CONTRIBUTIONS TO THE ECONOMICS OF TIME PREFERENCE

by

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This dissertation addresses four hypotheses in regards to future valuation by individuals. These include a hypothesis that the provision of public goods in the far future, a period in excess of an individual's lifetime and the lifetimes of his/her immediate descendants, is a likely component of utility functions. The second hypothesis is that the importance of distant future public goods provision is unaffected by contemporary consumption levels. The third hypothesis suggests that individuals discount the far future differently than they discount future events in the near future. The final hypothesis is that the extent of future valuation is determined by specific concern based upon religious or ethical considerations as well as concern for descendants.

Evidence supporting all four hypotheses was derived from a survey instrument administered to a group of 147 students at the University of Wyoming and a second group of 60 office workers in Illinois. These responses were largely consistent with a zero discount rate on far future events.

These results imply that far future impacts are undervalued in benefit-cost analysis. A cautious approach is recommended in policy analysis, especially when contemporary activity is characterized by irreversibilities.

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With much love, I dedicate this dissertation to my father, George H. Case, Sr., a man too young at heart to give up and damn determined that I will not either.

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Chapter I

Valuation of the Future: an Introduction

How do people value the distant future? Do they value events that will occur to future generations? How and why do they formulate these beliefs? What factors are important and what factors are unimportant? If an opportunity were afforded individuals to transfer wealth and/or mitigate negative impacts to future generations would it be utilized?

A major reason for the contemporary importance of such questions is the fact that man, substantially more than at any other time in his past history, now possess the ability to irreversibly alter the resources, environmental quality, and total level of welfare available to future society. In fact, for the first time man has come to realize, in stark contrast to the mainstream of social and scientific thinking which has developed since the Renaissance, that the likelihood of endowing the future with a negative inheritance is large and increasing. The large scale resource and environmental problems facing the world are numerous. Climate may be affected by stratospheric pollution and increasing atmospheric concentration of carbon dioxide; future environmental quality is jeopardized by exotic pollutants such as DDT, PCBs, and plutonium; and

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future availability of nonrenewable resources is impacted by current consumption levels.

Chapter II considers the concept of future valuation as developed by the mainstream of neoclassical economic theorists. In this chapter the rational for discounting is developed via consideration of the two justifications most often cited for placing a lessened weight on future events, opportunity cost and time preference. The implications of utilizing high and low discount rates in social decision making is discussed through the process of analogizing the discount rate to a "time window."

The literature of mainstream economists is summarized in detail in this chapter. The literature survey begins with the works of Pigou (1920) and follows the development of the discounting literature to its present level.

Chapter III considers alternative concepts of future valuation as embodied in the works of non-mainstream economists and other disciplines. Religious and ethical basis for future valuations are also considered and the implications of the teachings of three religions on the valuation of far future activity are discussed. These religions include Christianity, Budhism, and Islam. In addition, four major ethical frameworks are analyzed; these include Rawlsian, Nietzschean, Utilitarian, and Paretian.

In Chapter IV, a theoretical model of an individual's future valuation is developed. This model is used to

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analyze specific hypothesis regarding an individual's concern for the provision of public goods in the distant future. The model utilizes a three period utility function in which the periods are the present, the near future and the far future. Present and near future periods are assumed to encompass the period of an individuals lifetime and the lifetimes of immediate family members while the far future period is occupied by distant generations. From this model four hypothesis of future perception are developed. The first hypothesis is that the far future availability of public goods is important. The second hypothesis is that the importance of distant future public goods provision is unaffected by present and near future consumption levels. The third hypothesis is that individuals discount the far future differently than they discount future events in the relatively near future. The final hypothesis is that the "rate" which governs the individuals valuation of public goods in the distant future is determined by specific factors in the utility function. These factors may include ethical and religious considerations as well as concern for descendents.

Chapter V considers the possibility of empirical verification of future values exhibited in the hypothesis developed in Chapter IV. The potential for application of market and non-market techniques is explored. The applicability of market based techniques such as weak

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separability, hedonic specification, and others are largely dismissed due to the apparent nonexistence of a relationship between the distant future and contemporary market prices. Allocation of future public goods via a contemporary referendum is discussed. It is demonstrated that under most voting rules the allocation of future public goods is likely to be non-optimal. Finally, the feasibility of utilizing contingent valuation methodology is considered. Potential biases, which some have argued are inherent in the contingent valuation approach, are discussed along with some recent results of the willingness to pay literature. The chapter concludes that contingent valuation offers the only possible means of determining how individuals value the distant future availability of public goods.

In chapter VI, an experiment is developed to determine the answers to the hypothesis presented in Chapter IV. This experiment utilizes the contingent valuation technique to determine how individuals value the far future provision of public goods. The design of a survey instrument utilized in the analysis is detailed. This instrument enables individuals, through the mechanism of a contingent market, to reveal preferences for future public goods. Furthermore, the impact of the individual's religious, ethical, and descendent-related leanings upon this valuation can be investigated.

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Chapter VII presents the results of the contingent valuation analysis. These results substantiate the hypotheses contained in Chapter IV. In addition, the chapter contains suggestions for further research. The impact of these results for policy formulation is explored in Chapter VIII. The most important impact is the fact that far future effects should be included in cost-benefit analysis and these effects should be discounted at a reduced, or possibly zero, rate of discount.

Appendix I contains the survey instrument utilized in this analysis. Appendix II contains a general equilibrium model of discounting behavior and the preservation versus development question.

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Chapter II

Valuation of the Future:

The Neoclassical Economist's Viewpoint

In this chapter the neoclassical economist view of the future is detailed. The chapter begins with a review of the two generally accepted reasons for discounting: time preference and opportunity cost. The importance of this rate in policy analysis is discussed along with an illustration of the impact of different rates in traditional discounting formula. Following this discussion, a review of the prominent neoclassical writers on the discount rate is conducted. This review begins with the work of Pigou (1920) and traces the history of the literature to its present level.

Economics has been concerned with the future since the beginning of the discipline. However, with the advent of very long term federal water resource programs, which required the development of techniques to determine the financial feasibility of water projects, a need developed to put an explicit perspective on the value of future economic events. In this context, economists generally agree that the value of a future economic event, say for example the receipt of $10,000 dollars in benefits from a water project

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in the year 2010, is less than its face value when considered in today's terms. That is, the "present value: of $10,000 to be received at some time in the future is something less than $10,000.

There are two generally accepted reasons for this time dependent devaluing, or discounting of the magnitude of a future occurrence: time preference and opportunity cost. Time preference, economists, psychologists and others would certainly agree, arrives from the fact that individuals would readily prefer an equal amount of consumption today rather than at some future date.[1] That is, if given a choice between receiving two pounds of commodity X today, or the same amount of the commodity one year from now, the rational consumer would prefer the former alternative, assuming that X is a good, i.e. something that yields utility. Two general explanations of individual time preference behavior are often cited. The first of these is

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[1]While most economists agree that the consumer does discount future economic activity, many would argue that such discounting is not appropriate. This principle was put forward as early as 1888 by Bohm-Bawerk who remarked that "to goods which are destined to meet the wants of the future, we ascribe a value which is really less than the true intensity of their future marginal utility." E.V. Bohm-Bawerk, The Positive Theory of Capital, (1888), W. Smart Translation (New York: G.E. Stechert and Company, 1891), p. 253. Other economists who believe that the discounting of future utility is in some sense irrational include Marshall (1920), Pigou (1920), and Strotz (1955-56).

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the fact that, with growing incomes, most individuals expect to be earning a larger income in the future. When this factor is combined with the standard notion that the relative marginal evaluation of a dollar's worth of consumption decreases with income, an explanation for time preference behavior is provided. The second factor which provides an additional explanation of such action is that individuals can never be absolutely certain that a future event will occur in a prescribed manner - or even that they will be able to take advantage of it if it does occur.

Opportunity cost, the second major reason for discounting the magnitude of future economic events, occurs due to the notion of the time value of money. This time value of money arises from the fact that, assuming an interest rate of i%, a dollar received today may be invested to yield a total of (1+i) dollars one year from now. Therefore, in order for two payments occurring 1 year apart to have equivalent present value, the latter payment must exceed the former one by i% in order to account for the lost opportunity of the foregone return.[2]

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[2]Combination of these two explanations for time preference behavior seems less than satisfactory. The reason I eat the ice-cream bar in my refrigerator today instead of next week has nothing to do with the fact that next week I may have higher income or that in the interim I may die, suffer a loss of electrical power, or be forced to

(Footnote Continued)

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Explicitly, the weighting scheme devised to account for the effects of time preference and opportunity costs take the following form:

$$PV = \frac{FV}{(1+r)^t}$$

where PV equals the present value of some future value (FV) to be received t time periods distant and r is the discount rate.[3] The discount rate represents the weight that is applied to the value of future income or consumption. Notice that the larger is r, the smaller is the present value of some future economic activity. If r = 0, the future values and present values are equivalent.

Of course, most instances of computing present values from future values are much more complex than that described above. Often, the decision to undertake a project which spans several years will require the consideration of future returns and future costs in each year. In this context, and

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(Footnote Continued)
stand-in for my boss at an out-of-town conference due to the untimely death of his sister.

[3]The logical progression of this formula from the opportunity cost argument is readily apparent. If $1 is invested for one year at a rate of i% it will grow to $\$1(1+i)^1$. This amount equals the FV. If r=i, then the $FV/(1+r)^1 = \$1$. Note however, that no logical link from this geometric formulation to the time preference argument can be formulated.

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for time frames longer than one year, a more general formula is used:

$$NPV = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t}$$

where:

NPV = Net Present Value

B_t = Benefits occurring in time t

C_t = Costs occurring in time t

r = the discount rate

t = a particular year

and T = the last year in which benefits and/or costs occur (i.e., years = 1, 2, ..., t, ..., T).

Note that the net present value of a project depends on three factors: the time horizon, the distribution of costs and benefits, and the discount rate. Both the time horizon and the distribution of costs and benefits depend only on the project being analyzed. However, the discount rate is a choice parameter; it is this choice which gives rise to much controversy. Different rates can force net preset value to be larger, smaller or even negative.

To illustrate this, consider a project such as the construction of a dam, involving high initial costs for several years and moderate benefits for many years afterwards. A relatively low discount rate will make the project feasible because future benefits remain relatively

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unaffected. However, a high discount rate will drive the present value of distant, future benefits to near zero thus making the project infeasible from an economic standpoint.

In this context the discount rate is a "time window". A high rate gives us a very myopic view of the future and a low rate preserves our futurescopic vision. A discount rate of zero would yield perfect futurescopic views and cause us to value future costs and benefits as if they occurred today.

The choice of a low rate of discount implies that we place high values on future economic activity while choice of a high rate implies that future activity is valued much less in relation to the present. This gives rise to several ethical questions regarding the choice of a discount rate since often the utilities of different generations are being compared. These ethical questions will be discussed in Chapter III.

The choice of proper discount rate(s) for evaluating public investment decisions has occupied a large bulk of the presumably, productive time of economists for decades. The list of authors is this area is long and the list of myriad conclusions is perhaps longer. The proper conclusion of any paper on discounting is that there is no conclusion. Mayhem abounds. Authors have approached the discount rate decision by arguing that it should be the long run consumption rate of interest, the opportunity cost of capital -- either as an

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overall average or as a weighted average of the cost of capital in the various sectors of the economy from which the funds are derived, and even by a weighted average of the consumption rate of interest and the opportunity cost of capital approaches (the latter which could also be some weighted average of returns in different sectors!). Some authors have argued that none of the above so called attempts at measuring opportunity costs, either of consumption or of investment, are correct. This latter set of authors argue that the rate that should govern societal investment (and possibly private investment also) for the future has nothing to do with the opportunity cost measures discussed by most authors, but should reflect the autonomous worth society feels towards the future. These authors have developed the notion of discounting via the use of "socially" derived rates. And of course there are those that argue that this "social" rate can be proxied with other rates in society -- perhaps by using the consumption rate of interest. Finally, some authors have, as one can guess, argued for combinations of social and opportunity cost criteria. This is perhaps the ultimate extension of the complexity of the discounting debate. Unfortunately, the profession is only perhaps slightly closer to resolution of the issue of what constitutes a proper rate of discount.

Pigou (1920) argued that individual investment decisions are myopic. He believed that the government is

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the guardian of the interests of future generations as well as the interests of the present generation. Therefore, welfare in the Pigovian model is a function of the level of utility of all individuals whether they are born yet or not. Under this arrangement, it becomes the role of government to consider the interests of the future as well as the present generation when making decisions which affect these groups. Because discounting would force society to place less weight on impacts which occur to future members of society it would lessen the representation of future individuals in the government process. Thus the effect of discounting is to force government to a reduced level of consideration of future impacts; discounting is then, a way to pass judgement on the merit of future generations' utility and is therefore inappropriate.

F.P. Ramsey (1928) is a historical opponent to the discounting of utility. In his paper he described the practice as being one "which is ethically indefensible and arises merely from the weakness of the imagination..."[4] Despite this statement, in Section II of this paper, Ramsey extended his basic model of national savings behavior to the case where future utility is discounted. Further, he was

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[4]F.P. Ramsey, "A Mathematical Theory of Saving," Economic Journal, 38 (1928), p. 543.

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careful in this extension to point out that the rate of discount which should apply to future monetary sums had nothing to do with the rate which should be utilized to discount future consumption.

Ramsey's (1928) work would, if the single statement mentioned above was ignored, seem to indicate acceptance of the idea of some form of discounting of societal decisions. Ramsey apparently resolved this conflict as in a later work (1931) he argued for the need to place a perspective on time.

Krutilla and Eckstein (1958) argued that the discount rate should reflect the cost of removing resources from the private sector. This "social cost" approach looks at the various sources of funds and estimates the value attached to these funds in their alternative uses. Thus it is necessary to ascertain the interest rates faced by individuals and firms. Further, one must also determine what proportion of these costs are "requisitioned" from the various sectors of the economy. This method abstracts from charges in distribution of income; who receives the benefits and who receives the costs is a matter of indifference.

Eckstein (1958) pointed out that use of an opportunity cost-based discount rate as a selection criteria would wipe out the justification for most public works projects. He argued that this was inappropriate and maintained that:

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> Social policy as derived from the political process, may prefer rejection of present intertemporal preferences in favor of a redistribution of income towards future generations... It is not logically inconsistent for the same person to be willing to to borrow at a high interest rate to increase his present consumption while voting to spend tax money to build a project from which future generations will benefit, for in the case of a vote to tax, he can be sure that other individuals can be compelled to act similarly.[5]

In light of this, Eckstein maintains that a low (social) interest rate should be used for project evaluation. However, he did not believe that opportunity costs should be ignored, especially in light of the fact that such a low rate could be misused to enable "the justification of projects with little economic value."[6] He suggested that opportunity costs should be determined via an analysis of where funds are requisitioned. These costs thus become indirectly reflected in the evaluation process.[7]

Eckstein's method involves use of a sliding scale of benefit cost ratios and discount rates that correspond to a project's minimum economic criteria equalling the opportunity cost of funds withdrawn from the the private

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[5]Otto Eckstein, Water-Resource Development: The Economics of Project Evaluation, (Cambridge, MA.: Harvard University Press, 1958), pp. 99-100.

[6]Eckstein, p. 100.

[7]See Krutilla and Eckstein (1958).

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sector. Under Eckstein's proposal, projects with benefit-cost ratios of unity require evaluation using a discount rate which is equal to full opportunity cost while projects with higher ratios may be discounted at lower rates.[8]

Steiner (1959) believed that the discount rate should be a social time preference rate which is derived from the opportunity cost of deferring consumption. Others have referred to this rate as the consumption rate of interest. Steiner also argues that opportunity costs must be considered. His conclusion in this area was similar to Eckstein's (1958) in that only in the case where a project is evaluated via a time preference rate which equals the projects internal rate of return and the market return on investment are opportunity costs equal to zero. If the time preference rate used in project evaluation is greater than the projects internal rate of return and the market's marginal return on investment, then opportunity costs of public investment are negative. Alternatively, if the market return and the project's return are both higher than

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[8]Eckstein's proposal also requires that project life-span and ratios of operating cost to fixed cost be considered. Ceteris paribus, longer lives require higher rates of discount while a higher ratio of operating cost to fixed expenditures necessitates evaluation at a lower discount rate.

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the time preference rate, then opportunity costs of public investment are positive.

In practice, Steiner identified three specific types of opportunity cost. The first of which represents the purely public opportunity cost of utilizing the public budget for one project over another. This cost is related to the internal rate of return of a particular public project and the social time preference rate (the consumption rate of interest). If federal budgets are fully flexible this cost is zero. The second type of opportunity cost captures the effect of displacing specific private projects with public investment. This cost depends on the net benefits of the private projects evaluated at the social time preference rate. Steiner noted that in an economy with a large percentage of under employed resources, this value is likely to be zero. The third type of opportunity cost is identically equal to that identified by Eckstein (1958) and Krutilla and Eckstein (1958). This is the opportunity cost of transferring funds from the private to the public sector. It is calculated by an analysis of the sectors of the private economy where public funds are originated. In the special case where only unutilized resources are transferred from the private to the public sector, this cost is also zero.

Marglin (1963A) focused his arguments regarding the discount rate on the relationship between generations. He

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explicitly argued that the social rate of discount is less than the market rate because of the welfare aspects of present social investment on future generations. He rejected the ideas that 1.) "the rate of interest determined in an atomistic competitive market need have any normative significance in the planning of collective investments," and 2.) that the market determined rate of growth of the economy is optimal in a welfare sense.[9] This suggests that government might maximize the welfare function (which includes future generations) by encouraging investment (both private and public) via use of a lower rate. In practice, discounting is not used at all in the Marglin model; decisions are based on the rationale of the "collective, political capacity," as a final result of which, investments are undertaken which have future returns too low to justify private investment.

Marglin postulated the existence of a social discount rate by asking the rhetorical question, "Why do governments require citizens to sacrifice current consumption in order to undertake investments that will not yield their benefits until those called upon to make the sacrifice are all

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[9]S.A. Marglin, "The Social Rate of Discount and the Optimal Rate of Investment," Quarterly Journal of Economics, 77 (1963A), p. 111.

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dead?"[10] Marglin proposed three explanations for this behavior. He proceeded to reject the first two of these postulates and accepted the third. The first explanation, Marglin termed the "authoritarian answer," was the same one suggested by Pigou (1932). This is the notion that government represents the interests of the unborn.[11] Marglin rejected this postulate on the grounds that a government which is actively pursuing the interests of the unborn at the expense of the electorate can not fulfill the democratic principle the requires consideration of the wishes of the body politic.

The second postulate, which Marglin called the "schizophrenic answer," is a notion that individuals possess two sets of preference orderings. One set governing their behavior as individuals and the other governing behavior as citizens or members of society. Under this dual arrangement, we can explain behavior which is consistent with both the observation of individual self-interest and at the same time collective altruism. Marglin expresses great sympathy for this view but in the end he is forced to reject it -- mainly due to the difficulty of deciding which one of

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[10]Marglin, 1963A, p.95.

[11]Pigou's work is discussed earlier in this section.

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the dual preference arrangements should be used by society to determine investment levels.

Marglin's third postulate, and the one which won his support, is the "interdependence answer." In developing this answer he assumed the following utility function:

$$U_i = U_i\ (C_i, C_f, C_p - C_i)$$

where U_i is the utility of individual i which is a function of his own consumption, C_i, the consumption of future generations, C_f, and the consumption of his contemporaries in the present generation, $C_p - C_i$. Total differentiation of this function yields:

$$dU_i = \frac{\partial U_i}{\partial C_i} dC_i + \frac{\partial U_i}{\partial C_f} dC_f + \frac{\partial U_i}{\partial (C_p - C_i)} d(C_p - C_i).$$

Marglin made the following assumptions regarding the magnitude of the marginal values existing in a neighborhood around C_i, C_p, and $C_p - C_i$:

$$\frac{\partial U_i}{\partial C_i} = 1, \quad \frac{\partial U_i}{\partial C_f} = \alpha, \quad \frac{\partial U_i}{\partial (C_p - C_i)} = \beta$$

If we utilize these relationships and the fact that $d(C_p - C_i) = dC_p - dC_i$, the total differential becomes:

$$du_i = dC_i + \alpha dc_f + \beta(dC_p - dC_i).$$

And if we assume that at the margin, the sacrifice of one dollar of present consumption yields k dollars to the consumption level of the next generation, i.e.,

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$$MRT_{C_f C_p} = k,$$

then this implies that an individual receives a satisfaction level of αk when he invests one dollar for future generations. Therefore, it becomes rational for the individual to unilaterally invest if $dU_i = -1 + \alpha k$ is nonnegative. That is, the change in the utility of individual i is equal to the sum of utility loss to i due to a reduction in present consumption by $1.00 plus the gain in i's utility which arises out of the fact that the consumption of future generations is increased by αk dollars. This unilateral investment criteria reduces to $\alpha k = 1$.

In the same manner the investment criteria that governs he desire of the individual to see one of his contemporaries invest a dollar for future generations is determined by the following relationship:

$$dU_i = -\beta + \alpha k.$$

That is, the incremental change in individual i's utility is equal to the sum of i's utility loss due to the reduction of one of his contemporary's consumption by $1.00 plus i's gain due to the increase in the consumption of future generations. This contemporary investment criteria reduces to $\alpha k \geq \beta$. If a society is made up of homogeneous members, then it is conceivable for some $\beta < \alpha k < 1$, that all members of the society would like to see each other invest but none would do so individually.

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The argument for investment is strengthened considerably if all individuals in the society invest $1.00. Assuming n individuals, the change in utility for individual i becomes:

$$dU_i = -1 + \alpha kn - \beta(n-1)$$

Where of course, -1 is individual i's utility loss due to the reduction in consumption by $1.00, αkn is the gain in utility to individual i arising out of the investment of n dollars, and $\beta(n-1)$ is the utility loss to individual i which comes about because his/her n-1 contemporaries have sacrificed current consumption by $1.00 each. This collective investment criteria implies that all individuals are better off if:

$$\alpha kn \geq 1+\beta(n-1).$$

Note that as n becomes large, the utility change for individual i approaches n times the utility change arising from a dollar investment by one of i's contemporaries. That is, as $n \to \infty$

$$dU_i \approx n[-\beta + \alpha k].$$

This implies that for large societies the condition required for each individual to favor collective investment reduces approximately to condition required for individual to favor investment by others.

Marglin supported the conclusion of his interdependence answer and argued that this is the source of motivation for long-term societal investment. Note that the operational

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discount rate implied by this procedure is a purely social rate which has absolutely nothing to do with any other rate prevalent in society -- including the consumption rate of interest. Facilitating confusion on this issue is the fact that the consumption rate of interest has been termed a "social" rate by other writers.[12]

In a follow up paper the same year, Marglin (1963B) reiterated the conclusions of his earlier work (1963A) and expressed the view that the opportunity costs of displaced private investment must be considered when resources are transferred from the public to the private sector. According to Marglin, this displacement must be accounted for because of two reasons. The first of these occurs because of the discrepancy between the rate Marglin feels should govern public decisions and the rate which governs private decisions (this discrepancy formed the thesis of his earlier paper). That is, since the optimal public rate is lower than the appropriate rate in the private sector, the marginal productivity of private capital will, of course, be greater. Obviously, when private capital is transferred to lower valued uses in the public sector, society incurs some loss because of the different marginal productivities of

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[12]See Eckstein (1958), Steiner (1959), and Lind (1982).

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capital in the two sectors and as a result less private investment is undertaken than would otherwise be the case.

A second reason for displaced private investment is, according to Marglin, the fact that government performs many duties which may be performed by the private sector. He argued that this displacement occurs due to the fact that the "boundary between the public and private investment sectors is not absolute in modern capitalistic economics."[13] Opportunity costs must be accounted for in the project evaluation phase to reflect this displacement of resources.

In order to account for displaced private investment, he supported the notion, pioneered by Eckstein (1958) and expanded by Steiner (1959), that the evaluation of public investments be directly altered.

> Since the marginal social rate of discount reflects the community's marginal weight on consumption at different times, the appropriate basis for comparison of alternative public and private investment is the present value of their net benefits to society evaluated at the marginal social rate of discount. Thus, in the planning of public investment, the present value of the social benefits of private investment that public investment displaces, evaluated at the marginal social rate of discount, supersedes the money cost of public investment as the measure of its true social cost...but, in evaluating the social cost of public investment, an opportunity cost reflecting the social value of utilizing resources in private investment replaces the money cost of the portion of the

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[13]Marglin, 1963B, p. 275.

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> resources that comes from the private investment sector.[14]

In this context Marglin also supported a symmetric approach -- that the value of public investment also be beefed up to account for the benefits which accrue to the private sector as a result of public undertakings.

Tullock (1964) commented on the Marglin (1963A) paper. Tullock conceded that the idea of collective investment to support some group is a sound one. Indeed, he cited the work of Vickrey (1962) who argues that individuals would often be encouraged to make transfers to other members of society if they knew that others would also make such transfers. Despite this, however, Tullock disagreed with the Marglin conclusion. He argued that it is ridiculous to collectively reduce consumption today in order to increase the income of the future generation. This is due to Tullock's belief (and of course that of others also) that the future generation is going to be wealthier. Therefore, in Tullock's view, Marglin's scheme "taxes the poor to help the rich."

Lind (1964) also commented on the Marglin (1963A) work. He showed that in a homogeneous society, "if each individual, given the market equilibrium, feels that the

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[14]Marglin, 1963B, pp. 277-78.

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marginal rate at which he is willing to trade present for future consumption is correct for every other individual, then his private and social rates of discount are equal..."[15] The implication of this is that in societies characterized by similar tastes and incomes, the market rate of interest should be used to determine the relative merit of public investment decisions which benefit future generation.

