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Discounting the future

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Introduction

Discounting is probably one of the most disputed issues in ecological economics. Current human activities may cause immediate and long-term environmental damages. Discounting, the usual procedure to give a present value to financial flows occurring in the future, seems to give outrageously low values to future damages, and thus, to "play against" the environment and future generations. On the other hand, low discount rates would imply more sacrifices for present generations, although future generations may be richer. And using various discount rates would lead to inefficiencies in selecting investment policies.

There might be two different, but not unrelated, ways out of this dilemma. One may use decreasing discount rates, in particular to deal with uncertainty on future economic growth. One may also, in light of this discussion, assign non substitutable, non reproducible environmental assets a value growing over time at a pace close to the discount rate itself.

The first section introduces discounting and its rationale. The second challenges the view that discounting might be considered, by itself, "unfair" to future generations. The third section shows that the rate of return on investment cannot be higher than the growth rate of the economy for ever. The fourth section reviews how uncertainty on future economic growth rates affects discount rates. The fifth section discusses the "reverse side" of the discounting issue – that of valuing environmental amenities and assets, as neither reproducible nor substitutable assets. The concluding section summarises and links the various arguments, and then draws a few more general lessons from this analysis.

1. Why discounting?

Discounting is a procedure that allows computing the present value of financial flows that will take place in the future. Discounting is needed in cost benefit analysis to calculate net present values – the key criterion for investments. At a more global level, discount rates relate to investment rates: the lower the former, the higher the latter. As such, discounting reflects the balance between present and future well being.

As Irving Fisher established in 1930, discounting reflects both the productive nature of our economies and individual or society's "impatience". The latter itself combines pure time preference and expectation of rising per capita income of decreasing marginal utility. In a world without market failure, tax and risk, one would write $i = r = \rho + \theta.g$ where i is the rate of return on investment, r the social rate of time preference, ρ the pure time preference, θ the absolute value of the income-elasticity of marginal utility of income, and g the per capita growth rate. When taxes introduce a hedge between the social rate of time preference and the rate of return on investment, determining the appropriate discount rate is a complicated and somewhat controversial issue reflecting diverging views on the role of public and private investments in the economy. As riskier investments generally produce higher market interest rates, risk is also an element to consider when defining a discount rate from market interest rates; however, investments should not be selected from their "rates for return" – but from computing their "net present values" using one only discount rate, after considering all possible outcomes weighted by their probabilities of occurrence. We will leave aside these discussions here (see, e.g., Lind *et al.*, 1982), simply noting that i is always considered as a maximum value for r.

We generally discount future amounts of money using constant discount rates, that is, discount factors of the form $1/(1+r)^t$. This is usually referred to as "exponential discounting". As a result, values in the far future tend to have present values close to nothing. For example, damages of €1 million 100 years hence have a present value of €52,000 at a discount rate of 3% annually, and only €455 at a discount rate of 8%. At his latter rate, the sum of an infinite series of discounted yearly fluxes of 1€ equals 12,5€ - and the first forty years account for more than 12€: what follows is essentially negligible.

2. Is discounting unfair to future generations?

One often made argument is that discounting would be "unethical": people's welfare should not be valued less simply because they live at a different time. The pure time preference, or "utility discounting", would be acceptable as far as it reflects individuals' choices – but not in an intergenerational context (see, e.g., Pigou, 1920; Ramsey, 1928; Harrod, 1948 or even Solow, 1992). Thus, for example, Cline (1992) sets the pure time preference to zero. This allows him to use a low discount rate (2%) in computing the net present value of future damages arising from climate change. As a result, more near term mitigation action is warranted.

The shortcomings of this reasoning might be that in the same intergenerational context, the other component of the discount rate would have to be looked at differently as well. Can it be the mere product of the per capita growth rate times the "income elasticity of the marginal utility of income" – while the income in question is not that of the same individuals? If future generations are richer than the current one, there is little justification of depriving additional money from the current, poorest generation in order to increase wealth of subsequent ones. In other words, if one chooses to be ethically "prescriptive" (Arrow *et al.*, 1995) on pure time preference, consistency requires a similar approach – but with opposite results – on the "wealth effect". For example, a Rawlsian maximin approach would give an infinite value to the coefficient θ - and hence, to the discount rate – even though pure time preference would be prohibited. Naturally, such discount rate could only apply to investments having only intergenerational effects (but note this may well be the case of climate change mitigating investments, with very small near term effects). More generally, discounting the future does not appear unethical, for if discounting utility of future generations might be, discounting their consumption might not be – provided per capita economic growth is real. As Baumol (1968, p. 800) wrote, *"a redistribution to provide more for the future may be described as a Robin Hood activity stood on his head – it takes from the poor to give to the rich. Average real per capita income a century hence is likely to be a sizeable multiple of its present value. Why should I give up part of my income to help support someone else with an income several* *times my own?"* In this sense, an ethical appraisal of discounting does not conflict with Fisher's lesson: the productive nature of the economy legitimates discounting[1].

