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The Discount Rate Debate in Climate Politics

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Introduction

> *"Few topics in our discipline rival the social rate of discount as a subject exhibiting simultaneously a very considerable degree of knowledge and a very substantial level of confusion."*
> *– William J. Baumol*

Some might call the social discount rate the bane of climate change economics. Even slight variations in its value can completely change whether a policy or project is determined as economically viable or not. Thus, experts are far from consensus on which discount rate is the most appropriate to use, especially in the context of climate change policy. Yet in order to understand this debate, we must first understand why discounting is applied in the first place.

People have a natural tendency to prefer consumption in the present rather than in the future (even if the value of the good or service consumed is the same).[1] A direct consequence of this time preference is the concept of the time value of money: money today is worth more than money tomorrow. This principle underlies investment and explains why investors are willing to forgo spending money now only if they expect a favorable return on their investment in the future.

When conducting cost-benefit analysis (CBA) of private as well as social projects, discount rates are used to account for the decreasing value of money in the future. Whereas private investments use market based discount rates, determining which discount rates to use for government and other social projects is a subject of heavy debate. This because of the compounding nature of discount rates; the higher the discount, the more quickly future social costs and benefits decline in value. Hence for large, long term, intergenerational social projects, using market-based discount rates (which tend to be higher) is controversial.

In the context of climate policy, lower social discount rates are proposed in order to encourage investment in a low-carbon future. Economists view these rates as valuing future generations more equally in contrast to higher discount rates, which devalue the future social costs and benefits to the extent where they can be become irrelevant. This paper attempts to provide the relevant background for understanding the discount rate debate and its effects on climate policy. We will explore two case studies that illustrate the importance of discount rates and discuss potential alternatives to the single, fixed discount rate. By no means is this paper meant to provide a conclusive solution to the discount rate debate, but rather increase encourage economists and policymakers alike to revisit their assumptions about discount rates and recognize the need for more flexibility in their approach to discounting.

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[1] Doyle, John R. "Survey of Time Preference, Delay Discounting Models." *Judgment and Decision Making*, vol. 8, No. 2, Mar. 2013, pp. 116–135. *2*.

Background

In this section, we will briefly explain some economic terminology as well as show how returns on investments are calculated and where discount rates come into play. We will give some background specifically on social discount rates and their controversial role in the context of policymaking. Finally, we will use a case study on nuclear energy to examine the effects of discount rates on long term investments.

I. Private Discount Rates

In the private sector, the time value of money concept states that money today is worth more than the identical sum in the future since money today has a potential earning capacity. This is possible even with very low risk, such as investing into government bonds, which almost guarantee an interest rate of 1-2%. To accurately perform a CBA, one calculates a *discounted cash flow analysis* (DCF)[2]. This is done by estimating and summarizing all future incomes and expenditures into yearly *cash flows* (CF_i), where i is the number of years before the future cashflow occurs, and then discounting these cash flows in order to calculate their *present value* (PV):

$$PV = \frac{CF_i}{(1+r)^i}$$

where r is the *discount rate*. All present values are then summed up in order to calculate *net present value* (NPV) of the investment:

$$NPV = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \cdots + \frac{CF_n}{(1+r)^n}$$

The result of the NPV is important as it determines whether the entire project makes a net positive return. Although there are uncertainties when predicting future cash flows, it is important to realize the compound effect of discounting makes the discount rate a crucial parameter when determining the returns of an investment.

The private discount rate is determined externally through market forces and can be empirically estimated. This is known as the *weighted average cost of capital* (WACC), a

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[2] "Discounted Cash Flow Definition." *Wall Street Oasis*, 29 Sept. 2011, www.wallstreetoasis.com/finance-dictionary/what-is-a-discounted-cash-flow-DCF.

measure of the rate of return investors demand for investing into the company[3]. The WACC is determined depending on how a company decides to finance its projects (through its own equity or through debt) and is measured by the share of equity times the cost of equity (K_e) plus the share of debt times the cost of debt (K_d).

$$WACC = \frac{E}{E+D}K_E + \frac{D}{E+D}K_D(1 - T_C)$$

The cost of equity reflects the risk-free rate of return (government bonds) plus a premium to compensate investors for taking a certain amount of risk. The cost of debt, on the other hand, is the interest paid on borrowed funds. However, since debt is tax deductible, the actual cost of debt is reduced through the corporate tax rate (T_C), incentivizing companies to borrow. The WACC is the private discount rate companies use to determine the exact cost of financing a project.