In addition, Lind suggested that when tastes and incomes are not nearly homogeneous, the operative discount rate for investment decisions may be greater or smaller than the market rate of interest. The magnitude of this rate depends upon the relative marginal valuation that an individual places upon consumption by himself, by his contemporaries, and by future generations. Lind stated that in this situation it is impossible to achieve some optimum amount of investment and that no social discount rate exists.

Feldstein (1964) advocated the use of a shadow price to reflects social time preference considerations on funds withdrawn from the private sector to fund public projects. In addition, Feldstein argued that this shadow price should

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[15]Robert C. Lind, "The Rate of Discount and the Optimal Rate of Investment: Further Comment," Quarterly Journal of Economics, 78 (1964), p. 345.

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also reflect the productivity of funds in private investment.[16] This latter requirement is necessary in the Feldstein analysis due to the fact that "the interest rate of even a perfect capital market would be unsuitable for evaluating public investment projects."[17] This holds partly due to notions of social time preference, but it also arises for due to the fact that an autonomously determined rate of interest in the private sector, which reflects private opportunity costs, can not possibly reflect social opportunity cost:

> Investment enhances the productivity of labour and other factors of production, and, as a result, increases their income. This is a cost to a private investor, who calculates his rate of return net of payments to other factors. But to society as a whole, those increased factor incomes should be treated as a gain. The social rate of return on investment, i.e., the marginal output-capital ratio, may therefore be much greater than the private marginal efficiency of capital.[18]

This point was also raised by Sen (1961).

Furthermore, Feldstein rejected, at least partially, the notion that the prevailing rate of interest is determined via the equating of the marginal productivity of

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[16]See Eckstein (1958), Steiner (1959), and Marglin (1963B).

[17]M.S. Feldstein, "The Social Time Preference Discount Rate," The Economic Journal, (June 1964), p. 379.

[18]Feldstein, p. 364.

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investment and the marginal time preference of consumers.[19] He argued that given the prevalence of "liquidity preference theories which emphasize the 'non-real' monetary nature of interest rate determination" and the impossibility of producers and consumers knowing optimal investment and consumption paths through time, the market rate of interest can have little consequence as a societal decision criteria.[20]

Feldstein agreed with Marglin that the social rate of time preference must reflect the notion that public investment is a public good and concludes, as did Marglin (1963A) that social time preference determination can only be accomplished by explicit government action. However, he disagreed with Marglin's belief that government must only undertake activity consistent with the wishes of the present populace, as opposed to the notion raised by Pigou (1920), Ramsey (1928), and Sen (1960) that the government must also represent the interests of the unborn and/or has a obligation to hand out prescription glasses to correct for myopic time vision. In essence his position is that the social rate may reflect all of these factors. Feldstein argues that the magnitude of this government-determined rate

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[19]See Lind (1964).

[20]Feldstein, p. 363.

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should vary over time to reflect growth in consumption levels and population and changes in society time preference.

Diamond (1968) commented on Marglin's (1963B) work on the opportunity costs of public investment. He argued that the assumptions necessary to justify Marglin's advocacy of shadow pricing capital to indicate opportunity costs while discounting projects at the social rate of discount are too restrictive to make the technique of any practical value in policy analysis.

Baumol (1968, 1970) argued that if some consumers are willing to purchase long term government bonds at an interest rate of r percent, this constitutes an acceptable estimate of their time preference. However, Baumol pointed out that even if r is a passable measure of marginal time preference it is not even remotely an adequate indicator of the social opportunity costs of public investment, i.e. the marginal return to private investment. This divergence between the private rate of time preference and the opportunity cost of social capital is unavoidable and is also responsible for much confusion in the literature. The divergence occurs for two major reasons: the distorting effect of corporate and other taxes and varying accommodation of risk between the public and the private sectors.

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To illustrate the first cause of divergence between private rates of time preference and the marginal return on private investment, the wedge-driving effects of taxes, assume:

(1) full employment,

(2) no risk,

(3) corporations are the sole provider of goods and services,

(4) corporations are financed solely by equity (no debt financing),

(5) a uniform corporate tax of 50%,

(6) a single rate of interest say r, and

(7) taxes are only paid by the corporate sector.

Since under these assumptions, all inputs to government come from the corporate sector, the opportunity cost of using resources is the return that they would have earned in the that sector, i.e. the marginal efficiency of private investment in the corporate arena. Under these assumptions, the marginal investor would be indifferent between investments in the public and the private sector only if realized returns are the same. However, since one-half of all corporate earnings are taxed away, private sector investments must yield twice those of public investments in order to compensate investors by the same amount after taxes are paid. Therefore, the marginal pre-tax rate of return in the private sector must be 2r in order to satisfy investors'

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expectations. This implies that if the rate of return on government securities (one measure of private time preference) is 5%, then the rate of return in the private sector, and the single social opportunity cost discount rate, must be 10%.[21] Generally, for these assumptions and any corporate tax rate t, the before-tax rate of return in the private sector equals the after-tax rate of return divided by (1-t).[22,23]

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[21]It should be noted that this figure represents a minimum in that it is based on those investors participating in the market for government securities (or other long term "safe" securities or bonds). It is probable that the time preference of other individuals is higher than r, and the corresponding measure of social opportunity cost would, on average, be higher.

[22]This follows directly from the fact that the after-tax rate of return is equal to the before-tax rate of return multiplied by (1-t).

[23]In a later paper, Baumol (1970) extended his analysis to the situation where government investment displaces several sectors, each of which has a different tax rate, t_i. In each case the ratio of before to after-tax income will be:

$$\frac{1}{1-t_i} = \frac{\text{Before tax income in sector i}}{\text{After tax income in sector i}}$$

Therefore, Baumol argues that the appropriate rate of government investment is a weighted average of the before-tax rates of return. The appropriate "weight" is the proportion of investment displaced from each industry. Or, more formally:

$$r_g = r_a \sum_i W_i \frac{1}{1-t_i}$$

(Footnote Continued)

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The second cause of divergence between private rates of time preference and social opportunity cost is the existence of risk in private sector undertakings. Risk requires that private firms pay investors a premium in order to encourage them to choose this investment as opposed to the other safe alternatives. According to Baumol this premium should also be included as a social opportunity cost due to the fact that the transfer of resources from the private to the public sector prevents this premium from being earned. In this sense, the risk of private investment functions in an equivalent manner as the taxes discussed above. Risk requires that resources be employed in uses which yield a greater return than the same resources would be required to yield without the risk premium. Furthermore it is these investments, and their corresponding returns, that are forgone when resources are transferred from the private to

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(Footnote Continued)
where:

r_g = the government rate,
r_a = the after-tax rate of return in the
w_i = the relative proportion of government funds coming from sector i, and
t_i = the tax rate for sector i.

In this paper, Baumol also extended this analysis to consider multi-sector risk as premiums for risk are analogous to the taxes discussed earlier. Thus, in a system with the displaced investment subject to different tax rates and different premiums for risk, the appropriate rate of discount for the government is a weighted average of the observed before-tax rates of return.

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the public sector, and therefore the appropriate measure of opportunity costs is the return that those resources are required to generate in their private uses - inclusive of risk premiums for investors. This is the essence of Baumol's theory regarding the affect of risk. Baumol further asserted that since premiums are required to induce investment in risky projects, this higher required rate of return is the relevant opportunity cost (after taxes), and that the elimination of private risk that occurs if the government undertakes an investment is not to be regarded as a social gain. In other words, the change in the amount of risk is not to be considered as producing a change in the level of anyone's utility. Baumol notes that the only way to eliminate the need to consider this risk premium is for government to subsidize private investment to offset it.

Baumol's proposed treatment of risk places him squarely at odds with Samuelson (1964), Arrow (1966), Hirshleifer and Shapiro (1970), Arrow and Lind (1970), and Arrow and Kurtz (1970). The basis for conclusions of these authors is that risk is reduced in the public sector because of the large number of public projects and therefore risk premiums should be excluded from the discounting process. Throughout Baumol's argument, he maintained that the opportunity costs are what must be measured in the discount rate analysis and these opportunity costs include the risk premiums that would have been paid to investors in private projects.

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Thus unless the corporate tax is eliminated and the government undertakes a program to subsidize private investment by the amount of the risk premiums, the divergence between private time preference and social opportunity cost is inevitable. Baumol acknowledges that the divergence between time preference and social opportunity costs leads one to the necessity of choosing which rate is appropriate for project evaluation. On this issue he favors opportunity costs.

> The basic premise on which this analysis will proceed is that the appropriate rate of discount for public projects is one which measures correctly the social opportunity cost. The decision to devote resources to investment in a public project means, given the overall level of employment in the economy, that these resources will become unavailable for use by the private sector. And this transfer should be undertaken whenever a potential project available to the government offers social benefits greater than the loss sustained by removing these resources from the private sector. The social rate of discount, then, must be chosen in such a way that it leads to a positive number for the evaluated net benefits of a public project if and only if its gross benefits exceed its opportunity costs in the private sector.[24]

While Baumol is a firm advocate of an opportunity cost measure of the appropriate rate of discount he does not share with other opportunity cost writers embracement of popular methodologies for measuring this opportunity cost.

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[24]Baumol (1968), 789-90.

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Baumol strongly dislikes techniques, proposed by Eckstein (1958), Krutilla and Eckstein (1958), Steiner (1959), Marglin (1963B), which attempt to reflect opportunity costs by tracing the sources of public funds. Besides rejecting these methods on the basis of their complexity and ignorance of the then prevalent notions of functional finance, Baumol argued that such a process is unnecessary.[25]

> If it is true that, in real terms, what the government takes from the private sector is input resources, then to determine the relevant rate of discount one need not inquire beyond the rate of return currently being earned by users of such inputs. One can ignore in this calculation the subjective time preferences of consumers, the difference between the disutility of paying taxes and of lending and a host of other issues which clutter unnecessarily some of the of the public project discount rate calculations. That the government's use of resources does deprive consumers of some goods is true but beside the point because consumers implicitly but very definitely indicate how they feel about this foregone consumption through the rate of return they are currently providing to business firms.[26]

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[25]Under the functional finance notion, government activity is removed from dependency upon sources of funding. Furthermore, such activity is largely conducted for the purposes of accomplishing macroeconomic goals. Baumol also mentions the balanced budget multiplier through which an expansion in the economy can be achieved with an equal increase in government spending and taxation. Thus the existence of this expansion implies that real resource cost of the government spending must be somewhat less that the equivalent dollar amount in taxes. Baumol (1968), p. 792.

[26]Baumol (1968), p. 792.

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One more factor that must be considered and the one that economists know the least about practically, is Baumol's argument regarding externalities. Baumol argued that:

> The firm whose output pollutes the atmosphere obviously provides a net social return significantly lower than the figure given by its yield on capital. Similarly, the company that produces external benefits...yields social product greater than is indicated by its financial returns.[27]

Such externalities are not limited only to the private sector and therefore are not a source of divergence between public and private discount rates. Rather the existence of such externalities represents a justification for altering the level of both rates. Baumol admits that implementation of this principle is likely to be extremely difficult.

Part of the Baumol externality argument arises because investment in the future is a public good. Baumol is sympathetic to this Marglin-type (1963A) view but he believes that in general, the more appropriate view belongs to those, like Tullock (1964), who believe that it is foolish to burden members of the present society by transferring wealth to the already promising future. Baumol does provide for exceptions to this policy, however. These

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[27]Baumol (1968), p. 282.

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exceptions include assets - such as the Grand Canyon - characterized by irreversibilities.

In summary, Baumol argued that the percentage rate of return in the private sector is greater than the individual marginal private rate of return, and that the latter equals the market rate of interest. Under this approach Baumol believed that the true opportunity cost of public investment is the before-tax return on capital. And as to the choice of an appropriate rate of discount, Baumol concluded that:

> It is my inclination at the moment to look with some favor at a figure toward the higher end of the range - at a discount rate closer to what may be considered the cost of capital to private firms. My grounds for this preference are hardly convincing even to me - they rest largely on the feeling there is a very tangible loss in the transfer of resources from a high rate of return use to an employment in which their yield is very low. On the other hand I can attribute much less significance to a time preference rate which is constantly shifted about and made to adjust to the dictates of a monetary policy.[28]

Steiner (1968) presented a very different view of the discounting process. He argued that private and public investment have no close, substitutable relationship. In the Steiner model, congress (or some other authority) analyzes proposed projects to decide their merit. If a project is chosen, money is appropriated. The basic point of the Steiner model is that determination of the budget is

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[28]Baumol (1968), p. 801.

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partially or totally independent of the economic evaluation of the project. Therefore, substitution between public and private projects does not enter the discounting decision. He argued that the major concern is to optimally fix the level of the budget and that this process may require quite different evaluations of future costs and returns between different programs and projects. (Note the similarity to the Marglin theory.)

Usher (1969) accepted Baumol's position as to the causes of divergence between the consumption rate of interest an the opportunity cost of private investment, but he differed as to the proper opportunity cost of public investment. In comments on Baumol's (1968) paper he suggested that the correct opportunity cost is somewhere between the pre-tax rate of return in the private sector and the individual private rate of return. Usher's analysis is based upon explicit modeling of second best considerations. He demonstrated that under certain assumptions, including a homogeneous distribution of preferences and assets, the optimal rate of discount on government projects is between the time preference rate and the opportunity cost rate.

Ramsey (1969) also accepted the Baumol position that risk and taxes prevent the equalization of the marginal rate of return in the private sector and the market rate of interest. However, Ramsey noted that individual savings are also taxed, and that these taxes will cause a divergence

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between the individual marginal rate of return and the market rate of interest. Therefore, Ramsey argued that the proper social rate of discount is a linear combination of the individual rate and the private sector rate (both pre-tax) which are properly weighted by the source of funds.

Haveman (1969) was a strong advocate of the opportunity cost approach to determining the appropriate rate to employ in the evaluation of public investment projects. He rejected any notion of a socially determined rate for two reasons. First, he rejected any idea that society should explicitly transfer wealth to the future through the application of a social rate which is lower than the rate prevailing in the private sector:

> That the people would collectively agree to provide a standard of life to unborn generations greater than that implied by our current rate of economic growth is highly doubtful. It seems especially so when people seem unable to meet adequately the needs of the hungry, the uneducated, and the sick in their own generation.[29,30]

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[29] Robert H. Haveman, "The opportunity Cost of Displaced Private Spending and the Social Discount Rate," Water Resources Research, 3, 5 (October 1969), p. 948.

[30] Obviously Haveman's argument that future generations are going to be wealthier as a matter of the normal course of economic growth follows the mainstream of economic thinking. Certainly, this has been the observed outcome of economic progress for centuries. It does not consider the possibility that, perhaps through side effects arising from present economic activity, the current generation may be endowing the future with a smaller -- and perhaps negative

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Secondly, he argued that the use of a social rate would also either require the shadow-pricing of project costs or the application of decision criteria based on a benefit cost ratio greater than unity in order to prevent the transfer of resources from higher return private projects to lower return public projects. He rejected both of these approaches because of fear that the elected body of representatives is incapable of coming to grips with this decision and would be easily swayed by a small organized group who would benefit by public investment.

Haveman analyzed four opportunity cost approaches. These include use of the opportunity cost of before tax business investment alone, the use of a rate reflecting the reduction in both consumption goods and investment goods both of which are reflected in profits of business firms, the use of a rate reflecting the private credit restriction and additional savings that occurs in an economy which loans money to the government for investment, and finally a weighted rate of return on private sector consumption and investment spending which is displaced by public investment. Haveman concluded that the latter method is the preferred approach. He estimated this rate to be 7.3% for 1966.

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-- endowment of wealth. One possible method that this may occur is through stratospheric ozone depletion.

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Arrow and Lind (1970) and Hirshleifer and Shapiro (1970) approached choosing the approximate discount rate by use of state-preference theory. However, they came to opposite conclusions. The basic point of divergence between these writers occurred because of imperfections in the existence of markets. Let us begin with the latter paper.

Hirshleifer and Shapiro argued that risky investment opportunities prevent private investment to the point where the percentage rate of return on the marginal unit of capital in the private sector equals the market rate of interest. Therefore, they further argued that the government should use the "risky" private rate of return as a measure of social opportunity cost.

Their analysis began by assuming a "basic claim". A basic claim is a claim to one dollar to be received at a future date. This claim is contingent on the existence of a certain state of the world, and represents prices in the future. Under this arrangement let:

$$Vo = -Po\Delta i_o + P_{1a}\Delta S_{1a} + P_{1b}\Delta S_{1b} + \ldots$$

represent certainty equivalent value, where:

Δ_{io} = an increment of investment

ΔS_{1a} = net returns in period one given that state "a" exists in this period

P_{1a} = Basic Claim to receiving $1.00 in period one under state "a" where this is the discounted

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$$\text{value of \$1.00 or \$1.00} \cdot \frac{1}{1+r}$$

However, the world is not characterized be certainty, and we would need to account for this by allowing r to deviate from the riskless rate and by adding a probabilistic analysis. Therefore the model becomes: (For two periods)

$$\Delta Vo = Po\Delta io + \frac{\pi_{1a}\Delta S_{1a} + \pi_{1b}\Delta S_{1b}}{1 + r}$$

where: ΔVo = again represents certainty equivalent value
π_{1a} = the probability that state "a" occurs in period one, and
r^* = the risky rate of interest.

Using this analysis, Hirshleifer and Shapiro concluded that the optimal rate of discount should reflect the risk premium, i.e., that the social rate of discount should equal r^*. This rate reflects the opportunity cost of private investment.

Arrow and Lind (1970) used a similar approach and derived an opposite conclusion. They stress that there are imperfections in the market for future claims. These imperfections prevent the determination of r^*. Imperfections arise from two sources in the Arrow-Lind analysis: 1.) the moral hazard problem and 2.) the imperfections caused by transaction costs for future markets. Basically, the Arrow-Lind argument boils down to the fact that the adverse effect of private risk is reduced when funds are transferred to government because the risk is

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shared by all. Moral hazard fits into their argument if we assume that a government bureaucrat makes very conservative decisions in order to avoid losses which may raise questions regarding his competence. Whatever the cause, moving funds from the private sector to the government brings about a different and more advantageous distribution of risk-assuming risk-aversion. The policy implication is that government should ignore risk premiums of private investors and use a "risk-free" rate of private return as the measure of the social opportunity cost of displaced capital.

This same policy conclusion was derived by Arrow and Kurz (1970). However, Arrow-Kurz added the fact that there is a fixed savings behavior which prevents the equalization of the marginal private rate of time preference and the market rate of interest. Therefore, the social rate of discount lies below the percentage rate of return on the marginal unit of capital in the private sector because of risk, but they were unable to conclude anything about the relationship of the discount rate to private savings activity because of uncertainty.

Bradford (1975) provided a theoretical framework to determine the shadow price of resources withdrawn from the private sector of the economy and utilized to finance public investment. One of the basic principles of the Bradford model was that, in the broad sense, government is restricted

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from investing in the same types of activities as the private sector. Therefore:

> ...apparently attractive returns in the private sector may not represent opportunity costs for the government at all, or at least not directly. When the private investment opportunities are not also government investment opportunities, private rates of return become irrelevant to government choices.[31]

Bradford developed a model to indicate when public investment is justified. His methodology focused on a comparison of the marginal reduction in private capital formation caused by a shift of one dollar to the public sector and the marginal increase in private capital formation induced by an increase in one dollar of government services. The value of this capital is expressed in terms of its ability to increase the discounted present value of a subsequent consumption stream. This is the shadow price of capital. The discount rate used to derive this shadow price is the social time preference rate. Investment is induced by government spending due to the fact that this money is returned to the economy and utilized for capital formation. The proportion utilized for capital formation depends on the magnitude of the aggregate marginal propensity to save.

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[31]David F. Bradford, "Constraints on Government Investment Opportunities and the Choice of Discount Rate," American Economic Review, (December 1975), p. 888.

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Since government spending is financed from investment and consumption the shadow price of funds withdrawn from the private sector is something less than it would be if all financing were at the expense of private investment. Furthermore, since government expenditure is also responsible, through the marginal propensity to save, for generating a future consumption stream, government projects with a specific internal rate of return may be justified even if this rate is substantially below the private rate of return on investment.[32]

Lind (1982) established a framework for the discount rate issue which combines elements of social time preference and the opportunity cost approach. In general, Lind's approach followed closely on the work of Eckstein (1958), Krutilla and Eckstein (1958), Marglin (1963B), Feldstein (1964), Diamond (1968), Feldstein (1970), and Bradford (1975). This method, termed the "shadow price of capital approach," unburdens the discount rate from trying to simultaneously fulfill the dictates of social time preference and the requirements of signalling the

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[32]Indeed one of Bradford's examples illustrates the possibility that a government project may be justified even if its internal rate of return is lower than the social rate of time preference. This is the case where all government-utilized resources are derived from private consumption and all government expenditure is ultimately converted to private capital. Bradford, pp. 891-2.

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opportunity cost of capital. Lind advocated the removal of opportunity cost considerations from the discount rate being utilized. He argued that opportunity costs are better considered by adjusting monetary costs of public expenditures (or private expenditures required by public action) to reflect opportunity costs that arise due to the displacement of resources from the private sector. Under this arrangement, the discount rate is therefore only required to reflect social time preference, and this Lind argues, is best approximated by the real rate of return on essentially riskless long-term government securities. Thus the social discount rate utilized in Lind's analysis is the consumption rate of interest.[33]

Thus it is fairly obvious that the mainstream of the economics profession is severely divided on the issue of what constitutes a proper method of evaluating the consequences of societal decisions which have future impacts. However, one does note some developing agreement in a few areas, most notably of which is that the

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[33]It seems a bit peculiar that when applying the shadow price of capital approach, costs of capital -- which should adhere rigorously to the geometric discount formulation derived from capital growth rates -- are shadow priced and that social time preference -- which has no a priori justification to be handled in any particular weighting scheme -- is handled in the standard logarithmically linear discounting fashion.

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opportunity costs of public investment must be accounted for. Unfortunately, there would still appear to be much disagreement as to the operational method of accounting for these costs. The majority of writers would prefer to account for opportunity costs via explicit alteration (shadow pricing) of monetary streams, while some economists require that they be accounted for through the use of an opportunity cost discount rate.

For those willing to accept the use of discount rates which reflect something other than opportunity cost of funds withdrawn from the private sector, the preferred method appears to be to utilize the consumption rate of interest as the rate of discount. Disagreement exists as to why this is appropriate. Arguments for utilizing the consumption rate of interest either espouse the notion that it directly represents social time preference considerations, or that it is only an acceptable proxy of social time preference.

In either event, the conclusion of the bulk of economic writers is that the consumption rate of interest, as determined by, say the real rate of interest on long-term government securities, passbook accounts, or home mortgages, represents the minimum rate by which future impacts should be evaluated.

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Chapter III

Accounting for the Future: An Alternative Framework

In the previous chapter, the views of many traditional neoclassical economists regarding the future were discussed. Recall that most of these views have as their basis notions of certainty, smoothly functioning futures and capital markets, and a lack of taxes. And even when methods take on much more practical forms, i.e., the shadow price of capital approach and others, the fact remains that these methods rely on capital markets which allocate resources over relatively short periods of time -- hardly a blink of an eye in the history of modern man.

Now it is appropriate to discuss how other disciplines and individuals evaluate the future. One factor that should strike the reader in particular is that, to a much greater extent than the body of neoclassical economists, the works of Pigou (1932), Ramsey (1931), and Marglin (1963A) would seem to be held in high regard by many of these others.

Consider the impact of any real discount rate derived via some of the models proposed by the authors discussed in the previous chapter. As a practical matter, the consumption rate of interest may be the smallest rate to come out of any of traditional works. Let us say for purposes of example, that the rate is 3%. If we discount

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one billion dollars at only 3% it has a present value of $52,032,856.00 if the payment is made after 100 years. If payment is delayed for two hundred years then the present value drops to $2,707,418.10. And if payment does not occur for 500 years, then the present value of a billion dollars falls to only $381.41. For all practical purposes, the 3% rate of discount has nearly wiped out the magnitude of all impacts accruing after a relatively few years.

We can see that the application of discount rates derived from relatively certain short term capital markets would indicate little concern for future generations. This result is the only answer most economists can give to a society that is suddenly finding itself having to deal with some very profound long-term issues.

With the advent of the nuclear age, large scale fossil fuel conversion, fluorocarbons and many other factors, the present society has become acutely aware of its potential to impact the health, wealth, and even the very existence of future society. Along with the technological capability to irreversibly alter man's environment, people have been increasingly motivated to develop expressions to account for these impacts on future generations while weighing the wisdom of undertaking development projects with irreversible effects.

This line of thinking is drastically different than those of the economists (and others) who have looked at the

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increasing wealth of passing generations and decided that the future will take care of itself. This has been the operational argument of many for centuries and indeed correctly so. Since the advent of the renaissance, man has endowed future generations with more wealth, knowledge and a better way of life. Now however, man possess to a greater extent than before, the capability to provide the future with a negative endowment.

It is true that the future has faced the problem of a greatly reduced endowment before -- but this has only occurred in a few specific commodities. Timber, wildlife, and natural lands have all been the focus of conservation movements dating from the late 19th century to the early 20th century. It is notable that even under these threats -- it was assumed that there would be someone around in the future to enjoy them if these items were saved. And presumably they would be wealthier in all aspects -- except the ones mentioned above.

It must be noted that some individuals outside of neoclassical economics would indeed subscribe to its principle regarding the valuation of future society. However, the fact remains that a large number would not.

This chapter considers a subset of the individuals who have written about future valuations from a non-neoclassical perspective. Three distinct classifications are considered:

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the works of social and physical sciences, theology, and ethics. Within these classifications subsets are analyzed.

