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Dual discounting in cost-benefit analysis for environmental impacts

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ABSTRACT

Discounting has been a long-established intertemporal efficiency tool in cost-benefit analysis which focuses on project selection at communal level with a view to maximising the social welfare. However, with the relentless growth in environmental stress that, in good parts, stems from investment projects the established criterion in discounting appears to be inadequate especially when environmental issues are taken into consideration. This paper looks at how dual focus on efficiency and sustainability can be achieved by using dual discounting, i.e. discounting environmental benefits separately and differently from other costs and benefits and applies this alternative criterion to an afforestation scheme in the United Kingdom which contains carbon sequestration in addition to timber benefits.

1. Introduction

This article seeks to explore how environmental impacts might be discounted, in effect weighted, in cost-benefit analysis so as to achieve both efficiency and sustainability. Discounting has a critical impact on sustainability because with conventional discounting even when a declining rate is adopted, as in the case for the UK, the focus will be on the present and the near future. The main argument is that environmental effects should be discounted separately and differently from economic impacts. That is, dual discounting ought to be adopted in cost-benefit analysis for projects that would have substantial environmental impacts especially at a time like this when the global environment is under stress. This approach takes its strength from the neoclassical theory by focussing on the social time preference rate which is now used as the main criterion in determining the British rate by the Treasury.

The United Kingdom is one of the earliest countries to establish a formal discounting policy for public sector investment projects including environmental ones. This endeveaour started in 1967, with the publication of a white paper, the Economic and Financial Obligations of Nationalised Industries, Cmnd 1337 (1961), which is still evolving. In 2003 the Treasury published its long awaited Green Book in which it recommended that a 3.5% declining rate should be used for projects with long term impacts, over thirty years, as opposed to the standard practice, HM Treasury (2003). This rate should fall to 3.0%, 2.5%, 2.0%, 1.5% and 1.0% in years 31, 76, 126, 201 and 300 respectively. However, it was demonstrated by Kula (2008) that these declining figures make no practical impact on long-term discounted net benefit streams when net present value is used in their appraisal.

The British social discount rate contains a number of parameters one of which is the growth in welfare based upon the growth rate of income. The elasticity of marginal utility of income is another parameter in which income growth equates to increasing output of goods and services that enables increasing consumption and with increasing consumption the marginal utility of income diminishes. In essence, we place less weight on future consumption because as our level of consumption progressively increases, then a further increase in consumption means relatively less value to us. The third parameter in the British rate is the risk of a catastrophe concerned with the likelihood of the destruction of capital resulting from non-insurable risk sources such as natural disasters and wars. A final item is the pure time discount rate which reflects our tendency to prefer benefits sooner rather than later and the reverse for costs, i.e. costs are preferred later rather than sooner.

The main tenet of this paper is that the growth rate of income based parameters in the social time preference rate should not apply to environmental benefits of investment projects, if any, because these are in a different category of attributes as compared with conventional ones which are actually undermined by the economic growth. Then we consider the rationale for treating environmental benefits separately within the framework of the sustainable development debate and apply dual discounting to an afforestation project in the United Kingdom which yields environmental benefits (carbon sequestration) as well as conventional timber benefits. The results show that dual discounting would enhance, substantially, the economic viability of investment projects which yield environmental benefits.

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2. Roots of the UK rate, future generations and the environment

The British social discount rate takes its strength from a number 19th and 20th century economists who constructed a theory of discounting at the time when global environmental stress was not an issue. Their aim was to achieve efficiency in intertemporal allocation of scarce resources to maximise social welfare. For a comprehensive review see Kula (1997).

The largest component part of the current British rate (2% out of 3.5%) is based upon income growth which relates to the old concept of the diminishing marginal utility of increasing consumption over time. In many societies standards of living enjoyed by individuals are improving. As the income of a nation increases steadily the satisfaction gained also increases, but at a slower rate because each absolute addition to income yields a successively smaller increase in economic welfare. The roots of this concept can be traced the works of Gossen (1854) and Jennings (1855) but it was Irving Fisher who first used it rigorously in his analysis of the interest rate and also the justification of a progressive income tax scheme, Fisher (1907 and 1927).

