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# THE DUAL FUNCTION OF FINANCIAL MARKET INSTRUMENTS IN AN ENVIRONMENT OF CLIMATE CHANGE UNCERTAINTY: PROTECTION AND SPECULATION

Harvey Stern*
School of Earth Sciences,
University of Melbourne, Victoria, Australia

## 1. INTRODUCTION

The author, in a number of papers (referred to by Stern, 2017), has explored the role of financial market instruments in the area of climate variability and change.

The current paper updates this previous work, taking advantage of the emergence in financial markets of very long term maturity (100-year) bonds.

## 2. BACKGROUND

A 17-Feb-2017 speech by the Australian Prudential Regulation Authority (APRA)'s Executive Member (Insurance), Geoff Summerhayes provides a very nice background to what follows.

Mr Summerhayes said, in part:

"While climate risks have been broadly recognised, they have often been seen as a future problem or a non-financial problem ... this is no longer the case. Some climate risks are distinctly 'financial' in nature. Many of these risks are foreseeable, material and actionable now".

## 3. PURPOSE

The cost of protecting against, and speculating about, global climate change may be established by applying financial market mathematics to data associated with drivers of that change. This approach is used to derive a risk management model that evaluates the cost of protection.

## 4. METHODOLOGY

Data employed to develop the model include long-term time series of measures associated with such drivers. The data are statistically analysed to establish their relative importance. Not surprisingly, it is found that Atmospheric Carbon Dioxide is of profound importance, but that other drivers do have an influence.

* *Corresponding author address: Harvey Stern, School of Earth Sciences, University of Melbourne, Parkville, Victoria, Australia, 3010;* e-mail: hstern@unimelb.edu.au

The findings are then applied to derive the statistical distribution of possible future trends out to 2100 of the Global Mean Temperature, based upon a set of Monte-Carlo-generated scenarios.

## 5. RESULTS

### 5.1 *Statistical distribution of the likely future Global Mean Temperature*

These scenarios show that it is *very likely* for the Global Mean Temperature in 2030 to be higher than it is currently, and *almost certain* to be higher than that, soon thereafter.

Figure 1 presents an illustration of the probability distribution of the likely future Global Mean Temperature so derived, out to the year 2100. It shows that the expected (median estimate) temperature for the year 2030 is about 15°C, for the year 2050 is about 15.3°C, and for the year 2100 is about 16.5°C (about 2°C warmer than in recent years.

Figure 1 also underlines the possibility of the Global Mean Temperature being considerably higher than these values. It suggests that there is a 1% chance of a Global Mean Temperature for the year 2030 of 16°C, for the year 2050 of 16.8°C, and for the year 2100 of 18.8°C (about 4°C warmer than it is currently.

Figure 1 indicates that, by the year 2100, there is only a 5% chance of a Global Mean Temperature cooler than it has been in recent years.

### 5.2 *Interrogating the statistical distribution*

The statistical distribution is then interrogated to provide estimates of what are the 'fair value' prices of put and call options on Global Mean Temperature futures contracts set to expire on Dec-31 in each year out to 2100.

The options considered are *European style options* (exercise only on expiry date), and *Bermudan style options* (exercise on any Dec-31 prior to expiry date).

Figure 2.1 illustrates the 'fair value' premiums (costs) of a set of call options purchased on 31-Dec-2016 with a strike of 15°C and a premium (value) of $100 per °C at expiry.

Figure 2.2 illustrates the 'fair value' premiums (costs) of a set of put options purchased on 31-Dec-2016 with a strike of 15°C and a premium (value) of $100 per °C at expiry.

## 6. ILLUSTRATIVE EXAMPLES

### 6.1 *Example 1*

Let us consider the illustrative example of a European style call option sold on 31-Dec-2016 with a strike of 15°C and a premium (value) of $100 per °C on the expiry date of 31-Dec-2100.

The 'fair value' premium of selling the option on 31-Dec-2016 is $3.50.

Suppose that on 31-Dec-2100, the *Global Mean Temperature* is 15°C or less, that is, below the strike.