II. Social Discount Rates

In contrast to private discount rates, social discount rates are used to determine the measurable benefit of investment in public or social welfare projects. These projects usually have much longer time spans than most private ventures, and thus affect future generations significantly. For example, someone looking to buy stock at a firm would probably calculate a NPV based on a 10 to 20 year time span. The decision to invest concerns only the present generation (the lifetime of this individual). On the other hand, governments deciding whether to invest in renewable energy, which has much longer lasting impacts, would need to consider the costs and benefits for future generations as well as today's society.

For this reason, social discount rates play a crucial yet highly controversial role in climate change economics. Essentially, the discount rate determines how much society today should invest in limiting the impacts of climate change in the future. This intergenerational CBA weighs the benefits of mitigating climate change to future generations against the investment costs to society today. The higher the social discount rate, the less beneficial aggressive climate change policies will seem.

Using high discount rates exponentially reduces future social costs and benefits (i.e. they approach zero more quickly as time goes to infinity). For example, the long term social cost of carbon in the atmosphere is dramatically reduced under higher discount rates and hence imposing a strict carbon tax today to limit carbon emissions would seem redundant. Yet given the atmosphere lifetime of carbon dioxide – over 100 years – and the resulting long term risks

[3] "Weighted Average Cost of Capital (WACC) Definition." *Wall Street Oasis*, 6 Oct. 2011, www.wallstreetoasis.com/finance-dictionary/what-is-weighted-average-cost-of-capital-WACC.

of pollution, there is a strong push to reduce carbon emissions through policies like carbon taxes. Many climate change economists and activists thus argue against basing social discount rates on (typically higher) financial market based discount rates that would discourage implementing such policies.

The biggest factor in determining social discount rates is how much future generations are weighted, yet determining these weights is a complex and often unclear process. Should the empirical market data inform our estimates for social discount rates at all? Should we value a unit of investment the same as a unit of consumption? Should we consider future (unborn) generations in our calculations? In other words, should our cost-benefit analysis be inter- or intra-generational? These are questions economists and policymakers continue to wrestle with when deciding which discount rate to use.

III. Case Study: Nuclear Energy

Nuclear power plants are expensive to build but relatively cheap to run. The US Nuclear Energy Institute estimates that capital costs make up 74% of the levelized cost of electricity (the average revenue required per unit of electricity to cover the building and operating costs of the plant lifetime)[4]. In the energy industry, this is an extraordinarily high figure when compared to competing energy sources (63% for coal and 22% for natural gas). This implies that nuclear plants must run for a long time period in order to recover the initial capital costs. Consequently, discount rates matter since they diminish returns exponentially with time.

Furthermore, since fuel costs for nuclear power are so minimal in comparison to the initial capital costs, once built, plants want to operate at maximum capacity in order to maximize revenue. This is especially difficult to realize in deregulated energy markets where prices are driven by short-term price signals. As a result, in order to secure revenues for nuclear power plants, governments often intervene and negotiate a fixed price and quantity of electricity prior to the construction of a nuclear power plant (so called "strike price").

An article published by the Energy Collective Group addresses specifically the risk of investment in nuclear power[5]. A DCF analysis was computed for 1 KW of nuclear power for a five-year construction period followed by a 50-year operating period.

