot be rejected. However, there is no evidence of nonlinearity with respect to RGDP gap.

3.2.2. Inflation Rate as the Threshold Variable

To examine the conjecture of policy asymmetry, a nonlinear monetary policy reaction function that allows the existence of two policy regimes—in which the weights of inflation and output deviations differ in the two—instead of a linear rule, is specified. The switch in policy depends on whether the inflation rate is above or below a threshold value. Through estimation of nonlinear policy rules, we want to find out if ignoring possible asymmetric reaction of the monetary instrument to the inflation variable might lead to misleading results. If there is no asymmetry in policy maker's behavior when inflation is high or low, the results of linear policy rules should be consistent.

Similar to the cited studies, a simple way for taking into account nonlinearities in policy behavior is to estimate a threshold model whereby the policy rule switches into a different regime whenever a certain variable—in this case, inflation rate-exceeds the threshold level.[1]

1. In line with the literature on threshold monetary rule it seems natural to explore the possibility of a threshold model in which the central bank acts aggressively when the rate of inflation is high. This, however, does not preclude output gap as another natural candidate for the threshold variable.

We start by assuming that the growth rate of monetary base (the instrument) might be subject to two different regimes depending on whether the inflation of the previous quarter (π_{t-1}) is above or below the threshold level ($\bar{\pi}$). If π_{t-1} is below that level, the growth rate of monetary base will follow an autoregressive process—indicating business as usual. However, once inflation rises above a given threshold level the central bank may assume a stronger stance by cutting more aggressively the growth rate of monetary base to upward movements in the rate of inflation. Let the growth rate of monetary base to respond to changes of inflation and output-gap according to the hybrid rule mentioned in first section. This would suggest a two-regime model.[1]

$$\Delta MB_t = \alpha_0 + \alpha_1 \Delta MB_{t-1} + \alpha_2 \pi_t + \alpha_3 (y_t - \tilde{y}_t) + \varepsilon_t \qquad if\ \pi_{t-1} > \bar{\pi}$$

$$\Delta MB_t = \beta_0 + \beta_1 \Delta MB_{t-1} \qquad if\ \pi_{t-1} \le \bar{\pi} \tag{10}$$

where the disturbance term (ε_t) is assumed to be white noise. Note that this model nests the simple linear hybrid rule model in first section. If $\bar{\pi} = 0$, then the auto-regressive process in (10) does not stand because we know that in the case of Iran, inflation over the sample period is considered to be not negative. The equations in (10) may also be written as:

$$\Delta MB_t = (\alpha_0 + \alpha_1 \Delta MB_{t-1} + \alpha_2 \pi_t + \alpha_3 (y_t - \tilde{y}_t)) D(\pi_{t-1} > \bar{\pi}) + (\beta_0 + \beta_1 \Delta MB_{t-1}) D(\pi_{t-1} \le \bar{\pi}) + \varepsilon_t$$

where D is a dummy variable. In order to estimate $\bar{\pi}$, we follow the approach suggested by Hansen (1996). The threshold $\bar{\pi}$ can be estimated through sequential conditional least-squares estimation (CLS). For each possible value of the threshold parameter, we estimate the above equation and keep the sum of squared errors. This procedure is repeated from the 15th up to the 85th percentile

1. In order to test the robustness of policy rule estimation regarding to the definition of growth rate, in this part we define the growth rate of monetary base and the rate of inflation as quarterly change (instead of annual change considered in linear estimation). We will show that changing the definition of growth rate does not change the results significantly.

of the threshold variable (inflation rate) so that each regime includes an adequate number of observations. The LS estimator for $\bar{\pi}$ is the value that minimizes the sum of squared errors:[1]

$$\bar{\pi}^{*} = \arg\min \mathrm{SSR}(\bar{\pi}) \tag{11}$$

Hansen (1996) has shown that a grid search that minimizes the total sum squared residuals will provide consistent estimates of both the thresholds and the model parameters.

3.2.3. Estimation of the Threshold Models

The result of estimating the threshold model (equation 10) using Hansen (1996) approach is shown below:

$$\begin{aligned} \Delta MB_t = {} & (\underset{(0.001)}{10.6} - \underset{(0.002)}{0.80}\Delta MB_{t-1} - \underset{(0.926)}{0.045}\pi_t - \underset{(0.0304)}{1.02}(y_t - \tilde{y}_t))D(\pi_{t-1} > 5.76) + \\ & (\underset{(0.000)}{6.2} - \underset{(0.000)}{0.41}\Delta MB_{t-1})D(\pi_{t-1} \le 5.76) + \varepsilon_t \end{aligned} \tag{12}$$

R^2=0.26 adjusted R^2=0.22 D-W=1.84 SSR=3374

Note: numbers in parenthesis are P-values.

