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From Discounting to Incorporating Decisions' Long-Term Impacts*

Elizabeth Atherton**

The debate over how to value the future has been raging for years. Philosophers have argued about our obligations to future generations from several view points: that we owe them everything and that we owe them nothing. At the same time, psychologists have conducted countless laboratory experiments to determine "how" people act and observed real situations to discover peoples' attitude about the future. Economists and proponents of "rational decision theories" have argued for constant discount rates and consistent, logical actions. So, how "should" we value the future? At the moment, most decisions are made by using constant discounting. This gives more weight to the present than to the future; but, is using constant discounting justifiable for long term policies? This paper will examine and contrast some of these arguments and describe new way of valuing the future and structuring the issues.

Philosophical Debates

Valuing the long term future requires us to think about our obligations to future generations and look at how our actions affect them. Many different views relate to this topic and philosophers have passionately argued for each one. Routley and Routley outline some of the most popular views:[1]

- Every person should be given the same value independent of whether they live now or in the future;

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1 *See* Richard Routley & Val Routley, *Nuclear Power — Some Ethical and Social Dimensions,* in And Justice For All: New Introductory Essays in Ethics and Public Policy, 116 (Tom Reagan et al. eds., 1982).

- We have some obligation to future generations, but much less than to those living now;
- We have obligations to the next generation, but none beyond that; and
- We have no responsibility towards future generations.

The obligations we think we have to future generations determine how we value the future and whether we discount it. Discounting often covers three issues:

- How to value the future;
- How to value future money streams; and
- How to value the negative impacts of decisions, i.e., pollution.

Decision makers' opinions on these issues help to determine the discount rate used and it is often important to analyze each of the issues separately. Two important aspects that also need to be considered involve:

- The ethics of the decision, the rights and wrongs of devaluing future generations; and
- The effect of the discount rate on the efficiency of the option chosen.

Some argue that high discount rates are unethical because they give a low value to the future;[2] while others have argued that low discount rates can result in the adoption of inefficient projects.[3]

Goodin expresses very strong views against devaluing the future and states that "future generations... are being deprived insofar as, when making decisions, we weigh their interests less heavily than our own. And their deprivation is unjustifiable because the arguments offered in defence of this practice fail in various ways."[4] Bickner says that discounting amounts to saying "the hell with the values of a generation yet unborn, or at least ten percent the hell per annum."[5] Goodin claims that discounting shows favoritism to some generations, which means treating people unequally and, therefore, works against general public policy.[6] Kavka comments that "[l]ocation in space is not a

2 *See* Robert Goodin, *Uncertainty as an Excuse for Cheating our Children: The Case of Nuclear Waste,* 10 Pol'y Sci. 25 (1978).

3 *See* Emmett Keeler & Shan Cretin, *Discounting of Life-Saving and Other Non Monetary Effects,* 29 Mgmt. Sci. 300 (1983).

4 Goodin, *supra* note 2 at 27.

5 Robert E. Bickner, *Pitfalls in the Analysis of Costs,* in Pitfalls of Analysis 57, 68 (Giandomenico Majone & Edward S. Quade eds., 1980).

morally relevant feature of a person determining his worthiness for consideration or aid. Why should location in time be any different?"[7]

Philosophers and economists have put forward many arguments as to why we have some or no obligations to future generations. In the following sections, I discuss several of these arguments and examine their validity.

Economic Posterity

Some people claim that future generations will be better off economically and, therefore able to deal with any problems that we leave them.[8] This argument assumes that money or technology can replace everything. In reality, this is not true. Goodin discredits the idea of using technological advances to solve the problems we make.[9] He notes that such advances remain uncertain and, at most, will help decrease the effects of the bad outcomes we create. It is, therefore, unrealistic to rely on technological advances too heavily.

Economists have argued that people will exhibit decreasing marginal utility over time. If a country's economy continues to grow, then the benefit people will receive from an extra unit of a commodity in the future will be less than the benefit they would experience today. This is because people will be better off in the future. Therefore, an increase in the goods they have will be less important because they will have decreasing marginal utility. For example, say you have no shoes, then the first pair of shoes you receive will be worth a great deal to you, but the second pair of shoes will be worth less to you because you already have a pair, and so on. Each consecutive pair of shoes is worth less to you and its value to you will not be as high as the first pair you received.

Decreasing marginal utility is sometimes used as a reason for discounting, but this assumes increases in per capita income. We cannot guarantee that per capita income will increase over time. In some cases, interest rates can be negative; therefore, future outcomes are worth

6 *See* Robert Goodin, *Discounting Discounting*, 2 J. of Pub. Pol'y 53 (1982).

7 Gregory Kavka, *The Futurity Problem*, in Obligations to Future Generations 186, 188 (Brian Barry & R.I. Sikora eds., 1978).

8 *See* Keeler & Cretin, *supra* note 3.

9 *See* Goodin, *supra* note 2.

more than immediate ones. If per capita income was increasing, it would have to increase at a constant rate per year to justify a geometric discount function.

In some cases, people cannot be compensated for the loss of a good by an increase in the amount of the other goods they possess. When this is true, only an increase in the actual good will give them decreasing marginal utility with respect to that good. An increase in the economy and wealth of a population cannot be used to justify discounting a non-tradable good on the grounds of decreasing marginal utility.[10] The discount rate of the non-tradable good will depend on how much more of that good a person will have in the future. It will reflect the rate of return of investment on that good, or its accumulation over time. The availability of some non-tradable goods, i.e., the environment, may be decreasing. Therefore, their marginal utility will actually be increasing, so that their value in the future should also increase. These are all arguments against using economic posterity and decreasing marginal utility to justify discounting goods.

