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Ragnar Jonsson's paper is included in this version, but is missing from the paper copy.

Hyperbole, Hypocrisy and Discounting that Slowly Fades Away

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Abstract

Mainstream economists have begun voicing disquiet about how discounting affects values ascribed to the distant future. It has been proposed that discount rates should decline through time. Some reasons for this (hyperbolic discounting by one individual, fair treatment of future generations, different time perspectives of presently living individuals) lead to inconsistent decisions through time. Diminishing marginal utility provides a robust and stable justification for discounting. Combination of different income groups, different goods and different scenarios yields discount functions in which discount rate does tend to decline, though not always similarly. Uncertainty about future return on investment affects discounting arguments based on compensation or endowment of future generations, but drives these arguments in opposite directions. Time preference rates so derived have no normative significance. The most politically appealing argument for declining discounting is that it rejects environmentally damaging projects, and supports the claims of the distant future, without requiring great sacrifice in the present.

Keywords: time preference, intergenerational justice, diminishing marginal utility, rate of return, disaggregation

Introduction

The fashionable though ill-defined concept of sustainability is difficult to reconcile with the long-established and clearly delineated process of discounting. Sustainability requires the same attention to be paid to the well-being of the future as is done to the present generations. Yet at customary commercial discount rates, 4%-10%, the value attributable even to massive environmental catastrophe 500 years in the future is entirely negligible (see figure 1). Increasing numbers of economists are beginning to express doubts about the validity of the process when applied to very long-term decisions. (See the collection of views given in Portney and Weyant, 1999.)

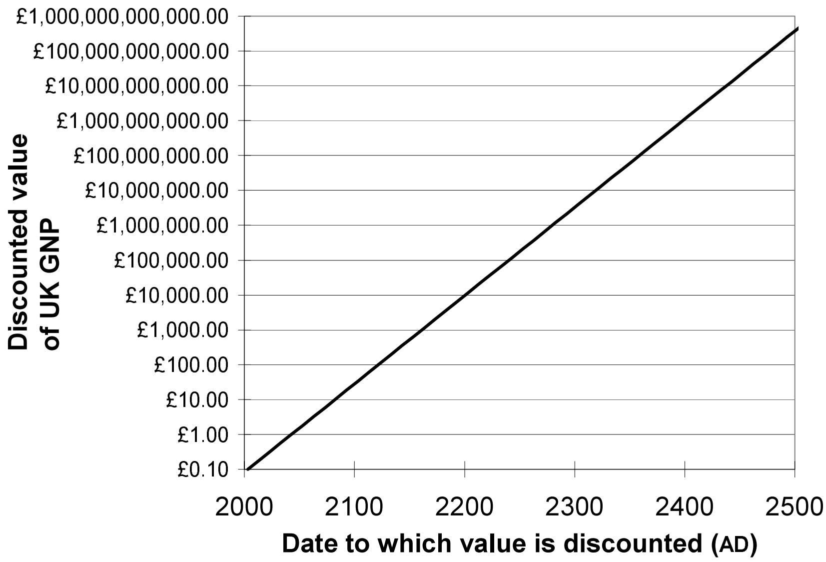

Figure 1. Effect of discounting on the value of a huge distant-future sum

Yet, mindful perhaps of the capital rationing role of discounting, economists are reluctant to give up this investment appraisal tool all at once. The suggestion is increasingly heard, from many quarters and perspectives, that lower discount rates should be set for longer time periods. This paper critically examines the credentials of arguments advanced for declining discount rates. Some suffer from inconsistency of results. Others are better met by disaggregating the entities to which discounting is applied. In some cases similar arguments can result in discount rates which increase through time. From the political perspective, a declining discount rate may produce convenient results, excluding certain types of investment which are, for unspecified reasons, not favoured. It may also excuse a political entity from taking immediate action in favour of the distant future, by representing delayed action as economically less costly.

A further written account is forthcoming in Price (in press a).

Not a negative exponential …?

Recently a number of academics have proposed that discounting should be done in a way that differs from the traditional negative exponential. Journal papers (Weitzman, 1998), reports of research institutes (Newell and Pizer, 2001), advice to government departments (OXERA, 2002) and even government departments themselves (Her Majesty's Treasury, undated) have begun to recommend that the discount rate employed should be reduced, the longer the period over which discounting prevails. If the discount rate varies discontinuously, the result is a cusped profile of discount factors over time (see figure 2). This is far from convenient: there are no continuously differentiable net present value functions; discount factors increase sharply in the year following a change of discount rate - in optimal rotation calculations, for example, rotations lasting 31, or 76, or 121, or 201, or even 301 years would be suddenly popular.

