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Non-Linear Inflationary Dynamics based on the Concept of Missing Money in Iran

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In this research, non-linear inflationary dynamics based on the concept of missing money is studied using the threshold autoregressive models based on seasonal data of the time interval (1990:04-2016:07) for the economy of Iran. The finding of the research shows that simple and Divisia liquidity growth variables are determined as threshold variables, and inflation reacts to changes in the growth of money through a three-regime process. The variables of simple liquidity growth, Divisia liquidity growth with a time lag and inflation expectations are the most critical factors influencing inflation. In both clarifications, GDP has anti-inflationary effects. In both models, the exchange rate has a stronger and positive impact on inflation than other policies under expansionary monetary policy conditions. The simple liquidity growth variable in the low monetary growth policy, due to the stimulation of economic activities shows anti-inflationary effects, and in the medium-term monetary growth, the policy explains the expected inflationary effects. Lagged Divisia liquidity growth in these policies always shows visible inflationary effects. It seems that the use of Divisia liquidity variable instead of a simple liquidity variable explains the non-linear behavior of inflation in a more satisfactory way.

Keywords: Inflation, Non-Linear Dynamic, Simple and Divisia Monetary Aggregates, Threshold Autoregressive Models.
JEL Classification*:* E31, E51, E52

1 Introduction

Given the importance of the phenomenon of inflation in economic activities, recognizing the dynamics of its behavior in modeling, forecasting, and policy-making in the macroeconomic field are of great importance. Generally, inflationary flows create instability of economic structures in the society, and the emergence of this phenomenon poses a serious threat to effective

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macroeconomic policy-making. Today, according to studies conducted in most countries, the relationship between money growth and inflation has been accepted, and from this perspective, money plays an essential role in balancing the price level. According to the theory of money, the effects of increasing money supply on the general level of prices do not appear quickly, and money changes over time influence prices, so the correct perception of the process of this effect can lead to explaining the real behavior of inflation in the economy. In many types of research, the impact of monetary policy in different inflationary systems have been evaluated asymmetrically, and the reasons for this are factors such as the instability of money demand and the interruption of monetary policy efficiency. In this way, the linear relationship between money growth and inflation has been weakened, and the power of forecasting inflation in the coming period has decreased through the channel of money growth. The studies of Arango and Gonzalez (2001), Greigorio and Kontanius (2009), Arize and Malindretos (2012) and Zoe (2013) confirm this. Also, Goldfeld (1976), by examining the US demand function for money, states that the money M1 definition is not stable and that the money demand function in the given period cannot be accurately estimated. He calls this a "missing money phenomenon" and believes that this phenomenon has led to a lack of proper forecasting of money demand. Therefore, the appropriate specification of money and monetary aggregates and paying attention to their effects on the economy is of particular importance. Many documents in the 1980s also show that the use of a monetary aggregate using simple sum has a poor performance, and questions have been raised regarding the proper definition of monetary aggregates and the processing of monetary resources and the sustainability of money demand. Developments in financial systems make possible the exchange and substitution between M1 and M2 money and other assets. Of course, financial innovations and new monetary instruments were not the only reason for the instability of money demand, but the simple sum method of central banks to determine the M1 and M2 monetary aggregates also led to unsustainable in money demand and its supply. In the simple sum method for monetary components, weight and importance are considered to be the same, and it is assumed that the degree of liquidity of all monetary assets is equal to each other. The defect in the definition of simple monetary aggregates has led to the development and use of new monetary aggregates definitions, the most famous of which is the Divisia monetary aggregates. In this new definition, monetary components are assigned a specific weighting coefficient that can be measured by the flow of monetary services. Therefore, considering the importance of money in the occurrence of inflation, it is necessary to pay attention to the concept of money and its components. In Iran's economy, despite the monetary nature of inflation, it has been observed in recent years that the effect of liquidity growth on inflation has decreased and despite the increasing liquidity growth, its effect as the most important influencing factor on inflation was different, and they are not in line. Therefore, the study of nonlinear inflation behavior based on the new definitions of monetary aggregates in the economies of developing countries, especially Iran’s economy, provides a more accurate explanation of the monetary analysis of inflation. The main goal of this study is to investigate the effect of the growth of simple monetary aggregates and Divisia (based on the concept of missing money) on inflation behavior in monetary regimes and different threshold values in Iran's economy. For this purpose, the threshold autoregressive model has been used during 1990-3 to 2016-06. In the second part of the study, the theoretical foundations of the research are discussed. The third section is dedicated to reviewing empirical studies and research background. In the fourth section, the experimental results obtained from the estimation of the research model are presented, and in the fifth section, a summary and conclusions from the issues mentioned above are presented.

2 Literature Review

The theoretical foundations of this research are based on the viewpoints of economic doctrines on inflation and emphasizing on non-linear inflationary dynamics. Also, after the concept of missing money emerged, the importance of examining and determining monetary components in the economy became apparent, in which emphasis was placed on the proper specification of money and monetary components. It is also notable that although different factors affect inflation in Iran, it can be said that there is a general agreement about the dominant influence of money on inflation, so that many studies have considered inflation as a monetary phenomenon in Iran. Since inflation takes effect from various economic and noneconomic factors, the behavioral pattern variation in the Iranian inflation process can be investigated; therefore, inflation is modeled as a regime change process, and it is assumed that the inflation rate is determined through regime change, controlled and guided.

