SUSTAINABILITY AND INTERGENERATIONAL EQUITY WITH VARYING DISCOUNT RATE: THE CASE OF RENEWABLE RESOURCE

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Abstract: The relationship between natural resource exploitation and the discount rate in economic theory is well documented. The discount rate is deemed to influence resource utilization such that a higher discount rate will speed up natural resource exploitation in market oriented economy and a lowering rate will act otherwise. This fact is proven mathematically and is known as the Hotelling lemma. Basically an optimal utilization of renewable natural resource is attained when its growth rate per time is equated to the existing discount rate. The current study attempts to establish the fact that discount rate which is used as the discounting factor in dynamic optimization is technically useful for the attainment of production sustainability of a renewable resource. However, it has a far reaching economic and environmental implication in terms of resource distribution pertaining to the equity issue between the present and future generation. The finding seems to suggest that higher discount rate would favor greater exploitation of resource, thus raises the issue of resource sustainability in long run. Using panel data from forestry resource the linear fixed and random effect demand functions were estimated. A simplified dynamic optimization technique was then applied with the objective to investigate the impact of varying discount rate on the renewable forestry resource and thus the distribution of natural resource in the light of intergenerational equity distributional issue. The mathematical objective of intertemporal optimization equity issue is to maximize the net social benefit between the economic and environmental benefits and costs. Environmental degradation which tends to increase following intensity of resource exploitation was observed.

Keywords: discount rate, natural resource use, intergenerational justice, intertemporal optimization and sustainability.

INTRODUCTION

Discount rate is nonetheless useful that provides practical solution to the problem of optimization technique for intertemporal situation which involves time as a variable. Specifically discount rate is used as a weight in the valuation of property overtime in that the value of any asset depreciates over the years and inversely appreciates towards the current years. Nevertheless, discount rate has an adverse impact on the resource utilization that economists seem to overlook and perhaps disregards when dynamic optimization is applied. The issue is most economists realize that discount rate is the driving force that determines the utilization of resource at its optimum level when equated to the resource growth rate. Thus higher discount rate tends to draw resources use in a shorter time duration and vice-versa when continuous function is applied. The paper explores the impact of discount rate for a discrete dynamic optimization. The results apparently suggest that resources will be over exploited more over time with a higher discount rate compared to a lower discount rate. Furthermore, considering resource distribution between the present and the future generation, it tends to favors present generation with a higher discount rate and vice-versa. Only when the discount rate is set at zero a fair distribution is realized between the present and future generation.

The choice of appropriate discount rate to reflect the true value of cost-benefit of a project has long been debated with inconclusive result. One thing certain about the discount rate is that project that benefits the society usually uses low social discount rate relative to those benefiting the private entity. One of the issues in choice of discount rate relates to consideration as to what should be done to be ethically sensible in the distribution of natural resource wealth. The objective of this paper is to investigate the impact on natural resource utilization when discount rate swings from zero to a higher value. By retaining the discount rate at a specific level, say 5 percent per annum how long natural resource can be optimally utilized in relation to the sustainability goal?

REVIEW OF DISCOUNT RATE APPLICATION

In general discount rate is used for deciding on the viability of a project and is associated closely with the estimated net present value (NPV). Briefly for a positive NPV the project is considered viable, that is, the project will add value to the firm's profitability and vice versa. Alternatively, using the firm's benefit and cost at a given discount rate, the internal rate of return (IRR) is calculated; if IRR>0 then the project is accepted otherwise this investment may not be profitable. Higher discount rate may be costly therefore social discount rate which is normally lower would be utilized to evaluate project that benefits the society. It is often argued that a higher discount rate is used to account for future risk. Since the future is uncertain it would be appropriate to adjust to the need of risky element accordingly as it comes. Hence, variations in the choice of discount rate will affect the discount factor which in turn could influence the viability of an investment cash flow.

