CHAPTER 4

LITERATURE REVIEW: PART 3 – AN OVERVIEW OF DISCOUNTING ISSUES

Decisions involving environmental and health issues almost always have intertemporal aspects; both individuals and society are usually required to make trade-offs between today and the future. Although a few personal, individual health-related decisions involve remedies with immediate payoffs (e.g. the treatment of head aches and the common cold), most health-related decisions are of a more long-run nature. For example, an individual's choice of diet, exercise habits and smoking behavior will certainly have a long run impact on his or her personal health. In addition, decisions regarding surgical procedures have an intertemporal aspect. An operation may provide one with improved health in the long run, but it also has risks associated with complications during the surgery itself. Society is also confronted with decisions of an intertemporal nature. As an example, consider the case of the drug Taxol. Taxol was found to be effective in treating several cancers, including ovarian, lung, and breast cancer. However, in order to make the drug, it was necessary to destroy one hundred year-old Pacific Yew trees, which are not easily replaced in the short term. The U.S. government was forced to trade off the present benefits of saving lives against long run environmental consequences of destroying the trees. Many environmental projects have effects that will be spread out over a long time horizon. Such areas include, in addition to groundwater protection, global climate change, radioactive waste disposal, mineral depletion, and loss of biodiversity.

The U.S. government currently requires discounting of future benefits and costs in benefit-costs analyses of federal public investment projects. As noted by Lind (1982), the choice of discount rate is critical because it is a major determinant of whether the net present value of benefits is positive, the relative attractiveness of competing projects, and the optimal timing of projects. If the discount rate used by government agencies is lower than the social discount rate, there will be too much public investment in long-term projects. On the other hand, if society discounts future benefits at a lower rate than the rate used by government agencies, there will be too little public investment in long-term projects. The base rate of discount used by the United States Office of Management and Budget Policy is currently 7%; however, alternative discount rates are sometimes permitted (US OMB, 1992). The necessary trade-off between present and future benefits creates problems that have been seriously considered by many people for many years, but little consensus has been reached.

4.1 A Historical Overview of the Discounting Debate

Robinson (1990) characterizes the debate surrounding social discounting as a basic tension between those who feel that future events should be discounted by government at the same rate used by individuals in their private decisions, and those who believe that the concept of opportunity cost requires that market forces determine the social rate of discount. Jeremy Bentham and David Hume, the 18th century founders of utilitarian social theory, both regarded time preference as playing a critical role in understanding the economic and political world. Rather than viewing the fact that individuals discount the future as justification for governmental discounting, Bentham and Hume felt that this placed responsibility on the government to counteract the

detrimental effects of self-interested citizens. Bentham felt that government should be active in determining what is good for society, and in guiding citizens in a manner consistent with that which it had determined to be good. Hume observed that human motivations and actions are determined by a combination of reason and passion, and that passion often has the upper hand. Thus, the purpose of individual ethics and political institutions is to protect reason from the harmful, intense influence of passion. Although Hume viewed time preference as an inherent aspect of human nature, he felt that its effects are detrimental and thwart social cooperation by leading individuals to break promises in order to obtain relatively small, immediate gains at the expense of much larger future benefits. In the case where time preference threatens the public good, Hume argued that public policy must fight against the tendency to prefer present consumption to future consumption (Robinson, 1990).

Alfred Marshall, whose *Principles of Economics* dominated economic theory for many years after it was first published in 1890, held pure time preference as an intellectual and moral flaw, which afflicts some individuals to a greater degree than others. Marshall's position was in accordance with that of John Stuart Mill (Mill, 1848). John Stuart Mill viewed consumer time preference and the "unfortunate" decisions resulting from it as one of the two main exceptions to the rule that individuals are the best judges of their own best interest (the other exception was children in need of parental guidance). Pigou (1920) held that the fact that individuals value present gratification over future gratification of the same type and magnitude merely because it is present is the result of "defective" reasoning and "wholly irrational preference". Pigou viewed this failure on the part of individuals as having serious detrimental effects on overall utility

and well being by reducing the wealth of the community over time. Pigou also believed that the government should not base it decisions upon individual citizens' rates of time preference, but should counteract society's inclination towards reckless use of available resources (Pigou, 1920, pp.29).

In 1928 Ramsey presented a formal model of intertemporal decision-making. The objective in the model is to maximize the aggregate utility of all individuals throughout time without regard to the generation to which they belong. Aggregate utility could be increased by significant rises in the rate of saving and investment. However, although Ramsey agreed with Marshall and Pigou, he never used his model to advocate intergenerational utilitarianism without discounting. Ramsey's view on subjective time preference, coupled with his hesitancy toward pure intergenerational utilitarianism, provided an impetus for future discussions amongst economists who resisted the movement toward subjective measures of value and remained proponents of objective need and welfare. For example, as a Keynesian concerned about insufficient aggregate demand and macroeconomic depression in the immediate postwar period, Harrod (1948) viewed time preference to be socially useful due to its tendency to reduce savings and spur current consumption. Nevertheless, Harrod maintained that the government should not pay attention to pure time preference, describing it as "a polite expression for rapacity and the conquest of reason by passion" (Harrod, 1948, pp.40). Dobb (1960) criticized the use of individual time preferences in social decisions as "individualistic", but approved of social discounting based on diminishing marginal utility of income and uncertainty regarding future consumption relative to present consumption. Sen (1960, 1961) held a similar position.

The 1930s and 1940s saw a major revolution in thought about discounting. Mainstream economics shifted from evaluation of social welfare based on normative values towards evaluation based on individual subjective preferences. Marshall, Pigou and their colleagues viewed economics as a means to promote social well-being. Robinson argues, "Their concept of utility was an objective one, composed of the satisfaction of needs common to all human beings. Interpersonal comparisons of utility were central to their policy recommendations" (Robinson, 1990, pp.257). In the 1930s, a body of thought called "the new welfare economics" emerged as economists began moving from notions of objective welfare towards concepts of subjective satisfaction of desires. Hicks and Allen (1934), and Samuelson (1938, 1950), maintained that all the important principles of economics could be retained using a preference-based notion of utility, without the need for theoretically messy concepts of relative happiness across different people. In 1932, Robbins proclaimed that distributional concerns were outside the realm of economists, as they are based on normative judgments rather than on scientific analysis. Kaldor (1939) developed the Kaldor compensation criterion, whereby government programs could be deemed acceptable using preference based utility if the winners could compensate the losers and still be winners. However, this compensation need only be feasible; conveniently, such compensation does not have to actually occur.

The "new welfare economics" had major consequences for the manner in which economists came to view intergenerational transfers and the social rate of discount. The appropriate rate of discount for government projects was now deemed to be the rate preferred by the majority of contemporary members of society. This is in contrast to the utilitarian emphasis on the equal weight of individuals, regardless of the generation to

which they belong. Eckstein (1957) and Marglin (1963) were proponents of the importance of individual preferences, but were hesitant concerning the extent to which market data on consumer choice between consumption and savings accurately portrayed individuals' true attitudes towards the benefits of long-term public investments. They considered that people might possess different sets of preferences for individual and collective decisions, with the preferred discount rate for public projects being lower than the preferred rate for private decisions. Others continued to turn to market data alone as the appropriate source for the social rate of discount. Robinson (1990) argues that while the "new welfare" economists have bickered amongst themselves to some degree, they retain two basic principles, neither of which stems from economic theory. First, individuals know better than anyone else what is good for them, and hence, subjective time preferences in one year are sufficient guides for public investments that will affect utility in future years. Secondly, only the preferences of the current members of society are relevant for public policy; the subjective rate of time preference for the current generations serves as an adequate guide for investments affecting future generations (Robinson, 1990, pp.258-259).

Robinson (1990) notes, however, that philosophers question most economists' reverence for individual consumer preferences. He notes that such preferences are often "hastily obtained, unreflectively maintained, and subject to all the cognitive frailties enumerated by psychologists and students of consumer risk perception" (Robinson, 1990, pp.260). Robinson credits some welfare economists for recognizing that consumer preferences are often misguided, but notes that such economists continue to maintain that "principles of liberty demand that individuals be allowed to make their own decisions

without paternalistic influence from the government" (Robinson, 1990, pp.260). Robinson dismisses this argument as irrelevant to decisions whose effects will be felt mainly by future generations rather than by the decision makers themselves. In addition, he maintains that preferences are endogenous and cannot live up to the "desired role of undetermined determinants of public policy" (Robinson, 1990, pp. 261). He argues that individuals' attitudes towards themselves, their environments, and the future are shaped by the public investments we do or do not make (Robinson, 1990).

4.2 The Classical Model of Discounting

The seeds of the classical model of discounting, which is so prevalent in the economics literature today, were sown in Irving Fisher's *The Theory of Interest* (1930). Fisher was the first to apply indifference curve analysis to intertemporal choice. Figure 4.1, located at the end of this chapter, presents an indifference curve diagram similar to the one presented by Fisher. The slope of the tangent line to any indifference curve may be interpreted as the individual's rate of time preference, i.e. her willingness to trade present consumption for future consumption. As the tangent line grows steeper, the individual requires greater and greater amounts of future consumption in exchange for forgoing one unit of present consumption, or marginal rate of substitution. In 1937, Paul Samuelson developed the now pervasive constant rate discounted utility, or classical, model. This model states that consumption sequence ($c_1, c_2, \ldots, c_n$) is preferred to sequence ($d_1, d_2, \ldots, d_n$) if and only if:

$$\sum U(c_t)d^t > \sum U(d_t)d^t \qquad (4.1)$$

where U is a utility function (with a positive first derivative and a negative second derivative), and δ^t is the discount function, with $0 < \delta < 1$. This model of discounting

assumes both positive time preference and constant rate discounting. Positive time preference requires that individuals prefer to experience benefits, or positive outcomes, sooner rather than later. Constant rate discounting requires that a constant discount rate be applied to all outcomes, including different categories of consumption goods, and to all time periods (MacKeigan, 1993). This model was widely accepted by economists and had been applied to areas as diverse as savings behavior, labor supply, security valuation, education decisions, and crime (Loewenstein and Prelec, 1992).

Olson and Bailey (1981) believed that positive time preference results from two factors: decreasing marginal utility and pure time preference (the belief that people prefer to experience favorable outcomes sooner rather than later, or are "impatient"). Gafni and Torrance (1984) examined time preference specifically in the context of a chronic health state, identifying three influences: 1) the effect of decreasing marginal utility of health, 2) a gambling effect, which results from the presence of uncertainty and 3) a pure time preference effect. The constant rate discounted utility model can handle all three effects, since the shape of the individual's utility function reflects his decreasing marginal utility and attitude towards uncertainty, and pure time preference is reflected in the discount rate. However, Gafni and Torrance (1984) suggest that separating out these three effects is very difficult.