Another factor influencing an individual preference is the risk, which is well recognised in economic literature. Fisher (1907) argued that since all individuals are mortal it is reasonable for them to exhibit a preference, or impatience, for consumption today, because they may not be alive to enjoy it tomorrow. Lutz (1940), Eckstein (1961) and Henderson (1965) saw the possibility of calculating a mortality based time preference rate for the community as well as individuals in which the utility to be enjoyed at each future point in time ought to be multiplied by the probability of being alive at that time. Since this probability falls with the remoteness of time a perfectly rational and legitimate discount rate should emerge. Another part of the risk component is that although an individual may survive from one period to the next, his/her deferred consumption, i.e. investment, may not materialise due a to a host of factors. Money lent to a person may not be returned if the borrower becomes dishonest, dies without assets or heirs, or he/she may become bankrupt unable to pay the money back. Money lent to commercial banks is also vulnerable to risk and thus Hicks (1946) emphasised that every loan is, essentially, a gamble and thus the interest charge must reflect the risk taking.

For the risk component the British government employed 1% for possible environmental or other disasters. “Catastrophe risk is the likelihood that there will be some event so devastating that all returns from policies, programmes and policies are eliminated, or at least radically and unpredictably altered. Examples are technological advancements that lead to premature obsolescence, or natural disasters, major wars etc.”, (HM Treasury, 2003, p. 97). The other part of the rate, 0.5%, accounts for impatience to reflect preference for consumption now, rather than later, Jevons (1871). Altogether the British rate becomes 3.5% which declines over time reaching 1% in year 301. However, Evans (2004 and 2005) contends that a social time preference rate in the United Kingdom based upon empirical evidence is likely to be around 5% as opposed to the government's figure of 3.5%. The product of economic growth and the diminishing marginal utility of consumption is the largest component of the social time preference rate that accounts for more than fifty percent of the current figure and it is for this part that dual discounting becomes relevant.

Conventional discounting is an intertemporal efficiency tool and as such designed to promote economic growth whereas sustainable development is about striking a balance between economic, social and environmental goals. The conventional method of discounting has been criticised as being a discriminatory practice against future generations. Pearce et al. (1990) set out 3 reasons why the higher the rate of discount, the greater will be the discrimination against future generations. They argue both that the process of discounting appears to counteract against intergenerational justice (p.47) and that the burden of accounting for future generations' interests should not fall on the discount rate. In effect they are saying that discounting is a biased tool and that the bias should somehow be constrained.

Lowering rates across the board is rejected because it would lead to more projects passing the cost-benefit rule and thereby increased demand for resources and environmental services. Pearce et al (ibid) point out that a lower discount rate for environmental projects is likely to run into problems of deciding what is and what is not an environmental project, as most projects will impact positively or negatively on the environment. If the scale of environmental impact is used to classify projects as environmental or not environmental, there will be a cut-off point which would be an arbitrary feature of the procedure. They also argue for compensating investments that maintain the flow of services from a given stock of environmental goods, and to include costs and benefits of such investments along with the investment under consideration which means a changed cost profile for the project. This in turn means valuation of the cost of resource and receiving environmental damage. It is then recommended that including within any portfolio of investments one or more shadow projects whose aim is to compensate for the environmental damage from the other projects in the portfolio which appear to be offsetting. This approach of requiring shadow projects appears to be an alternative to either not undertaking a project with adverse environmental impacts or ameliorating these adverse impacts through redesigning the project which is distinct from the hypothetical compensation envisaged by Kaldor/Hicks — i.e. about equity and sustainability rather than efficiency. However, there are some questions here: firstly, are these compensating projects to be selected using a biased tool, namely discounting? Will a biased tool achieve optimal resource allocation? What could compensate for an irreversible loss? Given the difficulties described above regarding the valuation of environmental impacts how is the value of the compensation to be estimated?