Opportunity Costs

Sometimes the discount rate applied to a project is calculated from the opportunity cost of using the resources in the project. The opportunity cost is the potential rate of return that could have been gained from alternative uses of the resources. In the case of money this would be the interest it could have earned had it been invested. The fact that money invested now will grow in the future, due to interest rates, is sometimes used to justify discounting the future. A pound tomorrow is worth less than a pound today because today's pound could be invested and earn interest.

Instead of spending money today to avoid harming future generations or to protect them, money could be invested now so that it will be available in the future for future generations to spend. It could be argued that future generations will have a better idea of what to spend their money on and that we should leave them the money to deal with their own problems in a manner they think best. It would only be

10 Non-tradable goods are goods that cannot be directly exchanged for other goods. For example, health cannot be exchanged for money. It is possible to buy health care, but this does not lead to a definite increase in the amount of health someone possesses.

efficient to do this if less money needs to be invested now to compensate future generations (after it has earned interest) than is required now to prevent the problem. This would involve setting up a trust fund and investing the money, so that it would accumulate and be available to compensate future generations.

This idea presents many difficulties. How the trust fund should be set up and maintained are difficult questions. Is it possible to guarantee a constant interest rate to justify a constant discount rate? Trying to prove a constant opportunity cost across all periods is not easy. Inflation changes over time, as do interest rates. Banks can no longer be viewed as stable institutions, as the Baring's case.[11] A more recent example is the collapse of the banks in Russia and parts of Asia. Thus, it is not possible to guarantee that money invested will increase in value in the long term. The consequences of the decisions being considered span hundreds of years; therefore, it will be almost impossible to guarantee a constant interest rate over the lifetime of the outcomes. This makes it unreasonable to use a constant discount rate. It is also impossible to estimate exactly how much it would cost future generations to reverse any negative consequences caused by our actions. Hence, it is hard to know how much we need to invest now to enable them to cope with the troubles they inherit. Therefore, it is problematic to compare prevention costs with abatement costs in the future.

Not all damages can be converted into monetary equivalents, and many valuable items, i.e., health, cannot be replaced by money. Setting up a trust fund will not enable us to compensate future generations for all of their losses or to rectify all the problems we leave them. The fact that not all goods are tradable invalidates one of the main assumptions of this justification of discounting and discredits the theory. The opportunity cost argument is valid only when we are can convert all goods into their monetary equivalents and can determine the interest rate lost.

Goods could be traded for more of the same good. This applies to any interest bearing resource, that is, one that will increase in magnitude if it is not consumed now. Money spent now on lifesaving could instead

[11] On February 26, 1995, Barings PLC, the oldest and arguably the most distinguished investment bank in England, collapsed after sustaining a loss of approximately $950 million on futures and options trading.

be spent on research, which might save more lives in the future. In this way, lives now could be traded for lives in the future. The opportunity cost would be the extra number of lives saved in the future by doing the research. This does not tell us whether it is acceptable to trade lives or at what rate we should trade lives now for lives in the future. All it tells us is that if there are two future projects available, the one that gives the best rate of return on lives saved is better. It does not say how to compare the present and the future. These ideas enable us to calculate the opportunity cost for a good and, thus, determine its discount rate, but it is debatable whether this would be an appropriate rate or not.[12]

The theory is limited; it only applies to "interest bearing" goods, and not all non-market goods are "interest bearing."[13] For example, plans to protect the environment do not give an increase in the amount of environment available, they just change the rate at which it is degraded. If the amount of a non-market good available will decrease in the future, then the opportunity cost argument states that we should use a negative discount rate, as the good will be more valuable in the future.

Uncertainty of the Future

The future is uncertain. We know that forecasting techniques are only reliable in the short term, which gives us limited ability to predict the future. The long term future is more uncertain than the present and immediate future, therefore, some people claim that we should disregard it.[14] In reality, the probabilities of outcomes do not become much more uncertain as we progress into the future. Where risks are involved, it is often the fact that there is the possibility of a risk that is important and not the size of the probability.

Williams looks at the following two types of uncertainty:[15]

- People may die before receiving the utility; and
- The utility may not be available in the future.

12 *See* Goodin, *supra* note 6 for further discussions.

13 Non-market goods are goods that are not traded on an open market and so do not have a clearly defined monetary value.

14 *See* John Passmore, Mans Responsibility for Nature (1974); *see also* Charles Hitch & Roland McKean, The Economics of Defense in the Nuclear Age (1960).

15 *See* Mary B. Williams, *Discounting Versus Maximum Sustainable Yield*, in Obligations to Future Generations 169 (Brian Barry & R.I. Sikora eds., 1978).

Although these uncertainties may apply on an individual basis and therefore give a reason for discounting the future, on a societal basis they are invalid. It is very unlikely that the whole of the human race will be wiped out in the near future. Williams argues that the best chance of survival is to maximize available resources, which means valuing the future and preserving resources.[16] She shows that the possibility of extinction means that it is not utility-maximizing for society to discount the future. It has been argued that we are unsure of the utility of future generations, while we are sure of our utility. However, Williams says that the uncertainty involved works both ways and that we are equally uncertain about how much future generations may depend on resources we currently do not depend on. Therefore, we should act cautiously with the world's resources.

The relationship between time and uncertainty will vary for different goods over different time periods. Some uncertainty may not increase over time and we may actually be more certain about some issues in the future. Even if uncertainty does increase over time, and this is why we are discounting, it would have to increase at a fixed rate per year to justify geometric discounting.

Moore and Smart argue that future negative outcomes will be small and, therefore, negligible.[17] They claim that the future can be discounted because the good and bad outcomes will cancel each other out. However, Goodin believes that there is an asymmetry in the outcomes of events.[18] The bad outcomes of decisions are often far worse than the good, so much so that they do not balance out. Therefore, he reasons that it is unjust and even irrational to ignore or discount future outcomes because of the gravity of their effects.