2.1 Inflation in Various Economic Doctrines

Classical economists were the first to raise the theory of money inflation; they believed that monetary factors were able to explain inflation fully. Their theory of economic literature is known as the "quantity theory of money." Fischer, through his equation of exchange, explained inflation on a monetary basis, then Marshall looked at the "quantity theory of money" from the Cambridge doctrine. After that, in a new form of the quantity theory of money, Friedman expressed his interpretation of the quantity theory of money as a theory of demand for money. Also, the followers of this doctrine, considering the conditional expectations of the formation of inflationary expectations based on past information, believe that monetary policies in the short run will affect the level of production and other real variables, but in the long term, they will make money neutral. In the rational expectation model, it is also emphasized that the person does not just look at the past information in forecasting inflation, but serves all the available data for prediction. Also, people do not make systematic mistakes in their predictions. Regular errors are easily discovered and corrected over time, and the way of shaping their expectations varies in the same way. New classics, believing in the formation of expectations based on rational expectations, argue that monetary policies are both neutral in the short run and the long run, only unforeseen monetary policies affecting real variables in the short term. The theory of demand-pull inflation also sees the cause of the rise in inflation as the increase in demand. Increasing demand could be driven by an increase in investment and independent consumption, expansionary fiscal policy, expansionary monetary policy, declining money demand and increasing exports and reducing imports. John Maynard Keynes offers his argument for inflation to be that if demand for consumer goods exceeds supply, then this excess demand creates an inflation gap and prices raise so much so that this gap is filled. In the cost-push inflation theory, contrary the doctrine of money and the Keynes doctrine, the imbalances in the supply sector, and in particular the increase in the cost of production and transmission of the total supply curve is the main reason for rising prices. In Structural Break Theory, we can say that structural break means that inflation is likely to develop due to the state of unbalanced economic, political, and cultural structures. Various and often complex factors play a role in creating and sustaining this inflation.

In analyzing the inflationary dynamics, attention to the process of its linear or nonlinear behavior is of particular importance because the existence of extreme volatility and uncertainty in the behavior of some economic variables such as inflation due to the nature of these variables can lead to economic instability in society. Therefore, the existence of these uncertainties causes behavioral inflation to be based on nonlinear functions, not considering the nonlinear behavior of economic variables causes an error to be made clear. Studies in Iran's economy also confirm the non-linear inflationary dynamics. Therefore, the use of linear models to investigate and explain the influence of other economic variables on inflation cannot reveal the realities of the economy altogether. Sarjent and Wallas (1973) showed that when policymakers are pushing for budget financed by printing money, inflation is a nonlinear process that can have two distinct equilibrium conditions. Orphanides and Wieland (2000) state that when the inflation rate is near or within the target range, the central bank may focus on other goals such as adopting a policy of stabilizing production or reducing unemployment. In Iran, studies by Moshiri (2001), Khodavisi et al. (2013), Asgharpur and Mehdilou (2014) have obtained evidence of asymmetric and nonlinear behavior of inflation. Also, regarding the asymmetric effects of monetary policy in different economic situations, it can be pointed out for reasons such as the existence of the credit channel in monetary transmission, the asymmetric adjustment of prices and wages (Ball & Mankiw, 1994, Kuzin &Tober, 2004) and changes in money velocity (Estrella & Mishkin, 1997).

2.2 The Concept of Missing Money and Monetary Aggregates

In the classical economy, with the assumption of the absence of instability and uncertainty, money is an intermediary for trading in the community, and it is the unit of measurement. In Keynesian economics, when society faces a reduction in total demand, money also plays the role of wealth reserve, and even money can be used to pay for future commitments. Fisher (1911), based on the quantity theory of money, only considers banknotes and coins as money and excludes scriptural money. Pigou (1917), in addition to the banknote, added scriptural money to Fisher's definition of money, which corresponds to the current concept of M1. Kaynes also accepted the M1 definition of money in the 1930s and believes that M1 money does not receive interest and puts it against other financial assets that have yield and the motive for speculation or money-buying to the Pigou’s goals of keeping money by people.

The concept of missing money refers to the fact that since the early '70s, the function of contractual demand for money was predicting money demand more than reality. The error rate grew more intensively from 1974 to 1976, and Goldfeld (1976) states that the M1 definition of money is not stable and it is not possible to estimate the function of money demand during the years mentioned above. He believes that demand for scriptural money is the leading cause of instability, while demand for cash is more stable. He also believes that changes to the deposit accounts have been made to other types of deposits and the M1 has become unstable. Goldfeld has called the transition from M1 to other assets “missing money phenomenon.” In other words, not considering the financial assets and the monetary components of the economy that can play the role of intermediary in exchanging money leads to an inappropriate correction of the money stock, and thus we will see the missing money in the economy. These developments in totaled to a rethinking of monetary aggregates in the economy. Barnett (1980) states that a simple sum of monetary aggregates is justifiable when monetary components are entirely substituted for each other, while this condition is not seen in the conventional definitions of money. So, Barnett provides the possibility of introducing Divisia monetary aggregates by introducing the cost of using the money.