With the option now worthless, the seller would keep the premium, which, with the 84-year bond interest rate at 4.538%, would have grown to $\$(1.04538^{84}) \times 3.50$, that is, $146 in 2100 dollars, on that date.

### 6.2 *Example 2*

Let us consider the preceding illustrative example (of a European style call option sold on 31-Dec-2016 with a strike of 15°C and a premium (value) of $100 per °C at expiry date of 31-Dec-2100), but with a different outcome.

Once again, the 'fair value' premium of selling the option on 31-Dec-2016 is $3.50.

However, let us suppose that on 31-Dec-2100, the *Global Mean Temperature* is 18°C, 3°C above the strike. In *2100 dollars*, the option would be worth about $300 on that date (which is what the seller would have to pay the buyer).

## 7. CONCLUDING REMARKS

The paper shows how to evaluate the cost of hedging and speculative instruments related to climate change.

Such instruments provide the opportunity to protect against costs associated with possible future climate change scenarios, and also to place speculative 'bets' on one's views as to the likely future climate.

## 8. REFERENCE

Stern, H. 2017. Developing financial market instruments to protect against what could be dramatically escalating costs, should certain possible future climate change scenarios be realised. *Australia & New Zealand Disaster and Emergency Management Conference Proceedings,* Gold Coast, QLD, Australia, 22-23 May 2017.
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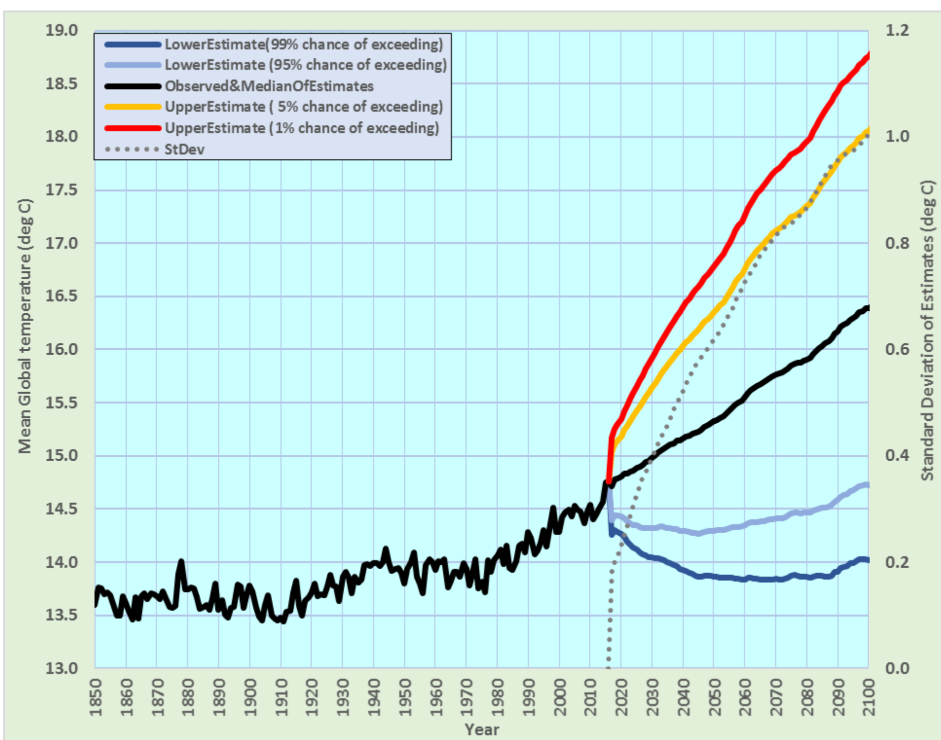


***Figure 1*** An illustration of the probability distribution of the likely future Global Mean Temperature out to the year 2100 (with the corresponding standard deviations of the estimates as measures of the uncertainty).

