Valuing intergenerational sustainability and energy projects

Mark Freeman

15th May 2010

Outline

1. The sensitivity of medium-term project valuation to the cost of capital
2. The sensitivity of very long-term project valuation to the cost of capital
3. The Stern Review
4. The precautionary principle
5. The economics of nuclear accidents

Present values

The NPV formula

Suppose we have a project that requires initial investment I and will pay one cash flow (only) C_T at some future time T. Then the general rule for deciding if this is a good project or not is if

$$-I + \frac{E[C_T]}{(1+r)^T} > 0$$

where r is the "Cost of Capital".

Calculating the cost of capital

The CAPM

In both theory and practice, the standard way of estimating the Cost of Capital for all equity financed firms is to use the Capital Asset Pricing Model (CAPM)

$$r = r_f + \beta E[r_m - r_f]$$

where r_f is the risk-free rate, β is the systematic risk of the project and $E[r_m - r_f]$ is the "equity premium"

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What values should we use?

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Project beta

For example, there are a number of different techniques that could be used to calculate the project beta. These may well give significantly different answers.

Which risk-free rate should we use?

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Long term T-bond

Copeland, Weston & Shastri (2005), Damodaran (2001), Lumby & Jones (2001), Schlosser (2002), Shapiro & Balbirer (2000), Vernimmen et al. (2005)

The equity premium

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Big differences

The lower / upper quartile estimates were 4.5% and 7%. The lowest and highest estimates were 2% and 12%.

An example

10-year project

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Expert B

Expert B uses the 10-year T-bond rate of 4.0% as the risk-free rate and believes the equity premium is 7.0%. He estimates the beta of the project as 1.1.

The project's NPV

Expert A

Expert A calculates a cost of capital of $0.6\% + 0.85 \times 4.5\% = 4.425\%$ and therefore calculates the value of the project as $10m/(1.04425)^{10} =$ £6.485m

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Important disagreement

This means that Expert A places a value on the project almost twice that of Expert B. This gives the manager a major problem when making a decision.

Taking an average

A possible route forward

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Alternatively, the average NPV from the two experts is (£6.485m + £3.307m) / 2 = £4.896m

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Not much difference

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So, in practice...

Standard practice is to take an "average" estimate of the cost of capital and calculate the NPV using this.

A hundred year project

Adjusting the example

Take exactly the same example as before, but now assume that the project has a duration of 100 years, rather than 10 years. This is the horizon of many environmental and energy projects.