Indeterminacy

Golding has argued that we only have obligations to future generations if we can reliably predict their needs.[19] He claims that because we do not have reliable information about people living in the

16 *See id.*

17 *See* George Edward Moore, Principia Ethica 152 (1971); *see also* J.J.C. Smart, *An Outline of a System of Utilitarian Ethics*, in Utilitarianism: For and Against 3 (1973).

18 *See* Goodin, *supra* note 2.

19 *See* Martin Golding, *Obligations to Future Generations*, 56 Monist 97 (1972).

future, we have no obligations to them. We cannot accurately determine the effects of our actions will have the needs of future generations, but we do know that there is a risk of adverse effects. Decisions made about the present often account for risks with very small probabilities. The fact that there is a risk matters in that decision making process. There is no obvious reason why we should deal with the future in a different way. It is easy to see that future generations will still need a healthy earth and will not benefit from an increased risk of illness. We, therefore, have an obligation to ensure that these things are available. To say that we are very uncertain about the needs of future generations is to give a high probability to the idea of their world being dramatically different from ours, which is in itself unrealistic.

Baier also argues that many of the "wrongs" that we do to future generations depend only on human nature and not on people's special needs.[20] She claims that we know that future human beings will need air, water, food, and that their lives will be harmed by poison and toxins. Therefore, we should try to preserve and reduce these things respectively. Goodin and Kavka make the same point.[21]

Unequal Distribution of Benefits and Costs

In many long term decision situations, the current generation receives the benefits, while the future generations incur the costs. Nuclear energy illustrates this point. Current generations benefit from the electricity that it produces, but future generations are left with the waste. Cost benefit analysis using discounting can be used to justify strategies with short term benefits and long term costs because the future is discounted. This gives the costs much less value. Even in the present generation, risks are not always equally distributed. This usually results in public outcry and some sort of compensation, which is what "should" happen with regards to future people. Unfortunately, future generations are unable to argue about why they should be given equal value. If we think in terms of compensation, it may actually be more equitable to give future generations more weight in our cost benefit analysis, as they will suffer involuntarily from our acts.

20 *See* Annette Baier, *For the Sake of Future Generations,* in Earthbound: Introductory Essays in Environmental Ethics 214 (Tom Regan ed., 1984).

21 *See* Goodin, *supra* note 2; *see also* Kavka, *supra* note 7.

Non-Market Goods

The issue of discounting often depends on the object being discounted. Discounting money is usually accepted, though if the monetary sums equal a significant proportion of GDP, one might argue against it. In Belarus, the consequences of Chernobyl are claimed to cost on average 10-20% GDP per annum, therefore, discounting may not be appropriate.

To make judgments on the marginal cost per unit dose of radiation averted by countermeasures after a nuclear accident, decision makers use a reference value for the cost of the man-Sievert.[22] This value is called α and creates an equivalence relationship between money and dose. Through α, units of dose equal money, discounting money is equivalent to discounting dose, which may occasionally be accepted. By the linearity hypothesis, dose is equivalent to expected number of years of life expectancy lost.[23] Discounting may be acceptable because individuals do discount the last years of their lives by smoking, for example. However, not everyone will be comfortable with this idea and if life expectancy is reduced by a large amount, people may be even more averse to discounting. The linearity hypothesis also means that dose equals number of deaths, and as society dislikes discounting lives, this is unlikely to be acceptable to decision makers. Dose also equals number of genetic defects. It is doubtful whether society would discount these, unless there is a guarantee of medical advances.

This leads to the conclusion that, in decisions concerning radiation, discounting money has the effect of discounting many other factors because of the use of α and the linearity hypothesis. These result in discounting being inapplicable to radiation decisions because long term consequences reach into future generations. This is true in this particular case because there is a way of putting a monetary value on lives.

22 Dose is a generic term for the quantity of radiation that impacts or is absorbed by an individual. Its scale is such that under the linearity hypothesis the value is directly related to the increased risk of cancer the individual faces from the exposure. *See* S. French et al., *Event Conditional Attribute Modelling in Decision Making When There is a Threat of a Nuclear Accident*, in The Practice of Bayesian Analysis 131 (Simon French & Jim Smith eds., 1997) and NRBP, Living With Radiation (1989). A man-Sievert is the amount of radiation expected to increase the chance of cancer by 5%. That is, 20 man-Sieverts would result in an extra cancer in the population.

23 Research has shown that there is a linear relationship between the dose received and the increased risk of cancer, the expected loss in life expectancy and the number of deaths and genetic defects from the exposure to radiation.

The public does not feel comfortable discounting certain commodities. For example, why should the environmental welfare of an area be valued less in the future than it is now? If there is environmental degradation elsewhere, a particular area may actually become more valuable. With some commodities, it will be impossible to compensate future generations with money or technology if it is lost. If this is true, then the commodity cannot be traded for money, and in this case, it should not be treated or discounted in the same way.

The Same Rate For All Goods Every Year

If, despite all the arguments against discounting, decision makers decide to value the future less than the present, why should the value decrease geometrically? Parfit comments that the moral importance of future events does not decrease at *n* percent per year.[24] Psychological studies show that people do not generally exhibit constant discount rates over time and often have different discount rates for different commodities. The argument for discounting all goods at the same rate depends on the assumption that they are all tradable, i.e., lives can be completely replaced by money. In reality, this is rarely true. If commodities are not completely interchangeable, then there is no reason to discount them at the same rates. Okun and Goodin argue these points.[25] They note that only goods which are completely tradable should be discounted at the same rate. In this case, the rate to use is the highest growth rate of the interchangeable commodities. For non-market goods, the discount rate should be the rate at which they accumulate over time. This would result in different commodities having different discount rates.

