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Policy Time-Inconsistency: A Comparison of Managed Floating Exchange Rate and Controlled Exchange Rate Regimes

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Some empirical and theoretical studies have emphasized on fixed exchange rate regime in controlling time inconsistency, while others consider the role of target zone regime as an important factor. Thus there is no general consensus to decide which exchange rate regime may bring about less time-inconsistency. The main purpose of this study is to investigate policy time-inconsistency in exchange rate regimes of Iran (controlled exchange regime between 1991-2001 and managed Floating between 2002-2012). For this purpose, a fuzzy prediction system is used which includes three steps for estimating time-inconsistency. In the first step, fuzzy C-Means is used to calculate membership functions. Then Takagi Sugeno Model (TSM) is applied to identify the model structure, and finally Recursive Least Squares (RLS) is conducted to estimate the amount of time-inconsistency. The results show that the amount of policy time inconsistency under managed Floating exchange rate regime is less than controlled exchange rate regime. Thus it is suggested to policy makers to continue managed Floating exchange rate regime, so that the fluctuations of output decreases. At the same time, since managed Floating exchange rate regime imposes more price fluctuation on economy it is necessary for the policy makers to pay enough attention to the issue.

Keywords: Time Inconsistency, Real Exchange Rate, Regularity, Discretion, Fuzzy Clustering
JEL Classification: C11, C15, E32, E37, F31

1 Introduction

It is possible to generally define time inconsistency as the difference between optimization ex ante and ex post (Snowdan & Vane, 2005). It was first used by Strotz (1955) to explain the consumers' behavior. Then, Kydland and Prescott (1977) were the first ones who tried to model time inconsistency in macroeconomic. Mardani (2012) explains that it is possible for policy makers to choose a specific policy that they believe is the best at that time, and on the other side, people and agencies make some expectations accordingly. Yet

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there may exist some possibility that economists' decisions are not necessarily the best ones, so in such situations those policy makers may choose new policies. Such a change discredits the economic agents' expectations, which causes the appearance of time inconsistency in return. But if people believe in the honesty of policy makers, then inflationary expectations reduces and as a result, the economic performance improves.

The type of exchange rate regime chosen is one of the causes of policy time inconsistency. Zhu (1997), by checking the fixed, Floating, and the target zone exchange rate regime finds that although the price and output volatilities are the same in both Floating exchange rate regime and target zone, it is more attractive to the policy makers to choose target zone regime, because the fluctuations of exchange rate is less than the other exchange rate regime. Moreover, target zone exchange rate regime is capable to control exchange rate fluctuations, so policy makers are able to make the policy time inconsistency less than any other exchange rate regimes. Davis and Fujwara (2015), also, finds that fixed exchange rate regime can reduce the time inconsistency through producing a nominal anchor for fiscal policy which brings about regularities in policy making. So, based on his study, policy makers bring better welfare than other discretionary policies, in addition to increasing the credibility by making regular decisions.

It is concluded from different studies that the governmental involvement plays an important role in discretionary policy making. Since the monetary authorities try to stabilize the exchange rate applying fixed exchange rate regime, they continuously interfere in fiscal policy making. However, under Floating exchange rate regime, the exchange rate is determined by the market, and the government intervention is limited. Since the involvement of government in the fixed exchange rate regime is more, the possibility of time inconsistency occurrence is increased. Policy makers' contradictory and surprising comments on exchange market of Iran have made the economic agents to pay no attention to announced policies. In the conditions when the exchange, financial, and fiscal policies are not systematic, and the economic policies announced by the authorities are not valid, exchange market becomes volatile and turbulent, which results in the occurrence of time inconsistency.

It is necessary to mention that some part of exchange rate volatilities in Iran can possibly be explained through the above framework; therefore, figure (1) the real exchange rate may be used as an indicator to explain the time inconsistency.

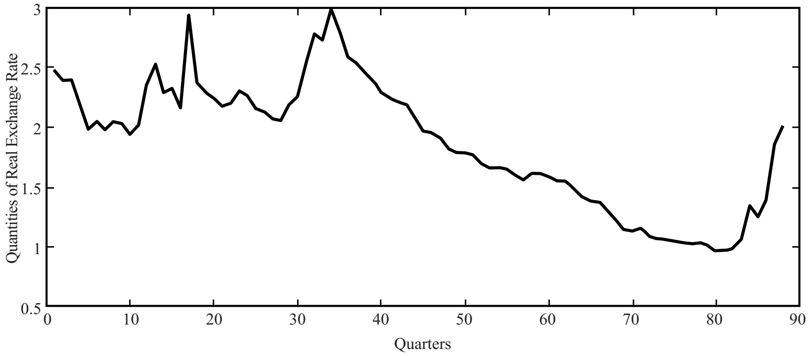

Figure 1. Quarterly real exchange rate development in 1990-2012. *Source*: Research Findings

There are two periods specified in this figure; the first period is between 1990-2001, with controlled exchange rate regime, and the second period is between 2002-2012 with managed Floating exchange rate regime. When the above figure is matched with the economic realities of Iran, it becomes clear that there are various reasons for high volatilities in the real rate of exchange during controlled exchange rate regime, such as structural adjustments, international sanctions, oil revenues fluctuations, and speculative demands in the exchange market. But in the most recent years with managed Floating exchange rate regime, the economy had a stable situation because of abundant exchange resources; it is only in the later years of the period that the regime confronts with some shocks after oil revenues reduced and international sanctions tightened. Since there are more fluctuations in real exchange rate under controlled exchange rate regime than managed Floating exchange rate regime, there would be more uncertainty on the controlled exchange rate regime which both surprises the economic agents and intensifies time inconsistency.

