RESEARCH PAPER

Estimating Social Discount Rate Trend in Iran

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Abstract
The Discount rate is one of the important variables in the inter-temporal analysis which makes it possible to compare the current and the future values and enables economic agents and policymakers to make better decisions. In this context, the discount rate is a vital variable for the accurate evaluation of economic projects. Considering the different approaches that governmental and private sectors use to implement the investment projects, for evaluation of the governmental and public projects, a separate discount rate is used called social discount rate (SDR). In this article by using the structural equation modeling, we have estimated the SDR trend in the Iranian economy during the period 1996-2016. To do that by extracting influencing & consequence factors of SDR (as a latent variable), we applied a Multiple Indicators and Multiple Causes (MIMIC) model. The SDR trend, as the main finding of this paper, seems to be robust enough due to its explanatory power for fluctuations of the Iranian economy in reality. The results imply that the SDR has had a mild decreasing trend in Iran's economy during the sample period and among influencing variables, the inflation rate has had the most impact on its trend. Accordingly, when the level of prices rocketed during the periods 2012-14, the SDR trend experienced a more than 60% increasing jump. However, the GDP has been the variable that mostly affected by the SDR fluctuations. It seems that controlling inflation and consequently social inflationary expectation can be proposed as a proper policy recommendation to manage SDR and its distorting impacts in Iran.
Keywords: Social Discount Rate, MIMIC Model, Iran, Economic Evaluation.
JEL Classification: H43, H54, R42.

Introduction

The economic analyses show that the Discount rate plays an important role in the evaluation of economic projects, especially in projects with long-term horizons. Due to the different approaches of the governmental and private sectors for investment in projects as well as the requirements for it, a special discount rate called the social discount rate (SDR), which is different from the discount rate of the private sector, is used in the economic literature for the evaluation of public plans (Armitage, 2017). Opting for the SDR is one of the most critical procedures in the cost-benefit analysis of governmental projects and policies (Moore et al., 2013; Lopez, 2008; Zhuang et al., 2007). The SDR, by definition, refers to the rate that shows how (at which rate) a society evaluates the future valued (e.g. costs and benefits) in comparison with the present ones (European Commission, 2008). In other words, this rate measures the rate at which a society is willing to trade present consumption for future consumption (Lopez, 2008). Therefore, the SDR is known as one of the most important

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parameters used to evaluate the governmental and public projects (Weitzman, 2001), so that the fluctuations of this parameter will change the resource allocation and efficiency (Halicioglu and Karatas, 2013). This is because of the fact that applying the discount rate above reality (what it should be) causes many projects that can be financially (and economically) justifiable to be excluded from the analysis cycle and not to be selected. In addition, early return projects are prioritized in this case through the allocation of less weight to the costs and revenues of projects in the far future. In contrast, selecting a discount rate lower than the reality (what it should be) also leads to the selection of many projects that lack the required capability for investment, and causes projects that can become profitable at later stages to be prioritized for selection, which can lead to deviations in the decisions (Mozayani, 2017). There are four approaches to SDR calculation in the economic literature: 1- social rate of time preference (SRTP), 2- social opportunity cost of capital (SOC), 3- weighted average method (WAM), and 4- shadow price of capital (Zhuang et al., 2007).

The present study aims at investigating the SDR trend for the Iranian economy during the period 1996-2016 using the structural equation modeling and the multiple indicators and multiple causes (MIMIC) approach, which has not been explored in Iran yet since the studies having been conducted in this area so far have mostly tried to estimate the value of this variable in a specific time period. The present paper consists of four sections. The present introduction section is followed by the second section which deals with the literature review. The third section is devoted to data and methodology and the summary and conclusion are discussed in Section four.