Under the Social and Physical Science classification four divisions are considered. These include neoclassical economics, which was the focus of Chapter One; multi-disciplinal steady-state theorists who argue that mankind must immediately initiate a policy of zero growth; entropy theorists who argue that zero growth is not enough; and other physical scientists who argue for a scientific solution which can allow for continued growth. Under the theology classification, specific religions are considered. These include Christianity, Buddhism, and Islam.

Finally, under the ethical classification, four specific divisions are considered using an intertemporal analysis. These include Rawlsian, Nietzschean, Utilitarian, and Paretian.

One group with strong convictions regarding the proper course of society is somewhat loosely gathered under the banner of the steady-state theorist. This group possesses an extensive history which has as its beginnings, the writings of Thomas Malthus. The theories embodied by this group were further developed by classical economic thought and were perhaps best conveyed by John Stuart Mill. Modern day steady-staters are highly critical of neoclassical economics' notions regarding the intertemporal allocation of the world's resources. Contemporary economists who make

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camp with the steady-staters, such as Kenneth Boulding, Herman Daly, and Talbot Page, have found themselves criticized by their neoclassical brothers.

To a very great extent, major support for steady-state theories has come from members of the hard sciences. Ecologists, biologists, and physicists seem to be more explicitly preoccupied with the problems of a finite earth than are other disciplines -- most notably economics.

Note that all steady-staters would seem to be arguing that the future is undervalued by present society. Thusly, the applicable discount rate, according to these individuals, should be less than the rate attributable to neoclassical evaluations of far future events.

Thomas Malthus (1798, 1830, Flew 1970), whose writings on the potential for geometric population increase in a world of finite resources earned economics the title of the dismal science, was perhaps the first of the steady-state theorists. Malthus maintained that the tendency for unchecked population to double itself approximately every twenty-five years, when weighed against the likelihood of a food supply that at best increases arithmetically, necessitated the intervention of events to check population growth. According to Malthus:

> The great question then, that remains to be considered, is the manner in which this constant and necessary check upon population practically

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operates.[34]

In his writings, Malthus suggested that this check may take many forms, among them: starvation, disease, and moral restraint.

John Stuart Mill (1857) synthesized earlier work on classical economics. Mill advocated the "stationary state" as being not just necessary by the earth's physical limits, but desirable as well:

> I cannot, therefore, regard the stationary state of capitol and wealth with the unaffected aversion so generally manifested towards it by political economists of the old school. I am inclined to believe that it would be, on the whole, a very considerable improvement on our present condition. I confess I am not charmed with the idea of life held out by those who think that the normal state of human beings is that of struggling to get on; that the trampling, crushing, elbowing, and treading on each other's heels, which form the existing type of social life, are the most desirable lot of humankind, or anything but the disagreeable symptoms of one of the phases of industrial progress.[35]

This notion that the steady-state is a desirable outcome has survived in the works of present writers on the

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[34]Thomas A. Malthus, A Summary View as quoted in A. Flew, Malthus, An Essay on the Principle of Population, (London: Pelican Classics, 1970), p. 242.

[35]John Stuart Mill, Principles of Political Economy With Some of Their Applications to Social Philosophy (New York: D. Apleton and Company, 1909), II, p. 336.

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steady state. This result is in direct conflict with the views of neoclassical economics.

Kenneth Boulding, perhaps the premier economist of the steady-state theorists, explicitly recognizes a difference between the discount rate applicable to the near future and the far future (Boulding, 1966). The fact that he regards the spaceship economy to be in the far future is evident:

> It may be said, of course, why worry about all this when the spaceman economy is still a good way off (at least beyond the lifetimes of any now living)...It is always a little hard to find a convincing answer to the man who says, 'What has posterity ever done for me?'[36]

Boulding does advocate the discounting of near time events:

> It is a well known phenomenon that individuals discount the future, even in their own lives. The very existence of a positive rate of interest may be taken on at least strong supporting evidence of this hypothesis. If we discount our own future, it is certainly not unreasonable to discount posterity's future even more, even if we do give posterity a vote.[37]

Indeed, Boulding would argue that the application of neoclassical principles would improve the relatively short-run state of the world and that some other, more

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[36]Kenneth Boulding, "The Economics of the Coming Spaceship Earth," in Henery Jarret ed., Environmental Quality in a Growing Economy, (Boston: Johns Hopkins Press, Inc., 1966), p. 11.

[37]Boulding, p. 12.

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explicit intervention scenario is necessary to handle fundamental long run impacts.

> It may be complained that the considerations I have been putting forth relate only to the very long run, and they do not much concern our immediate problems. There may be some justice in this criticism and my main excuse is that other writers have dealt adequately with the more immediate problems of deterioration in the quality of the environment.[38]

This it can be readily seen that Boulding would prefer some form of intertemporal weighting that would enhance the outcome of the far future.

Herman E. Daly (1973, 1975, 1977, 1980) is a very strong critic of mainstream economics. Daly's proposals to achieve the steady state call for drastic intervention in the economy and the lives of individuals. His policies to achieve steady-state goals impact all segments of the market economy. The distribution of wealth is corrected through the imposition of minimum and maximum levels of individual wealth and income and the limiting of the size of corporations.[39] Resource utilization is curbed through the explicit modification of the market for natural resources into a two-tiered process. Buyers, who wish to participate

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[38]Boulding, p. 13.

[39]See Herman E. Daly, "Seventh Essay," Towards a Steady-State Economy, (San Francisco: W.H. Freeman and Company, 1973),

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in the resource market would first be required to purchase a depletion quota which is established by the government at some optimum level which is independent of considerations of supply and demand.[40] Birth rates are controlled in the Daly proposal through the use of transferable licenses for child bearing.[41]

Talbot Page also is an economist who finds himself camped with the steady state theorists. Like Boulding, Page would seem to a great extent to accept the broad principles of neoclassical economics. However, unlike Boulding, Page would not only argue for a far future discount rate less than the rate applicable to the near future, he would argue for the existence of an r^* as well. This r^* would indeed be a socially derived rate that is less than r, and presumably equal to δ which would encourage the preservation of resources for the future.

Page (1977) advocates, as a means to effect these transfers to the future, a severance tax on the extraction of non-renewable resources. This tax is a necessary policy instrument to improve the distribution of resources to

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[40]Herman E. Daly, Steady-State Economics: The Economics of Biophysical Equilibrium and Moral Growth, (San Francisco: W.H. Freeman and Company, 1980), pp. 159-61.

[41]Daly, 1973, pp. 158-60. This idea is adapted from Kenneth E. Boulding, The Meaning of the Twentieth Century, New York: Harper and Row, 1964, p. 136.

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individuals in the future. In practice, however, this tax is necessary because of the fact that market determined interest rates (combined with the existence of a depletion allowance) encourage the present exploitation of endowments reserved for the future.

One group, the Club of Rome, has been extensively involved in producing research orientated towards the notion of a world doomed to extinction. This international group was largely responsible for the development of a large system dynamics model at the Massachusetts Institute of Technology. The simulation, known as the Club of Rome Model or World3, was part of the Club's Project on the Predicament of Mankind. Development of the model was directed by Dennis Meadows, an engineer; other project members were physicists and biophysicists. The results of the Club of Rome Model have been documented in numerous publications.[42]

Using the Club of Rome Model, researchers simulated time paths through the year 2100 for several interrelated factors important to man's continued existence on the earth. These factors included: population, resource stocks, industrial output, food production, and pollution. Numerous scenarios were derived by varying assumptions regarding

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[42]See for example Donnella H. Meadows et al. (1974), Dennis L. Meadows and Donnella H. Meadows (1973), and Dennis L. Meadows et al. (1974).

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consumption, pollution control, agricultural and energy production, and population growth. Under the "standard run" of the Club of Rome Model, all variables are developed using historical growth paths (since 1900). The standard run predicts the resource-driven collapse of industrial society around the year 2000 and the decimation of the population through a lack of food and medical services within a few years after industrial output falters. Under a variant of the standard run the discovery of more nonrenewable resources is of little consequence; a doubling of resource reserves buys society only slightly more time, i.e. less than 30 years, and the resultant residuals directly impact population levels. These residuals end up destroying mankind in the mid part of the 21st century under a third scenario which assumes that unlimited nuclear power and recycling largely eliminate man's need to utilize exhaustible resources. With the addition of effective pollution control to the unlimited energy scenario, population begins to decline only after all irrigable land has been utilized for food production.

More scenarios include other developments, a doubling of agriculture productivity, perfect birth control, and mix and matches of all of the above. In each case the outcome is more or less the same, man's position and number on the earth eventually declines due to the devastating effects of his production and consumption activities. In the most

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optimistic of these scenarios, the inevitable is forestalled until the later mid-21st century.

In only one series of scenarios is man's existence able to continue, in significant form, into the far future. These scenarios all have as their root an absolute stabilization of world population as of 1975. This stabilization was obviously unattainable when the model was developed (and obviously far removed from what actually has occurred) and thus the Club of Rome model is without question, a doomsday prediction.

Kenneth E.F. Watt (1974), a zoologist, also shares the viewpoint of the rest of the steady-staters. Watt conveys at least the urgency of the Club of Rome in his pleas. Watt is very critical of nearly all outcomes and developments of our present economic system, and equally critical of that system's economists. Of overwhelming importance to Watt is the fundamental notion of irreversibility as it applies to contemporary activity. He argues that while the downfall of all past societies has been accompanied by a rebirth of a new civilization this can no longer be true because the causes of the collapse of our present society will be a squandering of irreplaceable resources. This misallocation

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will have permanent effects on the world and thus thwart any attempt of civilization to reorganize itself.[43]

Apparently, Watt has little faith in the law of demand and the ability of the price system to allocate natural resources. He says:

> In economics, an article of conventional wisdom is that as a resource becomes scarce, the price rises accordingly and there is a decline in the use of that resource. Unfortunately, the historical record does not bear out this assertion. The exceptions range all the way from seafood to electricity. They include, on the one hand, those cases where price increases have not been sufficient to discourage use, for the reasons that incomes were rising at about the same rate; on the other, and still worse, are those cases where use has gone up but prices have not. In 1960, 234 million pounds of tuna were imported into the U.S. at a price of 12.6 cents a pound; by 1971, with the price at 23.5 cents a pound, the total imported had risen to 473 million pounds.[44,45]

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[43]Kenneth E. F. Watt, The Titanic Effect, (New York: Kenneth E. F. Watt, 1974), p. 11.

[44]Watt, p. 20.

[45]Besides not acknowledging the economic safety net of ceterus paribus, Watt neglected to account for inflation in his analysis. During this period the real price increase in tuna was only 36% while the real increase in income was 39%. Furthermore, population over the same period increased 15%. Finally, in that Watt only considered the demand for fresh or frozen tuna, we are probably witnessing a change in demand for a superior good. This hardly represents an example of an allocation mis-function.

U.S. Bureau of the Census, Statistical Abstract of the United States: 1972 (92nd edition.) Washington, D.C., 1971, Tables 557, 1077.

U.S. Bureau of the Census, Statistical Abstract of the United States: 1975 (95th edition.) Washington, D.C., 1975,

(Footnote Continued)

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The combination of these factors with pollution, inflation, overpopulation, market saturation, etc. led Watt to the conclusion that "the titanic effect" -- the point at which mankind has blown his inheritance to the earth -- is just around the corner. The avoidance of the Titanic effect lies in the abandoning of our present policies which encourage positive growth and the imposition of government control in those markets where the price system appears to be failing.[46]

Nicholas Georgescue-Roegen (1971A, 1971B) argued that even the steady-state economy is not sustainable, not to mention the present growth in the consumption of the world's resources. Georgescue-Roegen pointed out that man's economic system is bound by the inescapable laws of thermodynamics. These laws include the fact that order in matter and energy tends to disintegrate into disorder. It is order, perhaps in the form of a concentrated mineral deposit, which fuels our economic system. Concentrated

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(Footnote Continued)
Table 631.

U.S. Bureau of the Census, Statistical Abstract of the United States: 1984 (104th edition.) Washington, D.C., 1983, Table 2.

[46]The above discussions concentrated on a relatively small portion of the authors who have written on the merits of the steady state. For more the reader is referred to Donnella H. Meadows et al. (1982), Bruce Hannon (1975), Jay Forrester (1977), and Amory Lovins (1979).

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sources of energy or minerals are said to have low entropy. Disorder, on the other hand, in the form of widely dispersed mineral and caloric waste, is the inevitable outcome of life processes. The substance of this outcome is said to have high entropy.

This fundamental progression from a low to a high entropy state is an inevitable function of the universe. Man can only effect to a limited extent, the rapidity with which it comes about. In this vein, Georgescue-Roegen(1975) argues the steady-state is a "topical mirage" and that the "crucial error" in this line of thinking "consists in not seeing that not only growth, but also a zero-growth state, nay, even a declining state which does not converge toward annihilation, cannot exist forever in a finite environment."[47] Thus there is no sustainable stationary state and constant consumption of low entropy reserves is a necessity. Man's present actions are major determiners of the welfare of future society where this welfare is measured by its endowment of low entropy resources, "this is why in bioeconomics we must emphasize that every Cadillac or every Zim -- let alone any instrument of war -- means fewer plowshares for some future generations, and implicitly,

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[47]Nicholas Georgescue-Roegen, "Energy and Economic Myths," Southern Economic Journal, 41, 3 (January 1975), p. 367.

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fewer human beings too."[48] Georgescue-Roegen insists that the best way to deal with the inevitability of our high entropy fate is to stave it off as long as possible. This requires that the earth's population decrease through the production of less than two children for every two adults, the conversion of our economy, in as much as possible, to the utilization of solar energy, etc.

It is evident from Georgescue-Roegen's work that he is largely concerned with the very long run. He does not deny the fact that present consumption levels can be maintained and even increased for decades to come. However, he argues that with each and every step we endow tomorrow and 500 years from tomorrow with a reduced endowment of low entropy resources.

Perhaps the best example of those who believe in a scientific solution is provided by Richard L. Meier (1966). Meier, a natural scientist, envisioned a world where cheap nuclear and other energy abounds, algae is a staple foodstuff, and "...that 50 billions can live moderately well on the planet..."[49] While one can be quick to criticize Meier for his optimism, it is far more useful to consider

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[48]Nicholas Georgescue-Roegen, 1975, p. 370.

[49]Richard L. Meier, Science and Economic Development: New Patterns of Living, 2nd ed., (Cambridge Ma.: the Massachusetts Institute of Technology), p. 147.

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the era in which it was written. The 1950's and early 60's were generally characterized by overwhelming scientific achievement. Indeed the promise of medical advances and experience with the "green revolution" were legion; perhaps these advances only paled in the presence of an ever greater promise -- that of nuclear generated electricity that would be "too cheap to meter." Meier believed that nuclear energy, combined with energy from solar and other sources would provide such incredible energy abundance that we will face a quandary in determining how to use it:

> Now that it seems possible, even probable, that the world can be assured of a continuing supply of the familiar forms of energy at not unreasonable costs for tens of thousands, or even millions, of years into the future, an embarrassing question must be asked. Energy for what purposes? How much energy is really necessary?[50]

Certainly, with out current 20 more years of experience with nuclear energy such a rosy prediction can be no longer sustained. The graphic accident at Three-mile Island, nuclear costs overruns of over 500%, delays in nuclear generating plant construction of nearly half a decade, and a failure to solve the waste disposal problem have all dealt the promise of nuclear power a serious, perhaps fatal, blow. However, the other proposals advanced by Meier seem more

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[50]Meier, p. 101.

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reasonable, and one must be amazed by the completeness of his vision.

Meier describes solutions for the broad bulk of mankind's problem with increasing demands on the earth. The problems range from extending our 100 year supply of coke in order that steel production can be maintained for the indefinite future to offering a portable solar powered cooker to India's poor in order that vegetation need not be utilized for fuel in food preparation.

This vision has as its key the Barnett and Morse (1963) concept of resource scarcity -- in that the problem is not a lack of material abundance, the problem is one of insufficient concentration. Therefore, the solution requires the application of energy and technical skill to effectively utilize grades of ore with lower and lower concentrations of recoverable material. Indeed, the limit to this process, according to Meier is not reached until after common igneous rocks (granite, basalt, etc.), and one third of the earth's land mass have been processed. Meier even believes that such a process could be self-sustaining. "The uranium and thorium in such rock are sufficient to energize the whole operation and probably would leave a

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considerable surplus of power for transmission to nearby cities."[51]

Meier envisions these reforms being accomplished with strong government participation. Little if any hope is extended for a decentralized economic solution.[52] Furthermore, throughout its entirety, Meier's book only occasionally considered waste disposal and these references indicates that he believes the problem of waste disposal to be relatively minor. Certainly, Meier completely missed the notion that arrived later in the 1960's -- that of a civilization which was about to die by its own pollution.

In that Meier advocates tremendous contemporary expenditures in order to advance the cause of far future inhabitants of the earth, it seems fundamental that this behavior would be associated with an negative rate of discount. Meier's belief in the capabilities of science and optimistic outcome for mankind arising from the application of advanced technology to the fundamental problems of our contemporary existence is a study in direct contrast to the future vision espoused by those who believe that society is

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[51]Meier, p. 125.

[52]In spite of this, Meier's work was heavily endorsed by the American Economic Review.

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doomed in the relatively near future unless radical measures are undertaken.

Theology also forms the bases for valuations of future events. The future vision of three specific branches of theology are considered in this section. These branches include Christianity, Buddhism and Islam. In addition, three subclasses of Christian thinking are also considered. These categories are loosely titled the "the conqueror," "the husbander," and "the eminent destructionist."

Let us consider the conqueror first. John Cobb (1980) considered the fact that Christian beliefs have provided man's rationale for subduing the planet. This point of view features man as being separate from all other biological activity on the earth and of course, superior to them. Under this belief, western culture has been driven to mastery over its environment. The justification for this drive has divine origin and through the vehicle of modern science has achieved its most powerful level.

The idea that The New Testament provides a justification for rapid domination of our present world without regard to impacts on future society was also considered by Boulding (1966). Boulding argues that The New

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Testament "advocates that we should take no thought for tomorrow and let the dead bury the dead."[53]

The above depiction of Christian beliefs as providing rationalization and motivation for the conqueror is a study in sharp contrast to the notion, fostered by the same religion, of man as a caretaker or husbander of his environment. This point was also considered by Cobb (1980):

> If we Christians take seriously the idea that the Word, which is Christ and which fully became flesh in Jesus, is also found in the life of all living things, we will cease to be part of the problem and will be freed to participate in the healing of a suffering biosphere. Our service to God as Christ will be the commitment to God as the urge and call to life and its enhancement and not an orientation away from the natural world toward a purely human and transcendent sphere. We will love and serve the God who cares about the grasses of the field and the death of a sparrow and not one who treats nature as a mere stage on which the human drama is enacted.[54]

Cobb argues that source of man's conquering tendencies cannot be the Bible as the Bible itself:

> ...is not antropocentric but theocentric, and the God who is the center of all things is the creator of all nature, not only of human beings...God knows and cares for plants

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[53]Kenneth Boulding, "The Economics of the Coming Spaceship Earth," in Henry Jarrett ed., Environmental Quality in a Growing Economy, (Boston: Resources for the Future, Inc., 1966), p. 12.

[54]John Cobb, "Ecology, Ethics, and Theology," in Herman E. Daly, ed., Economics, Ecology, and Ethics: Essays Toward a Steady-state Economy, (San Francisco: W.H. Freeman and Company, 1980), p. 175.

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> and animals as well as for human beings...
> God is the creator of all life.[55]

Under this framework, Cobb argues for a much more long-run view of the impacts of man's present actions. This would thus lend support for explicit modification of present actions as a result of consideration of the future's welfare.

The final branch of Christian ideology considered in this work is one which can be termed the eminent destructionist. Holders of this viewpoint believe that the time is rapidly approaching where upon the Lord will be making his return to earth. According to this belief, the destruction of the world is already at hand and most importantly, this destruction cannot be dissuaded by individual or collective actions of man. To holders of this belief, speculation on any event in the distant future is ridiculous and thus any future valuation is irrelevant.

It is important to note than this viewpoint has gathered significant support in recent years, although not all practitioners emphasize its consequences with equivalent zeal or conclusions as to <u>when</u> destruction will occur. Perhaps one of the most influential of all these

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[55]Cobb, p. 175.

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practitioners is James Watt, the former United States Secretary of the Interior.

E.F. Schumacker (1968) considered the economic implications of Buddhism. According to Schumacker, one aspect of the teachings of Buddha is strict husbandry for renewable and conservation of non-renewable resources. This is in strict adherence to the Buddha's teachings with regard to consumption: a strong emphasis on simplicity and on making do with less. Under the Buddhist's doctrine, choices between renewable and non-renewable are fundamentally different:

> From a Buddhist point of view...the essential difference between nonrenewable fuels like coal and oil on the one hand and renewable fuels like wood and water power on the other can not be simply overlooked. Nonrenewable goods must be used only if they are indispensable, and then only with the greatest care and most meticulous concern for conservation.[56]

This can be contrasted with more traditional western economic approaches, which according to Schumacker, "does not distinguish between renewable and nonrenewable

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[56]E.F. Shumacher, "Buddhist Economics," in Herman E. Daly, ed., Economics, Ecology, Ethics: Essays Toward a Steady-State Economy, (San Francisco: W.H. Freeman and Company, 1980), p. 143.

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materials, as its very method is to equalize and quantify everything by means of a money price."[57,58]

In fact the Buddhist would consider the misuse of resources to be an act of violence. This especially applies to nonrenewable resources. The population which relies heavily on nonrenewable materials for continued existence is:

> ...living parasitically, on capital instead of income...As the world's resources (nonrenewable)...are exceedingly unevenly distributed over the globe...their exploitation is an act of violence against nature which must almost inevitably lead to violence between men.[59]

Buddhist economic philosophy tends to be held in high esteem by those who are proponents of the steady-state approach. This behavior is consistent with a valuation of future events as if these events were occurring today. Thus the appropriate discount rate applicable to far future events would be zero.

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[57]Schmacker, p. 143.

[58]Obviously, Schumacker missed the point of Hotelling's article which proved a difference between nonrenwable and renewable price paths over time. Specifically, by applying calculus of variations methods, Hotelling showed that in a competitive equilibrium, the price of nonrenwable resources will tend to increase at at least the rate of interest and produce an optimal depletion path, ceterus paribus. See Hotelling, H. "The Economics of Exhaustible Resources," Journal of Political Economy, 39 (1931) pp. 137-75.

[59]Shumacker, pp. 143-4.

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Islam also provides a prospective on individual and societal valuations of future events. Fundamental to Moslem constructs is the notion that individuals (who are able) are required to pay a part of profits or wealth to others - even if these others are future generations. This concept is known as zakāh.[60] For those eligible to pay it, zakāh may may be any amount at or above the minimum amount of 2½% up to an upper limit which is defined by what is left over after meeting ones needs. Thus a Muslim has three options with respect to his wealth, he may: 1) hoard it and pay a penalty of 2½% (at a minimum) each year, 2) employ it as a Qard-i-Hasan (a non-interest bearing loan), or 3) if he chooses to keep his wealth intact, invest it to earn an amount at least equal to the minimum zakāh.[61]

d'Arge (1985) analyzed the implications of zakāh on the pattern of non-renewable resource extraction. In this context, the concept of zakāh has two reinforcing impacts on the intertemprol extraction path of an exhaustible resource. The first impact arises directly from the fact that zakāh requires that a society preserve a portion of its wealth, in

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[60]The implication of zakāh on the aggregate savings rate of an Islamic economy was considered by M. Fahim Kahn. "Macro Consumption Function in an Islamic Framework." Journal of Research in Islamic Economics, 1, 2 (Winter 1984), pp. 1-24.

[61]Kahn, p. 7.

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the form of non-renewable resources, to provide a direct, zakāh-related, transfer to future generations. The second effect arises due to the intertemporal implications of zakāh on the prevailing level of interest rates in a society. This latter impact occurs because the existence of zakāh causes interest rates in a society to be lower than they otherwise would be and thus through interaction of the Hotelling (1931) model, extraction rates will be lowered.[62] d'Arge also points out that the fact that resources are societally owned and state mined in Moslem countries will eliminates the problem of common property resources, i.e. the "if I don't get it fast, I won't get it at all" problem of western countries were resources are extracted by private firms. d'Arge concludes that Islamic culture embraces a type of Rawlsian ethic (Rawls, 1971) of resource extraction. Further discussion on Rawlsian ethical tenants follows below.

In addition to theology and the other patterns by which the future can be viewed, ethical and moral constructs provide guidelines for future valuation. As in the case of religion, different ethical philosophies yield sharply differing outcomes. Furthermore, as will be seen, the same

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[62]For a discussion of the implications of zakāh on the prevailing rate of interest in a society, see Kahn (1984).

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ethical construct can yield differing future valuation under different assumptions.

Subscription to Rawlsian principles (Rawls, 1971) could presumably justify any relationship between present and future valuations. This principle, also known as the max-min principle, dictates that society is judged by the welfare of its most disadvantaged members. Therefore, social motivation along Rawlsian lines would necessitate the transfer of wealth from the more fortunate to the less fortunate. That is, social forces should be directed towards the maximization of the welfare of those individuals who currently experience the minimum level of welfare. Continuous application of Rawlsian principles would lead to a society with a homogenous level of welfare.

Extension of Rawlsian principles to an intertemporal analysis was accomplished by Kneese and Schultze (1983). To illustrate this application to the present model consider the following intergenerational utility function:

$$U = \min (u_1, u_2, u_3)$$

where

U represents the welfare function, and

u_i represents the level of welfare prevailing in three successive societies, i = 1, 2, and 3.