This study investigates that if policy makers prefer rule based policies rather than discretionary policies, which exchange rate regime will have a better performance. Furthermore, choosing an ideal exchange rate regime retains the exchange rate as the de facto measure and concurrently guides expectations properly and reduces time inconsistency. Moreover, it prevents the bad effects of choosing incorrect exchange rate on various economic sectors.

In order to more closely examine the issue, this study compares and contrasts policy time inconsistency in both controlled and managed Floating exchange rate regimes. So the study consists of six sections. After the introduction there is the theoretical foundations in section two. In the third section, a literature review is presented, and later in the fourth section, research methodology is introduced. Fifth section specifies the results, and finally the sixth section contains conclusion and policy recommendations.

2 Theoretical Foundations

Time inconsistency was first modeled by Kydland and Prescott (1977) in an article titled “Rules Rather than Discretion”. Time inconsistency happens when the preferences of economic decision makers change during time periods, in a way that what is preferred in one time will be inconsistent with the preferences made in some other time (Nassiri, 2008).

Kydland and Prescott (1977) assume in their model that $\pi = (\pi_1, \pi_2, \ldots, \pi_T)$ is the policy adoption by the authorities during the time of 1 to T, and $X = (x_1, x_2, \ldots, x_T)$ are the decisions made by the agents. Social objective function that has been widely accepted is $S = (x_1, x_2, \ldots, x_T, \pi_1, \pi_2, \ldots, \pi_T)$. In this model, agent’s decision in time t depends on all policies adoption and previous decisions. Now policy π will be consistent for all periods if first, social welfare, π_t, is maximum, and next, previous decisions are $X = (x_1, x_2, \ldots, x_{t-1})$; then future policies, such as π_s(s>t), will always be adopted in this way.

The model by Kydland and Prescott (1977) for two periods is:

$$S = (x_1, x_2, \pi_1, \pi_2) \tag{1}$$
$$x_1 = (\pi_1, \pi_2) \tag{2}$$
$$x_2 = X_2(x_1, \pi_1, \pi_2) \tag{3}$$

In order to have a consistent process, π_2 in relation 1 should be maximum in the relations 1 to 3, while all previous decisions are considered as a limitation for relation 3.

$$\frac{\partial S}{\partial x_2}\frac{\partial x_2}{\partial \pi_2} + \frac{\partial S}{\partial \pi_2} = 0 \tag{4}$$

Here, for a policy to be consistent, the effect of π_2 on x_1 should be zero.

When adding the limitation for welfare function and the condition of maximum social welfare:

$$\frac{\partial S}{\partial x_2}\frac{\partial x_2}{\partial \pi_2}+\frac{\partial S}{\partial \pi_2}+\frac{\partial x_1}{\partial \pi_2}\left[\frac{\partial S}{\partial x_1}+\frac{\partial S}{\partial x_2}\frac{\partial x_2}{\partial x_1}\right]=0 \quad (5)$$

In relation 5,it is necessary to emphasize that consistent policy is optimized when either $\frac{\partial x_1}{\partial \pi_2}$ which is the influence of π_2 on x_1, or $\frac{\partial S}{\partial x_1}+\frac{\partial S}{\partial x_2}\frac{\partial x_2}{\partial x_1}$ which is the sum of direct and indirect influence of x_1 are unequal to zero (Kydland and Prescott, 1977).

According to time inconsistency, policy makers have to follow policy rule to obtain credits in order to be consistent in terms of time. One way for policy makers to obtain credits is to choose systematic exchange policy for its anti-inflationary credibility that can address the economic agents' expectations in a correct direction through which to solve time inconsistency. Accordingly, undertaking fixed exchange rate regime sometimes helps policy makers to decrease time inconsistency and increase their credibility among economic agents by producing a nominal anchor for fiscal policy (Herendorf, 1999). While in some other time, target zone exchange rate regime can increase policy makers' flexibility to control exchange rate fluctuations, in order to impose less time inconsistency.

In recent studies, Fiscal dominance is one of the most important issues in developing countries. In such countries, monetary policy is influenced by fiscal policy and government usually borrows from the central bank for compensating budget deficit which stemmed from reducing oil revenues. This process can abstain successful and efficient monetary policy in developing countries (Asgharpour et al., 2015). Subsequently, fiscal dominance can increase financial indiscipline. Moreover, fiscal dominance can surprise economic agents in a way that policy makers lose their credibility among agents. Such a framework can deteriorate policy time-inconsistency. As a result, curtailing fiscal dominance is a key in achieving and maintaining long term stability in the economy and establishing fiscal policy credibility can protect economy against time inconsistency behavior.

