19. Discounting and climate change

The rationale for discounting

Discounting allows us to compute the present value of financial flows that will take place in the future. Discounting is needed in benefit–cost 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 (1930) established, discounting reflects both the productive nature of our economies and an individual's or society's impatience. In a world without market failure, tax, and risk, the return on investment would be equal to the social rate of time preference, which accordingly is the sum of the pure rate of time preference and the product of the growth rate of per capita income multiplied by the elasticity of the marginal utility of income (Ramsey, 1928), sometimes named the 'wealth effect'.

We generally discount future amounts of money using a discount rate that is constant through time, leading to 'exponential discounting'. As a result, values in the far-distant future are reduced to very low levels. For example, damages of €1 million in 100 years have a present value of €52 000 at a discount rate of 3 per cent (annually). At a discount rate of 8 per cent, their present value is only €455, and the present value of the sum of an infinite series of discounted annual amounts of €1 equals €12.5. While the first 40 years account for more than €12; values beyond this point are negligible.

The dispute over the Stern Review

One argument often made is that discounting is 'unethical': people's welfare should not be valued less simply because they live at a different time. Pure time preference would be acceptable as far as it reflects individuals' choices – but not in an intergenerational context.

In his influential review of the economics of climate change, Nicholas Stern (2006) put the rate of pure time preference at 0.1 (to account for the possibility of extinction of the human species), and the elasticity of income at 1. Assuming a per capita growth rate of 1.3 per cent, Stern gets a discount rate of 1.4 per cent, leading to high present values of future climate change damages, and therefore justifying strong climate change mitigation action.

The economists who disagreed with the conclusions of the Stern Review focused their criticism on its low rate of discount. For example, Nordhaus (2007) noted that this number does not match the observed market rates of interest. Defenders of the conclusions of the Stern Review often did not support Stern's arguments relative to the discount rate but instead referred to the uncertainty on the future states of the word, and to the relative evolution of prices resulting from the non-substitutability of natural assets. These are the main points discussed here.

As Weitzman (2007, p. 703) expressed it in a comment on the Stern Review, 'spending money to slow global warming should perhaps not be conceptualised primarily as being about consumption smoothing as much as being about how much insurance to buy to offset the small chance of a ruinous catastrophe that is difficult to compensate by ordinary savings'. Today this 'chance' does not appear to be that small – but this only increases the relevance of Weitzman's vision.

Discounting is not unfair to future generations

Why is Stern's argument on discounting not fully convincing? Setting the pure time preference at or very close to 0 on ethical grounds questions the other component of the discount rate, the 'wealth effect'. If future generations are richer than the current one, there is little justification of depriving additional money from the current, relatively poor generation to increase wealth of subsequent ones. In other words, if one chooses to be ethically prescriptive on pure time preference and set it at or near 0, consistency requires us to use a similar approach, but with opposite results, in relation to the wealth effect.

Discounting the future does not appear unethical, for if discounting the 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.

It is possible, however, that people receiving future benefits are not better off than those incurring current costs. For example, this might apply in 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 for adapting to climate change. Given the extent of disparity between developed and developing counties, people from developing countries in the future may well still be poorer than current people in developed countries.

However, does this mean that in case of climate change one should use a zero or even negative discount rate, as some have argued? Probably not. Funds spent in climate change mitigation have opportunity costs. It may be more efficient to devote the resources to development projects to help people in developing countries to achieve faster economic development. Climate change mitigation investments should thus compete with other development projects, using discount rates that are appropriate for projects in developing countries. Given the scarcity of capital, these are usually higher, not lower, than rates used in developed countries.

Discounting per se is not unfair, provided future generations are effectively richer. Indeed, discounting helps to ensure the greater wealth of future generations by allowing them to select efficient investments. Discounting may also have an environmental upside, for in its absence, or if we used discount rates that are too low, many more investments would be warranted, which would increase the pressure on natural resources and ecosystems with little additional benefit for the populations.