Previous studies have estimated discount rates from purchases of consumer durables, such as air conditioners and refrigerators (see Hausman, 1979; Gately, 1980). These purchases usually involve an immediate cost (the purchase price) and a series of delayed charges (electricity costs). Since more expensive models tend to be more energy efficient, it is possible to calculate the discount rate (or the range of discount rates)

implicit in a particular purchase. A second source of empirical estimates of discount rates comes from studies of saving (Landsberger, 1971) and intertemporal labor-leisure substitutions (Hotz, Kydland and Sedlacek, 1988; Moore and Viscusi, 1988). The estimates from these two groups of studies are dramatically different. Studies of consumer durables purchases display very high discount rates, from 25% (Hausman, 1979) to 45-300% (Gately, 1980). Savings behavior and labor supply studies have typically found much lower discount rates-below 25%. Some authors have argued that influences beyond those discussed above have an effect of the rate of time preference, and these influences present a significant challenge to the assumption of positive time preference. For example, Loewenstein and Prelec (1992) attempt to explain the disparity between discount rates estimated from purchases of consumer durables and those estimated from savings and labor supply studies. These arguments will be discussed in detail later in this chapter. Let us first turn to a discussion about how one might go about choosing a rate of discount for the evaluation of public projects that have future benefits and costs.

4.3 Choice of Discount Rate

The debate about the appropriate rate of discount centers on the concepts of the marginal rate of time preference and the marginal rate of return on private investment. The term “marginal rate of time preference” refers to the trade-offs that individuals make between consumption now and consumption in the future, while the “marginal rate of return on private investment” is the rate at which private entities (firms) transform marginal current production into marginal future production. The firm must recognize

the opportunity cost of forgone interest when dollars are spent in the present, rather than being invested for future use.

In a competitive, undistorted capital market, the individual's subjective rate of time preference, or marginal rate of time preference, must equal the market interest rate (for a demonstration of this assertion, see Boardman et al., 1996). Since in a perfect capital market, all individuals face the same market interest rate, all individuals must have the same marginal rate of time preference. An additional feature of a perfect capital market is that the firm's marginal rate of return on private investment also equals the market interest rate. This is why it is often argued that the most appropriate choice for the social discount rate, the rate at which future public benefits and costs are discounted, is the market interest rate.

However, we must ask ourselves what the appropriate social discount rate is if the capital market is imperfect, as this is the situation we face. Taxes, risk, transaction costs and other distortions create a divergence between the rate of return on investment and the rate at which individuals are willing to trade present consumption for future consumption. Boardman et al. (1996) discuss four alternative choices for the appropriate social discount rate when capital markets are not perfect: the marginal rate of social time preference, the marginal social opportunity cost of capital, the weighted average method, and the shadow price of capital. Let us examine each of these options in turn.

4.3.1 The Marginal Social Rate of Time Preference

The social rate of time preference is the rate at which society is willing to trade consumption now for consumption at some future date. An obvious difficulty is that a society is, by definition, a collection of individuals, and each individual may not be

willing to exchange present consumption for future consumption at the same rate as her neighbor; i.e. each individual may have a different rate of marginal time preference. In addition, individuals may have different rates of time preference for public investments (e.g. groundwater protection programs) than they do for their individual, private intertemporal investments (purchases of consumer durables such as refrigerators or air conditioners). Individuals may have different marginal rates of time preference for different goods, a possibility that will be discussed in detail later in this chapter.

An individual may recognize that while his life is finite, society's is not. Many of our actions reflect a desire to ensure the well being of future generations; for example, we often leave sizable inheritances to our children, to other loved ones, or to charitable organizations. Since the needs and desires of future generations are not voiced in current economic markets, one may argue convincingly that the social discount rate should be lower than both the individual's marginal rate of time preference and the private sector's marginal rate of return on investment (Boardman et al., 1996). As we have noted earlier in this chapter, some have gone so far as to advocate a social discount rate of zero, giving equal weight to this generation's consumption and the consumption of each future generation to come.

However, some have argued to the contrary, maintaining that future generations will benefit from a growing stock of capital and knowledge that compensates them for this generation's consumption of natural resources. Proponents of this view, including Tullock (1964) and Baumol (1968), point out that the standard of living has generally increased, and argue that allowing for a lower social discount rate effectively subsidizes

future generations that they believe will be better off than this generation. Baumol argues:

> …it is incumbent on us to ask ourselves whether we really want to undertake such a redistribution of income-as in any such re-division of the pie the answer depends heavily on who the recipients are to be, and on their economic circumstances…in our economy if past trends and current developments are any guide, a redistribution to provide more for the future may be described as a Robin Hood activity stood on its head-it takes from the poor to give to the rich (Baumol, 1968, pp.800).

Baumol believes that the marginal social opportunity cost of capital is a more appropriate choice of discount rate for analysis of public investment projects. We now turn to a discussion of this argument.

4.3.2 The Marginal Social Opportunity Cost of Capital

Boardman et al. (1996) note that since the government and the private sector typically compete for the same pool of funds when they finance long-term investment projects, efficiency requires that investments made by the government to yield the same marginal rate of return as investments made by the private sector. William J. Baumol (1968) states that the social discount rate must be chosen in such a way that an analysis of the public investment project's net benefits is positive if and only if the project's gross benefits exceed the project's private sector opportunity cost. If government projects fail to yield as high a return as private investments, one may argue that total welfare would be increased if resources were channeled to the private sector. This argument forms the basis for choosing the marginal social opportunity cost of capital in the private sector as the appropriate discount rate to use in benefit-cost analyses of federal projects. The marginal social opportunity cost of capital is approximated by the marginal before-tax rate of return on private investment.

Some have argued that if marginal social opportunity cost of capital is adopted as the appropriate rate of discount, it should be adjusted downward because of the likely presence of market distortions by externalities and monopolistic prices, and the possibility that private investments may generally be riskier than public investments. Lind (1982) argues the marginal social opportunity cost of capital without adjustments "perpetuates the distortions in the private sector of the economy that cause a bias against investments in general, and against long-lived investments in particular, in the evaluation of public policy decisions" (Lind, 1982, pp. 444-445). Noted economists Kenneth Arrow (1966) and Paul Samuelson (1964) have argued that a risk premium should be excluded from the discount rate used to evaluate public investment projects, basing this argument on the law of large numbers; since the government invests in a wide variety of projects, the overall outcome is essentially certain. Baumol (1968) finds fault with this argument, suggesting that private and public investments are equally risk-less from the viewpoint of society, since society will enjoy the flow of benefits stemming from the project regardless of who actually carries out the project. However, he uses this observation to argue against excluding a risk premium for the social discount rate, stating "the very absence of real risk means that the private rate discount should also enter the social discount rate" (Baumol, 1968, pp.795). In the case of relatively high rates of return observed in the private sector that may result in part from the inclusion of significant risk premium, he argues that "it is irrelevant to argue that this high return is produced by artificial distortions-taxes, risks which for society do not exist, etc. The fact that the source of this rate of return is 'artificial' makes the resulting yield figure no less substantive" (Baumol, 1968, pp.796).

4.3.3 The Weighted Average Method

One may argue that the social discount rate should reflect the source of the resources that are used in the specific project one is evaluating. Thus, if the proposed project necessitates that present consumption must be forgone, the marginal rate of social time preference may be viewed as the appropriate social rate of discount for evaluation of the particular project, while if the project displaces private investment, the marginal rate of return on private investment would be chosen as the appropriate social rate of discount. The weighted average method (WAM) reflects this viewpoint, calculating the social discount rate as an average of the social opportunity cost of capital (SOC) and the social rate of time preference (SRTP), which are each weighted based on what proportion of resources from the project are displaced from private investment and private consumption, respectively. Thus, the appropriate social rate of discount is given by:

$$WA = (a)SOC + (1-a)SRTP \tag{4.2}$$

where WA is the weighted average, a is the proportion of resources, i.e. costs, displacing private investment, and (1-a) is the proportion of resources displacing current private consumption.

A natural question that arises when examining this method is how one determines the parameter a. Lind (1982) noted that there is no clear method for choosing the weights, and that the weights may vary from project to project. There is much debate about whether public investment displaces primarily private investment or private consumption, or if public projects are in actuality financed by foreign loans. Proponents of the "crowding out" argument maintain that public investments are typically financed by borrowing, and often suggest the rate of return on Aaa-rated corporate bonds as a first

approximation for the appropriate social discount rate. However, others point to the lack of a strong correlation between U.S. government borrowing levels and interest rates, leading support to the position that public investment is heavily funded by foreign loans (Boardman et al. 1996). In Lind's (1982) examination of the discounting issue, he assumes both full-employment and a savings rate that is unaffected by the interest rate; consequently he assumes that public investments that are financed via increased deficits must crowd out private investment one-to-one. However, he points out that his analysis holds even if the economy is at less than full employment, or if the savings rate is, in fact, quite responsive to the interest rate. We will discuss Lind's approach to the discounting question in more detail later in this chapter.

4.3.4 The Shadow Price of Capital

One possible way to approach the debate surrounding the appropriate rate of social discount is to convert costs and benefits to changes in consumption, and then use the marginal rate of time preference as the appropriate measure of the social discount rate. Under this approach, benefits add to consumption levels, while costs reduce either consumption or investment levels. If private investment is displaced, then one must value the stream of consumption that would have resulted if such displacement had not occurred. To estimate the value of forgone consumption, the concept of the "shadow price of capital" is used.

The shadow price of capital is an estimation of the price of capital in terms of consumption; it must be inferred rather than directly observed in a market. Four parameters are typically used to derive the shadow price of capital: 1) the pre-tax gross rate of return on private capital, which is the yield on a unit of capital per year; 2) the

depreciation rate, which is the natural rate of decline in the value of a unit of capital per year; 3) the gross savings rate, which is the fraction of gross return on investment that is re-invested; and 4) the marginal rate of time preference. Randall M. Lyon (1990) assumed that capital stock depreciates geometrically and derived the following expression for the shadow price of capital, q :

$$q = \frac{W - SW}{d + d - SW} \tag{4.3}$$

where W is the pre-tax gross rate of return on private capital, d is the depreciation rate, S is the gross savings rate, and d is the marginal rate of time preference. Boardman et al. (1996) caution that while this expression may appear to express a simple way to calculate the shadow price of capital, there is by no means certainty as to what the values of the four parameters of the expression are. In addition, another drawback to the shadow price of capital approach is that it is not always possible to definitively classify costs as reductions in either present consumption or private investment.