In this area, some studies have already been investigated the connections between fiscal dominance and exchange rate regimes. In these studies, it is tried to show how an exchange rate regime can decrease fiscal dominance, so then how policy makers can reduce policy time-inconsistency. Accordingly, they have shown that fixed exchange rate regimes are worse fiscal performance compared to Floating exchange rate regimes (Duttagupta & Tolosa, 2006). A critical turning point was reached in the mid 1990 in which many countries began to roll back the chronic fiscal dominance of the previous decades by avoiding exchange rate control and moving from pegged exchange rate to floating exchange rate regimes (Adam, 2009). Consequently, using floating exchange rate can sometimes decrease both fiscal dominance and time inconsistency.

Real exchange rate misalignment which means the deviation of actual real exchange rate from ideal real exchange rate, is another factor that can deteriorate time inconsistency in developing countries (Razin & Collins, 1997). Misalignment volatility is due to different factors such as real disturbance, exchange rate regimes and macroeconomic policy. Accordingly, Persistent misalignment that is considered as an overvaluation of the currencies, is often the sign of the inconsistency of the macroeconomic policies in oil exporting countries which are highly relying on the exogenous oil revenues (Mozayani & Parvizi, 2016). Therefore, there is a close relationship between real exchange rate misalignment and policy time inconsistency. According to this fact, clarifying the concept of misalignment can help policy makers to know how to use their policy properly while time inconsistency decreases. Moreover, exchange rate regime can be considered as another factor which can intensify misalignment. A number of studies attempt to show that floating exchange rate may be better suited to ensure the efficient adjustments of real economy to external shocks thereby can avoid prolonged real exchange rate misalignments. Thus, using floating exchange rate help authorities credibly signal to the private sector, and both real exchange rate misalignment and policy time inconsistency will decrease.

In addition, in some developing countries, government budget has a close relationship with oil revenue. So, oil revenue volatility is an important factor on instability of too many variables such as liquidity and inflation. Accordingly, rising oil revenue can increase monetary base and liquidity while it can increase inflation. Whereas decreasing oil revenue results in budget deficit. In this condition, government usually tries to borrow money from the central bank which can increases liquidity (Shakeri, 2016). Consequently, most of incorrect monetary policy is happened due to financing budget deficit (Khalili Iraqi & Goodarzi Farahani, 2015), which can intensify time inconsistency due to increasing fiscal dominance in the economy.

In modeling the relation between exchange rate regimes and time inconsistency, Zhu (1997) described a small open economy in perfect capital mobility environment. The mathematical form of its model is:

$$y_t^s = \beta\,[\pi_t - \pi_t^e | I(t-1)] + \hat{y} + \upsilon_t \quad (6)$$
$$y_t^d = \alpha\,[\; s_t + p_t^* - p_t] + f y_t^* + \varepsilon_t \quad (7)$$
$$m_t - p_t = h y_t - \gamma i_t + u_t \quad (8)$$
$$i = i_t^* + (\, s_{t+1} - s_t) | I(t) \quad (9)$$

In this model, he considers three shocks related to supply, demand, and fiscal as white noises. Relation 6 is about the total supply and π_t is inflation rate, $\hat{y}$ natural output, υ_t shock in terms of supply, and $\pi_t^e | I(t-1)$ is expected inflation of t in the time of $t-1$. $I(t)$ is also the data at hand for policy makers and institutions in the time t. In relation 7, s is exchange nominal rate, and ε_t shock from demand. Relation 8 is the money balance in the market in which m is money stock, h, is income elasticity of demand for money, and γ is interest semi-elasticity of demand for money. Relation 9 relates to the covered interest parity to support that different interest rate is a function of the expected exchange rate variations. Now considering above relations, a policy maker tries to minimize his loss function. Loss function is in the form of relation 10 in which w is relative weight of inflation.

$$L = w\,\hat{\pi}_t^2 + (y_t - k\bar{y})^2 \quad (10)$$

Regarding the points mentioned, there are three fixed, Floating, and target zone exchange rate regimes reviewed in this study. Zhu findings show, although the price and output volatilities are the same in two Floating and target zone exchange rate regimes, real exchange rate fluctuations in target zone exchange rate regime is less than Floating exchange rate regime; therefore, target zone exchange rate regime is more attractive for the policy makers to be adopted.

It is also shown that the greater the role of supply shock, the greater the welfare loss imposed by fixed exchange rate regime on economy. It is also shown that target zone exchange rate can solve time inconsistency, in addition to reducing inflationary bias; while Floating exchange rate regime intensifies time inconsistency in addition to bringing about large fluctuations in real exchange rate.

Davis and Fujwara (2015), generalizes Kydland and Prescott model (1977) to examine the relation between exchange regimes and time inconsistency, and uses new Keynesian model to show that it is necessary for nominal exchange rate to be stable in order not to have time inconsistency. Therefore, the more deviation from targeting, the more time inconsistency. He proposes two plans for decreasing time inconsistency. First, total inflation targeting ($\pi_t^H = 0$). He believes there should be a coordination between promised and actual prices. Second, stability of nominal exchange rate ($\widehat{S_t}$ = 0): in order to facilitate controlling time inconsistency. Davis and Fujwara's final theoretical model is:

$$L_t = 1/2 \sum_{t=0}^{\infty} \beta^t \ ((\Phi_y(\widehat{Y_t} - \hat{Y}_t^T)^2 + \Phi_\pi(\pi_t^H)^2 + \Phi_q(\hat{Q}_t)^2) \quad (11)$$