Literature Review

Theoretical Background

Rae (1834), Böhm-Bawerk (1890), Ramsey (1928), Fisher (1930), and Samuelson (1937) have been original studies that discussed discount rate (rate of time preference). Most of these studies engaged in the concept and primary role of the discount rate (time preference rate) in economic decision making. Among these studies, Ramsey (1928) was the first and distinguish one in which discount rate (time preference) was used in an inter-temporal framework. To do that he developed his famous growth model as follows:

$$MAX \int_0^\infty U\big(c(t)\big)e^{-\rho t}, U' > 0, U'' < 0, \mathrm{U(c(t))} = \frac{c(t)^{1-\theta}}{1-\theta}$$

$$S.T.: \dot{K}_t = f(k_t) - C_t, g = \frac{\dot{C}_t}{C_t}, \theta > 0, \rho - n - (1-\theta)g > 0$$

$$r = f'(k_t) = \rho + \theta g \qquad \theta = -\frac{u''}{u'}c$$

According to the last equation, the rate of return on savings (r) is equal to the discount rate of utility (ρ) plus the marginal rate of consumption (θ) multiplied by per capita consumption growth rate (g). Soon after researchers elaborated on different aspects of discount rate and applied the Ramsey model in their studies. Among these studies, some researchers discussed influencing factors of the discount rate. For instance, Hausman (1979), Arrow and Lind (1978), Viscusi and Moore (1989), Lawrance (1991), Bardhan (1995), Becker and Mulligan (1997), Lumley (1997), Moseley (2001), Frederick et al. (2002), Dalali Isfahani et al. (2009); Tanaka et al. (2010), Urminsky and Zauberman (2015) can be categorized in this group. Likewise, some of the studies such as Hotelling (1931), Solow (1974), Markandya and Pearce

(1988), Gaudet (2007), and Cardenas and Carpenter (2008), analyzed the consequence of discount rate on other variables.

From the theoretical and empirical perspective, the Factors that influence and are influenced by the social discount rate can be shown in the Figure (1):
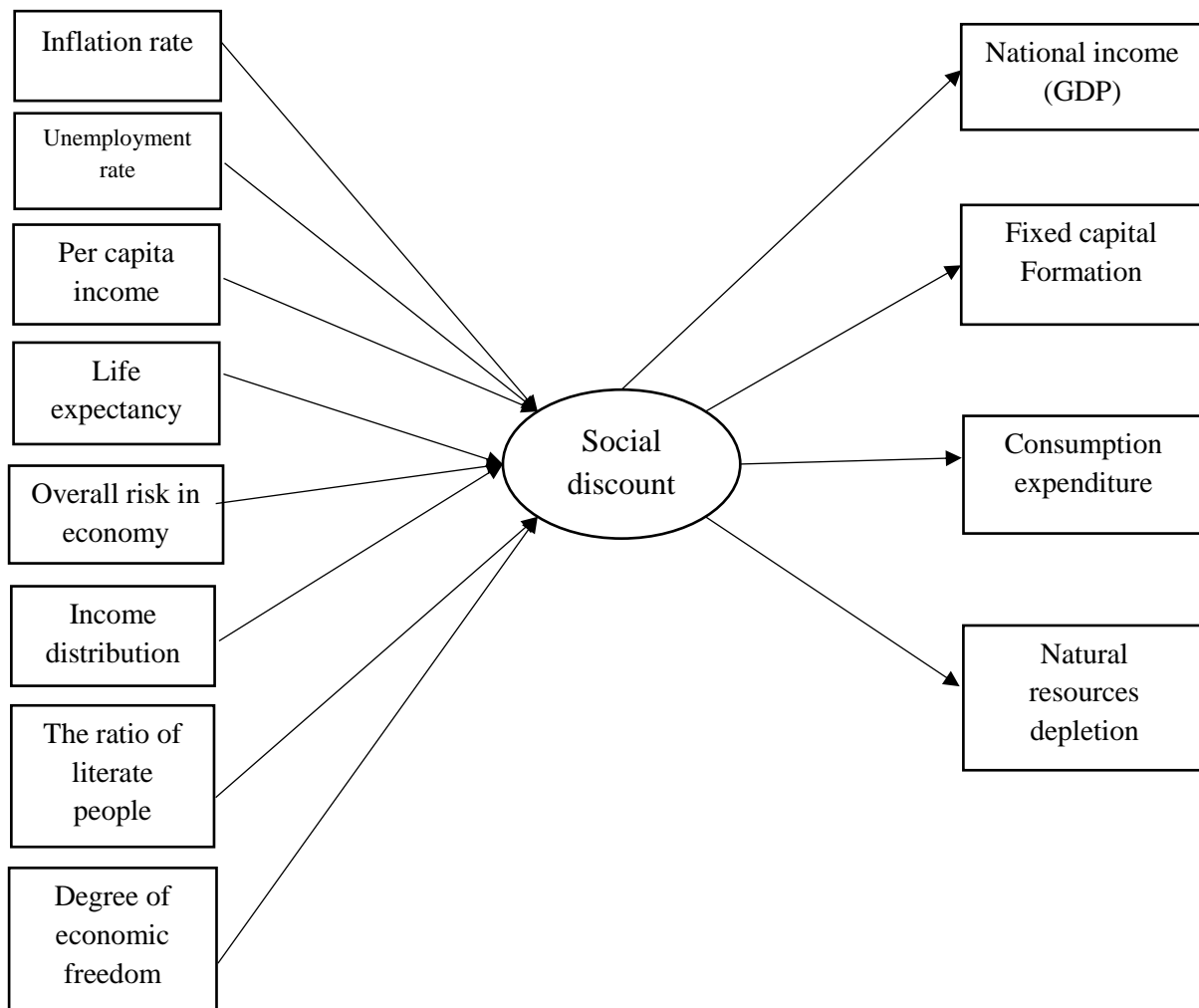