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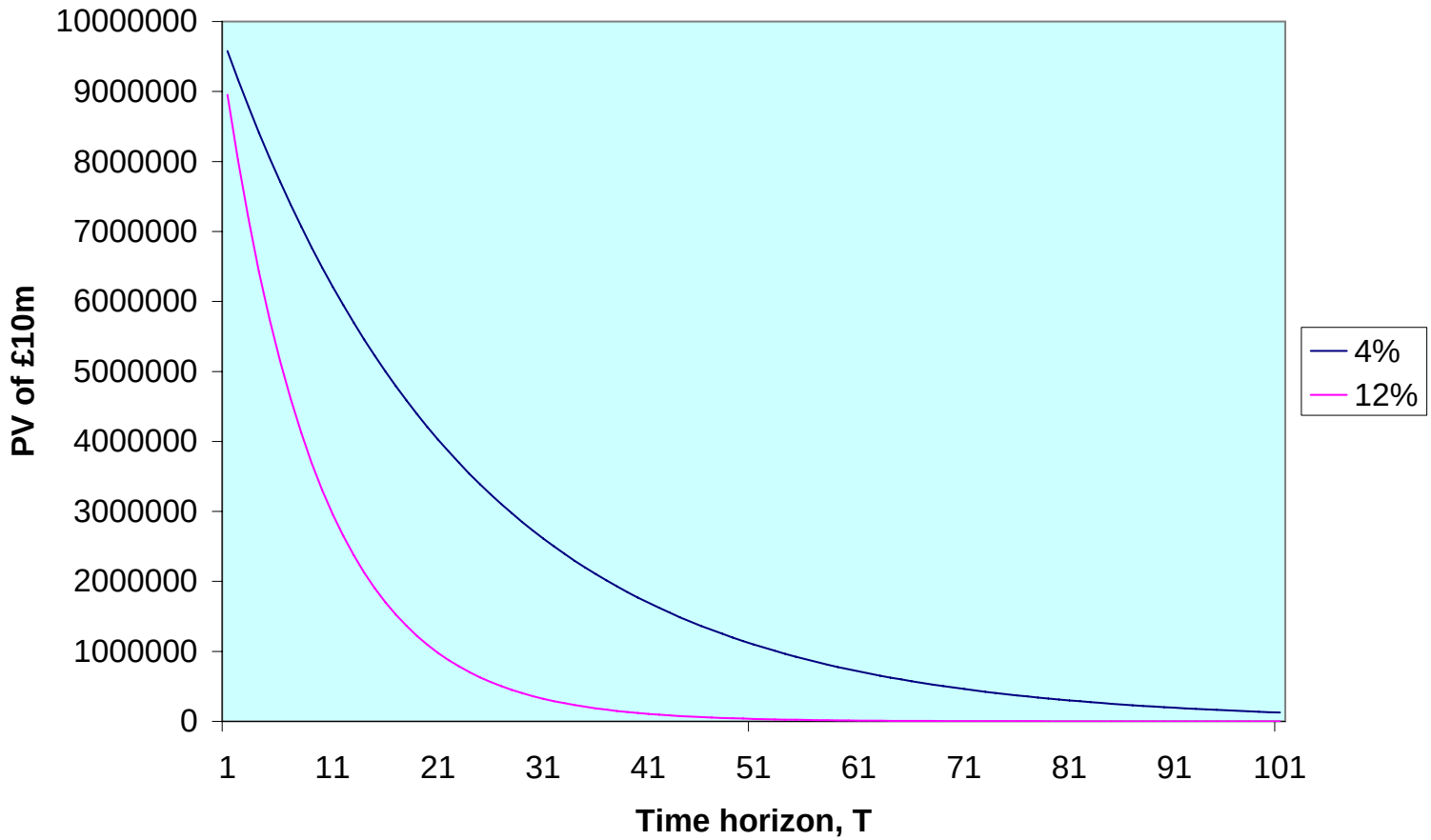
The two experts' valuations

Expert A calculates the value of the project as $10m/(1.04425)^{100} =$ £131,690 while Expert B calculates the value of the project as $10m/(1.1170)^{100} =$ £157. Notice that Expert A now values the project nearly 1,000 times more than Expert B.

