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THE EFFECT OF MONEY VOLUME GROWTH ON FORMATION AND STABILITY OF INFLATION REGIMES IN IRAN ECONOMY

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Abstract: In this paper an attempt is made to study the role of monetary policy of the central bank in the increasing of money volume growth and its effects on both formation and stability of inflation regimes in Iran economy using seasonal data from 1989-2016. Accordingly, in some models, Markov switching model may have been explained by supposing the confirmed and explained transition probabilities have been expanded by inflation rate variable. Based on the results of the modeling, in medium inflation regime and high inflation rate regime, the meaningful effect of money volume growth on inflation was not identified. The results of Markov switching model with explained transition probabilities have indicated the positive effect of money volume growth in continuing the medium inflation periods in Iran economy.

Keywords: Money volume growth, inflation regime, Markov switching model.

1. INTRODUCTION

Long term movements at the same time with money volume growth and inflation in a wide range of countries in different time periods have been confirmed so that we can mention the studies of Locus (2008), Benati (2009), and Sarginet and Sorico (2008). In most studies, documents and reasons about changes along with money volume growth and inflation variables have been studied, by observing the smoothed values, based on moving average or frequency domain technique. While these techniques are useful in identifying the relevant experimental relation, their results for outer time period of the studied sample in not reliable, so that in this case, it is not considered as a reliable tools for future policy makings (Amosano and Fagan, 2010). Accordingly in international studies, some of the standard predicting techniques are expanded based on Philips' curve models (Gerlach, 2004) or predicting models of unique linear equations (Nicoletti, 2001; Fisher, Lenza, Pill, and Reichlin, 2008) have been used. These studies show that passed money volume growth include useful information about future inflation so that they represent simple and surface relations of such a relationship; however, in recent years (especially for low and constant inflation) in most studied countries, the relationship between money volume growth and inflation has been weak and the predicted powerful relations to infer the surface results from affectivity of the money volume (and the wide spectrum of other variables) have been weak for the future. In this case we can point to the results of Stock and Watson studies (2006), America and lenza (2006) and for Euro zone. The reason of the above studies results is that in a low inflation regime, in fact the correlation between money volume growth and inflation may be realized weakly and the money volume growth based on predicted inflation has less value but this conclusion is reliable as long as the economy remains in the regime with low inflation because as Estrella and Mishkin (1997) velocity shocks have tendency to fade or delete the signals releasing from money volume in low inflation regime. So it is possible that the money volume growth sends important and

on time notice signals about the danger of exiting the economy from a fixed price regime (or any price regime) and moving it to another price regime. In this article it was tried to study such a supposition for Iran economy. For this purpose, according to Evans and Wachtel (1993) for USA and Ayuso, Kaminsky and López-Salido (2003) for Spain and Ricketts and Rose (2003) that inflation is supposed as Markov change process that inflation rate is controlled and guided by regime change process in which inflation will be changed from low inflation regime to high inflation regime or vice versa. In this study, based on Abiad studies (2003), Filardo (1994), Kim and Nelson (1999) it is supposed that movement probability to other outer variable is a closed model. This way of thinking leads to an inflation process modeling that is different from the standard linear methods which have been used by many texts, so that inflation will be specified by the model of regime change in which potential economy can change between low and high inflation rate. The purpose of expanding this model is to extract long term relation between money and inflation so that it proved the possibility of using an inflation notice index based on money volume for policy makers so that the above index is changed in different inflation regimes.

It is possible that in some inflation regimes, money volume is not necessarily useful for predicting the inflation in future periods. However, money volume growth plays an important role in signing the probability of changing the economy from the regime with low inflation to the regime with high inflation. Meanwhile, the results of this index are dependent on last relation between money volume growth and inflation, this relation probably will be found in the data of samples in which central bank didn't have suitable reaction against the inflation dangers and completely was not successful in keeping the prices fixed. On the other hand, based on Woodford's (1994) study, if the central bank reacts to the inflation dangers in a period of time by money and other indexes and fix the prices successfully, probably it will show the weak forward index standard experimental tests for predicting the future inflation. Therefore, based on high inflation in Iran economy in recent decades, another question that is studied in this study is the role of monetary politics of the central bank in moving the high inflation regime to a low one (and vice versa).