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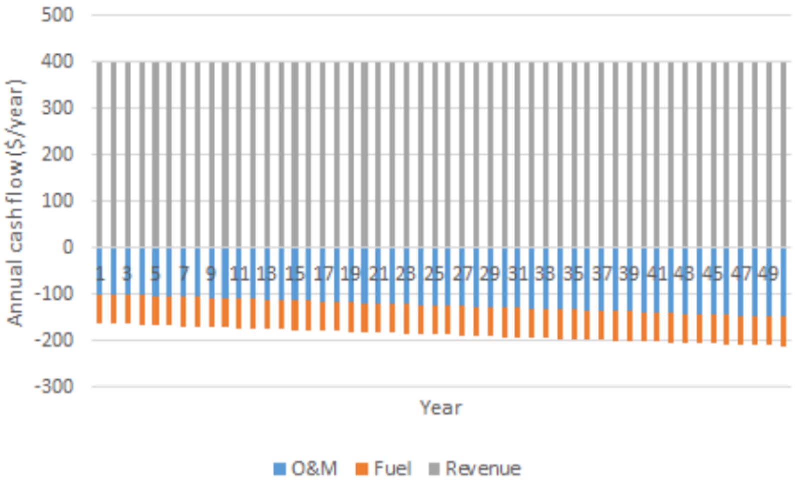
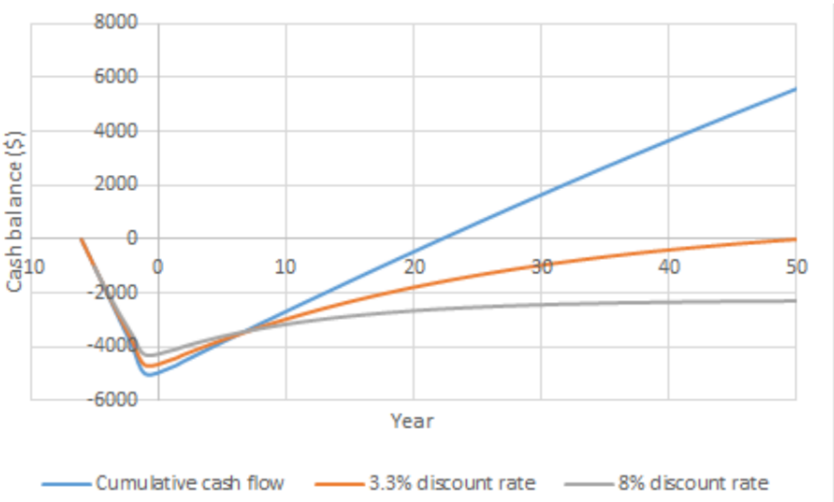
[4] U.S. Energy Information Administration (EIA) – Source. Eia.gov. Retrieved 2015-11-01.

[5] Cloete, Schalk. "What Are the Risks Related to Nuclear Power Investment?" *What Are the Risks Related to Nuclear Power Investment? | Energy Central*, www.energycentral.com/c/ec/what-are-risks-related-nuclear-power-investment.



The graph above shows the plants annual cash flows reflecting yearly increasing fuel and operation and management (O&M) costs. The values are based off a 2015 International Energy Agency (IEA) report on electricity costs. Despite this, we can see that the plant is still easily profitable after 50 years. However, after applying a discount rate to the future cash flows and computing a NPV it becomes immediately clear that the exact rate used is a deciding factor in whether the initial investment can be recovered.



From the graph above, we can see that without the effect of discounting, the initial investment is recovered after around 22 years. However, applying a 3.3% discount rate shows us the initial capital investment is only recovered after 50 years and in the case of an 8% discount rate, the investment can never be recovered. Through DCF analysis, it is apparent that nuclear power struggles to compete due to its high initial costs, even if governments can guarantee private investors fixed prices and volumes.

It is important to note that nuclear energy started with the expectation that it would be "too cheap to meter."[6] However, due to fears of nuclear disasters the technology has become politically and socially unpopular. Governments have responded by increasing regulations, making the construction of power plants more difficult and expensive. Consequently, current investment into nuclear energy is low, especially in deregulated energy markets.

However, nuclear energy does have several benefits. Firstly, it is one of the few reliable large-scale carbon free power generators. This is considered crucial in an age where global warming due to carbon emissions is becoming urgent, and there are very few viable substitutes for the current fossil fuel dominated energy sources. In order to make nuclear an attractive investment once again, governments should simplify regulations and even help finance nuclear energy. By accounting for the social benefits of reduced carbon emissions for future generations, financing nuclear power via lower social discount rates could be a solution to climate change.

[6] "'Too Cheap to Meter' – the Infamous Nuclear Power Misquote..." *"Too Cheap to Meter" – the Infamous Nuclear Power Misquote...*, 17 Sept. 2015, www.thisdayinquotes.com/2009/09/too-cheap-to-meter-nuclear-quote-debate.html.