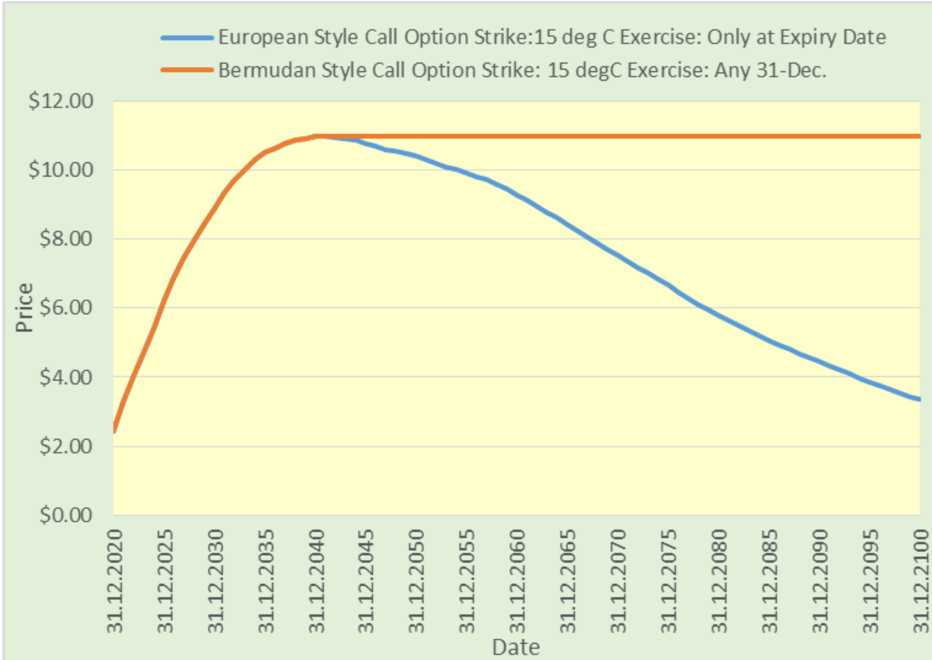


***Figure 2.1*** The ‘fair value’ premiums (costs) of a set of call options purchased on 31-Dec-2016 with a strike of 15°C and a premium (value) of $100 per °C at expiry.

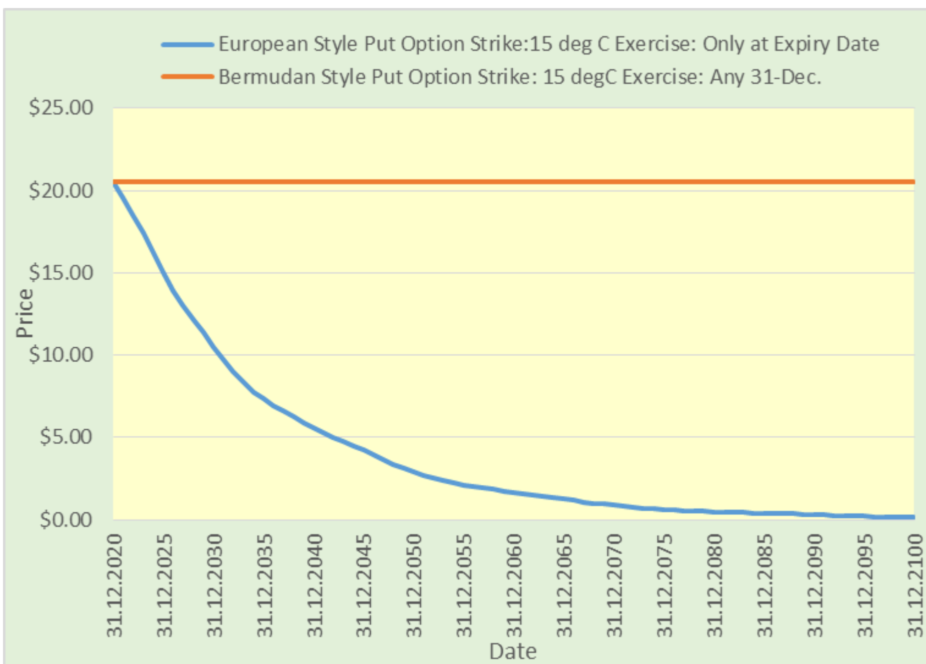


***Figure 2.2*** The ‘fair value’ premiums (costs) of a set of put options purchased on 31-Dec-2016 with a strike of 15°C and a premium (value) of $100 per °C at expiry.