It is possible, however, that people receiving future benefits are not richer than those incurring current costs. This may be the case of climate change: those more likely to reduce greenhouse gas emissions today are people in industrialised countries, while those more likely to benefit from reduced emissions in the future are the poor in developing countries lacking resources to adapting to climate change. And – given the depth of the North South divide, developing country people in the future may well be still poorer than current developed country people. Therefore, nothing would justify positively discounting future costs of climate change: we have ruled out pure time preference and wealth effect would not apply either. However, does this mean that in case of climate change one should use a zero or even negative discount rate, as some have argued (see, e.g., Azar & Sterner, 1996)? Probably not: it would be more efficient to spend more money today in development projects to help developing country people to achieve faster economic development. Climate change mitigation investments should thus compete with other development projects, using the discount rates used for all projects in developing countries – usually higher, not lower, than those used in developed countries given the scarcity of capital.

3. Opportunity cost

Discounting is not "unfair" per se, provided future generations are indeed richer – and precisely, discounting helps ensuring the greater wealth of future generation in taking part in cost-benefit analysis used to select effective investments. This is the "opportunity cost" argument for discounting – and the World Bank response to Cline (Birdsall & Steer, 1993).

Rabl (1996) points out a difficulty here: the rate of return on marginal investment cannot be durably higher than the growth rate of the economy. This would lead to paradoxes: any investment, whatever small, but with a return rate greater than the growth rate of the economy, would after enough time has elapsed, have an output greater than the whole economy, "clearly an absurdity". Over long periods of time,

[1] A related argument is the "isolation paradox" exposed by Sen (1961, 1967) and Marglin (1963) and taken up by Broome (1992) in the context of climate change. Savings for future generations are partly public goods, likely to be undersupplied by free markets. For a discussion, see Philibert (1998).

compound interest rates give strange results. One gram of gold saved with an interest rate of 3,25% when Jesus was born would be worth today 6,000 billions of billions of tonnes of gold – planet Earth's weight (Crozet, 1994). This does not prevent marginal rates of return on investments to be higher, at any time, than the economy growth rate; but the output of these investments are largely consumed, and only in part reinvested.

Cost benefit analysis suppose that possible beneficiaries of the investment or policy under scrutiny could "compensate" any possible losers. Discounting future damages (for example resulting from climate change) that could be avoided thanks to some investment (e.g. emissions mitigation) rests on the implicit hypothesis that alternative investments would have an equivalent rate of return. However, rates of return higher than GDP growth rates cannot be sustained for ever. Thus, discount rates in the long run must come close to the growth rate of the economy. Rabl suggests a two-tier discounting procedure, using the conventional rate for a short period (30 years, for example) and then a reduced rate for intergenerational effects, equal to the rate of long term economic growth.

The first problem of that proposal is "time inconsistency", as Solow (1999) notes after Ramsey (1928). The value of a capital in 2030, equal to the discounted sum of its future net benefits, will not be the same whether it is calculated in 2000 or in 2030. A second problem is that it considers future growth rates exogenous. Such an assumption would not hold in the cases he considers, i.e. when the investment at stake – or its future consequences – are not "marginal" anymore. If an investment were made today with a high rate of return, and the proceeds continuously reinvested with the same high rate of return, a likely consequence would be to accelerate economic growth. Conversely, if some future damage from any decision made today were so high that no credible investment could compensate future generation, this damage would also possibly slow economic growth, and even more likely the utility enjoyed by future generations (this distinction may be relevant since many damages, e.g. car accidents, do indirectly increase GDP while reducing utility).

This leads, however, to consider another possible motive for using declining discount rates: the view that the economy itself is limited by our planet's "carrying capacity". Sterner (1994) suggests that economic growth may follow a logistic curve leading to a steady state in the long run – say, ten times current GDP in 250 years. Rates of return on investment would thus decrease over time. Growth rate would start at 3% then level off. Discount factors would be close to exponential discount factors in the first decades but then progressively depart from them, being kept forever to 1/10 after 250 years.