This study is organized in five chapters, in the second chapter the research background of the mentioned theories about the relation between inflation and money volume and the research background of domestic were represented. In the third chapter the theoretical bases of the study have been represented, in the fourth chapter the results of the analysis of the data were presented. Finally, in the fifth chapter the results of the study have been presented.

2. METHOD

2.1. Markov Switching Model

Recently, some experimental models, have emphasized the relation between the content of change in commercial eras and change in regime (Krolzig 1997, Clements and Krolzig 1998, 2000; Diebold and Rudebusch 1996; Kim and Nelson 1998, 1999). The basic advantage of change process in the regime is their abilities in acquiring the nonlinear event to model the time asymmetry as well as final conditions that will be reminded in economy time series (Diebold, 1986; Hamilton and Susmel 1994). In order to study the way of affecting the money volume growth on the inflation, first in Markov switching model it is supposed that increasing the prices level (Δp_t) follow a p-th order autoregressive process:

$$\Delta p_t = c(S_t) + a_1(S_t)\,\Delta p_{t-1} + \cdots + a_p(S_t)\Delta p_{t-p} + \varepsilon_t \quad (1)$$

If S_t gets M the different representative value by integer 1, 2, 3, …, M, the relation (1) a combination of M shows the auto regression model. In a two-regime case, model (1) shows the low inflation situation (when $S_t = 1$) as well as high inflation (when $S_t = 2$) in the variable of prices level growth. So, a growth of low prices level can be shown as below relation (2):

$$\Delta p_t = c_1 + a_{11}\Delta p_{t-1} + \cdots + a_{p1}\Delta p_{t-p} + \varepsilon_t \quad (2)$$

While if the growth of the prices level is high will be modeled as relation (3):

$$\Delta p_t = c_2 + a_{12}\Delta p_{t-1} + \cdots + a_{p2}\Delta p_{t-p} + \varepsilon_t \quad (3)$$

The parameters of conditional process are dependent on a regime that is supposed to be accidental and invisible. So, in order to describe the created process completely, describing the modeling regime creation process is necessary. By supposing two regimes ($i = 2$), the regime

will be shown by hidden variable S_t. Transferring between regimes is controlled through first place Markov process by Hamilton (1989) and is as below relation (4).

$$\begin{aligned}(\mathrm{P}(s_t = 0/s_{t-1} = 0) &= p_{00}\\ (\mathrm{P}(s_t = 0/s_{t-1} = 1) &= 1 - p_{11}\\ \mathrm{P}(s_t = 1/s_{t-1} = 0) &= 1 - p_{00}\\ \mathrm{P}(s_t = 1/s_{t-1} = 1) &= p_{11}\end{aligned} \quad (4)$$

In relation (4) current regime S_t is dependent on last regime S_{t-1}. In addition p shows the probability that economy in the time t change from situation 1 (or 0) to situation 0 (or 1). We can summarize these transition probabilities in a matrix (2 × 2) as $\begin{bmatrix} p_{00} & 1-p_{11} \\ 1-p_{00} & p_{11} \end{bmatrix}$ that in sum the probabilities are equal 1. Based on Hamilton and Susmal (1994) Cai (1994) and Henry (2009) by this supposition that primary transition probabilities is true, their functional form is as relation (5):

$$p_{00} = \frac{e(\theta_0)}{1+e(\theta_0)} \quad \text{and} \quad p_{11} = \frac{e(\partial_0)}{1+e(\partial_0)} \quad (5)$$