If we have the same discount rate for both a good and money, over time this implies that the future relationship between the value of the good and money is constant. In reality, the relationships between goods and money depend on whether the wealth of the society and the availability of the good is increasing or decreasing. Schieber, Poullier, and Viscusi found that as a country's wealth increased, it spent more on health care.[26] This suggests that the monetary value of health care is

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24 *See* Derek Parfit, *An Attack on the Social Discount Rate*, 1 QQ — Report from the Centre for Philosophy and Public Policy 8 (1981).

25 *See* Arthur Okun, Equality and Efficiency (1975); *see also* Goodin, *supra* note 6.

not constant but can vary as a function of GNP. Therefore, to justify keeping the discount rates of health and money equal, we would have to show that the relationship between them remains constant over time. Similarly, the relationship between the environment and money will probably change over time. As environmental commodities become rarer or polluted, their value will increase. There does not seem to be any evidence to back up the assumption that the relationship between money and other commodities remains constant over time. Thus, there seems to be no reason for discounting all goods at the same rate over time. Nijkamp et al. also point out that discounting a non-monetary good is only justifiable if there is evidence to show that the price level is a constant.[27]

Keeler and Cretin claim that using different discount rates for attributes can cause indefinite postponement of projects.[28] If health care has a lower discount rate than money, then delaying by a year will make a project more cost effective. They claim that this results in no project's ever being adopted. Ganiats notes that, when choosing projects to implement, society looks at cost effectiveness.[29] A project cost effective this year will be implemented, even if it would be moreso next year. Therefore, cost effective projects can be implemented even if different discount rates are used for the attributes of the project.

Incorrect Assumptions

Kula points out the false assumptions which conventional discounting is based upon:[30]

- People live forever, or society is one being with an eternal life;
- People do not die before the end of a project; and
- It is acceptable to discriminate against future generations, by valuing them less.

26 *See* G. Schieber & J. Poullier, *International Health Care Expenditure Trends*, 8 Health Aff. 169 (1989); *see also* W. Kip Viscusi, *Risk-Risk Analysis*, 8 J. of Risk and Uncertainty 5 (1994).

27 *See* Peter Nijkamp et al., *Multiple Futures and Multiple Discount Rates in Multiple Criteria Analysis*, 4 Project Appraisal 1 (1989).

28 *See* Keeler & Cretin, *supra* note 3.

29 *See* Theodore Ganiats, *Discounting in Cost Effectiveness Research*, 14 Med. Decision Making 298 (1994).

30 *See* Erhun Kula, Time Discounting and Future Generations (1997).

People alive at the beginning of many projects will die before they end. Nuclear waste must be stored thousands of years, and such facts are not taken into account in conventional discounting methods, making them unsound. The question about whether it is permissible to devalue future generations is discussed above, and the evidence shows unjust situations. These issues undermine the validity of the conventional discounting methods.

Psychological Research

Discounting the future and adopting the particular discount rates adopted have sometimes been justified by observation of human decisions. It has been argued that the future should be discounted on the basis of society's time preference. Psychological research has been carried out to investigate how people discount various commodities over time and what affects their discount rate. Benzion et al. and Thaler found that:[31]

- Small outcomes have higher discount rates than larger outcomes;
- Discount rates are higher for gains than for losses;
- People have very high discount rates for short time delays; and
- Discount rates decrease with the time necessary to wait for the outcome.

Ahlbrecht and Weber also cite evidence that:[32]

- People want considerable compensation to delay a good outcome and yet invest at low interest rates; and
- People prefer small immediate outcomes to larger delayed ones.

Cognitive theories claim that these occur because people are averse to waiting and fail to picture the future adequately. The research shows that discount rates depend on the context and framing of the decision.[33]

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31 *See* Uri Benzion et al., *Discount Rates Inferred from Decisions: An Experimental Study*, 35 Mgmt. Sci. 270 (1989); *see also* Richard Thaler, *Some Empirical Evidence on Dynamic Inconsistency*, 8 Econ. Letters 201 (1981).

32 *See* Martin Ahlbrecht & Martin Weber, *Hyperbolic Discount Models in Prescriptive Theories of Intertemporal Choice*, 115 Zeitschrift fur Wirtschafts — Sozialwissenschaften 535 (1995).

33 For more detailed discussions of the issues in intertemporal contexts; *see* George Loewenstein & Drazen Prelec, *Anomalies in Intertemporal Choice: Evidence and an*

According to normative theories of intertemporal choice, discount factors are and should be constant. Non-constant discount rates violate the stationarity axiom of Discounted Utility Theory (DUT). The axiom states that the preference for two outcomes is independent of the time when the outcomes are evaluated. The preference should, therefore, depend only on the absolute time difference between the outcomes. Behavioural research has shown that discount rates depend on the time until the outcome.[34] People often have discount rates that decrease as the time to the outcome increases. There are persuasive reasons why discount rates should depend on the timing of the outcomes.[35] Hyperbolic discount models have discount rates that change over time and allow decision makers to give more weight to the very long term future.[36]

The situation that applies to individuals is very different from that facing society as a whole. Individuals are finite and have a short life span relative to the human race. Society as a whole (it is hoped) will last for much longer and the risks it faces are very different. Thus, it does not seem logical to use personal discount rates for valuing societal decisions.

Dynamic Consistency and Stationarity

There are two points in time that need to be considered when thinking about decisions which have consequences in the future:

- When the preferences are stated and the decision made; and
- When the outcome occurs.