Figure 1. Influencing & Consequence Factors of SDR (Conceptual Model of Research)
Source: Author's compilation based on literature Review.

To better understand the dimensions of the subject, we need to discuss the theoretical foundations of the SDR and its consequences. The components of the conceptual model of the research are briefly mentioned in the following.

Unemployment Rate: If there is a high unemployment rate in a country, people will meet a lot of problems in earning a living and this occupational and financial insecurity will make them unable to provide their daily livelihood needs. Therefore, they will focus more on providing their consumption at the present time, pay little attention to the future, and ask for higher discount rates in order to avoid consumption at the present time (Ramsey, 1928; Dalali Isfahani et al., 2009).

Per Capita Income: The higher the per capita income in a society, the lower the SDR. Societies with higher per capita income enjoy a relatively higher level of welfare, and people are less concerned about their future lives. In other words, the citizens of such societies have a more secure future. Hence, it is expected that the (relatively) higher level of the per capita income of a community causes the citizens of that community to demand lower discount rates

(Becker and Mulligan, 1997; Hausman, 1979; Bardhan, 1995; Lumley, 1997; and Moseley, 2001).

Life Expectancy: The higher level and better quality of the health and well-being of a community cause the people living in the community to have a more positive and hopeful prospect about the future of their lives, and an increase in the average life expectancy of people will cause them to have lower discount rates due to their less consumption during the present time (Becker and Mulligan, 1997; Fuchs, 1982).

Inflation Rate: The Higher inflation rate in a community will lead to the higher price expectation to the impatience of most people in that community and cause people to convert their future incomes into present consumption, which will increase their level of consumption. As a result, under inflationary conditions people, by higher SDR, will be more impatient for converting their income into present consumption (Ramsey, 1928; Dalali Isfahani et al., 2009).

Overall Risk in Economy: The greater risk in a country's economy will manifest itself in economic activities such as consumption and investment more considerably, So that people in these communities will be more likely to become more impatient and more inconsistent when they avoid present consumption in the present time, and as a result, these communities will have higher SDR (Arrow and Lind, 1978; Tanaka et al., 2010).