2.2. Effects of Money Volume Growth on Inflation

This purpose of this section is to answer the question as to whether money volume growth affects inflation or not. The dynamic relation between money volume growth and inflation will be discovered by adding delayed coefficient of the money volume growth variable to Markov switching model for Δp_{t-i} At first, an expansion of relation (1), that has been introduced as Markov switching Intercept (MSI) model are estimated as relation (6) and (7):

$$\Delta p_t = c(\mathrm{S}_t) + \sum_{i=1}^{p} a_i(\Delta p_{t-i}) + \sum_{j=1}^{q} \gamma_j \Delta m^*_{t-j} + \varepsilon_t \quad (6)$$

$$\varepsilon_t \sim \mathrm{IID}(0, \delta^2) \quad (7)$$

In relation (6), Δm^*_t is the money growth. In addition S_t is a hidden variable that shows inflation situation. Relation (6) denotes that a change in Intercept $c(S_t)$ is a smooth deviation from increasing the prices level after changing in the regime. Note that model MSI, by supposing the same variance is the relation (7), in addition model (6) – (7) can be generalized in to two general directions:

Because inflation rate oscillation in low inflation state is generally different from high inflation state, by expanding one-variable model, we can combine a regime variable variance of disorder expression as relation (8) in mentioned models.

$$\varepsilon_t \sim \mathrm{IID}(0, \delta^2(S_t)) \quad (8)$$

Relations (6)-(8) define the MSI-heteroskedastic (MSIH).

The second direction deals with the parameters of the autoregressive part of the MSI models, which become functions of the state variable S_t. Formally, the MSI-autoregressive (MSIA) model is written as:

$$\Delta p_t = c(\mathrm{S}_t) + \sum_{i=1}^{p} a_i(\Delta p_{t-i}) + \sum_{j=1}^{q} \gamma_j(\mathrm{S}_t)\Delta m^*_{t-j} + \varepsilon_t \quad (9)$$

While the MSI-autoregressive-heteroskedastic (MSIAH) specification is obtained by combining Eqs. (8) and (9).

The way of estimating the maximum likelihood (ML) the above relations is based on Expectation-Maximization (EM) algorithm (Hamilton, 1989). The weakness of this model is that Brunetti et. al., (2008) claim that fixed transition probabilities is a limiting supposition and it seems that transition probabilities are dependent on economic variables and as the time waiting for stagnancy and splendor can be different but they have to be fixed over the time; based on Filardo and Gorgon (1998) by fixed transition probabilities, waiting times don't change on the cycles it means that outer shocks and great economy policy don't affect the probability of what time contraction or expansion could be constant. To solve this problem, since change in transition probabilities don't lead to change in waiting time (Filardo and Gorgon, 1989), in this time variable transition probabilities model have been entered into the model so that represent information about the direction of economy movement. For this purpose probability matrix p will be considered as dependent on X_{t-1}. So, time variable transition probabilities matrix will be formulated as relation (10):

$$\mathrm{P}(t) = p^t_{ij}(x_{t-1}) = \mathrm{P}\left(s_t = \frac{j}{s_{t-1}} = i, x_{t-1}\right)$$

$$= \begin{bmatrix} p_{00}^{t}(x_{t-1}) & 1-p_{11}^{t}(x_{t-1}) \\ 1-p_{00}^{t}(x_{t-1}) & p_{11}^{t}(x_{t-1}) \end{bmatrix} \quad (10)$$

In relation (10), X_{t-1} is information variable for changing the invisible regime form. In analyzing this study the variable of money volume growth information is (Δm_t^*) that not only affects the inflation rate average but also affects transition probabilities of inflation regimes. In relation (10) X_{t-1} is the information variable of adjusted money volume growth (Δm_{t-1}^*) in the period $t-1$. Filardo (1994) represented that the regime transition probabilities can be modeled as follow:

$$p_{00}^{t} = \Pr(s_t = 0) = \frac{e(\theta_0 + \theta_1 x_{t-1})}{1 + e(\theta_0 + \theta_1 x_{t-1})}$$
$$p_{11}^{t} = \Pr(s_t = 1) = \frac{e(\partial_0 + \partial_1 x_{t-1})}{1 + e(\partial_0 + \partial_1 x_{t-1})} \quad (11)$$