For stationarity to hold, the trade-off between two periods must only depend on the temporal distance between them. This means that a constant discount factor should be applied, regardless of whether the periods are close to the present or a long way in the future (assuming that preferences about the future are stated now). Non-constant discount rates do not obey stationarity.

Interpretation, 107 Q. J. of Econ. 573 (1992); Elizabeth Atherton & Simon French, *Issues in Supporting Intertemporal Choice*, in Essays in Decision Making 135 (Mark Karwan et al. eds., 1997).

34 *See* Benzion et al., *supra* note 31; *see also* Ahlbrecht & Weber, *supra* note 31.

35 *See* Simon French, Decision Theory: An Introduction to the Mathematics of Rationality (1986); *see also* Atherton & French, *supra* note 32.

36 *See* Charles Harvey, *Proportional Discounting of Future Costs and Benefits*, 20 Mathematics of Operational Res. 381 (1995).

Dynamic consistency requires that decision makers know their future preferences today. The ranking of outcomes should not depend on when the assessment takes place or how close the outcome is to occurring. As people and their circumstances change over time, this may not be feasible or even desirable.

Varying discount rates can lead to a violation of dynamic consistency, meaning that decisions will depend upon when they were made, even if in all other respects the situation was identical. If a constant discount rate is used, options are ranked in the same order, independent of whether they are evaluated now or any time in the future. If a non-constant discount rate is used, then relative and absolute time changes do not always give the same rankings of the options. If options are evaluated at a future date, then their rankings may change.

Ahlbrecht and Weber discuss what conditions must hold for dynamic consistency and stationarity to be equivalent.[37] If decisions are binding, then dynamic consistency and stationarity are not equivalent, and dynamic consistency arguments are inappropriate. Therefore, stationarity is not a requirement of rationality. This is the case in many decision situations, e.g., where to build a nuclear power plant and where the decision is irreversible and will not be re-evaluated in the future. This emphasizes that the choice about whether to use constant or non-constant discounting should depend on the decision makers' time preference and the decision being made. It would seem unreasonable to use constant discounting if it does not reflect the decision makers' preferences and if stationarity is not an issue.

Affinity to Time Frames

People's Affinity to Different Time Periods

Now	Very imminent and imaginable	Very important
1 - 25 yrs	Affects the decision maker & their children	
26 - 50 yrs	Affects decision maker's children & grandchildren	
51 - 100 yrs	Affects grandchildren & great grandchildren	Important
101 - 500 yrs	Some distant descendants	
501 - 1000 yrs	World will have changed dramatically	
1001 - 5000 yrs	Will human race still be around?	Not that important

37 *See* Ahlbrecht & Weber, *supra* note 32.

As shown above, the importance decision makers place on the future dwindles as they have fewer relations with people they know still living. People also tend to section the future, giving less thought to the long term. For example, they may have clear plans for today, aims for the week and then more general goals for the month. Atherton and French asked subjects to section a thousand years into distinct eras.[38] Most of the subjects divided time into eras of increasing length and gave less weight to the long term future, though more than is advocated by constant discounting.

Loewenstein found that people value the present more than any other time in history.[39] In light of this and the fact that people tend to discount hyperbolically, it seems logical that the evaluation of attributes and alternatives is time dependent. If this reflects the decision makers' time preference, then the discount rate should change over time.

Technological developments have a large effect on the outcomes of decisions. Technology is developing at a faster rate than ever before and it is difficult to predict what will happen in the future. The more remote an outcome is, the more uncertain we are about its effects. This needs to be taken into account when modelling decisions.

People are sometimes less concerned about the future because they cannot imagine what it will be like and feel very distant from it. However, the political climate is changing because environmental groups are encouraging people to be more long term focused and to think about the effects of their actions on future generations. Although people may still disregard the latter years of their lives, for example by smoking, they are becoming more concerned about the long term effects of their actions on society and future generations. As people become more aware of the long term consequences of their actions, they will want to take them into account in their decision making.

Discounting Models

Discounting models have been developed in several research disciplines. Normative models say "how" the future should be valued,

38 *See* Elizabeth Atherton & Simon French, *Should We Discount Discounting in Long Term Projects*, in Working Paper (1999).

39 *See* George Loewenstein, *Anticipation and Valuation of Delayed Consumption*, 97 The Econ. J. 666 (1987).

while descriptive models try to predict and model human behavior. In the following sections, three particular models are compared with comments made on their appropriateness for long term intertemporal decisions.

In DUT, the value of an outcome stream $(x_1, x_2, \ldots, x_n)$ is:

$$V(x_1, x_2, x_3, \ldots x_n) = x_1 + dx_2 + d^2x_3 + \ldots + d^{n-1}x_n \quad (1)$$

Where *d* is the discount function such that $d = \frac{1}{(1+r)}$ (2)

and *r* is the discount rate.

Harvey suggests a varying discount rate which could 'devalue the future' at a much slower rate.[40]

$$V(x_1, x_2, \ldots x_n) = \left(\frac{b}{b+1}\right)^r x_1 + \left(\frac{b}{b+2}\right)^r x_2 + \left(\frac{b}{b+3}\right)^r x_3 \ldots + \left(\frac{b}{b+n}\right)^r x_n \quad (3)$$

Where $b > 0$ is the *temporal mid-value,* i.e., the point in the future assigned half the value of the present; and $-\infty < r < \infty$ reflects how the ratio of the outcomes is related to the ratio of the time effects. As time tends to infinity, expression (3) decays to 0 more slowly than (1) and, therefore, gives relatively more importance to long-term outcomes. The model looks at the ratio between time periods, not absolute differences.

Harvey's model offers two ways of determining *b*. Harvey advocates that decision makers state their *temporal mid-value*. He claims that this encourages them to think about the whole lifetime of the project. Alternatively, decision makers can be asked to give a discount rate *d*, then $b = 1/d$.