4.3.5 Four Methods, No Easy Answers

In 1968, William J. Baumol wrote "few topics in our discipline rival the social rate of discount as a subject exhibiting simultaneously a very considerable degree of knowledge and a very substantial level of ignorance" (Baumol, 1968, pp.788). Baumol did not see any reason why his strong stance that the private opportunity cost of capital is the appropriate social discount rate would preclude action to rectify what Pigou felt were society's myopic tendencies; Baumol argued that if indeed we are as myopic as Pigou suggested, the rate of interest on government securities could be lowered, perhaps to 2.5%. Baumol maintained that this would serve to encourage both private and public

investment. In Baumol's view, the discounting debate has continued to persist because those doing the debating have different criteria for optimality; some are focusing on achieving an efficient allocation between public and private investment, while others are focusing on the individual's subjective rate of time preference. Baumol maintained that no single rate could meet both groups' optimality conditions, since he felt that the private opportunity cost of capital was some positive multiple of the rate of interest on government securities, *kr* (where *k* is greater than 1), while the individual's subjective rate of time preference is simply *r*, the rate of return on government securities. Thus, Baumol (1968) concluded that achieving consensus as to the appropriate rate of social discount was highly unlikely:

> …there is a basic contradiction in the optimality requirements for the social rate of discount. The condition for efficiency in the allocation of resources between the private and public sector requires a discount rate significantly higher than that called for by the public's time preferences. Only by elimination of the corporate income tax and the substitution of a subsidy to private investment to offset the difference between public and private risks can the two requirements be reconciled. Since neither of these changes seems, to say the least, very likely to be instituted in the foreseeable future, some arbitrary choice will have to be made (Baumol, 1968, pp. 800-801).

Baumol felt strongly that the necessarily arbitrary choice should favor a relatively high rate of discount, close to the private opportunity cost of capital. He saw no reason to "lower artificially the social rate of discount in order to increase further the prospective wealth of future generations", arguing that "the future can be left to take care of itself" (Baumol, 1968, pp. 801). However, he recognized the need for special consideration where irreversibility is a serious concern (e.g. preservation of the Grand Canyon), stating that "for this purpose the appropriate instrument would appear to be a set of selective

subsidies rather than a low general discount rate that encourages indiscriminately all sorts of investment programs whether or not they are relevant" (Baumol, 1968, pp.901).

Not much has changed since 1968; it seems that we are still faced with having to choose the rate of discount somewhat arbitrarily. While Boardman et al. (1996) describe four alternative methods for choosing the appropriate rate of social discount, they recognize that, in practice, these methods are rarely rigorously employed. This may very well be because to do so would be quite impossible, as there is no consensus as to what even the marginal rate of time preference is. Henderson and Bateman (1995) describe the inherent difficulties surrounding the question of the appropriate discount rate, noting that the costs of borrowing capital differ amongst individuals, firms, and governments, as do the returns on savings. In addition, they point out that the consumption rate of interest may be viewed as a measure of people's personal rate of time preference, but this forces us to confront additional questions because an individual may be both a borrower and a saver at various rates of interest. Many Americans hold some amount of money in a traditional savings account, which typically bears a very low rate on interest (e.g. 2%), while simultaneously carrying a balance on their credits cards, which may have rates as high as 6%-19%.

4.4 The Discounting Debate Re-Emerges

Prior to the Nixon Administration, there was no consistency in the discounting practices of federal agencies and some did not discount at all. Baumol observed in 1968 that the discussion surrounding the discounting question "…may with little exaggeration be described as a sorry spectacle--outstanding members of our profession providing in print estimates of the social discount rate ranging from four and one-half to eight or nine

percent" (Baumol, 1968, pp. 788). He noted that, at this time, some government agencies had used rates as low as 3% in their analyses.

In 1972, under Nixon's administration, the U.S. Office of Management and Budget (OMB) issued a directive that require most federal agencies to discount at a rate of 10% (US OMB, 1972). However, exceptions were granted for federal water projects; Congress established the formula to be used to determine the rate of discount for water projects in Section 80-A of the Water Resources Development Act of 1974. Lind (1982) argues that the 10% rate was supported for most projects because the 10% rate was believed to approximate the marginal real rate of return for private capital. In addition, a relatively high rate of discount had the desired effect, from the Nixon Administration's point of view, of reduced federal spending and fewer government projects since the higher rate of discount made it more difficult for proposed projects to pass the benefit-cost test. However, many exceptions to the 10% rule existed, and different projects continue to be discounted at different rates. Lind (1982) notes that discount rates ranging from 2%-13% have been used for evaluating energy policy options. Exceptions continue to exist under the current 7% rate adopted in 1992 by the United States Office of Management and Budget Policy. In addition, there is no consistency in the discount rate chosen for analysis of investments on the state and local level. Zerbe and Dively's (1990) study of 90 U.S. municipalities with populations greater than 100,000 persons found that only 43% of these municipalities use discounting when evaluating projects. Those municipalities that do discount use an average discount rate of about 3%.

In 1977, the nonprofit organization Resources for the Future held a conference that addressed the issue of the discount rate in the evaluation of national energy policies

and options. The papers from the conference were later collected and edited by Robert C. Lind (1982). Lind stated that we are essentially operating in a "second-best" world due to the various market distortions; he viewed the corporate and personal income taxes as the primary sources of distortion. Lind contributed a substantial body of additional work to the original papers of the conference participants. Specifically, he developed an approach that made it possible to use a single rate of discount for the evaluation of energy projects by distinguishing between the issues of time preference and the displacement of private capital. This approach involved three steps: 1) all future benefits and costs should be converted to corresponding changes in the consumption of the affected individuals whenever possible, 2) if private capital formation is affected, the consumption-equivalent measure of benefits and costs should be adjusted to incorporate the marginal productivity of capital, and 3) the adjusted streams of consumption equivalents should be discounted using the social rate of time preference. Adjustments of benefits and costs to their consumption equivalents are achieved by employing the shadow price of capital.

Lind argued that the consumption rate of interest, as measured by the after-tax rates of return on market securities, should be chosen as the social rate of time preference. For energy projects, he advocated choosing a rate of discount that falls between the after-tax expected rate of returns on a riskless asset and on a market portfolio. He felt that energy projects were deserving of evaluation at a lower rate of discount for two reasons. First, he argued that returns to energy investments would be negatively correlated with returns to other investments when energy prices rose. Secondly, he maintained that the relatively long-term nature of energy investments called

for a lower rate of discount. For the purposes of his argument, Lind assumed the social rate of discount to be about 4.6%, close to the real after-tax rate of return on the market portfolio, while for energy projects, he estimated the appropriate social rate of discount to be 3%, which fell between the real after-tax rate of return on the market portfolio and the 2% rate on long-term government bonds. However, Lind also pointed out that his methodology could be implemented even in the likely case where the social rate of time preference is chosen by the political process (Lind, 1982).

Lind (1982) felt that his framework had the additional advantage of recognizing that both public consumption and public investment expenditures affect private capital formation; if increased consumer spending is financed through increased taxes or increased debt it displaces capital just as investments in public projects would. In fact, he believed that, in many cases, expenditures on public investment held greater potential for stimulating private investment than public consumption. Lind also felt that discussions regarding public investments often overlook the fact that most public investment inevitably involves investments in the private sector, and often the costs of a "public" investment are borne by the private sector. As an example, he pointed out that if the government were to require automobile manufacturers to raise the energy-efficiency levels of their vehicles, almost all of the investment would occur in the private sector; the government need only bear the costs of monitoring and enforcement. Thus, he believed that any framework for discounting in benefit-cost analysis must address the analysis of benefits and costs that fall on the private sector. Specifically, the framework must be able to account for the effect of such benefits and costs on private capital formation (Lind, 1982).

Lind (1982) recognized that his approach has several shortcomings and that there are questions that it simply cannot answer. Of particular relevance for us, he noted that his approach failed to deal adequately with the special case of environmental benefits, particularly "intangible" environmental benefits such as lower health risks or increased aesthetic appeal of the environment. He argued that such benefits were not viewed as affecting an individual's wealth, or savings and consumption decisions. Lind also felt that these types of benefits could not be truly measured, and consequently, the development of an appropriate multiplier was not necessary. More importantly, Lind strongly felt that we must not rely on benefit-cost analysis and the rate of social discount alone to determine issues of intergenerational equity. He wrote:

> Although of great value in providing guidance about how to think about such issues, the theory itself does not decide the issues. Other rules or judgment must be evoked in deciding whether to incur risks for the future…these major issues of intergenerational equity should not be decided by, or buried in, the choice of the discount rate for social benefit-cost analysis (Lind, 1982, pp.457).

Lind reflected upon the overall usefulness of his approach for public policy by noting that market distortions "…seriously distort the economy away from savings and investment toward consumption and, perhaps as importantly, against long-term investments" (Lind, 1982, pp.456-457). However, he concluded that his approach "…corrects for these distortions in analyzing public policies and investments while taking account of the major effects of these distortions on private capital formation". At the same time Lind recognized "…it is strictly a second-best methodology designed for evaluating social choices in an economy as we now know it" (Lind, 1982, pp. 457).

Portney and Weyant (1999) suggest that the 1982 collection of papers stemming from the Resources for the Future conference, and in particular Lind's substantial

contribution to this collection, reflect a tone of temporary agreement regarding the discounting debate. However, Portney and Weyant (1999) suspect that economists were lulled into a sense of agreement regarding Lind's suggestions because the collection of papers was very much influenced by the energy crisis of the 1970s, and the need to find a short term answer to the issues the oil crisis brought to the forefront of policy debate. Although Lind was obviously concerned with long-term investment, the energy projects of primary concern to him had relatively short-term time horizons (twenty to fifty years) compared with many of today's environmental concerns, particularly global warming, where time horizons of hundreds of years are involved.

This temporary state of consensus was disturbed in the mid 1990s primarily by growing concern about the long-term threats posed by global warming. Arrow et al. (1996) discussed, in an Intergovernmental Panel on Climate Change report, two views on the discounting issue, which were described as "prescriptive" and "descriptive". The "prescriptive school" of thought held that the choice of discount rate should be based upon some group of ethical principals that guided how the welfare of each generation should be weighted. In contrast, the "descriptive" school maintained that the discount rate must be chosen based on observed rates of return to capital in various assets (Portney and Weyant, 1999). Arrow et al. (1996) believed that adopting a "prescriptive" approach would almost certainly lead to the choice of a lower discount rate than the "descriptive" approach would.