Kula (1981 and 1997) argues that discrimination against future generation stems from the contention that traditional analysis treats society as if it is like a single individual with an eternal, or a very-long life. In his model, society consists of mortal individuals with overlapping life spans in which each individual, or generation, discounts its own utility but not those of others. As a result a different pattern of discounting emerges, called the modified discounting method, which is less severe on future incidents.

3. Sustainability and rationale for dual discounting

Today the challenge is to set the discount rate for environmental impacts at a rate that will achieve either a rate of natural capital depletion maximising consumption utility of current and future generations or the maintenance of natural capital. A common discount rate for both natural capital and man made capital cannot be assumed as natural capital is finite and limited whereas man made capital is not limited. Hence there should be dual discount rates. It is possible that the dual rates could coincide but only if the demand for ecosystem goods and services were not to outstrip the regenerative capacity of the ecosystem.

There may be two approaches to dual discounting — a separate and different discount rate for environmental projects or a separate and different discount rate for environmental impacts. The reason given by Pearce et al (ibid) for rejecting the approach of a lower discount rate for environmental projects, namely arbitrariness, appears sound. The utility arising from ecosystem goods and services tends not to be adequately captured in cost-benefit analysis whereas financial impacts are captured to a greater degree. A separate and different discount rate for environmental impacts is a step towards adjusting for this bias and might be expected to increase well-being. However, a better understanding of environmental impacts is needed. Environmental impacts are impacts on natural systems — these systems are akin to renewable resources up to the point of overload and thereafter are akin to non-renewable resources that are subject to depletion. The factors leading to ecosystem stress are increasing with population growth and increasing levels of per capita consumption, Brundtland Commission (1987). When levels of consumption use not just the flows from natural systems but deplete the stocks that give rise to the flows, they erode or shrink natural capital's production frontier. The need for a systems approach is illustrated by Worm (2006) in their report on ocean system depletion where marine biodiversity loss is increasingly impairing the ocean's capacity to provide food, maintain water quality, and recover from perturbations.

Marshall (1899) envisaged natural capital as an "annuity fixed by nature". We now appreciate that natural capital can be degraded and depleted so that the annuity can be eroded. This can be hidden for a while by liquidating natural capital and not recognising that we are in fact running down the principal that gives rise to the annuity. In reality what is happening is that the marginal productivity of ecosystems is diminishing. Increasing pollution and overfishing followed by reduced fish stocks and catches are an example of this. Whenever the marginal productivity of natural capital is diminishing, i.e. whenever the rate of degradation or depletion exceeds the rate of regeneration, the standard discounting is difficult to justify. Given the non-linear nature of the impact of degradation on ecosystem function, moving swiftly to a zero discount rate could be argued to be no more than an application of the precautionary principle.

The Stern Review (2006) adopts a more radical approach using a very low discount rate and is open to the possibility that the discount rate for environmental impacts could be negative when the environment is deteriorating. The Financial Times (2007) in an interview with Sir Nicholas Stern commented "The most forceful criticism was about the study's use of a very low discount rate, which is used to translate the probable costs and benefits of climate change decades ahead into a value for today". Stern's answer to these comments was that to use a higher discount rate, such as those more commonly used in economic modelling of future costs and benefits, would not properly reflect the costs of climate change to future generations. He argued that the lives of children born 20 to 50 years from now should be given the same value as those living today, which would imply the kind of very low discount rate he used. Stern appears to be saying that a very low discount rate should be used to reflect the costs of climate change to future generations which is clearly a separate and different discount rate to that more commonly used in economic modelling of future costs and benefits.

Whilst the Stern Review envisaged that "…if conventional consumption is growing but the environment is deteriorating then the discount rate for consumption would be positive but for the environment it would be negative.", (section 2A.3, p52). However, a negative discount rate is counter intuitive and impractical for it would mean that adverse environmental impacts are preferred sooner rather than later. Extending the logic should also favour at least a low positive rate as opposed to a zero rate, since the latter value would imply that today's society would be indifferent as to the timing of the adverse impacts. Furthermore, technology has the potential to assist us to both use ecosystem goods and services more efficiently and also to remediate adverse environmental impacts.