The Ratio of Literate People: The more educated the people of a community, the more accurate their understanding of the future. More educated people will act more rationally in evaluating consumption in the present and future, and this logic will be manifested more considerably in their economic behaviors. Hence, the higher the ratio of literate people, captured as the ratio of university graduates to the population, the lower the discount rates of that community (Becker and Mulligan, 1997; Viscusi and Moore, 1989).

Income Distribution: The more unfair the distribution of income in a country, the greater problems the people will face in reaching a standard level of living and general welfare. As people in such communities psychologically and mentally feel a lack of economic and social justice, they try to get their share of injustice. Consequently, they are likely to become more impatient for consumption at present, and they have little hope of access to the present value in the future, demanding higher discount rates to avoid the consumption at present (Ramsey, 1928; Lawrance, 1991).

The variables influenced by the SDR in the proposed model are energy and natural resource depletion, fixed capital formation, and GDP. The influence of the SDR on these variables may be interpreted in such a way that the higher the SDR, the greater the energy resource and natural resource depletion. This means that following an increase in the discount rate, people will find the present time more important than the future, leading to their greater and excessive use of energy and natural resources (Solow, 1974; Hotelling, 1931; Gaudet, 2007). On the other hand, the greater discount rate in a community, the greater impatience the people of that community will have for present consumption rather than future consumption, which reduces their investment (Markandya and Pearce 1988; Cardenas and Carpenter, 2008), and this decline in investment will, in turn, reduce the GDP. Accordingly, the most important factors that influence and are influenced by the SDR may be summarized into variables such as inflation, unemployment, income distribution, the ratio of literate people, life expectancy, overall risk, per capita income, fixed capital formation, overall consumption, and natural resource and energy depletion, as depicted in the conceptual model of the research (Figure 1). This model will be used as the basis for the quantitative calculations of this study. We used the annual data during the period 1996- 2016 to extract the SDR trend. So, we will use the MIMIC model by STATA Software to examine the trend of this rate. The sources of information are as follows:

The information about the GDP, inflation rate, unemployment rate, Gini coefficient (for income distribution), the ratio of graduates to population and per capita income was gathered from the Central Bank of the Islamic Republic of Iran. The information about life expectancy, natural resource depletion, energy resource depletion and fixed capital formation was collected from the World Bank.

A Brief Review of the Practical Studies

Review of the literature implies that most of the practical studies have been devoted to the calculation of SDR values in countries through different approaches. For instance, Lopez (2008) studied SDR for nine Latin American countries by STP approach and concluded that the SDR will fluctuate between 3-7 percent during 1961- 2006. Halicioglu and Karatas (2011) by using STP approach calculated the average SDR for the Turkish economy as 5.06 percent during 1980 - 2008 or Kula (2004) calculated SDR for the Indian economy based on the STP approach as 5.2 percent. Also, Akbulut and Seçilmiş (2018) calculated the SDR for the Turkish economy by applying the STP approach between 4.13 and 4.88 percent respectively. Moreover, in this group some studies can be mentioned which were conducted by Abdoli (2009), Shirdel et al. (2017), and Daneshmand et al. (2018) who calculated SDR for the Iranian economy as 7.2, 5.12, and 5.8 percent.

On the other hand, some studies used SOC approach for the calculation of SDR. For instance, Spiro (2010) calculated it 7.7 percent in Canada, Burgess and Zerbe (2011) estimated the SDR between 6% and 8% and Abelson and Dalton (2016) estimated it 6.5 percent for the Australian economy. Meanwhile, some researchers such as Edwards (1986) believe that the SDR for a small open developing economy, under certain circumstance, should be calculated by the weighted average approach of the STP and the SOC. Finally, there are few studies in the literature that have calculated SDR by using "shadow price of capital" (SPC) approach. For instance, Boardman et al. (2010) by discussing SPC approach advantages calculated SDR for the Canadian economy as 3.5 percent.

According to the review of literature, it can be argued that most experimental studies focused on spot estimation of SDR value in sample countries (including Iran) in a cross-sectional approach and no independent study has been conducted for estimation of SDR trend during a specific period of time, has been observed. This study tries to estimates the historical trend of SDR and its influencing and consequences factors in Iran's economy which has not been done so far. So, it can be considered as a new contribution to the literature. However, the SDR trend data entails applicable information for analyzing community time preferences and behaviors.