In which Y is the value of output, Y^T the value of output from its steady state level, and their difference (Y from Y^T) is deviation of anticipated output from steady state output. In relation 11, π_t^H is the domestic price indicator, and $\hat{Q}_t$ is the real exchange rate. The important factor in relation 11 is Φ, the indicator for weight and influence of each variable. In this relation, L_t shows dead weight loss and indicates the value of deviation existed from optimized policy. According to the model, applying systematic policies decreases output gap, and strengthens real exchange rate. At the same time, undertaking discretionary policies increases inflationary expectations and will be a factor in wide fluctuations in output and real exchange rate. So, the more changes in the exchange rate, the greater deviation from optimized policy; and as a result, it is expected that using discretionary policies bring more time inconsistency than systematic policies.

Reviewing the studies about relations between policy time inconsistency and exchange regimes shows that according to each country's economic condition, any of the fixed and/or target zone exchange regime may reduce time inconsistency. Therefore, there is no consensus on which exchange rate regime may bring less time inconsistency. Accordingly, sometimes the source of impulses, and governmental structure of the economy, plays a determining role in choosing exchange rate regime to control time inconsistency. It is therefore suggested to the policy makers to consider all welfare impacts of exchange rate regime in order to reduce time inconsistency.

In this study, we try to show which exchange rate regime may bring less time inconsistency by demonstrating time inconsistency in Iran exchange rate regimes.

3 Literature Review

There are lots of different studies about time inconsistency, the summary of which is presented in table 1. It appears, there is no domestic study about time inconsistency in various exchange regimes. Also, time inconsistency is not limited to developing countries, as it is seen in studies by Chappel & Mcgregor (2003). On policy time inconsistency in exchange rate regimes, Edwards

(2006) and Davis and Fujwara (2015) are mentioned whose explanations will come in the following.

Table 1
A Summary of Literature Review

Authors	Research limitations	Model	Results
Chappel & Mcgregore (2003)	USA 1970-1978	Federal Open Market Committee Method (FOMC)	Time inconsistency is one of the main reasons for Federal Reserve stimulus policies. Two factors of policy pressure and interaction between inflation and unemployment in Philips curve are of the most important reasons for using anti-inflation policies by the Federal Reserve.
Marinas & Zoican (2013)	Romania (2008)	Baroo-Gordon Model	Inflation Targeting decreases time inconsistency, and by decreasing inflationary bias, it is possible to make the output closer to its potential level.
Dargahi & Atashak (2002)	Iran 1959-1998	Error Correction Model	There are no requirements and assumptions for targeting inflation in Iran. There is therefore necessary to provide proper conditions for correct implementation of the policy.
Bastanifar (2014)	Iran 1976-2009	Ordinary Least Squares (OLS), Augmented Dickey-Fuller (ADF), and Vector Autoregressive (VAR)	In Iran, undertaking discretionary policies cause time inconsistency.
Khalili Iraqi & Goodarzi Farahani (2015)	Iran 1971-2010	State Space Model and Filter Kalman	There becomes time inconsistency problem between unemployment and inflation in short run.

Source: Research Findings

Edwards (2006) uses Structural Vector Autoregressive (SVAR) to examine the relation between targeting inflation, and exchange rate in 2 developed and 5 newly emerged countries in the years between 1985 to 2005 and concludes that the fluctuations in exchange rate in countries having targeted inflation regimes is tangibly different from those countries with fiscal discretionary policy regulations.

In recent years, Davis and Fujwara (2015), also tries to examine the role of targeting exchange rate and inflation in time inconsistency, using panel data model for 96 countries during 1998-2010. The results show that targeting nominal exchange rate can solve the problem of time inconsistency and regulate exchange policy. A summary of the most important experimental studies about time inconsistency is presented in the table 1.

Some important points are resulted from the studies about time inconsistency in exchange rate regimes. First, fixed exchange rate regime makes the ground for regulating policy making by producing nominal anchor for fiscal policy, which is a tool for solving time inconsistency problem, while target zone exchange rate regime is capable of increasing policy makers' maneuverability by controlling exchange rate fluctuations. Studying and examining other studies about time inconsistency take us to the point that despite the existence of various studies in this concern, there is not enough attention to the relation between exchange rate regimes and the problem of time inconsistency, especially for Iran's economy. The present study tries to compare and contrast fixed and managed Floating exchange rate regimes in Iran, in order to clarify the relation between exchange rate regimes and the problem of inconsistency, and the way to solve the problem.

4 Research Methodology

Time inconsistency has become an interesting research subject in economics recently. Economists believe that time inconsistency is mostly exposed due to uncertainty. Furthermore, uncertainty plays an important role especially for medium term forecasting in economic models. Thus prediction of time inconsistency is not an easy task due to its dynamic behavior. So, using an efficient technique which can deal with uncertainty is necessary. According to this fact, a fuzzy system which uses an explicit and systematic nonlinear prediction system, is suitable for solving complicated and random problems which have less accurate solution in the framework of classical economics like as economic policy evaluation, uncertainty and time inconsistency (Ponsard, 1988). So the employment of fuzzy models makes it possible to deal with different types of issues which cannot be treated effectively with conventional techniques (Zadeh, 1983). Fuzzy models not only can guarantee the feasibility of development in economics but also can play an important role in economic tremendous achievements (Ponsard, 1988).