Dual Discounting

One possible reason for difficulties in determining the most appropriate discount rate to use could be exactly that: we continue to look for *the* most appropriate discount rate. As Lawrence Goulder and Roberton Williams suggest in "The Choice of Discount Rate for Climate Change Policy Evaluation,"[7] a substantial part of the dispute over which discount rate to use could be resolved by a dual approach to discounting. This section explores how and why the authors distinguish between a financial discount rate and a social-welfare discount rate. We will also look at the impact of social discount rates on climate policies to illustrate why dual discounting could be an attractive solution.

I. Motivation

As previously mentioned, a major axis of the debate over social discount rates is how much the discount rate should be based on empirical market observations (more objective) as opposed to ethical considerations (more subjective). Goulder and Williams indicate the structure of numerical optimization models as the source of confusion:

> *"In all of the optimization models we have encountered, the same function — the objective function — serves both as a behavioral function (to indicate how individuals actually would behave under various conditions) and as a social welfare function (to indicate how individuals or societies should behave). This means that the same parameters calibrated or statistically estimated to generate a plausible behavioral function must be parameters of the social welfare function — since only one function is involved. This forces the social welfare function to be directly based on actual behavior and the opportunity cost of capital."*

Using two distinct functions, a social welfare function and a behavioral function, would allow the separation of the single discount rate into two distinct discount rates, a *social welfare consumption discount rate* (r_{SW}) and a *financial consumption discount rate* (r_F), as defined by Goulder and Williams. Formally, r_{SW} translates future consumption into the "social welfare equivalent" of current consumption. In contrast, r_F equates current and future consumption in financial terms; it is simply the opportunity cost of capital.

II. Social Welfare Discount Rate

The Ramsey equation[8] below shows how r_{SW} is calculated:

$$r_{sw} = \rho + \eta * g$$

[7] Goulder, Lawrence, and Roberton Williams. "The Choice of Discount Rate for Climate Change Policy Evaluation." *Climate Change Economics*, vol. 3, no. 4, Aug. 2012, doi:10.3386/w18301.

[8] For the full derivation, see Section II of "The Choice of Discount Rate for Climate Change Policy Evaluation" (Goulder and Williams 2012).

Here ρ is the *social rate of time preference*, or how much we value consumption now rather than in the future. (The higher the value of ρ, the more the value of utility in the future is discounted.) The choice of ρ is largely based on the ethical question of how much future generations should be weighted relative to the present generation. Since the probability that future generations cease to exist is extremely low, one could argue that ρ should be 0 and hence all generations are weighted equally.[9]

In addition, η is the elasticity of marginal utility of consumption, or how sensitive changes in utility are to changes in consumption. Consumption is directly related to the economic growth rate, g.[10] Societies do see a diminishing marginal utility of consumption as they grow wealthier over time, which should be accounted for in the social discount rate. Overall, it is influenced mostly by how we allocate value inter-generationally – ρ – but is also influenced by how we interpret the effect of consumption on social welfare – η.

III. Case Study: Stern vs. Nordhaus

In October of 2006, Sir Nicolas Stern published a 700-page report called the *Stern Review on the Economics of Climate Change.* This landmark study assessed in detail the costs and risks associated with climate change, stating that immediate global action would be required to avoid the worst impacts. One year later, William Nordhaus of Yale University published a response[11] to the *Stern Review* criticizing the usage of a low social rate of time preference (and thus a low discount rate). Stern believed that using higher discount rates was unethical because it devalued future generations, whereas Nordhaus argued that lower discount rates put too much burden on the present generation to mitigate climate change.

Applying the Ramsey equation from above to the Stern-Nordhaus debate allowed Partha Dasgupta, economics professor at Cambridge, to calculate[12] the social welfare consumption discount rate, r_{SW}, used by both parties.[13]

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[9] Gollier, Christian. *Pricing the Future: The Economics of Discounting and Sustainable Development*. Princeton University Press, 2011.

[10] Goulder and Williams, 2012.

[11] Nordhaus, William D. "A Review of The Stern Review on the Economics of Climate Change." *Journal of Economic Literature*, vol. 45, no. 3, Sept. 2007, pp. 686–702., doi:10.1257/jel.45.3.686.

[12] Here g is assumed to be 1.3%, based on Dasgupta's estimate of the growth rate of consumption under a "business as usual" scenario.

[13] Dasgupta, Partha. "Discounting Climate Change." *Journal of Risk and Uncertainty*, vol. 37, no. 2-3, 2008, pp. 141–169., doi:10.1007/s11166-008-9049-6.