According to some economists the social rate of discount in cost-benefit analysis should be consistent with the aim of achieving a new synthesis of social time preference and opportunity cost discount rates for environmental impacts. As regards functional form for time preference, the evidence cited by Heal (1997) supports a hyperbolic, i.e. a varying, discount rate for environmental impacts. Whilst a logarithmic discount function is intuitively appealing from a psychological perspective, what is relevant is not human perception of the ecosystem but instead the ecosystem as it actually is. As McIntosh (1995) writes: "Nature was established out with an anthropogenic mythopoesis, but anthropogenic constructs must ultimately stand the test of nature, within which they are held".

As regards the opportunity cost of natural capital, the aim is to use natural capital so that the marginal productivity of ecosystems is not degraded over time, Kula (1998). The impact of a change in the stock of natural capital would be expected to be inversely proportional to the pre-existing natural capital stock. However, two considerations militate against conventional discount function for environmental impacts. Firstly, discounting is primarily about the weight to be given to future impacts rather than the valuation of those impacts. Secondly, uncertainty about the trajectory of technology, population growth and per capita environmental impact may increase over time. In the case of the Treasury's Green Book, the uncertainty in question only concerns the appropriate value of the discount rate itself and if growth of consumption and the elasticity of marginal utility of consumption were to be excluded, then it is merely uncertainty concerning the appropriate value of the pure time discount rate.

It is also worth considering whether an opportunity cost rate lower than the regeneration rate is justified in project appraisal. For example, the growth rate of a forest and therefore the corresponding carbon sequestration rate may exceed a very low opportunity cost environmental discount rate. Clearly deforestation and emissions are increasing globally, and as the sustainable development perspective is a global one, then the use of discount rate lower than the regeneration rate may be justified because regeneration should be considered at the ecosystem level rather than the project level.

Whilst cost-benefit analysis is in essence a tool of marginal analysis, decisions are made taking account of the wider context. Hence in a cost-benefit analysis of forestry, the environmental objective is more likely to be to maximise the carbon sequestration and carbon substitution benefit rather than that the forest should be carbon neutral. Hence the marginal productivity or regeneration rate of the forest is not a basis for the opportunity cost discount rate whenever the objective is framed in broader ecosystem terms, namely the atmospheric carbon dioxide equivalent concentration.

Ecosystems goods and services serve two distinct purposes. When demand is within supply, transformation of natural capital into man made capital increases economic welfare by increasing consumption and capital formation with little or no opportunity cost. However, when the demands on ecosystems exceed regeneration, then the opportunity cost of further transformation becomes very high. Bearing in mind Marshall's reference to the annuity fixed by nature, the objective should be to maintain that annuity and not to consume the principal that gives rise to that annuity. Sustainability therefore entails conserving natural capital so as to preserve the annuity of ecosystem goods and services to be invested in human and man-made capital. Hence an understanding of optimal economic growth is about more than the transformation of natural capital into man-made capital. Developing the concept of a hierarchy of capital, perhaps better envisaged as a pyramid of capital; what then constitutes the base of the pyramid?

Taking the ecosystem annuity to be fixed by nature, the dimensions of the base of the pyramid are fixed, while the height of the pyramid can be increased as human development increases. It may be argued that the base of the pyramid is the carrying capacity of our ecosystem, which offers simple interest not compound interest. Efficiency would therefore be better redefined as living within the simple interest from our ecosystem and then reinvesting this at compound interest in human, social and man made capital. Efficiency and sustainability are clearly best served by living within our ecosystem means or budget constraint, Nordhaus (2006). However, there also needs to be an equity constraint — the ecological and economic minimum standards of both the current and future generations need to be met.