Data and Methodology

In order to extract SDR trend, we used MIMIC model that is a specific case of the Structural Equation Models (SEM). These models are being widely applied in many social sciences such as sociology, marketing and economics that show the relationship of latent variables and observed indicators and causes. In economics, one of the first studies on the application of the SEM method was conducted by Goldberger (1979) in which a special form of structural equation, called multiple indexes and multiple causes was used. The MIMIC model consists of two separate parts: structural equations (structural model) and measurement equations (measurement model). The structural model with a set of visible indices is presented in Equation (1) as follows:

$$Y_i = \lambda_i \eta + \mu_i \tag{1}$$

In the case of the present study, Y_i represents observable social discount rates indexes, η is the latent variable, u_i and λ are random errors structural and measurement model. Equation2 (measurement equation) is as follow:

$$\eta = \alpha_1 X_1 + \alpha_2 X_2 + \cdots + \alpha_P X_P + V \tag{2}$$

In the equation above, X_P indicates a set of visible causative variables such as inflation rate, unemployment rate, life expectancy, etc. α_P are structural parameters model, V and η stand for disturbance term and latent variable (social discount index). Equations (1) and (2) can be rewritten as follows:

$$Y = \gamma\eta + u \tag{3}$$
$$\eta = \alpha X + u \tag{4}$$

In these equations, it is assumed that there is no correlation between the error statements as follows:

$$E(UV) = 0, E(V^2) = \sigma^2, E(U'U) = \theta^2$$

for obtaining a function of observable variables, we can put Equation (4) into Equation (3) to solve the model, and then can achieve Equation (5) as follows:

$$Y = (\alpha X + V)\lambda_i + u \tag{5}$$

Also, by defining $\prod = \lambda Y$ and $W = \lambda V + \mu$ Equation (5) can be rewritten as follows. The result can be considered as the shape of the MIMIC model.

$$Y = \prod{}'X + W$$

Moreover, the matrix of the equation system will be as follows:

$$\begin{vmatrix} Y_1 \\ Y_2 \end{vmatrix} = [\eta] + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix}$$

$$[\eta] = [\alpha_1 \ \alpha_2 \ \alpha_3 \ \alpha_4 \ \alpha_5] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \end{bmatrix} + [u]$$

In order to select the superior model for estimating the social discount rate, we applied the following approaches: A- Frey and Weck- Hanneman approach (1984) that emphasizes on statistical and theoretical consistency of variables. B- Giles approach (1999) emphasizes on general fitness of the model. We intend to try a combination of models through the maximum likelihood (ML) approach by "STATA-14" software and choose the final model(s) due to general fitness criteria (LISREL). But before estimation of the model, it is necessary firstly to fulfill stationary test for all variables to avoid fictitious results. To investigate the stationary of variables we applied the augmented Dickey-Fuller (ADF) test and "Eviews-8" software. The results are depicted in Table (1).

Table 1. ADF Unit Root Tests Results

Variables[1]	ADF Test	Critical Value	Result
Inflation rate	-3.47	-3.02	Stationary
Unemployment rate	-3.34	-3.02	Stationary
Life Expectancy	-6.49	-3.71	Stationary
The ratio of graduates to the population	-4.57	-4.57	Stationary
Per capita income	-2.29	-3.67	Non stationary
GDP	-1.47	-3.65	Non stationary
Income distribution	-5.27	-1.95	Stationary
Energy resource depletion[2]	-2.64	-3.65	Non stationary
Natural resource depletion[2]	-2.60	-3.65	Non stationary
fixed capital formation	-4.68	-3.65	Stationary
Overall risk[3]	-5.14	-3.65	Stationary
Degree of Economic Freedom[4]	-5.92	-1.95	Stationary

Note: Statistically significant at the 5% level
Source: Research finding.