	ρ (%)	η	g (%)	r_{SW} (%)
Stern (2007)	0.1	1.0	1.3	1.4
Nordhaus (2009)	3.0	1.0	1.3	4.3

This minor difference in the social discount rate leads to drastic differences in the recommended intensity of climate change policy. Stern found that the optimal carbon tax for 2015 would be 364 USD per ton, whereas Nordhaus calculated 36 USD per ton. In his analysis, Nordhaus used a DICE model with a discount rate of 4.3%, showing that the optimal policies for carbon emissions reduction should aim for a 14% reduction by 2015. However, when run with a discount rate of 1.4%, the same model recommended a 53% reduction in carbon emissions by 2015.[14]

Clearly, small changes in the discount rate applied to climate change policies have a huge ripple effect in CBA. Nordhaus was able to recommend such mild action on carbon emissions reduction because of how much a discount rate of 4.3% devalues future costs of carbon emissions. Intuitively, this higher discount rate means only modest reductions in emissions are needed now to mitigate the effects of carbon pollution in the future.

In his critique of the *Stern Review*, Nordhaus stated that such low discount rates are not supported by market data and thus "unrealistic." This language makes it challenging for governments to justify more intense climate change policies based on lower social discount rates. Yet as shown above, increasing the discount rate sharply devalues the negative impacts of climate change on future generations. Governments should be wary of this and be ready to defend why it makes sense for social discount rates in climate policy to be based more heavily on ethical considerations: the longer the timespan of a social project, the more future generations are hurt by higher discount rates.

IV. Which Rate to Use?

Goulder and Williams further illustrate how the distinction between which rate to use should depend on the evaluation metric for a given policy. Using r_{SW} is appropriate if the objective is to determine whether the policy would improve social welfare; using r_F is appropriate if the objective is to determine whether the policy would offer a potential Pareto improvement (i.e. pass the Kaldor-Hicks test).[15]

[14] Goulder and Williams, 2012.

[15] For a given policy, the Kaldor-Hicks test determines whether those who gain value could theoretically compensate those who sacrifice value. As a simple example, a gas power plant operator wants to set up a new plant in Village A, which would incur some pollution costs upon the residents. The residents demand a payment

Because r_F is more closely related to actual market behavior and modeled using the behavioral function, it makes sense for its value to be more based on empirical financial market data. Usually this means r_F would be higher than r_{SW} because r_{SW} also takes into account future generations. In terms of climate change, it seems more reasonable to keep r_{SW} low, giving future generations more weight, because the impacts of climate change will affect future generations more. For instance, we showed how when applied to nuclear energy, even relatively low social discount rates could make an investment seem like it would not provide a high enough return. Yet distinguishing between r_{SW} and r_F in calculating NPV would show that when more weight is placed on future generations, the benefits of investing in nuclear energy are actually significant.

The appeal of this dual discounting approach is that now a policy can be shown to improve social welfare even if it does not provide a potential Pareto improvement. Consider a new, stringent carbon tax implemented across the EU. Perhaps it would be impossible for the beneficiaries of the tax (future generations) to fully compensate those who sacrificed (today's society) monetarily. This means that the tax would fail the Kaldor-Hicks test, and would not seem like a good investment when r_F is applied. However, if we place enough weight on the wellbeing of future generations (reflected in the value of r_{SW}) then we could still show that the tax would provide a social welfare gain.

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of 100 CHF form the operator in return for allowing the plant to be built. Suppose that setting up a plant in Village B, the next best location, would cost the operator an additional 150 CHF. Then there is a possibility for mutually beneficial gain, a Pareto improvement, between the operator and Village A. Note that the Kaldor-Hicks test does not state that those who sacrifice will be surely compensated by those who gain, just that the potential for compensation exists.