The seemingly endless obstacles to a true, somewhat permanent, consensus regarding the choice of an appropriate social discount rate have led Henderson and Bateman (1995) to conclude that "the calculation of a single 'correct' discount rate for all

possible projects is not uniquely possible" (pp.413). Much earlier, Baumol (1968) had reached essentially the same conclusion, as discussed in detail above. Several other authors have also echoed this viewpoint, including Stiglitz (1982), Luckert and Adamowicz (1993), and Scheraga (1990). Many have continued to maintain that we collectively have different preferences for public investments than we do for our own private intertemporal decisions (Goodin, 1982; Sen, 1982; Sagoff, 1988). Finally, Lind (1982) has noted that the theoretically correct rate of discount that economists have spent a great deal of time pursuing is not the only aspect to be considered in the discounting debate:

> Because the choice of the discount rate can influence strongly which public policies can be supported by benefit-cost analysis and which cannot, it is a matter of concern to politicians as well as policy analysts. The choice of the discount rate is itself a public policy decision that in most cases will be politically determined. While philosophers, economists, and financial analysts may debate the appropriateness of one rate as opposed to another for public policy purposes, and while their arguments may well be influential, the final choice will often be determined politically. It will depend not only on the merits of the supporting economic arguments but also on policy implications of one choice versus another and on the political strength of forces in support of those implications (Lind, 1982, pp.5).

The re-emergence of the discounting debate led *Resources for the Future* to hold another conference in 1999, which yielded a second collection of papers examining discounting issues. Portney and Weyant (1999) note, as the editors of this collection of papers, that while conference participants by no means reached consensus regarding the appropriate rate of discount for long-term projects, there did appear to be limited agreement in some areas. Most conference participants agree that it is appropriate to discount future benefits and costs at some positive rate. In particular, for time horizons of 40 years or less, many adopted the "descriptive" viewpoint, accepting the opportunity cost of capital as the

appropriate rate of discount. The sticking point was projects with time horizons of greater than 40 years. Many participants were eager to explore some form of non-constant discounting, i.e. an alternative to the constant exponential rate discounting (see Weitzman, 1999; Kopp and Portney, 1999; Cropper and Laibson, 1999), as there is growing empirical evidence that individual's rates of time preference decline as the time horizon involved increases (Horowitz, 1991; Thaler, 1981; Ainslie, 1992; Cropper et al., 1991, 1994). Let us turn to a brief overview of some of the arguments that were made in the 1999 collection of papers.

Kenneth Arrow (1999) views the discounting question as essentially one of ethics, notes that treating other generations as we would treat ourselves requires a zero discount rate, and this requirement demands that the current generation save at a rate that far exceeds what we would likely consider reasonable. Thus Arrow concludes, "a reconciliation must be based on the notion that individuals are not required to describe fully to morality at any cost to themselves" (Arrow, 1999, pp.13). He notes that his point is not a novel one, having been made by both the philosopher Scheffler (1982, 1988) and fellow economist Ng (1989). Arrow believes that the implications of Phelps and Pollack's (1968) paper, which discusses a non-cooperative game that is played amongst successive generations, are of great relevance to the discounting debate. In this paper, each generation behaves somewhat selfishly and believes future generations will replicate its behavior. Arrow maintains that in most cases it is inappropriate to discount long-term, irreversible, investments at a lower rate than short-term investments (Arrow, 1999).

Martin L. Weitzman (1999) notes that many argue that environmental problems that will arise in what he terms "the deep future" (i.e. many generations or centuries from

now) are not cause for significant concern because this generation can save now and then the savings can be used to address the problems when the time comes. However, Weitzman observes that this argument only holds "if the underlying trend of the real interest rate remains about the same" (Weitzman, 1999, pp.24) and he believes that the question of what the real interest rate will be in the "deep future" lies at the heart of the discounting debate.

Weitzman suggests that there are there are essentially two responses to this question, as there are two schools of thought in the "limits to growth" debate. Some believe that we are essentially doomed to run out of at least one critical resource, in which case diminishing returns will set in, and the productivity of investment will cease to grow, eventually falling to zero. Others maintain that technology will develop to meet whatever challenges the future presents. Weitzman feels that the likelihood of the latter outcome depends almost exclusively on the potential of individuals to come up with new ways to get ever increasing output from the same amount of inputs. Because Weitzman believes that most "new" ideas are essentially reconfigurations of existing ideas, he states that the productivity of capital is unlikely to decline in the "deep future". However, he recognizes that his speculation regarding the productivity of capital in the "deep future" is riddled with uncertainty. This recognition leads him to advocate the use of a "declining" discount rate; a rate that starts at the present market rate, but declines to the smallest possible rate that may exist in the "deep future". Thus, he concludes that "the moral of the story is 'just keep discounting, but…' at a declining interest rate for very long-term projects" (Weitzman, 1999, pp. 29).

Weitzman also wrote an earlier paper (1994) that examined the appropriate rate of discount in the environmental arena. In this paper, he pointed out that, in the classical model, the discount rate is assumed to be constant and argued:

> Constancy of discount rates, however, is not an innocuous assumption. It implicitly amounts to assuming some stationarity over time. This may be a particularly inappropriate assumption for a world seemingly evolving toward an ever increasing degree of environmental concern (Weitzman, 1994, pp.200).

Weitzman believes that society's increasing concern for environmental issues warrants the use of low and declining rates in the discounting of environmental projects. Assuming no market distortions other than negative environmental externalities, he derived a model in which the ratio of the social discount rate, *r*, to the private discount rate, *i*, is a function of two parameters: the fraction of national income spent on environmental improvement, *Z*, and the elasticity of environmental improvement with respect to environmental spending, *E*:

$$r = i\left[1 - Z\left(1 + \frac{1}{E}\right)\right] \tag{4.4}$$

Weitzman then defines a "correction factor", γ:

$$g = Z\left(1 + \frac{1}{E}\right) \tag{4.5}$$

This "correction factor" indicates the degree to which the social rate of discount, *r*, should be adjusted downward from the private rate, *i*. Thus, the ratio of the social to the private rate can now be expressed as:

$$r = i(1 - g) \tag{4.6}$$

Weitzman interprets the "correction factor", γ, as the coefficient of "environmental drag". "Environmental drag" occurs through the imposition of environmental standards that are

designed to discourage capital formation that results in environmental externalities; the "drag" factor eats away at some fraction of the future consumption that could be enjoyed by investment today at the private rate, i. The amount of environmental drag, γ, grows as the fraction of national income spent on environmental improvement (Z) increases, and as the elasticity of environmental improvement with respect to environmental spending (E) falls. While Weitzman speculates that the elasticity of environmental improvement with respect to environmental spending is likely to remain relatively constant, he suspects that that the fraction of national income spent on environmental improvement will increase over time. Consequently, over time the social rate of discount, r, will fall relative to the private rate, i; the negative effects on the environment from the economic activity necessary to generate an extra unit of consumption will no longer be offset by the enjoyment that extra unit of consumption yields. Thus, Weitzman concludes, "…environmental considerations themselves argue in favor of using ever-lower interest rates to discount ever-more-distant future costs and benefits in social project analysis" (Weitzman, 1994, pp.207).

Kopp and Portney (1999) propose an alternative to the classical model of discounting, which they argue is inappropriate for areas where time horizons longer than thirty to forty years are involved; their approach is that of a mock referendum. They point out that this approach has great practical appeal, as it is similar to the political process so familiar to citizens of the U.S. A particular public project would be chosen for analysis; as one example, Kopp and Portney use a tax of $50 per ton of carbon equivalent to address the problem of global climate change. A representative sample of U.S. households is then drawn, and presented with information about the effects of the

proposed policy, as well as the likely effects of maintaining the status quo. Kopp and Portney note that it is important that this descriptive information be clear about who is most likely to benefit from the proposed policy, and how the proposed policy will directly affect the household. Returning to their example, the proposed carbon tax may result in increased gasoline, home heating oil, and electricity prices. In addition, the distribution of both the benefits and costs of the proposed policy over time must be clearly spelled out, but the descriptive materials must also be forthcoming about the uncertainties involved. For example, the negative impacts of climate change may not be felt for hundreds of years. Kopp and Portney argue that one may estimate a willingness-to-pay equation by varying the information that is presented to the households and by collecting socioeconomic data about each household. They believe that this approach is especially attractive because it allows each household to apply its own rate of discount to future costs and benefits, rather than trying to capture the preferences of all households by use of a single discount rate. In addition, Kopp and Portney argue that responses to the mock referendum inform U.S. elected representatives as to the true feelings of the American public regarding a specific public policy, providing a barometer of the degree of support such a policy would actually receive should efforts actually be taken in the political process to implement it. Kopp and Portney do recognize that this approach has all of the familiar problems typically associated with stated preference methodology (see Chapter Three), but also point out that in analyses of many environmental projects, even if one employs the classical model of discounting, one must first use stated preference techniques to estimate the benefits (e.g. the benefits of species protection) of the proposed project. Thus, they argue that it is often not possible to avoid completely the

pitfalls of stated preference techniques, even if one clings to the constant rate discounted utility model (Kopp and Portney, 1999).

Thomas C. Schelling (1999) approaches the problem of discounting in the specific case of climate change from the viewpoint that "any abatement program is essentially a foreign aid program" (Schelling, 1999, pp.99). He supports this stance by noting that 1) in the next century, between 80%-90% of the earth's inhabitants will live in the less-developed nations, 2) the economies of the less-developed nations are most susceptible to climate change and 3) the less-developed nations will continue to have lower per-capita income than the developed nations, even if they do experience higher rates of economic growth in the next century. Schelling argues that the traditional method of analyzing investment decisions simply does not apply here:

> There can be, for example, no 'time preference' of the traditional sort. Time preference, often associated with impatience, relates to impatience about one's own future consumption, that is, the consumption in the future by the person who currently forgoes consumption in the interest of investment. Greenhouse gas abatement is a foreign aid program, not a savings-investment program of the familiar kind. One can be more interested in the welfare of Chinese and Indian children born in 2050 than those born in 2075, or in 2100, but that would hardly be due to impatience or any of the usual ingredients of time preference (Schelling, 1999, pp.100).

Schelling also maintains that the usual concerns about transferring wealth from the current generation to potentially wealthier future generations are not valid here either, since future generations in the less-developed countries are likely to still be poorer than the current generation in the U.S. (Schelling, 1999).