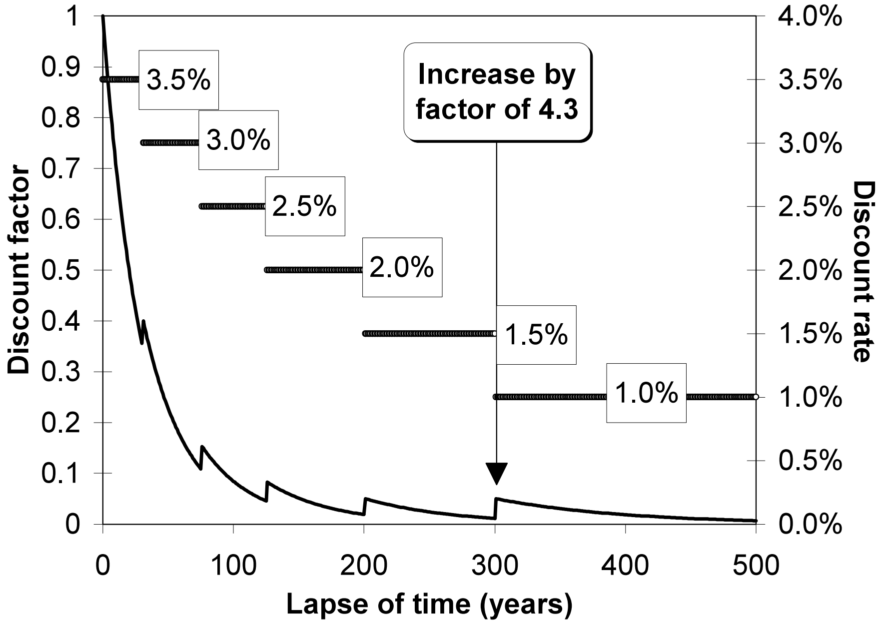

Figure 2. Discount factors based on rates proposed by OXERA (2002)

However, the basis for such discount profiles is not simply aversion to the results of negative exponential discounting, but derives from some belated rethinking of the rationale of discounting. This rethinking has been done from empirical, ethical and theoretical perspectives.

Hyperbolic discounting

It has very often been observed that humans' impatience puts heavy weight on the immediate rather than delayed gratification of desires, but very much less weight on the distant-future rather than the further-delayed gratification of desires (Thaler, 1981; Benzion *et al.*, 1989; Ainslie, 1991; Henderson and Bateman, 1995; Cropper and Laibson, 1999). In extreme cases, we discount heavily over a day's delay in the immediate future, but hardly at all over a day's delay ten years in the future. This profile of values has given rise to what is termed hyperbolic accounts of discounting, in which, typically, the discount factor is

$$\frac{1}{\left(1+[\text{discount rate}]\times[\text{delay}]\right)} \quad \text{rather than} \quad \frac{1}{\left(1+[\text{discount rate}]\right)^{[\text{delay}]}}.$$

(It might be noted in passing that neither this, nor other formulations appearing in the literature, are strictly hyperbole.)

Figure 3 gives an illustrative profile of hyperbolic discount factors, and the discount rates equivalent to them. The annual factor is the ratio between values given to consumption occurring after 49, and after 50 years. As lapse of time brings time 49 closer, so the annual discount factor declines: eventually, dramatically.

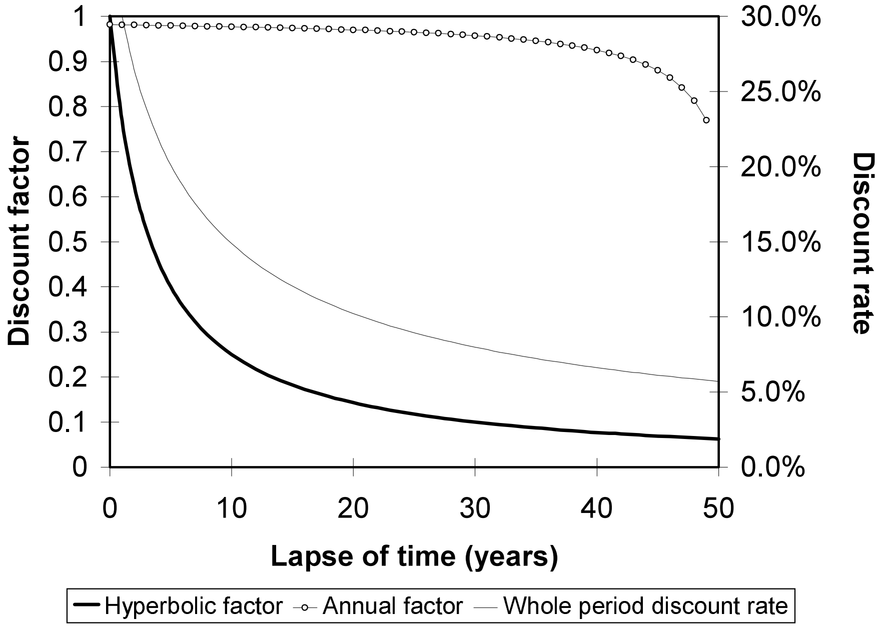

Figure 3. Hyperbolic discounting functions

A propensity to discount like this has clear survival value in a world without proprietary rights, where the imperative is to "seize the day" - take whatever opportunities for feeding or mating come one's way, before they are seized by another individual. It is much less appropriate in a world where postponed consumption is nonetheless reasonably *assured* consumption, and even less so where individuals have the option of transforming consumption through time by investing at interest. Such, nonetheless, is our evolutionary heritage, and we can evade it only by paying attention to our intellectual rather than our instinctive inclinations.

