Iranian Journal of Economic Studies
Vol. 1, No. 2, Fall 2012, 107-124

Calibration of Fair Social Discount Rate in Utilizing Iran Oil Resources: An Islamic View Point

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Abstract

There is a controversy in economics about the fairness of intergenerational discounting. In other words, the question is whether it is fair to discount the utility of future generation less than that of the present one. Ramsey (1928) was the first economist to criticize the intergenerational discounting. He argued that the just rate of discounting should be zero. Using Islamic perspective, this paper attempts to calculate the just rate of intergenerational discounting for the Iranian economy when allowing oil revenue to be invested in other forms of capital. More specifically, we develop an overlapping generation model to calculate a just rate of social discount from an Islamic point of view. Our results show that the value of social discount rate before imposing the intergenerational justice condition is 0.04 and -0.014 afterwards. Using the recent Iranian data, the just social discount rate which satisfies the intergenerational justice from an Islamic point of view is between zero and minus one.

Received: 18/12/2011 Accepted: 5/8/2012
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Keywords: Intergenerational Justice, Discounting, Social Discount Rate, Overlapping Generations Model
JEL Classification: C68, D58, D63, O13, Q32, Z12

1. Introduction

There is a controversy in economics about the question of whether intergenerational discounting is just or not; i.e. whether it is just to value the utility of future generations less than that of the present one. This criticism against discounting goes back at least to Sidgwick (1907, p. 414) that argued on the philosophical ground. Sidgwick believed that the time at which a man exists cannot affect the value of his happiness from a universal point of view. Also Ramsey (1928) was the first economist that criticized discounting in an infinite horizon framework. Pigou (1932) was also a pioneer economist that believed discounting was ethically questionable.

It is common among neoclassical economists that one should discount the future because present goods, as a general rule, worth more than future goods of equal quality and quantity. But this assumption would thwart the principle of generational justice because costs and benefits of future generations would count less than those of present generations while time in itself should not *generally* be considered a legitimate discount factor. Moreover, Dasgupta and Heal (1974) and also Solow (1974) show that constant and positive utility discounting leads to an outcome that does not appeal to commonly shared ethical intuitions, and is not compatible with sustainable development because with the level of production on the input of an exhaustible natural resource (such as oil), applying a positive utility discount rate will in the long run force the consumption level to approach zero, even though positive and non-decreasing consumption is technically feasible. It means that for long-term projects that have significant implications for future generations, discounting the future is a controversial issue not only at the philosophical level but also at the level of practical implications.

But for us, discounting is critical because of ethical reasoning i.e. because of intergenerational justice. Howarth (1997) discusses that utility discounting denies future generations to be considered equal both in social decision making and in opportunity to enjoy the benefits of society's initial resource endowment. Also it is remarkably

discussed that discounting will bring about resource exhaustion, environmental deterioration, and steady decline of the economy[1] and thus it violates the intergenerational justice. For instance, alternative policy actions with long-run environmental consequences should be evaluated by benefit-cost analysis, using discounting (at the social rate of discount), and the results of this analysis should be taken as one factor in the decision process. But there is no simple way to justify the choice of a discount rate for investments in which the benefits and costs span several generations in spite of its main role in welfare of future generations and that's why we can see that there are three opinions about the amount of social discount rate in economic literature: first of all, zero rate of discounting that is based on just, fair or ethical views (for example Ramsey(1928), Pigou(1932), Harrod (1948) and Solow (1974) defended it). Second, the positive and constant rate of discounting that is common in economic analysis (for example Hepburn (2006)) and finally the positive but diminishing rate of discounting (see: Streich & Levy (2007) and also Hepburn (2006)) that is recently considered from and accepted by some governments (Roumboutsos, 2010).

According to what was mentioned above on the role of social discount rate in intergenerational justice scene, we will try to calculate the just rate of discounting for Iran with respect to Islamic thoughts. Hence, firstly we will review briefly the literature on estimating the social rate of discounting in part 2. Then, our presumption on Islamic intergenerational justice definition is argued in part 3. Next, in section 4 we calculate the social discount rate for Iran in current situations and after imposing the Islamic condition of intergenerational justice using an overlapping generations model with analyzing the results.