Torgerson and Raftery (1999) in their study of health economics published in the British Medical Journal argued that discounting of health is quite a different matter compared to wealth which yields economic returns. If future benefits of health are not discounted this implies good health enjoyed this year and those enjoyed in 20 or 30 years are of equal value (p.2). At a later stage of our life the risks of running into health problem may be greater compared to the current year health condition. It is an opportunity cost that everyone has to make whether or not to invest in the current year for the better and healthier old age retirement. Torgerson and Kanis (1995) gave examples of hip fracture prevention among elder women; first measure is 10 years of hormone replacement therapy (HRT) (given at 50-year old) that can prevent 50% of the incidents, and the other measure is 10 years of calcium and vitamin D (CND) (given at 70-year old) which could prevent 30% of the incidents. Without discounting the HRT proved to be less costly than CND but with discounting the reverse is true. Thus the decision on the choice of hip fracture prevention plans depends heavily on their discounting cost-benefit and the choice of rate of discount. In general they still believe that prevention should come at an earlier age based on the fact that people tend to value their current health more than their future health (Cairns 1994). However, if health is to be sustained throughout our life then a lower discount rate should be used for future health gains implying that more weight is given for the future health condition. Contrary to health economics, many economists would prefer the normal practice of discounting perhaps with discount rate that favors the present.

One of the recent controversies concerns the discount rate employed in the 700-page report of "The Stern Review on the Economics of Climate Change", which was released on 30 October 2006 (Varian 2006). The Review is still being discussed today because of its conspicuous recommendation that the world decision maker should invest 1 percent of global GDP to avoid paying 20 percent of GDP due to the anticipated damage of the future global warming. Many economists have mixed stances about the finding. Nordhaus of Yale and Dasgupta of University of Cambridge criticized the use of social discount rate used in the projection. With an almost zero discount rate of 0.1 percent it implies equal weight is given to both present and future generation. Nordhaus suggested a 3 percent discount rate followed by a lower rate of 1 percent with a tax on carbon emissions would have greater impact to reduce global warming. He then posed the question; is it right for the current generation whose income is far below the future to support their richer and wealthier counterpart? Dasgupta was concerned about the economic growth with the projected social discount rate and suggested that global decision maker should start to invest more today to raise the standard of living of the future generations.

A comprehensive review of ethics of discount rate about intergenerational justice and with reference to Stern Review is provided by Beckerman and Hepburn (2007) in World Economics. In defending the choice of zero discount rate The Review cited the analogy of our emotional attachment to our children and the grandchildren. If the parents are willing to discount our children and grandchildren why should we disagree not to discount future generation?

Beckerman and Hepburn argued that we may be fair to our family members or close friends in distributive justice but may discriminate the others. Thus the global decision maker may not necessarily be doing injustice to our distance descendents of the future generation if less weight is placed on them. In the case of majority domination over the minority groups, that is, the majority rule we seldom question the individual's preference. The future generation who has no representation in today's decision making is similar to that of the minority groups (see pp. 199-200). In general economists seem to agree on the global equity issue between the rich and poor countries but the disagreement continue to persist on the issue of intergenerational injustice.

In assessing distance future of uncertain cost-benefit assets Gollier and Weitzman (2010) mathematically proved that discount rate must decline over time which in their own words read, "*When future discount rates are uncertain, but have a permanent component, then the 'effective' discount rate must decline over time toward its lowest possible value.*" (p. 353). Empirically, rather than using a constant 0.1 percent discount rate but a decline rate as suggested above for the uncertain future, the Stern Report may have less problems with the reviewers because the outcome may not be that disturbing as it was then.

METHODOLOGY

First, the continuous dynamic optimization is presented to establish the important interrelationship between the discount rate and natural resource utilization. Second, the discrete dynamic utilization is developed to construct the theoretical framework for the current study. In intertemporal optimization time is treated as a variable and discount rate is used to assess the present and future values of natural resource assets which are subject to depreciation just like normal physical capital over the years. In the first case, it will be shown that the discount rate that affects the value of natural resource assets would be used as a guiding principle to achieve optimality when its value is equated the rate of growth of the resource over time. In the second case, opinions pertaining to the issue of intergenerational equity distribution of natural resource assets, in particular, those which are important to the future generation will be analyzed. The concern is based on the observation that natural resource use because of the economic benefits seems to favor the present instead of the future.

