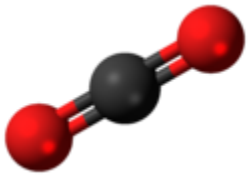

Actuaries' Carbon Collaboration

Acting on climate solvency

ACC discussion paper 1
Time value of money and carbon

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Introduction

Actuaries regularly use discounting as a tool for determining the present cost of future payments. This discussion paper considers the applicability of discounting to carbon emissions and whether there are other tools that could be used to address the time value of carbon.

Time value of money

Actuaries (and many others) accept that the value of money depends on when you have it. In most circumstances a pound now is worth more than a pound in the future – you can spend it or invest it, and if it's in your pocket you definitely have it, whereas if it is promised in the future there is an element of risk involved. We allow for this time value of money through discounting using compound interest. A positive[1] interest rate gives the usual result – a pound now is worth more than a pound in the future, or in other words, the use of compound interest means that the value of money decays quite rapidly as its timing recedes into the future.

[1] A negative interest rate can be used for the rare situations in which the reverse is true.

Determining the discounted value

Determining the discounted value is a technical exercise which can use a number of different methodologies. A distinction can be drawn between different types of actuarial calculations that use discount rates[2]:

- Matching calculations
- Budgeting calculations

Both types of calculation are concerned with comparing assets and liabilities) – although the categorisation is not perfect and some calculations have aspects of both types.

In **matching calculations**, the basic concept is that liabilities should be valued in terms of a set of market instruments (or simulated market instruments) whose cash flows match the characteristics of the liability cash flows. Discount rates are based on the rates that are implicit in the market prices of the instruments. Matching calculations are often appropriate for transactional work, such as company accounts, capital adequacy and hedging and considered "mark to market" calculations.

In **budgeting calculations**, the basic concept is that liabilities should be valued in terms of the investments that would finance them. Discount rates are based on the expected returns from an agreed investment strategy, usually retaining a much larger element of embedded risk, or making an implicit allowance for the riskiness of the future cash flows. Budgeting calculations are often appropriate for long term financial planning, such as pension scheme accruals.

The importance of ergodicity

Both matching and budgeting calculations rely on assumptions that there is some stability in the world – that there aren't drastic and fundamental changes within the term being considered. For example, a budgeting calculation for calculating pension contribution rates, which uses discount rates to compare the value of future contributions and future benefit payments, implicitly assumes that the pension scheme will not run out of money to pay the benefits as they fall due between over the term of the calculations, even if the rates used implicitly allow for future uncertainty. In other words, these discounting calculations assume that **no irreversible changes occur** – that any shortfalls are temporary and can be reversed by future payments.

This assumption of **ergodicity**[3] is important! The basic thing to think about is whether the following give the same results:

- Looking at an individual trajectory across time
- Looking at a set of trajectories at a single point in time

In an ergodic system they are the same (time average is the same as ensemble average). In a non-ergodic system they are different. Most financial calculations, including discounting calculations, assume ergodicity, even though most actual financial processes are non-ergodic (for example, an entity will not fund limitless losses in the hope that they eventually come right).

[2] See Daykin and Patel 2010, Cowling et al 2011, Framework 2012 – all available at https://www.actuaries.org.uk/learn-and-develop/research-and-knowledge/actuarial-research-centre-arc/commissioned-projects/project-discount-rates

[3] See discussions on ergodicity and its application to economics for more details. A couple of introductions are https://jasoncollins.blog/ergodicity-economics-a-primer/ and https://taylorpearson.me/ergodicity/

Ergodicity and the value of social benefits

Discount rates are also used for other types of calculations. For example, the **social time preference rate** is a tool that is primarily used by governments to allow for the perceived value of having a social benefit earlier rather than later. There is a thorough discussion of the application of social discounting to the risk management of climate change in Gutterman 2020[4].