For purposes of this work one may think of these societies as being the present generation, the future and the far future. Application of Rawlsian social principles

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would dictate that forces be motivated to transfer resources to the time period which is most disadvantaged. Thus, if the a priori level of welfare prevailing in a period two is less than that prevailing in periods one and three, explicit social actions should be utilized to transfer "welfare" to period two from the other periods.

In our present analysis, the direction of welfare transfer is reflected in the operational rates of discount. If the second period is disadvantaged with respect to the other two, then the appropriate social policy would be reflected in a decrease in the discount rate applied between periods one and two and in increase in rates of discount applicable to the events in the far future. Furthermore, there is no restriction on how far a discount must be decreased or increased -- the rate may even necessarily change sign. Obviously, a similar relationship holds if the most disadvantaged period is period one or period three.

In order to apply Rawlsian principles in an intertemporal analysis, one must make predictions regarding the operational level of welfare for future society appropriate to any social policy. Depending on the nature of this prediction, any policy can be justified. For example, if one subscribes to traditional economic notions of an increasing endowment to the future, then explicit social policy along Rawlsian principles calls for a bit more "eat, drink, and be merry" as embodied in higher discount

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rates. Alternatively, if one believes that man is on the verge of leaving a negative endowment to the future, then lower, perhaps negative, discount rates are consistent with Rawlsian principles.

The determination of intergenerational transfers under a Nietzschean ethical framework would represent an opposite approach than that of a Rawlsian. This framework, also known as the max-max principle, dictates that a society is judged by its highest achievements. Thusly, welfare is improved when the welfare of a society's most elite members is improved in absolute terms.

Applied to a static society, the Nietzschean framework would justify the transfer of resources from the less to the more fortunate. Presumably, the only limit to the extent of this transfer would be the point where any further reduction in the welfare of society's poorest individuals would also reduce the welfare of the most elite. Presumably, depending on the nature of a particular society, this point may or may not be below the subsistence level.

Applied to an intertemporal society, this Nietzshean framework would justify intergenerational transfers. Consider the following three period utility function:

$$U = \max (u_1, u_2, u_3).$$

When the elements, U, and u_1, u_2, and u_3 are identical to the corresponding elements utilized to illustrate intertemporal Rawlsian criteria. However, note the one

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difference in the two models is the fact that the Nietzschean criteria calls for the measurement of intertemporal welfare based on the highest single level of welfare attainment of the most well-off generation. Thusly, if the utility of individuals in period two is considered to be the highest, then social investment policies would optimally require the transfer of resources from period one and period three to period two. Obviously, in the transfer from one to two would require a very low rate of discount, while the transfer from three to two would necessitate that a very high rate be applicable in the evaluation of period two's utility vis a vi that of period three.

It seems difficult to imagine any application of Nietzschean philosophy to others. It would seem that the most fundamental reason for the application of such a philosophy is to improve the welfare of a contemporary group. Presumably this group also possesses the power to effect the transfer; Nietzschean philosophy provides a pseudo justification. Furthermore, in a intertemporal application, only one body possess the power to effectively invoke a transfer from the other two periods. This body is of course being the present members of a society. It would seem therefore that the ethical foundation would most likely be used to justify the transfer of welfare from the future to the present. This would be reflected in the heavy discounting of future impacts.

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Under the dictates of a utilitarian framework a society's welfare is judged to be the cardinal sum of the welfare of its individual members. Interpersonal comparisons of utility levels are thus required, however the utility of all members is weighted equally with respect to the utility of all other members. In an intertemporal framework welfare in different periods must continue to be weighted equally in order to satisfy the utilitarian ethic. This means that the welfare of the unborn must be considered on an equal footing with that of the born and thus discounting is not appropriate. Thus the applicable intertemporal utility function is

$$U = u_1 + u_2 + u_3.$$

And present evaluation of future impacts are made in an identical manner as contemporary impacts are evaluated. Thus, the applicable discount rate is zero.

The Paretian framework forms the basis for neoclassical economics. Under this philosophy a society's position is judged to be improved if a least one member's position is improved and the welfare of all other members is not diminished. While this philosophy has formed the basis for neoclassical propositions, there does not seem to be any fundamental justification for discounting within its framework.

The effective discount rates arising from these alternative viewpoints are summarized in Table I. In order

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Table I

Valuations of the Future by Selected Groups and Individuals

	Near Future r	Far Future δ	Relative Magnitude $r - \delta$
Social and Physical Science			
Neoclassical Economics	$r > 0$	$\delta > 0$	$= 0$
Steady-State Theorists			
John Stuart Mill	$r > 0$	$\delta \geq 0$	> 0
Kenneth Boulding	$r > 0$	$\delta \geq 0$	> 0
Herman E. Daly	?	$\delta = 0$	≥ 0
Talbot Page	$r > 0$	$\delta < 0$	> 0
Medows (Club of Rome)	?	irrelevant	undefinable
Watts	?	irrelevant	undefinable
Scientific Solution			
Meiers	?	$\delta < 0$	?
Entropy Theorists			
Georgescue-Roegen	?	$\delta \geq 0$	≥ 0
Theology			
Christianity			
Conquorers	$r > 0$	$\delta > 0$	≤ 0
Husbanders	?	$\delta = 0$	≥ 0
Eminent Destructionists	$r > 0$	irrelevant	undefinable
Buddhist	?	$\delta = 0$	≥ 0
Islam	$r > 0$	$\delta > 0$	$= 0$
Ethics			
Rawls			
If future is consistently advantaged with respect to the present.	$r > 0$	$\delta > 0$	< 0
If future is consistently disadvantaged with respect to the present.	$r < 0$	$\delta < 0$	> 0
Neitzsche*	$r > 0$	$\delta > 0$	?
Utilitarian	$r = 0$	$\delta = 0$	$= 0$
Paretian	$r = 0$	$\delta = 0$	$= 0$

* If present is superior, which is most likely.

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to consider the possibility of a difference between near-future and distant-future time windows, a distinction is made between them for purposes of analysis. Near-term rates are specified by r while distant rates are specified by δ. Of course, this specification does not prevent the rates from being equal.

In the following chapter a theoretical model of individual discounting behavior is developed. This model forms the basis for an empirical evaluation of individual time preference over the periods encompassed by r and δ.

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Chapter IV

A Theoretical Framework for Discount Rate Analysis

The purpose of this chapter is to develop a theoretical framework for use in analyzing hypotheses concerning any individual's concern for the provision of public goods in the distant future. In this chapter four hypotheses are postulated. The first of these hypotheses is concerned with the existence of arguments in individuals' utility functions which include the availability of public goods in the far future. The second is concerned with the separability of future public good availability from other arguments in the utility function. The third hypothesis deals with the issue of whether or not individuals value the availability of public goods in the distant future differently than the availability of other goods, both public and private, in the near period of their lifetimes (or the lifetimes of their immediate heirs'). The final hypothesis relates to the factors that determine an individual's value for the far future provision of public goods.

Prior to considering the nature of the utility function it is useful to briefly review the writings discussed in Chapter II and Chapter III. From Chapter II, one notes that Pigou, Marglin, Tulluck, Haveman and Baumol all discuss the future generation issue. So do many of the non-mainstream

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and non-economic viewpoints discussed in Chapter III. All of these writers point to whether or not it is appropriate to worry about the future. Tullock, Haveman and Baumol argue that transfers to the future are a "get rich on the backs of the poor" scheme. However, it seems fundamental that if people want to make transfers to the future these arguments regarding poor to rich transfers have little merit. Certainly imposition of a contrary outcome would be a violation of consumer sovereignty that economics could not tolerate.[63]

The essence of these questions then boils down to determining whether or not the future, or any aspect of it, is a component of the utility function of individuals. And if it is, how is the fact that it is in the future affect valuation?

If the far future provision of public goods is a component of peoples' utility functions then why can it not be observed? One may attempt to argue that nothing prevents people from unilaterally making transfers to the future. And the answer to that question would most likely be that they do, somewhat. Consider some examples: the existence of numerous foundations whose purpose is to save the whales;

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[63]The implementation of an outcome contrary to the wishes of the majority of voters in a society would also be a violation the basic principle of democracy.

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contributions to the Friends of the Earth organization; and financial support for lobbying efforts to establish more wilderness areas. However, use of these instruments is essentially limited. One cannot be quick to use these examples to draw conclusions regarding the individual (or societal) valuation of the distant future because these goods once provided for the distant future are generally also provided for the near future. The latter point requires consideration of free rider impacts and thus the possibility that individuals will not reveal their true preferences. Thus these mechanisms are likely to be inefficient mechanisms for individuals to make future transfers. The broad fact remains that there is no acceptable market mechanism to facilitate direct consideration of far future public goods provision; there is simply no such thing as a market for contingent claims on far future events.

What about the allocation of far future public goods through the political system? Since a democratic system allows the wishes of the voter to be expressed at the polls, doesn't this mean that future values, if they occur, have already manifested in our present societal investment levels and procedures? The shortcomings of the democratic system as an allocation mechanism are discussed in Chapter V, however it is appropriate to note some of its shortcomings here. These include the prevalence of "single issue"

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elections that propel representatives into offices which require consideration of multilateral issues, large information costs for voters, incentives for politicians not to reveal true opinions, over emphasis on compromise and logrolling -- perhaps in an effort to reduce political transaction costs, and the nonexistence of an efficient voting rule from an allocation and a procedural standpoint. For these reasons, it must be concluded that the democratic process, perhaps to even less of an extent than the market system, is unlikely to yield efficient allocation of far future commodities. And therefore, it is likely that contemporary outcomes of the political system are not representative of individual or societal future valuation.[64]

Consider for a moment evidence of far future valuation of a more subtle nature. It has been suggested that the users of the Grand Canyon, i.e. the floaters and hikers, exhibit a remarkable ethic regarding their recreation. The

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[64]Thus far the discussion of the political process has ignored the issue that the future constituency is not even directly represented. Recall that Pigou (1920) argued that it is the duty of the government to represent the unborn. Pigou's argument runs directly opposite to Marglin (1963A) who said that he considers it "axiomatic" that democratic government only represent the wishes of the body politic. However, it does seem possible that since one function of government is the protection of minority rights, i.e. speech, religious freedom, etc., the government may be justified in protecting the future majority from the present oligarchy - even if that oligarchy is a democracy in present terms.

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Canyon is filled with Indian ruins and artifacts. Yet, despite the visits of literally thousands of recreationalists each month, the canyon remains largely pristine and, to the greatest of extents, the artifacts remain where they were examined by the last visitor. Of course, one can attribute this husbandry to the fact that there are substantial fines for littering and worse awaits the vandal or the thief; however, this theory does not seem altogether satisfactory when one considers that the canyon is a vast area, exceeding several hundred square miles, and thus is virtually unpatrollable. Furthermore, since it is not a common practice for authorities to search the gear of recreationalists upon exiting the canyon, the possibility of discovery and punishment is extremely remote. Thus one must conclude that there is something more behind this behavior. Perhaps this ethic arises from the self interest-related notions of user or option value, i.e. the recreationalists believes that there is a positive probability that they will return and thus these are the source of the "canyon ethic." Some have suggested that option value can be intergenerational. Under this notion, justification of the canyon ethic does not require that the recreationalist have a positive possibility of returning, but that his/her descendant does. Others have suggested that the is a value to individuals just in knowing that the canyon exists and that this existence value is unrelated to the possibility

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that the canyon will be utilized by the individual and/or his descendants.

Certainly, one can argue that this special case is not illustrative of wide spread future valuation, and that it is not necessarily a case of far future valuation at all. It is sufficient however, to note that this example is likely to wet the appetite and invite a more thorough investigation of the existence and level of far future values.

Assume for a moment that public goods in the far future are a component of the utility function of contemporary individuals. Now other interesting problems present themselves. The first of these is whether or not these instances of future valuation are isolated exceptions, e.g. the Grand Canyon, or wide ranging, e.g. all future goods. The second question is why or how are they there, i.e. by what manner do they present themselves? Are they related solely to an interdependent utility function phenomenon surrounding the rather narrow notion of the utility of family and descendants (intergenerational option or user value)? Or are they a manifestation of altruism? Altruism, if it exists is likely to also have foundations in interdependent utility functions. However, most would agree that it encompass a much broader interdependency, such as one's fellow man, Americans, or Christians, etc. In this context altruism may also be related to the notion of user or option values. It does not however, seem necessary to

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rely on the elusive notion of existence value for far future valuation to occur.

Perhaps future valuation is related to other factors. What are these factors and how do they play a role? Are religious and ethical concepts, such as were considered in Chapter II, the (or a) basis for positive future values? What is the source of these concepts? Do religious and/or ethical values spring from interdependences of utility functions? Do fatalistic concepts such as karma play a role? Or is religiously motivated concern for ones fellow and future man a manifestation of fear regarding the final judgement of the almighty?

To begin this investigation, let us start with the simple case whereby future public goods are important to individuals. Let us ignore for the time being why they are in the utility function. Consider the following intertemporal utility function:

(1) $$U = U\ (C_o, C_1, P_o, P_1, P_2)$$

where C_t and P_t are the consumption of private goods and public goods respectively.

Note that this utility function is defined for three time periods. For purposes of analysis it is convenient to think of the periods 0, 1, and 2 as corresponding to the present, the near future, and the distant future, respectively. The near future period may best be thought of the period of one's own lifetime and the lifetime of his/her

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immediate heirs. Ignoring for the time being the relationship of P_2 to the utility function, it is reasonable to assume that utility increases as levels of C_o, C_1, P_o, and P_1 increase. That is:

$$(2) \qquad \frac{\partial U}{\partial C_o}, \frac{\partial U}{\partial C_1}, \frac{\partial U}{\partial P_o}, \frac{\partial U}{\partial P_1} > 0.$$

Further, it is also reasonable to assume that:

$$(3) \qquad \frac{\partial^2 U}{\partial C_o^2}, \frac{\partial^2 U}{\partial C_1^2}, \frac{\partial^2 U}{\partial P_o^2}, \frac{\partial^2 U}{\partial P_1^2} < 0.$$

Expression 3 indicates that subsequent increments of consumption of C_1, C_2, P_1, and P_2 add less to total utility than previous increments; that is, there is diminishing marginal utility for these four arguments. In addition, under this expression it is normally considered reasonable to assume that $\forall$ i,j = 0,1:

$$(4) \qquad \frac{\partial^2 U}{\partial C_i \partial C_j}, \frac{\partial^2 U}{\partial C_i \partial P_j}, \frac{\partial^2 U}{\partial P_i \partial P_j} \neq 0$$

Expression 4 indicates that the utility derived from the consumption of C_1, C_2, P_1, and P_2 is influenced by the consumption levels of the other goods. That is, utility derived from the consumption of any amount of either of these four goods is not independent of the consumption levels of the other three.

Equations 1, 2, and 3 describe the relationship of present and near future private and public goods to the

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utility function; the relationship between the availability of public goods in the distant future, P_2, and the utility function forms the subject of the hypothesis considered in this chapter.

In its essence, the question boils down to the following one: do people care about the availability of public goods in the distant future? That is, is $\frac{\partial U}{\partial P_2} \neq 0$ and more specifically is $\frac{\partial U}{\partial P_2} > 0$? And thus the first hypothesis is:

$$H_1 = \frac{\partial U}{\partial P_2} > 0.$$

The sign of this expression is positive because presumably the discussion is in regards to goods. However, if one considers the impact of public bads on the far future, then for most people the relevant expression is likely to be negative. Perceptions regarding the sign of this expression are largely based upon application of the principle that most people do not receive enjoyment from the fact that other people have an undesirable experience. The difficulties involved in a determination of whether or not an individual's utility is influenced by the existence or non existence of future public goods formed the basis for much of the discussion in the earlier portion of this chapter.

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While it is not necessary to hypothesize regarding the sign of the second derivative, it would seem reasonable that given H_1, $\frac{\partial^2 U}{\partial P_2^2} < 0$. That is, the consumer has diminishing marginal utility with respect to P_2.

The second hypothesis is concerned with the issue of whether or not utility levels from the availability of P_2 are affected by any of the other arguments in the utility functions. That is, can we write the utility function as:

(5) $$U = U_A\ (C_o,\ C_1,\ P_o,\ P_1) + U_B\ (P_2)$$

where the subscript A denotes the present and near future periods and B denotes the far future?

Note carefully the separability imposed by this formulation. This type of separability is known in the literature as being weakly additive.[65] The formulation implies that the marginal rate of substitution between components of U_A are unaffected by the component of U_B and vice versa. This, of course, means that cross partials for pairs of commodities in A and B are identically zero. Thus, we derive our second hypothesis:

$$H_2 = \frac{\partial^2 U}{\partial C_t \partial P_2},\ \frac{\partial^2 U}{\partial P_t \partial P_2} = 0$$

where t = 0 and 1, respectively.

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[65]See James M. Henderson and Richard E. Quandt, Microeconomic Theory: a Mathematical Approach, 3rd ed., (New York: McGraw-Hill Book Company, 1980), p. 39-40.

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Note the radical departure of the formulation in (5) from that of (1). In practical terms, this formulation argues that people separate the utility effects of P_2 from the utility effects of everything else. The explicit result here is that the marginal utility derived from P_2 are, for the individual, unaffected by other components in the utility function, particularly levels of consumption of the other goods, both public and private. Further note, that as specified in equation (5), the structure of the utility function has changed - not just the arguments. That is, the utility function U_A is not structurally the same as that of U_B.

Alternatively, the structure of the utility function could be such that, while the elements in each subgroup change, the utility function is the same in each period. To illustrate this possibility further, imagine a three period lifetime utility function which is a function only of consumption in each of the three periods. That is, consider the function given by:

(6) $$U = U\ (C_1,\ C_2,\ C_3).$$

Imposition of separability that maintains the same structure of the utility function would imply that:

(7) $$U = U\ (C_1) + U\ (C_2) + U\ (C_3)$$

This can be contrasted to the formulation of (5) in which the utility functions for the different periods have different properties. A more general formulation of the

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structure inherent in (5) can be formed from (6). That is, separate utility structures imply for this example, that:

(8) $$U = U_1\ (C_1) + U_2\ (C_2) + U_3\ (C_3)$$

The advantage of using a utility specification such as (8) as opposed to the one expressed in (7) is that we can explicitly introduce the notion that people weight utility in the future differently than present utility. The application of this concept allows for the introduction of time preference and permits development of the third hypothesis. For example, in its most simple formulation assume that people discount future consumption in a logarithmically linear fashion. Then the specific of (8) could have the following components:

(9) $$U_1(C_1) = U(C_1)$$
$$U_2(C_2) = \frac{U(C_2)}{(1+r)}$$
$$U_3(C_3) = \frac{U(C_3)}{(1+r)^2}$$

Thus we can see that the formulation embodied in (8) can allow us to make some assumptions regarding these weights.

Our third major hypothesis follows this line of reasoning by considering explicitly the weights that the consumer places on future consumption. That is, how does the consumer discount the near future and the distant future? In order to adequately reflect the possibilities in this area let us first consider the consequences of imposing

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an additional degree of separability upon the utility function of equation (4). Consider the following formulation:

$$U = U_A(C_o,P_o) + \frac{U_A(C_1,P_1)}{(1+r)} + \frac{U_B(P_2)}{(1+\delta)^2} \tag{10}$$

where r and δ represent utility rates of discount. This formulation of separability is still considered to be weakly additive although the reader will note the additional restrictions placed upon this function from equation (4). The implications of this arrangement are that the consumer's marginal rate of substitution between C_o and P_o, and C_1 and P_1, are also unaffected by the availability of goods in the other group.

The third hypothesis concerns the relative magnitudes of r and δ. For example, if r=δ then this would indicate that the individual discounts events in the distant future using the same rate that he uses to discount the more immediate future.[66] That is:

$$H_3: \quad r \neq \delta.$$

The fourth hypothesis relates to the determinants of δ. In order to address this question it is appropriate to

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[66]Of course, the compounding affect of time in the model will mean that the actual weight applied to the distant future would be different than the weight applied to the near future.

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develop a model of respondent profiles to determine δ. This model will be useful in the empirical portion of this dissertation. The model has as its foundation the assumption that a person's valuation of far future events depends on three factors:

1) religious beliefs,
2) ethical and moral beliefs, and
3) concerns for descendant(s).

The first two of these factors were discussed in Chapter III of this dissertation as they relate to future perspectives other than that offered by neoclassical economics.

It is important to note that what is modeled in this section is not what particular religious, ethical/moral, and descendent-related concerns a person may hold, but what these beliefs imply about their concern for the availability of future public goods. In this sense, it is not the means by which a person develops their beliefs, but how these beliefs are reflected in valuation that is important. As an example consider religious beliefs, a Buddhist and a Christian may both hold the same degree of valuation for the future if the Christian falls within the class of husbanders discussed in Chapter III.

Each of these factors may provide the basis for three levels of future valuation: a high level, a moderate level, and a zero level of valuation. Suppose, that a person's religious convictions are such that they can be

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characterized as a Christian eminent destructionist. Then on the basis of this factor alone, a zero valuation of far future events would be implied. Similarly, certain ethical and/or moral beliefs will determine the degree of valuation for future events. Finally the same levels could be determined out of concern (or lack of concern) for an individual's descendents.

There is no a priori reason to believe that these factors are independent, although for some individuals this may be true. The addition of an assumption that these factors are independent would imply, for example, that and individual's morals-determined valuation of far future events is not a function of his/her religious convictions. Such a requirement seems unduly restrictive and does not add anything to the predictive power of this model.

Finally assume that an individual's valuation of future events is determined by the maximum valuation of each category and the stage is set for the derivation of the fourth hypothesis. That is, if an individual's ethical/moral and religious leanings both imply a zero level of future valuation and a great level of concern for his/her descendents yields a high level of future value, then the operational level of valuation that this individual feels towards the future is high. Mathematically, we can express this hypothesis as:

H_4: $FV = \max(R, E, D)$

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where

FV = the level of an individual's valuation for the future;

R = the level of an individual's valuation for the future determined by his/her religious beliefs;

E = the level of an individual's valuation for the future determined by his/her ethical/moral convictions; and

D = the level of an individual's valuation for the future determined by his/her level of concern for his/her descendents;

and where

FV, R, E, and D have values of high (H), medium (M) and zero (0).

The fact that under this formulation, the determined level of FV is the maximum of values existing under R, E, and D would seem to be reasonable. It is certainly reasonable to assume that the FV of an individual whose pattern of religious and ethical convictions imply a very high level concern for the future would not be influenced by the fact that they do not plan to leave any descendents. Similarly, another individual's FV may be solely determined by the level of D if R and E both have a level of zero.

At first glance, the assumption that FV is independent of all but the maximum of R, E, or D may appear to be in

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conflict with the assumption that allows for interdependence of R, E, and D. This is not the case. The fact that, for some individuals a moderate value for R also implies a moderate value for E does not in any way affect the fact that the operational level of FV is high because of concern for descendents. Furthermore this fact does not change if the high level of D is determined in some way by the moderate levels of E and R.

As a result of the above formulation, a 27 cell, 3x3x3 matrix of outcomes is determined. The dimensions of the matrix are the three possible determinants of FV, i.e. R, E, and D. Each dimension has three values: H, M, and 0. Let us consider the possible outcomes which are possible for a person who has a value of 0 for D. This can be thought of as a conditional arrangement where the level of FV is derived conditional on the fact that D=0. Under this arrangement, all possible values for FV must be determined by the corresponding levels of R and E due to the fact that D is at a minimum. A graphical portrayal of these possible outcomes provides one, 9 cell, slice of the 3x3x3 matrix. This slice is depicted in Table IIa.

Note that the values in the nine cell slice of the outcome matrix represented in Table IIa. range from 0 to H depending on whether or not R or E has the highest value. Furthermore, given the structure of the FV function, in that the level of FV is the maximum level applicable to R, E, and

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Table II a.

Possible Values of FV if D = 0

		R		
		H	M	0
	H	H	H	H
E	M	H	M	M
	0	H	M	0

Table II b.

Possible Values of FV if D = M

		R		
		H	M	0
	H	H	H	H
E	M	H	M	M
	0	H	M	M

Table II c.

Possible Values of FV if D = H

		R		
		H	M	0
	H	H	H	H
E	M	H	H	H
	0	H	H	H

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D (in this case D=0), then five cells have a value of H, three cells have a value of M and one cell has a value of 0.

If the slice of the matrix pertaining to D=M is considered, the possible outcomes are as portrayed in Table IIb. Note that the difference between this slice and the slice depicted in Table IIa. is that the cell corresponding to values for R and E both equal to zero has a value of M. This is due to the fact that for this cell, the corresponding entry is determined by the level of future valuation indicated by D. That is the future value function for this cell is

$$FV = \max (R=0,\ E=0,\ D=M) = M.$$

Finally, the slice pertaining to all possible values for FV if D = H is presented in Table IIc. This outcome is relatively trivial in that no matter what values pertain to R and E, the applicable value for FV is H, the value corresponding to D.

It is important to note that the likelihood of any particular value for FV is not in any way influenced by the fact that a majority of cells of the outcome matrix have a value of H. One should be careful to realize that what is depicted are all possible outcomes, not the outcome attributable to any one individual. Any particular individual occupies only one position in the 27 cell matrix. This position corresponds to his/her values for R, E, and D and the value for that particular cell is determined from

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the FV function. While it is true that a level of H for either R, E, or D would predetermine the value of FV, without more information it is impossible to determine whether or not a level of H is actually present.