The rights of future generations ("ethical" discounting)

A similar profile of declining discount rates arises from concern for future generations. Under consumers' sovereignty, it is argued, the present generation is entitled to discount its own future well-being, but not that of future generations. A number of formulations have been put forward which use different protocols for discounting the share of consumption accruing to present and future generations (Kula, 1988; Bellinger, 1991; Bayer, 2003). The most persistent of these has been Kula's formulation, which combines normal [time preference based] discounting of the share of future consumption that falls to the present generation, with discounting of the share to future generations only during the period from their birth up to the accrual of consumption. This yields the following profile of discount factors for separate and combined generations (see figure 4).

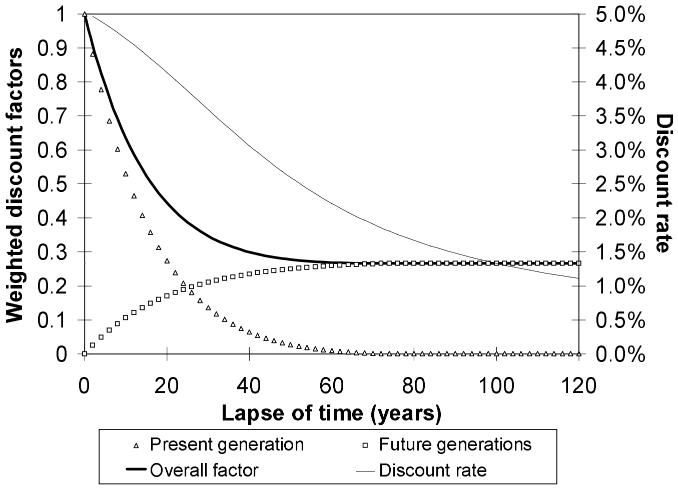

Figure 4. Discount factors according to Kula

Different time preferences

This account follows a protocol similar to that suggested by Li and Löfgren (2000). "Society" is represented by one conservationist who does not discount, and three utilitarians who discount at 5%. [This characterisation of utilitarians is actually quite inappropriate: as Broome (1991) argues, there are many versions of utilitarianism, and there should be no presumption that the philosophy is short-termist in outlook. Indeed, the utilitarian philosopher Sidgwick (1874, p.414) asserts that "… the interests of posterity must concern a Utilitarian".] The social discount factor is the weighted mean factor for these four representative persons.

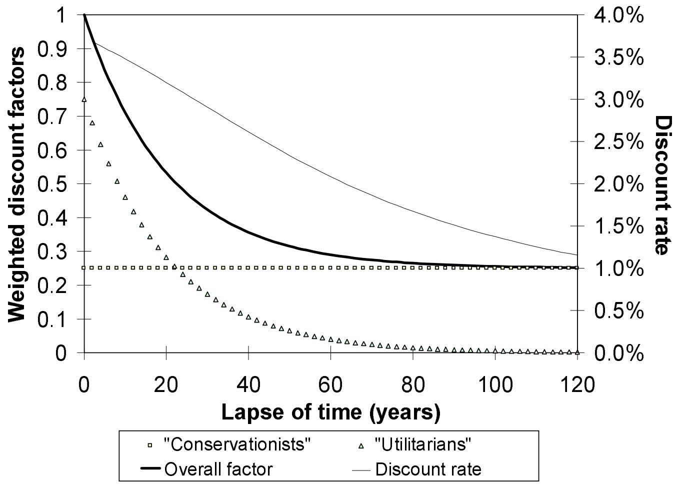

Figure 5. Components of the discount factor according to Li and Lofgren's protocol

Dynamic inconsistency

The above three very different arguments for declining discount rates share a practical problem: dynamic inconsistency (Strotz, 1956). Suppose Scots pine (*Pinus sylvestris*) is established on a low productivity site, with cash flows per hectare as shown in table 1. Discount factors for 40, 80 and 120 years are 0.35653, 0.26513 and 0.25215, derived by summing utilitarian and conservationist factors as in figure 5. From the perspective of AD 2004, a rotation of 120 years appears profitable. However, in AD 2084 the revenue from immediate felling exceeds the discounted revenue from delaying until AD 2124. The crop is felled at age 80 years. Yet, had that felling age been anticipated at the time of establishment, the crop would not have been deemed worth planting.

Table 1 Options for Scots pine (*Pinus sylvestris*) rotation

Event	Cash flow per hectare	Discounted value seen from time AD 2004	Discounted value seen from time AD 2084
Establish	–£2000	–£2000	
Fell at age 80	£6000	£6000 × 0.26513 = £1591	£6000
Fell at age 120	£12000	£12 000 × 0.25215 = £3026	£12 000 × 0.35653 = £4278

Similar results arise with the hyperbolic and “ethical” discount factors.