William D. Nordhaus (1999) also addresses discounting specifically in the case of climate change, employing an economic model of global warming called the DICE model

(Dynamic Integrated Model of Climate and the Economy). This model chooses levels of investment in both capital and greenhouse gas reductions by maximizing a social welfare function. Nordhaus recognizes that the program that is most "efficient", in the sense that it optimizes the social welfare function, may be unacceptable to society. He explores four alternatives: 1) raising the savings rate or lowering the overall discount rate, 2) differential discounting, which involves applying different discount rates to different projects, 3) climate targeting, and 4) emission or concentration limitations. Based on the results of the DICE model, Nordhaus finds that the first two alternatives, either lowering the discount rate or differential discount rates, are poor alternatives compared to the options of climate targeting or concentration limitations. Hence, he concludes:

> …ad hoc manipulation of a discount rate on goods to achieve long-term goals is a very poor substitute for policies that focus directly on the ultimate objective…focusing on the ultimate objective has the advantage of showing trade-offs explicitly, making the cost of violating a benefit-cost rule transparent and allowing public decisionmakers to weigh the options rather than having technicians hide the choices in complicated and abstrusely argued second-best rules of thumb (Nordhaus, 1999, pp. 158).

Lind (1999) considered the discounting debate once again, writing: "I do not believe that a decision such as whether to go forward with a program to mitigate global warming can be made on the basis of a decision model that projects future costs and benefits and discounts them to a present value using any rate of discount" (Lind, 1999, pp.174). He distinguished between public investments with very long time horizons and those with relatively shorter time horizons, noting two important differences: 1) intergenerational transfers, either forward or backward, are simply not feasible due to the difficulty of establishing and maintaining a commitment between intervening generations and thus, Kaldor's compensation criterion is not applicable, and 2) there is much greater

uncertainty about the state of affairs several generations down the road (i.e. uncertainty about individual's preferences and income, and technology). Lind echoed Schelling's (1995) view that any potential expenditures for mitigation of problems that would likely affect primarily future generations must be analyzed "as a gift to someone else, not as an investment for one's own future consumption" (Lind, 1999, pp. 175-176). Lind further explained:

> …the appropriate question for weighing costs and benefits in a dynamic decision process is, how much are people willing to pay today for the knowledge (a benefit to them) that we will have certain options open for dealing with climate change in the future given the information and technology available to society in the future? This is a different concept of costs and benefits than in the traditional benefit-cost paradigm (Lind, 1999, pp. 176).

Clearly, the 1999 Resources for the Future conference was a serious, thoughtful discussion of different viewpoints, but it did not achieve anything close to a consensus regarding the discounting of long-term investments. However, the nature of the debate was very different from that of the 1977 conference, which focused on energy policy. In the face of global warming and other seemingly remote environmental threats, the definition of "long-term" has changed. The dialogue surrounding discounting must now consider time horizons as long as two hundred and three hundred years; thus, questions of intergenerational equity cannot be avoided. These are not easy questions. Robert Solow (1999) concludes:

> The fact is that we-those making or voting on policy decisions today-know almost nothing about the technological and economic possibilities that will be available 200 years from now. This is not so much a matter of uncertainty or of sheer ignorance or even of vocabulary. One device that is appropriate in some bits of economics is to reflect uncertainty by deeper discounting. But that seems quite inappropriate here: we want to allow for the fact that we don't know, not that we don't care (Solow, 1999, pp. ix).

We now turn to a detailed discussion of the alternatives to the classical model's description of intertemporal decision-making, and the large body of empirical evidence that suggests the constant discounted utility model may not be valid in many circumstances. We are particularly concerned with whether the classical model is an appropriate description of how individuals make intertemporal choices regarding decisions that affect both their health and the health of others.

4.5 Challenges to the Classical Model of Discounting

4.5.1 Kahneman and Tversky's Prospect Theory

Kahneman and Tversky (1979) developed "prospect theory", the idea that losses are weighted more heavily than gains. The theory had been supported empirically for monetary losses or gains (Tversky and Kahneman, 1981) and in health-related decision contexts in which mortality outcomes has been framed as probabilities of survival (a gain) or death (a loss) (McNeil et al., 1982). Benzion et al. (1989) and Thaler (1981) provide evidence that future monetary gains are discounted more heavily than losses, which suggests that this gains-losses effect on time preference for monetary outcomes might carry over to time preference for health-related outcomes.

4.5.2 Loewenstein's Theory of Intertemporal Choice

Loewenstein's theory of intertemporal choice (1987), which draws on both economic and psychological concepts, proposes that intertemporal choice is a function not only of the utility derived from experiencing consumption (consumption utility), but also of the utility derived from anticipating a future consumption experience (anticipation utility). Consumption utility depends on the desirability and duration of consumption.

As an event is delayed into the future, its consumption utility, regardless of whether it is positive or negative, diminishes relative to the utility of its immediate consumption. This is called "positive time preference", and is assumed by the classical model of discounting. At any point in time *t*, anticipation utility is influenced positively by the desirability, duration and vividness of the consumption event, and negatively by the time delay to consumption. Looking forward to a desirable future event produces positive anticipation utility which, if it exceeds the devaluation in consumption utility due to delay, results in a greater overall utility for delayed consumption than for immediate consumption. This is referred to as "negative time preference". In this case, one prefers to defer the desirable event. MacKeigan et al. (1993) provide the example of individuals who plan a vacation long in advance, anticipating how wonderful it will be.

Alternatively, apprehension or dread from an undesirable future event produces negative anticipation utility, which people will alleviate by pushing up the event in time, i.e. "getting it over with". This is also a case of negative time preference. For example, one may wish to get a dreaded dental procedure over with as soon as possible (MacKeigan et al., 1993). Loewenstein (1987) tested this theory on a small sample of university students. His subjects devalued delayed monetary gains and losses (described by as "non-vivid" events) relative to immediate gains and losses. However, the subjects inflated the value of delayed non-monetary events that were both vivid and fleeting; these events were an electric shock and a kiss from a movie star.

It is reasonable to believe that anticipation and dread are especially likely to influence the individual's rate of time preference for health-related outcomes. Several additional studies provide empirical support for the significance of anticipation and dread

as influences on intertemporal preferences (see, for example, Varey and Kahneman, 1990; Loewenstein and Prelec, 1991).

4.5.3 Kahneman and Thaler: Intertemporal Preference for Sequences

Kahneman and Thaler (1991) discuss adaptation, interpersonal comparisons and loss aversion as significant influences on intertemporal preferences for sequences. They distinguish between *experience utility* and *decision utility*. Experience utility, an older notion of utility than decision utility, focuses on the pleasures of consumption. It views some aspects of compensation, such as the timing of payments and workers' earnings profiles, as highly relevant, while the standard model of decision utility would ignore such aspects if they did not change the after-tax present value of the compensation payments. Adaptation, or anchoring, refers to the tendency of individuals to view one's normal situation as neutral, i.e. neither bad nor good. Loss aversion, also discussed in Chapter Three and in section 4.5.1 of this chapter, refers to a value function that is steeper for losses than for gains. Adaptation and loss aversion combine to create a world where real value to the individual lies in *changes in his level of well being*, rather than in his *absolute level of well being*.

Kahneman and Thaler (1991) argue that the results of studies that examine income satisfaction, and the effect of income on self-reported happiness, can be summarized in three propositions: 1) a cross-sectional study of any society at any time will likely suggest a strong correlation between income and satisfaction, 2) although societies may vary significantly in income levels, they have similar mean levels of satisfaction, and 3) one's income satisfaction is determined by comparisons to others and to one's past. They provide further support for the concept of adaptation by referring to

Brickman and Campbell's (1977) study of paraplegics and lottery winners, which indicated that once each of these two groups adapted to their situations, they rated themselves as just about as happy as non-paraplegics and non-lottery winners. Kahneman and Thaler argue that, given the process of adaptation, the worker's stream of compensation can be adjusted, even while the total dollar amount of compensation remains the same, to yield the worker greater utility than an even distribution of payments. To support this assertion empirically, they point to the results of a study of Cornell University undergraduates. These students were offered the choice between a salary of $26,000 paid in weekly increments of $500 or a salary of $25,000 paid in equal weekly increments, with a $1,000 bonus at midyear. Seventy three percent of the students preferred the latter option. Kahneman and Thaler point out that individuals will often take steps to ensure that they receive "lumpy" payment at some point in the year; as an example, Shefrin and Thaler (1988) remind us that many individuals structure the payment of their income taxes so as to receive a lump sum refund from the IRS, effectively giving the IRS an interest-free loan.

4.5.4 Loewenstein and Prelec's Four "Anomalies"

Loewenstein and Prelec (1992) describe four anomalies that arise in intertemporal choice: the *common difference effect*, *absolute magnitude effect*, *gains-loss asymmetry*, and *delay-speedup asymmetry*. The *common difference effect* occurs if one's preference between two delayed outcomes switches when both delays are incremented by a given constant amount. Thaler (1981) provides a helpful example: a person might prefer one apple today to two apples tomorrow but at the same time prefer two apples in 51 days to

one apple in 50 days. The common difference effect gives rises to dynamically inconsistent behavior.

The *absolute magnitude effect* refers to the tendency of individuals to discount large dollar amounts less heavily than smaller ones. Thaler (1981) found that subjects who were, on average, indifferent between receiving $15 immediately and $60 in a year, were also indifferent between an immediate $250 and $350 in a year, as well as between $3,000 now and $4,000 in a year. Loewenstein and Prelec (1992) appealed to the magnitude effect to explain the disparity between estimated discount rates from the analyses of consumer durables purchases and estimated discount rates from analyses of savings and labor supply behavior. They suggested that the relatively small, delayed electricity costs associated with the consumer durables will be substantially devalued due to the dependence of discounting on outcome magnitude. Consequently, consumer durables purchases will be insensitive to electricity charges and the discount rates estimated from those purchases will appear high. Discount rates estimated from more serious economic decisions, such as saving and labor supply, would not be subject to such small magnitude effects.

Gains-loss asymmetry describes a situation where losses are discounted at a lower rate than gains. For example, subjects in a study by Loewenstein (1988) were, on average, indifferent between receiving $10 immediately and receiving $21 in one year, and indifferent between losing $10 immediately and losing $15 in one year. Thaler (1981) reported even more dramatic loss-gain asymmetries. He estimated discount rates for gains that were three to ten times greater than those for losses. Several subjects

exhibited negative discounting, in that they preferred an immediate loss to a delayed loss of equal value.

Delay-speedup asymmetry, an asymmetrical preference between speeding up and delaying consumption, was documented in Loewenstein's 1988 work. In general, the amount required to compensate for a delay in receiving a reward by a given interval, from *t* to *t+s*, was from two to four times greater than the amount subjects were willing to give up to speed up consumption by the same interval, from *t+s* to *t*. These results constitute a framing effect.