This equity constraint must apply to both the current and future generations which echoes Dasgupta's reference to the "equity parameter" in his comment to the Stern report, (Dasgupta, 2006). Other human beings, both those currently alive and future generations, should from an ethical perspective, count equally, subject to the

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proviso that minimum standards must always be met for those currently alive. For the current generation it means that what is needed for a dignified human existence has first call on resources. It also means that sufficient resources should be conserved for future generations to be able to exercise whatever are their preferences for ecosystem goods and services and economic activities must be sustainable.

Neither economic growth nor diminishing marginal utility of consumption of ecosystem goods and services should have any place in the social time preference discount rate for environmental impacts whilst scarcity is increasing. Economic growth as we have experienced so far actually undermines the natural environment that provides utility just like other goods and services. In this new model of discounting, environmental impacts in all cost-benefit analyses would be discounted separately and differently from other costs and benefits. This is therefore a different approach to that considered and rejected by Pearce et al. (ibid), namely distinguishing between environmental projects and other projects.

To facilitate dual discounting, economic and social costs and benefits should be streamed separately from environmental costs and benefits within a cost-benefit analysis. Indeed each stream should have its own set of objectives and constraints, costs and benefits, risks and uncertainties. Discounting environmental impacts separately and differently would be a first step in enabling cost-benefit analysis to move to a dual focus on both efficiency and sustainability. Not delaying with the switch to dual discounting is arguably consistent with the precautionary principle. The Green Book definition of the precautionary principle is "The concept that precautionary action can be taken to mitigate a perceived risk. Action may be justified even if the probability of that risk occurring is small, because the outcome may be very adverse". Other parts of the social time preference rate (0.5%), namely catastrophe risk (1%) and the pure time discount rate, can apply to all benefits, environmental or otherwise.

4. An application of dual discounting to an environmental project

Human activities, in particular the burning of fossil fuels and the depletion of forests, are causing the level of CO2 in the atmosphere to rise. The rate at which greenhouse gases are being released into the atmosphere has been increasing mainly due to the burning of fossil fuels for both domestic and industrial purposes but also as a result of deforestation. It has been estimated that deforestation adds about 1 gigatons of CO2 to the atmosphere per annum, which is nearly one quarter of the problem, Richards and Stokes (2004). It is possible to increase the rate at which ecosystems remove CO2 from the atmosphere by halting deforestation and also by creating new forests which act as biological scrubbers. It has now become a policy objective in many countries that sufficient lands are available for afforestation to mitigate significant shares of annual CO2 emissions which is in fact a relatively inexpensive means of addressing the climate change.

Economic evaluation of afforestation projects now includes carbon sequestration benefits which mitigates against the greenhouse effect of athmospheric pollution. These benefits are recognised in the Kyoto agrrement which came into effect in January 2005 when the European Union allocated permits to all member states. Trees because of their large amount of biomass per unit area of land continue to make an important contribution to the global carbon cycle. Therefore, afforestation projects will make a significant contribution to the mitigation of climate change. So in addition to the wood value of plantation forests the rate at which CO_2 is removed from the atmosphere and the quantity retained in the forest as a carbon reservoir should be assesed in accordance with the Kyoto Protocol. Annex B countries of the Kyoto Deal have committed to an average 5% reduction of greenhouse gas emissions relative to 1990 levels by the first commitment period of 2008–2012. To assist the country implementation of this target, the protocol identified a series of flexible measures designed to ensure maximum emission reductions which includes establishment of new forests on previously cleared land. Forests act as carbon sinks by removing carbon dioxide from the atmosphere and thus can be used to create carbon credits against emission occurring elsewhere. Such credits can be used directly by business with greenhouse gas emissions or could be sold or traded into a future emissions trading scheme. The rules for the implementation of the Kyoto Protocol were agreed at the Marrakech Conference in 2001 which placed limits on the amount of credits which can be obtained from forest management.

Table 1
Cost details of afforestation project, 30 ha, 2006 prices.