More sums of negative exponentials

Differences in discount rates are not confined to individuals’ time preference, nor are they a radically new concept. Li and Löfgren’s protocol is but a special case of the general result of combining more than one discount rate, of which numerous previous examples have been discussed (Price, 1993). The most consistent source of such varied discount rates is diminishing marginal utility - the reduction in value of an additional unit of consumption as the total of consumption increases. Diminishing marginal utility is the easiest cause for discounting to defend ethically (Price, 2003). In a world of advancing technology and rising personal affluence, the standard expectation is of marginal utility of consumption decreasing indefinitely into the future.

Income growth

But not every entity or agency is affected to the same extent. Suppose the costs of future global climate change were to fall equally on two representative countries, each having the same population. One has a growth rate of real income per head of 2.5% (similar to the UK presently): the other, 0.5% (like many developing countries where high official growth rates probably overstate the gain in real income per head (Price, 2003)). The elasticity of marginal utility of income is taken illustratively as -2, but similar results are obtained with lower and higher elasticities. Suppose that both countries’ income started at the same level. A discounting protocol based on the weighted sum of discount factors for the two groups would indeed produce a profile of discount rates like OXERA’s (see figure 6).

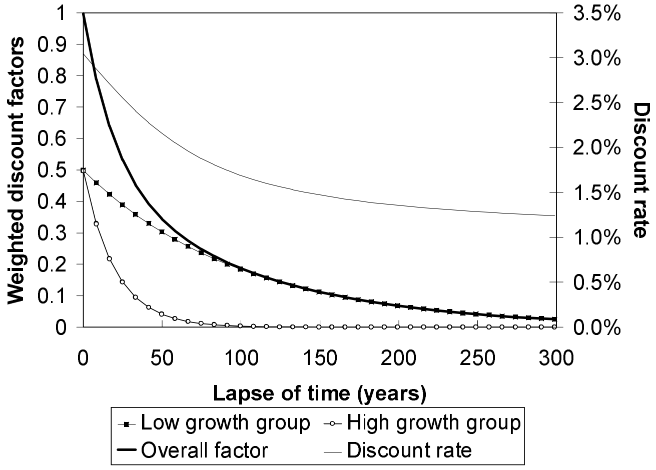

Figure 6. Discounting the effect of climate change: two different income growth rates

But if the low-growth country is also a low-income country, a very different picture emerges. Suppose its initial income per head is a twentieth that of the high-growth country. The lower curve in figure 7 shows that the discount rate based on individual utilities is uniformly low. The utility function gives little weight to marginal costs falling on the rich country. The upper curve, by contrast, shows a discount rate based on the income of the two countries taken together, and thus is dominated from the outset by the high-income country. The obvious conclusion is that the fundamental problem is disparity in appropriate discount rates between groups, rather than that any disparity emerging over time periods. The imperative is to disaggregate the appraisal by income group, not time period.

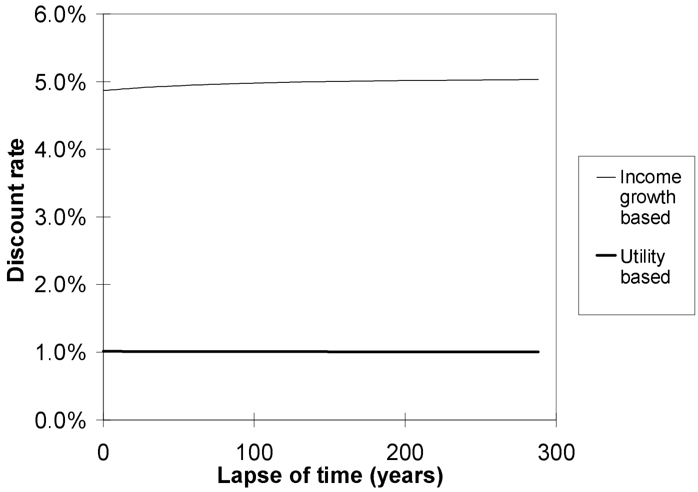

Figure 7. Discounting the effect of climate change: two different initial income levels

See Price and Nair (1985) for a fuller account.

Aggregating goods

Like marginal utility of income, so marginal utility of goods falls at different rates with increasing consumption. Figure 8 presents the case for two products with very different elasticities of utility of consumption. For simplicity, these two are taken to represent the whole consumption basket. At low income levels, consumption is dominated by the good having high elasticity of marginal utility of consumption. This is often associated with basic needs goods, such as wood products for fuel and house construction. As income rises, at first the (rapid) diminution of marginal utility of consumption is attributable largely to this basic good. But the "luxury good" - perhaps consumption of aesthetic services of forests - comes increasingly to dominate marginal purchases, and the implicit discount rate declines. The situation superficially resembles Li and Löfgren's formulation of overall discount rate for two individuals with different discount rates (figure 5). However, the profile of discount rates is quite different: there is an initial flat section where the basic good dominates, before the rate declines asymptotically to the rate appropriate to the luxury good. It is also noticeably different from that advocated by OXERA (2002).