In Barnett's opinion, the appropriate method for collecting money should be considered to be the function of the demand for money assets; otherwise, the forecast of the results of the supply and demand of money will be accompanied by volatility, and there will be ambiguities in results. From the microeconomic point of view, the utility simple sum index of individuals is considered linear and therefore assumes that monetary assets are a substitute for each other. If these assets have different prices, it will be a corner solution, and in balance, the only asset is kept that its price is lower, while in reality, it is not, and people hold a variety of monetary assets in their Stock Portfolio. Anderson (1997) and Bloonja (1996) argue that because of the broad definition of the money and the vast items in it, the use of a simple sum to define money is incompatible with microeconomic theories and the instability in the demand function of money is due to the accumulation of money. Before the 1980s, Friedman also referred to the weaknesses of the simple sum method for calculating monetary aggregates. The implementation of monetary policies requires a proper definition of money and monetary aggregates because of the close connection between the theoretical definitions and empirical economic phenomena are undeniable. Also, the application of effective monetary policies by the world's central banks requires that the amount of money in the economy can be properly explained and measured, through which the rate of money growth and inflation can be controlled. What is currently considered in the empirical analysis and the source of monetary services is a simple sum of monetary components. Based on the simple sum of monetary aggregates, all monetary components with the same weight and importance are considered in terms of money, which has led to misleading results in economic analysis. The studies that were undertaken to solve the simple sum monetary problems were some based on the number theory of statistical indexes, and some others were based on the aggregation theory. The number theory of statistical indexes provides a group of quantitative and price indexes that can only be based on information on quantities and prices. Simple sum index and Divisia index can be considered as examples of statistical index numbers, but the simple sum-index is a particular type of that which the price is not included. In aggregation theory, we try to find out the amount of money based on the microeconomic foundations and by maximizing a utility function whose money and its components are also dependent on its arguments. In this situation, the utility function acts as an aggregation function.

Divisia index is in practice derived from the estimation of a non-linear function of the values of monetary components and their corresponding prices. The growth of the Divisia index is also a linear combination of growth rates of its parts; for each of the elements, the respective weights are the average distribution of expenditures. By definition, the simple sum-index is as follows:

$$M_{it} = \sum_{i=1}^{n} m_{it} \tag{1}$$

So:

$$\frac{dM_{it}}{M_{it}} = \sum (m_{it}/M_{it})(dm_{it}/m_{it}) \tag{2}$$

Where in, m_{it} is equal to the value of the i-th asset. So, we can say approximately:

$$\text{Ln } M_{it} - \text{Ln } M_{it-1} = \sum S_{it}\big(\text{Ln}(m_{it}) - \text{Ln }(m_{it-1})\big) \tag{3}$$

Where in $S_{it} = \frac{m_{it}}{M_{it}}$ is equal to the share of the i-th monetary component. This equation shows that the monetary aggregate growth rate derived from the simple sum of a linear combination of growth rates of its components is that the weights of each element are also equal to the ratio of the values of each of the parts to the sum of all parts in a simple sum method.

The cost of using monetary components is calculated in both nominal and real terms, whose respective relationships are as follows:

$$P_{it} = \frac{p*(R_t - r_{it})}{1+R_t} \tag{4}$$

$$P_{it} = \frac{(R_t - r_{it})}{1+R_t} \tag{5}$$

Where P * is the actual cost of living index, R_t is the standard asset rate, and r_{it} is the i-th asset yield rate at time t. In calculating the Divisia index, the contribution of expenditures spent on each monetary component to the total expenditures spent of or all types of monetary services, in which case this ratio represents the “distribution of expenditures." In the Divisia method, the prices for each of the components are also required in the calculation, which requires having the interest rates of each of the components. However, by calculating the cost of using monetary components for each of the monetary components, the ground for calculating a quantitative index of Divisia is provided.

3 Empirical Studies

The review of related empirical literature and the results obtained from them indicate that the monetary value of inflation and the effect of monetary components have been confirmed in many of these studies. These studies also show that nonlinear models are more capable of explaining inflation behavior than linear models. Table (1) summarizes the results of the most important empirical studies on inflation in the economy of Iran and the world.

Table 1
Studies Conducted with a Nonlinear Approach

A. Studies in Iran:				
Researcher	**Year**	**Research period**	**Empirical method**	**Result**
Mehrara et al	2012	1959-2008	Nonlinear time series model	The results show that nonlinear models are more capable of explaining inflation behavior in Iranian economy than linear models. The main variable influencing inflation in the low-income oil regime is liquidity growth, and demand gap is the most critical factor influencing inflation in the high-income oil regime.
Slamloueian and Oji Mehr	2013	1991-2011	Exponential smooth transition autoregressive model	The results indicate that the inflation rate and its nonlinear behavior are in the economy, and impacts can have a lasting effect on inflation in Iran, and as a result, it is very costly to apply anti-inflationary policies to monetary authorities.
Mehrara and Fatemi	2016	1990-2015	Markov regime change model	Based on the results of the inflationary effect of liquidity growth in the low inflation regime is far lower than the high inflation rate. This model introduces the growth of liquidity and market price imbalances as factors of transition from low inflation to high inflation.
Zaranejad and Hamid	2009	1959-2007	STR	The results indicate that based on the designed network, the inflation rate is expected to be between 10.59 to 21.98 from 2008 to 2012.
Fallahi et al	2008	1990-2008	Dynamic Artificial Neural Networks	The influence of inflation variables, the formation of the government's capital and expenditures on economic growth depends on the regime in which the economy is located.