4.5.5 Empirical Evidence of Non-Constant Discounting

Cropper et al. (1991) tested the hypothesis of constant exponential discounting in the context of choices between two life-saving programs. One life-saving program saved lives in the present, while the other saved lives in the future. Both programs cost the same amount of money. The individual is asked to indicate which program he prefers. The individual is assumed to receive utility $U_A = aX$ from program A and $U_B = bY$ from program B. Consequently, the individual will choose Program A if:

$$aX > bY, \text{ which implies } b/a < X/Y$$

where *b/a* is the fraction of a person saved today who is equivalent to saving one person at time *T* (or the marginal rate of substitution between lives saved today and at time *T*), *X* is the number of lives saved by Program A, and *Y* is the number of lives saved by Program B. If individuals discount future lives saved at a constant exponential rate, the marginal rate of substitution between lives saved now and at time *T* is:

$$\frac{b}{a} = \exp(-dT) \qquad (4.7)$$

There exists a one to one correspondence between the marginal rate of substitution and the discount rate *d*. This implies that the discount rate applied to a life saved at *T*=100 to discount it to *T*=50 is the same one applied to a life saved at *T*=50 to discount it to the present (*T*=0) (Cropper et al., 1991). Loewenstein and Thaler (1989) previously found that the discount rate used to discount lives from *T*=50 to *T*=0 is greater than the discount rate used to discount lives at *T*=100 to *T*=50, which suggests that the discount rate falls over time. Cropper et al.'s results are consistent with the results of Loewenstein and Thaler, indicating that the mean discount rate falls as the time horizon increases. Based on all responses, the mean discount rate is approximately 8% for a 25-year horizon, 6% for a 50-year horizon, and 3% for a 100-year horizon (Cropper et al., 1991). In later work by Cropper et al. (1994), the null hypothesis of constant exponential discounting was again rejected. Median discount rates ranged from 17% for a five-year horizon to 3.7% for a one hundred-year horizon. George Ainslie (1992) also found evidence of non-constant discounting.

4.5.6 Empirical Evidence of Negative Rates of Time Preference

Empirical evidence suggests that some individuals may, in fact, have negative discount rates in certain contexts (Frank, 1992; Frank and Hutchens, 1993; Loewenstein and Sicherman, 1991; Varey and Kahneman, 1990; Ross and Simonson, 1990). Cropper et al. (1994) found that about 10 percent of respondents had negative discount rates in the context of public programs to save lives; they choose the program that saved lives at some point in the future over the program that saved lives in the present, even when the future-oriented program saved fewer lives than the present-oriented program.

It appears that many individuals would rather experience "bad" or undesirable outcomes sooner rather than later. This preference has been attributed in part to the experience of dread and loss aversion, both of which combine to form a strong desire for a sequence of improving outcomes. Because one may argue that people consider relative changes in consumption, rather than absolute levels of consumption, sequences of improvement are viewed as a series of relative gains, while declining sequences are viewed as a series of relative losses (Loewenstein and Prelec, 1991). Loewenstein and Prelec (1991) note that while it is true that if negative time preference were uniformly applied to all choices, we would witness drastic declines in present consumption in favor of future consumption, the absence of this observation does not imply positive time preference. Loewenstein and Prelec argue that negative time preference is applied selectively to events that are viewed as part of a meaningful sequence, where the sequence has a well-defined beginning and end. They conclude that while individuals may exhibit a good deal of impatience in intertemporal trade-offs that are unrelated to other events, once the trade-off is embedded in the context of two alternative sequences, the individual's mindset changes. He becomes far more patient, preferring to delay the preferred outcome. Thus, although he may prefer an apple today rather than tomorrow, if given the choice between the apple today and an undesired orange tomorrow, or the undesired orange today followed by the desired apple tomorrow, the individual will likely choose to delay consumption of the preferred good, the apple, preferring an improving sequence of fruit consumption.

4.6 Health as a Unique Commodity

As we reflect upon the issues raised by the intertemporal nature of many health-related programs, it is important to recognize that health differs from money and other commodities in a number of ways. Redelmeir, Heller, and Weinstein (1994) state that the optimality of the neoclassical economic model hinges on the assumption that individuals face a constant marginal rate of substitution between health and other goods and adjust their consumption such that marginal rates of substitution are equal across individuals over time. However, they note that health cannot be transferred across time or individuals. Many health outcomes are irreversible in nature. However, Viscusi (1995) maintains that although health is a very distinctive commodity, it enters individual utility functions in a similar way as other commodities.

4.6.1 Should Future Health Benefits Be Discounted?

The practice of discounting future health benefits has been advocated for two reasons. First, Keeler and Cretin's (1983) "paralyzing paradox" states that if health benefits are undiscounted, or if they are discounted at a lower rate than monetary costs and benefits, it will always appear cost effective to delay any health intervention. Secondly, Drummond et al. (1987) argue that if health benefits are discounted at a lower rate than costs, any project which involves a large annual capital outlay and provides minimal annual benefit will appear to be cost effective because future costs will be more heavily discounted than future benefits.

Parsonage and Neuburger (1992) responded to the work of Keeler and Cretin by stating that Keeler and Cretin are confused as to which measures of cost effectiveness are appropriate under specific circumstances. They argue that cost per Quality Adjusted Life

Year (QALY) calculations are used not for setting size of budgets or for their distribution over time, but for setting priorities within a fixed budget year by year. In the case where health planners have no means of deferring current funds to the future, it cannot be paralyzing to rank projects according to cost per undiscounted QALY. Parsonage and Neuburger advocate a zero discount rate on the basis that discounting tends to give lower weight to interventions that have long lasting effects. They note that a zero discount rate will improve the relative cost effectiveness of programs aimed at the young, such as neo-natal care, and of programs that affect future generations, such as reducing the incidence of infectious disease. If discounting must occur, they feel that, particularly in cases where the benefits of a proposed policy stretch far into the future, one should utilize sensitivity analysis to examine the use of different discount rates.

Redelmeir, Heller and Weinstein (1994) have responded to Keeler and Cretin's work by noting that the paralyzing paradox is almost never observed. They believe that this is a result of countervailing forces, rather than commitment to exponential discounting for health effects. For example, political factors, such as the greater value people assign to identified lives relative to statistical lives, may demand that resources be allocated to immediate concerns rather than to future problems. Redelmeir et al. also consider that public accountability may lead to a liberal definition of “essential services” that exceeds the available resources. Self-interested voters may hinder proposals to defer health benefits to future generations. Finally, as noted by Keeler and Cretin themselves, budget procedures often require spending this year’s budget this year, leaving few opportunities to retain unspent dollars (Redelmeir et al., 1994).

The valuation of health related outcomes poses an additional problem because it is possible that future benefits are discounted twice. Since health outcomes typically must be defined with reference to time, individuals may incorporate their rates of time preference to some degree when making choices among various outcomes in a utility assessment process, e.g. choosing among various health prevention programs. If further discounting by a government agency occurs, double discounting may occur (Krahn and Gafni, 1993; Gafni, 1994).

The now familiar concerns about intergeneration equity are also voiced in the debate surrounding the economic evaluation of health care programs. Keeler and Cretin (1983) also maintain that failure to discount benefits implies that we should always be willing to transfer resources away from present health needs to those of future generations. They argue that there are several reasons to object to such transfers. They assert that it is hard to guess how future generations would want to spend the resources, as we don't know the values they will put on health versus other uses of the money. In addition, they contend that "justice is not served" by diverting resources from poor to rich, or from sick to well, as future generations will probably be richer and live longer than the present generation. W. Kip Viscusi (1995) echoes the sentiments of Keeler and Cretin, pointing out that as a result of the positive income elasticity of the valuation of health status and failure to discount, we can argue that the further in the future the lives are saved, the more highly they will be valued, assuming future generations are more affluent. While Viscusi concedes that the transfer of some resources to future generations is desirable, he shares Arrow's (1999) position that our generosity to the future has limits. He concludes that weighing the present value of $1 in health effects equally with $1 in

health effects a century from now would lead to a significant income redistribution to richer future generations. Consequently, he doubts such a policy would be pursued if the full implications of such a policy were understood (Viscusi, 1995, pp.135).

Many, such as Rawls (1971), have continued to oppose discounting based on intergenerational justice issues, as discounting gives greater weight to benefits occurring now than those occurring in the future. Parfit (1984) argued that each generation should be treated equally, and consequently, benefits should remain undiscounted. Finally, Coyle and Tolley (1992) note that positive discounting of health benefits favors programs that yield small, immediate benefits in mortality and morbidity, as opposed to programs aimed at behavior modification to lower the incidence of chronic disease in the future. Yet if we do not discount health benefits, such health prevention and promotion will appear more cost effective than they would after discounting. Consequently, Coyle and Tolley argued for a delicate balance between resources allocated to long-term health promotion and those allocated to short-term interventions.

4.6.2 Is the Constant-Rate Discounted Utility Model Appropriate for Health-Related Outcomes?

Bleichrodt and Gafni (1996) argue that the constant rate discounted utility model is particularly inappropriate as a representation of intertemporal preferences in evaluation of health care programs. Although it is widely maintained that individuals prefer to experience benefits sooner rather than later, Bleichrodt and Gafni (1996) argue that the assumed impatience of individuals may not hold for health-related outcomes because of the experience of anticipation and dread that often accompanies adverse health outcomes.

Bleichrodt and Gafni maintain that in the context of health related decision making, it may not be irrational to prefer to experience adverse outcomes sooner rather than later.

Empirical studies that have attempted to elicit the rate of discount individuals apply to health-related decision have all rejected the constant rate discounted utility model (Redelmeier and Heller, 1993; Olsen, 1993a; Mackeigan et al., 1993; Cairns, 1994). These studies were performed using subjects as diverse as students, physicians, health policy makers, and the general public. These studies all exhibit a pattern where the discount rate is relatively high for proximate years and relatively low for more distant years.

There is conflicting empirical evidence regarding whether or not we discount future health benefits at the same rate we discount future monetary benefits. Cropper et al. (1994) found similar discount rates for money and health. However, there appeared to be less variation in discount rates for money than in those for health. Moore and Viscusi (1990b) used labor market data to analyze the implicit rates of time preferences that workers reveal through their willingness to bear risk on the job. Wage responses to life years at risk provide direct estimates of the discount rate workers apply to future streams of utility. This estimated discount rate equals approximately 2%, which is consistent with financial market rates for the period. Moore and Viscusi find no clear evidence of systematic discount rate differences for money and health. Therefore, they conclude that there is no empirical support for applying a different rate of discount to health benefits.