Intertemporal Optimization and Discount rate

The objective of intertemporal optimization is to maximize the social welfare function for the society subject to the availability of the natural resource stock. Mathematically for a continuous intertemporal optimization the objective is to maximize the social welfare function which is equal to the utility derived from the resource benefits *U[R(t)]* weight by the e^{-rt} which can be written as

$$\text{Maximize } SW_t = \int_0^T U[R(t)]\, e^{-rt} dt \qquad \text{Subject to } \dot{s} = -R(t) \tag{1}$$

where $\dot{s}$ is *dS/dt* for 'S' representing the stock of natural resource available to the society and 't' is time. The solution to this intertemporal maximization of social welfare is obtained from the Hamiltonian expression and is represented as

$$H = U[R(t)] + \lambda(t)[-R(t)] \tag{2}$$

The optimal intertemporal extraction condition is given as $\frac{\partial H}{\partial R(t)} = 0$. Applying this rule to the above Hamiltonian expression assuming that an efficient price λ will take a certain amount of resource extraction at time t, $\lambda(t) = \alpha + \beta R(t) = g(R(t))$then the following result is obtained

$$\lambda(t) = \frac{\partial U(R)}{\partial R(t)} - g[R(t)] = 0 \tag{3}$$

Considering only the RHS (the middle elements) equation (4) is obtained

$$\frac{\partial U(R)}{\partial R(t)} = g[R(t)] = g[R(0)]e^{rt} \tag{4}$$

The intertemporal optimal condition requires that the change in the utility of resource use over time should be equated to the g[*R(t)*]. However, this optimal dynamic condition is similar to the continuous growth rate equation in that where g[*R(0)*] = g[*R(t)*] e^{-rt} or simply g[*R(t)*] =g[*R(0)*] e^{rt}. Differentiating this last equation with respect to time equation (5) is obtained

$$\frac{\partial R(t)}{\partial t} = rg[R(0)]e^{rt} = rg[R(t)] \tag{5}$$

$$r = \frac{\partial R(t)}{\partial t}\frac{1}{g[R(t)]} = \frac{\dot{g}[R(t)]}{g[R(t)]} \tag{6}$$

The optimum intertemporal result of equation (6) is the fundamental principle used by economist which states that the extraction of natural resource should be at its optimal when the discount rate is equated to the growth rate of the resource itself. Evidence to this golden rule is cited in many studies (Hotelling 1931; Perman et al. 1999; Nik Hashim 2008). It can be shown that given the necessary data the outcome of using dynamic optimal condition in equation (6) yields maximum return to the investor.

Discount Rate and Social Wellbeing

Net social benefit (NSB) is defined as the difference between total social benefit (TSB) and the total social cost (TSC). The social benefit covers both the private benefit such as all benefits enjoyed by the firms derived from the individual firm activities. For instance, a major portion of a company's income is derived from sales of its products and services while a real estate businessman obtain direct income from the sale of houses, an auto dealer gets income from the sale of automobiles and services relating to road tax and processing fees. The society's benefit from the sale of products and company's service if its location helps the community in terms of cost saving in transportation, closeness to their residence and relatively cheaper prices or better quality for the same products available elsewhere. Similarly, the private cost includes direct expenses incurred in the actual production while the society's cost could be in terms of environmental damage — air, water and sound pollutions. Assuming the market operates in a perfectly competitive environment and the availability of resource is reflected by its initial value and the resource balance over the duration of the years to the terminal period the 'n' number of years.

The current study defines the natural resource problem from the standpoint of net social welfare using a discrete intertemporal objective function as defined in equation (7),

$$\text{Maximize } NSB = \frac{1}{(1+r)^{i-1}}(TSB - TSC) \quad \text{for } i = 1,2,3,\ldots,n \tag{7}$$

$$\text{Subject to } \bar{S} = R_0 + \sum_{i=1}^{n} R_i$$

where $\bar{S}$ is total natural resource stock availability R_0 is the initial natural resource extraction at time 0, the summation of the natural resource extraction for the subsequent periods or years. The total natural resource stock availability $(\bar{S})$, is assumed to be a constant although it can be renewable with a completely new stock such as in forestry for logging. Similarly the initial resource extraction (R_0) is known and a variable like the other R_i.