B. Studies in Other Countries:				
Researcher	**Year**	**Research period**	**Empirical method**	**Result**
Arango and Gonzalez	2001	1998-1989	Smooth transition autoregressive model	Inflation of merchandise follows a linear pattern, while the inflation core is explained by the smooth transition autoregressive model with an exponential function and changes in the consumer price index based on the autoregressive model of the logistic transfer function.
Eriz and Malandrotos	2012	1980-2009	Smooth transition autoregressive model	Based on the status of the static situation, it was concluded that the inflation rate in the African countries is unstated linearity and after confirming the nonlinear behavior of inflation using a Smooth transition autoregressive model with an exponential function, they use statistical test of static nonlinear KSS to study the inflation rate.
Rickets and Rose	2007	1960-2007	Markov regime change model	For the North American countries, the low inflation rate was stable in the early 1960s and 1980s, and the low inflation regime was established in the United States in the mid-1980s but did not continue. Japan has also experienced a completely low inflation regime. Germany, France, and Britain were also in medium-term inflation.
Burger and Sterolm	2008	1970-2006	Bayesian Auto-Registering	The money is the cause of inflation, and this result is not only long-term but also on the short-term and middle term.
Amiensano and Fagan	۲۰۱۳ 2013	1960-2013	Markov regime change model	The results of the research indicate that the warning signals are confirmed by the liquidity growth variable for the high inflation rate.

Source: Research Findings

Following the weakening of the relationship between money and inflation in recent years, the linear behavior of inflation has been questioned, and researchers have explained the behavior of inflation in the form of nonlinear econometric models.

4 Estimates and Empirical Results

Generally, the threshold autoregressive models influenced by non-linear features of asymmetric observations in time series processes that have incremental and decreasing behavioral patterns. The threshold variables control the behavioral change in the time series and allow the slope of the coefficients and other econometric characteristics to change in each regime.

In TAR model, the coefficient of a variable is not constant and depends on the value of another variable selected as the threshold variable. Regarding the structural break and nonlinear behavior of variables in a different regime, in addition to the variable of time, other variables can also be considered as the source of policy changes. In other words, in time series discussions, each variable can accept the role of the threshold variable, and the coefficients of other variables change from that of the threshold of a regime to another regime. The threshold autoregressive models are considered as nonlinear models, and their parameters are variable and are defined as the function of the regime. In these models, each system is determined based on certain values of one of the variables in the model. Therefore, contrary reversible autoregressive time series models, TAR models seem to be more efficient in providing complex and irreversible systems that are analyzed in terms of time series. Also, the capabilities of TAR patterns can explain the complexities of linear subsets that are connected by threshold processes. A general TAR (k) model, in which k is the number of regimes, is shown as follows:

$$y_t = \sum_{j=1}^{k} \left[(\emptyset_0^{(j)} + \sum_{i=1}^{p_j} \emptyset_i^{(j)} y_{t-1} + \varepsilon_t^{(j)})\, I(r_{j-1} < z_{t-d} \leq r_j) \right] \quad (6)$$

Which y_t; shows the time series; j = 1, ..., k, and k; the number of regimes; p_j is also the delay of the j-th AR policy; $\emptyset_0^j$ is the intercept and $\{\emptyset_0^j \,|\, i = 1,2,3,\ldots,P_j\}$ are AR coefficients for the j-th regime; I (0) is a functional representative and r=(r_1 ,…, r_{k-1}) such that $r_{k-1} > \cdots > r_1$ is the threshold values; $r_0 = -\infty$ and $r_k = \infty$ and z_{t-1} is a threshold variable with d as a positive delay parameter; for each j, $\left\{\varepsilon_t^{(j)}\right\}$ is the sequence of differential of martingale such that $E\left(\varepsilon_t^{(j)} \middle| F_{t-1}\right)=0$ and $sup_t\ E\left\langle\varepsilon_t^{(j)} \middle| \delta \middle| F_{t-1}\right\rangle < \infty$ for some $\delta > 2$, such that F_{t-1} included $\sigma - field$ which created by $\left\{\varepsilon_t^{(j)} \middle| i = 1,2,\ldots,j = 1,\ldots,k\right\}$.

This research is based on the relevant structural break test; the TAR model is investigated by three regimes. The method for estimating this model is presented by Tang (1983) based on search methods and information criteria. For each threshold variable, the value of C in its set of values is changed so that the sum of the residual squares is minimized. Among the different models based on different threshold variables, a model is selected that has a minimum value for selecting model criteria. Therefore, nonlinear models in this study for the first model are:

$$DCPI = \alpha_0 + \alpha_1\, DGDP + \alpha_2\, DEX + \alpha_3\, SM + \alpha_4\, DCPI_{t-1} + \alpha_5\, \mathrm{ECM}_{t-1} + I(SM > b_0)(\alpha_6 + \alpha_7\, DGDP + \alpha_8\, DEX + \alpha_9\, SM + \alpha_{10}\, DCPI_{t-1} + \alpha_{11}\mathrm{ECM}_{t-1}) + I(SM > b_1)(\alpha_{12} + \alpha_{13} DGDP + \alpha_{14}\, DEX + \alpha_{15}\, SM + \alpha_{16}\, DCPI_{t-1} + \alpha_{17}\, \mathrm{ECM}_{t-1}) \quad (7)$$

Where have the following conditions:

$I(SM > b_0) = 1$ if $SM > b_0$
$= 0$ if $SM \leq b_0$

$\mathrm{I}(SM > b_1) = 1$ if $SM > b_1$
$= 0$ if $SM \leq b_1$

and for the second model, it is stated as follows:

$$DCPI = \alpha_0 + \alpha_1 DGDP + \alpha_2\, DEX + \alpha_3\, DM + \alpha_4 DM_{t-1} + \alpha_5\, \mathrm{DCPI}_{t-1} + I(DM > b_0)(\alpha_6 + \alpha_7\, DGDP + \alpha_8\, DEX + \alpha_9\, DM + \alpha_{10}\, DM_{t-1} + \alpha_{11}\, \mathrm{DCPI}_{t-1} + I(DM > b_1)(\alpha_{12} + \alpha_{13}\, DGDP + + \alpha_{14}\, DEX + \alpha_{15}\, DM + \alpha_{16}\, DM_{t-1} + \alpha_{17}\, \mathrm{DCPI}_{t-1}) \quad (8)$$

Where have the following conditions:

$I(DM > b_0) = 1$ if $DM > b_0$
$= 0$ if $DM \leq b_0$

$\mathrm{I}(DM > b_1) = 1$ if $DM > b_1$
$= 0$ if $DM \leq b_1$

Which that;
DGDP: Gross domestic product growth at constant prices
DEX: The growth of the exchange rate in the informal market
DCPI: Inflation (growth of total index)
SM[1]: Simple liquidity growth

[1] SM includes simple sum of currencies, demand deposits and time deposits which is based on data from economical reports of central bank of IRAN.

DM[1]: Divisia liquidity growth

In this section, we study the non-linear inflationary dynamics in Iran's economy. For this purpose, the econometric model of threshold autoregressive model is used. This research is based on the data published by the Iran Central Bank with seasonal frequency during the period of 1990: 04 to 2016: 07.

Before estimating the desired model, it is necessary to examine the static characteristic of the variables by using the related static tests. For this purpose, all variables are tested using the Phillips-Perron unit root method.

4.1 Examining the Static of Research Variables

Before we estimate the model, we examine the static of research variables. If in estimating econometric equations use non-static data, the statistical deduction will not be valid when variance, mean, and covariance of variables are not independent of time.

Table (2) also shows the results of the Phillips-Perron (PP) test for variables:

Table 2

The Results of the Phillips-Perron Test (PP)

Variables	PP (No trend)	PP (with trend)	Result
DCPI	-6.998***	-7.149***	stationary
DGDP	-24.596***	-24.388***	stationary
DEX	-9.174***	-9.137***	stationary
SM	-15.016***	-14.951***	stationary
DM	-17.533***	-19.702***	stationary

*** denote rejection of the null hypothesis at the 1% level, respectively. Source: Research Findings.

The first step in the threshold autoregressive model is determining the number of regimes, the threshold variable, and its optimal level. In this research, we study the non-linear inflationary dynamics by the approach of missing money, the estimation of the research model using thresh threshold autoregressive model in the form of two different explanations, the first

[1] Values regarding DM are based on own calculations by using Data of monetary components (currencies, demand deposits and time deposits) and interest rate of time deposits which are extracted from economic reports of central bank of IRAN. For more information refer to Barnett, W, A (1980), "Economic Monetary Aggregates: An Application of Aggregation and Index Number Theory".

explanation is based on the simple liquidity growth variable and the second explanation is based on the growth of Divisia liquidity. In the latter case, from the perspective of the concept of missing money, we examine the relationship between inflation and the Divisia monetary aggregation.

Due to the nonstatic of the levels of the variables, the cointegration among them is examined based on economic theory. If there is a long-term relationship among the general level variables of prices, gross domestic product, simple liquidity, and exchange rate, the residuals are considered as the error correction in the price equation.

Therefore, at this stage, we test the cointegration among these variables using the Johansen test. According to the results of this test, there is a long-term equilibrium relationship between the variables.

Table 3

Tests of Effect and Maximum Eigenvalue for Estimating the Number of Cointegration Vectors

Template variables: LOG(CPI),LOG(EX),LOG(GDP), LOG(M2) Definite variables: intercept							
cointegration space							
maximum eigenvalue test				Trace Test			
null hypothesis	Alternative hypothesis	test statistic	p-value 95٪	null hypothesis	Alternative hypothesis	test statistic	p-value 95٪
r=0	r=1	17.68	21.13	r=0	r=1	26.59	29.79
r≤1	r=2	8.82	14.26	r≤1	r=2	8.9	15.49
r≤2	R=3	0.08	3.84	r≤2	R=3	0.08	3.84
Cointegrated vectors							
LOG(M2)	LOG(GDP)	LOG(EX)	LOG(CPI)				
-1.56 (0.27)	4.32 (1.14)	0.57 (0.23)	1	ECM(LOG(CPI)-LOG(CPI*))			

Note. The numbers in parentheses are the coefficients of the t-ratios. Source: Research Findings.

4.2 First Pattern explanation (Inflation and Simple Liquidity)

At first, we examine the results of the existence or absence of structural break based on the model variables. Table 4 lists the number of regimes and threshold variables. According to the results of the test, the null hypothesis on the absence of a structural break about F statistic and its scale value is not accepted. The existence of two structural breaks against a structural break is investigated to determine the number of optimal regimes. The corresponding statistic shows that the null hypothesis cannot be accepted, so two structural breaks with three regimes are confirmed.