2. Literature Review

In order to estimate the social discount rate, there are generally two main approaches: first, the social rate of time preference approach. The social time preference rate is the rate at which consumption in one period can be substituted for consumption in the previous period without any change in overall wellbeing. This approach is the most popular among other approaches. For example Halicioglu and Karatas (2011) estimated a social discount rate in the order of 5.06% for Turkey and Parker (2009) estimated it in the order of 4% (real) for

New Zealand based on this approach and also Lopez (2008) employed it to estimate the social discount Rate for nine Latin American countries.

Second, the social opportunity cost of capital approach. The opportunity cost of capital can be obtained by looking at the rate of return on the best investment of similar risk that is displaced as a result of undertaking the project in question. In other word, this approach is based on the estimation of the opportunity cost of capital and requires assumptions about the alternative uses of resources used for investment and typically reflects the cost in financial market terms and measures the opportunity cost of locking up capital in public sector assets. For instance, the UK Treasury in 1989 adopted regimes based on this approach that led to a discount rate of 8% for the nationalized industries (Spackman, 2011, p. 11). Also in 2007 the Canada Treasury Board Secretariat recommended a discount rate of 8% with sensitivity rates of 3% and 10% based on the social opportunity cost of capital approach.

Accordingly, we will choose the first approach to calculate the social discounting rate in section 4.

3. Intergenerational Justice from Islamic Point of View

According to Islam intergenerational Justice has been regarded when oil revenue totally is invested in other kinds of capital. This condition is the logical result of some predicates as follow:

First, with respect to Quran (Baqare'/29) natural resources such as oil belong to all generations. Second, according to Quran (Nisa'/5) natural resources should be used in such a way that the society remains stable and sustainable. Third, keeping the natural resources entire, intact and unchanged is in contrast with Holy legislator's aim in creating the natural resources. Fourth, if we utilize the natural resources in such a way that they are not transformed into other capitals, either they will not remain for other generations or the society may not be sustained and stable. Thus, justice defined as "To put anything in its specific location" requires oil revenue to be totally invested in other kinds of capital[2].

But there is a problem: If a society invests the oil revenue but its return is for example only 50 percent because of the low level of technology, it means that the value of other capitals accumulated is

half of the oil revenue invested. So in that situations oil revenue investing does not result in maintaining and remaining the natural resources for future generations. Therefore, while the former condition is necessary for intergenerational justice, it may not be sufficient especially in the case that the level of technology is too low. In that situation, it requires some limitation on the discount rate in cost-benefit analysis of new projects that involve intergenerational effects. We will discuss it more in section 4.Therefore, "oil revenue investing entirely" is considered as the necessary condition and criteria of intergenerational justice from Islamic point of view.

4. Calculating the rate of discounting

Now, we try to calculate the social discount rate for Iran in current situations using an overlapping generations model that is based on Rausch and Rutherford's (2010), (2007) and also Rasmussen and Rutherford's (2004), (2001). We calculate the social discount rate after imposing the Islamic condition of intergenerational justice. Then we analyze the result as just rate of discounting.

It is worth mentioning that overlapping generations (OLG) model is a standard tool for applied policy based on the seminal contribution of Auerbach and Kotlikoff (1987). Many researchers (such as Broer et al. (1994), Altig et al. (2001) and Kotlikoff et al. (2001)) have subsequently adopted the AK-OLG framework for applied work.

4.1 Model

The model begins with a household optimization problem and continues with adding a one-sector production model that provides the simplest possible structure consistent with the components of aggregate demand side and finally we will impose the conditions that are needed for an open economy.

Demand Side of Economy

The demand side of our aggregate economy is characterized by national account balances relating capital income (*R*), labor income (*L*), government transfers to households (*T*), private sector consumption (*C*), private sector net saving (*S*), the primary government budget deficit (*D*) the trade deficit (*B*), investment (*I*) and net tax rates on income from capital and labor $(\tau^r \text{ and } \tau^l)$.