The objective function for the current problem can be presented as the Lagrange expression presented in equation (8.0).

$$NSB = \frac{1}{(1+r)^{i-1}}(TSB - TSC) + \lambda((\bar{S}) - R_0 - \sum_{i=1}^{n} R_i) \tag{8.0}$$

$$= \frac{1}{(1+r)^{i-1}}(pR_i - cR_i) + \lambda((\bar{S}) - R_0 - \sum_{i=1}^{n} R_i)$$

$$= \frac{1}{(1+r)^{i-1}}[(\alpha - \beta R_i)R_i - (cR_i)] + \lambda((\bar{S}) - R_0 - \sum_{i=1}^{n} R_i)$$

$$\frac{\partial NSB}{\partial R_0} = \frac{1}{(1+r)^0}[(\alpha - 2\beta R_0 - c)] - \lambda = 0 \tag{8.1}$$

$$\frac{\partial NSB}{\partial R_1} = \frac{1}{(1+r)^1}[(\alpha - 2\beta R_1 - c)] - \lambda = 0 \tag{8.2}$$

$$\frac{\partial NSB}{\partial R_2} = \frac{1}{(1+r)^2}[(\alpha - 2\beta R_2 - c)] - \lambda = 0 \tag{8.3}$$

. . . . .

$$\frac{\partial NSB}{\partial R_{n-1}} = \frac{1}{(1+r)^{n-1}}[(\alpha - 2\beta R_{n-1} - c)] - \lambda = 0 \tag{8.n-1}$$

$$\frac{\partial NSB}{\partial \lambda} = \frac{1}{(1+r)^n}(\bar{S} - R0 - \sum_{i=1}^{n} R\,i) = 0 \tag{8.n}$$

The indirect demand function in equation (8.0) is assumed to be a linear function of quantity of resource extractions where α and β are parameters with the second term a negative ($\beta < 0$). The total cost function comprises the private and social cost that is $TSC = c\,R_i$ where c is a constant parameter stands for a composite of private and social cost ($c = c_p + c_s$). The RHS equations of (8.1) through (8.n) can be further simplified and rearranged into the following 5x5 matrix solution as

$$\begin{bmatrix} \frac{2\beta}{(1+r)^0} & 0 & 0 & 0 & 1 \\ 0 & \frac{2\beta}{(1+r)^1} & 0 & 0 & 1 \\ 0 & 0 & \frac{2\beta}{(1+r)^2} & 0 & 1 \\ 0 & 0 & 0 & \frac{2\beta}{(1+r)^3} & 1 \\ 1 & 1 & 1 & 1 & 0 \end{bmatrix} \begin{bmatrix} R_0 \\ R_1 \\ R_2 \\ R_3 \\ \lambda \end{bmatrix} = \begin{bmatrix} \frac{\alpha - c}{(1+r)^0} \\ \frac{\alpha - c}{(1+r)^1} \\ \frac{\alpha - c}{(1+r)^2} \\ \frac{\alpha - c}{(1+r)^3} \\ \frac{\alpha - c}{(1+r)^4} \end{bmatrix} \tag{9}$$

DATA FOR DEMAND EQUATIONS

Estimate of demand equations for this study is obtained from forestry panel data for ten timber species starting from 1993 to 2007 covering a time frame of fifteen years each. Stata econometric software was used in analyzing the results. Results of regression analysis between price and quantity of timber consumed annually by major species are presented in Tables 1. Panel data for this study are represented by the various timber species generally consumed domestically and internationally. These species are defined by dummy variables with their local names as Balau (d1), Cegal (d2), Merbau (d3), kempas (d4), Keruing (d5), mengkulang (d6), Jelutong (d7), Meranti Merah Tua (d8), Mersawa (d9) and Nyatoh (d10). Results of t-ratios are statistically significant mostly at 0.01 probability level while the coefficient of R^2 denotes that the variation in price are well explained by the variations in the consumed quantity and the dummy variables.

Hausman tests were applied to choose between the appropriate demand equation estimated by fixed and random effects and the tests apparently approved the application of fixed effect model. The estimated coefficients were consistent under H_0 and H_a and these equations are presented in Figure 1 showing interrelationship between price and quantity consumed for the selected timber species. As evidence from the graph in general the estimated linear demand functions are generally fairly elastic indicating that changes in quantity demanded will have very minimal effect on the timber prices.