Such decreasing discount rate may not be time inconsistent: the value of a capital in 2030 would be the same if computed today or in 2030 if – as would be implied by the logic of Sterner's proposal – the discount rate used in 2030 starts at a lower level than today.

The view that the physical limits of the planet put a ceiling to the economy is, however, highly controversial. As writes Weitzman (1999), *"technical progress, which is just a synonym for human ingenuity or inventiveness, prevents capital productivity from falling over time".* As our economy dematerialises, it may not be limited by the Earth's limits. The "carrying capacity" is usually defined as the maximum number of a species that can be supported indefinitely by a particular habitat – not their wealth.

4. Uncertainties

Even if we do not believe that our economy will be limited by the carrying capacity of the planet, can we entirely rule out that possibility? How sure are we that some environmental damages we are currently creating will not harm future growth? More generally, future growth rates and future rates of return on investment are uncertain, as is almost everything about the future. But how do these uncertainties affect discount rates?

Let us imagine two states of the economy one hundred years hence. One corresponds to a slow growth, the other to high growth. The former is associated with a low discount rate, the latter with a high discount rate. Let us consider them as equally probable. Let us now consider the present value of a sum of money at that time. It should be the weight average of the net present values computed using these two discount rates. However, as noted by Weitzman (1998), this average is clearly dominated by the value computed using the low discount rate (and is well above the NPV that would be computed using an average of discount rates). As a result, if future growth is uncertain, the discount rate should come progressively closer to the lowest possible discount rate. High discount rates simply tend to discard situations that would precisely justify them.

A numerical example might help. Imagine growth rate is uncertain – from 1% to 3% per year. 100 euros 100 years hence are valued today 5 to 37 € (for sake of simplicity, we use only constant discount rate equals to the economy growth rate). Using (improperly) an average rate of 2%, we would value this sum 14€. If we suppose that the two states of the world resulting from yearly growth rates of 1% and 3% have equal probabilities of 50%, the average net present value comes to 21,087. This would have been the result of discounting with about 1,6% – not 2% discount rate. More striking is what happens now, if one continues the thought experiment for one more year. The average net present value (with the same equal probabilities) after 101 years is now 20,828. The expected value thus declines by 1,25%.

Newell & Pizer (2002) propose a more sophisticated treatment of uncertain discount rates. Their starting point is not the future growth rates, but rates of return on investments, based on observed risk-free market rates. They compute over long periods of time yearly benefits accruing from climate change mitigation. Results obtained using fixed discount rates are then compared with results obtained with uncertain discount rates set at the same initial level. Because *"unexpectedly low discount rates raise valuations by a much larger amount than unexpectedly high discount rates reduce them",* uncertainty always raises valuation of future benefits. Newell & Pizer find that effective discount rates should decline in the future to take uncertainty into account – in agreement with Weizman (1999).

Using declining discount rates because of uncertainty would not be time inconsistent, although the value of a given capital in 2030 as computed in 2000 may take a lower value in 2030. This value may legitimately change with the passage of time, for the latter progressively reduces the uncertainty on future growth rates (Philibert, 1999). In other words, behaviour that would be time-inconsistent in a deterministic world is legitimate state-contingent behaviour in a world with uncertain discount rates (Newell & Pizer, 2002).

5. Substitutability, not discounting, is the issue

There seems to be a number of arguments for using declining long term discount rates. This is not, however, the end of the story. Thinking about discounting leads us to think deeper about valuation of the environment in the future.

As wrote Krutilla (1967), *“natural environments will represent irreplaceable assets of appreciating value with the passage of time”.* How should this value grow over time? An extensive literature has looked at this point by trying to assess people’s willingness-to-pay for future environmental assets, with no clear answer emerging (see, e.g., Fisher & Krutilla, 1974 & 1975; Hanley & Spash, 1993; Desaigues & Point, 1993).

If, however, one considers that the real justification for discounting is the productivity of the economy rather than individual or social preferences, then one may link the valuation of environmental assets to the discount rate. Referring implicitly to the “Hotelling” rule (1931) regarding optimal use of non-renewable natural resources, Boiteux (1976) writes that *“All economic models show that in a growing economy the prices of resources available in strictly limited quantities should be assumed to grow at an annual rate that is at least equal to the discount rate (…).* In his view, this rate could be even greater than the discount rate as a result of a growing preference for the environment. That hypothesis is not needed, according to this framework, to set the rhythm of increase in value equal to the discount rate: this only rests on the non reproducible nature of Nature. As a result, writes Boiteux, *“In the long run, the discounting process clears everything that is of secondary importance because it can be controlled by human proficiency, to stress what is essential: i.e. whatever is intrinsically scarce and cannot be reproduced.”*

For Neumayer (1999a) also, taking example from climate change, *“discounting is not the issue, but substitutability is”.* Valuing environmental assets in monetary terms rests on the assumption that environmental and other values are substitutable for each other. Such assumption is at the heart of the *“weak sustainability”* paradigm, but is unacceptable for tenants of the *“strong sustainability”* paradigm, which states that natural capital as such should be kept intact. However, neither paradigm of sustainability can be falsified under scientific standard (Neumayer, 1999b).