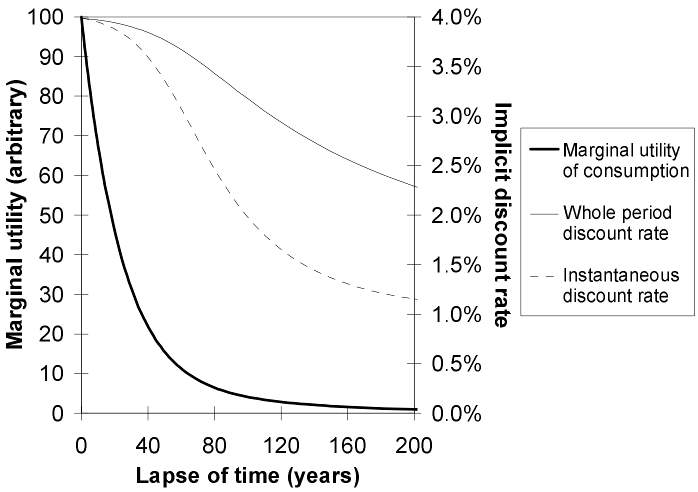

Figure 8. Discount rates for a basket comprising one basic and one luxury good; constant income growth rate

Aggregating scenarios

In an uncertain world, neither the growth of future income nor the future abundance of goods is known. Nor, therefore, is the appropriate discount rate based on diminishing utility.

Figure 9 considers the value of projected future effects of climate change, with two polar economic projections. The optimistic scenario projects economic growth of 5% per year, and zero population growth: the pessimistic scenario projects economic growth at 2% per year, and 1.5% per year population growth. Elasticity of marginal utility of consumption is again taken as -2. Growth of income per head is economic growth rate minus population growth rate. As customary (Fankhauser, 1995), damage resulting from climate change is proportional to economic activity, so that the rate of economic growth offsets discounting due to diminishing marginal utility.

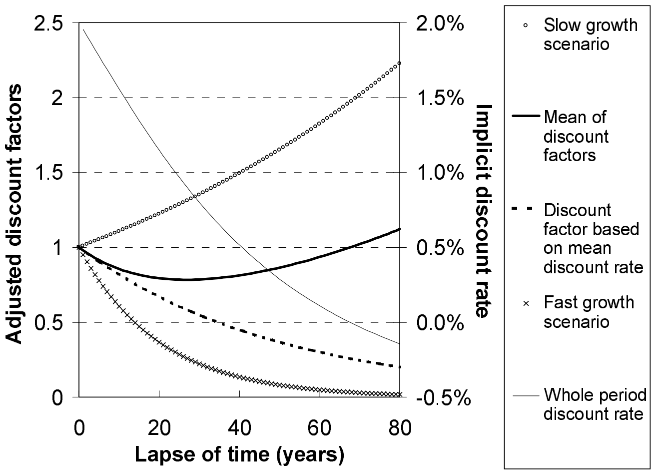

Figure 9. Averaging discount rates and discount factors for climate change damage

Thus under the optimistic scenario the appropriate diminishing marginal utility discount rate is (5% - 0%) ´ |-2| - 5% = 5%; under the pessimistic scenario it is (2% - 1.5%) ´ |-2| - 2% = -1%; and, it might be thought, if both scenarios were deemed equally probable, that the mean discount rate would be 2%. But figure 9 shows that the discount rate consonant with the mean of discount factors changes not only in magnitude through time, but also in sign, being positive initially, eventually becoming negative.

Figure 10 represents values accruing to a poor household. Its income is derived entirely by gathering and selling a portfolio of non-timber forest products, whose price fluctuates randomly by anything up to 50% over one time period. The figure is derived by the aggregation of 100 000 replicates of a 25-year time period. As might be expected with so many replicates, the mean portfolio price is constant through time.

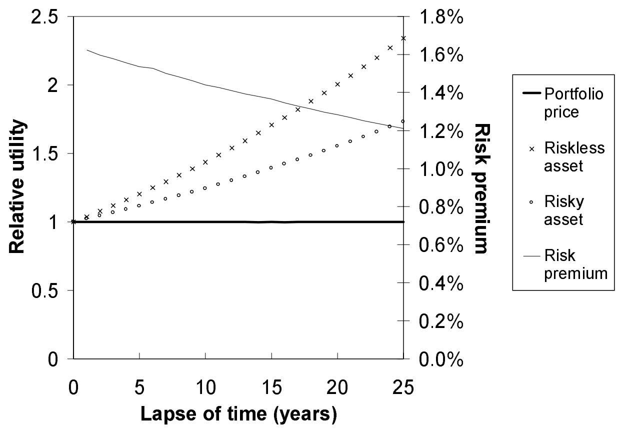

Figure 10. Randomly varying price and risk premium on discounting

The household has the opportunity to invest either in a riskless income-yielding asset, or in the means of increasing the efficiency of utilisation of the non-timber forest products - which owing to price fluctuation is risky (technically, the beta-coefficient is +1). At times of low prices, both investments have enhanced value, because of the high marginal utility of income. This more than offsets the low value at times of high prices. Thus both assets grow in value through time, as the limits of possible variation of the portfolio price become wider. However, the riskless asset is more valuable because the income derived from it is constant. Figure 10 shows the expected value of the two additional investments through time. The declining risk premium represents the difference in rates of value change between risky and riskless investments. Given the large potential scale of fluctuation, the risk premium might seem surprisingly small: but it declines, as in all the other instances of aggregating values discounted at different rates.