Discussion

I. Alternatives and Solutions

We looked in depth at one alternative to the single discount rate, namely the dual discounting approach proposed by Lawrence Goulder and Roberton Williams. Yet there are numerous potential solutions that attempt to tackle the discount rate challenge. Time adjusted discount rates is one suggestion. The table below shows estimates published in the Green Book (a guide compiled by the HM Treasury to inform policymaking and government programs in the UK) in 2003:

Discount rate (%)	Project time horizon (years)
3.5	0 - 30
3.0	31 - 75
2.5	76 - 125
2.0	126 - 200
1.5	201 - 300
1.0	> 300

One disadvantage of this approach is arbitrariness in the cutoffs for each bracket. How exactly do we decide whether the cutoff for the lowest social discount rate should be? And should there ever come a point where the discount rate becomes zero? This again comes back to the ethical question of how much to weight future generations. A slightly more elegant idea might be declining discount rates, which decrease over time but smoothly. For instance, with a hyperbolic discount rate, the discount applied to costs or benefits tends toward zero with time. This makes it better suited to projects with high upfront costs and long term benefits, such as investment in nuclear energy.

Alternatively, some economists propose keeping with fixed standard social discount rates of 3-5%, but varying the actual values of costs and benefits over time.[16] Although this does complicate CBA, this method captures the dynamic nature of certain costs and benefits (this is especially relevant for environmental costs). An example is marginal damage functions that increase over time; these more accurately model the cumulative harm of greenhouse gases that can persist in Earth's atmosphere for hundreds of years.

[16] Attema, Arthur E., et al. "Discounting in Economic Evaluations." *PharmacoEconomics*, vol. 36, no. 7, 19 May 2018, pp. 745–758., doi:10.1007/s40273-018-0672-z.

II. Open Questions

Despite extensive literature and the variety of creative alternatives for discounting, many questions remain subjects of ongoing research. One concerns risk-free versus risk-adjusted discount rates, which attempt to incorporate uncertainty in the market. Usually, doing so means increasing the discount rate (to account for potential disaster related losses in the future). This process is less clear for social discount rates due to the ethical factor and depends on whether policies are correlated with positive or negative economic activity.[17]

We must also remember that discount rates are used in models dealing with not only consumption but also utility (of health, life, etc.) For pure consumption, discounting seems reasonable since we do see the value of cash flows change over time. Yet many experts argue that regarding utility, the discount rate should be 0% because it is wrong to discount the value of life.[18] This is an important ethical point to consider, especially in the context of climate change policymaking.

Another consideration is how different countries and governments should agree upon which discount rates or discounting methods to use. Discount rates worldwide are far from consistent; the table below[19] shows the discount rate (calculated using the Ramsey equation) and associated parameters for six different countries:

	ρ (%)	η	g (%)	r_{SW} (%)
Australia	1.5	1.9	1.4	4.7
France	1.0	1.9	1.3	3.5
Germany	1.0	2.2	1.6	4.1
Japan	1.0	2.5	1.4	5.0
UK	1.0	2.1	1.5	4.2
JSA	1.5	2.2	1.3	4.6

[17] Attema, et al., 2018.

[18] Drupp, Moritz A., et al. "Discounting Disentangled." *American Economic Journal: Economic Policy*, vol. 10, no. 4, 4 Nov. 2018, pp. 109–134., doi:10.1257/pol.20160240.

[19] David J. Evans, and Haluk Sezer. "Social Discount Rates for Six Major Countries." *Applied Economics Letters*, vol. 11, no. 9, 4 Aug. 2006, pp. 557–560., doi:10.1080/135048504200028007.

Countries like Japan that use a higher discount rate will therefore be able to justify more mild climate change policies than countries like France. This then begs the question of which countries should shoulder more of the burden of mitigating climate change, especially with regards to developing versus industrialized countries.

Finally, some analysts even question whether we should use discount rates at all[20], because they imply a steady and continuous change over time. In reality, we cannot be sure that our economic environment will develop this way, especially as the effects of climate change grow increasingly drastic.

[20] Drupp et al., 2018.

Conclusion

Ultimately, we must remember that the discount rate is a somewhat arbitrary parameter, which represents nothing more than our assumptions about how value changes over time. Despite this, the discount rate has a profound effect on the results of economic analyses and the policies built on these analyses. For instance, we have seen how a small variation in the discount rate applied changes the social cost of carbon by tenfold, and thus could be the reason why a policy supporting clean energy subsidies is accepted or rejected.