Cost details	Year	Expenditure
Ploughing	0	9550
Draining	0	13,330
Planting	0	19,000
Fertiliser	0	1900
	1	2850
	2	950
Beating-up	1	5700
Road construction	29	45,600
Land rent	0–30 (throughout)	1900

Our afforestation project was established in County Tyrone, Northern Ireland on soil which is both wet and low lying where the Department of Agriculture describes the area as severely disadvantaged due to its poor agricultural potential. The project is based upon a 30 year single rotation which includes a no-thinning regime — a practice becoming quite common in Northern Ireland as well as parts of Great Britain. The species planted is Sitka Spruce, the most favoured tree by foresters throughout the British Isles, for it grows very quickly in the oceanic climate that exists in Ireland and the west coast of Britain. The plot is 30 ha and was normally used for rough grazing during the summer months. Although it has poor agricultural potential the soil is suitable for forestry offering a Yield Class of 22 meaning that the stand is expected to grow 22 m^3 on average per year.

Table 1 shows the establishment costs in terms of 2006 prices. The rental value of the whole site is £1,900 which goes throughout rotation. Drainage could be a costly operation in this part of Ireland as the soil gets waterlogged and this is the case here. It takes place in Year 0 of the project and the cost of drainage amounts to £13,300. Ploughing and planting are the other costly items incurred at the begining of the rotation. Fertilising takes place in Years 0, 1 and 2 after the saplings have been planted. On this location fencing did not take place due to the position of the land next to a well fenced farm. The process of beating up, also called supplying or beating, which is the replacement of plants that died in the initial planting takes place in Year 1. Road building is postponed until year 29 in order to boost the internal rate of return of the project.

Table 2 shows the estimated future output of the project which consists of pulpwood, boxwood and saw quality timber. The output details are worked out on the basis of information given by the Forestry Commision's Forest Management Tables, Forestry Commission (1971). Management table figures are reduced by 10% to allow for the space lost by fencing, draining and the creation of passageways.

Table 3 shows the price of coniferous wood in 2006 in Northern Ireland. Over the past few years, timber prices have been rather low

Table 2
Wood yield details.

Output class	Output volume, m^3 in year 30
Pulpwood	9670
Boxwood	5010
Sawwood	1860

Table 3
Average prices (£ per cubic meter) of Coniferous Timber, 2006. Average volume per tree over bark (M^3).

Pulpwood	Boxwood	Sawwod
0.124–0.224	0.225–0.424	0.425–1.0 and over
20.30	19.6	25.29

Source: Forest Service Annual report (2007).

largely due to the combined effect of imports and the substantial amount of domestic produce coming onto the market. In determining the net price £10 must be deducted to allow for the cost of felling and extraction. Then net prices become £10.30 for pulpwood, £9.60 for boxwood and £15.30 for sawwood. Based upon these figures the annual net benefits (revenue minus cost) were found in terms of wood production (Column 2 of Table 4). In this it is assumed that there will be no change in wood prices over the period of rotation length. The net present value of this investment with uniform 3.5% Treasury discount rate yielding a negative figure meaning that the project is not worth while (the internal rate of return turns out to be 2%).

Most scientists believe in the importance of managing the emissions of greenhouse gases as a mechanism for combatting global warming. The Kyoto Protocol includes the reduction in the consumption of fossil fuels and options involving carbon sequestration through forestry activities. Article 3.3. of the Protocol states that "The net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each Party included in Annex I", (United Nations Framework Convention on Climate Change, 1997). That is to say the Kyoto protocol gives carbon credits for newly created forests which can be traded on the open carbon market.

Carbon sequestration is about capturing CO2 from the atmosphere through biological, chemical and physical process for the mitigation of global warming. CO2 may be arrested as a pure by-product in process related to petrolium refining or from flue gasses from power stations. In forestry it involves planting or replanting of trees on land to transfer carbon dioxide from the atmosphere to new biomass. Dewar and Channel (1991) estimate that since 1950s 52% of carbon sequestration in Ireland came from from the trees, 38% from the soil and the rest from the products and litter.