Comparable results with different elasticities of marginal utility of income are presented in Price (1993). Gollier (2002) has also treated uncertainty via diminishing marginal utility effects.

Intertemporal transformation of funds

The traditional basis for discounting is the rate of return on investment, which may transform purchasing power between time periods. Early possession of funds is more valuable than later possession, because early funds may be transformed into greater purchasing power over the intervening time period.

This concept has recently found new expression via capability to pay compensation for environmental and other harms. The later the degradation occurs, the less need be invested presently in order to generate adequate compensation. On the other hand, the later that revenues accrue from resource exploitation, the less is their ability to fund compensation at a given future time. The norms of negative exponential discounting are perfectly justified.

The argument does of course require the following improbable premises.

1. Funds for compensation are *actually* set aside.
2. They are protected absolutely as an investment until the time when compensation is required. If on the other hand they are increasingly at risk of depredations as time goes on, that would result in a declining discount rate.
3. Diminishing marginal utility of money (in an increasingly affluent world) does not significantly reduce the value of a given compensatory sum.

Compensation for environmental and other harms

If premise (3) is not true, the required monetary compensation for a given harm will increase progressively, the later the harm occurs. If the marginal utility of income is more elastic than -1, the required present investment will also increase for later harms, implying a negative discount rate (Price, 2000). For all plausible cases, the discount rate decreases through time - but not with the same profile as OXERA use. Figure 11 shows the appropriate discount rate decreasing at an increasing rate through time, becoming negative, and eventually indefinitely so.

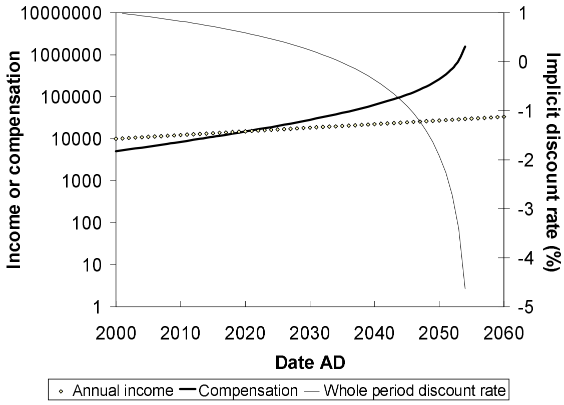

Figure 11. Discounting and compensation for harms

This issue is discussed in detail elsewhere (Parfit, 1984; Broome 1994; Price, 2000).

Compensation from a fund of uncertain returns

The future entails uncertainty about rates of return, as well as about environmental and market conditions. Suppose the rate of return follows a random walk. It is possible that a sequence of high rates of return will reduce the investment required to finance a given amount of future compensation. Thus the theoretical lower limit of required investment tends towards zero through time. It is also possible that a sequence of low rates of return will increase the investment required. Unless returns are allowed to be negative, the theoretical upper limit of required investment tends through time towards equality with the final compensation. As with the several other cases already reviewed, the aggregation of these and less extreme time paths yields a mean expectation of a falling discount rate, as shown in figure 12.

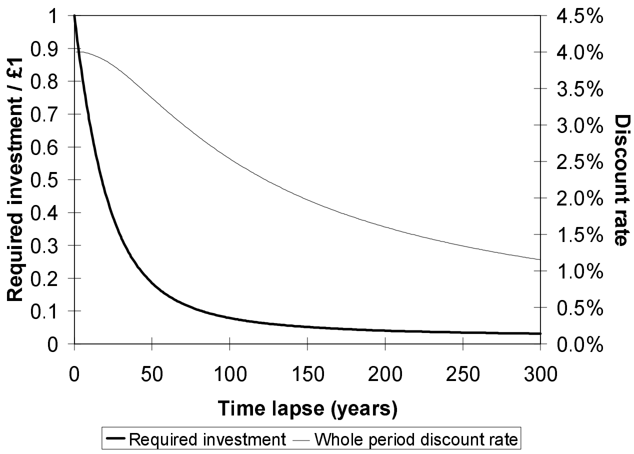

Figure 12. Mean investment required for compensation with risky returns, based on 10 000 iterations of a stochastic model, with 4% starting rate of return and maximum variation ±20% per period.

The profile, derived from similar data to that in Newell and Pizer (2001), is itself similar to theirs.

The maximum endowment for future generations

In complete contrast, the traditional rate-of-return argument for discounting is this. Investment funds have opportunity cost. If they were not invested in a forestry project, they could grow at the general investment rate of return. Concern for future generations requires the present generation to invest in whichever way provides the greatest possible future endowment.