The inverted effect of compound interest



Taking averages again

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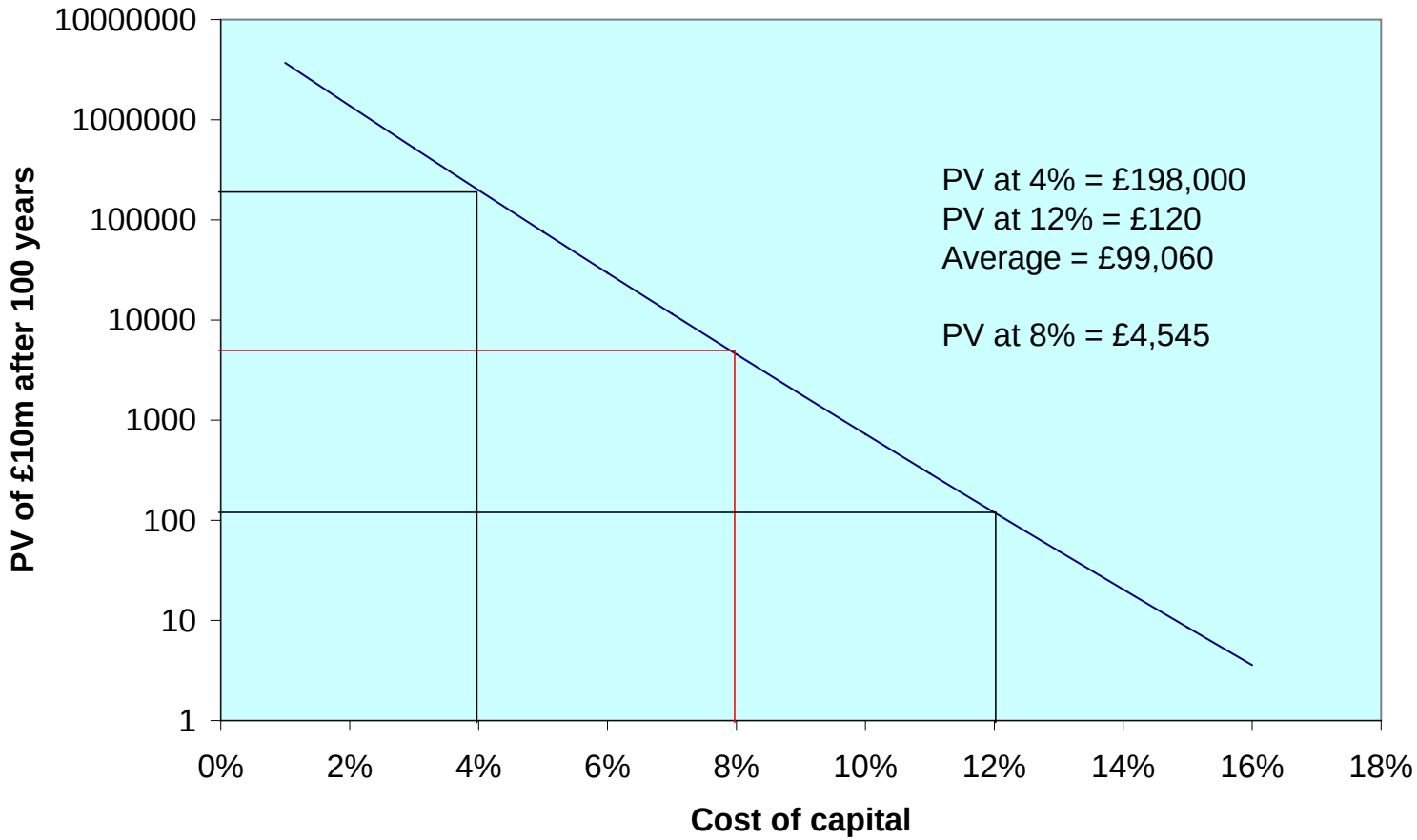
Now there is a big difference

Now there remains a fifteen-fold difference in the valuation depending on how the averaging is done. This starts to become of huge economic significance.

Jensen's inequality



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High values for environmental projects

This therefore gives higher present values for environmental projects than is currently acknowledged.

Working backwards

What is the correct discount rate

If we accept that £65,923 is the correct PV for this project, then we can work out the correct discount rate r_d by working backwards