INTERGENERATIONAL DISTRIBUTION OF NATURAL RESOURCE ASSET

Using Maple software the optimal intertemporal resource extraction of sawlog for Cengal species were derived with varying values of discount rate. These optimum resource extractions with discount rate varied between 0 percent to 0.20 (20%) are shown in Table 1. Before discussing the optimum extraction results it would be useful to understand the concept of 'discounting' which is used in financial analysis involving time. Discount rate is utilized by investors who wish to find out the capability of an asset to generate net present value (NPV) of returns on an investment. A prospective asset will provide the investors possitive NPV the higher this monetary return the better is the investment while the less worthy assets will not be able to yield satisfactory return perhaps due to the initial outlay cost is too high. Thus discounting is a technique of assigning values to a stream of potential returns in the coming years, say for 20 years of future returns, valued at the present time. Furthermore, discounting technique utilizes the weight. For a discrete function $1/(1+r)^i$ is used where 'r' is the discount rate and i = 0, 1, 2,. . ., n is the number of years. These returns are evaluated against the flow of economic and social costs also valued at the present time using the same discrete weight.

In natural resource management, the fundemental issue raised against the current utilization of resource extraction is that: are we the present generation who is empowered to make decision for ourown benefit acted fairly and equitably in preservation and distribution of this wealth in terms of their quantities and services for the future generation? To present this intergeneration distributional issue a simple case of two time periods; T1 represents the present and T2 represents the future, are presented to assess the natural resourse use of sawlog exploitation which is endangered in relation to varying discount rate associated with the optimum extractions. As formulated the objective function is to maximize net social benefit (NSB) subject to the availability of natural resource stock of Cengal species of 52,000 m^3 as the constraint.

Table 2 discloses that with an increase in the discount rate from 0 to 0.05, 0.10 and finally 0.20 the distribution of resource extraction apparently favors the current generation relative to the future generation. This is evident from production levels under the columns of T1 and T2. For instance, with discount rate of zero percent the cengal resource is fairly shared at 75,000 m^3 for both generations, but as discount rate rises to 0.10 (10% per annum) the share of present generation is 95,085.9 m^3 while the future generation will receive only 54,914.1 m^3. This could only be true if the availability of Cengal is set at 150,000 m^3 for the two periods. The general view of many economists is that the unequal distribution between present and future generation is compensated by the capital formulation and know-how developed during the current for the future generation. Thus the uneven share of the present generation can be translated as the capital accumulation which will benefit the future (see Tietenberg p. 94). The imbalance intergenerational distribution of natural resource nevertheless further creates additional issue of resource sustainability intertemporally. In other words, distribution that favors the current generation in comparison to the future is not only unsustainable from the viewpoint of the next generation but most importantly they are not being represented fairly for the decision made in the current generation.

Table 1: Results of Regression Analyses between Price and Quantity of Timber 2011.

Source	SS	df	MS		
				Number of obs.	= 150
				F(11, 139)	= 156.71
Model	76178667	11	6925333.36	Prob> F	= 0.0000
Residual	6142648.02	139	44191.7124	R-squared	= 0.9254
				Adj R-squared	= 0.9195
Total	82321315	150	548808.767	Root MSE	= 210.22

price	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
cons	-.0008614	.00026	-3.31	0.001	-.001375	-.0003472
d1	912.6029	64.44361	14.16	0.000	785.1864	1040.019
d2	1264.866	56.10725	22.54	0.000	1153.932	1375.800
d3	799.0342	57.26261	13.95	0.000	685.8159	912.2526
d4	654.1174	76.76043	8.52	0.000	502.3483	805.8864
d5	730.8673	75.08942	9.73	0.000	582.4022	879.3325
d6	573.2446	55.15844	10.39	0.000	464.1865	682.3026
d7	551.2840	54.88757	10.04	0.000	442.7615	659.8064
d8	898.3213	79.37906	11.32	0.000	741.3747	1055.268
d9	701.3084	58.5036	11.99	0.000	585.6364	816.9804
d10	746.7282	66.72183	11.19	0.000	614.8073	878.6492