For a particular population, no a priori information exists in regards to the probability of each cell outcome. If a study of frequencies were conducted across a large number of individuals, then it would be possible to determine individual probabilities applicable to each cell and to make a priori predictions regarding the value attributable to FV. The sum of all probabilities in each of the 27 cells is one and the probability of achieving a value of H, or M would depend on the individual sum of the probabilities in each cell that corresponds to a particular value. Probabilities in 19 cells would be summed to determine the probability of FV equal to H, while probabilities in the seven cells would be summed to determine the probability of FV equal to M. The probability of a FV equal to 0 is the probability of the single cell that corresponds to FV = max (R=0, E=0, D=0).

This completes development of the hypothesis to be analyzed in the empirical portion of this dissertation. However, prior to moving to a discussion of potential empirical methods to test the hypothesis, it is useful to reflect on the relationship between the discount rates

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considered in this chapter and those rates which prevail in the capital market.

The discount rates, discussed so far in this chapter are utility discount rates. These rates provide for the individual, an assignment of current values to future consumption. In a smoothly functioning economy characterized by a lack of taxes and perfect information, the utility discount rate for consumption in the near future, r, may also equal the consumption rate of interest and the opportunity cost of capital. Yet, the economy does not function smoothly, taxes predominate the corporate and personal arena and drive a wedge between the consumption rate of interest and the opportunity cost of capital. Even the concept that the utility discount rate equals the consumption rate of interest is hampered by the fact that not all individuals have equal access to the credit market. By this consequence and others, some face real interest rates of 3% for a home mortgage from their local savings and loan (obviously, this has not occurred recently) while others pay 50 - 100% or more to certain, perhaps unscrupulous, extensions of the normal credit market to finance their activities in other arenas - perhaps at the local race track.

An example of the wide range of utility discounts occurring across individuals can be found in Hausman (1979). In his study, Hausman estimated the individual discount

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rates of people purchasing energy using durables. He identified income dependent discount rates ranging from about 5% for incomes of $50,000 to almost 90% for incomes of $6000.

Overwhelming the fact that prospects for a near future utility discount rate equal to the consumption rate of interest appear bleak, is the fact that the possibility of equating our utility discount applicable to the far future with some similar measure derived via credit markets is nonexistent. Intergenerational credit markets, where they exist, would seem to be characterized by at least an equal number of faults as the short term markets. In addition, existing long-term markets, i.e. the market for government bonds, home mortgages, and other high quality corporate and municipal instruments, seem to be accessible to a relatively small portion of society. Finally, the mere fact that the longest terms available in these vehicles are generally limited to 30 years - hardly a time period involving society's "far future" - limits any conclusion in this area.[67]

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[67]Exceptions to the thirty year time limit do exist. However, they are few and far between and if anything, becoming rarer. It is interesting to note that the English government of the 19th century had outstanding a number of perpetual instruments which were callable by the issuer. The government exercised its option and exchanged these

(Footnote Continued)

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In the next chapter the possibility of empirically estimating the value that individuals place upon far future provision of public goods is explored. Potential methods to test the hypothesis derived in this chapter are evaluated. Techniques considered include exploration of the relationship between market goods and non market goods, analysis of voting behavior, contingent valuation, and market creation.

(Footnote Continued)
bonds for noncallable, fixed term instruments of 100 years duration. See Homer, Sidney and Martin L. Leiboweitz, Inside the Yield Book: New Tools for Bond Market Strategy, (London: Prentice Hall, 1972), pp. 33-34.

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Chapter V

Empirical Estimation of Individual's Values for the Distant Future

In this chapter the possibility of empirically estimating the values that individuals have for the level and quality of future public goods is explored. The chapter discusses estimation techniques that may possibly be applied to the availability of public goods in the far future. One technique, contingent valuation, is shown to offer the possibility of resolving the hypothesis presented in the last chapter. Each potential valuation method is one of four basic classes of techniques that can be applied in an attempt to obtain valuations for public goods.

The first method explores the relationship between market goods and public goods. It attempts to exploit this relationship to derive inferences regarding the value that individuals hold for the provision of public goods. Three valuation approaches which are components of this market based method are weak complementarity, hedonic pricing, and travel cost analysis.

The second approach attempts to elicit public good values from their voting behavior. In this context, public good supply becomes a referendum issue. As currently utilized in the vast majority of public decision making,

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such referendums are usually bilateral in structure. That is they require a yes/no response to a specified level of public goods provision.

The third technique is also a nonmarket procedure. This is the use of artificial markets to elicit nonmarket values via survey techniques. This approach is known in the literature as contingent valuation. Using this methodology, the researcher constructs a hypothetical market for a public good and queries individuals regarding their willingness to pay (or in some cases their willingness to accept) for changes in the level of the good. This technique can be affected through either a written or a verbal medium or both.

A fourth approach to future valuation is to create a market for far future events. Presumably, this could occur if government or some other guarantor provided appropriate assurances to investors that their investments would be realized. Obviously direct application of this approach by any entity except government is extremely difficult. The final section of this chapter details the desirable characteristics and implications of this approach. Furthermore, a "contingent" version of this approach will be discussed in the empirical analysis that is developed in Chapter VI.

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Approaches Which Exploit Relationships Between Public Goods and Private Goods

In order to determine the potential for utilizing one or more of these techniques to determine individual's valuation of public goods in the far future, it is necessary to consider these techniques in much more detail. The first approach to be considered is the market based technique of weak complementarity.

Weak Complementarity[68]

Consider the following demand function:

$$X_i = X_i(P,Q,Y)$$

where X_i is a private good, P is a vector of prices, Q is some public good and Y is income. If the conditions necessary for weak complementarity were to hold, then it would be possible to infer the demand price for Q from the demand function for X. Further, when weak complementarity is applicable, then it is not necessary to integrate the demand function to derive the underlying utility or expenditure function. Two be applicable to the problem of determining a demand price for Q, two conditions must hold:

1) there must be some price, $\hat{p}_1$ at which demand for X

[68]This discussion follows closely on Freeman, 1979B, pp. 72-74.

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is zero, i.e.,

$$X_1(\hat{P}_1,P,Q,Y) = 0$$

2) and with the expenditure function defined by

$$E = E(\hat{P}_1,P,Q,\bar{U})$$

where $\bar{U}$ is a fixed level of utility, the partial derivative of the expenditure function with respect to Q must be zero, i.e.

$$\frac{\partial E}{\partial Q} = 0$$

Practical application of weak complementarity can be illustrated with the following example. Imagine that the demand curve for X_1, given a level of public good equal to $\bar{Q}$, is defined by $D_{\bar{Q}}$ in Figure 1. Assume further, that the price of X, increases from P_1^1 to P^{11}_1 and thereby consumption of X_1 falls to zero. To maintain the consumer's level of utility he/she would have to be compensated by an amount equal to the area determined by ABC. If at this point the level of Q increases to $\bar{\bar{Q}}$ then the demand curve shifts to $D_{\bar{\bar{Q}}}$. Presumably, at the price P_1^{11} the change in the level of Q holds no interest for the consumer as his consumption of X_1 is zero. However, if the price of X_1 returns to the original price of P_1 then the consumer's welfare has increased by the area determined by BDEC if compensation payments equal to ABC are discounted.

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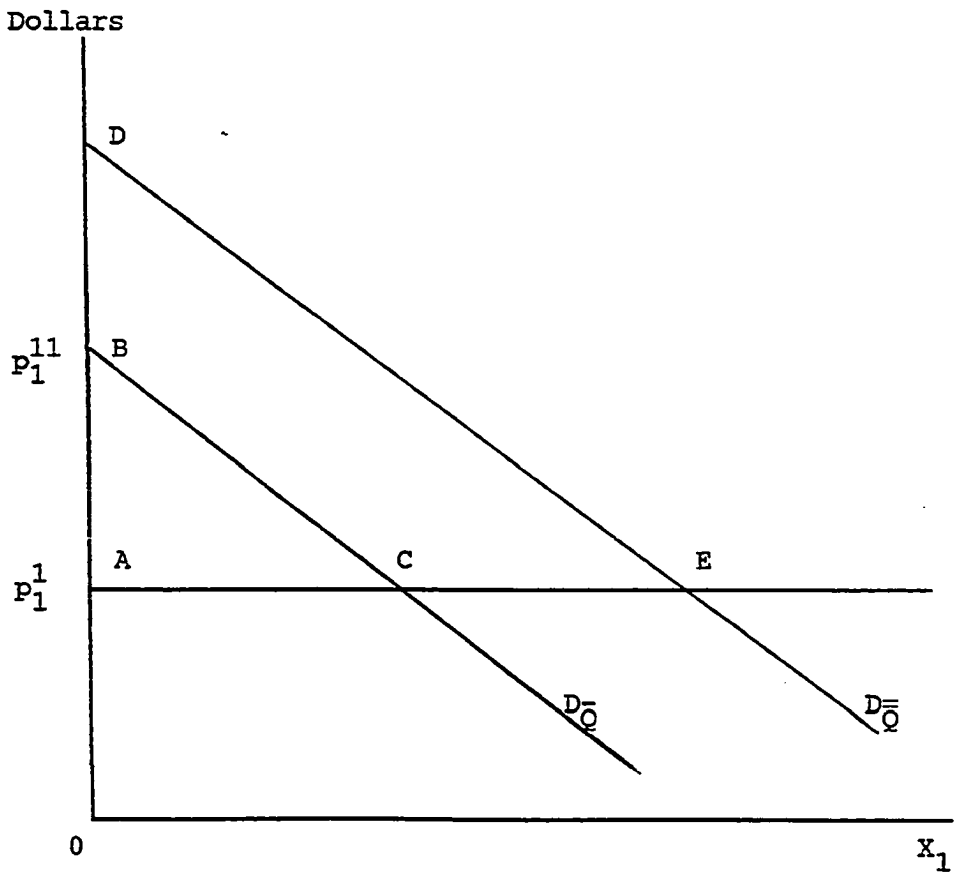
Figure 1

Weak Complimentarity



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Consider the possibility of applying the technique to the utility function defined by equation (5) in Chapter IV. Recall that (5) had the following formulation:

(5) $$U = U_A(C_o, C_1, P_o, P_1) + U_B(P_2)$$

It should be obvious to the reader that weak complementarity can not be applied to derive the individual's valuation for P_2. Unfortunately, this is due to the fact that the demand curves for C_o and C_1 are not functions of the level of P_2 because of the separable nature of the utility function. Therefore we fail the requirement for weak separability as

$$\frac{C_t}{P_2} = 0.$$

The implications of this separability were discussed in Chapter IV. And given the nature of P_2, public goods in the far future, separability would seem to be appropriate. For this reason, the possibility of applying weak complementarity to this problem is zero and we must continue our search of other techniques.

Hedonic Pricing

The other alternative which can sometimes be used to value relationships between market goods and public goods is the use of hedonic pricing. This approach was pioneered through the efforts of Tiebout (1956), Lancaster (1966), and Rosen (1974) and surveyed by Freeman (1979A and B). The

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hedonic technique exploits the relationship between a goods price and its characteristics to derive implicit prices for nonmarket attributes. For example, consider the factors which determine the price of a home. Such items as number and size of bedrooms, age, size of lot, existence of a swimming pool, etc. are all characteristics which determine the market price of a particular home. In addition, this market price is also a function of non-structural characteristics such as neighborhood attributes and environmental quality. Mathematically, we can express this relationship as:

$$P_{h_i} = P_{h_i}(S_{i1}, S_{i2}, \ldots S_{in}; Q_{i1}, Q_{i2}, \ldots Q_{im})$$

where:

P_{h_i} = the hedonic price function for the ith unit of h,

S_{ij} = the quantity of the jth structural characteristic in unit h_i, and

Q_{ik} = the quantity of the kth environmental characteristic in unit h_i.

With this formulation, the hedonic price of a characteristic can be determined by differentiating the hedonic price function with respect to a particular characteristic. Thus

$$\partial P_{h_i}/\partial Q_{ik} = P_{Q_{ik}}(S_{i1}, S_{i2}, \ldots S_{in}; Q_{i1}, Q_{i2}, \ldots Q_{im})$$

is the hedonic price function for Q_{ik} which illustrates the marginal expenditure on h required to get one more unit of Q_k.

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The applicability of this technique to the problems discussed in Chapter Four is probably non existent due to the fact that the far future availability of public goods is not a determinant of current prices. Therefore

$$\partial P_{h_i} / \partial Q_{it} = 0,$$

where

Q_{it} = some future quantity of a public good.

Thus we must continue our search for valuation techniques.

Travel Cost Analysis

Travel cost analysis was developed by Hotelling (1949) and applied to recreation benefits by Clawson (1959). The methodology is based upon the notion that the benefits that one receives from a recreational activity must be at least as great as the expenditures incurred to travel to the recreation site. Application of the methodology requires that the researcher construct a series of travel zones, often concentric circles, from which travel costs and per-capita visitation rates are calculated. Summation of the travel costs from each zone yields an estimate of the total recreation value of the site.

There are several severe problems with the travel cost methodology which restrict its application. Perhaps the most serious problem is the fact that the travel cost methodology presumes that recreation benefits can only be obtained from the site and that no enjoyment can be obtained

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from any other source. Thus the travel cost methodology ignores the fact that individuals may receive benefits from other sources, such as socializing with family and friends or perhaps through the traveling to the site itself. In addition, there is no consistent evidence regarding appropriate level of valuing peoples' time. Another problem with the travel cost methodology is that it is largely useless for applications to multiple destinations.

Further consideration of the travel cost method is unnecessary. There is obviously no possibility of applying this methodology to public goods in the far future.

Thus none of the three market-based approaches have proved to offer hope to answer the hypotheses developed in Chapter IV. It is now appropriate to explore the possibility of utilizing non-market based valuation techniques which do not rely on exploitation of the relationship between market goods and nonmarket goods. The first of these to be considered is the referendum.

Referendum

The second category in our search for valuation techniques to apply to the future availability of public goods is that of utilizing a referendum. Numerous economists have written in regard to voting procedures. Under some circumstances the application of the referendum process can lead to efficiency of supply of public goods.

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Obviously, since pareto efficiency requires that no one be harmed by an action and the fact that citizens are taxed to provide public goods this circumstances is limited to the case of unanimity for public goods provision. This point was first made by Wicksell (1896) and was later made by Buchanan and Tullock (1962). For multidimensional public good provision questions, Lindahl (1919), Malinvaud (1970-71), and Drèze and de la Vallèe Poussin (1971) argue that a tâtonnement process between all alternatives may be used. Obviously, this approach can be criticized for the transaction costs required to conduct the number of polls required to reach consensus.[69] Transaction costs occur for an indirect reason also due to the fact that the unanimity rule encourages strategic behavior, i.e. incentives for individuals to not reveal their true preferences in order to extract surpluses from others. That is, since unanimity requires the participation of all members of society, the marginal societal benefits of coercing the nth member of an n-number society to vote "yes" with the others is equal to the sum of the individual valuations, and presumably individual benefits are sufficient to make both individually sponsored and societal coercion probable. Thus each member of society will seek to extract surplus from the others; it

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[69]Buchanan and Tullock 1962 ch 2 Black 1958pp.146-7

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is this form of additional bargaining that increases transactions costs. These transaction costs arising out of strategic behavior on the part of the voter are detailed by Black (1958), Buchanan and Tullock (1962), Barry (1965), and Samuelson (1969); they represent the foremost obstacle to application of the unanimity rule.

Note that the above discussion was concerned with strategic behavior vis a vis the extraction of surplus from others. Use of the unanimity rule eliminates strategic free-rider behavior when public goods are considered. This is the notion, pioneered by Samuelson (1954), that individuals will not reveal their true preferences because the good once provide for one is provided for all members of a society. Under a market allocation scheme this encourages individuals to understate willingness to pay for the good. Such behavior is eliminated under the unanimity rule because the vote of each and every member is essential for provision. This proposition holds as long as quantity and tax share are decided prior to the goods provision.

Other voting rules exist which offer decreased transactions cost (but more prevalent strategic behavior) while penalizing efficiency. The most common of these in actual use is the simple majority rule. In some cases, in order to increase efficiency, the rule is modified so that a significant majority is required for passage. The use of a majority rule will generally impose further distortions.

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One major problem with the majority voting rule is that it can lead to cycling both within and across issues. Across issue cycling was discussed by Condorcet (1785), Dodgson (1876), Black (1948b), and Kenneth Arrow (1951). Cycling can be defined as intransitively of voting outcomes. It occurs when the outcome of pair-wise comparisons of more than two alternatives depends upon the order in which comparisons are voted.[70] The problem of cycling encourages voters to trade their votes on separate issues in order to form winning coalitions on issues that are more important to them. Cycling is not required for vote trading, or logrolling, to occur. Taylor (1971) and Ridker and Brams (1973) suggested that vote trading may force non-traders into a disadvantaged position and therefore lower overall gains. Tullock (1959) argued that logrolling increases the overall level of government spending.

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[70]Further explanation of cycling is warranted. Assume a society of three voters: one, two and three. Further assume that three alternatives are to be voted upon. Designate these alternatives as A, B, and C. Finally assume transitivity of preferences and that the following preferences hold: voter one prefers alternative A to B and B to C; voter two prefers alternative B to C and C to A; and voter three prefers alternative C to A and A to B. Under this arrangement, pair-wise comparisons can lead to any outcome. For example if alternative A is pitted against B in the first round alternative A will win only to lose to C in the second round. Finally, it should be noted that if an election between all three candidates is held and if all three voters vote for their first choice, the system is deadlocked.

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Other voting rules may also be utilized also. These include the plurality rule, the Condorcet criterion, the Borda count, exhaustive voting, and approval voting. All suffer from some type of distortion. Furthermore, none of these rules are generally used to determine an allocation of public goods; they are however, often utilized to select candidates and representatives for public offices.[71]

So far the discussion has been centered on the technique of direct voter participation in the allocation of public goods. However, the majority of public goods allocation occurs through the vehicle of the representative government.[72] Ignoring Federalistic reasons for this

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[71]Dennis C. Mueller, Public Choice, (New York: Cambridge University Press, 1979), pp. 59-60.

[72]Apparently there is a belief in our society that a direct democracy is better than the representative government on certain sorts of allocation questions. We often require such treatment for some "taxation" issues like school bonding for the new gymnasium or increasing the mill levy for the general fund. These items are handled via a direct mechanism while other allocation decisions are processed through the vehicle of the representative government. Ignoring Constitutional and historical practice, apparently one reason for this is because the individual impacts of the decision on the individual are greater and the transaction costs relatively low. However this reason does not seem adequate; as the decision to construct new high school and a comparable federal proposal to launch a new defense initiative both require approximately the same level of payment from the individual. Furthermore, the biggest decisions, i.e. to send men to the moon or - if your a ratepayer to an electric utility - to build a nuclear powerplant, do not require referendums

(Footnote Continued)

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arrangement, such a process provides for a further reduction in transactions cost at the expense of decisional efficiency. Obviously, representative forms of government suffer doubly from the problems described above -- strategic behavior, cycling, logrolling -- due to the fact that these problems are prevalent when the representative is elected and when the representative votes on an allocation question. Other, more real world, problems begin to surface also. These include the existence of single issue elections which tend to produce candidates who are unqualified to serve in offices requiring multiple decision dimensions, large information costs for voters, incentives for politicians not to reveal true opinions, overemphasis on compromise and logrolling -- perhaps in an effort to reduce political transaction costs, gerrymandering, and a franchising mechanism that excludes parties from the voting process.

The above discussion has demonstrated that, under any form of government or voting rule, the observed level of public goods allocation is likely to be different than the optimal one. That is, the prevailing level of public goods

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despite the fact that the impact on the individual is much greater.

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provision will not be indicative of the preferences of individuals.[73]

The bottom line of this discussion is that it is not possible to make a determination regarding individual values for the far future provision of public goods from the existing observed allocation provided by the present government. However, this does not mean that improvements may not be made in the system. In fact, it is interesting to speculate as to how people would reveal there preferences if they were afforded the opportunity to directly vote on the level and quality of public goods provided for the far future.[74]

Contingent Valuation

The third method of achieving valuations for non-market goods is the use of contingent valuation. Under this

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[73]One must be careful here to not confuse the issue of revealing preferences with the issue of providing an efficient allocation of public goods. Even if we suppose the existence of a perfect preference-revealing process, the outcome is likely to be inefficient due to the difficulties inherent in transcribing mandate into action. This later problem would also prevail in the contingent valuation process.

[74]This possibility will be considered in Chapter VI. In that chapter, a survey is designed, based upon the contingent valuation approach, which affords people the opportunity to vote for a far future allocation of public goods through specific actions in a hypothetical market.

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approach, households or individuals are directly asked to state their valuation for non-market goods. Early attempts to value public goods using the survey approach were made by Davis (1963), Bohm (1972), Hammack and Brown (1974), and Randall et al. (1974).

As applied in interview and survey forms, contingent valuation represents a two step procedure. First, the good under evaluation is described to the respondent along with any necessary background information. This first step may include any necessary visual aids or other material necessary to present the respondents with a consistent and accurate impression of the public good at various levels of provision. Secondly, the respondent is queried regarding his/her willingness to pay (or willingness to accept) for various levels of public good provision. Alternatively, if bids are not utilized, the respondent may be queried as to behavioral changes.

Evidence continues to mount that indicates that where non-market goods are well defined, i.e. well known and identifiable by the respondent, contingent valuation is an acceptable methodology. Results obtained via willingness to pay approaches have been demonstrated to be free from bias, stable and have been replicated in repeated studies, and verifiable with other non-market valuation techniques.

Many economists an others have speculated that the outcomes of a contingent valuation study are likely to be

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biased. Three basic types of bias have been proposed. These include strategic bias, information bias, and vehicle bias. Strategic bias is the incentive for a respondent to not reveal his/her true preferences in an attempt to influence outcomes of the study. Information bias relates to the notion that a respondent's answer is affected by the amount and type of information revealed in the interview (or survey). Vehicle bias causes valuations to not be independent of the collection medium.

The possibility of strategic behavior on the part of individuals confronted with an opportunity to influence the provision level of a public good was first discussed by Samuelson (1954). This notion arises due to the fact that since a public good once provided is provided for all, individuals have an incentive to not reveal their preferences and "free ride." For example, consider a fund drive to raise money to provide a community with mosquito control. Many individuals are likely to under pay, i.e. contribute amounts less than their marginal valuation of mosquito abatement, because they strategically plan to free ride on the abatement funded by others. Obviously, if a substantial number of people react in this manner, the amount of mosquito protection provided is likely to fall far short of the optimal level.

Strategic bias can take other forms also. One type may occur if an individual would like to see a level of public

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goods provision which is different than that which he/she believes will be justified by the average of his/her true marginal valuation and the valuations of other individuals. In this circumstance the respondent may report a different valuation in hopes of changing the average level of valuation.

Research has demonstrated that the hypothetical nature of contingent markets tends to minimize this behavior. This is especially true if respondents are informed that their responses will have no impact on policy decisions. Randall et al. (1974), Brookshire et al. (1979), and Rowe et al. (1980) were all able to disprove the existence of strategic bias in survey responses. Such bias is minimized by careful survey design.

Information bias arises if respondents are presented with deficient levels of information or the information is provided inconsistently. The hypothetical and complex nature of public goods supply questions often make some element of information bias inevitable. However, such bias can be minimized by careful survey design which in as thorough a manner as possible, acquaints the respondent with all of the relevant ramifications of changes in supply of the public good. Another related form of information bias is known as starting-point bias. Starting-point bias exists when the observed level of maximum willingness to pay is influenced by the initial level of valuation suggested by

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the interviewer. Rowe et al. (1980) found significant levels of information bias, including starting-point bias. In this study respondents increased their bids when informed that their original willingness to pay was insufficient to maintain pollution from power plants in the southwestern United States at their present levels. However, no information bias in either form was detected by Thayer (1981). Starting point bias was eliminated by Rahmatian (1982) and Brookshire et al. (1980) by simply allowing respondents to choose their own starting points.

Vehicle bias also has been noted in the literature. This form of bias is also known as instrument or payment bias. Under this for of bias, responses are affected by the method by which payments are to be collected. For example, willingness to pay in a hypothetical survey of wildlife may be affected by the fact that the payment is to be collected in the form of increased fees for hunting licenses as opposed to a general tax increase. Respondents may bid higher when the payment vehicle is a general tax increase because they feel that hunting is a "right," or they may feel that the state game and fish department is inefficient and may waste the money. Rowe et al. (1980) found evidence of vehicle bias. Their study determined that willingness to pay was higher if the survey vehicle was a payroll tax as opposed to an increase in entrance fees. Sorg (1982) found that big game hunters' willingness to pay for wildlife was

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statistically lower if the payment vehicle was a license fee payment as opposed to a total expenditure vehicle.

The potential for bias indicates a need to ensure that surveys are well constructed. In addition, it is important that, in as much as possible, every attempt is made to develop the well defined nature of the public good. A review conducted by Shultze et al. (1980) suggests that bias is not a serious problem.

Substantiation of the results of contingent valuation methods via methodological cross checks has been achieved in several different studies. These verifications have taken three basic forms: 1) comparison of non-market values obtained in different contingent valuation studies; 2) comparison of valuations obtained via travel cost studies and values derived in contingent valuation; and 3) comparison of non-market values from hedonic property value studies and contingent valuation.

Evidence has mounted which indicates the ability to replicate of contingent valuation results. Shultze et al. (1981) compared six different contingent valuation studies and found that results from the studies were consistent as relatively free of bias. Sorg (1982) found that in home interviews yield the same results as interviews conducted in the field.

Contingent valuation methods have also been found to be roughly comparable to some travel cost studies. Bishop and

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Heberlein (1980) compared several variants of contingent valuation to the travel cost methodology for Canadian Goose hunting in Wisconsin's Horicon Marsh. As a precondition for their study, an actual market and a hypothetical market were established to compare values obtained by hunters who sold their hunting license. From this first round, Bishop and Heberlein found that the contingent valuation methodology yielded results that were statistically larger than those derived from cash payments. This bias was utilized to evaluate results of later comparisons of contingent valuation and the travel cost methodology. The authors found that travel cost values were significantly lower than those obtained via contingent valuation. However, it should be noted that this result is expected as travel cost yields, in some sense, a lower bound.[75] The fact that willingness to accept values were significantly, but not outrageously, higher indicates that they conform to expectations.