These include aggregate income balance:

$$R + L + T = C + S \quad (1)$$

Savings-investment balance:

$$S - D + B = I \quad (2)$$

And the public budget constraint:

$$\tau^r R + \tau^l L = G + T - D \quad (3)$$

That the values of these data that will be used to running the model are derived from Iran Input-Output table for 2001.

Capital earnings and investment are linked via the capital stock which evolves according to:

$$K_{t+1} = (1-\delta)K_t + I_t \quad (4)$$

where δ is the constant depreciation rate. The return to capital covers (after tax) interest plus depreciation on the capital stock, and investment covers growth plus depreciation. Hence the steady-state assumption implies that *R* and *I* are proportional:

$$\frac{R}{I} = \frac{\bar{r} + \delta}{\gamma + \delta} \quad (5)$$

Consumption Behavior

A household of generation g is born at the beginning of year t = g, lives for N + 1 years, and makes labor supply decision in each period $g \leq t \leq g + N$. He is endowed with an amount $W_{g,t}=W(1+\gamma)^g$ that represents units of time. As such W is an income scaling factor and is constant over the life cycle. Leisure time, $L_{g,t}$, enters in a constant-elasticity-of-substitution (CES) function with consumption, $C_{g,t}$, to create full consumption, $Z_{g,t}$. Expressed with present value prices the optimization problem is

$$\begin{aligned}
\max_{c_{g,t},\ell_{g,t}} u_{g,t}\left(z_{g,t}^{1-\theta}\right) &= \sum_{t=g}^{g+N}\left(\frac{1}{1+\rho}\right)^{t-g}\frac{z_{g,t}^{1-\theta}}{1-\theta} \\
s.t. \qquad z_{g,t} &= \left(\alpha c_{g,t}^{\sigma}+(1-\alpha)\,\ell_{g,t}^{\sigma}\right)^{\frac{1}{\sigma}} \\
\sum_{t=g}^{g+N} p_t^c c_{g,t} &\leq \sum_{t=g}^{g+N}\left[p_t^l \pi_{g,t}(\omega_{g,t}-\ell_{g,t})+p_t^f \zeta_{g,t}\right] \\
\ell_{g,t} &\leq \omega_{g,t} \\
c_t,\ell_t &\geq 0,
\end{aligned} \tag{6}$$

where $C_{g,t}$ is consumption, ρ is the utility discount rate, $1/\theta$ is the intertemporal elasticity of substitution, and p_t is the present value price index. Also α is the weight on consumption in full consumption, 1= (1-σ) is the elasticity of substitution between consumption and leisure, $p^c{}_t$ is the price of consumption, $p^l{}_t$ is the wage rate, $\pi_{g,t}$ is an index of productivity over the life cycle, $p^f{}_t = p^f{}_0\,(1+\bar{r})^{-t}$ is the price of foreign exchange, and $\int_{g,t}$ is a lump sum transfer from the government. So, the first-order conditions for generation zero are:

$$\begin{aligned}
\frac{\partial U(c_t,\ell_t)}{\partial c_t} &= \lambda \bar{p}_t \\
\frac{\partial U(c_t,\ell_t)}{\partial \ell_t} &= \eta_t \\
\eta_t - \lambda \bar{p}_t \pi_t &\geq 0 \qquad \perp \qquad \ell_t \leq \omega \\
\sum_{t=0}^{N} \bar{p}_t c_t &= \sum_{t=0}^{N} \bar{p}_t\left[\pi_t(\omega-\ell_t)+\zeta_t\right] \\
\ell_t &\leq \omega,
\end{aligned} \tag{7}$$

where λ and η_t are, respectively, the shadow prices of the lifetime

budget constraint and the time endowment in each year, and where benchmark quantities are scaled so that $\bar{p}_t = (1 + \bar{r})^{-t}$ is the common present value price index in the initial steady state. The present value price index is:

$$\overline{p}_t = (1 + \overline{r})^{-t} \tag{8}$$

Therefore, we can define the reservation wage i.e. the present value price of leisure as:

$$p_{g,t} = \frac{\eta_{g,t}}{\lambda_g} = p_g^{\ell} + \mu_{g,t} \tag{9}$$

For the solution to the households' maximization problem, as characterized by F.O.C.s, to be consistent with the aggregate data it must be the case that summing the relevant variables at the household level over all the different generations alive in year zero gives the values in:

$$R + L + T = C + S \tag{10}$$

So, In the case of labor income, *L*, and consumption, *C*, this requires:

$$\begin{aligned} L &= \sum_{t=0}^{N} \frac{\pi_t(\omega - \ell_t)}{(1+\gamma)^t} \\ C &= \sum_{t=0}^{N} \frac{c_t}{(1+\gamma)^t}. \end{aligned} \tag{11}$$

From F.O.C.s we derive Euler Equation as follow:

$$1 + \bar{r} = (1+\rho)\,(1+\gamma_t^z)^{\theta+\sigma-1}\,(1+\gamma_t^c)^{1-\sigma}, \tag{12}$$

Where

$$\gamma_t^c = \frac{c_t}{c_{t-1}}, \quad \gamma_t^z = \frac{z_t}{z_{t-1}}, \tag{13}$$

are the growth rate of consumption and the growth rate of full consumption over the life cycle respectively.

Production Behavior

The one-sector production model described below is constructed with the aim of providing the simplest possible structure consistent with the components of aggregate demand. In particular, we assume that all markets are perfectly competitive; technology is of the CES form; trade is modeled according to the standard assumption that foreign and domestic goods are imperfect substitutes and the price of foreign goods is given on the world market according to a small open economy assumption.

Output, Y_t, is produced using inputs of labor and capital services so that

$$Y_t = \phi_Y \{\beta_Y L_t^{\varepsilon} + (1 - \beta_Y) K_t^{\varepsilon}\}^{\frac{1}{\varepsilon}}, \tag{14}$$

where 1/(1-ε) is the elasticity of substitution, and where the φ and β are parameters
that are selected to match the baseline.

Foreign Sector

Exports, X_t, are distinguished from output for the home market, H_t, by a constant elasticity of transformation function:

$$\phi_X [\beta_X X_t^{\epsilon} + (1 - \beta_X) H_t^{\epsilon}]^{\frac{1}{\epsilon}} = Y_t, \tag{15}$$

Where 1/(1+ε) is the elasticity of substitution.

Similarly, on the import side, output for the home market combines with imports, M_t, to produce an input composite, A_t, where

$$A_t = \phi_A [\beta_A H_t^{\epsilon} + (1 - \beta_A) M_t^{\epsilon}]^{\frac{1}{\epsilon}}. \tag{16}$$

It should be noted that A_t - that is known as Armington function – is used in CGE models because in standard models of international trade it makes no economic sense to engage in trade in both directions in the same product. Nonetheless, a characteristic of real world trading patterns is that countries often simultaneously import and export goods in the same product category. In the applied literature this is

accommodated via the Armington assumption. The specification is almost universal in CGE models, so much so that they are often referred to as `Armington type' models. In the approach, consumers are assumed to have a `love of variety' that generates demand for both domestic and foreign produced products within a product category. Hence, the Armington approach is a special case of the horizontal product differentiation.

Finally, the input composite may be used for household consumption, investment, or government consumption implying the following condition for balance between aggregate supply and demand:

$$A_t = C_t + I_t + G_t \qquad (17)$$

The representation of foreign and domestic goods as imperfect substitutes has the implication that although there is a constant interest rate on the international bond market, the domestic interest rate may deviate from the world market rate during a transition period.

The final component of aggregate assets is the domestic capital stock. Following Lau et al. (2001), the terminal capital stock is handled by requiring that investments grow at the steady-state rate in the last model period:

$$\frac{I_T}{I_{T-1}} = 1 + \gamma. \qquad (18)$$

4.2 Data

We will use the aggregated derived from Iran Input-Output table for 2001 as follows:

Table 1: Iran Input-Output table for 2001

	activities	government	investment	household	export	import	sum
products	733	-97	-193	-413	-153	123	0
labor	-326			326			0
capital	-401	133		268			0
tax	-6	6					0

	activities	government	investment	household	export	import	sum
foreign trade			-30		153	-123	0
saving		-42	223	-181			0
sum	0	0	0	0	0	0	0

Also we capture all generations alive in the first model period (year 0) and all those born in the span of the subsequent 150 years, where generations are labeled according to the year in which they are born i.e. in year 0 there are 50 generations that their ages are 55, 54, 53, … ,5 and in year 0 the first new generation is born that we name generation 1 and in year 1 the second new generation is born that we named generation 2 and so on since the year 149 that the last generation (generation 150) is born. The model is solved in 5-year intervals with each new generation being born at the start of a period and living to the age of 55.