The paradoxes of long-term discounting

Rabl (1996) points out a difficulty in the use of standard discount rates over the very long term: 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, however small, but with a return rate greater than the growth rate of the economy would have, after enough time has elapsed, an output greater than the whole economy: clearly an absurdity. Over long periods of time, compound interest rates give dramatic results. One gram of gold saved with an interest rate of 3.25 per cent when Jesus was born would be worth today 6000 billion tonnes of gold – the weight of planet Earth. This does not mean that marginal rates of return on investments cannot be higher, at any time, than the growth rate of the economy; part of the explanation for this is that the output of these investments is largely consumed, and only in part reinvested.

Benefit–cost analysis supposes that possible beneficiaries of the investment or policy under scrutiny could, in principle, compensate any losers. Discounting future damages (e.g. 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 a rate of return at least equal to the discount rate used. However, rates of return higher than gross domestic product (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.

One problem with that proposal is time inconsistency, as Solow (1999) notes after Ramsey (1928). Using Rabl's suggested approach, the value of a unit of capital in 2030, equal to the discounted sum of its future net benefits, will differ depending on whether it is calculated in 2000 or in 2030.

Discounting uncertain futures

Can we be sure of future growth rates of per capita welfare, and can we be sure that the environmental damages we are currently creating will not harm future growth? Of course not. The dramatic collapse of biodiversity and climate change strongly suggest the opposite. Hence the discount rate to give a present value of future environmental damages, and thus determine the proper level of investment in mitigating them, cannot be set exogenously.

Let us imagine two states of the economy 100 years hence. One corresponds to slow growth (for which a low discount rate is appropriate), the other to high growth (leading to a high discount rate). Let us consider them as equally probable. Let us now consider the present value of a sum of money from 100 years hence. Using the standard approach of decision theory, it should be the weighted average of the net present values computed using the two discount rates. However, as noted by Weitzman (1998), this average is dominated by the value computed using the low discount rate. In the high discount rate scenario, the present value is discounted to a trivially small level. As a result, if future growth is uncertain, the discount rate should come progressively closer to the 'lowest possible' discount rate. A risk-averse attitude would further stress this argument.

Newell and Pizer (2003) brought this insight to their study of uncertain discount rates. Their starting point was rates of return on investments based on observed risk-free market rates. Over long periods of time they computed yearly benefits accruing from climate change mitigation. Results obtained using uncertain discount rates were compared with results obtained using a fixed discount rate set at the expected value of the uncertain distribution.

Because unexpectedly low discount rates raise valuations by a much larger amount than unexpectedly high discount rates reduce them, the uncertainty about the discount rate always raises the valuation of future benefits. Newell and Pizer (2003) concluded that effective discount rates should progressively decline.

Using declining discount rates because of uncertainty would not be time inconsistent, although the value of a given unit of 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 and Pizer, 2003).

An expert panel gathered in September 2011 by Resources for the Future revealed some consensus around this conception that included critics of the Stern Review such as Richard Tol and William Nordhaus together with supporters such as Kenneth Arrow, Christian Gollier, Robert Pindyck, Thomas Sterner, Martin Weitzman, and others (Arrow et al., 2012).

Relative prices and discounting

As Krutilla (1967, p. 783) wrote, 'natural environments will represent irreplaceable assets of appreciating value with the passage of time'. How should this value grow over time? Referring implicitly to the Hotelling (1931) rule regarding the optimal use of non-renewable natural resources, Boiteux (1976, p. 830) 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'.

As a result, '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' (Boiteux, 1976, p. 831). In other words, if correctly valued (given values growing over time), the natural environment will not be disadvantaged by discounting because discounting progressively erases the values of the fruits of one's labour, but not the irreplaceable environmental assets.

However, giving any environmental asset a value growing over time at the pace of the discount rate eventually leads to the paradox discussed by Rabl: over time, this asset will be valued more highly than the rest of the economy. One consequence is that the destruction of an environmental asset (e.g. extinction of a species) would have the same present cost whenever it happens. And delaying damages would have no value. However, delaying irreversible damages leaves open the possibility that it will not happen due to technical progress or other developments.