Desvousges et al. (1982) also compared the travel cost method and contingent valuation. This study analyzed water quality related recreation benefits for the Mongahela River in Pennsylvania. Desvousges et al.'s results indicated a

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[75]See the discussion of the travel cost methodology presented earlier in this chapter.

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strong correlation between results obtained via contingent valuation and travel cost analysis.

Brookshire et al. (1982) compared the hedonic property value method to contingent valuation for air pollution in the Los Angeles metropolitan area. Their study compared households willingness to pay for an improvement in air quality and pollution-induced differences in property values revealed in the sales prices of single family homes. Besides substantiating the results of contingent valuation methods, Brookshire et al. demonstrated that the magnitudes of air quality valuations were within ranges suggested by economic theory. Using a simple utility maximization model, they demonstrated that the annualized cost difference between homes in two different air quality areas will exceed annual willingness to pay for an equivalent improvement in air quality, ceteris paribus. Brookshire et al. are quick to point out that their extremely well-ordered results are largely due to the fact that air pollution in the Los Angeles basin is a particularly well-defined good.

Similar results were obtained by Leohman et al. (1982). This study was a straight-forward extension of the Brookshire et al. results to air pollution in the San Francisco Bay area. Again, willingness to pay values obtained using contingent valuation yielded predicted relationships to values derived with the property value method.

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Cummings et al. (1982) conducted a study of hedonic wage differentials and willingness to pay measures for an increase in community infrastructure. The study was conducted utilizing data from communities in New Mexico and Wyoming. Willingness to pay values in the study were obtained by asking people how much they would be willing to forgo, in the form of reduced money wages to obtain a higher level of infrastructure. In addition, the authors estimated a hedonic wage gradient for the different levels of wages and infrastructure occurring across the communities. No significant difference was found between the results derived from the hedonic analyze and those obtained utilizing contingent valuation.

Other research has centered on the particular form of contingent valuation studies. This research has centered around whether or not values derived represent maximum willingness to pay and whether or not the explicit introduction of a budget constraint effected derived levels of payment. Sorg (1982) found that payment card bids, utilized in written surveys and occasionally in personal interviews, do not capture maximum willingness to pay for wildlife. This result collaborates results derived by Rahmatian (1982) for air quality. Sorg concluded that use of the payment card alone provides a willingness to pay measure which is biased downward and that the amount of this

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bias depends on the elasticity of demand for the public good.

Sorg also tested the effects of a budget constraint. She found that no statistical difference exists between mean bids with and without a budget constraint. According to Sorg, this was due to the fact that the good under consideration, big game hunting, was well defined. This result was also derived by Rahmatian (1982) and Brookshire et al. (1982).

Thus it can be seen that the contingent valuation approach offers substantial promise to provide answers to the hypotheses developed in chapter IV. However, contingent markets must be carefully constructed. In order to better construct such a market it is important to consider how an actual market for far future public goods may operate.

Market Creation

One conceivable method to observe individual behavior with regards to future goods is to create a market for future events. In such a market direct consideration of future values is possible. Under such an arrangement individuals could purchase claims to far future activity. Presumably, this could occur if government or some other guarantor provided appropriate assurances to investors that their investments would be realized. Obviously direct

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application of this approach by any entity except government is extremely difficult.

Consider the implications of a contemporary sale of perpetual instruments, such as were issued in England in the nineteenth century.[76] These callable instruments were issued by the English government. If variations of such instruments were available today, future valuations could be directly observed in the market. Certainly it would be interesting to observe purchasing behavior. Consider, how much would you be willing to pay for a bond that pays one dollar per year for the rest of eternity? a lot? a little?

Much could be learned about the way people value the future if a observations were made of an intergenerational bond market. The market could be structured in order that people could purchase bonds with perpetual payments, the first of which is distributed one-hundred years (500 years, 1000 years) from now to the recipients, or causes of their choice. With extremely minimal possibility of strategic behavior, future values could easily be determined directly.

Obviously an important consideration for the potential participant in such a market is the likelihood of the payments being distributed. This is the primary reason why

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[76]These instruments were mentioned in footnote 67 of Chapter IV.

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such a market would require government backing to minimize uncertainty regarding payment streams. Uncertainty may still remain a problem with government backing, and an observation of non-participatory behavior does not, in and of itself imply a zero value for the future.[77] Uncertainty, may also cause individuals to discount the value of the bonds and therefore the market value would likely be smaller than it would be in the absence of uncertainty. However, despite the problem of uncertainty in such a market, it seems fundamental that if the bonds illustrate some non-negative value, evidence of far future valuation is secured.

Unfortunately, construction of such a real market for the far future provision of public goods is politically impossible and thus it is not realistic to utilize market creation to answer the hypothesis of chapter IV. However, this exercise is most useful. Information gathered from a proposed actual market for future events can be combined with knowledge of the application of the contingent valuation technique described earlier to design a hypothetical market for future events. Such a contingent

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[77]Admittedly, it may be more difficult to satisfy peoples' belief in a perpetual government today than it was to satisfy the monied English in perpetuity of England in the nineteenth century.

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market is designed in the next chapter. This market has as its foundation a bond auction similar to the market described above.

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Chapter VI

Experiment Design and Sample

In this chapter a survey instrument is developed to answer the hypotheses developed in Chapter IV. The need for a survey approach was established in Chapter V. The survey instrument designed in this chapter combines elements of the discussion of an actual market for far future public goods with contingent valuation methodology. These techniques for determining values were discussed in Chapter V.

Prior to discussing the actual design of the survey utilized to answer the hypothesis developed in Chapter IV, it is useful to consider the components of an ideal survey instrument. Such an instrument would be unbiased, of moderate length, and would contain clear and specific questions as well as easily comprehensible instructions. The chosen sample for the survey would be random and without bias; the sample size would be large enough to provide incontestable statistical significance to the results.

By necessity, the survey utilized to answer the hypotheses of this dissertation must deviate from the norms of the perfect survey. This is due to the fact that the concept of future valuation is a difficult one and the inherent complexity of the hypotheses and underlying factors which determine a respondents view of the future. The

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survey utilized in this analysis is relatively lengthy, however it is hoped that the other goals will be achieved.

Survey Design

In this section the survey utilized in this study is discussed in detail. An copy of the survey utilized in this analysis is presented in Appendix I. Specific criticisms and shortcomings of the survey instrument will be discussed in Chapter 7.

The respondent is introduced to the future valuation survey with the following statement:

> The purpose of this survey is to determine how you value the future and why you feel the way that you do. It represents part of a research project on future valuation conducted by the University of Wyoming Department of Economics. Would you pleases take a few minutes of your time to fill out the survey? Thank you.

With the introduction complete the respondent is asked to consider his/her impression of what the future will be like through a series of questions:

1. Do you think today's society will leave the future better or worse off that we are today?
   ___generally better off
   ___generally worse off
   ___don't know

2. In what ways will future society be better off? (Check all that apply.)

   ___more knowledge
   ___more resources
   ___less chance of war
   ___improved spiritual outlook
   ___improved values
   ___better health
   ___more goods and services

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___other 1 (specify)_____

___other 2 (specify)_____

3. In what ways will future society be worse off? (Check all that apply.)

___fewer resources
___greater chance of war
___deterioration of spiritual outlook
___poorer health
___deterioration of values
___overcrowded
___fewer goods and services
___spoiled environment

___other 1 (specify)_____

___other 2 (specify)_____

An individual's impressions regarding the level of welfare in the future when combined with information regarding the individual's ethical leanings. As discussed in Chapter III, ethical criteria can provide a means of explaining future valuation. For example a person who believes that the future will be worse off than the present but who does not wish to make transfers to the future and in fact wishes transfers to be made from the future to the present may be a Nietzschean. Alternatively, a desire for the same transfer could be in accordance with a Rawlsian framework if the respondent believes that the future will be better off than the present. Further clarification of past, present and future perceptions welfare are provided by the following series of questions:

4. How long do you believe society will continue to be at least as well off as today?

___ 10 years
___ 25 years
___ 100 years
___ 1,000 years
___10,000 years
___1,000,000 years
___forever
___other (specify) _____years

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5. How long do you believe mankind will continue to inhabit the earth?

___ 10 years ___10,000 years
___ 25 years ___1,000,000 years
___ 100 years ___forever
___ 1,000 years ___other (specify) _____years

6. In what manner do you believe mankind's existence on the earth will cease or be sharply reduced? (Check all that apply.)

___return of the Lord ___environmental pollution
___nuclear holocaust ___lack of resources
___famine ___none, mankind will exist forever
___disease
___other (specify) _____

7. Is the world a better place for mankind that it was

100 years ago?	___yes	___no
50 years ago?	___yes	___no
10 years ago?	___yes	___no

8. Is mankind better of now than

100 years ago?	___yes	___no
50 years ago?	___yes	___no
10 years ago?	___yes	___no

The next two questions attempt to directly elicit the respondents time preference for amounts of money at two different points in time. This provides an estimate of time preference behavior over near future events and thus provides an estimate of "r" which was discussed in Chapters III and IV. The first question presents the respondent with a series of choices:

9. Assuming no inflation, which of the following alternatives would you prefer to receive in <u>each</u> set?

Set 1:	___$100 today	or	___$5,000 10 years from now
Set 2:	___$100 today	or	___$2,000 10 years from now
Set 3:	___$100 today	or	___$1,000 10 years from now
Set 4:	___$100 today	or	___$ 500 10 years from now
Set 5:	___$100 today	or	___$ 250 10 years from now
Set 6:	___$100 today	or	___$ 150 10 years from now

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If the respondent's money discount rate is between 4 and 48%, then a switch from the right hand choices to the left hand blanks should be observed. For example, a person whose discount rate is between 35% and 26% would check the right hand side of sets 1 and 2 and the left hand side of sets 3 through 6.[78] Thus the individual is is indifferent between the choice of $100 dollars today and between $1000 to $2000 ten years from now. Technically, in this case the respondent is indifferent between $100 and some amount X, such that $1000 $\leq$ X $\leq$ $2000. Inclusion of the endpoints of the interval is necessary because the question did not differentiate indifference.

The second question in this series is included as a consistency check. This question utilizes a five year time horizon so that the respondent can not simply restate a portion of his/her answer to question 9.

10. Complete this statement: Assuming no inflation, I would be just as happy receiving $50 today as I would be if I received $_____ five years from now.

---

[78]The derivation of these rates of discount is based on the notion that a present value (PV) is equal to a future value (FV) divided by one plus the rate of discount (r), where the denominator is raised to the number of years (i). That is, in this case the following formula is utilized:

$$PV = \frac{FV}{(1 + r)^{i}}$$

Since, PV, FV, and i are known in each set, the problem becomes one of solving for r.

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From this question it is possible to directly calculate the discount rate that is implied by the respondent's indifference between the two dollar amounts. Because the respondent supplies the dollar figure which makes him indifferent, there is no range of rates as there was in question number 9.

The next portion of the survey allows the respondent to vote on the future provision of petroleum. This question allows the respondent to vote on the possibility of taxing contemporary petroleum supplies so that stocks can be preserved for future generations:

11. The price of oil has fallen significantly in recent months. As a result, gasoline prices are lower and people are using more petroleum. Over the long term, low petroleum prices will stimulate demand and significantly decrease the amount of petroleum available for future generations. Would you be in favor of increasing the price of petroleum, perhaps through a tax, so as to preserve supplies for future generations?

    ____yes ____no

This question is based upon the discussion of the referendum process which was considered in Chapter V. It provides a practical and concrete opportunity for the respondent to indicate preferences towards the future. Furthermore it should be noted that such a tax has been recently considered in the U.S., although the purpose of the tax was not to "preserve supplies." The tax was proposed on <u>foreign</u> petroleum imports in order to increase the competitive relationship of domestic production.

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After the above question now more abstract questions regarding future valuation. The first of these (12A) gives respondents the opportunity to express their perceptions regarding the relevance of future impacts in contemporary decisions.

12 A. Do you think that today's society should explicitly consider the impacts of its actions on future society when determining our present course of action?
___yes ___no

The second and third questions in this series (12B and 12C) build upon the first question. These questions are only asked to those who feel that society should explicitly consider the impacts of its actions on future society. The second questions inquires in regards to motives for high future valuation. Three motives are suggested (the respondent may write in two others). These motives coincide with the religious, ethical, and descendent-related motivations developed in hypotheses four of Chapter IV.

B. If your answer to the last question was yes, why should we worry about future generations? (check all that apply.)
____It is our ethical and/or moral duty.
____It is our religious duty.
____It is our duty to our descendants.
____Other 1 (specify)_____
_____
____Other 2 (specify)_____
_____

The final question of this series asks the respondent to explain how future impacts should be valued in a contemporary decision process.

C. If you answer to question 12A was yes, how should

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impacts on future generations be considered in our present decisions? Suppose for example, that we are considering a course of action that will cause future society to spend an extra $1,000 in today's dollars. How should this impact be considered in our present decision? (Choose the one that applies.)

____ It should be considered at the same magnitude as if this impact were happening to ourselves today.

____ It should be considered at a magnitude which is smaller than the magnitude which would apply today but at the magnitude as if this impact was happening to ourselves in the future.

____ It should be considered at a magnitude which is smaller than the magnitude we would apply if this impact were to occur to ourselves in the future.

____ It should be considered at a larger magnitude than if this impact was happening to ourselves today.

Recall that the first hypothesis developed in Chapter IV was that the far future provision of public goods is important to the individual. This hypothesis is tested by asking individuals a series of questions regarding factors that are in their utility function. This is accomplished through nine questions in the survey (questions number 13-21). The first of these questions is a simple ranking of seventeen present and future goods. In this question the respondent is asked to rank the six most important item on the list.

13. Rank the six most important things to you in the following list. (1 being highest, 6 being the lowest)

___the availability of a clean environment for present society

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___the availability of a clean environment for future generations
___peace for contemporary society
___peace for future society
___education for contemporary society
___education for future society
___a high level of contemporary religious values
___a high level of religious values for future society
___contemporary goods and services
___goods and services for future society
___the welfare of future society
___the availability of goods and services for your grandchildren
___the welfare of your grandchildren
___the availability of goods and services for your children
___the welfare of your children
___the availability of goods and services for your distant descendants
___the welfare of your distant descendants

In questions 14 through 20 pair-wise comparisons of present and future goods are made. Under this scenario the respondent is asked to compare eight different states of the world. These states include: the chance of nuclear war is reduced 10%; the respondent receives a new car; fewer resources are used today so that more resources are preserved for future society; people become more religious; more goods and services are available for consumption today; more goods and services are available for future society;

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more emphasis is placed upon pollution control today; and lastly, the moral fiber of contemporary society is improved.

The following is a series of questions in which you are asked to choose between two alternatives. There are seven questions in all.

14. Would you consider yourself to be better off under state A or state B?
    A.___the chance of nuclear war is reduced 10%.
    B.___you receive a new car.

15. Would you be better off in state C or D?
    C.___fewer natural resources are used today so that more resources are preserved for future society.
    D.___people become more religious.

16. Now consider your answers for the above questions; would you be better under:
    E.___your answer to question 14 (A or B).
    F.___your answer to question 15 (C or D).

17. Would you be better off in state G or H?
    G.___more goods and services were available for society's consumption today.
    H.___more goods and services were available for future society.

18. Would You be better of in state I or state J?
    I.___more emphasis was placed on pollution control today.
    J.___the moral fiber of contemporary society was improved.

19. Now consider your answers for the above questions, would you be better off under:
    K.___your answer to question 17 (G or H).
    L.___your answer to question 18 (I or J).

20. Finally, consider your answers to question number 16 and question number 19. Would you be better off under:
    M.___your answer to question 17 (state A B C or D).
    N.___your answer to question 18 (G H I or J)

Finally, question 21 asks the respondent to name and to rank in order the four things that give them most utility:

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21. Rank in order the four most important things to you. That is, what four things make you feel most well off or satisfied with life?

First _____

Second _____

Third _____

Fourth _____

An important part of the survey is the contingent transfer of wealth to the future. This is accomplished in the survey through the use of a intergenerational bond market similar to the instruments discussed in Chapters IV and V. The development and focusing of this contingent market requires eleven questions (Q22 to Q32). Under this approach, the surveys alternate between a 200 year and a 500 year market.

The contingent market is first proposed to the respondent in question 22. The market is very flexible. The respondent is informed that he/she can have the distribution payments made in any manner of their choosing.

22. Suppose that it is possible to purchase a $1 bond which pays $1 per year forever, the first payment is distributed in 500 years to the recipients or causes of your choice.

Would you be willing to purchase any of these bonds?
____ yes ____ no

Again note that approximately 50% of the surveys involve a 500 year game and the rest utilize a 200 year game. Respondent who answer affirmatively as to whether or not

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they would be willing to purchase any of the bonds are then asked how many.

23. If your answer to question number 22 was yes, how many bonds would you purchase? (You may choose any dollar amount)

____ dollars worth

The respondents proposed recipient is ascertained in the next question:

24. If your answer to question number 22 was yes, who or what would you want to receive the interest payments? (Specify)

_____.

A very important part of the survey process is to ascertain why individuals would choose not to participate in the contingent market proposed in question 22. As emphasized in Chapter V, the fact that a person does not wish to participate in such a market does not, in and of itself, constitute proof that the individual does not value far future public goods. One major reason that people may not wish to participate in the market discussed above is that they are unsure as to whether the contingent payment would be distributed.

25. If your answer to question number 22 was no, that is you do not want to purchase any of the bonds, is it because

____you have no desire to transfer money to the future.
____money will not solve the future's problem.
____you do not believe that such a program could work.

____other (specify) _____

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26. If you checked the third box above (i.e., you do not think that the program could work) would you be likely to participate in the program if it was government guaranteed?

____ yes ____ no

If the respondent was willing to participate in a government-guaranteed market, then he/she is re-asked how many bonds they would purchase and who the recipients would be under the guaranteed program.

The final series of questions in this section allow the respondent to transfer other things besides money to the future. The rational for this form of the game is based the rather common notion outside of pragmatic economics, that aid or support should be given in the form of in kind transfers. Despite the economic shortcomings of such practice, this is the basis for the food stamp program in this country as well as numerous other social programs that make transfers in the form of education, utility services, or food. Based on the prevalence of such practice in the US, it may be hypothesized that people would prefer to make use of in-kind transfers to make their payments to the far future provision of public goods. This opportunity is afforded the respondent in questions 29 through 32. These questions follow the basic format of the earlier questions, only now the transfers are in-kind.

29. A. Suppose that instead of money payments, the interest was paid out (after 500) years in the form of

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anything that you choose, (i.e. clean air, education, hot dogs, religion, etc.) would you be willing to participate?

____ yes ____ no

B. Would you prefer this type of payment mechanism over one that utilized money payments?

____ yes ____ no

30. If you would be willing to participate in a program which gave the future interest payments in the form of any good that you choose. What form, besides dollars, would you chooses to utilize to make the interest payments? (Specify)

_____

31. If you would be willing to participate in a program which gave the future interest payments in the form of any good that you choose, how many bonds would you purchase?

____ dollars worth

32. Who or what would you want to receive the interest payments (in the form of your chosen good)?

_____

The respondents level of religious conviction is ascertained in the following question regarding the intensity of his/her religious predilections:

33. A. Are you

___very religious
___religious
___slightly religious
___agnostic
___atheist
___other, (specify)_____

B. If you are religious, what religion are you?

_____

34. What statement best describes your feelings about the future:

____ the end of the world is near, so we do not have to worry about taking care of future generations.

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____ it is our destiny to utilize the planet as we need to; we should not worry about the future as the future will take care of itself.

____ it is our duty to take care of the earth for future generations.

Economic theory indicates that income may be an explanatory variable of far future valuation, as well as other socio-economic factors. Therefore the survey instrument includes questions regarding political leanings, past, present and expected economic status, age, education, and education of the respondent's parents or guardians. Political orientation is gathered via the following question:

35. Politically, do you consider yourself to be
____ very liberal
____ liberal
____ moderate
____ conservative
____ very conservative
____ other (specify)_____

Educational achievement is recorded in the following question:

36. What is the highest level of education that you have obtained?
____ less than grade school
____ grade school
____ high school
____ more than one year of college
____ Bachelor's degree
____ advanced degree

In addition, a question is included to document any special experiences that influence the method by which the respondent views impacts to future generations:

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37. A. Did any of your childhood or religious experiences give you a way to look at events occurring to future generations?

____ yes ____ no

B. If yes, please explain (use back of sheet if necessary):

Income is addressed in the next three questions. Since, economic theory suggests that permanent income is an important determinant of consumption behavior, these inquires are in regards to past, present, and future income.

38. How would you describe the economic status of your upbringing?

____ very poor
____ poor
____ lower middle income
____ middle income
____ upper middle income
____ wealthy
____ very wealthy

39. What do you consider your present economic status to be?

____ very poor
____ poor
____ lower middle income
____ middle income
____ upper middle income
____ wealthy
____ very wealthy

40. What do you expect your future economic status will be?

____ very poor
____ poor
____ lower middle income
____ middle income
____ upper middle income
____ wealthy
____ very wealthy

In order to determine some of the characteristics of the respondent's upbringing, he/she is asked to provide the

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education level achieved by one or more parents or guardians.

41. What was the highest education level obtained by one or more of your parents (guardians)?
    ____ less than grade school
    ____ grade school
    ____ high school
    ____ more than one year of college
    ____ Bachelor's degree
    ____ advanced degree

As was discussed in Chapter IV, a persons concern or level of valuation for the future may be shaped by whether or not the individual has or plans to have children. The existence of such motivation is obtained in the following two questions:

42. How many children do you have? ____

43. If you do not have children now do you plan to have children?
    ____ yes ____ no

The respondent's age is determined in question 44.

44. What is your age? ____ years

The last question provides the respondent with the opportunity to comment on the survey.

45. If you have any comments about this survey, please feel free to indicate them in the space below and on the back of the sheet if necessary. Thank you for your help in this project.

Sampling Technique

Two separate samples were used to obtain survey data. The first group surveyed were undergraduate economic

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principles students at the University of Wyoming. Data was collected from 147 economic students in April of 1986. Due to the obvious drawbacks of basing results on such an extreme sample, data was also collected from a non-student group in Chicago Illinois. The later group consisted of 60 office workers. This survey was conducted in October of 1985. Differences in the results between the two groups are discussed in Chapter VII.

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Chapter VII

Results of the Survey Analysis

In this chapter the results derived from this analysis and the contingent valuation survey are presented. Estimates of near and far future discount rates are derived in order to address the hypotheses developed in Chapter IV. In addition, the chapter contains a critique of the experiment and some suggestions and guidelines for future work.

Summary of Raw Survey Results

Completed surveys were returned from a total of 207 respondents. Of this number 60 surveys were completed by the Chicago sample and 147 were from the Wyoming sample. In Table IIIa, results are reported for each question. Results for the 500-year sample are reported for the contingent bond market section. Table IIIb contains the corresponding results for the 200-year market. For those questions with response distributions that are continuous, only the mean and number of responses are reported.

Individual Sample Characteristics

Obviously, considerable differences exit between the two samples utilized in this analysis. The larger sample of

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Table IIIa

Summary of Results of Valuation Survey

1. Do you think today's society will leave the future generally better or worse off than we are today?

106	generally better off
60	generally worse off
36	don't know

2. In what ways will future society be better off? (Check all that apply.)

193	more knowledge	39	improved spiritual outlook
40	more resources	50	improved values
26	less chance of war	155	better health
		119	more goods and services
25	other 1 (specify) 18 ways		
1	other 2 (specify) 1 way		

3. In what ways will future society be worse off? (Check all that apply.)

132	fewer resources	86	deterioration of values
102	greater chance of war	124	overcrowded
63	deterioration of spiritual outlook	26	fewer goods and services
		41	famine
23	poorer health	137	spoiled environment
11	other 1 (specify) 10 ways		
3	other 2 (specify) 3 ways		

4. How long do you believe society will continue to be at least as well off as today?

44	10 years	4	10,000 years
61	25 years	2	1,000,000 years
47	100 years	14	forever
10	1,000 years	19	other (specify)_____years

5. How long do you believe mankind will continue to inhabit the earth?

2	10 years	38	10,000 years
4	25 years	18	1,000,000 years
13	100 years	44	forever
37	500 years	3	other (specify)_____years
31	1,000 years		

6. In what manner do you believe mankinds's existence on the earth will cease or be sharply reduced? (Check all that apply.)