The variables are:

Table 2: The Exogenous Variables

variable	value	source
Annual discount rate	6.2%	Shahmoradi et al. (2010)
Annual population growth rate	1.6%	Economic indicator No. 27
Annual depreciation rate	4.2%	Amini , Neshat-Haji (2005)
Inverse inter-temporal elasticity of consumption	1.5	Zangene (2009)
Elasticity of substitution (C vs L)	0.8	Rausch, S., T. F. RUTHERFORD (2007)
Consumption share parameter	0.8	Rausch, S., T. F. RUTHERFORD (2007)
Elasticity of transformation D vs. X	4	Rasmussen, T. N., T. F. RUTHERFORD (2001)
Armington elasticity on imports	4	Rasmussen, T. N., T. F. RUTHERFORD (2001)

It is necessary to mention that because of using Iran Input-Output table for 2001 in our model, we tried to consider the values of exogenous variables correspondent with that time i.e. year 2001. For instance, the population growth rate of Iran was 1.6 percents in 2001

or the interest rate estimated by Shahmoradi et al.(1389) was 6.2 percents for 2001.

4.3 Model Formulation and running

Now, we intend to calibrate the social discount rate. To formulate the model in a GAMS program as a gams/mcp code, it is necessary to know briefly how the models are formulated according to a mixed complementarity problem (MCP) approach. In this approach, three classes of equilibrium conditions characterize an economic equilibrium as follows:

Zero profit conditions: All constant-returns-to-scale production activities earn zero excess profit in equilibrium, and this zero profit condition exhibits complementary slackness with respect to the associated activity level.

The associated equilibrium condition is:

$$- \pi_j (p) = C_j(p) - R_j(p) \geq 0 \tag{19}$$

Market clearance conditions: Supply must be greater than or equal to demand for each primary factor and produced good, and these inequalities must exhibit complementary slackness with respect to market prices. The associated equilibrium condition is:

$$\sum_j y_j \frac{\partial \pi_j(p)}{\partial p_i} + \sum_h w_{ih} \geq \sum_h d_{ih}(p, M_h) \tag{20}$$

Income definitions: In equilibrium, the income for household h equals the value of factor endowment at equilibrium prices:

$$M_h = \Sigma\, p_i\, w_{ih} \tag{21}$$

Now, we use the equations arising from the household utility maximization problem and other related equations to set up a mixed complementarity problem and use the solver PATH to find the value of social discount rate that satisfies all the equations in the system for Iran in 2001.

4.4 Social Discount Rate Calibration:

According to what was mentioned above, now the social discount rate is calibrated. Calibration results imply the value 0.04 for social

discount rate in 2001. It is worth mentioning that Shahmoradi et al. (1389) also reached to the same amount by another approach. GAMS report shows that the parameter social discount rate has been calibrated very precisely:

Major Iterations. . . . 7
Minor Iterations. . . . 10
Restarts. 0
Crash Iterations. . . . 1
Gradient Steps. 0
Function Evaluations. . 11
Gradient Evaluations. . 9
Total Time. 0.114000
Residual. 4.600347e-009
Postsolved residual: 4.6003e-009

The intergenerational justice dictates that oil revenue is totally invested in other kinds of capital. Therefore we conclude that 0.04 can be considered as the unjust social discount rate. So, it is very interesting to calculate the just social discount rate by imposing the intergenerational justice condition to the model.