In this study a momentary fuzzy prediction system is applied to examine time inconsistency in two fixed and managed Floating exchange rate regimes. Fuzzy prediction system uses three steps. In the first step, it uses FCM models to calculate membership function and the number of clusters. In the next step, it utilizes Takagi-Sugeno (TS) model to identify the structure of the model. And in the final step, it uses a Recursive Least Squares (RLS) method to estimate and update extracted fuzzy parameters from the previous stage. Figure 2 shows how the fuzzy prediction system defines time inconsistency, the definition of which comes later.

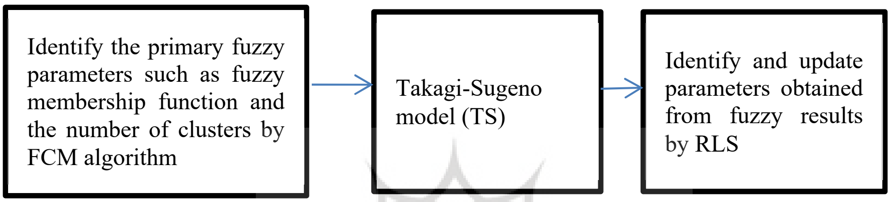

Figure 2. Fuzzy prediction and an advice for identifying time inconsistency of real exchange rate in exchange rate regimes of Iran

First, the Fuzzy C-Means (FCM) will be explained which is responsible to calculate membership functions and the number of classifications.

4.1. FCM Model:

Clustering analysis generally consists of a wide range of methods which try to attribute some data such as x to a cluster. An observation may belong to a cluster or another. The task of membership function is making the ground for determining the value of the sample belonging to a cluster. Membership functions value between zero and one, in which closer to zero shows the reality that the given sample is far from a cluster. On the other hand, being closer to one shows the given sample is more similar to the members of a cluster (Bezdek, 1985). So the existence of such features increases the flexibility of the model to provide more accurate and more detailed data (Oliveira & Pedrycz, 2007). Different membership functions can be generally extracted from FCM, and Gaussian membership function will be used in this paper.

FCM is used for analysis based on distance between various input data points. Accordingly, using FCM model is to minimize following objective function:

$$J_m = \sum_{i=1}^{N} \sum_{j=1}^{C} u_{ij}^{m} \,||x_i - c_j||^{2} \quad 1 < m < \infty \tag{12}$$

In the above equation, m is fuzzy factor, any real value larger than 1, u_{ij} is the degree of membership x_i in the cluster j. Here c_j is the mean value of the cluster and $||x_i - c_j||^{2}$is Euclidean distance between observation x_i and the cluster j .To calculate u_{ij} the following relation is used:

$$u_{ij} = \frac{1}{\sum_{k=1}^{c} \left(\frac{||x_i - c_j||}{||x_i - c_k||} \right)^{2/m-1}} \tag{13}$$

Where c_j is obtained from:

$$c_j = \frac{\sum_{i=1}^{N} u_{ij}^{m} x_i}{\sum_{i=1}^{N} u_{ij}^{m}} \tag{14}$$

The FCM function takes a data set and a desired number of clusters and return optimal cluster mean and membership function grades for each data point (Ghosh & Dubey, 2013). Accordingly, FCM first determines a mean for each cluster randomly. Then makes it possible to compute membership functions (u_{ij}) with the mean at hand. Then by updating the clusters and the membership grades for each data point, FCM can move clusters mean to the right location within a data set (Ghosh & Dubey, 2013). In the final stage, the value of J will be calculated. This will continue till J becomes less than a definite value and is when u_{ij}^{k+1}-u_{ij}^{k}<ε, and then the procedure ends. The end of the procedure actually means that each data is gone to the cluster which most probably belongs to. Thus using FCM has some advantages. First, the membership function of FCM can identify the characteristics of each cluster well. Also, the process usually converge to a fixed point (Dun, 1974) and finally FCM is considered as an unsupervised learning process which does not require any labeled dataset as training data (Ghosh & Dubey, 2013).

4.2. Takagi-Sugeno Model (TCM)

Takagi-Sugeno (1985) tries to present a mathematical tool to make a fuzzy model of the system. This model is capable of identifying model structure and creating fuzzy rules as a systematic method. Furthermore, this method can reduce linear relationship in multidimensional case. So this model is consistent with the reason method. In other words, this method of identification enables us just the same parameters as the original system, if we have a sufficient number of noiseless output data for identification. Primary form of Takagi-Sugeno model is:

If for R_i, (k)x_1 is equal to (i)A_1 and …(k) x_N equal to (i)A_N, then:

$$y_i(k)= \theta_{i1}x_1(k)+ \ldots + \theta_{iN}x_N(k) \quad i= 1,\ldots, c \tag{15}$$