The estimated value of the threshold is 5.76 percent or about 23% of annual rate. On this basis, we consider two regimes: a high inflation regime, if quarterly inflation is above 5.76% and a low inflation regime below this threshold. As shown in equation (12) with the non-linear rule, the sign of the coefficients of inflation rate and output gap are consistent with what is generally expected; they are both negative, implying anti-cyclical output and an anti-inflation stance. However, note that while the coefficient of output is significant at the 5% level, the coefficient of inflation is not. In addition, the coefficient of the lagged value of the instrument (MB_{t-1}) is highly significant in both regimes. This result indicates that during higher than threshold inflation level, CBI did not undertake measures to counter inflation but assumed an anti-cyclical stance regarding the output gap.

1. For estimating the TR model, a program was written in Eviews 7.

An alternative way to define the threshold level for inflation is to average inflation rate in the preceding two quarters. We estimated equation (10) using this definition of a threshold:

$$\Delta MB_t = \alpha_0 + \alpha_1 \Delta MB_{t-1} + \alpha_2 \pi_t + \alpha_3 (y_t - \tilde{y}_t) + \varepsilon_t \quad \text{if } (\pi_{t-1} + \pi_{t-2})/2 > \bar{\pi}$$
$$\Delta MB_t = \beta_0 + \beta_1 \Delta MB_{t-1} \quad \text{if } (\pi_{t-1} + \pi_{t-2})/2 \le \bar{\pi} \tag{13}$$

the results are shown in equation (14).

$$\begin{aligned}\Delta MB_t = {} & (11.3 - 0.602\Delta MB_{t-1} + 0.13\pi_t - 0.043(y_t - \tilde{y}_t))D((\pi_{t-1} + \pi_{t-2})/2 > 6.032) + \\ & (0.009) \quad (0.004) \quad \big(0.817) \quad (0.925)\big) \\ & (6.07 - 0.45\Delta MB_{t-1})D((\pi_{t-1} + \pi_{t-2})/2 \le 6.032) + \varepsilon_t \\ & (0.000) \quad (0.000)\end{aligned} \tag{14}$$

R^2=0.27 adjusted R^2=0.23 D-W=1.89 SSR=3335.6

Note: numbers in parenthesis are P-values.

As shown by equation (14), the estimated threshold is around 6%. The coefficient of inflation rate is positive and statistically insignificant. Therefore, the hypothesis regarding a change in monetary policy stance in the direction of combating inflation during high inflation periods cannot be confirmed, which is consistent with the previous findings in this paper.

We also tested with another form of threshold model for conducting monetary policy as follows:

$$\begin{aligned}\Delta MB_t = {} & \alpha_0 + \alpha_1 \Delta MB_{t-1} + (\alpha_2 \pi_t + \alpha_3 (y_t - \tilde{y}_t)) * D((\pi_{t-1} + \pi_{t-2})/2 > \bar{\pi}) + \\ & (\beta_2 \pi_t + \beta_3 (y_t - \tilde{y}_t))D((\pi_{t-1} + \pi_{t-2})/2 \le \bar{\pi}) + \varepsilon_t\end{aligned} \tag{15}$$

In this model, we assume that CBI's preferences regarding the target variables change in each regime, instead of considering the auto regressive process for low inflation regime. In (15) α_2 and β_2 are the weights that central bank assigns to inflation rate in high and low inflation regimes, respectively, and in a similar way to output gap. Therefore, the sample of observations is separated depending on the level of inflation (above or below the threshold). The results of estimating this model are shown in equation (16):

$$\Delta MB_t = \underbrace{9.48}_{(0.000)} - \underbrace{0.465}_{(0.000)}\Delta MB_{t-1} + (\underbrace{-0.185}_{(0.559)}\pi_t - \underbrace{0.58}_{(0.125)}(y_t - \tilde{y}_t)) * D((\pi_{t-1} + \pi_{t-2})/2 > 4.425) +$$
$$(\underbrace{-0.942}_{(0.082)}\pi_t + \underbrace{2.1}_{(0.0035)}(y_t - \tilde{y}_t) * D((\pi_{t-1} + \pi_{t-2})/2 \le 4.425) + \varepsilon_t \quad (16)$$

R^2=0.30 adjusted R^2=0.26 D-W=1.89 SSR=3204.9

Note: numbers in parenthesis are P-values.