5. Just Social Discount Rate

To calculate the just social discount rate it is required to impose the intergenerational justice condition to the model either by adding some equations or by adjusting the data associated with the condition. According to the second approach, we assume the government's saving of oil and gas revenue is its total revenue i.e. 133 billion dollars instead of only 42 billion dollars from 133 billion in current situations (See: Iran Input-Output table for 2001). So, the intergenerational justice condition is satisfied and we have:

Table 3: Revised Iran Input-Output table for 2001

	activities	government	investment	household	export	import	sum
products	733	-6	-284	-413	-153	123	0
labor	-326			326			0
capital	-401	133		268			0

	activities	government	investment	household	export	import	sum
tax	-6	6					0
foreign trade			-30		153	-123	0
saving		-133	314	-181			0
sum	0	0	0	0	0	0	0

Now, the social discount rate is calibrated with new data again and the just social discount rate is generated. Recalibration of the model results in the value -1.014 for social discount rate. It means that the value of just social discount rate is -0.014.

GAMS report shows that the parameter has been calibrated very precisely:

Major Iterations. . . . 8
Minor Iterations. . . . 13
Restarts. 0
Crash Iterations. . . . 1
Gradient Steps. 0
Function Evaluations. . 12
Gradient Evaluations. . 10
Total Time. 0.075000
Residual. 1.287570e-007
Postsolved residual: 1.2876e-007

As discussed in section 2, investing all oil revenues in other kinds of capital is necessary for intergenerational justice. But in current situations our economy is dependent on oil revenue and we need to expend some oil revenue in financing public projects. Hence, investing oil revenues totally is not possible and therefore the intergenerational justice is not practical. As a result, the intergenerational justice criteria require some limitations on the discount rate in cost-benefit analysis of new projects that involve intergenerational effects as following on:

It is not possible for the economy to look over oil revenue and invest it totally. It means that the society has to expend it even if the intergenerational justice is not satisfied. In such circumstances, the policy on the value of social discount rate should be made in such a

way that the future is encountered with minimum unjust effects. To this purpose, the best value of social discount rate is an amount between zero and minus one. Hence, in evaluating two projects, one will be accepted that its future returns are greater than another because of its greater NPV:

$$NPV_0=R_0-C_0+R_1/(1+r)+R_2/(1+r)^2+ \ldots +R_T/(1+r)^T \qquad (22)$$

On the other words, if we have two projects with the characteristics $R_1>R_2>\ldots>R_T$ for the first and $R_1<R_2<\ldots<R_T$ for the other, NPV of the second project will be greater with negative value for social discount rate.

Moreover, greater future returns mean that through the time the posterities gain more payoffs. As a result, with negative value for social discount rate the projects that make the future better off will be justified financially.[3]

As we saw above, when the intergenerational justice condition is imposed on the model, we reach to a social discount rate that is between zero and minus one as just social discount rate.

6. Conclusion

Because of the main role of social discount rate in intergenerational justice scene, we tried to calculate the just rate of discounting for Iran with respect to Islamic thoughts. Hence, we discussed our presumption on Islamic intergenerational justice definition very briefly and concluded that according to Islamic point of view, intergenerational Justice had been regarded when oil revenue was totally invested in other forms of capital i.e. human, physical, or financial capital. Then, in part 3 we calculated the social discount rate for Iran in current situations and after imposing the Islamic condition of intergenerational justice using an overlapping generations' model. Accordingly, it was observed that the value of social discount rate is 0.04 before imposing the intergenerational justice condition and -0.014 after that. Then, it was explained that in current economic situations of Iran, the best social discount rate which can satisfy the intergenerational justice, was an amount between zero and minus one. Since the social discount rate is negative, the projects that increase the welfare of future generations are justified financially.

Endnotes

1. For example see Howarth (2007), Arrow et al. (2004), Moore et al. (2004), Farmer & Randall (1997) and Baumol (1968).
2. Detailed and comprehensive discussion about our opinion on Intergenerational Justice from Islamic view has been presented in economic faculty of Imam Sadiq University in a workshop and as a working paper to be published.
3. Detailed and comprehensive discussion about our opinion on just social discount rate has been presented in Economic Faculty of Imam Sadiq University in a workshop and as a working paper being published.

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