As can be seen in Table (1), the absolute values of augmented Dickey-Fuller statistic for variables: per capita income, GDP, consumption expenditures, natural resource depletion, energy resource depletion, are smaller than the absolute value of the critical level at 5% and it implies that these variables are non-stationary. Therefore, for solving the non-stationary problem, the ADF test for the first-order difference must be performed. The Results (Table2) show that all these variables are I(1).

Table 2. Augment Dickey-Fuller Test for First Difference of Selected Variables

Variables	ADF Test	Critical Value	Result
Consumption Expenditure	-3.38	-3.04	Stationary
Natural resource Depletion	-5.81	-3.04	Stationary
Energy resource Depletion	-5.85	-3.04	Stationary
Per capita income	-3.08	-3.02	Stationary
GDP	-3.44	-3.02	Stationary

Note: statistically significant at the 5% level
Source: Research finding.

Table 3. Results of Macroeconomic Variables Impact on Social Discount Rate

Variables/Models	Model 1	Model 2	Model 3
Per capita income	-0.08 (-1.50)	---------	-0.05 (-1.18)
Unemployment rate	0.05 (0.95)	0.26 (1.31)	0.02 (0.41)
Inflation rate	0.02 (1.08)	0.31 (3.25)	----------
The ratio of graduates to the population	----------	----------	----------
Life Expectancy	----------	----------	-0.04 (-0.22)

Note: Distributions are in parenthesis
Source: Research finding.

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1. Most data collected from Central Bank of Islamic Republic of Iran, unless stated otherwise.
2. www.data.worldbank.org/country/iran-islamic-rep
3. www.prsgroup.com
4. www.fraserinstitute.org

After making sure about the stationary situation of variables, we perform our MIMIC models estimations. The Results of three superior estimations are shown in Table (3). The estimation results can be interpreted as follows:

1. In the estimated models, all of the variables are compatible with the theoretical foundations of the model and the values of the parameters have relative stability. Yet, some of the variables are not statistically significant.

2. Among the macroeconomic variables that influence the SDR, the inflation rate is the most influential variable.

3. The unemployment rate shows a positive relationship in all of the models so that an increase in the unemployment rate is followed by an increase in the SDR.

4. The per capita income has a negative relationship with the SDR in all of the models. The negative sign means that the higher the per capita income in the community, the lower the SDR.

5. Among the variables that are influenced by the SDR, the variables of energy resources depletion, natural resource depletion, fixed capital formation and GDP are consistent with the theoretical foundations of social discount.

We can use the relative fitness index besides the absolute fitness index to better evaluate the SDR trend and ensure that no misleading results may be obtained in the model. The Chi-squared and the Akaike information criterion (AIC) are among the general fit criteria, with smaller values indicating a better fit of the model. These criteria are based on the assumption that a smaller difference between the covariance matrix from the sample data and the variance and covariance matrices of the model shows a greater fit of the model with experimental data. These criteria are influenced by the sample size. In addition to these criteria, the goodness of fit index (GFI), adjusted goodness fit index (AGFI), and normed fit index (NFI) are among the indices of the model's goodness of fit. The values of this index are between one and zero, and the closer these values are to one, the better fitting the model. These indices are not influenced by the sample size and emphasize the relative superiority of the LISREL general fit. Another criterion of superiority is the Root Mean Square Error of Approximation (RMSEA) index. The values of these indices for very good models are 8% or less. Values greater than 8% indicate poor fit.

Table 5. Results of Model Estimation Based on Absolute Fit Index

Index	Model 1	Model 2	Model 3
Degree Freedom (DF)	12	11	12
$\chi 2$ (Chi-squared)	11.23	11.10	6.22
$\chi 2$ /DF	0.93	1	0.51
RMSE	0.77	0.02	0.09
AIC	-185.84	-55.67	-273
BIC	-173.30	-44.18	-261.06
CFI	0.85	0.95	0.74
GFI	0.93	0.98	0.91

Source: Research finding.