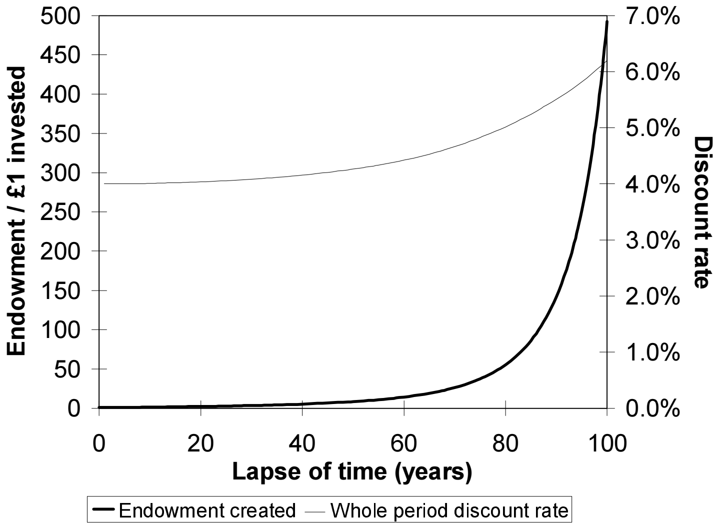

Figure 13. Mean endowment generated with risky returns, based on 10 000 iterations of a stochastic model, with 4% starting rate of return and maximum variation ±20% per period

The interpretation of figure 13 is this. If forestry would provide a revenue after 50 years, the investment required, alternatively invested, would on average yield an endowment which is equivalent to a rate of return only slightly above 4%. But if forestry revenue were expected after 100 years, the opportunity cost rate of return by that time exceeds 6%. [The result is rather unstable, as it is dominated by very rare events in which the rate of return grows to very high levels.] As with the "compensation" argument, the *mean expected rate of return* remains at the initial 4%. But as time elapses, the rate of return that would generate the *mean final endowment* is increasingly dominated by increasing rate of return scenarios. Of course, stochastic variation in forestry returns should be included for a balanced analysis.

The compensation and endowment arguments, superficially similar, in fact lead to opposite conclusions on the appropriate profile of discount rates. Essentially, this is because the compensation argument averages negative exponentials (discounting), while the endowment argument averages positive exponentials (compounding).

The conversion from Newell and Pizer to time preference rates

However, Newell and Pizer (2001) interpret the discount rates so derived quite differently: because of the supposed equilibrium in capital markets, time preference rates are "dragged" in whatever direction and to whatever extent rates of return may vary.

There are many problems with the concept of equilibrium in the capital market, such as the effect of the "wedge" between pre- and post-tax rates of return. Particularly, the equilibrium position represents not only the marginal rate of return (which *is* relevant to transforming marginal funds), but also the *marginal* rate of time preference (which is *not* relevant to discounting the utility of the *entire basket* of consumption).

Besides, as many others than myself have argued, individual pure time preference is an extremely unsatisfactory basis for public choices about the future.

· It under-represents the interests of future generations.
· It is inconsistent over time periods.
· It changes not only magnitude but also sign as time elapses, bringing the future to the present, and the present into the past.
· It may be conflated with diminishing marginal utility effects which are variable by circumstance.

The interpretation of time preference most consistent with the array of evidence is that it represents a preference for *immediate time* rather than *early historical time*. As future time moves into the present, consumption in that moment is given the heaviest weighting. Quite simply, time preference is not relevant to discounting as conventionally practised (Price, 1993; in press b).

With time preference seen in this light, what matters is not the rates at which utilitarians and conservationists discount future values, but the values that future utilitarians and conservationists will put on their own well-being (and even what value present utilitarians and conservationists will put on their own well-being when the future has become their present).

Whatever else the expected variation in future rates of return tells us therefore, it does not tell us what weight should be put on consumption in the future.

Political convenience

Given the differences between circumstances, the cases reviewed above seem to favour disaggregation of discounting by the kind of cost or benefit, rather than by time period. Moreover, those arguments for declining discount rates which are based on compensation or time preference seem to have fatal weaknesses. So why should politicians have taken any interest in the declining discount rate protocol?

Discounting to avoid headaches

One reason is its relative simplicity: once the tariff of discount rates is allocated unambiguously to time periods, nobody has to think about discounting any more. There is minimal scope for wrangling among turbulent economists about how a particular product or income group should be treated.

But there are subtler political reasons.

Correctly used, discounting delivers advice to politicians on what should, given a set of values, be the preferred option. However, discounting is often deployed in the opposite way: a discounting protocol is sought to select an option which is already politically favoured. There are two specific circumstances in which the declining discount protocol might meet this requirement.

Discounting to filter out disfavoured projects

It may be desired to reject projects, such as nuclear power stations, whose characteristic profile is a short period of cost (often construction cost) followed by a moderate period of benefit, followed by a very long period of cost (often environmental damage). Evaluations of such projects have sometimes been used to demonstrate the unwanted effects of lowering the discount rate, which may cause medium-term benefits to outweigh short-term costs, thereby admitting an environmentally damaging project.

Figure 14 represents the cash flow predicted for the UK's Sizewell B Nuclear Power Station. An annual £12 million cost for monitoring and health hazards, no doubt omitted through an oversight, has been added at the end of the generating life.