In which i=1, …, c is the number of clusters. R_i actually show the rule, and each rule is a row of matrix θ which is needed for calculating the output. Now regarding all above, we have:

$$y(k)= \sum_{i=1}^{c} \omega^{-i}[x(k)]x(k)\theta_i= \psi(k)\,\Theta \tag{16}$$

In this relation i is from 1 to C, and the membership function is given as Gaussian. So:

$$x(k)= [x_1(k),\ldots,x_N(k)] \tag{17}$$

$$\mu A_i^j\,(x_j)= \exp\left(-\frac{(x_j-\nu_{ij})^2}{\delta_{ij}}\right) \quad j=1,\ldots,N \tag{18}$$

$$\omega^{-i}\,[x(k)]= \frac{\prod_{j=1}^{N} \mu A_i^j\,(x_j)}{\sum_{i=1}^{C}\prod_{j=1}^{N} \mu A_i^j\,(x_j)} \tag{19}$$

$$\theta_i = (\theta_{i1}, \ldots, \theta_{iN})^T \tag{20}$$

$$\Theta=[\theta_1^T, \ldots, \theta_C^T]^T \tag{21}$$

$$\Psi(k)= [\ \omega^{-1}[x(k)]x(k),\ \ldots,\ \omega^{-1}[x(k)]x(k)] \tag{22}$$

In above relations ν_{ij} and δ_{ij} are the members of membership function (Antecedent Parameters), the former is the mean and the latter is the standard deviation.

Therefore, Takagi- Sugeno Model is computationally efficient with adaptive techniques which make it attractive in controlling dynamic nonlinear systems. Furthermore, these adaptive techniques also can be used to customize the membership function so that fuzzy systems can model data in the best way (Kaur & Kaur, 2012).

4.3. Recursive Least Squares Method (RLS)

Using of recursive method has some advantages. First, this method uses an adaptive process for updating time varying and nonlinear parameters with adequate accuracy (Young, 2011); furthermore, this method can strengthen Takagi-Sugeno model performance. Also, this method does not require a large amount of data in the training process (data is limited in this research). On the other side, rolling methods which uses an iterative process, needs a large amount of data in the training process. Additionally, rolling method is a common method which is suitable for out of sample estimations (Rossi & Sekhposyan, 2009). Finally, rolling analysis is generally discussed in technical analysis literature and rarely used in statistical properties analysis. So according to what has mentioned above, it is decided to use a recursive method rather than rolling method.

This method is used to estimate and update model parameters, so in each recursion, estimates of parameter vector will be updated by this method.

$$\theta_i(l)=\theta_i(l\text{-}1)+\frac{\theta_i(l-1)\,\psi_i^T}{1+\xi_i}\,[y_i(l)-\psi_i(l)\theta_i(l\text{-}1)] \tag{23}$$

$$\psi_i(l)=(\omega^{-i}[x(l)]\ \ x(l)) \tag{24}$$

$$\xi_i=\psi_i(l)c_i(l\text{-}1)\,\psi_i^T(l) \tag{25}$$

$$y_i(l)=(\omega^{-i}[x(l)])y(l) \tag{26}$$

$$c_i(l)=c_i(l\text{-}1)\text{-}\frac{c_i(l-1)\psi_i^T(l)\psi_i(l)c_i(l-1)}{\xi_i^{-1}+\varepsilon_i} \tag{27}$$

In the above relations, θ is model results parameters (Consequent Parameters) which is updated by relation 23, and indicates how model parameters change during a period of time. In these relations, c is covariance matrix of RLS method which is updated by relation 27 (Rastegar et al, 2014).

(It is necessary to mention here that for predicting real exchange rate quarterly data related to lags in real exchange rate, gross domestic output, lags in gross domestic output, liquidity, lags in liquidity, oil revenues, and lags in oil revenue during 1990-2012 are used. Data related to nominal exchange rate, Iran consumer price index, liquidity, oil revenue, gross domestic output and budget deficit are gathered from the Central Bank of Iran[1], and data related to USA consumer price index from the US statistics site[2].)

5 Results

In order to implement the proposed algorithm, table 2 is first formed and the results are obtained from utilizing fuzzy clustering algorithm during the period related to controlled exchange rate regime (1991-2001). Table 3 is similar to table 2 but it is for managed Floating exchange rate regime (2002-2012)[3].

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[1] www.cbi.ir

[2] www.us inflation calculator.com

[3] Calculations done in MATLAB

Table 2
The Value of Real Exchange Rate Predicted Error in Controlled Exchange Rate Regime (1991-2001)

Year (Quarters)	**The Value of Predicted Error**	**Year (Quarters)**	**The Value of Predicted Error**
1991 (1)	7.5	1996 (3)	24.8
1991 (2)	-0.3	1996 (4)	46.2
1991(3)	0	1997 (1)	-59.4
1991(4)	-1.3	1997 (2)	165.4
1992 (1)	0.6	1997 (3)	317.8
1992 (2)	-6.7	1997 (4)	150.3
1992 (3)	0.8	1998 (1)	-349.8
1992 (4)	37.4	1998 (2)	401.3
1993 (1)	-17.3	1998 (3)	290.5
1993 (2)	-7.6	1998 (4)	79.9
1993 (3)	6.3	1999 (1)	-137.8
1993 (4)	0.4	1999 (2)	16.6
1994 (1)	-40.5	1999 (3)	-171.8
1994 (2)	-54.9	1999 (4)	-388.7
1994 (3)	-16.2	2000 (1)	-95.2
1994 (4)	32.1	2000 (2)	237.6
1995 (1)	-29.7	2000 (3)	-180.3
1995 (2)	10.8	2000 (4)	138.3
1995 (3)	-2.1	2001 (1)	64.6
1995 (4)	-3.8	2001 (2)	161
1996 (1)	19.5	2001 (3)	-204.5
1996 (2)	20	2001 (4)	195.9

Source: Research Findings

First, statistical indexes in two fixed and managed Floating exchange rate regimes will be compared and contrasted according to the results obtained in the present study, and shown in tables 4 and 5.