The assumption of no irreversible changes is possibly even less valid when considering the value of social benefits than in actuarial calculations comparing liabilities and assets, which makes the use of an ergodic social time preference rate even more problematic. Although Gutterman 2020 acknowledges the irreversibility of climate change effects, the author makes no mention of the importance of ergodicity when discussing social discounting to manage the risks of climate change.

Time value of carbon emissions

It is fairly clear that a tonne of carbon emitted (or not emitted) now is not exactly equivalent to a tonne of carbon emitted in 1970 or one emitted in 2070. Offsetting a tonne emitted now with a tonne sequestrated in 2070 does not help to achieve net zero by 2050. In fact, the effects of emissions are cumulative, so it's not only necessary to get emissions down to net zero by, say 2050, but it also matters how much carbon is emitted between now and then. In the limit, emitting at current levels until 2049 and then going to net zero all at once would not achieve the Paris agreement's aim of keeping temperature rises significantly below 2°C (besides being totally impractical). So there is a time value of carbon – a tonne now has in some sense a larger impact than one in the future. So how can we allow for that? Is discounting an appropriate mechanism?

Given its cumulative nature, we know that we have to reduce carbon emissions (and emissions of other greenhouse gases) today in order to keep within an acceptable temperature threshold. This is the concept of a carbon budget[5]: the total cumulative emissions since the start of the industrial era remain within certain necessary bounds. Exceeding these bounds is likely to result in global system changes that are hard to reverse[6].

Ergodicity and carbon emissions

This cumulative effect of emissions, as summarised above, makes it clear that we are talking about a non-ergodic system. If we exhaust the budget at any point, temperature rises are likely to exceed acceptable levels, even if the excess is sequestrated at a later date. Temperatures may come down in the future, if we have net negative emissions over a sustained period, but much of the damage will have been done. I would therefore argue that discounting is not an appropriate mechanism.

Conclusion

Discounted values of quantities are functions of time. Discounting may use a single interest rate, or a set of interest rates (again, depending on time) – for example, a market based yield curve, or a decreasing set (often termed a hyperbolic set) as suggested by Gutterman. However, in thinking about the equivalence of amounts of carbon emissions and sequestrations at different times, I would argue that it is not simply the elapsed time between the two quantities being compared that matters (which

[4] Available at https://www.soa.org/resources/research-reports/2020/social-discounting-climate-change/

[5] There are many useful discussions – see for example https://carbontracker.org/carbon-budgets-where-are-we-now/.

[6] IPCC Special Report 15: Global Warming of 1.5°C https://www.ipcc.ch/sr15/.

would be the case if a single discount rate is used) or even the combination of the elapsed time and the absolute times (yield curve or hyperbolic set).

It is instead the relationship of the quantities in question to the state of the carbon budget at the time they are emitted. And the state of the carbon budget at any given time depends crucially on the emissions and sequestrations that take place before that time. So, ideally, the discounted value of a tonne of carbon should be a function of the remaining carbon budget. An even better mechanism than discount rates might be to base decisions on carbon emissions by considering how close we are to the budget being exceeded. Further questions also need to be explored, such as: Are emissions worth exactly the opposite of sequestrations? Does it depend on the type of sequestration? For example, is a tonne of carbon sequestered for the long term (i.e., taking it out of the fast carbon cycle into the slow carbon cycle) worth more[7]?

In order to explore these further, I invite discussions on the credibility of approaches to remove carbon from the atmosphere today. We also need to think more deeply to devise economic frameworks to quantify these risks, whether by coming up with a discount rate that is a function of a carbon budget or by using different carbon prices to analyse different climate scenarios to understand the true cost of action or inaction in this area. I note there has been significant development in this area already, for example by Stiglitz and Stern[8], and believe that actuaries can actively contribute to this development.

[7]See https://en.wikipedia.org/wiki/Carbon_cycle#Fast_and_slow_cycles

[8] See Report of the High-Level Commission on Carbon Prices https://static1.squarespace.com/static/54ff9c5ce4b0a53decccfb4c/t/59244eed17bffc0ac256cf16/1495551740633/CarbonPricing_Final_May29.pdf.