Chapman and Elstein (1995) asked individuals to make both health and monetary discounting choices to examine if they used the same discount rate in the two domains. They assessed the correlation between the two domains to determine whether the

participants who display the highest discount rates in the money domain also display the highest discount rates in the money domain. They found that there was very low correlation in discount rates between the two domains, an effect they termed "domain independence". Chapman and Elstein concluded that decision makers do not adhere to discounted utility theory, but instead apply different discount rates for different domains. This study found higher discount rates for health than for money. In contrast, Cairns (1992) found that discount rates for health decisions were lower than those for monetary decisions (2% versus 18%). It is important to note that Cairns used negative health outcomes (losses), while Chapman and Elstein used positive health outcomes (gains). Thus, Loewenstein and Prelec's (1992) observation of the gains-loss asymmetry effect may partially explain the discrepancy between Chapman and Elstein's (1995), and Cairns' (1992), results.

MacKeigan et al.'s study (1993) asked subjects to imagine themselves as the hypothetical person in the health profile under a prescribed set of circumstances. The health gain was represented as a period of ill-health (an arthritic condition) followed by a period of excellent health. Under the loss scenario, the hypothetical person began the period in excellent health and then acquired the same arthritic condition. Each subject ranked 12 five-year profiles. Either a standard health gain or health loss (of 3 varying durations and 4 different delays of onset) was embedded within each profile. MacKeigan et al. found that delayed health gains were discounted more heavily than health losses of comparable duration. MacKeigan et al. suggest this may be explained by attributing greater vividness to the health losses. An alternative explanation for these results is that waiting for health gains may be a frustrating rather than pleasurable experience;

frustration triggers negative anticipation utility that complements the devaluation in consumption utility. All health gains were devalued with delay in a pattern consistent with positive time preference. However, the valuation profile of health losses over time depended upon the duration of the loss. Long-term loss was discounted more heavily with delay, preference for the intermediate duration did not change significantly with the delay, and the negative value of the fleeting loss became greater with delay. In the latter case, the loss was perceived to be worse when delayed.

Chapman (1996) attempted to address whether the discrepancy between health and monetary discount factors found in her earlier work, Chapman and Elstein (1995), would still persist if money and health had been expressed on a common utility scale. In three experiments, three variations of the hypothesis that domain independence is an artifact of different utility functions for health and money were tested. Chapman described three biases in intertemporal choice that were demonstrated in her experiments: the delay effect, the magnitude effect, and the sign effect. These biases correspond to Loewenstein's anomalies of the common difference effect, absolute magnitude effect, and gain-loss asymmetry, respectively. Chapman's three experiments demonstrated domain independence, which is consistent with her earlier findings in Chapman and Elstein (1995). This result was maintained despite three different attempts to remove the effect of different utility functions for money and health. Consequently, she states "these results indicate that domain independence is not an artifact of differing utility functions for health and money but rather a fundamental characteristic of intertemporal choice" (Chapman, 1996, pp. 787). The same biases (the delay, magnitude and sign effects) influence the discount rates for both money and health. However, these biases appear to

be more prevalent in health-related outcomes than in monetary outcomes (Chapman, 1996).

4.7 Alternatives to the Classical Discounting Model

Henderson and Bateman (1995) discuss alternatives to the constant rate discounted utility model, noting that the key characteristic of the alternative models is that they discount early costs and benefits more heavily, and later costs and benefits less heavily, than traditional exponential discounting**.** George Ainslie and Nick Haslam (1992) notes that a discount function that declines steeply over short time horizons, but that flattens over longer time horizons at a level higher than the constant exponential discount function, was observed as early as 1961 by Herrnstein. Let us examine some forms of the alternatives to constant rate exponential discounting.

Henderson and Bateman (1995) suggest that the findings of Cropper et al. (1991, 1992, 1994) support a hyperbolic discount relationship such as the following:

$$DF_t = \frac{1}{(1 + r_h t)} \tag{4.8}$$

where DF_t is the discount factor at time t, t is time in years, and r_h is the hyperbolic discount rate. Loewenstein and Prelec's model of intertemporal choice (1992) led to a set of preferences that implied a generalized hyperbolic function of the form:

$$f(t) = (1 + \alpha t)^{-\delta/\alpha}, \alpha, \delta > 0 \tag{4.9}$$

where the coefficient α describes how much the function deviates from the constant-rate exponential discount function, and δ is the constant exponential discount rate. Note that when α approaches zero, we approach the constant exponential discount function:

$$j(t) = e^{-\delta t} \tag{4.10}$$

Figure 4.2, located at the end of this chapter, graphically illustrates hyperbolic and exponential discounting for $d = 0.10$; it is clear that hyperbolic forms of discounting give much greater weight to benefits that occur far into the future.

Harvey (1994) suggested a potential alternative to constant discounting: proportional discounting. Under this method, the discount rate would decline as impacts of the program occur farther into the future, and would approach zero as the timing of the impacts of the program approach infinity. More formally, proportional, or slow, discounting assumes that the discount factor is given by:

$$a(n) = \frac{b}{(b + n)} \quad \text{for some parameter } b>0, \text{ where } n \text{ is the number of periods} \qquad (4.11)$$

Harvey (1994) points out that the impact on the present value of a public project of using proportional versus constant discounting is startling: discounting with a constant discount rate of 10% per year values outcomes that occur now to be about 14,000 times more important than outcomes that will occur in 100 years, while proportional discounting with an initial discount rate of 10% values outcomes that occur now to be 11 times more important than outcomes that will occur in 100 years. As discussed in detail earlier in this chapter (Section 4.4), Martin L. Weitzman has also advocated a form of "slow" discounting (1994, 1999).

Reluctance to accept hyperbolic discounting stems from the preference reversals that can exist under a hyperbolic discounting function. Henderson and Bateman (1995) dismiss the gravity of such preference reversals, arguing that individuals view their position in time relatively, rather than absolutely. They further argue that the government's willingness to allow the future benefits and costs of select projects that have intergenerational implications to be discounted at rate lower than the prescribed rate

stems from recognition of the underlying hyperbolic social discount rate. In order to ease some analysts' discomfort with the hyperbolic discount rate, Henderson and Bateman suggest that hyperbolic discount rates should be presented in addition to, rather than instead of, classical exponential rates to promote sensitivity analysis on the part of government agencies.

However, others have maintained that the time inconsistency resulting from the alternatives of hyperbolic or "slow" discounting is a significant hurdle. Robert Solow (1999) writes:

> Suppose an intelligent decision maker plans a strategy for the long future, beginning today. Five years from now, she reconsiders the strategy, having followed it so far. She will want to change to a different strategy, for no other reason than the passage of time. And in another five (or four or three or two) years, she will want to change again, and she will know that she will want to violate the current strategy. This sounds like a poor way to run a railroad (Solow, 1999, pp. viii).

Cropper and Laibson (1999) discuss the effects of hyperbolic discounting, examining the equilibrium of a game that the individual's temporal selves play. Analysis of this game suggests that the consumption path of an individual with a hyperbolic discount function is not different than the consumption path of an individual with a constant rate exponential discount function. However, Phelps and Pollack (1968) demonstrated that the equilibrium of this game is Pareto inefficient, since individuals will be better off if they save more in all years. Thus, Cropper and Laibson argue that there is a role for the government in the case of hyperbolic discounting; the government should subsidize the return on capital or lower the required rate of return on investment projects by about 2%. Cropper and Laibson point out that this approach does not favor investments of an environmental nature over other types of investments, but rather

promotes all investment; they view this as a necessary step due to the hyperbolic individual's tendency to undersave.

4.8 Relationships between Rate of Time Preference and Individual Characteristics

Cropper et al. (1991) found that discount rates were heavily influenced by the personal characteristics of individuals. In all cases, the mean discount rate for Non-Caucasians was higher than that of Caucasians. Older persons had a higher rate of discount than younger ones. Finally, respondents with children under age eighteen also had higher discount rates than those who did not. However, income and education did not have a significant effect on the discount rate. In their later work, Cropper et al. (1994) again found that discount rates increased with age and found that discount rates were higher for African Americans than for other races. For time horizons of 25 years or more, they found that individuals with children under the age of 18 exhibited higher discount rates. Income and education remained insignificant in determining an individual's rate of time preference.

Attempting to explain these results, Cropper et al. (1994) suggest that self-interest may explain why older individuals and parents with young children have higher discount rates. Older individuals may believe that they will not be alive to enjoy the benefits of future-oriented life-saving programs. People with children under the age of 18 may have higher discount rates because they feel that protecting their child, and themselves as the primary caretakers of that child, is more important while the child is young than when he or she is an adult. Consequently, motivated by a desire to protect their young children, these parents may express stronger preferences for present-oriented programs than do individuals who do not have young children. Cropper et al. asked respondents whether

they had considered the effect the programs would have on themselves or their families when making their trade-offs between present- and future-oriented programs. Forty percent of the respondents indicated that they did so. However, the probability that the respondent chose the present-oriented program was not significantly higher if he considered how the program would affect him personally than if he did not (Cropper et al., 1994). Cropper et al. note that other authors (Lawrance, 1991; Leigh, 1986) have found that African Americans have higher discount rates for monetary outcomes than do people of other races. They suggest that this may occur as a result of cultural factors or the fact that African Americans have shorter life expectancies than whites. Finally, while Cropper et al. are somewhat surprised that income and education are not determinants of the discount rate, they conclude that there is no particular reason that a poor person should discount anonymous lives more heavily than his more affluent counterparts (Cropper et al., 1994).

Interestingly, Hausman (1979) found that the discount rate was inversely related to income in his study of air conditioner purchase and utilization. Perhaps the relationship between income and the discount rate depends upon the nature of the commodity, i.e. whether it is a private good (as in Hausman's work) or a public good (as in the case of Cropper et al.'s life-saving programs). Another possible explanation for the contradictory findings of the two studies is that Hausman's study examined actual market behavior, while Cropper's results are based on stated preferences in a hypothetical context. It is very likely that Cropper's subjects neglected to consider their budget constraints.

4.9 The Individual versus the Citizen: Which role do we play when we attempt to place a value on public goods?

A literature review of the debate surrounding both stated preference methodology and intertemporal choice suggests that individuals often behave in ways that are unexpected if one takes the classical economic model to be gospel. Mark Sagoff cites one study where the authors concluded that responses to contingent valuation method surveys reveal "social or political judgments rather than preferences over consumer bundles" (Sagoff, 1996, pp.909). Consequently, we seek explanations for why many individuals deviate from classical behavior.