The estimated threshold level is 4.42%. R^2 is higher in this model compared to the first and second models (equation 10 and 13), SSR is smaller. When the average inflation rate in the preceding two quarters is equal or less than 4.42%, the coefficient of output gap is positive and significant. This means that during “low inflation periods”, CBI conducts expansionary monetary policy which accommodates increases of the output gap, instead of closing the gap by reducing the growth rate of MB. The coefficients on inflation in high and low regimes are both negative but only significant (at 10%) in the low inflation regime. The narrative that can be read from (16) is that, if negative supply shocks are absent in and the "low inflation" states, CBI's policies tend to support economic activity. However, during "high inflation" periods, presumably when negative supply shocks are present, CBI does not exercise anti-inflation policy but such a policy does not accommodate output growth. In this state, CBI seems to be ineffective in managing the economy.

4. Summary of Empirical Results and Concluding Remarks

Simple instrument rules are useful ways to describe policy stance and the reaction of the monetary authority to changing macroeconomic conditions. We presented estimates for several forms of reaction functions that are widely cited in the literature. Moreover, we estimated various hybrid rules, particularly those in which the growth rate of monetary base serves as the instrument, with inflation, exchange rate, and output gaps as the target variables. Based on the empirical results obtained from all estimations of standard and hybrid versions of the linear (for the 1990:2-2010:1 period) and non-linear policy rule (for the 1990:2-2011:3 period), it is clear that CBI did not follow a specific monetary policy rule and did not respond to inflation rate and output gap in the conventional counter-cyclical manner. We tested for (non-linear) threshold effects and we could not reject the hypothesis of non-linearity for inflation. Threshold estimates show that when inflation is below the threshold, usually when positive supply and terms of trade shocks are present, monetary policy is in a position to accommodate output. When the inflation rate is above the estimated threshold levels, often corresponding to periods when negative supply shocks are present, CBI did not react to inflationary pressures by assuming an inflation-fighting stance and the trend growth in money (business as usual policy) did not accommodate output growth. Monetary policy seems to be ineffective in this state.

What stands out in the empirical tests carried out in this paper is the persistence displayed by the policy instruments, in particular, monetary-base growth rate. This implies a process in which either the policy-maker elects to stick with a policy of accommodation in spite of an ongoing moderate inflation rate in the economy—with occasional fluctuations or flare ups of inflationary pressures—perhaps, due to potentially high cost of breaking the inflationary process, as was experienced in a number of developed countries in the 1970s and the early 1980s. Or, other forces impinge the policy maker to follow an accommodating monetary stance. In both cases the result could be chronic inflation, a phenomenon that was observable in a relatively large number of emerging economies, but at long last, it has become a less frequent occurrence due to implementation of macroeconomic reforms and institutionalizing disciplined monetary policies. Economic history has shown that individuals and economic systems can live with moderate chronic inflation for extended periods of time, because, in many circumstances, the stake holders' incentive for changing it is not sufficiently strong. In the absence of large external shocks, the rate of inflation in the "moderate chronic inflation" regimes fluctuates around an average rate; 15 to 30 per cent, for the countries in the sample examined by Dornbusch and Fischer (1993) and 17.11 per cent per annum in Iran during 1989-2010. Under this regime inflation indexation provides some protection for the workers; higher prices are passed on by firms to consumers, and inflation tax helps government financing. Periodic nominal wage and price adjustments are the ordinary measures to compensate for the ongoing price and cost inflation. With full and partial indexation, wages are set to capture all or part of past inflation. Firms periodically adjust their prices to cover higher costs.[1] In such a setting, monetary growth becomes endogenous with respect to the nominal rescaling of the economy and fiscal (and quasi-fiscal) exigencies dictate money supply growth with little or limited reaction to the evolving macroeconomic conditions (e.g. inflation) by the central bank. Since the economic and political costs of stopping chronic inflation are significant, ending persistent inflation has always been a challenge to policy makers. In the absence of monetary policy autonomy, fiscal discipline, and structural measures to enhance productive capacity, demand-side growth and redistributive policies requires monetary and credit expansion.[2] Prolongation of these policies generates chronic inflation and an accommodating monetary process.

1. This behavior may be influenced by the particular legal and administrative setups for wage-bargaining and price adjustments and the frequency with which they allow wage and price adjustments.
2. This policy approach has been practiced in various parts of the world. "Latin America's economic history seems to repeat itself endlessly, following irregular and dramatic cycles. This sense of circularity is particularly striking with respect to the use of populist macroeconomic policies for distributive purposes. Again and again, and in country after country, policymakers have embraced economic programs that rely heavily on the use of expansive fiscal and credit policies and overvalued currency to accelerate growth and redistribute income." Dornbusch and Edwards (1991), p. 7.

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