

Long-run discounting

Recent economic theory shows that a *declining discount rate* should be used for long-term project evaluation. This article explains why, and examines the implications of the current incorrect practice of using a *constant discount rate*.

Evaluation of every investment opportunity requires a trade-off to be made between the present and the future. The standard approach is calculate a 'net present value' for the opportunity by applying a constant discount rate to the stream of costs and benefits over time.

However, recent results from the world of economic theory have startling real-world implications. The theory tells us that when the future is uncertain — as it always is — employing a constant discount rate is flawed. Instead, it is correct to use a discount rate that declines over time. Failure to use a declining discount rate can have an enormous impact upon projects with a horizon of 30 years or longer; infrastructure projects would be an example.

Over 80% off the future

The concept of discounting the future, which is as old as civilization, received formal treatment by Paul Samuelson in 1937.¹ Since then it has been a foundation of modern economics and is employed extensively in firm valuation, government policy appraisal, and even personal decision-making.

Nevertheless, economists, including Samuelson himself, have wondered whether the foundation was secure. For some time, the appropriate number to employ has been the subject of ferocious debate. Recommended discount rates differ from firm to firm, and from one nation to another. While the Treasury 1997 Green Book recommended a 6% discount rate, the draft currently under consultation proposes that it should be unbundled into its component parts, and lowered to 3.5%.²

Alongside the debate about the 'correct' discount rate, another curiosity has troubled economists for several decades now. Even with a relatively low (constant) discount rate, the far-distant future is inevitably discounted to almost nothing. For instance, £1,000,000 earned in 50 years time, discounted at a constant rate of 3.5%, is worth only £179,000 in present value terms — a discount of more than 80%. Moreover, what happens a century or two from now simply doesn't enter the picture. The underlying logic, of course, is that due to the immense power of compound interest, a very small savings program started today will become an enormous store of wealth in a century if the underlying real interest rate remains about the same.

New insights

And there, hiding in the apparently innocuous clause tacked on the end of the previous sentence, is the critical assumption. It seems reasonable to assume that the real interest rate, which has been relatively stable for the past couple of centuries, can just be projected into the future. However, the further we look into the future, the greater the number of potential states

¹ Samuelson, P. A. (1937), 'A note on measurement of utility', *Review of Economic Studies*, 4:2 155–61.

² HM Treasury (2002), 'The Green Book: Appraisal and Evaluation in Central Government: Treasury Guidance: Draft under construction', July.

of the world. It may be that we are on the cusp of a golden age, where technology and social advances imply a world of above average economic returns and improvements to standards of living. In this world a discount rate of 6% might be appropriate. Equally, we might be entering a period where the pressure exerted on our natural climate and ecosystems becomes so intense that increasing effort must be exerted just to maintain the standard of living. Here a discount rate of perhaps 1% is more applicable.

On average, however, future real interest rates are probably unlikely to be much different from what they are today. Hence we can just take an arithmetic average over the different states of the world, to come up with a discount rate of about 3.5%. Right?

Not quite. The discount rate, r , is different from the discount factor, $1/(1+r)^t$. It is the discount factor that gives the weight applied to each time period. Hence, when averaging over two states we must find the arithmetic mean of the discount *factor*. Having found this, we can then determine the implicit mean discount rate, r^* .

Table 1: Uncertainty implies a declining discount rate

Time from present	Discount Factor (r=1%)	Discount Factor (r=6%)	Mean Discount Factor	Mean r^*
1 years	0.99	0.94	0.97	3.4%
5 years	0.95	0.75	0.85	3.3%
10 years	0.91	0.56	0.73	3.2%
50 years	0.61	0.05	0.33	2.2%
100 years	0.37	0.00	0.19	1.7%
200 years	0.14	0.00	0.07	1.4%

It turns out that r^* is implicitly a harmonic mean, rather than the usual arithmetic mean.³ As Table 1 illustrates, r^* declines over time. In fact, it declines asymptotically to the value of the less optimistic state, here 1%.