75	return of the Lord	75	environmental pollution
116	nuclear holicaust	70	lack of resources
48	famine	17	none, mankind will exist forever
43	disease		
22	other (specify) 15 manners		

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7. Is the world a better place for mankind than it was

100 years ago?	168	yes	36	no
50 years ago?	165	yes	36	no
10 years ago?	132	yes	68	no

8. Is mankind better off now than

100 years ago?	172	yes	30	no
50 years ago?	165	yes	33	no
10 years ago?	133	yes	64	no

9. Assuming no inflation, which of the following alternatives would you prefer to receive in <u>each</u> set?

Set 1:	30	$100 today	or	167	$5,000	10 years from now
Set 2:	43	$100 today	or	149	$2,000	10 years from now
Set 3:	72	$100 today	or	118	$1,000	10 years from now
Set 4:	126	$100 today	or	64	$ 500	10 years from now
Set 5:	162	$100 today	or	30	$ 250	10 years from now
Set 6:	179	$100 today	or	12	$ 150	10 years from now

10. Complete this statement: Assuming no inflation, I would be just as happy receiving $50 today as I would be if I received $_____ five years from now. $354.47 (mean, of 195 responses)

11. The price of oil has fallen significantly in recent months. As a result, gasoline prices are lower and people are using more petroleum. Over the long term, low petroleum prices will stimulate demand and significantly decrease the amount of petroleum available for future generations. Would you be in favor of increasing the price of petroleum, perhaps through a tax, so as to preserve supplies for future generations?
    106 yes 100 no

12. A. Do you think that today's society should explicitly consider the impacts of its actions on future society when determining our present course of action?
    185 yes 20 no

    B. If your answer to the last question was yes, why should we worry about future generations? (Check all that apply.)
    137 It is our ethical and/or moral duty.
    63 It is our religious duty.
    135 It is our duty to our descendants
    38 Other 1 (specify) 27 reasons
    0 Other 2 (specify)_____

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C. If your answer to question 12A was yes, how should impacts on future generations be considered in our present decisions? Suppose for example, that we are considering a course of action that will cause future society to spend an extra $1,000 in today's dollars. How should this impact be considered in our present decision? (Choose the one which applies.)

80 It should be considered at the same magnitude as if this impact was happening to ourselves today.

56 It should be considered at a magnitude which is smaller than the magnitude which would apply today but at the same magnitude as it this impact was happening to ourselves in the future.

13 It should be considered at a magnitude which is smaller than the magnitude we would apply if this impact were to occur to ourselves in the future.

32 It should be considered at a larger magnitude than if this impact was happening to ourselves today.

13. Rank the six most important things to you in the following list. (1 being highest, 6 being the lowest.)

1	2	3	4	5	6	
20	18	26	13	19	6	the availability of a clean environment for present society
7	23	11	29	15	20	the availability of a clean environment for future generations
55	21	19	14	8	6	peace for contemporary society
22	39	23	21	18	15	peace for future society
14	7	20	17	18	4	education for contemporary society
0	16	18	20	12	34	education for future society
18	5	9	5	13	5	a high level of contemporary religious values
7	14	8	5	6	10	a high level of religious values for future society
2	3	3	7	12	9	contemporary goods and services
1	3	4	9	7	10	goods and services for future society
3	8	14	8	15	22	the welfare of future society
0	1	2	8	3	3	the availability of goods and services for your grandchildren
0	15	8	7	10	7	the welfare of your grandchildren
3	7	5	9	7	13	the availability of goods and services for your children
39	12	19	16	18	11	the welfare of your children
0	0	0	1	6	7	the availability of goods and services for your distant descendants
0	0	2	1	2	8	the welfare of your distant descendants

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The following is a series of questions in which you are asked to choose between two alternatives. There are seven questions in all.

14. Would you consider yourself to be better off under state A or state B?
    A. 117 the chance of nuclear war is reduced 10%.
    B. 89 you received a new car.

15. Would you be better off in state C or state D?
    C. 131 fewer natural resources are used today so that more resources are preserved for future society.
    D. 75 people become more religious.

16. Now consider your answers for the above two questions; would you be better off under:
    E. 96 your answer to question 14 (A or B).
    F. 110 your answer to question 15 (C or D).

17. Would you be better off in state G or H?
    G. 99 more goods and services were available for society's consumption today.
    H. 106 more goods and services were available for future society.

18. Would you be better off in state I or state J?
    I. 107 more emphasis was placed on pollution control today.
    J. 99 the moral fiber of contemporary society was improved.

19. Now consider your answers to the last two questions, would you be better off under:
    K. 47 your answer to question 17 (G or H).
    L. 158 your answer to question 18 (I or J).

20. Finally consider your answers to question number 16 and question number 19. Would you be better off under:
    M. 98 your answer to question 16 (state A B C or D).
    N. 101 your answer to question 19 (G H I or J).

21. Rank in order the four most important things to you. That is, what four things make you feel most well off or satisfied with life?

    First: 195 respondents 41 answers

    Second: 193 respondents 43 answers

    Third: 188 respondents 55 answers

    Fourth: 172 respondents 57 answers

(Questions 22 - 31 contain responses for the 500-year game only. Answers to the 200-year game are presented in Table IIIb.)

22. Suppose that it was possible to purchase a $1 bond which pays $1 per year forever, the first payment of which is distributed in 500 years to the recipients or causes of your choice.

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Would you be interested in purchasing any of these bonds?
60 yes 46 no

23. If your answer to question number 22 was yes, how many bonds would you purchase? (You may choose any dollar amount)
$188.88 (mean of 57 reponses)

24. If your answer to question number 22 was yes, who or what would you want to receive the interest payments? (Specify)

57 respondents chose 14 different recipients

25. If your answer to question number 22 was no, that is you do not want to purchase any of the bonds, is it because

6 you have no desire to transfer money to the future.
11 money will not solve the future's problem.
29 you do not believe that such a program could work.

11 other(specify) 10 reasons.

26. If you checked the third box above (i.e., you do not think that the program could work) would you be likely to participate in the program if it was government guarenteed?

9 yes 27 no

27. If you checked yes to the above question, how many bonds would you be willing to purchase? (You may choose any dollar amount.)
$ 44.63 (mean of 8 responses)

28. If you checked yes to question 26, who or what would you want to receive the interest payments? (Specify)

4 respondents chose 1 recipient

29. A. Suppose that instead of money payments, the interest was paid out (after 200 years) in the form of anything you choose, (i.e., clean air, education, hot dogs, religion, etc.) would you be willing to participate?
76 yes 27 no

B. Would you prefer this type of payment mechanism over one that utilized money payments?
64 yes 35 no

30. If you would be willing to participate in a program which gave the future interest payments in the form of any good that you choose. What form, besides dollars, would you choose to utilize to make the interest payments? (Specify)

78 respondents chose 26 methods

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31. If you would be willing to participate in a program which gave the future interest payments in the form of any good that you choose, how many bonds would you purchase?
    $257.10 (mean of 69 responses)

32. Who or what would you want to receive the interest payments (in the form of your chosen good)?

    72 respondents chose 17 causes

33. A. Are you
    - 14 very religious
    - 94 religious
    - 78 slightly religious
    - 11 agnostic
    - 4 atheist
    - 1 other, (specify) _____

    B. If you are religious, what religion are you?
    164 respondents chose 21 different religions

34. What statement best describes your feelings about the future:

    - 3 the end of the world is near, so we do not have to worry about taking care of the world for future generations.
    - 23 it is our destiny to utilize the planet as we need to; we should not worry about the future as the future will take care of itself.
    - 176 it is our duty to take care of the earth for future generations.

35. Politically, do you consider yourself to be
    - 2 very liberal
    - 26 liberal
    - 101 moderate
    - 57 conservative
    - 8 very conservative
    - 8 other (specify) _____

36. What is the highest level of education that you have obtained?
    - 0 less than grade school
    - 2 grade school
    - 43 high school
    - 113 more than one year of college
    - 28 Bachelor's degree
    - 17 advanced degree

37. A. Did any of your childhood or religious experiences give you a way to look at events occurring to future generations?
    81 yes 119 no

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B. If yes, please explain (use back of sheet if necessary):
55 respondents gave 26 different experiences

38. How would you describe the economic status of your upbringing?
1 very poor
11 poor
53 lower middle income
68 middle income
61 upper middle income
8 wealthy
2 very wealthy

39. What do you consider your present economic status to be?
11 very poor
23 poor
30 lower middle income
72 middle income
61 upper middle income
6 wealthy
1 very wealthy

40. What do you expect your future economic status will be?
2 very poor
2 poor
4 lower middle income
50 middle income
102 upper middle income
32 wealthy
10 very wealthy

41. What was the highest education level obtained by one or more of your parents (guardians)?
8 less than grade school
63 grade school
33 high school
56 more than one year of college
43 Bachelor's degree
4 advanced degree

42. How many children do you have? .75 (mean of 202 responses)

43. If you do not have children now do you plan to have children?
117 yes 25 no

44. What is your age? 28.1 years (mean)

45. If you have any comments about this survey, please feel free to indicate them in the space below and on the back of the sheet if necessary. Thank you again for your help in this project.
42 respondents had 17 different comments

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Table IIIb

Specific Answers to the 200 Year Game

22. Suppose that it was possible to purchase a $1 bond which pays $1 per year forever, the first payment of which is distributed in 200 years to the recipients or causes of your choice.

Would you be interested in purchasing any of these bonds?
57 yes 44 no

23. If your answer to question number 22 was yes, how many bonds would you purchase? (You may choose any dollar amount)
$189.33 (mean of 49 responses)

24. If your answer to question number 22 was yes, who or what would you want to receive the interest payments? (Specify)

49 respondents chose 13 recipients

25. If your answer to question number 22 was no, that is you do not want to purchase any of the bonds, is it because

6 you have no desire to transfer money to the future.
17 money will not solve the future's problem.
22 you do not believe that such a program could work.

13 other(specify) 10 reasons.

26. If you checked the third box above (i.e., you do not think that the program could work) would you be likely to participate in the program if it was government guarenteed?

7 yes 19 no

27. If you checked yes to the above question, how many bonds would you be willing to purchase? (You may choose any dollar amount.)
$ 42.14 (mean of 7 responses)

28. If you checked yes to question 26, who or what would you want to receive the interest payments? (Specify)

5 people chose 2 recipients

29. A. Suppose that instead of money payments, the interest was paid out (after 200 years) in the form of anything you choose, (i.e., clean air, education, hot dogs, religion, etc.) would you be willing to participate?
69 yes 27 no

B. Would you prefer this type of payment mechanism over one that utilized money payments?
55 yes 38 no

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30. If you would be willing to participate in a program which gave the future interest payments in the form of any good that you choose. What form, besides dollars, would you choose to utilize to make the interest payments? (Specify)

    72 chose 22 methods of payment

31. If you would be willing to participate in a program which gave the future interest payments in the form of any good that you choose, how many bonds would you purchase?
    $266.34 (mean of 61 responses)

32. Who or what would you want to receive the interest payments (in the form of your chosen good)?

    71 people chose 14 different recipients

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147 economics principles students at the University of Wyoming contains predictable differences from the Chicago sample of 60 office workers. Significant differences exist in age, income, number of Children, and education. The mean age of the Wyoming sample was 21.6 while the average age of the Chicago group was 43.7 years. An overwhelming majority of the Chicago sample (96.7%) described their present income status as middle income or higher, this was substantially greater than the perception of college students among whom 43% described their present financial status as lower middle income or poorer. The student group had a predictable average number of children of only .2, far surpassed by the office workers average 2.1 children. Education levels differed substantially; 68.3 percent of the white collar workers had at least a Bachelor's degree while 97.2% of the economics principles students had the predictable one year or less of college.

However, for many of the characteristics considered significant for purposes of this dissertation, remarkable similarities exist. The students were only slightly more pessimistic regarding the condition in which present society will leave the future. More than half (59.3%) of the Chicago group felt that the future would be left better off. This percentage was slightly smaller for the Wyoming sample where less than one half (49.7%) felt that the future would be left better off. Nearly identical percentages, 18.2 and

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16.9 in the Wyoming and Chicago groups respectively, replied that the future status was uncertain.

Similarities between the two groups were prevalent across all of the questions which asked how the future would be better or worse off. Virtual agreement existed on the state of the world and the state of mankind for the past 100, 50 and 10 years. In each and every case, the difference between the student and office worker sample varied by less than six percent. In fact, in three of these scenarios, the difference was less than 2%. Further evidence of future valuation among both sample groups is presented later in this chapter.

Even expected future income levels were not that different. Chicago respondents predicted that their future financial status would be middle income or better in 93.1% of the cases while the corresponding figure for the student sample is 97.1%.

Utility Discount Rates

One of the estimates of an individual's utility discount rate developed in this analysis was derived by presenting respondents with a series of six alternative choices between contemporary and future sums of money. In each of these question the respondent was asked whether they preferred to have $100 now or an alternative amount in 10 years. The latter amount was 5000, 2000, 1000, 500, 250 and

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150 dollars in each question, respectively. By observing which amounts the respondent would and would not prefer, a discount rate was derived. For purposes of identification, this rate shall be called rate1. It should be noted that rate1 is only a neighborhood estimate of the intrapersonal discount rate because of the discontinuity of the choices presented to the respondent. This rate is able to take on values of 47.9, 41.4, 30.4, 21.9 13.6, 6.9 and 4.1 percent, respectively, depending on which of above amounts that the respondent chooses in place of $100 today.

In actuality, while 47.9 and 4.1 percent indicate the exact discount rate implied by comparison of 100 today versus $5000 and $150 in 10 years, respectively, the other rates represent the midpoints between the ranges. The midpoint is utilized because it is impossible to determine the exact rate from the discontinuous choices offered in the survey. For example, if a respondent replies that they prefer $5000 in 10 years to $100 today and that they also prefer $100 today to $2000 in 10 years, then all that can be determined from this information is that his/her implicit discount rate is between the rates implied by these figures. That is, the actual rate must be between 47.9% and 34.9%. Thus for purpose of analysis the relevant rate is considered to be the midpoint of these two rates, i.e. 41.4%. For the same reason the rate for the endpoints of the survey choices must also be lower and upper bounds respectively. If a

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respondent chooses a contemporary payment of $100 in all cases one can only say that his intrinsic discount rate is no less that 47.9%.; a consistent choice of the larger dollar figure ten years hence indicated time preference of less than 4.1%.

Values for rate1 are presented in Table IV. In the first column, the ranges implied by the various choices are presented. While the question specifically asks respondents which choice is preferred between two monetary sums, one can not rule out the possibility of indifference and thus all ranges include the endpoints. In the second column various values for rate1, the pseudo mean, are presented. The third, fourth, and fifth columns contain the number of observations for each choice of rate1 in the total, Wyoming and Chicago groups, respectively. In general the distributions are bell shaped with slightly lower rates in the Chicago sample. Note that of the 180 respondents from whom information was determined, the mode was 21.9% while the median and mean were 22.2 and 25.7 percent, respectively. Rate1 for the Wyoming sample had a median of 22.6 and a mean of 25.8. The Chicago sample ran somewhat predictably more conservative with a median of only 16.9% and a mean of 21.9. The mode for the Chicago sample was 13.6% while the Wyoming mode was 21.9%. The mode for the total sample was also 21.9%.

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Table IV

Determination of Rate1

Range (Percent)	Rate1 (Percent)	Number of Observations: Total Sample	Wyoming	Chicago
$r \geq 47.9$	$\bar{r} \geq 47.9$	23	15	8
$47.9 \geq r \geq 34.9$	41.4	17	16	1
$34.9 \geq r \geq 25.9$	30.4	28	22	6
$25.9 \geq r \geq 17.5$	21.9	54	43	11
$17.5 \geq r \geq 9.6$	13.6	33	17	16
$9.6 \geq r \geq 4.1$	6.9	16	6	10
$4.1 \geq r$	$4.1 \geq \bar{r}$	9	9	0
	Total	180	128	52

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A test between the means of the two samples was unable to reject the null hypothesis that the means are equal at the 5% level of significance. However, it should be noted that since the distribution is not continuous, utilization of a test procedure via parameters derived for the normal distribution is not fully appropriate.

A second estimate of the respondent's discount rate was derived to provide a means to gain insight into the consistency of individual discount estimation capabilities. This rate is termed rate2. Rate2 was obtained by asking people to directly propose the value that they would accept in five years to be indifferent to $50 today. Because of the continuous nature of this distribution, rate2 has wider variability than rate1 and ranges from a low of 0% to a high of 188.5%.[79] This is also the range for the Wyoming sample. The Chicago group was predictably more conservative with an upper bound on the range of 120.3%. The median and mean values for rate2 were 15.0 and 33.6 percent respectively. The corresponding median and mean values for the Wyoming were 17.8 and 37.3 percent and for Chicago were 14.9 and 24.6 percent. A test of means revealed a marginal

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[79]One individual actually had a discount rate of <u>negative</u> 27.5%! This respondent, a resident of the Windy City, offered to exchange a guaranteed $10 in five years for $50 today.

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difference between the two samples at the 1% level of significance.

Interpersonal consistency between rate1 and rate2 was evaluated through the creation of an index.[80] This index was calculated as the ratio of rate2 to rate1. Sample values for this index ranged from 0 to 3.69 with the mode equal to 0 and the median and mean equal to 1.09 and 1.61 respectively. Consistency was also evaluated via a simple test of means of the two distributions for rate1 and rate2. As expected, the two distributions differ significantly with with a mean difference of 11.7%.[81] The source of this difference is indeterminable from the survey structure. It may be due to the inherent discontinuity of rate1, or the existence of a non logrithmically-linear structure of discount mappings, or both.

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[80]It must be noted that idea of checking for consistently between the two logarithmically derived rates must be questioned. If one is not convinced that the level of general interest rates should not provide a boundary for intrapersonal discount "rates", then it is difficult to presume why the functional form of logarithmically linear rates should prevail as well.

[81]In fact the higher mean is for the shorter time horizon, contrary to the prevalent monotonically increasing yield curves for financial instruments.

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In general, the rates derived from the survey do appear to be more than roughly consistent. Furthermore they appear to be consistent with results derived in other studies.[82]

Many economists would argue that the observed discount rates are too high, especially when one considers the fact the sample questions were designed to exclude an inflation premium. This argument holds that the individual utility discount rate should be nearer to market rates. Theory suggests that with a perfectly functioning capital market, individuals will enjoy unhampered access to the capital market at a single interest rate for borrowing and lending. This access provides a means for the individual to arbitrage differences between utility discount weights and market interest rates. With diminishing marginal utility, individuals participate in the intertemporal market until market and intrinsic time preference are equalized.

However, this representation is far from reality. Capital markets, especially at the individual level are far from perfect. Transactions costs drive a substantial wedge between lending returns and borrowing costs. Many individuals with a poor or non-existent credit history have only one-way access to this market -- they can lend but not borrow. Other high-risk individuals are able to borrow only

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[82]See Hausman (1979).

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if they pay rates substantially above the rates paid by low-risk individuals and corporations.

For these reasons, it should come as no surprise that the average discount rate observed in the samples utilized in this analysis substantially exceed market interest rates. Furthermore, based upon the lower incomes and absence of a credit history for most college students, the average rate in the Wyoming sample should exceed the mean rate prevailing for the Chicago group.

Evidence of Support for Hypothesis

Recall that the first hypothesis described in Chapter IV was that the provision of far future public goods is important to individuals. That is, the provision of public goods to future generations is a component of peoples' utility functions.

Analysis of the survey data strongly indicates support for this hypothesis. Of the 206 respondents who replied to this question, 51.5% (106) felt that the price of oil should be artificially raised in order to preserve supplies for future generations.[83] The individual groups were somewhat divided on this notion; only 41.7% (25) percent of the Chicago sample was in favor of the tax while 55.5% (81) of

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[83]One observation was missing from the Wyoming sample.

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the students supported it. Still, this difference does not seem that great when one considers the disparity in the character of the two samples. In either event however, very strong support is indicated for the first hypothesis.

The question of whether or not present society should explicitly consider the impacts of its actions on future generations was affirmatively answered by 90.2% (185) of the respondents. The apparent gap in group attitudes towards future valuation from the oil tax question gap disappeared as 91.0% (132) of the Wyoming group and 88.3% (53) of the Chicago sample agreed that impacts should be considered.[84]

Other evidence of future valuation can be gleaned from the rating questions as well. In the question where the respondent was asked to rank the six most important things from a list of seventeen choices of present and future goods, future public goods were very popular. The most popular future public good was peace which was selected by 66.7% (136) respondents. The second and third most popular future public goods were a clean environment with 51% (105) and education with 47.5% (100) of the respondents selecting them. Future general welfare was the fourth most popular public good followed by future religion. These goods

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[84]Two observations were missing; both from the Wyoming sample.

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received 33.8% (70) and 24.2% (50) placements in the top six rankings, respectively.

In the second set of rating questions, respondents were asked to make pair-wise comparisons of eight choices. In this group, the second most popular selection was the reduction in present consumption of natural resources so that supplies are preserved for future generations.

Finally, evidence of far future valuation is yielded by the fact that a substantial number of respondents offered to make transfers to the far future in the contingent markets of the survey. The original game generated a positive bid from 52.2% (109) of the respondents while the government sponsored game and the in-kind game achieved positive participation from 7.2% (15) and 68.6% (142) of the respondents, respectively.

From these answers it would appear that the availability of future public goods is a component of the utility function of most individuals. Thus support is rendered for the first hypothesis of this dissertation.

The third major hypothesis developed in Chapter IV was that individuals have a different time preference for far future public goods than they do for consumption levels of goods in the near future. Evidence in support of this hypothesis was received from the 185 respondents who felt that future impacts of contemporary decisions should be explicitly considered. These respondents were then asked

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how future impacts should be considered in present decisions.

An astonishing 17.7% (32) advocated behavior consistent with a negative discount rate for far future impacts. These respondents stated that future impact should be considered at a larger magnitude than if this impact was happening to ourselves today. In the most common response, 44.2% (80) of the sample believed that any future impact "should be considered at the same magnitude as if this impact was happening to ourselves today." Thus these persons believe that a zero discount should apply to such impacts. That is, a future impact is valued as if the "time window" yielded perfect (undistorted) images.

The second most common response, that the impact "should be considered at a magnitude which is smaller than the magnitude which would apply today but at the same magnitude as if this impact were happening to ourselves in the future" garnered 30.9% (56) of the responses. Such a response is consistent with a discount rate for far future public goods which is greater than zero but less than the rate applicable to the near future. In this case future impacts are discounted, but the time window provides better views of far future events than it does to near future events.

Only 7.2% (13) of the sample believed that the impact "should be considered at a magnitude which is smaller than

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the magnitude we would apply if this impact were to occur to ourselves in the future." This latter answer does not rule out the possibility that far future vision is less distorted than the views provided of the near future. However, it also would support behavior consistent with an equal capability for far future and near future vision as well as far future capabilities inferior to near future vision.

These outcomes are summarized in Table V. Table V also includes a breakdown by sample. Consistent with the designation afforded the two discount rates in the earlier chapters, the rate over near future events is labeled r while the corresponding rate for far future occurrences is δ.

A second and perhaps more critical example of support for the third hypothesis lies in the fact that no significant differences exist between the outcomes of the 200-year contingent game and the 500-year contingent game. This sample was characterized by a few outliers that skewed the comparison between the two games.[85] However if all bids above $1000 are removed from the sample, the mean bid of

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[85]For the original transfer question, these outliers both occurred in the 200 year game where two respondents bid in excess of $10,000 -- a full order of magnitude above the next closest bid. More outliers were observed in the in-kind scenario; the 200-year game was characterized by 5 bids in excess of $10,000 while the 500-year game had 3 such bids.

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Table V

Summary of the Implication of Replies to

"How should future impacts be considered?"

	$\delta < 0$	$\delta = 0$	$0 < \delta < r$	$0 > r ? \delta$
Chicago	18.9%	37.7%	41.5%	1.9%
	(10)	(20)	(22)	(1)
Wyoming	17.2%	46.9%	26.6%	9.4%
	(22)	(60)	(34)	(12)
Total	17.7%	44.2%	30.9%	7.2%
Sample	(32)	(80)	(56)	(13)

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those who bid was $188.88 for the 500-year game and $189.33 for the 200-year scenario. A two tailed test for differences in means revealed that the null hypothesis that the means are equal can not be rejected.

Under the government sponsored program mean bid was $44.63 for the 500-year game and $42.14 for the 200-year game. A t-test for differences in the means of the two bids yielded acceptance of the null hypothesis that the two means are equal. It should be noted that the opportunity to participate in the government-sponsored program was only afforded to those individuals who declined to participate in the original program and who "do not believe that such a program could work." Recall that the purpose of asking this question was to attempt to alleviate the respondent's fear regarding the lack of a guarantor for the program. Since these individuals were already reluctant to participate in such a transfer mechanism it should be expected that the mean bid should be smaller than the mean bid of those who offered to participate without a government guarantee.

In-kind payments were the most popular among the respondents. The mean in-kind bid under the 500-year game was $257.01 while the corresponding bid for the 200-year game was $266.34. A two-tailed test for differences in the sample means was unable to reject the null hypothesis that the sample means were equal.

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The number of respondents choosing to participate was also consistent between the 500 and the 200-year games. Of the 106 persons who received the 500-year game, 53.8, 7.5 and 65.1 percent bid a non-zero amount in the standard, government-sponsered and in-kind questions respectively. The corresponding figures for the 101 persons who received the 200-year game was 48.5, 6.9 and 60.4 percent respectively.

A near identical distribution of reasons for not participating in the original game was given by the respondents in the 200 and the 500-year games. Exactly the same number of respondents, 12.2% (6),in each game stated that they had "no desire to transfer money to the future." Slightly more individuals in the 200 year game agreed with the statement that "money will not solve the future's problem." This amount was 34.7% (17) as compared with 22.4% (11) in the 500 year game. Slightly more individuals believed that the program can not work in the 500-year game, 44.9% (22) versus 59.2% (29) in the 200-year game.

Since no significant difference exists between the bids for the 500-year and the 200-year game and given the fact that the number of respondents who choose to participate was nearly identical in each case, it would seem that the time frame is not a determining factor. Evidently, the fact that the perpetual interest payments do not begin for either 200 or 500 years has little or no impact on respondents desire

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to ensure a better future. Thus it can be concluded that the observed rate of discount occurring between the two observations, 200 years and 500 years, is zero. Since this rate is lower than the rate observed for near term interpersonal monetary tradeoffs, $\delta < r$ as hypothesized in the third hypothesis developed in Chapter IV.