The factor *r* is obtained by analyzing how the ratio of outcomes is related to the ratio of time trade-offs. If the outcomes have the same ratio as their indifferent extra weighting times, $r = 0$. In this case, the time weights are:

$$a(t) = \frac{b}{b+t} \quad (4)$$

The model, then called a Proportional Discounting Model, is used in this paper.

Kula created what he calls the Modified Discount Model (MDM).[41] This, he claims, gives far more weight to the future. The

40 *See* Harvey, *supra* note 36.

theory is based on the idea of using cohorts (the people born each year) to determine the weight that should be given to the future. The function has two parts: one that looks at those who are alive before the project starts and one that looks at those who are born after the project starts. The value given to people already living is discounted to the start of the project, while the value given to people who are born after the project begins is discounted to their year of birth.

The method is based on the following assumptions for the U.K.:[42]

- The population size is a constant;
- The life expectancy of the population is 73;
- There are the same number of people in each generation;
- The number of births equals the number of deaths each year; and
- Benefits are shared equally between all generations.

The first assumption, although true for developed countries, may not be true for developing countries whose population sizes are often increasing at a very fast rate. In many developed countries, life expectancy is increasing, people are tending to live longer, and then deteriorating very quickly at the end of their lives. This is changing the demands made on health care and the distribution of health care over people's lives. (However, this is not taken into account in the model). Assuming that each age group consists of the same number of people is slightly dubious; however, Kula does point out that the parameters in the model can be changed to give more weight to certain generations, if they have more people in them. The assumption about births and deaths will depend on whether the country is developed or not. The final assumption is dependant on the project and a weighting factor could be introduced if it is not true.

The model mixes normative and descriptive assumptions together. The discussion about the principle of value judgments with regards the future is normative, but the assumption about life expectancy is descriptive. Some of the descriptive assumptions put very tight constraints on the population growth model that are not necessarily

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41 *See* Erhun Kula, *Future Generations and Discounting Rules in Public Sector Project Appraisal,* 13 Envtl. Plan. A 899 (1981).

42 *See* Erhun Kula, *Discount Factors for Public Sector Investment Projects Using the Sum of Discounted Consumption Flows — Estimates for the United Kingdom*, 16 Envtl. Plan. A 689 (1984).

true. If the assumptions are weakened, they can give an unrealistic population model pattern. Separating the normative and descriptive elements of the model may improve its validity.

The function is shown below:

$$\frac{1}{n}\left[\frac{1}{(1+s)^t}*(n+1-t)+\sum_{i=1}^{t-1}\frac{1}{(1+s)^t}\right] t \leq n \tag{5}$$

$$\frac{1}{n}*\sum_{i=1}^{n}\frac{1}{(1+s)^t} \quad t > n \tag{6}$$

where n is the life expectancy of the population; s is the social discount rate; and t is the age of the project.

Kula suggests that the social discount rate should be based on the social time preference rate, also known as the consumption rate of investment. This measure is based on:

- A mortality based pure time discount rate;
- The growth rate of per capita consumption in real terms; and
- The elasticity of marginal utility of consumption.

See Kula for the derivation of the consumption rate of investment for the United Kingdom which he estimates to be about 2.6%.[43] In the following analysis, a rate of 3% is used. Yaffey has investigated the validity of Kula's assumptions for the United Kingdom and the effect on the model of changing them.[44] He points out that:

- There are different numbers of people in each cohort group;
- The age of death does not equal 73 for everyone; and
- The population is not stable, but decreasing.

Among existing cohorts, the perturbations do not matter because the age distribution does not affect the weights. Similarly, any decrease in total population size does not affect unborn cohorts because it is the relative sizes of the groups that matter. Yaffey adjusted the cohort weights to reflect the differences in cohort groups. He found that the final discount function was not significantly different from the one

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43 *See* Erhun Kula, *Social Interest Rate for Public Sector Appraisal in the United Kingdom, the United States and Canada*, 2 Project Appraisal 169 (1987).

44 *See* Michael Yaffey, *Modified Discount Model Revisited*, 12 Project Appraisal 79 (1997).

given by Kula. Therefore, Kula's assumptions seem to be adequate for the United Kingdom.

Bellinger has proposed a Multi-generational Value Formula that is similar to Kula's MDM, but allows decision makers to apply different discount rates to intra and intergenerational issues.[45] He also points out the importance of the type of good being analysed and the effect this should have on its discount rate.

Kula's MDM has been criticized by several authors. Price argues that MDM gives inconsistent results when decisions are reviewed at a later date.[46] As discussed in the section on dynamic consistency, this is only important if the decision is reversible and will be re-evaluated in the future. This is not an issue in the context we are considering. Price also states that a low discount rate should be used for long term projects, rather than modifying the discounting method. This can still be unreasonable when the decision spans hundreds of thousands of years. In such cases, Price advocates not discounting at all. This, however, means assuming that there is no trade-off between the present and the future, which is clearly untrue.

Thomson argues that decision makers must bow to pressure from present generations who he claims want to discount the future.[47] He says that they want benefits now, but not the costs. Atherton and French, show that even though people may discount the future, the rate used is sometimes far less than that advocated by constant discounting and people want to take the future into account in their decision making.[48]

As has been noted, after the project year reaches the life expectancy of the population, the discount rate does not decrease. Bateman questions the implications of this.[49] He says this implies that after a

45 *See* William Bellinger, *Incorporating the Future Multigenerational Value: Modifying the Modified Discounting Method*, 6 Project Appraisal 101 (1991).

46 *See* Colin Price, *Equity, Consistency, Efficiency and New Rules for Discounting*, 4 Project Appraisal 58 (1989).