While Krutilla's approach may still be qualified as referring to the "*weak sustainability*" paradigm, the Boiteux proposal is more ambiguous. It does not reject monetary valuation. However, giving any environmental asset a value growing over time at the pace of discount rate, it leads to the paradox discussed by Rabl: over time, this asset will be valued more than the whole GDP. Weak from the onset, but rather strong over time indeed! One consequence is that the destruction of an environmental asset (e.g., specie extinction) would have the same present cost whenever it happens. The advantage is that discounting – at whatever constant or decreasing, high or low rate – would not anymore eliminate environmental damages from economic analyses. The downside is that delaying damages would have no value. This, somehow, does not take into account the fundamental uncertainty about future. Delaying irreversible damages always leave open the possibility that they will not happen, or be delayed for much longer than expected.

This may be one reason to state that non-reproducible nor substitutable environmental assets should be given a value growing over time at a rate close to the discount rate – but not equal to it. As a result, environmental assets would be submitted to what Krutilla & Fisher (1975) called "effective discounting" – but at a very low rate, what could be called "slow effective discounting".

More deeply, no effective discounting would give the current generation an unlimited responsibility with respect to future generations – and this may be the problem with (too) strong sustainability. As writes Ricœur (1995), *"Completely ignoring the side effects of the action would make it dishonest, but unlimited responsibility would make it impossible. It is indeed a sign of human limitations that the disparity between the desired effects and the innumerable consequences of the action is itself unmanageable, and calls upon the practical wisdom gained throughout the history of earlier trade-offs. A happy medium must be found between escaping from the responsibility for consequences and the inflation of infinite responsibility".*

How would "slow effective discounting" of environmental assets be interpreted in terms of sustainability? Clearly it belongs to the weak sustainability paradigm. However, it does not take for negligible a damage to the environment simply because it will happen in the future as a result of current action. As such, it helps ensuring that welfare will not decline over time – the requirement that weak sustainability adds to neo-classical economics. It makes the weak sustainability paradigm stronger – its exact strength depending on how much the environmental assets are valued today.

6. Conclusion

Simple arithmetic suggests that discount rates higher than economic growth are not sustainable over the long. This combines with the inherent uncertainties on future economic growth and rate of return to suggest that one may use declining discount rates.

As far as the environment is concerned, the most important point is to recall that environmental assets that are not substitutable nor reproducible should be given a value growing over time at a pace close to the discount rate. This would, as a result, give greater net present values to future damages arising to the environment and, for example, justify greater immediate greenhouse gas mitigation efforts.

Another likely consequence may be to reinforce the arguments for declining discount rates. Future environmental damages may, in this framework, become so large that they would likely shrink future welfare. If they may not fully justify an economic interpretation of the "carrying capacity" of the Planet, they would at least stress the uncertainty on future economic growth – with more or less the same results for discounting.

A third important consequence arising from the ever-growing valuation of environmental assets is that they will likely dominate any assessment of the long-term consequences of current policies. But environmental assets are usually the hardest to value, for they are only marginally present on current markets. As a result, present value of future environmental damage increases, but the uncertainty on these damages increases as well.

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References

Arrow, K.J., W.R. Cline, K.-G. Maler, M. Munasinghe, R. Squitieri & J.E. Stiglitz, 1996, Intertemporal Equity, Discounting, and Economic Efficiency, in Bruce J.P.,

H. Lee & E.F. Haites (Eds), *Climate Change 1995 - Economic and Social Dimensions of Climate Change*, Cambridge University Press, UK, 125-144

Baumol, W.J., 1968, On the social rate of discount, *American Economic Review*, **58** (4), 788-802

Birdsall, L. N. & A. Steer, 1993, Act Now on Global Warming - But Don't Cook the Book, *Finance & Development*, **30**(1): 6-8

Boiteux, M., 1976, A propos de la 'Critique de la théorie de l'actualisation', *Revue d'économie Politique*, Septembre-Octobre

Broome, J., 1992, *Counting the cost of Global Warming*, White Horse Press, Cambridge, U.K.