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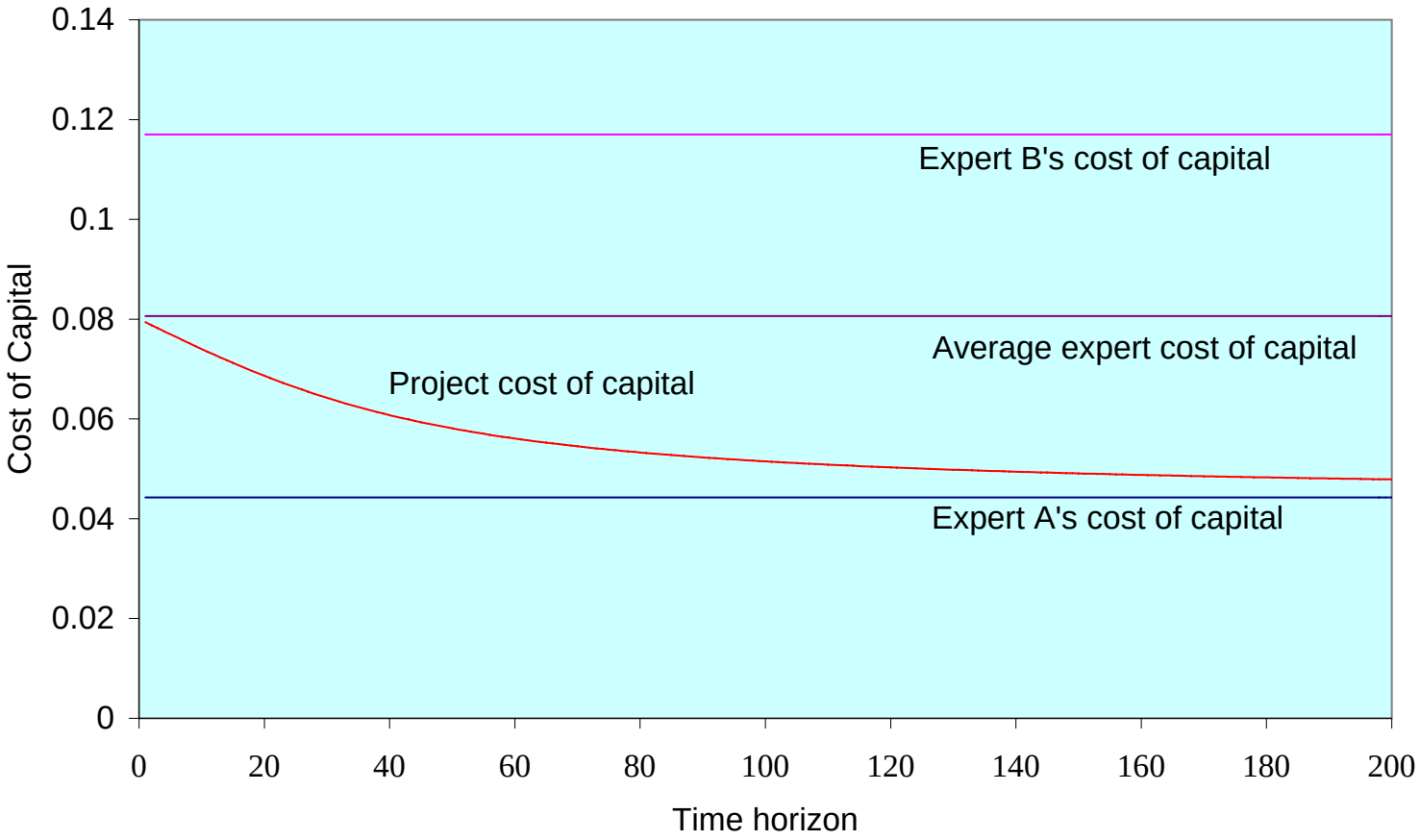
Low discount rate

This gives a value of 5.15%, which is much closer to the lower estimate than the higher estimate. This effect becomes more pronounced the longer the horizon.

Jensen's inequality



The cost of capital depends on the project horizon

Declining discount rates

It has recognised in the environmental economics literature for some time that the cost of capital should decline with the project horizon.
The main theoretical work was done by Weitzman(1998, 2001). A number of authors have worked out schedules of this effect for risk-free discounting

Influence on policy

The UK

The UK Treasury Guidance on Appraisal and Evaluation in Central Government 2006 (the "Green Book"), incorporates the idea that far horizon social discount rates should be low in comparison to short-term rates. For real discount rates:

Years	0-30	31-75	76-125	126-200	201-300	301+
	3.5%	3.0%	2.5%	2.0%	1.5%	1.0%

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France

"Since 2005, the French public institutions are required to use a 4% rate per year to discount cash flows up to thirty years, and to use a 2% rate for longer horizons." (Gollier, 2009)

The Stern Review

Background

"The Stern Review on the Economics of Climate Change is a 700-page report released on October 30, 2006 by economist Lord Stern of Brentford for the British government, which discusses the effect of climate change and global warming on the world economy. Although not the first economic report on global warming, it is significant as the largest and most widely known and discussed report of its kind". Wikipedia.

The findings

The Stern Review argues that...

"This Review has assessed a wide range of evidence on the impacts of climate change and on the economic costs, and has used a number of different techniques to assess costs and risks. From all of these perspectives, the evidence gathered by the Review leads to a simple conclusion: the benefits of strong and early action far outweigh the economic costs of not acting." (Executive summary)

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This, though is not uncontroversial

Many others, including Nordhaus and Boyer (1994, 2000) and Lomborg (2001) have argued that the likely future effects of climate change are not sufficiently great to justify the required level of spending on mitigation today.