Carbon sequestration as part of the Kyoto Protocol has become an important issue and thus forestry authorities in the British Isles are trying to develop and improve integrated carbon accounting systems designed to provide confidence in estimates. In a recent article Johnson (2009) contends that assumptions made about carbon sequestration are, sometimes, unrealistic. In particular he challenges the current carbon footprint calculations by the World Business Council for Sustainable Development and the World Resource Institute when they assume that biomass combustion is neutral and thus excluded from footprints. Robust research shows that biomass fuel is often not carbon neutral but is positive compared with fossil fuel. Of course, unrealistic assumptions about carbon sequestration could be damaging for Kyoto credits as well as in other estimates.

Carbon capture figures for our stand are estimated on the basis of the work done by Matthews (1991), Forestry Commission (2003) and Galagher et al. (2004) and they are shown in the third column of Table 4. These figures show that in our even aged stand the rate of carbon accumulation is low during the early part of the investment but it increases during the full rigour period in the second half of the rotation (years 17–20). It levels off as we get closer to the felling age. Incremental annual CO2 storage in the stand falls to 120 tons in year 30, same as in year 11.

Table 4
Carbon storage and discounted total net benefits of the project by using the green book rate and environmentally revised discount rates.

Year	Net wood benefits	Incremental CO2 storage tons	Annual incremental CO2 benefits, £	Discounted net benefits using Green Book rate of 3.5% throughout, £	Discounted net benefits using Green Book rate of 3.5% for timber and 1.5% for CO2 benefits, £
0	−29,450	0	0–29	450	−29,450
1	−10,450	0	0	−10,097	−10,097
2	−2850	30	387	−2299	−2277
3	−1900	30	387	−1365	−1332
4	−1900	30	387	−1318	−1276
5	−1900	30	387	−1274	−1222
6	−1900	60	774	−916	−794
7	−1900	90	1161	−581	−372
8	−1900	90	1161	−561	−327
9	−1900	90	1161	−542	−284
10	−1900	90	1161	−524	−242
11	−1900	120	1548	−241	164
12	−1900	120	1548	−233	201
13	−1900	150	1935	22	599
14	−1900	150	1935	22	631
15	−1900	150	1	1935	21
16	−1900	150	1935	20	691
17	−1900	210	2709	666	1786
18	−1900	220	2838	436	1454
19	−1900	220	2838	18	772
20	−1900	220	2838	18	796
21	−1900	200	2580	17	820
22	−1900	200	2580	16	843
23	−1900	150	1935	16	864
24	−1900	150	1935	15	885
25	−1900	150	1935	15	904
26	−1900	150	1935	14	923
27	−1900	120	1548	14	941
28	−1900	120	1548	−134	621
29	−1900	120	1548	−16,945	−16,176
30	175,155	120	1548	62,760	62,760
Total	36,505	3730	48,117	−27,323	7141

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Carbon benefits based upon the price of £12.90 per tonne of carbon in 2006, an average estimated by JC Consulting (2007) which are in the fourth column of the table. These are real environmental benefits and thus must be taken into account in cost benefit analysis of forestry projects, column 4. Now we have two sets of benefits; timber values and carbon sequestration benefits. Summing these benefits up and then discounting them by using the full British rate of 3.5% (column 5) gives a negative net present value of 27 323, meaning that the project fails. That is, when timber and carbon sequestration benefits discounted at the same rate the project becomes unviable.

In the last column of Table 4, however, timber benefits are discounted by using the Treasury rate of 3.5% but the environmental benefits, carbon sequestration, are discounted at 1.5%. In this case the net present value yields a positive figure of 7141 which makes the project economically viable. Once again carbon sequestration benefits are discounted at a lower rate because 2% in the British figure stems from the economic growth which, in fact, undermines the environmental quality, also a part of human well-being. There seems to be no rationale for discounting the environmental improvement part of this project by the economic growth rate that punishes the environment.