There come important results from comparing statistical indexes related to predicted error in two fixed and managed Floating exchange rate regimes. First, error MAX absolute value in controlled exchange rate regime is more than managed Floating exchange rate regime, while it is opposite for error MIN absolute value; therefore, the difference between the least and the most error in controlled exchange rate regime are more than in managed Floating exchange rate regime. This may be considered as an indicator of more uncertainty in controlled exchange rate regime than in managed Floating rate regime. Additionally, variance which is one of the other important indexes in recognizing uncertainty, is more in controlled exchange rate regime than managed Floating exchange rate regime.

Table 3
The Value of Real Exchange Rate Predicted Error in Managed Floating Exchange Rate Regime (2002-2012)

Year (Quarters)	**The Value of Predicted Error**	**Year (quarters)**	**The Value of Predicted Error**
2002 (1)	-15.6	2007 (3)	-0.6
2002 (2)	-11.6	2007 (4)	-68.2
2002 (3)	195.7	2008 (1)	62
2002 (4)	-202.9	2008 (2)	14.7
2003 (1)	-80.8	2008 (3)	-17.4
2003 (2)	219.6	2008 (4)	-51.8
2003 (3)	2	2009 (1)	73.8
2003 (4)	55.8	2009 (2)	-53.3
2004 (1)	-18.4	2009 (3)	5.4
2004 (2)	-112.2	2009 (4)	49.6
2004 (3)	-174.6	2010 (1)	-50.7
2004 (4)	-71	2010 (2)	11.7
2005 (1)	-80.2	2010 (3)	36.7
2005 (2)	-152.3	2010 (4)	30.8
2005 (3)	7.7	2011 (1)	25.7
2005 (4)	36	2011 (2)	30.9
2006 (1)	-78.5	2011 (3)	27.7
2006 (2)	-96	2011 (4)	364.6
2006 (3)	-27.5	2012 (1)	-93.4
2006 (4)	-2.3	2012 (2)	-31.9
2007 (1)	16.4	2012 (3)	-19.1
2007 (2)	-50.7	2012 (4)	-40.6

Source: Research Findings

Table 4
Statistical Indexes for Controlled Exchange Rate Regime

Fixed exchange rate regime	Median absolute value	Variance	Mean absolute value	Skewness	MIN absolute value	MAX absolute value
(1991-2001)	38.97	2.25×10^4	95.32	38.97	0.09	401.37

Source: Research Findings

Table 5
Statistical Indexes for Managed Floating Exchange Rate Regime

Managed Floating exchange rate regime	Median absolute value	Variance	Mean absolute value	Skewness	MIN absolute value	MAX absolute value
(2002-2012)	45.11	9×10^3	65.2	45.11	0.68	364.69

Source: Research Findings

It is necessary to mention that median which shows the value of data in two halves is larger for managed Floating exchange rate regime. The other most important statistical index is mean error, whose results show that it is larger for controlled exchange rate regime than managed Floating one. The value of skewness is positive in both cases and denotes that most errors are in the left side of the median, yet again smaller for managed Floating exchange rate regime than the controlled one. Accordingly, the number of small predicted error in managed Floating exchange rate regime is more than controlled exchange rate regime; and, error variance in controlled exchange rate regime is more than managed Floating one. So the results obtained from examining statistical indexes show us that the uncertainty in controlled exchange rate regime is greater than the managed Floating one. In such a situation, it is more probable for economic agents to be surprised in controlled exchange rate regime, which is consequently considered as a factor to intensify time inconsistency.

Then the results of the present study are compared with the realities of Iran economy. Studies show that in controlled exchange rate regime, there are serious impulses because of changes in oil revenue, international sanctions, and economic adjustments, which can both surprise the economic agents and bring about instability in the macroeconomic variables. It causes significant difference in the real value of real exchange rate in most quarters in this period (most quarters of 1996, 1997, 1998, 1999, 2000, and 2001). On the other hand, in managed Floating exchange rate regime, the conditions are different. To put it more precisely, the abundance of exchange resources in most quarters of the early period helped the policy makers to be more Floating, which causes significant difference in real value and predicted real exchange rate in early quarters of managed Floating exchange rate regime (some quarters of 2002, 2003,2004, and 2005). Alternatively, in the late period of managed Floating exchange rate regime, there are different and noticeable conditions with increased exchange volatilities because of foreign sanctions (Shakeri, 2016).

This is the main reason for significant difference in real value from the predicted value of real exchange rate in the end of 2011. Therefore, it is concluded that there are multiple and sever shocks in controlled exchange rate regime than in managed Floating one, which increases exchange instability in controlled exchange rate regime, and policy makers lose their creditability in front of the economy agents, and there comes a significant difference between real values and predicted real exchange rate in controlled exchange rate regime.