Based on relation (11), relation (12) is extractable.

$$\frac{\partial p_{00}^{t}}{\partial x_{t-1}} = \theta_1 p_{00}^{t}(1 - p_{00}^{t})$$
$$\frac{\partial p_{11}^{t}}{\partial x_{t-1}} = \partial_1 p_{11}^{t}(1 - p_{11}^{t}) \quad (12)$$

Filardo (1994) claimed that transition probabilities are negative ones. In addition they are functions of θ_1 and ∂_1 are the variable of adjusted money volume growth, for $\theta_1 > 0$, with positive shock in money volume growth, the inflation rate is willing to stay in zero regime and in contrast for $\theta_1 < 0$ with a positive shock in the money volume growth, inflation rate is more willing to stay in 1 regime.

3. RESULT AND DISCUSSION

3.1. Univariate MS Models

Analysis is started by testing the statistical characteristics of Markov switching model on inflation rate. At first it is necessary to determine the number of regimes and inflation rate auto regression sentence. After calculating the AIC criterion in kinds of Markov switching model of 2, 3 and 4-regime, all the Markov switching models in 2-regime have lower criterions AIC. Based on results, lag of autoregressive is meaningful only in lag one. In Table 1, testing the linear state study has shown the inflation rate:

Table 1
Models comparison

AR(3)	*MSIAH(2)-AR(3)*	*LR test statistica*
284.43	305.661	42.46***

Notes: The LR test statistic approximately follows a χ^2 distribution at the 1% significance levels.

Based on testing the likelihood ratio is $LR = 2 \times |\ln L_{MSIAH(3)-AR(3)} - \ln L_{linear\ AR}|$. According to the results of table (3) static χ^2 is a calculation in the meaningful level of 1% and the supposition of linear of time series in inflation rate is avoided. So, based on model results a classification is observed in two regimes. The estimated results MSIAH(2) – AR(1) model have been shown in Table 2:

Table 2
Estimated parameters of the MSH(2) – AR(3)

t-value	*Coefficient*	
	Regime 1	
11.248***	0.041	Intercept
9.903***	0.665	AR(1)
11.48***	0.009	Sigma
	Regime 2	
2.395**	0.048	Intercept
2.132**	0.624	AR(1)
5.08***	0.034	Sigma
Q(12) = 9.23	Q(11) = 8.92	

Notes: Figures in the parentheses are the *t*-values, ***, ** and * indicate significance at the 1%, 5% and 10% significance levels.

Based on estimated results, Intercept, autoregression coefficient and standard deviation in two estimated regime are in the meaningful level therefore MSIAH(2) – AR(1) model are selected as optimized models and structural changes while modeling process, the inflation rate should be considered.

In order to modeling the inflation rate series should be considered. In order to study the power of mentioned models in explaining the low and high inflation rate, transition probabilities in two models have been shown in Figure 1:

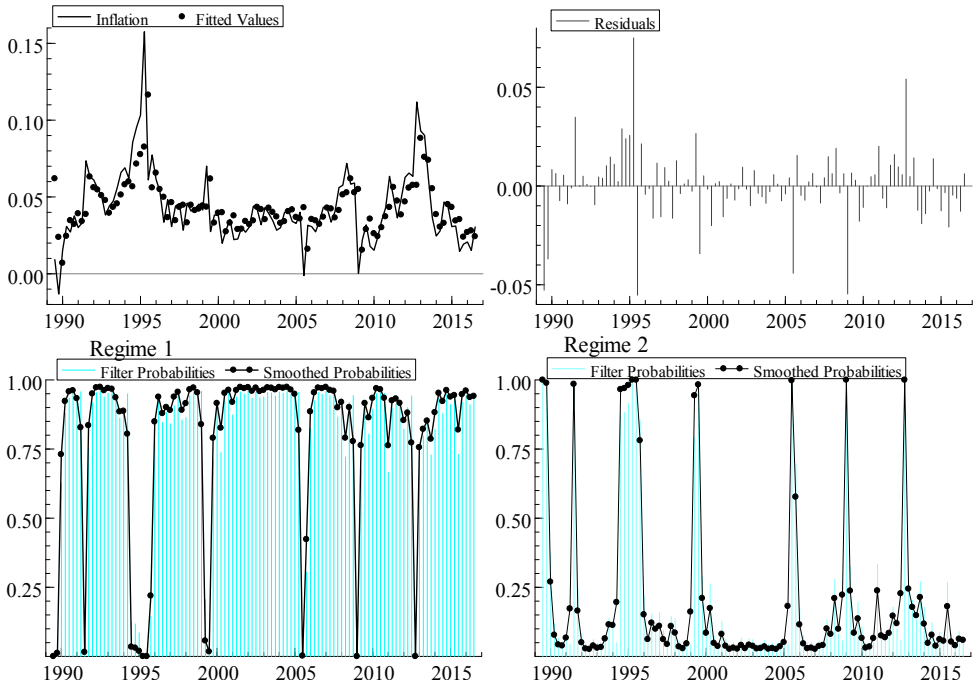

Figure 1: The estimated transition probabilities of MSIAH(2) – AR(1) model

Based on Figure 1, whatever regime probability in a period of time is nearer to 1, the probability of placing inflation rate in that regime is more in that period of time. Based on smoothed and filtered probabilities of model MSIAH(2) – AR(1), one-phase regime determines the medium inflation and two-phase regime determines the high inflation in Iran economy.

3.2. Effects of Money Volume Growth on Inflation with the Fixed Transition Probabilities

In this section in order to study the role of money volume growth in analyzing the inflation in Iran, Markov switching models was estimated and the inflation rate by accounting the money volume rate variable and with fixed transition probabilities have been expanded. The results from accounting the money volume rate variable are shown in MSIAH(2) – AR(1) model in which to the first delay the variable coefficient is meaningful. In Table 3 the results of MSIAH(2) – AR(1) model have been expanded and with a delay from money volume growth (MSIAH(2) – ARX(1)) has been represented:

According to estimated results of MSIAH(2)-ARX(1) model, the variable coefficient of the money volume rate in different regimes has not been recognized as meaningful.

Table 3
Rstimates of the MSIAH(2) – ARX(1) with fixed transition probabilities

t-value	*Coefficient*	
	Regime 1	
4.973***	0.034	Intercept
11.032***	0.668	AR(1)
0.531	0.025	Money volume growth
1.408	0.101	Money volume growth(1)
11.16***	0.009	Sigma
	Regime 2	
–0.207	–0.011	Intercept
1.736*	0.508	AR(1)
0.517	0.309	Money volume growth
1.211	0.635	Money volume growth(1)
5.5***	0.033	Sigma
Q(12) = 4.76	Q(11) = 10.73	

Notes: Figures in the parentheses are the *t*-values, ***, ** and * indicate significance at the 1%, 5% and 10% significance levels.

3.2. Effects of Money Volume Growth on Inflation the Explained Transition Probabilities

In this section we studied the role of first delay variable of money volume growth in the stability of Iran economy inflation regimes, based on relation (11) after

estimating model MSIAH(2) – AR(1) and considering explained transition probabilities by first delay of money volume growth, the parameters θ_0 and ∂_0 have been recognized as meaningless. So after omitting three parameters from the above model, the final model is as Table 4:

Table 4
Estimates of the MSIAH(2) – AR(1) with explained transition probabilities

t-value	*Coefficient*	
	Regime 1	
5.096***	0.034	Intercept
11.032***	0.667	AR(1)
0.519	0.024	Money volume growth
1.458	0.1	Money volume growth (1)
3.574***	36.55	θ_1
12.81***	0.009	Sigma
	Regime 2	
–0.197	–0.009	Intercept
1.723*	0.508	AR(1)
0.518	0.3	Money volume growth
1.28	0.634	Money volume growth (1)
–0.318	–2.4	∂_1
6.62***	0.033	Sigma
Q(12) = 5.35	Q(11) = 11.29	

Notes: Figures in the parentheses are the *t*-values, ***, ** and * indicate significance at the 1%, 5% and 10% significance levels.