Hence, whenever there is uncertainty about the future — as inevitably there is — a declining discount rate is the result. The question of interest is precisely what functional form the decline should take.

Case proven?

Martin Weitzman at Harvard University asked over 2000 economists to give their ‘professionally considered gut feeling’ on the appropriate discount rates for climate change mitigation.⁴ The results approximately followed a gamma distribution with mean discount rate of 4% and standard deviation of 3%. Taking this distribution to reflect the state of uncertainty about the future state of the world, Weitzman found that the discount rate should decline approximately as shown in Table 2.

Table 2: Gamma Discounting Rates

Time from present	Label	Marginal discount rate (%)
1-5 years	Immediate future	4
6-25 years	Near future	3
26-75 years	Medium future	2
76-300 years	Distant future	1
More than 300 years	Far-distant future	0

Interestingly, several other recent theoretical developments have also supported the use of a declining discount rate. Psychological studies of individual behaviour show that we

³ The harmonic mean of two numbers $a, b > 0$ is given by $2ab/(a + b)$. In our case, $(1 + r^*)^t$ is a harmonic mean of $(1 + r_1)^t$ and $(1 + r_2)^t$. The harmonic mean is not a novel concept— Greek mathematicians Nicomachus, Pappus, Iamblichus, and Theon of Smyrna all discuss the three principal means (along with 7 or so others) in their mathematical writings.

⁴ Weitzman, M. (2001), ‘Gamma Discounting’, *American Economic Review*, **91**:1, March, 261–271.

intuitively employ a declining discount rate that approximately follows a hyperbolic form — now known as hyperbolic discounting. Equally, economists such as Graciela Chichilnisky have noted the ‘dictatorship of the present over the future’ that results from discounting at a constant rate. She suggests taking a weighted average of a discounted stream (dictatorship of the present) with a stream representing a dictatorship of the future.⁵

Real-world implications

So, what are the implications of incorrectly using a constant discount rate? If the project under examination has a time frame of less than 20 years, the impact will be insignificant. However, for projects or investments with a long time horizon, it has significant ramifications. Several examples immediately spring to mind: climate change prevention, construction of nuclear power plant and the storage of nuclear waste, and investment in long term infrastructure such as roads and railways.

Consider the question of investment for climate change mitigation. The costs of taking action to slow climate change are incurred now, while the benefits will only be reaped in the far-distant future. With a constant discount rate, the benefits of reducing emissions are discounted to almost nothing and so abatement appears to be poor value for money. However, a declining discount rate results in greater weight being placed on the future benefits, and efforts to slow climate change suddenly become more attractive.

The nuclear industry is another interesting case where applying constant discount rates can produce misleading results. Correctly using a declining discount rate will have two impacts pulling in opposite directions. On the one hand, lower discount rates place more weight on far-distant decommissioning costs. Using a constant discount rate, the present-value costs of decommissioning are so small that they have almost no impact upon the economics of investment in new nuclear plant. As such, decommissioning is seen primarily as a political, rather than an economic, issue. However, rough calculations suggest that with a declining discount rate, present value decommissioning costs could increase by a factor of ten. This obviously increases the present value of the lifetime costs of nuclear plant, making new build less attractive.

However, a declining discount rate also increases the value of the revenue earned over the 40-year lifetime of the reactor. This makes nuclear energy appear more attractive. Indeed, early calculations suggest that this effect may offset the effect of placing greater weight on decommissioning costs.

In summary, correct use of a declining discount rate places greater emphasis on costs and benefits in the distant future. Investment opportunities with a stream of benefits accruing over a long project lifetime therefore appear more attractive. Thus, climate change mitigation is given a boost. So is public spending on road and rail infrastructure. On the contrary, liabilities accruing far into the future will no longer be discounted away to zero; with declining discount rates such far-distant future costs are correctly taken into account.

⁵ Chichilnisky, G. (1996), ‘An axiomatic approach to sustainable development’, *Social Choice and Welfare*, **13**, 231–257.