Table 4
Test of Determining the Optimal Regimes Model

Structural break test	F statistic	F statistic	Critical value
The null hypothesis versus 1 regime	6.24	37.45	20.08
Hypothesis 1 versus 2 regimes	3.79	22.75	22.11
Hypothesis 2 versus 3 regimes	1.65	9.95	23.04
Threshold variable: Simple liquidity growth (SM)			

Source: Research Findings.

Table 5
Results of the Model Estimation with Simple Liquidity Variable (SM)

Regimes Variables	SM < 0.05	0.05 ≤ SM <0.09	SM ≥ 0.09
Constant	0.023 (0.005)	-0.003 (0.87)	-0.012 (0.55)
DGDP	-0.011 (0.607)	**-0.065* (0.005)	**-0.23* (0.000)
DEX	**0.17* (0.000)	**0.11* (0.000)	0.013) (0.86
SM	-0.22* (0.094)	0.53** (0.046)	0.18 (0.31)
$DCPI_{t-1}$	**0.59* (0.000)	0.14 (0.1003)	**0.85* (0.000)
ECM_{t-1}	-0.069** (0.017)	**-0.15* (0.000)	**-0.24* (0.002)
The Goodness of fit Variables			
R-squared= 0.75	D-W=2.12 SC= -5.002	F= 16.16 HQC= -5.27	AIC= -5.45
Diagnostic Tests			
Serial correlation		1.29	(0.278)
Normality		0.46	(0.793)
Heteroskedasticity		1.9	(0.373)

*,** and *** respectively indicate a significant level of 10%, 5%, and 1%, and the numbers in brackets indicate the probability level. Source: Research Findings.

According to the results of this test, the simple liquidity growth variable is defined as the threshold variable for changing the pattern regimes. The first threshold of the simple liquidity growth variable is 5.8% per season (equivalent to 23.2% per annum) and the second threshold limit 9.1% per season (equal to 36.4% per year). In other words, the coefficients of the model variables in the values indicated for the simple liquidity variable undergo a structural change and show different behavior. The results of the research show that the position of monetary policy and simple monetary aggregation growth are an essential determinant in changing the regime and affecting inflation in Iran. Of course, the effect of simple liquidity growth in these three regimes is different. Table 5 presents the results of estimating the threshold autoregressive model.

The difference in the coefficients of the model variables in the estimated regimes shows the different influents of inflation and its nonlinear behavior in Iran's economy. The growth coefficient of explanatory variables measures the short-term effect, and the error correction coefficient measures its long-term impact. Regarding the significance of the error correction coefficient in all regimes, all variables have put the expected effect in the long run on inflation.

However, the dynamics of these effects are quite different in various regimes. In the expansion regime, the reaction of inflation to non-equivalence is far more powerful and faster than contraction regimes. It seems that contraction monetary regimes like the first regime can withstand this imbalance for a more extended period. The effect of production growth in short-term in all regimes is negative, but this effect in the expansionary monetary regime is far stronger than the contraction monetary regime. Therefore, supply-side policies and economic growth have stronger anti-inflationary effects in the expansionary monetary regime. In the short term, the variable of the growth rate in the low and middle monetary growth regimes has a positive effect, which is in line with theoretical expectations. The results show that by the passing of simple liquidity growth from the first threshold 5.8% gradually decreases the intensity of this effect and does not have a significant effect on the high monetary policy regime. In other words, in contraction monetary regimes, the growth of the exchange rate leads to more inflationary effects, and as the severity of monetary discipline decreases, the effect of the exchange rate on inflation also diminishes. Significant results can be pointed out to the anti-inflationary effects of the variable of liquidity growth in a short-term contractional monetary policy regime. Which may be due to a change in the combination of money and pseudo-money in the money stock, and an increase in the pseudo-money share and the low-flow of liquidity, and in low monetary growth, money demand is less affected than pseudo-money. Of course, after the passing of simple liquidity growth from the first threshold (monetary growth rates of less than 5.8%), significant inflationary effects of 0.53 appear in the economy, and it seems that inflation has a meaningful and effective response to a certain level of monetary growth.

After passing the variable of simple liquidity growth from the second threshold (monetary growth rates of more than 9.1%), this variable does not have a significant effect on inflation. In other words, in expansionary monetary policies, the importance of the variable of monetary growth is reduced and the variable of inflation expectations assumes a dominant role in explaining inflation behavior. In the case of the average liquidity growth, we can see the strong and effective role of the simple monetary growth variable on inflation, so that in this regime, per unit increase in monetary growth, inflation is increased by 0.53 units. The rise in inflation in Iran's economy during the research period can be explained only in the medium of monetary growth based on the quantity theory of money.

Inflation expectations also have a significant and positive effect on inflation in high and low monetary growth regimes and bypassing the second threshold; this effect will peak at 0.85. Indeed, in a high monetary growth rate, price deviations from long-term equilibrium and inflationary expectations are considered as one of the most critical factors in exacerbating inflation and increasing inflationary acceleration. Also, the significance of the error correction sentence coefficient in this expansionary monetary policy regime and the quick adjustment to long-term equilibrium can be considered in comparison with the previous two regimes. It means that in the third regime, it is expected that after four periods, we will see a modification of the model imbalance. The coefficients and results of the estimated equations for the first adjustment are as follows;

Table 6
Estimated Equations of the First Model

DCPI= 0.023 + 0.17 (DEX) – 0.22 (SM) + 0.59 ($DCPI_{t-1}$) - 0.069 (ECM_{t-1})	If SM <0.05
DCPI= - 0.065 (DGDP) + 0.11 (DEX) + 0.53(SM) - 0.15 (ECM_{t-1})	If 0.05< SM ≤0.09
DCPI= - 0.230 (DGDP) + 0.85 ($DCPI_{t-1}$) - 0.24 (ECM_{t-1})	If SM >0.09

Source: Research Findings.