Cline, W.R., 1992, *The Economics of Global Warming*, Institute of International Affairs, Washington D.C.

Crozet,Y., 1994, *Inflation ou déflation ? Actualité d'un dilemme*, Nathan, Paris

Desaigues, B. & P. Point, 1993, *Économie du patrimoine naturel*, Economica, Paris

Fisher, I., 1930, 1954, *The Theory of Interest*, Kelley & Millman, New York, N.Y.

Fisher, A.C. & J.V. Krutilla, 1974, Valuing Long Run Ecological Consequences and Irreversibilities, *Journal of environmental Economics and Management*, **1** (August)

Fisher, A.C. & J.V. Krutilla, 1975, Resource Conservation, Environmental Preservation, and the Rate of Discount, *Quarterly Journal of Economics*, August, 358-370

Hanley, N. & C.L. Spash, 1993, *Cost-Benefit Analysis and the Environment*, Edward Elgar Publishing Limited, Hants, GB

Harrod, R.F., 1948, *Towards a Dynamic Economics*, Macmillan

Hotelling, H., 1931, The Economics of exhaustible Resources, *Journal of Political Economy*, **39**, (2)

Krutilla, J.V., 1967, Conservation reconsidered, *American Economy Review*, **57**, 777-786

Lind, R.C., Arrow K.J., Corey G.R., Dasgupta P., Sen A.K., Stauffer T., Stiglitz J.E., Stockfisch J.A., Wilson R. (eds) (1982) - *Discounting for Time and Risk in*

Energy Policy, John Hopkins University Press for Resources for the Future, Baltimore, MD

Marglin, S.A., 1963, The social rate of discount and the optimal rate of investment, *Quarterly Journal of Economics*, **77**, 95-111

Neumayer, E., 1999a, Global warming: discounting is not the issue, but substituability is, *Energy Policy* **27**: 33-43

Neumayer, E., 1999b, *Weak versus Strong Sustainability: Exploring the Limits of Two Opposing Paradigms.* Cheltenham and Northampton. Edwar Elgar publishing

Newell, R. & W. Pizer, 2001, *Discounting the benefits of climate change mitigation: How much do uncertain rates increase valuations?* Pew Center on Global Climate Change, Washington D.C.

Nordhaus, W.D., 1999, Discounting and Public Policies That Affect the Distant Future, in Portney P.R. & J.P. Weyant (Eds), *Discounting and intergenerational Equity*, Resources for the Future, Washington D.C., April, 145-162

Philibert, C., 1998, *The Isolation Paradox and the Climate Change*, mimeo, http://philibert.cedric.free.fr/Downloads/isolat.pdf

Philibert, C., 1999, The economics of climate change and the theory of discounting, *Energy Policy* **27**: 913-929

Pigou, A.C., 1920, 1960, *The Economics of Welfare*, Fourth Edition, MacMillan, London

Rabl, A., 1996, Discounting of long term costs: What would future generations prefer us to do? *Ecological Economics*, **17**, 137-145

Ramsey, F., 1928, A mathematical theory of saving, *Economic Journal*, **38**, 543-559

Rawls, J., 1971, *A Theory of Justice,* The Belknap Press of Harvard University Press, Cambridge, MA

Ricœur, P., 1995, *Le juste*, Éditions Esprit, Paris

Sen, A. K., 1961, On optimising the rate of saving, *Economic Journal*, **71**, 479-496

Sen, A.K., 1967, Isolation, Assurance, and the Social Rate of Discount, *Quarterly Journal of Economics*, **81**, 112-124

Solow, R.M., 1992, *An almost practical step toward sustainability*, Resources for the Futures, October 8

Solow, R.M., 1999, Foreword, in Portney P.R. & J.P. Weyant (Eds), *Discounting and intergenerational Equity*, Resources for the Future, Washington D.C., April, vii-ix

Sterner, T., 1994, Discounting in a World of limited Growth, *Environmental and Resource Economics*, **4,** 527-534

Weitzman, M.L., 1998, *Why the Far-Distant Future should be Discounted at its Lowest Possible Rate*, Journal of Environmental Economics and Management, **36**, 201-208

Weitzman, M.L., 1999, Just Keep Discounting, But… in Portney P.R., Weyant J.P. (Eds), *Discounting and intergenerational Equity*, Resources for the Future, Washington D.C., April, 23-29