Criticism of the Stern Review

Areas of contention

- The environmental impacts of climate change over- / under- stated
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- The environmental impacts of climate change over- / under- stated
- The costs of climate change are overstated
- The costs of fixing climate change are understated
- The wrong discount rate is used. "We are actually a lot less clear about what interest rate should be used for discounting climate change than is commonly acknowledged". Weitzman (2007, p703).

Bringing this back to the cost of capital

How Stern calculates the cost of capital

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Low discount rate

However, consistent with the analysis that has been undertaken above, the rate he comes up with is low — 1.4% real

The sensitivity of the result to the discount rate

The dissenters

A number of highly eminent economists, though (Nordhaus, Tol & Dasgupta in particular) have argued that this cost of capital is too low. Effectively Stern should have used a rate closer to 4.5%.

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And this matters

As Nordhaus (2007) notes: "The Review's unambiguous conclusions about the need for extreme immediate action will not survive the substitution of assumptions that are more consistent with today's marketplace real interest rates and savings rates".

This is absolutely crucial

The PV in 150 years of £1bn

Using similar arguments to the above, the PV of £1bn of climate change damage in 150 years is £124m when discounted at 1.4% but only £1.3m when discounted at 4.5%.

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Where is the public debate?

So policy questions over the economic validity of CO_2 emissions reductions programmes are driven much more by the economic uncertainty than the scientific uncertainty. But where is the public debate on this?

Economics of the business cycle

Should we smooth the business cycle?

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Should we avoid depressions?

Recently, though, a number of authors have argued that society should be prepared to pay significant costs to avoid future Great Depression type states (see e.g., Salyer 2007, Chattergee and Corbae 2007; Barro 2007a, 2007b.). Allowing for rare, but highly unfavourable, economic outcomes significantly alters optimal policy decisions.

Catastrophic climate change

Preventing catastrophe

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Examples

Stern speaks of the potential for 'abrupt and large scale changes in climate', such as failure of the Atlantic Thermohalene or atmospheric circulations, or sudden melting of polar icecaps. These events could also exacerbate climate change through feedback mechanisms, such as the release of methane trapped in permafrost. All of which gives rise to the risk of a concomitantly catastrophic economic impacts: e.g. large scale migration and social conflict, diminished water availability, in addition to defensive expenditures (Stern Review, p 58).

Stern's economic treatment of catastrophic climate change

The science

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The economics

HOWEVER, the theoretical model on which Stern is based, implicitly assumes that the underlying process is smooth. In short — the climate change modelling of Stern allows for catastrophe but the discounting framework does not.

The impact of catastrophe on the cost of capital

Precautionary saving

It is well-known in financial economics that, as the risk of catastrophe rises so interest rates go down. This is because investors wish to save more as a means of insurance.

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A further justification for low discount rates?

If this argument is correct, then this would be a further reason to think that the Stern review was correct in using a low discount rate.

Martin Weitzman's view

Quotation 1

"spending money to slow global warming should perhaps not be conceptualized primarily as being about consumption smoothing as much as being about how much insurance to buy to offset the small change of a ruinous catastrophe that is difficult to compensate by ordinary savings" (Weitzman, 2007).

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Quotation 2

"the Stern Review was right but for the wrong reasons"

Social catastrophes

Examples

Climate change is not the only environmental area of social policy where the precautionary principle is important. For example

- Nuclear accidents
- Genetic damage caused by GM crops

Legal aspects of nuclear accidents

Who pays for nuclear accidents?

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Discounting the consequences of nuclear accidents

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Eeckhoudt et al. 2000

> *"...the usual approach consists of calculating the expected value of various accident scenarios (i.e. the sum of the accident scenario probabilities multiplied by their associated monetary consequences). The main criticism of this approach is that there is a discrepancy between the social acceptability of the risk and the average monetary value that in principle corresponds to the compensation of the consequences..."*

Implications

For climate change

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For nuclear power

However, nuclear power becomes less attractive as a means of reducing greenhouse gas emissions because of the increased PV of nuclear accidents, decommissioning and waste management.

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- Simon Taylor (Cambridge) and I are doing related work on declining corporate, as opposed to social, discount rates