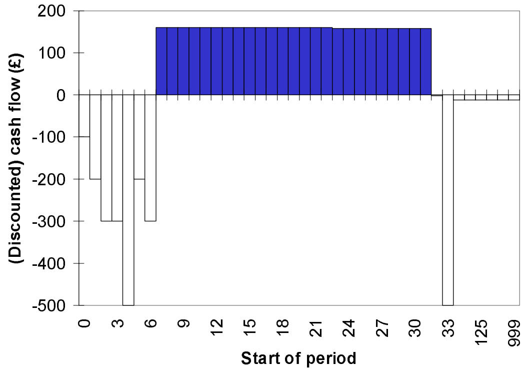

Figure 14. Undiscounted cash flows for a nuclear power station

At a 3.5% discount rate, discounted long-term costs are negligible. At a 1% discount rate, the medium-term benefits suffice to outweigh long-term costs. In either case the project is deemed worthwhile. By contrast a medium-term discount rate of 3.5% (substantially reducing discounted benefits), but falling eventually to 1% (substantially increasing discounted long-term costs) produces the "required" rejection of the project.

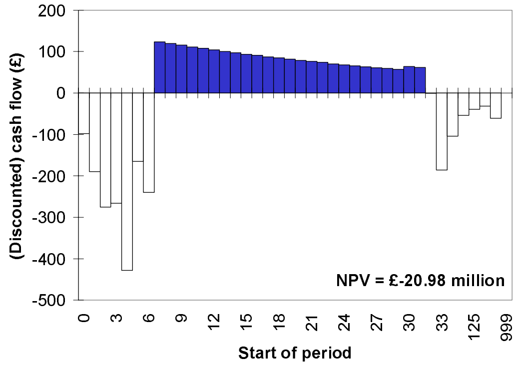

Figure 15. Cash flows for a nuclear power station discounted using OXERA's rates

However, if long-term environmental damage is the focus of concern, the same outcome may more simply be arrived at by discounting at a uniformly low rate - anything below about 0.7% achieves it. Such an approach may have politically undesired consequences, as below.

Discounting to put off the evil day

The moral force of sustainability, and its popular appeal, cause astute politicians publicly to embrace its broad philosophy (Gummer, 1994; Brown, 2004). However, as long as the voting population expresses a preference for good things *now*, it would be imprudent to follow through, ruthlessly, the implications of not-discounting future generations' well-being. Much would have to change. Much would have to be sacrificed. The politically convenient presentation of sustainable development is as a win-win strategy, in which both present and future generations can be made better off.

The declining discount protocol gives politicians what they need: the appearance of moving - with prudent caution - towards a more equitable treatment of the future, combined with an appraisal tool that in practice leaves things little changed.

Newell and Pizer (2001) show that the cost attributed to CO_2 emissions may rise from \$5.74 with constant discounting to \$10.44 with a declining discount rate (though their costing profile is in either case based on a serious misconception about CO_2 dynamics - see Price (1995)). Similarly, the capitalised value of \$1 000 000 damages caused every year in the future increases from \$29 000 000 at 3.5% to only \$44 000 000 with a declining discount rate. (After 300 years, the effect of discounting at 1% is just as belittling as the effect of discounting at 3.5% for 80 years.) Thus these changes imply no radical shift in policy, as cessation of discounting environmental effects, or an immediate reduction of rate to 1% would do.

Take, further, a world-wide project with benign long-term consequences, such as regenerating forests to absorb CO_2 or retain biodiversity - or even to provide the ground of material well-being. Take a simplified cash flow of £1 000 000 000 during the first year, followed by an annual benefit of £25 000 000 each year thereafter. This yields the 2.5% internal rate of return typical of forestry projects.

With the declining rate protocol, the project has positive NPV of £95 million. However, if the project's initiation were to be delayed by a generation - 30 years say - the NPV rises significantly to £282 million: the delayed project is a better project.

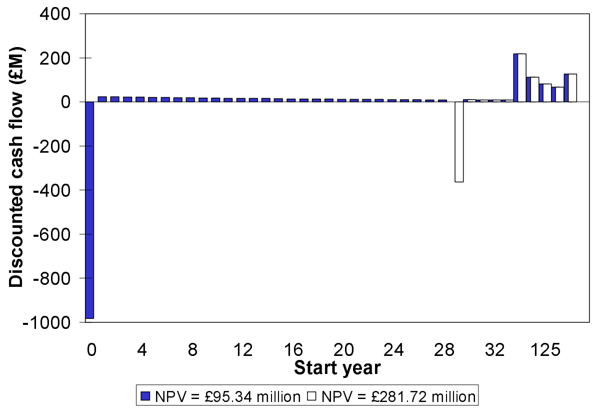

Figure 16. Discounted cash flows and project timing: dark bars show immediate implementation, light bars delayed implementation

In the same way, a phased programme to do the same thing, but with investment of only £33 000 000 per year for 30 years, would be repeatedly rolled forward, this year's share being successively reallocated to 30 years in the future.

Thus, while all generations might agree that the project is worth doing, each may pass responsibility for implementation to the next generation. Dynamic inconsistency rules, just as it does with other forms of (approximately) hyperbolic discounting. As St Augustine of Hippo might have said, “Let me be sustainable, but not yet”. And all on an electoral ticket that promises concern for the future. Does the title of this paper need to be explained further?

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