47 *See* K. Thomson, *Future Generations: The Modified Discounting Method — A Reply*, 3 Project Appraisal 171 (1988).

48 *See* Elizabeth Atherton & Simon French, *Valuing the Future: An Application of Hyperbolic Discounting with Time Era Weights*, 4 Risk Decision and Pol'y 1 (1999); *see also* Atherton & French, *supra* note 38.

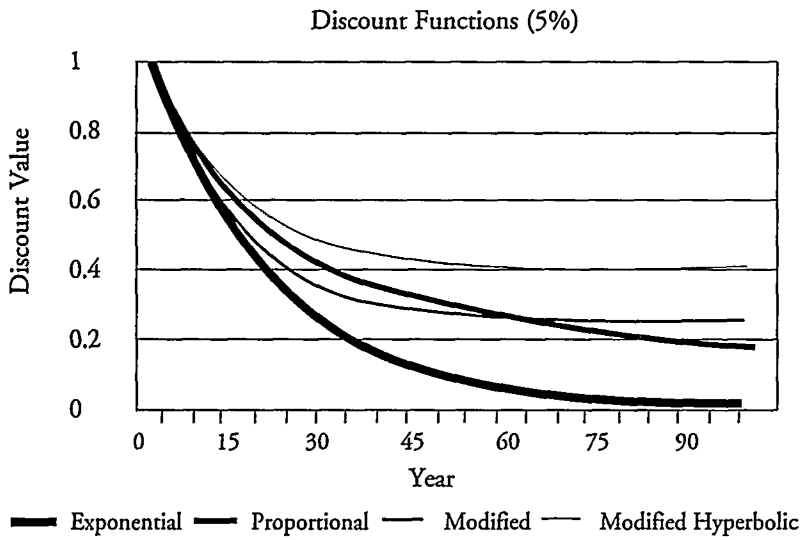
49 *See* Ian Bateman, *The Modified Discounting Method: Some Comments*, 4 Project Appraisal 104 (1989).

certain point in time, it is the size of an outcome that matters, and not when it occurs. This may be true for very long time frames, e.g., after a thousand years, but it is unclear whether this is true for shorter ones. In Kula's model, this would happen after 73 years for the United Kingdom.

Another possibility is to combine the Harvey model with the Kula model. A hyperbolic discount function would be used instead of a constant discounting function in Kula's model. This would give a social discount function that decreases more slowly over time.

The graph below shows how the different discount functions change over time. A discount rate of 5% is used, in line with general government policy. This means that in the proportional discounting model *b* is 20. The graph indicates that the modified hyperbolic discount model gives more weight to the future throughout the life of a project. It is clear that the constant discounting model tends to zero very quickly and so gives very little weight to the future.

Graph 1
Discount Functions with a 5% Discount Rate



Below, Table 1 shows that, with constant discounting, very little weight is given to events only 50 years into the future. With the proportional discount model, more weight is given to the long term future, but this is still negligible after 200 years or so. The proportional discount model gives more weight to the short term than either the modified discount model or the constant discount model. However, after 50 years, the modified discount model gives more weight to events than the proportional discount model. The modified hyperbolic model gives the most weight to the future at all times. With the modified discount model and the modified hyperbolic model, all the years after the estimated life expectancy of the population (in this case 73) are given the same weight. This means that the long term future is given far more weight than with the other two models.

Compared to the standard modified discounting method, modified hyperbolic discounting decreases the value given to the future more slowly. The underlying discount function also reflects more accurately the way that people discount future events.[50] The weight given to the long term future is also higher when the modified hyperbolic discounting method is used.

Table 1
The Values Given to the Future by the Discount Functions

Year	*Constant 5%*	*Proportional 5%*	*Modified 5% Hyperbolic 5%*	*Modified*
5	0.784	0.8	0.789	0.805
10	0.614	0.667	0.6356	0.684
50	0.0872	0.286	0.2776	0.428
100	0.0076	0.167	0.266	0.413
200	0	0.091	0.266	0.413
500	0	0.039	0.266	0.413

With constant and modified discounting, the decision maker only has to define the discount rate. The range of justifiable values for the discount rate is limited; the value used is usually the market interest rate or the social rate of time preference taken from studies. The proportional discount model gives decision makers more scope. They can define the discount rate by defining their *temporal mid-value*. This means that they can use much lower discount rates. All three methods, however, limit decision makers to valuing the future less than they value the present. They are confined to decreasing future values.

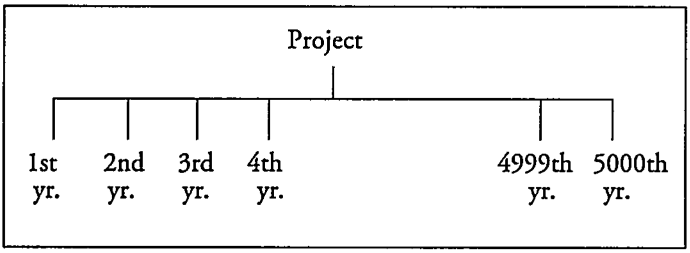
50 *See* Ahlbrecht & Weber, *supra* note 32.

Time Eras and Time Era Weights

An alternative method might be to use time era weights or give time era a weight to reflect its importance. This would allow decision makers to increase the weight they give to the future. They could also specify values which increase over time. The rate of decrease is also more under the decision makers' control. They can define weights that decrease quickly at first and then level out or which do not decrease at all. The discount values could, therefore, match the decision makers' preferences exactly and would not tie them to a set of values that they did not necessarily agree with.

If we think, for example, about a cost that is incurred during every year of a project, then it could be viewed as *n* separate attributes, one for each year. Figure 1 shows this diagrammatically in the form of an attribute tree.