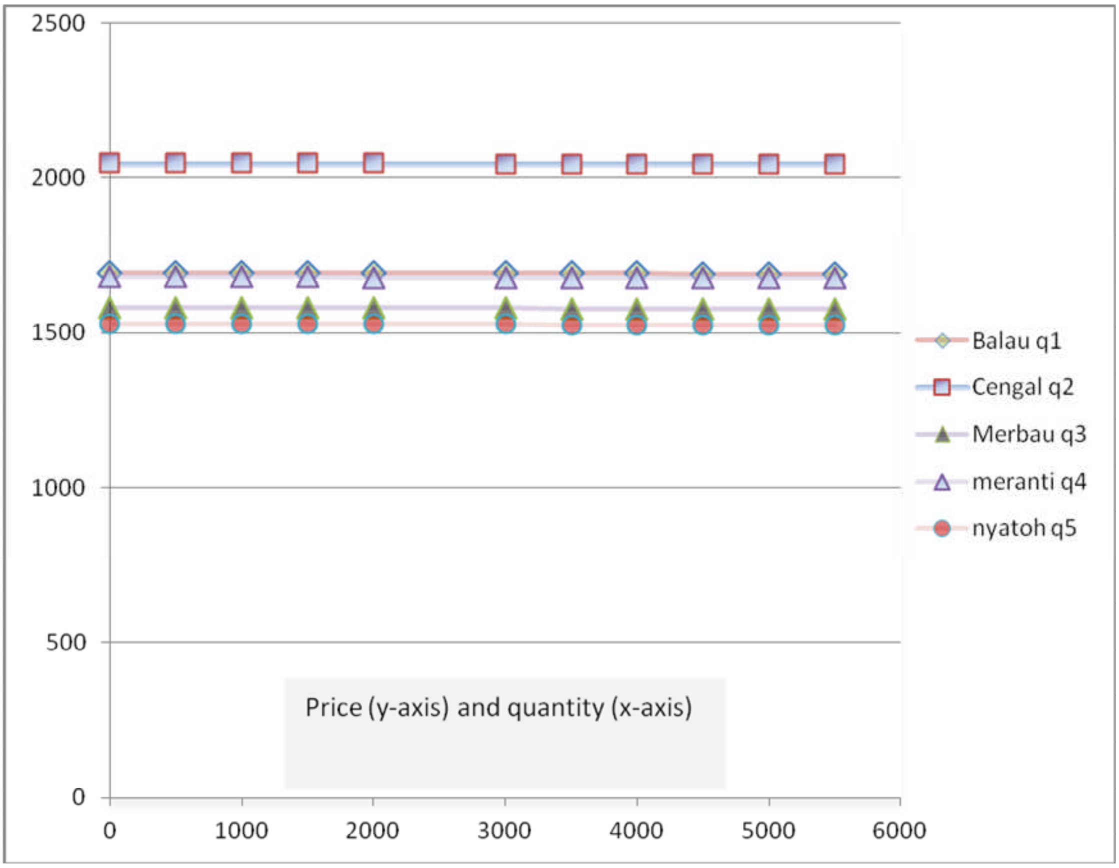

Figure 1: Indirect Demand Equations for Selected Timber Spicies

Table 2: Distribution of Natural Resource Asset of Sawog Cengal Spesies in Cubic Meter (m^3) between Two-Period of T1 and T2.

Discount Rate (r)	Production/Extraction T1 (m^3)	in 2 periods T2 (m^3)	Total Resource (m^3)	Present Value of Efficient Price (λ_{T1}) (MYR/m^3)	Current Value of Efficient Price (λ_{T2}) (MYR/m^3)
0	75,000	75,000	150,000	1,418.87	1,418.87
0.05	95,085.9	54,914.1	150,000	1,384.27	1,453.48
0.10	114,209.8	35,790.2	150,000	1,351.32	1,486.45
0.15	132,451.4	17,548.6	150,000	1,319.89	1,517.87
0.20	149,862.9	137.1	150,000	1289.89	1,547.87

Source: Estimates of intertemporal optimization obtained from outputs of Maple application for the endangered sawlog species of Cengal. Resource availabity is fixed at 150,000 m^3 for 2 periods.