It seems that simple liquidity changes (SM) cannot explain the significant part of inflation changes based on the quantity monetary theory during the research period, and a considerable difference is observed in the behavior of these two variables that can be explained in terms of the concept of missing money. In other words, if the degree of the succession of monetary aggregation components is not correctly considered in the calculation of the money stock, this variable will not be able to provide a proper interpretation of the effects of the money inflationary.

4.3 The Second Model's Explanation (Inflation and Divisia Liquidity)

In the following, we examine the results of the existence or absence of a structural break based on the variables of the second model. Table 6 lists the number of regimes and the threshold variable based on information criteria. According to the results of the test, the null hypothesis base on the absence of structural break about F statistics and its scale value is not accepted. To determine the number of optimal regimes, the existence of two structural breaks against one structural break is examined, which the statistic shows that the null hypothesis cannot be accepted, so two structural breaks with three regimes are confirmed for this pattern.

The zero hypotheses cannot be accepted, so two structural breaks with three regimes are approved for this template.

Table 7
Test of Determining the Optimal Regimes Model

structural break test	statistic F	statistic F Scale	Critical value
the null hypothesis versus 1 regime	4.71	28.3	20.08
the 1 hypothesis versus 2 regimes	5.12	30.77	22.11
the 2 hypotheses versus 3 regimes	3.23	19.39	23.04
Threshold variable: Divisia Liquidity growth (DM)			

Source: Research Findings.

According to the results of the above test, the Divisia liquidity growth variable is selected as the threshold variable for changing the pattern regimes. The first threshold value of this variable is estimated to be 6 percent per season (equivalent to 24 percent per annum), and its threshold value is estimated at 11.65% per season (equal to 46.6% per year). In other words, the coefficients of the model variables in the amounts indicated for Divisia liquidity are subject to structural change and show a different reaction. The results of this study suggest that Divisia liquidity growth is a significant determinant of regime change and has an impact on inflation in Iran. Of course, the effect of the Divisia monetary aggregation growth in these three regimes is different from each other. Table 7 presents the results of estimating the threshold autoregressive model with the Divisia liquidity growth variable.

Table 8

Estimated Results with Divisia Liquidity (DM)

regimes / variables	DM < 0.06	0.06 ≤ DM <0.11	DM ≥ 0.11
Canstant	0.003 (0.51)	0.034^{**} (0.04)	0.02 (0.37)
DGDP	-0.024 (0.23)	-0.043 (0.19)	$^{**}-0.207^{*}$ (0.000)
DEX	$^{**}0.12^{*}$ (0.000)	$^{**}0.097^{*}$ (0.005)	-0.007 (0.86)
DM	0.029 (0.67)	-0.052 (0.74)	-0.05 (0.74)
DM_{t-1}	$^{**}0.11^{*}$ (0.003)	$^{**}0.42^{*}$ (0.000)	-0.15 (0.36)
$DCPI_{t-1}$	$^{**}0.68^{*}$ (0.000)	0.07 (0.44)	$^{**}0.98^{*}$ (0.000)
Good of fitness variables			
R-squared= 0.78	D-W=2.29 SC= -5.12	F= 19.05 HQC= -5.39	AIC= -5.58
(Diagnostic Tests)			
Serial correlation		1.91	(0.153)
Normality		0.071	(0.965)
Heteroskedasticity		1.74	(0.024)

*, **, and *** respectively indicate a significant level of 10%, 5%, and 1%, and the numbers in brackets indicate the probability level. Source: Research Findings.

The insignificance of the sentence of error correction and the absence of a long-term equilibrium relationship among the economic variables of the model and inflation are remarkable results in specifying the model based on the Divisia liquidity growth variable. Regarding the fact that the adjustment coefficient of the correction in the specification of the above model is zero, it indicates that the dependent variable is not adjusted to the relevant imbalance and does not react to achieve long-term equilibrium; the error correction in the model estimation has been eliminated as an independent variable. The higher coefficient of determination in this model indicates its ability to explain more than the first one based on the simple liquidity variable, and the results of all diagnostic tests are also satisfactory. The GDP growth variable has a significant and anti-inflationary effect in the short-term, according to economic considerations, and in the case of expansionary monetary policy, it has the highest coefficient of influence equal to 0.2. Therefore, in this situation, by accelerating production growth, the general level of prices can be reduced, and in this regime, the anti-inflationary effects of economic growth are more perceptible. The increase of the exchange rate in this model in the low and medium liquidity growth situation has a positive and significant positive effect, but its impact on inflation is reduced from 0.12 to 0.09. In the case of high liquidity growth, this variable has no significant impact on the inflation rate. By applying expansionary monetary policies, exchange shocks are not able to make changes in the inflation rate. The Divisia of liquidity growth in any of the monetary regimes does not have a significant effect on the inflation rate. In other words, the inflation rate does not show any reaction to Divisia liquidity growth, which may be due to its late effects in the coming seasons. As the results show that the delay of this variable in the context of low and medium monetary growth policies has positive and significant effect with coefficients of 0.11 and 0.42, respectively, and by passing the first threshold value, the intensity of this effect increases. In both of these regimes, contrary to the previous explanation, we see the effects of a delay interruption in the growth of Divisia liquidity. In this model, the estimated coefficients for the Divisia liquidity growth variable with delay interruption indicate the different and nonlinear effects of this variable on the inflation rate. The results and coefficients of estimating the second explanation equations are as follows:

Table 9

Estimated Equations of the Second Model

DCPI= 0.12 (DEX) + 0.11 (DM_{t-1})+ 0.68 ($DCPI_{t-1}$)	If DM <0.06
DCPI= 0.34+ 0.097 (DEX) + 0.42 (DM_{t-1})	If 0.06< DM ≤0.11
DCPI= - 0.207 (DGDP) + 0.98 ($DCPI_{t-1}$)	If DM >0.11

Source: Research Findings.

According to the findings, it can be concluded that the Divisia Monetary (DM) aggregates prepared a more accurate explanation of the inflationary changes based on the quantity theory of money during the research period, and so-called, we do not observe the appropriate lack of clarification due to the missing money in the economy.

5 Conclusion

Controlling and directing monetary policies concerning inflation targeting has always been of great importance. The study of the process of money transfer and its effect on inflation has doubled this importance. According to the studies conducted in Iran's economy, the effectiveness of monetary policies via monetary aggregation on inflation has a volatile process that is mainly due to inflation expectations and the lack of recognition of the length of the interruption of influence. Therefore, in this study, the study of the inflationary dynamics is based on the missing money approach, which shows an appropriate definition of monetary aggregates.

In calculating the Divisia liquidity variable, contrary, simple liquidity that collects all monetary components in a simple way, each of the monetary components is assigned a weighting factor and aggregates based on the share of each (based on the power of liquidity). In other words, the concept of missing money in the economy and the creation of instability in money demand required a new definition of monetary aggregation in the form of the Divisia index. In this research, the non-linear inflationary dynamics and its relation with factors affecting inflation, including production, exchange rate, inflation expectations and with emphasis on simple liquidity and Divisia liquidity variables along with price imbalance in the past period have been studied. The estimated models in this study are based on Iran's economic data in the period from 1990 to 2016 and seasonally and based on nonlinear patterns of threshold autoregressive model.

Nonlinear behavior of inflation suggests that linear modeling is not able to explain the changes in inflation, and the use of nonlinear time series models can provide a better interpretation of the inflationary dynamics based on different regimes. Also, the nonlinear behavior of inflation can indicate the difference in the speed of convergence towards the inflation target in the economy. Based on the missing money approach, the model of a nonlinear model is in the first case with a simple liquidity growth variable, and the second case, with the Divisia liquidity growth variable.

In the first explanation, based on the simple liquidity variable, regarding the structural change of the coefficients, the existence of three regimes is confirmed, and simple liquidity growth variable is also defined as the threshold variable. The first threshold estimated at 5.8 percent per season and the second threshold is at 9.1 percent per season. The effect of GDP growth in the short term in all regimes is negative according to economic theories, but this effect is more potent on the monetary expansion regime than the contraction monetary regime. In the short term, the variable of the current growth rate in the low monetary growth regime has the highest positive effect on other regimes. The results show that bypassing the simple liquidity growth of the first threshold, the intensity of this effect gradually decreases and in the high monetary policy regime, it also has no significant effect. The simple liquidity growth variable in the first regime harms inflation, which can be due to the irritability of economic activities in the low-income policy. In this model, the highest inflationary effect is observed based on the inflation expectations variable in the first and third regimes, followed by the liquidity growth variable in the second policy. The deviation of inflation from its long-term equilibrium relationship leads to inflationary acceleration, which shows an increasing trend in higher levels of simple liquidity growth. In the second explanation, by an emphasis on the Divisia liquidity variable, this monetary variable has been selected as the threshold of the determination. The first threshold is 6 percent for each season and the second threshold 11.65 percent for each season is estimated. Also, due to insignificant of the correction of error, and the lack of a long-term equilibrium relationship among inflation and other model variables, this correction of error was deleted. In the context of contractual monetary policy, exchange rate growth variables and inflation expectations and Divisia liquidity growth with the first interrupt have significant coefficients. The GDP growth in this model has anti-inflammatory effects, which its severity in the high growth regions is more than in other regimes. The variable of exchange rate growth shows the inflationary effects in all regimes which, in the context of contractional monetary policy, increase its impact on inflation. In terms of expansionary monetary policies, inflationary expectations and production growth rates have the most impact on inflation. In this regime, inflation expectations account for over 98 percent of the level of inflation change in each season. It is also due to an increase in monetary disciplinary effects in the high levels of Divisia liquidity growth, which is evacuated on inflation through monetary policy channels. In all done explanations, the inflation expectations variable has a significant and undeniable effect on the inflationary level. The simple liquidity growth variable, concerning low and middle monetary growth regimes, has an increasingly and decreasingly different effect on inflation, while the Divisia liquidity growth with the first interruption in these regimes always has inflation effects according to economic theories. Based on the results of this study, it seems that the study of the non-linear inflationary dynamics using the Divisia liquidity variable rather than the simple liquidity variable shows more realistic results of how inflation behaves and its effect on monetary variables. Also, by increasing financial instruments and increasing the degree of substitution of monetary components, the use of Divisia monetary indices leads to an improvement in the evaluation of monetary policy channels.

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