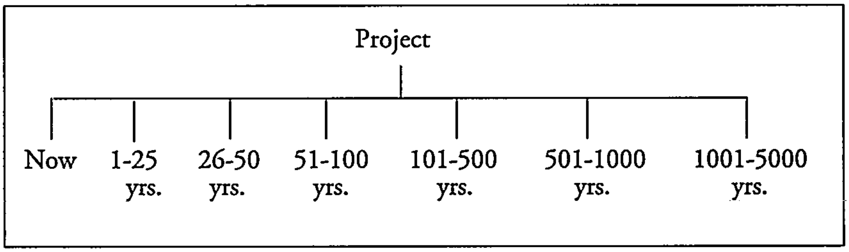
Figure 1
Attribute Tree for Costs Sectioned Into Years



This is not very intuitive, so the question is how to rearrange the attribute tree so that it is. It would be difficult to think about year 4999, for example, and to attach an importance weight to that year. Using a constant discount rate prevents decision makers from having to make such difficult valuations. However, it limits how people can value the future, tying them into giving the future less weight than the present, which may not be what they want to do.

Grouping the years into time eras may be more appealing to decision makers. Instead of having to think about individual years, they are required to think about groups of years and have to attach a value weight to each group of years. The attribute tree would then become what is shown below in Figure 2.

Figure 2
Attribute Tree for Costs Sectioned Into Time Eras



The time eras could be determined according to several different factors, e.g., the affinity of the decision makers to the different eras, changes in attributes or their values, or changes in the probability of the scenarios. Once defined, it is relatively easy to elicit decision makers' opinions about the importance of these eras. Structuring decisions in this way could help decision makers:

- Understand their situation better;
- Express their opinions;
- Allow attributes, their values, relative weights and the uncertainty surrounding them to change over time;
- Highlight the trade-offs that have to be made over time; and
- Focus attention on the long term aspects of a decision.

It would also give them the ability to give more value to the long term future of their projects. If their opinions and preferences were in line with the axioms underpinning constant discounting, then a constant discount rate could be used and the time eras could be used purely for modelling purposes. If, however, the decision makers' opinions do not conform to the constant discounting axioms, then they could use another discounting model, e.g., the hyperbolic model or even the time era weights idea suggested.

The application of the new structuring and the idea of time era weights have been investigated in several situations.[51] These experiments showed that the structuring was intuitive to the subjects and helped them to express the motivations behind their opinions.

51 *See* Elizabeth Atherton & Simon French, *Valuing the Future: A MADA Example Involving Nuclear Waste Storage*, 7 J. of Multi-Criteria Decision Analysis 304 (1998); *see* Atherton & French, *supra* note 48; *see* Atherton & French, *supra* note 38.

Most of the subjects were motivated by one of the following issues:

- Affinity to the people living in different eras;
- Obligations to the future;
- Developments in technology; and
- Increased uncertainty relating to future events.

The first two are value judgments, while the last two are related to the subjects' perceptions of the future. Using time era weights helped the subjects focus on these issues. The subjects wanted to give more weight to the future than is prescribed by exponential discounting, even with a very low discount rate. This may indicate that using time era weights and including time explicitly in the attribute tree helped the subjects to focus on the long term issues in the decision. The weights given by the subjects were closer to hyperbolic curves than exponential curves. Some gave equal and increasing weights to the future.

Conclusion

This paper has discussed some of the issues surrounding the trade-offs to be considered in intertemporal decision making. The validity of the arguments put forward for discounting the future have been investigated with respect to very long term decisions involving society, and they do not appear to be valid. Several models for valuing the future have been examined and a new way of structuring and valuing attributes over time has been presented, along with some of the advantages this may give.

The idea of time era weights could be used in two ways that emphasize their flexibility and use as a discussion motivator and/or modelling tool. Both uses will help with the structuring and modelling of long term decisions.

First, the weights given by the decision makers could be fitted to one of the discount functions outlined earlier. This function could then be used to value the future in the model. Using time era weights initially would help the decision makers consider the trade-offs they have to make in the project and express their opinions before searching for a specific discount function, be that exponential, hyperbolic, Kula's function, or any other. The discount function used would be the one that matched the decision makers opinions most accurately.

Second, time era weights could be used instead of a discount function. In this case, the weights used in the model would match the decision makers' preferences exactly. Using time era weights does not restrict decision makers to giving the future less weight than the present, unlike other value functions. The decision makers could give the time eras equal or increasing weights, if they so desired.

Policy makers should take into account the fact that the public wants to look at the long term impacts of projects when making societal decisions. The public is demanding more democratic decision making processes that involve them and take their opinions into account. They are becoming more environmentally aware and have greater concern about the long term impacts of decisions than ever before. This highlights the need to find more inclusive decision-making processes. The use of time era weights may provide a way of helping decision makers discuss the time trade-offs they have to make. Using time era weights makes the trade-offs explicit and enables decision makers to see which parts of the decision change over time. Instead of focusing on the search for a discount rate, the methodology allows decision makers to discuss what is motivating their opinions and explore common understandings.

Societal decisions often have long term impacts; those involving nuclear waste or the environment can have consequences which span over hundreds of thousands of years. Decision makers need to consider all the impacts of the decision they make. However, using a constant discount rate disregards the long term future, giving virtually no importance to events that occur after the first 50 years. This is not defendable behaviour, especially with projects that span hundreds or thousands of years, and it is important to find alternative ways of modelling decisions, so that these outcomes are taken into account. Models should only be used if they reflect the decision makers' opinions and capture the situation adequately. In addition, more research needs to be carried out to find suitable modelling techniques for long term decisions.