In March 2006 Agriculture Minister Jeff Rooker announced his vision for the future of forestry in Northern Ireland in a policy entitled "A Strategy for Sustainability and Growth". In this the Minister emphasised that development of forests and woods are important to the people of Northern Ireland and the government strategy will create a vision for forest expansion and sustainable forest management that will ensure the creation of a lasting legacy to future generations. Sustainable management entails meeting Ulster's current needs for wood production and economic activity, public access and environmental protection while at the same time safeguarding the resource for future generation. The Minister argued that in the long term (not specified) the amount of forests should be doubled. Unfortunately, in 2007 forested area in Ulster stood at about 80,000 ha as opposed to the year 2000 target figure of 120,000 ha. As this paper demonstrates when a policy is established to discount environmental benefits of afforestation projects differently from other benefits then such projects will gain priority and in the public sector leading to meeting target rates established by the government.

5. Conclusion

With conventional discounting environmental impacts are to a large extent submerged in a single net present cost or benefit figure that is reported to decision makers. In forestry, for example, lumping environmental and timber benefits together and discounting them at the same rate would be detrimental to many projects. Dual discounting, on the other hand, distinguishes between projects with similar net present costs or values but different environmental impacts and thus more environmentally friendly projects should be preferred to less environmentally friendly projects. The result with dual discounting will be to present decision makers with separate and different information about environmental impacts which will contribute to a new dual focus on the key resource use issues of efficiency and sustainability.

The issue of determining the optimum felling age for forestry investments has been a subject of intense debate in economic literature. Nobel Prize winning economist Paul Samuelson (1976) argued that many prominent economists prescribed less than perfect solutions when they tried to maximise wood production, maximum sustainable yield, as opposed to revenue maximisation, optimum sustainable yield. For a comprehensive review see Kula (1997). That was well before the carbon sequestration benefits of forestry, recognised by the Kyoto Protocol. Since these benefits become much more prominent well into the rotation the gap between maximum and optimum sustainable yields is bound to diminish. To what extend this will happen requires research for different species of forest in different region. Generally speaking, with carbon sequestration values added onto the benefit estimates resulting harvesting ages based upon optimum sustainable yield may become longer than the ones that are currently practiced.

Separate and different discounting of environmental impacts is primarily about informing and educating the "software" of environmental governance, i.e. the decision makers, who are ultimately Ministers. What is important is what informs decision makers, it is less important whether policy is implemented by regulation or by programme and project selection. It contributes to that which should inform policy, i.e. transparency and the best available model. International consensus is built on developing a common understanding of a common problem. Separate and different discounting of environmental impacts can contribute to this common understanding. Sustainable development guiding principles have already been developed at a UK level and for the devolved administrations in Northern Ireland, Scotland and Wales. Work is underway to develop sustainable development indicators. These high level guiding principles can help compensate for a key weakness of cost-benefit analysis, namely that it is a tool of marginal analysis. Furthermore, inclusion of carbon benefits will boost the economic viability of forestry projects paving the way to the plantation of more trees.

No tool, not even one as long established and as widely accepted as is discounting, should be used blindly. The economic theory of discounting finds one of its earliest, and certainly one of its most definitive, expositions in the work of Alfred Marshall. Yet Marshall's work on discounting should not be taken out of context. He also wrote of the annuity fixed by nature, that the "life of society is something more than the sum of the lives of its individual members and that the ultimate resolve must always lie with conscience and common sense". Kenneth Boulding (1966) argues that growth creates form but form limits growth which sums up our experience with the economic tool that is discounting. Nineteenth century growth in economic thought, in particular Alfred Marshall's neo-classical economics, gave form to discounting; but that form, the tried and trusted form that is conventional discounting, is now limiting the necessary evolutionary growth in economic thought to meet the challenge of sustainability. Lower discounting for environmental impacts should contribute to the new dual focus on both efficiency and sustainability, and thereby also be a significant step towards sustainable cost-benefit analysis.

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