Cédric Philibert

The current collapse of biodiversity and wildlife – sometimes termed the 'sixth extinction' – is now recognised as a major environmental challenge; however, species do not last forever, and the evolution has not begun with industry. In view of this, environmental assets that are neither reproducible nor substitutable should be given a value growing over time at a rate close to, but slightly less than, the discount rate. As a result, environmental assets would be submitted to what Fisher and Krutilla (1975) called 'effective discounting', but at a very low rate, which we might call 'slow effective discounting'.

The lack of effective discounting would give the current generation an unlimited responsibility with respect to future generations. As argued by Ricoeur (1995, p. 68),

> 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.

Other analysts have also underlined the evolution of relative prices. For Neumayer (1999), discounting is not the issue – substitutability is. Valuing environmental assets in monetary terms rests on the assumption that environmental and other values are substitutable for each other. Hoel and Sterner (2007) analyse a conceptual model of the economy consisting of one (conventional) sector which grows 'forever' and another sector (say, 'environmental services') that is constant (or maybe even declining due to pollution). The environmental sector can see its share of the economy grow in value terms, despite becoming physically smaller in comparison to the growing sector due to rising relative prices.

Sterner and Persson (2007) illustrate the implications in the case of climate change. They show that an emission scenario in a case with a high discount rate but in which the increasing relative price of the 'nonmarket' goods is taken into account is rather close to that of the Stern Review.

The uniqueness of discount rates

A single discount rate for all projects makes sense if they are 'small', having no influence on the broad economy: 'the government is able to pool risks' (Arrow and Lind, 1970). Building on the reflexions relative to the uncertainty on economic growth and the impact of projects on that growth, as well as risk aversion, more recent developments take account of the systemic macroeconomic risk, denoted φ (phi), and of the elasticity of the future benefits of a specific project on the per capita GDP, denoted β (beta). In short, the idea is to better valorise projects that induce more resilience to shocks and penalise more projects that increase economic risks.

In France, for example, Emile Quinet (2013) recommended to the French authorities a discount rate, $\rho = r_f + \varphi.\beta$, where r_f) is the riskless discount rate. He also recommended to take $r_f = 2.5$ per cent and $\varphi = 2$ per cent, so that for a project not entailing a deviation of economic growth ($\beta = 1$), the discount rate would be 4.5 per cent.

A panel under the chairmanship of Roger Guesnerie (2021) has revised this recommendation and proposed, for the period 2021 to 2070, $r_f = 1.2$ and $\varphi = 2$ per cent. When β is unknown, it should be considered equal to unity, in which case $\rho = 3.2$ per cent. While the riskless reference rate has been reduced considering low real interest rates and reduced long-term growth potential of the French economy, the risk premium is unchanged.

In practice, Guesnerie, following Quinet, recognises that assessing β project by project can be time and resource consuming, and the idea is instead to use specific βs for project categories. The only βs known today are relative to public projects in transports (1.1 for urban commuters; 1.4 for regional commuters; 1.7 for long-distance travellers; 1.4 for rail freight), and a working group has been tasked to provide values for all the economic sectors. However, it is not entirely clear if and how these refinements will effectively allow project evaluation to better take into account the specifics of individual projects in a given sector, which can have very different long-term consequences, notably for the climate and, more globally, the environment.

Conclusion

As far as the environment is concerned, the most important point put forward here is that environmental assets that are neither substitutable nor reproducible should be given a value growing over time at a pace close to, but slightly less than, the discount rate. This would result in greater net present values for prevention of future environmental damage and, for example, may justify greater greenhouse gas mitigation efforts in the short term.

This reinforces the argument for declining discount real rates based on the uncertainty relative to future growth. Future environmental damages may, in this framework, become so large that they would likely shrink future welfare.