Table 3: Intertemporal Distribution of Cengal Sawlog Species at 5% Discount Rate

Period	2 Yrs	3 Yrs	4 Yrs
T1	95,085.9	91,046.1	99,453.2
T2	54,914.1	50,672.3	59,499.6
T3		8,281.7	17,549.5
T4			-26,502.2
Efficient Price (MRY/m3	1,384.27	1,391.23	1,376.74
Total Resource (MT/yr)	150,000	150,000	150,000

Table 4: Intertemporal Distribution of Cengal Sawlog Species at 5% Discount Rate

Period	2 Yrs	3 Yrs	4 Yrs	5 Yrs
T1	143,867.1	122,768.5	122,653.6	130,717.0
T2	106,132.8	83,980.0	83,859.3	92,325.7
T3		43,251.5	43,124.8	52,013.7
T4			362.3	9,699.2
T5				-34,755.5
Efficient Price (MRY/m3	1,300.22	1,336.57	1,336.77	1,322.87
Total Resource (MT/yr)	250,000	250,000	250,000	250,000

Note: *Estimate utilises indirect demand function whereby price (P) is a function of Annual Production of Cengal, and marginal cost is fixed at RM500 per m^3 including the cost of royalty RM147.00 per m^3 and other operating costs.*

As noted the only fairly and equitably intergenerational distribution of natural resource: nonrenewable as well as renewable, like the forestry produce of sawlogs shown as an example here is when the discount rate is set at zero (0% per annum) as evident from results of Table 2 in row one. The total stock of 150,000 m^3 per annum Cengal species that can be harvested within two periods of time is 75,000 m^3 for each period. An economic implication from zero discount rate may not seem impressive for those who wish to earn profits from buying and selling activities of these natural assets. With zero discount rate the general view of most economists is that people will have less incentive to invest since there is no clear return from such activity and hence slow down the economy. A zero discount rate will never depreciate the value of asset overtime as did the prices of properties exploded with the use of interest rate. Thus a zero discount rate will sustain the value of a natural resource asset from depreciation over time relative to a situation when discount rate is greater than zero.

Table 2 also illustrates that the present value of efficient price (λ_{T1}) of *in situ* resource falls as the difference share of intergenerational distribution of asset becomes larger in favor of the present generation. The curreent value efficient price (λ_{T2}) is the difference between market price and the marginal social cost of resource extraction (P−MSC). It reflects the value of the extracted resource which is increasing overtime as the resource availability gets scarcer. It also represents the opportunity cost of using the resource that leads to an increase in future value of the left over stock. In practice the efficient price due to scarcity is also called as the *marginal user cost* of the resource asset. The highest present value of the efficient price is RM1,418.88 per m^3 when r = 0, this value apparently declines overtime as the distribution of resource increases such that when r = 0.20 the present value of efficient price (λ_{T1}) equals MYR1289.89 per cubic meter (m^3). However, the current value of the efficient price (λ_{T2}) rises with the decline of resource availability in the future. This is contrary to the present value ofefficent price which falls as the resource extraction increases for the present generation. These findings are consistant with the demand theory whereby price tends to decline with an increase in consumption or extraction of resources and vice-versa.

Tables 3 and 4 show the intertemporal optimum levels of sawlog extraction of Cengal species with varying number of years at a 5 percent pa discount rate. The numbers of years under investigation are two year duration (2Yrs), three years (3Yrs), four years (4Yrs) and five years (5Yrs) respectively. The objective is to illustrate that natural resource asset used in short time period differs from longer time in terms of sustainability of resource management.

For a given total available stock of Cengal sawlog of 150,000 m^3 and the policy of resource utilization is for two years (2Yrs) the production intensity and subsequently consumption is found to be relatively higher that is 95.1 thousand m^3 (T1) and 54.9 thousand m^3 (T2) per year. The environmental impact and ecological damage would be much higher with intensity of production, processing and consumption. Compare the two-year case (2Yrs) with the three years (3Yrs) the 150,000 m^3intertemporal optimum production is spread out gradually into 91.0 thousand m^3 (T1), 50.6 thousand m^3 (T2), 43.3 thousand m^3 (T3). Resource extraction that helps spread resource over a longer period of time has a lesser impact on degrading the environment as such this policy is undoubtedly more sustainable.