Recall that the fourth hypothesis was that valuation of far future public goods could be determined by the maximum intensity of one of three factors. These factors were related to religious, ethical and descendant-related concern for the future. This hypothesis was examined by first asking whether or not impacts arising to the future should be considered in society's present activities. Those respondents that answered affirmatively were then asked the subsequent question "Why should these impacts be considered?" Respondents were offered religious,ethical and descendant-related choices as well as the opportunity to supply their own reason(s). The specified categories captured the bulk of the responses. The most popular response, ethical motivation, captured 66.2% (137) of the responses. This was followed closely by descendant-related motivation which garnished 65.2% (135) of the responses. Religious motivation was cited by 30.4% (63) of the respondents. Other reasons to value the far future were supplied by 20.4% (38) of the sample. Most of these reasons were given by people who also checked one or more of the

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ethical, religious and descendant-related reasons; only 5.9% (11) offered an alternative without also checking one or more of these reasons. In total, 27 alternative justifications for future valuation were supplied. In fact however, many of these other reasons could be interpreted to fall in the ethical, religious or descendant-related categories.[86] Table VI indicates the amount of overlap between the answers received to the question "why should we worry about future generations?" Note that this table provides a more sophisticated representation of the data than can be obtained from Table III.

How many of these respondents offered to put their money where their mouth is? Table VII provides a cross-tabulation of the motivation for future concern by the level of bid in the in-kind game. This table contains the responses of 88.7% (126) of those who bid a positive amount in the in-kind game.[87] Ethical, religious, and

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[86]For example, reasons such as "we have to be considerate," "society is better off to consider the long run," and "they deserve what we have" all of which were offered as alternatives by the respondents and would indicate strong moralistic and possibly religious or descendent-related concern.

[87]Missing are 16 non-zero bids from individuals who did not answer the motivation question or who did not believe that future impacts should be considered.

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Table VI

Summary of Replies to

"Why should we worry about the future?"

MOTIVATION

Row Total	Ethical	Religious	Descendants	Other
Column Total	137	63	135	38
26	Yes	No	No	No
4	No	Yes	No	No
27	No	No	Yes	No
2	No	Yes	Yes	No
41	Yes	No	Yes	No
3	Yes	Yes	No	No
0	No	Yes	Yes	Yes
8	Yes	No	Yes	Yes
2	Yes	Yes	No	Yes
5	Yes	No	No	Yes
0	No	Yes	No	Yes
5	No	No	Yes	Yes
11	No	No	No	Yes
45	Yes	Yes	Yes	No
7	Yes	Yes	Yes	Yes
186*				

*18 Not Applicable, 3 No Answer

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Table VII

Summary of Replies to

"Why should we worry about the future?"

Cross-tabulated by Bid Level in the In-kind Game.

Motivation					Bid Level		
Total	Ethical	Religious	Descendants	Other	High (Bid≥$500)	Median ($500>Bid>0)	Zero (0)
20	Yes	No	No	No	4	11	5
3	No	Yes	No	No	0	1	2
25	No	No	Yes	No	5	15	5
2	No	Yes	Yes	No	1	1	0
37	Yes	No	Yes	No	5	20	12
2	Yes	Yes	No	No	0	0	2
0	No	Yes	No	No	0	0	0
8	Yes	No	Yes	Yes	3	5	0
2	Yes	Yes	No	Yes	0	2	0
4	Yes	No	No	Yes	0	3	1
0	No	Yes	No	Yes	0	0	0
3	No	No	Yes	Yes	0	2	1
11	No	No	No	Yes	2	5	4
42	Yes	Yes	Yes	No	11	23	8
7	Yes	Yes	Yes	Yes	0	7	0
162*					31	95	40

*Includes only those who answered the motivation questions and who also played the in-kind game.

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descendent-related concern is correlated with 83.8% (119) of those bidding a positive amount.

It is interesting to note that the most common recipient in each game was the respondent's descendants. The second most common response was society as a whole. Obviously, the fact that descendants are a popular recipient strongly indicated decendent-related motivation while transfers to all of society are more consistent with religious or moralistic concerns.[88] Thus

Recall that the fourth hypothesis also predicted the magnitude of future-related concern. The outcomes provided a 27 cell matrix with individual cell values of high, median, and zero based on the degree of intensity of the underlying motivation. Unfortunately such a refined prediction of magnitude is not obtainable from the question which generated Tables VI and VII. In fact, because of difficulties in interpreting the degree of descendant related and ethical related concern, only a 0-1 rendition is possible based on the results of this survey. Essentially, the problem in the descendant and ethical area is that no method was established to measure intensity. Similar

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[88]Presumably since many of the transferred goods are public, there is the possibility of intergenerational free rider activity; and thus an individual may make a transfer to "society as a whole" out of motivation to help his/her descendants.

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problems may characterize religious-related future concern, however respondents were asked to state how religious they were.

Respondents who either have children or plan to have children were found to exhibit no difference from those respondents who both do not have children and do not plan children as far as responses to the oil tax question are concerned. Of those voting for the oil tax 82.9% had or plan children the corresponding figure for the opponents to the tax was 82.5%.

A slight correlation was found between a respondent's self described religiousness and the the degree of future-related concern. For those who describe themselves as slightly religious, 51.3% also supported the notion of raising contemporary oil prices. Of the subsample that described themselves as religious or very religious this figure was 54.2% Only 40% of the group of atheists or agnostics were likely to support increased oil prices to curb present consumption. Religious individuals were also more likely to make contingent transfers to the future.

Critique and Suggestions for further work

Many problems were encountered in this analysis due to the length and complexity of the survey instrument. One must conclude that the ideal instrument should be shorter and perhaps not so ambitious. Better explanations of

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direction and clearer questions would improve the reliability of the outcomes.

Better definition of terms would improve reliability. For example, one term, "future generations," which was extensively utilized in the survey to indicate the far future, may have different meanings to different people. Some individuals may associate this term with time periods in excess of 100 years distant while others may apply a more immediate interpretation.

Reliance on two separate and possibly non representative groups should be questioned; in an ideal study the sample would be more random. This would provide more representative results.

Further problems surround the bids obtained in this analyses. It is not possible, based on this single experiment to ascertain their relevance. Replicability of the results is unknown. Structurally the bids revealed for future values may be improved by introducing (or reminding respondents of) the notion of the budget constraint and requiring respondents to identify the contingent opportunity cost of their bids.

Certainly the area of intrapersonal time preference should be explored further. An experiment to evaluate the consistency of intrapersonal discount rates should be better structured. An improvement would be to not presume the structure of discounting behavior as well as the level of

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discount rates. Given the apparent disparity in the rates from market levels there appears to be reason to question the applicability of logarithmically linear structure as well.

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Chapter VIII

Conclusions and Policy Implications

The results of this experiment have provided strong evidence that individuals value far future impacts. Individuals would seem to advocate contemporary behavioral changes in order to avoid negative impacts on future generations. This value would appear to be motivated by ethical, religious, and descendant-related concerns.

The major conclusion of this experiment was in regards to the relative values of individual discount rates applied to the near future and the far future. Evidence from the experiment indicates that individuals exhibit a discount rate for far future public goods which is smaller than the discount rate by which they value intertemporal consumption over the relatively near future.

Consequences of $\delta < r$

The implications of an individual's near future discount rate (r) exceeding the discount rate applicable to far future impacts (δ) are important. This implies that while people may be comfortable with reducing the effective magnitude of future impacts due to the passage of time, they are not willing to do so as much as if this impact was occurring over the passage of time in their own lifetime.

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As is apparent from the analysis contained in this dissertation, a zero rate rate of discount would seem to be appropriate for assessing the impact of man's present actions upon the far future. This would indicate that individuals believe that future impacts should be considered as if these impacts were occurring in the present. In practice this means that the future is considered to be just as important as is the present. This type of behavior is consistent with a Utilitarian or a Paretian ethical construct.

Given the fact that that many respondents exhibited behavior consistent with a negative discount rate for the far future, further interpretation is warranted. Such behavior implies that these individuals believe that the future is more important (or more highly valued) than the present. This action may be consistent with a Rawlsian ethical framework if the respondent believes that the future will somehow be disadvantaged with respect to the present. An alternative explanation for such behavior lies in application of a Nietzschean framework if the future is expected to be better off than the present. The former explanation would appear to be most likely for two reasons: 1) the existence of irreversibilities which cause the future to have a reduced endowment as a result of contemporary activity, and 2) the fact that projection of a Nietzschean framework would appear to be unlikely. This latter

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conclusion is based on the fact that Nietzchean frameworks are most likely utilized to justify transfers from those not holding the ethical structure to those who do.

It is important to note that the results of this analysis do not hinge upon collective action. That is, any requirement for consideration of far future impacts by an individual does not require that others behave similarly. Recall that such collective action was the basis for the Marglin (1963a) model.

These results are in opposition to the bulk of neoclassical theory of time valuation. Certainly they are inconsistent with both an opportunity cost or a time preference framework.

Implications for Policy Analysis

Several major policy implications are suggested by the results derived from the contingent valuation experiment. Perhaps first and foremost of these is the fact that individuals do care about far future impacts and thus the inclusion of these impacts in public policy decision criteria is mandated. Furthermore, since individuals do not appear to discount these impacts in the same manner as they do for intertemporal allocations over the more immediate future, differential treatment of far future impacts in benefit-cost analysis is warranted. This implies that decision makers should explicitly account for impacts

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affecting far future public goods provision through the use of lower and possibly zero rates of discount for these impacts in cost-benefit analysis. Given the uncertainty surrounding present activity induced physical impacts on the far future as well as uncertainty regarding the subsequent valuation of these impacts, a conservative approach is appropriate. This conclusion would appear to especially hold in the case of irreversible impacts of contemporary activity.

Finally, further research into future valuation is justified. Given the nature of the conclusions derived in this analysis and the extreme implications for benefit-cost analysis, it would appear that this research should research should be of high priority from a public policy standpoint.

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Appendix I

Survey of Future Valuation

The purpose of this survey is to determine how you value the future and why you feel the way that you do. It represents part of a research project on future valuation conducted by the University of Wyoming Department of Economics. Would you please take a few minutes of your time to fill out the survey? Thank You.

1. Do you think today's society will leave the future generally better or worse off than we are today?
   ____ generally better off
   ____ generally worse off
   ____ don't know

2. In what ways will future society be better off? (Check all that apply.)
   ____ more knowledge
   ____ more resources
   ____ less chance of war
   ____ improved spiritual outlook
   ____ improved values
   ____ better health
   ____ more goods and services
   ____ other 1 (specify)_____
   ____ other 2 (specify)_____

3. In what ways will future society be worse off? (Check all that apply.)
   ____ fewer resources
   ____ greater chance of war
   ____ deterioration of spiritual outlook
   ____ poorer health
   ____ deterioration of values
   ____ overcrowded
   ____ fewer goods and services
   ____ famine
   ____ spoiled environment
   ____ other 1 (specify)_____
   ____ other 2 (specify)_____

4. How long do you believe society will continue to be at least as well off as today?
   ____ 10 years
   ____ 25 years
   ____ 100 years
   ____ 1,000 years
   ____ 10,000 years
   ____ 1,000,000 years
   ____ forever
   ____ other (specify)_____years

5. How long do you believe mankind will continue to inhabit the earth?
   ____ 10 years
   ____ 25 years
   ____ 100 years
   ____ 500 years
   ____ 1,000 years
   ____ 10,000 years
   ____ 1,000,000 years
   ____ forever
   ____ other (specify)_____years

6. In what manner do you believe mankinds's existence on the earth will cease or be sharply reduced? (Check all that apply.)
   ____ return of the Lord
   ____ nuclear holicaust
   ____ famine
   ____ disease
   ____ other (specify) _____
   ____ environmental pollution
   ____ lack of resources
   ____ none, mankind will exist forever

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7. Is the world a better place for mankind than it was

100 years ago?	____ yes	____ no
50 years ago?	____ yes	____ no
10 years ago?	____ yes	____ no

8. Is mankind better off now than

100 years ago?	____ yes	____ no
50 years ago?	____ yes	____ no
10 years ago?	____ yes	____ no

9. Assuming no inflation, which of the following alternatives would you prefer to receive in <u>each</u> set?

Set 1:	____ $100 today	or	____$5 000 10 years from now
Set 2:	____ $100 today	or	____$2,000 10 years from now
Set 3:	____ $100 today	or	____$1,000 10 years from now
Set 4:	____ $100 today	or	____$ 500 10 years from now
Set 5:	____ $100 today	or	____$ 250 10 years from now
Set 6:	____ $100 today	or	____$ 150 10 years from now

10. Complete this statement: Assuming no inflation, I would be just as happy receiving $50 today as I would be if I received $_____ five years from now.

11. The price of oil has fallen significantly in recent months. As a result, gasoline prices are lower and people are using more petroleum. Over the long term, low petroleum prices will stimulate demand and significantly decrease the amount of petroleum available for future generations. Would you be in favor of increasing the price of petroleum, perhaps through a tax, so as to preserve supplies for future generations?

____ yes ____ no

12. A. Do you think that today's society should explicitly consider the impacts of its actions on future society when determining our present course of action?

____ yes ____ no

B. If your answer to the last question was yes, why should we worry about future generations? (Check all that apply.)

____ It is our ethical and/or moral duty.
____ It is our religious duty.
____ It is our duty to our descendants
____ Other 1 (specify)_____
_____
____ Other 1 (specify)_____
_____

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C. If your answer to question 12A was yes, how should impacts on future generations be considered in our present decisions? Suppose for example, that we are considering a course of action that will cause future society to spend an extra $1,000 in today's dollars. How should this impact be considered in our present decision? (Choose the one which applies.)

____ It should be considered at the same magnitude as if this impact was happening to ourselves today.

____ It should be considered at a magnitude which is smaller than the magnitude which would apply today but at the same magnitude as it this impact was happening to ourselves in the future.

____ It should be considered at a magnitude which is smaller than the magnitude we would apply if this impact were to occur to ourselves in the future.

____ It should be considered at a larger magnitude than if this impact was happening to ourselves today.

13. Rank the six most important things to you in the following list. (1 being highest, 6 being the lowest.)

____ the availability of a clean environment for present society

____ the availability of a clean environment for future generations

____ peace for contemporary society

____ peace for future society

____ education for contemporary society

____ education for future society

____ a high level of contemporary religious values

____ a high level of religious values for future society

____ contemporary goods and services

____ goods and services for future society

____ the welfare of future society

____ the availability of goods and services for your grandchildren

____ the welfare of your grandchildren

____ the availability of goods and services for your children

____ the welfare of your children

____ the availability of goods and services for your distant descendants

____ the welfare of your distant descendants

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The following is a series of questions in which you are asked to choose between two alternatives. There are seven questions in all.

14. Would you consider yourself to be better off under state A or state B?
    A.____the chance of nuclear war is reduced 10%.
    B.____you received a new car.

15. Would you be better off in state C or state D?
    C.____fewer natural resources are used today so that more resources are preserved for future society.
    D.____people become more religious.

16. Now consider your answers for the above two questions; would you be better off under:
    E.____your answer to question 14 (A or B).
    F.____your answer to question 15 (C or D).

17. Would you be better off in state G or H?
    G.____more goods and services were available for society's consumption today.
    H.____more goods and services were available for future society.

18. Would you be better off in state I or state J?
    I.____more emphasis was placed on pollution control today.
    J.____the moral fiber of contemporary society was improved.

19. Now consider your answers to the last two questions, would you be better off under:
    K.____your answer to question 17 (G or H).
    L.____your answer to question 18 (I or J).

20. Finally consider your answers to question number 16 and question number 19. Would you be better off under:
    M.____your answer to question 16 (state A B C or D).
    N.____your answer to question 19 (G H I or J).

21. Rank in order the four most important things to you. That is, what four things make you feel most well off or satisfied with life?

    First _____

    Second _____

    Third _____

    Fourth _____

22. Suppose that it was possible to purchase a $1 bond which pays $1 per year forever, the first payment of which is distributed in 200 years to the recipients or causes of your choice.

    Would you be interested in purchasing any of these bonds?
    _____yes _____no

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23. If your answer to question number 22 was yes, how many bonds would you purchase? (You may choose any dollar amount)
____ dollars worth

24. If your answer to question number 22 was yes, who or what would you want to receive the interest payments? (Specify)

_____

25. If your answer to question number 22 was no, that is you do not want to purchase any of the bonds, is it because

_____you have no desire to transfer money to the future.
_____money will not solve the future's problem.
_____you do not believe that such a program could work.

_____other(specify)_____.

26. If you checked the third box above (i.e., you do not think that the program could work) would you be likely to participate in the program if it was government guarenteed?

_____yes _____no

27. If you checked yes to the above question, how many bonds would you be willing to purchase? (You may choose any dollar amount.)
_____ dollars worth

28. If you checked yes to question 26, who or what would you want to receive the interest payments? (Specify)

_____

29. A. Suppose that instead of money payments, the interest was paid out (after 200 years) in the form of anything you choose, (i.e., clean air, education, hot dogs, religion, etc.) would you be willing to participate?
_____ yes _____ no

B. Would you prefer this type of payment mechanism over one that utilized money payments?
_____ yes _____ no

30. If you would be willing to participate in a program which gave the future interest payments in the form of any good that you choose. What form, besides dollars, would you choose to utilize to make the interest payments? (Specify)

_____

31. If you would be willing to participate in a program which gave the future interest payments in the form of any good that you choose, how many bonds would you purchase?
_____ dollars worth

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32. Who or what would you want to receive the interest payments (in the form of your chosen good)?

_____

33. A. Are you
____ very religious
____ religious
____ slightly religious
____ agnostic
____ atheist
____ other, (specify) _____

B. If you are religious, what religion are you?

_____

34. What statement best describes your feelings about the future:

____ the end of the world is near, so we do not have to worry about taking care of the world for future generations.

____ it is our destiny to utilize the planet as we need to; we should not worry about the future as the future will take care of itself.

____ it is our duty to take care of the earth for future generations.

35. Politically, do you consider yourself to be
____ very liberal
____ liberal
____ moderate
____ conservative
____ very conservative
____ other (specify) _____

36. What is the highest level of education that you have obtained?
____ less than grade school
____ grade school
____ high school
____ more than one year of college
____ Bachelor's degree
____ advanced degree

37. A. Did any of your childhood or religious experiences give you a way to look at events occurring to future generations?
____ yes ____ no

B. If yes, please explain (use back of sheet if necessary):

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38. How would you describe the economic status of your upbringing?
____ very poor
____ poor
____ lower middle income
____ middle income
____ upper middle income
____ wealthy
____ very wealthy

39. What do you consider your present economic status to be?
____ very poor
____ poor
____ lower middle income
____ middle income
____ upper middle income
____ wealthy
____ very wealthy

40. What do you expect your future economic status will be?
____ very poor
____ poor
____ lower middle income
____ middle income
____ upper middle income
____ wealthy
____ very wealthy

41. What was the highest education level obtained by one or more of your parents (guardians)?
____ less than grade school
____ grade school
____ high school
____ more than one year of college
____ Bachelor's degree
____ advanced degree

42. How many children do you have? ____

43. If you do not have children now do you plan to have children?
_____ yes ____ no

44. What is your age? ____ years

45. If you have any comments about this survey, please feel free to indicate them in the space below and on the back of the sheet if necessary. Thank you again for your help in this project.

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Appendix II

A General Equilibrium Model of Future Valuation

In this appendix a theoretical, general equilibrium model is developed. For this purpose assume the existence of a utility function in which the individual has a different discount rate for events over his/her lifetime and events after his/her lifetime. That is, assume:

$$(1) \qquad U = U(Co,Po) + \frac{U(C_1,P_1)}{(1 + r)} + \frac{U(P_2)}{(1+\delta)^2}$$

where C_t is consumption of a private good in period t, P_t consumption of a public good in period t, and r and δ are discount rates.

Note that the utility function has three time periods: 0, 1, and 2. Periods zero and one represent time periods occurring during the individual's lifetime while period two occurs after the individual is dead. One can think of the three periods as being the present, the future, and the far future. Further note that no consumption of private goods occurs in period two.

Assume production functions for the private and public goods. Output in any time period is determined by a Cobb-Douglas production function given by:

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(2) $$Y_t = AL_{yt}^{B} K_{yt}^{1-B}$$

where Y_t is output in period t, L_{yt} is land devoted to the production of output, K_{yt} is capital, and A and B are technical parameters of production.

Not all output must be consumed in any period and thus we can derive the savings function:

(3) $$S_t = Y_t - C_t$$

where S_t is savings in period t. The production function for the public good is given by:

(4) $$P_t = \alpha Lp_t$$

where Lp_t is land devoted to public good production and α is the technical parameter which tells how much of the public good can be produced with a given amount of land.

There is, of course, only so much land available for the two uses. This relationship is given by:

5) $$\bar{L} = Lp_t + Ly_t$$

where $\bar{L}$ is the fixed amount of land available.

Land can be converted from one use to the other. That is, land currently used to produce output can be applied to the production of the public good and vice-versa. However, this process requires the application of capital. For these purposes assume:

(6) $$K_t = K_t + K_{pt} + K_{Dt}$$

where K_t is the total amount of capital available in any given period, K_{yt} is capital used to produce output, K_{pt} is

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capital used to convert land into a suitable form to be used to produce the public good, and K_{Dt} is capital used to produce land suitable for output production.

The conversion of land from one use takes place via the following equations:

(7) $$\Delta L_{pt} = \Omega K_{pt} - \delta K_{Dt}, \text{ and}$$

(8) $$\Delta L_{Yt} = -\Omega K_{Pt} + \delta K_{Dt}$$

where Ω and δ are the technical parameters dictating the efficiency of land conversion.

From expressions (7) and (8) we can derive the following expressions:

(9) $$L_{Pt} = L_{Pt-1} + \Omega K_{Pt} - \delta K_{Dt}, \text{ and}$$

(10) $$L_{Yt} = L_{yt-1} - \Omega K_{Pt} + \delta K_{Dt}.$$

In order to allow for investment in this model, savings must augment the amount of capital. This is accomplished via the following relationship.

(11) $$S_t = K_{t+1} - K_t$$

For simplicity no depreciation of capital is assumed in the model.

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To complete the model, assume the existence of two individuals, 1 and 2. Further assume that the utility function for the two individuals are identical and follow the general formulation of (1). A simple specific formulation of this relationship is given by:

$$(12) \qquad U^1 = C_0^1 Po + \frac{C_1^1 P1}{(1+r)} + \frac{P_2}{(1+\delta)^2}$$

$$(13) \qquad U^2 = C_0^2 Po + \frac{C_1^2 Po}{(1+r)} + \frac{P_2}{(1+\delta)}$$

where the superscripts denote individuals the formulations of (12) and (13) imply

$$(14) \qquad C_t = C_t^1 + C_t^2, \text{ and}$$

$$(15) \qquad S_t = S_t^1 + S_t^2$$

Lastly, we note that in this system wealth can be represented by the discounted value of private consumption. Therefore:

$$(16) \qquad W = C_2^1 + (1+\pi)^{-1} C_1^1.$$

With the basic form of the model complete, several avenues of simplification present themselves. To begin, equation (4) can be eliminated via substitution into equations (12) and (13). This yields

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(17) $$U^1 = C_0^1 \alpha L_{Po} + \frac{C_2^1 \alpha L P_1}{(1+r)} + \frac{\alpha L_{P2}}{(1+\delta)^2}, \text{ and}$$

(18) $$U^2 = C_0^2 \alpha L_{Po} + \frac{C_1^2 \alpha L_{P1}}{(1+r)} + \frac{\alpha L_{P2}}{(1+\delta)^2}.$$

Further elimination of equations can be obtained by combining the relationships expressed in equations (6), (11), (2), (3), and (14). To accomplish this result, first substitute (6) into equation (11). This yields:

(19) $$S_t = K_{Yt+1} + K_{Pt+1} + K_{Dt+1} - K_{Yt} - K_{Pt} - K_{Dt}$$

Then substitution of (3) into (19) yields:

(20) $$Y_t - C_t = K_{Yt+1} + K_{Pt+1} + K_{Dt+1} - K_{Yt} - K_{Pt} - K_{Dt}.$$

Finally, substitution for Y_t from equation (2) and C_t from equation (14) yields:

(21) $$AL^B_{Y_t} K_{Y_t}^{1-B} - C_t^1 - C_t^2 = K_{Y_{t-1}} + K_{P_{t+1}} + K_{D_{t+1}} - K_{Y_t} - K_{P_t} - K_{Dt}$$

Note that it is not necessary to include both equation (9) and equation (10) as the relationship expressed in (5) makes one of these expressions redundant. Therefore, let equation (10) be eliminated.

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Our problem, in a pareto optimal framework, has simplified to maximizing:

(22) $$U^1 = C_o^1 \alpha L_{Po} + \frac{C_1^1 \alpha L_{P1}}{(1+r)} + \frac{\alpha L_{P2}}{(1+\delta)^2}$$

subject to:

(23) $$\bar{U}^2 = C_o^2 \alpha L_{Po} + \frac{C_1^2 L_{P1}}{(1+r)} + \frac{L_{P2}}{(1+\delta)^2}$$

(24) $$AL_{Y_t} K_{Yt}^{B} K_{t}^{1-B-} C_t^1 - C_t^2 = K_{Y_{t+1}} + K_{P_{t+1}} + K_{D_{t+1}} - K_{Y_t} - K_{P_t} - K_{D_t}$$

(25) $$\bar{L} = L_{Pt} - L_{Yt}$$

(26) $$L_{Pt} = L_{Pt-1} + \Omega K_{Pt} - \delta K_{Dt}, \text{ and}$$

(27) $$W = C_o^1 + (1+\pi)^{-1} C_1^1$$

Solving this system yields optimum values for the variables in terms of the paremeters and r and δ.

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