The classical model assumes that, when asked a question concerning public goods, individuals will provide the answer that maximizes their private gain. Sen (1982) argues that in the context of preferences for public goods, the gains-maximizing assumption may not be appropriate. He maintains that the issue is not whether people consistently respond truthfully, but whether they always give a gains-maximizing answer, or whether they give a gains-maximizing answer frequently enough to make that the appropriate general assumption for economic theory. It has been shown in controlled laboratory experiments that individuals playing the Prisoner's Dilemma game frequently do the unselfish thing. Sen criticizes the game theorist for his propensity to attribute this to a lack of understanding by the players. He argues that a more fruitful approach may lie in acknowledging the possibility that the individual is more sophisticated than the theory gives her credit for. For example, she may have asked herself what type of preferences she would want the other player to have, and on somewhat Kantian grounds, behaves as though she has those preferences, regardless of whether she actually does. Sen's thought

that the individual may be more complicated than traditional theory allows her to be leads us to the work of Margolis, who viewed the consumer as having two dimensions: the individualistic and the social.

Howard Margolis confronts what he describes as the "old puzzle of duality of human nature-man as private, self-seeking individual; man as citizen and social being" (Margolis, 1982, pp.x). Margolis argues that if individuals are seen to be behaving in a way that seems rational from a societal, but not individual, point of view, then we may say they are acting as if they had two different utility functions. Margolis points out that one may attribute altruism in the public goods case to the individual's taste for various public goods. However, he sees little value in this type of theorizing, since "it is able to explain everything but predict nothing". In addition, he argues that substituting "duty to" in place of "taste for" changes nothing essential. He contends that a nontrivial theory must say something about what governs the taste or duty to perform altruistic acts (Margolis, 1982, pp.12). Another possible justification for not modeling "moral duty" as an argument of the classical utility function is that individuals may not be willing to make trade-offs between moral duty and commodities; indifference curves representing the trade-off between moral duty and money (which is used to purchase goods and services) likely do not exist. Margolis concludes by arguing that the "dual-utilities logic emphasized the essentially mixed character of motivation that governs most real choices". To the extent possible, the individual seeks a "fair share" equilibrium between spending to satisfy private spending and spending to satisfy social preferences, an equilibrium where the individual feels neither selfish nor exploited. Thus, the dual nature of the individual is brought into harmony.

Edwards (1988) used the contingent valuation method to estimate the benefit of preventing one existing aquifer in the Cape Cod area from nitrate contamination. Surprisingly, households intending to move out of the Cape Cod area exhibited positive willingness to pay values for such protection (Hanley and Spash, 1993, pp.207). This finding helps to support the notion of that individuals view themselves as having a social role as a citizen, beyond their private, individualistic role. Though these individuals intended to move out of their community and would clearly not benefit from such protection, they may have feelings of moral responsibility to those that will remain, or other non-use values for the protection of the aquifer. Thomas P. Holmes (1990) found that altruistic motivations influenced referendum votes on environmental quality in the state of California; he examined data from votes on California's Proposition 65, which reduced the risk of drinking water contamination.

Many have asserted that individuals may possess both individual and social rates of time preference. One explanation for a lower social rate of time preference is that individuals recognize that their lives are finite, but society's is not. Individuals may feel a sense of moral responsibility to future generations in making decisions about public programs. Eckstein (1957) and Marglin (1963) suggested individuals might have distinct sets of preferences for individual and collective choices, and possess a lower social than private discount rate. Olsen (1993b) argued for a distinction between "selfish" time preference and "policy" time preference. Sen (1982) offered three main points as a basis for using a lower social discount rate:

> 1. Super-Responsibility: The government has a responsibility not merely to the current generation but also to future generations, over and above the concern already reflected in the preferences of the current generation.

2. Dual Role: The members of the present generation may be more concerned in their role as citizen about the welfare of future generations than they are in their personal, day to day, activities.

3. Isolation: Even within a given set of consistent preferences, members of the current generation may be willing to join in a collective contract of more savings by all, although unwilling to save more in isolation (Sen, 1982, pp. 327-328).

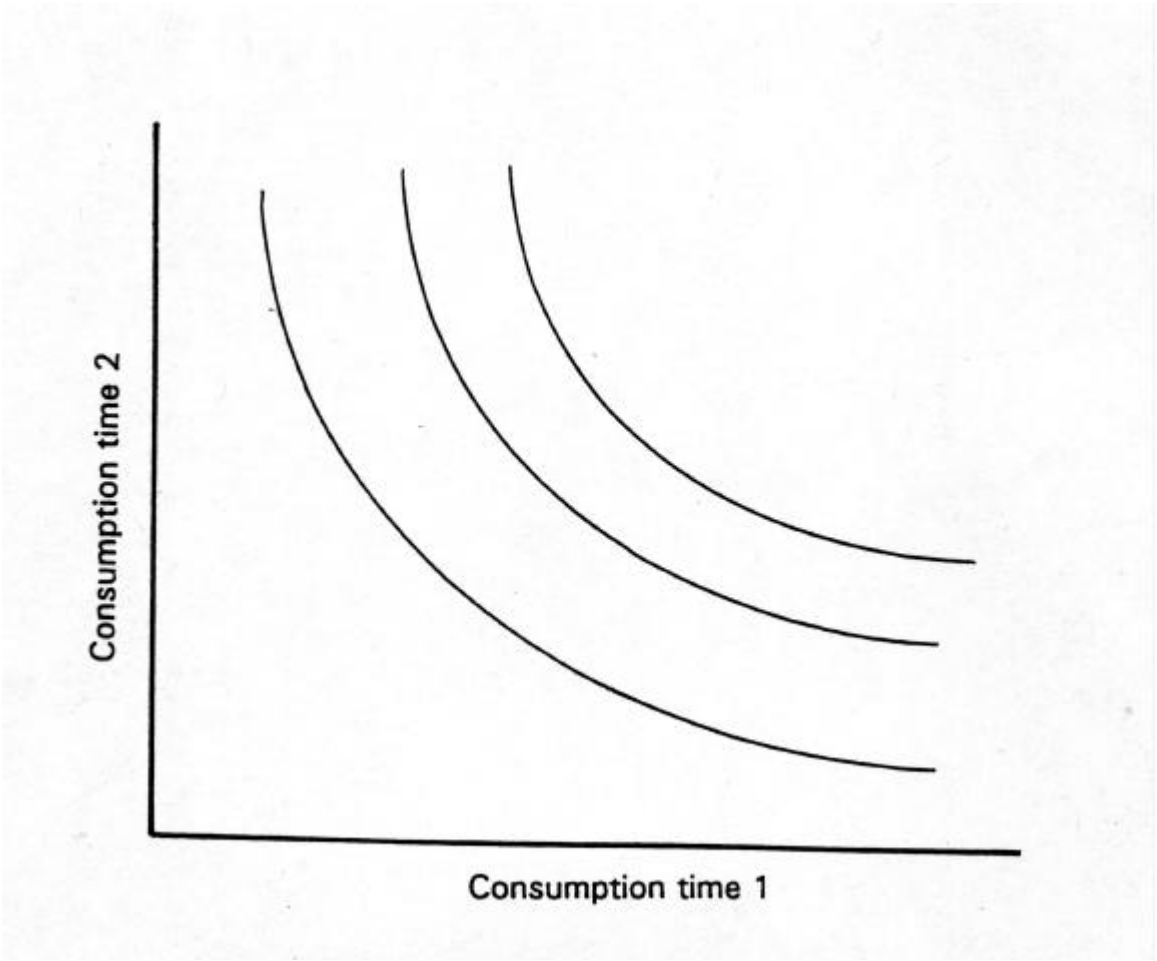
Cropper et al. (1994) found that about 10 percent of respondents had negative discount rates in the context of public programs to save lives from an unspecified threat; these individuals choose the future-oriented program even when it saved fewer lives than the present-oriented program. When asked about their choices, people suggested that their reasons for preferring the future-oriented program, though it saved fewer lives, partly reflected a feeling of responsibility toward future generations (Cropper et al., 1994, pp.251). Such results may indicate that at least some individuals do indeed have social discount rates that are lower than those they apply to more individualistic choices, such as the consumer durables we purchase or other monetary decisions.

4.10 Summary

This literature review provides a basis for the further investigation of several questions: 1) does the discount rate decline with the time horizon involved, 2) are discount rates significantly related to personal characteristics such as age, income, and the number of children in one's household, 3) do individuals discount different types of programs and commodities differently, and more specifically, 4) do individuals have different rates of discount for different types of goods? These questions lie at the heart of this research effort. Before turning to a discussion of the economic model and methodology employed, let us briefly discuss the role of risk in valuing health and safety

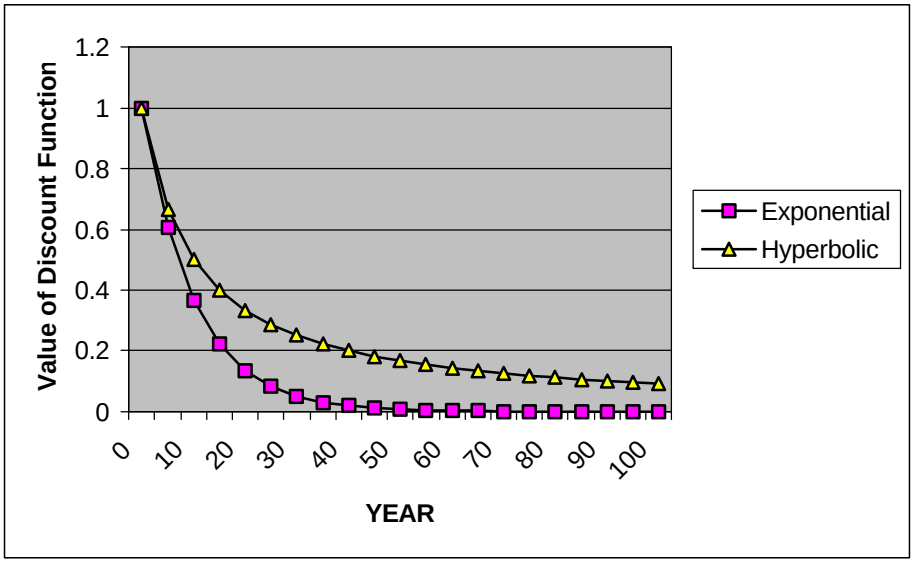
risk reductions, as the element of risk is a key component of this study's survey design, and individuals attitudes towards risk may have a considerable influence on the study's results.

Figure 4.1-Trade-offs between Present and Future Consumption



Source: Loewenstein, 1992, pp.16

Figure 4.2-Exponential versus Hyperbolic Discounting



Note: for $d = 0.10$