In Table 4 the total resource availability was increased to 250,000 metric tons the difference in resource utilization for the 3Yrs and 4Yrs is not conspicuous. The negative figures of total resource in 4Yrs (Table 3) and 5Yrs (Table 4) imply that the present generations are empowered to overexploit the resource shares at the expense of the future.

First, the external impact on the society arising from environmental degradation, ecological damage, air, water and sound pollution normally would be minimized from a policy that favors a longer periods of resource use 3 Yrs in relation to 2Yrs. Forcing the distribution of natural resource asset to be used for a shorter time horizon is synonymous with exploitation and is not friendly to the environment as well as conflicting to the idea of sustainable development goal. One can easily foresee the unfavorable socio-economic impact of adopting a short sighted policy that will deplete the resource within a short time period as such the chain of employment opportunities in this and related industries will have to be immediately immobilized. A policy that utilizes resources for longer duration of time enables plan actions be implemented to avoid possible future predicaments. The precautionary measures in forestry can be in the forms of replanting of new trees, mitigation measures, and cheaper cost associated with minimum environmental and ecological problems.

Second, intertemporal optimal allocation accords sustainability since utilization of natural resource takes a longer time period. Evidently, the share allocated to the present in terms of quantity is greater compared to the later generation. This finding apparently supports the earlier evidence presented in Table 1. With new technology and innovations developed by the current generation over older generations it is not impossible that the later will be more advanced than the current generation. New stock of natural resources might be found which benefit the future people but what is more concerned is that the current resources may be exploited to the point of no return for the later generation that inhibits the planet.

Third, the value of efficient price if delayed to a longer time of intertemporal optimal extraction tends to rise subsequently owing to the availabilty of resource which are gradual in facing the problem of scarcity (Table 4). For instance, for a two years (2Yrs) intertemporal optimal plan the efficient price is RM1,300.22 per m^3. This figure has increased to RM1,336.57 per m^3 for intertemporal plan of three-year duration (3Yrs) and subsequently to RM1,336.77 per m^3 for fourth-year intertemporal decision plan (4Yrs). In the fifth year (5Yrs) when there is a negative value efficient price tends to falls subsequentIy. Any natural resource facing limitation of stock availability a decision to prolong its utilisation for a longer optimum levels will help to increase the efficient price. This can only be true when the discount rate as in the current study is held constant at 5 percent per annum. Efficient price which is represented by the value of lambda (λ) differs from the market price since it reflects and varies with the availability of natural resource leftover stock or in short stock scarcity level. It is derived from the intertemporal optimization of net social welfare.

CONCLUSION

The use of discounting technique in assessing costs and returns for a reasonable short time horizon is central in benefit-cost analysis. However, the choice of an appropriate discount rate for a distance project assessment is no doubt difficult due to the possibility of wide variation such as the impact of climate change, hence arose much controversy and dissatisfaction. The issue of climate change in Stern Report which utilizes 0.1 percent discount rate for the whole analysis has brought many criticisms from practicality point of view. The discount rate which is close to zero will give almost an equal weight between the present and future generations. The objective of current study is to investigate the potential effect of zero to positive discount rates on the distribution of natural resource asset, that is, the timber resource between generations hoping to establish real world findings for policy formulation. In the name of intergenerational equity, zero discount rate would leave a fair distribution but as discount rate gradually rises it increases an impact on resource utilization in favor of present generation at the expense of the future. The biggest criticism perhaps would support the fact that business activities do not rely very much on the fairness distribution of intergenerational economic share of the natural resource wealth. The solution lies between an equitable discount rate that would promise flourishing business and economic activities to the nation. Then further question would arise, that is, how could the global society, be reassured of the clean environmental quality with the booming of business and economic activities?

Using a discrete intertemporal optimization technique the findings seem to support a broader objective of the study whereby with postponement of optimal resource into several periods, instead of fewer years not only yields better outputs in terms of resource management it constitutes toward the goal of sustainability of the renewable and non-renewable. The results are as stipulated would be useful for decision making in intertemporal resource management. Specifically this finding would be useful for Malaysia since natural resource will not be utilized in developing the country. As mentioned in the New Economic Model natural resource utilization will degrade the environment and the ecology and the external impact of such development strategy is generally passed to the society.

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