Also, time inconsistency of real exchange rate is studied in both controlled and managed Floating exchange rate regimes. To do so, a variable is defined as JJ which is a measure for time inconsistency and equals to the sum of error squares. So, according to the definition of variable JJ, the less value of the variable, the less time inconsistency[1]. All the calculations are demonstrated in table 6:

Table 6

Value of Time Inconsistency For Real Exchange Rate in Different Exchange Rate Regimes in Iran (1991-2012)

Time Period	Value of Time Inconsistency (JJ)
Controlled Exchange Rate Regime (1991-2001)	7.16×10^4
Managed Floating Exchange Rate Regime (2002-2012)	6×10^3

Source: Research Findings

The table shows that the value of time inconsistency in controlled exchange rate regime is more than the managed Floating one. So the results are compatible with the realities in Iran's economy. Accordingly, the existence of multiple and severe impulses which happened to the controlled exchange rate regime intensified the probability of discrediting economic agents' expectations; and, increased time inconsistency; while the abundance of exchange sources in most quarters of managed Floating exchange rate regime reduced exchange rate fluctuations and controlled time inconsistency. Additionally, controlled exchange rate regime in Iran acts according to Mishkin's model (1998). According to Mishkin's model, lack of policy makers' transparency in order to stabilize the exchange rate made uncertainty

[1] To solve the measure problem, the error mean is first calculated, and then the error mean is applied in calculating time inconsistency.

in macroeconomic variables which may cause the appearance of time inconsistency in the economy.

Furthermore, the existence of fiscal dominance is the other factor which can intensify policy time inconsistency. Accordingly, reducing oil revenue in controlled exchange rate increases budget deficit and subsequently, fiscal dominance increases. Moreover, increasing fiscal dominance deteriorates fiscal discipline in a way that can surprise economic agents' expectations and as a result policy time inconsistency will increase. While, abundance of exchange sources in managed Floating exchange rate regime in Iran, gives the economic agents enough confidence that the probability of increasing fiscal dominance is low, so policy time inconsistency will decrease due to reducing financial indiscipline. Consequently, fiscal dominance which stemmed from accumulation of budget deficit, is an important factor in determining the value of policy time inconsistency in Iran's economy.

And finally, since some studies emphasized on the role of exchange rate regimes in price and output volatilities, the fluctuations of these two important variables are studied in order to help policy makers to decide properly with complete information on the welfare effects of their policies. For this reason, tables 7 and 8 gives output and price volatilities:

Table 7
Estimation of Output Fluctuations in Iran Exchange Rate Regimes (1991-2012)

Period of time	Output fluctuations in comparison to steady-state condition
Controlled Exchange Rate Regime (1991-2001)	576.2
Managed Floating Exchange Rate Regime (2002-2012)	0.42

Source: Research Findings

Table 8
Estimation of Price Fluctuations in Iran Exchange Rate Regimes (1991-2012)

Period of time	Price fluctuations in comparison to steady-state condition
Controlled Exchange Rate Regime (1991-2001)	0.96
Managed Floating Exchange Rate Regime (2002-2012)	14.04

Source: Research Findings

Tables 7 and 8 depict the output fluctuations in Floating exchange rate regime are less but price fluctuations are more than controlled exchange rate regime.

However, this study has shown that policy time inconsistency in managed Floating exchange rate regime is less than controlled one. Therefore, it is suggested that continuing managed Floating exchange rate regime can pave the way much better for controlling policy time inconsistency. With such a policy, it is necessary to pay more attention to adopting monetary policy in order to relief all concerns about price volatilities; because, managed Floating exchange rate regime can intensify the price volatilities.

6 Conclusion and Recommendations

Though time inconsistency has been reviewed in lots of studies in various fields such as fiscal, financial, and trade policies, its relation to the issue of choosing proper exchange rate regime has not been paid much attention. Regarding the importance of exchange rate regime chosen, as one of the most significant elements in international finance, this study investigates the relation between exchange rate regime and time inconsistency in order to clarify which of them (controlled or managed Floating) should be applied in Iran, to impose less time inconsistency on the economy. The authors review the value of time inconsistency in exchange rate regimes in Iran (controlled 1991-2001, and managed Floating 2002-2012). The results indicate that time inconsistency in controlled exchange rate regime is more than managed Floating one in Iran. Thus, it is suggested to policy makers to control policy time inconsistency by continuing managed Floating exchange rate regime.

In conclusion, if policy makers are intended to use rule based policy in exchange market, it is suggested to adhere to managed Floating exchange rate. In this way, they can increase their credibility among economic agents. Furthermore, due to enhancing transparency and directing economic agents expectations properly, they can reduce policy time inconsistency. Accordingly, when they are going to implement a managed Floating exchange rate regime, policy makers should be conscious enough in adopting monetary policy, because managed Floating exchange rate regime imposes more price fluctuations. Finally, it must be mentioned that going toward managed Floating exchange rate, can increase the flexibility of policy makers. By following this strategy, policy makers can better ensure the efficient adjustments of real economy to external shocks (Adam, 2009) and it makes possible to deal with policy time inconsistency.

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