Given the acute sensitivity of climate change policy to the social discount rate, the best approach we can take is one of flexibility: to be open to adapting our estimates, models, and techniques for discounting. Of course, no single solution will put the debate over discount rates to rest, nor will any particular method be most appropriate one for every model or situation. Yet if we do not remain open to the possibility of using alternative solutions, policymaking will continue to struggle under the universal application of one unchanging discount rate. Economists and policy makers must learn to break away from the mindset that there exists a single "ideal" discount rate. Instead, the variety of approaches to discounting offer us the possibility of adapting the discount rate(s) we use on a case by case basis.

Finally, we must pay special attention to intergenerational tradeoffs in the context of climate change policy. The higher the discount rate, the less our generation needs to sacrifice towards mitigating climate change now, but the more future generations may suffer. We must ultimately recognize that no matter how small the discount rate, using one places future generations at a disadvantage. In determining how we discount costs and benefits, we face a difficult yet unavoidable question: who should shoulder more of the burden – our generation or generations of the future?

References

Attema, Arthur E., et al. "Discounting in Economic Evaluations." *PharmacoEconomics*, vol. 36, no. 7, 19 May 2018, pp. 745–758., doi:10.1007/s40273-018-0672-z.

Cloete, Schalk. "What Are the Risks Related to Nuclear Power Investment?" *What Are the Risks Related to Nuclear Power Investment? | Energy Central*, www.energycentral.com/c/ec/what-are-risks-related-nuclear-power-investment.

Dasgupta, Partha. "Discounting Climate Change." *Journal of Risk and Uncertainty*, vol. 37, no. 2-3, 2008, pp. 141–169., doi:10.1007/s11166-008-9049-6.

David J. Evans, and Haluk Sezer. "Social Discount Rates for Six Major Countries." *Applied Economics Letters*, vol. 11, no. 9, 4 Aug. 2006, pp. 557–560., doi:10.1080/13504850 4200028007.

Discounted Cash Flow Definition. *Wall Street Oasis*, 29 Sept. 2011, www.wallstreetoasis.com/finance-dictionary/what-is-a-discounted-cash-flow-DCF.

Division of Nuclear Technology Development and Economics. "Sustainable Development and the Application of Discounting to the Calculation of the Levelised Costs of Electricity." *OECD*, 22 June 2018. www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=NEA/NDC/R(2018)1&docLanguage=En.

Doyle, John R. "Survey of Time Preference, Delay Discounting Models." *Judgment and Decision Making*, vol. 8, No. 2, Mar. 2013, pp. 116–135. *2*.

Drupp, Moritz A., et al. "Discounting Disentangled." *American Economic Journal: Economic Policy*, vol. 10, no. 4, 4 Nov. 2018, pp. 109–134., doi:10.1257/pol.20160240.

Gollier, Christian. *Pricing the Future: The Economics of Discounting and Sustainable Development*. Princeton University Press, 2011.

Goulder, Lawrence, and Roberton Williams. "The Choice of Discount Rate for Climate Change Policy Evaluation." *Climate Change Economics*, vol. 3, no. 4, Aug. 2012, doi:10.3386/w18301. https://www.nber.org/papers/w18301.

Johnson, Laurie T., and Chris Hope. "The Social Cost of Carbon in U.S. Regulatory Impact Analyses: An Introduction and Critique." *Journal of Environmental Studies and Sciences*, vol. 2, no. 3, 12 Sep. 2012, pp. 205–221., doi:10.1007/s13412-012-0087-7.

Nordhaus, William D. "A Review of The Stern Review on the Economics of Climate Change." *Journal of Economic Literature*, vol. 45, no. 3, Sept. 2007, pp. 686–702., doi:10.1257/jel.45.3.686.

"'Too Cheap to Meter' – the Infamous Nuclear Power Misquote..." *"Too Cheap to Meter" – the Infamous Nuclear Power Misquote...*, 17 Sept. 2015, www.thisdayinquotes.com/2009/09/too-cheap-to-meter-nuclear-quote-debate.html.

U.S. Energy Information Administration (EIA) – Source. Eia.gov. Retrieved 2015-11-01.

Varian, Hal R. "Recalculating the Costs of Global Climate Change." *The New York Times*, The New York Times, 14 Dec. 2006, www.nytimes.com/2006/12/14/business/14scene.html.

Weighted Average Cost of Capital (WACC) Definition. *Wall Street Oasis*, 6 Oct. 2011, www.wallstreetoasis.com/finance-dictionary/what-is-weighted-average-cost-of-capital-WACC.