The results of Table (5) show that one model is in a better position. Hence, Model 2 is chosen as the top model. In the end, for measurement and analyzing the social discount rate trend, we need an equation that employing the coefficients of inflation and unemployment variables observe the volatility of this parameter. This equation is as follows and the extracted trend is depicted in Figure 2. This figure entails SDR fluctuation and its linear trend and moving average (by 3 lags). The linear trend implies that during the sample period SDR, despite great fluctuations, has been (a little bit) decreasing. It is worth noting that the vertical

axis of Figure 2 does not imply the absolute value of SDR and due to the methodology of MIMIC model, it shows the relative fluctuation of the latent variable (SDR) during the sample period.
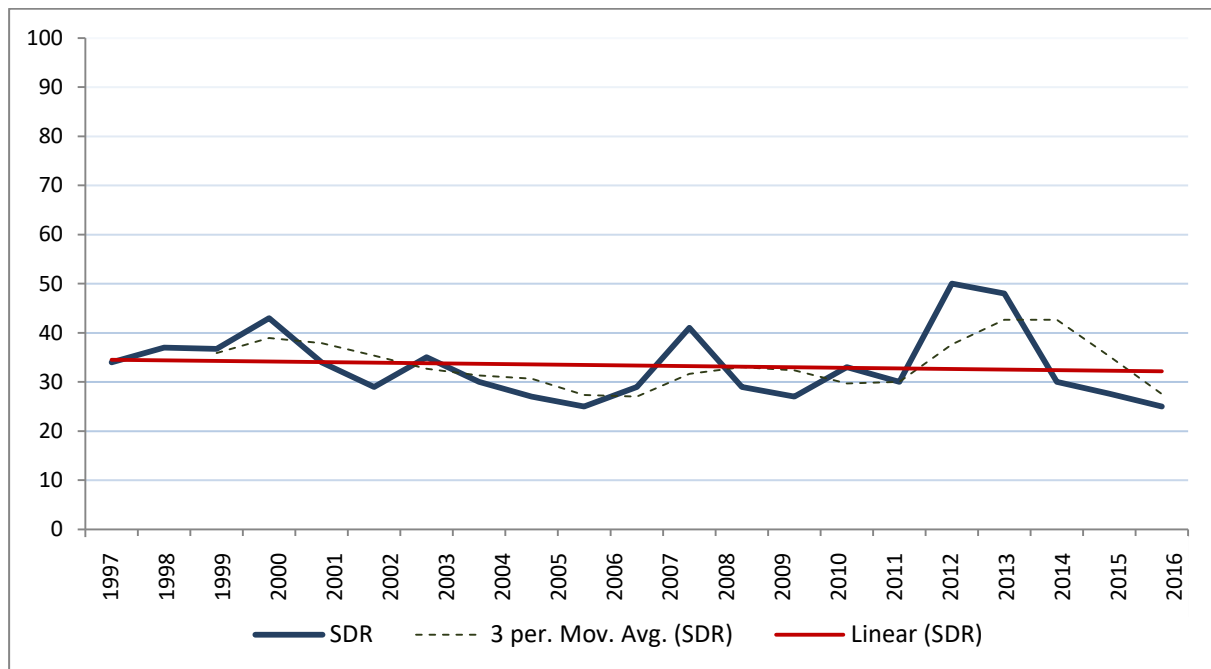
$$SDR = 0.31X_1 + 0.26X_2$$

Figure 2. Estimated Social Discount Rate Trend in Iran
Source: Research finding.

Summary and Conclusion

Considering the extracted trend for the SDR, the fluctuations of SDR based on the following time period can be analyzed as follows:

The Period 1997-2005

Considering the specific economic conditions of Iran during this period, we can analyze the fluctuations of the SDR from two perspectives:

   A) **The period 1997-1999:** A sharp decline in the price of oil in global markets especially in 1998, which had resulted from a decline in demand, reduced the country's oil revenues and caused a great negative impact on the economy due to the dependency of the economy on oil revenues. The decreased oil revenues caused the government to turn to borrow from the Central Bank, which led to a rise in the monetary base and an increase in the inflation rate so that the inflation rate reached 20.1% in 1999. As shown in the figure, the SDR has increased during this period.