The proposal to grow the valuation of environmental assets over time has another important implication: assessment of the long-term consequences of current policies will likely be dominated by environmental values. But environmental assets are only marginally present on current markets, and thus, their monetary value is often hard to estimate. As a result, the present value of future environmental damage increases, but the uncertainty surrounding its estimation increases. This is a clear limit of the cost–benefit framework in which the discounting procedure is essential. However, as Weitzman (2009, p. 18) concluded his examination of the economics of catastrophic climate change, 'acknowledging more openly the incredible magnitude of the deep structural uncertainties that are involved in climate-change analysis might go a long way toward elevating the level of public discourse about what to do about global warming'.

Cédric Philibert

References

Arrow, K.J., and R.C. Lind (1970), Uncertainty and the evaluation of public investment decisions. *American Economic Review* 60: 364–78.

Arrow, K.J., M.L. Cropper, C. Gollier, B. Groom, G.M. Heal, R.G. Newell, W.D. Nordhaus, et al. (2012, December), *How Should Benefits and Costs Be Discounted in an Intergenerational Context? The Views of an Expert Panel*. Resources for the Future, Discussion Paper 12-53, Washington, D.C.

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

Boiteux, M. (1976), A propos de la 'Critique de la théorie de l'actualisation'. *Revue d'économie Politique* 5: 828–31.

Fisher, A.C., and J.V. Krutilla (1975), Resource conservation, environmental preservation, and the rate of discount. *Quarterly Journal of Economics* 89: 358–70.

Fisher, I. (1930), *The Theory of Interest*. New York: Kelley and Millman.

Guesnerie, R. (Dir.) (2021), *Révision du taux d'actualisaation*. Paris : France Stratégie.

Hoel, M., and T. Sterner (2007), Discounting and relative prices. *Climatic Change* 84: 265–280.

Hotelling, H. (1931), The economics of exhaustible resources. *Journal of Political Economy* 39: 137–75.

Krutilla, J.V. (1967), Conservation reconsidered. *American Economic Review* 57: 777–86.

Neumayer, E. (1999), Global warming: discounting is not the issue, but substitutability is. *Energy Policy* 27: 33–43.

Newell, R.G., and W.A. Pizer (2003), Discounting the distant future: how much do uncertain rates increase valuations? *Journal of Environmental Economics and Management* 46: 52–71.

Nordhaus, W. D. (2007), The Stern review on the economics of climate change. *Journal of Economic Literature* 45: 685–702.

Philibert, C. (1999), The economics of climate change and the theory of discounting. *Energy Policy* 27: 913–29.

Quinet, É. (2013), *L'évaluation socioéconomique des investissements publics*. Paris: Commissariat Général à la Stratégie et à la Prospective.

Rabl, A. (1996), Discounting of long-term costs: what would future generations prefer us to do? *Ecological Economics* 17: 137–45.

Ramsey, F. (1928), A mathematical theory of saving. *Economic Journal* 38: 543–59.

Ricoeur, P. (1995), *Le juste*. Paris: Éditions Esprit.

Solow, R.M. (1999), 'Foreword', in Portney, P.R., and J.P. Weyant (eds), *Discounting and Intergenerational Equity*, pp. vii–ix. Washington D.C.: Resources for the Future.

Stern, N. (2006, October 30), *The Stern Review Report: The Economics of Climate Change*. London: HM Treasury.

Sterner, T., and U.M. Persson (2007, July), *An even Sterner review*. Resources for the Future, Discussion Paper 07-37, Washington, D.C.

Weitzman, M.L. (1998), Why the far-distant future should be discounted at its lowest possible

rate. *Journal of Environmental Economics and Management* 36: 201–08.
Weitzman, M.L. (2007), A review of *The Stern Review on the Economics of Climate Change*. *Journal of Economic Literature* 45: 703–24.
Weitzman, M.L. (2009), On modelling and interpreting the economics of catastrophic climate change. *The Review of Economics and Statistics* 91 (1): 1–19.