According to estimated results of MSIAH(2) – ARX(1) model, the variable coefficient of the money volume rate in different regimes has not been recognized as meaningful but θ_1 is meaningful, so that the money volume rate positively affects transition probabilities of inflation regimes in regime 1. In Table 5 by using LR test, we studied the meaningfulness of considering the first delay of money volume growth variable in explaining the transition probabilities of model MSIAH(2) – AR(1).

Table 5
Models comparison

MSIAH(2) – ARX(1)	*MSIAH(2) – AR(1)*	*LR test statistica*
309.812	305.661	8.318***

Notes: The LR test statistic approximately follows a χ^2 distribution at the 1% significance levels.

Table 6
transition probabilities matrix

	Regime 1	*Regime 2*
Regime 1	0.883	0.451
Regime 2	0.116	0.548

In Table 6, the transition probabilities $\text{Prob}(s_t = 1 \mid s_{t-1} = 1) = 0.883$ and $\text{Prob}(s_t = 2 \mid s_{t-1} = 2) = 0.548$ show the reliability of the inflation rate regimes in Iran economy, more reliable the regime 1 related to regime 2 propose the probability of existing the important asymmetry in inflation rate phase in Iran economy. In addition, after medium inflation phases, by probability of 0.451 inflation rate enter into high inflation phase and after that by probability of 0.116, the inflation rate enter into medium inflation phase. In order to study the power of above models in explaining the low and high inflation rate, this has been presented in two regime model in Figure 2.

Based on smoothed and filtered probabilities, model MSIAH(2) – AR(1) by considering the probabilities have been explained, one-phase regime capture the medium inflation phase and two-phase regime capture the high inflation. In comparison with Figure 1, we see that by considering a delay from money volume growth variable, MSIAH(2) – AR(1) model is able to capture the low and high inflation phases with more accuracy, the above result shows the effect of money volume growth variable in determining the probable stability of low and high inflation phase of Iran economy.

4. CONCLUSION

According to the importance of inflation in Iran economy, we studied the role of monetary policies of the central bank in increasing policies of money volume growth and its effect on forming the high and medium inflation regime of Iran economy and the role of above policies in inflation regime stability of Iran economy by using seasonal data from 1990 to 2016. So, in some models, Markov switching model with the supposition of fixed and explained transition probabilities by inflation rate variable were expanded. Accordingly, the results have been achieved in this study as follow:

Based on likelihood ratio (LR) and Akaike Information Criterion (AIC), two-regime Markov switching autoregressive Heteroskedastic with 1

autoregression lag (MSIAH(2) – AR(1)) has been selected as optimized models. Results show the nonlinear state on inflation rate series in Iran economy.

According to smoothed and filtered probabilities of estimated model, one-phase regime determines the medium inflation and two-phase regime determines the high inflation in Iran economy. The calculated transition probabilities show the reliability of Iran economy inflation regime. More reliable regimes 1 related to regimes 2 propose the probability of existing important asymmetry in the phases of high and medium inflation in Iran economy.

According to modeling results, the meaningful effect of money volume rate on inflation was not recognized. In addition, the results of Markov switching model with explained transition probabilities claim that they have positive effect of money volume growth in continuing the medium inflation periods in Iran economy. But the effect of money volume growth in continuing the high inflation regime has not been identified as meaningful.

According to the modeling, inflation increase factor in high inflation periods in Iran economy cannot be described based on some money theory and other factors as supply direction inflation and or structural inflation act as inflation continuity factor in high inflation periods in Iran economy. So, only in medium inflation periods in Iran economy, by limiting the money volume growth we can mostly prevent the inflation development in Iran economy.

The results of this study show the significant role (not complete) of money volume growth in continuing and positive effect on Iran economy inflation only in medium inflation periods. So, it is proposed that in future researches, we study other factors determining inflation in Iran economy especially in high inflation regime in economy.

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