   B) **The period 2000-2005:** Following an oil price shock, the Iranian government tried to help improve the economic status through appropriate economic policies such as controlling the level of prices, paying government debts, privatization, and so on. However, in addition to the economic policies of the government, it adopted some other policies in the areas of domestic and foreign policy (important issues such as a relatively open political space, a suggestion for a global dialogue of civilizations, and efforts to establish appropriate international relations with other countries) which proved effective in improving the country's

economic status. These points indicate that a relative improvement in the economic and political areas has led to a decrease in the SDR during this period.

The Period 2006- 2013

The important developments that took place in Iran's economic and political areas during this period caused the SDR to undergo severe fluctuations:

   A) The period 2006- 2009: The changes that occurred in the executive area of Iran in 2005 caused its economic and political statuses to undergo a lot of changes. In spite of an increase in the oil prices, the lack of proper management of the macroeconomy and the lavish spending of oil revenues increased the prices and the unemployment rate. In this period applying expansionary monetary policies and a sharp rise in liquidity volume and the excessive withdrawal of the reserve account for current consumption were the main factors influencing the rise in inflationary expectation and consequently social discount rate in 2007 (Central Bank of I.R. Iran, 2009). Besides, the lack of proper policies with regard to the country's specific conditions during that period and tensions in the internal and external atmosphere of the country should also be considered as other important factors that have led to a sharp fluctuation in the SDR. However, the SDR had a decreasing trend during 2008-9, when inflation and unemployment rates were associated with a relative decline when the government stabilized exchange rate to avoid inflation in imported commodities and increased its expenses for subsidized commodities in order to eliminate inflation.

   B) The period 2010- 2012: The events that occurred in the internal and external atmosphere of Iran from 2009 to 2013 led to a severe fluctuation in the SDR. The factors that influenced the SDR during these years can be summarized as follows:

   I) The Unwelcome political events that took place in Iran in 2009 had negative economic consequences for this country, affected economic stability at the level of investment activities, and led to an increase in the economic and political risk of the country.

   II) Following a tension in the area of foreign policy, severe international sanctions, subsidy orientation policy consequences, the reduction of oil revenues, a sharp increase in inflation, a sharp depreciation of national currency, and an imbalance in the government budget during the period 2010-2012 caused Iran's economic and political atmosphere to take conditions in which the SDR underwent very sharp fluctuation.

The Period 2013-2016

Iran's economic and political atmosphere underwent widespread changes at the executive level in 2013 and efforts were made to improve the economic status. There was also an achievement in the area of foreign policy, called the Joint Comprehensive Plan of Action (JCPOA), which reduced inflationary expectations at the community level. All of These factors together led to a decreasing trend in the social discount. Moreover, the successful policies adopted by policymakers to reduce the inflation and unemployment rates should also be considered effective in reducing the SDR.

   Figure2 shows that the SDR has undergone various fluctuations during 1996-2016, which have been consistent with the conditions of the Iranian economy during this period. For example, it was observed that the reduction of the inflation rate and inflationary expectations during the period 1997-2005 had led to a decreasing trend in the SDR in the Iranian economy. In addition, following a change in the executive power and executive management of the country during the period 2005-2009, strong fluctuations in the economic indicators resulted in an increasing trend in the social discount trend. It seems that the extracted SDR trend is

robust enough as it can explain properly the economic and political events of Iran during the sample period.

Finally, due to research findings and as a policy implication, controlling and monitoring inflation and consequently inflationary expectations as control variables can be recommended to policymaking, as MIMIC estimation results implied that most influencing factors on deteriorating (increasing) SRD in Iran economy has been inflation. However, the unemployment rate has had a significant impact on SDR as well.

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