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Perspective

Funding climate adaptation strategies with climate derivatives

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ABSTRACT

Climate adaptation requires large capital investments that could be provided not only by traditional sources like governments and banks, but also by derivatives markets. Such markets would allow two parties with different tolerances and expectations about climate risks to transact for their mutual benefit and, in so doing, finance climate adaptation. Here we calculate the price of a derivative called a European put option, based on future sea surface temperature (SST) in Tasmania, Australia, with an 18 °C strike threshold. This price represents a quantifiable indicator of climate risk, and forms the basis for aquaculture industries exposed to the risk of higher SST to finance adaptation strategies through the sale of derivative contracts. Such contracts provide a real incentive to parties with different climate outlooks, or risk exposure to take a market assessment of climate change.

Introduction

Adapting to climate change requires large amounts of capital investment, which is most often sought from central governments (Aakre et al., 2010), but could also be obtained from capital markets. The global derivatives market, with a value estimated to be greater than 100 trillion USD (Hull, 2009; Anonymous, 2011), is an untapped source of capital for adaptation efforts. Derivatives offer a financial incentive to parties with differing risk exposure, or opinions of future climate outcomes, to transact. Using downscaled climate model projections we calculated prices on which such transactions could be based.

Climate derivatives have potentially widespread application for funding adaptation efforts including in tourism, energy generation and agriculture (Thornes, 2003). Aquaculture represents an important source of food production in the future, but has concomitant economic and financial risks (Godfray et al., 2010). Recent climate forecasts and concern about the susceptibility of the Tasmanian salmon aquaculture industry to warming ocean temperatures motivated us to look for solutions to the climate challenges they face. The industry, worth over 500 M AUD in 2011–12 (DPIPWE, 2013), is considered vulnerable (Battaglene et al., 2008) because salmon are currently grown in coastal waters that in some years exceed a thermal limit of about 18 °C, with observed coastal warming in the region (Hill et al., 2008; Lough and Hobday, 2011)

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predicted to continue (Grose et al., 2010; Hobday and Lough, 2011). Efforts are currently underway to reduce the risk of warming coastal waters by several aquaculture companies; here we suggest that selling climate derivatives to investors could provide additional capital for these and extended efforts.

Climate derivatives

A derivative is a financial product that derives its value from an underlying asset or index such as a share price. It is a contract between two parties, where one (the writer) promises to make a financial commitment to another (the purchaser or contract owner) if pre-defined conditions associated with the underlying asset eventuate. In return for this promise and the financial risk it entails, the writer receives an up-front payment.

In general, financial derivatives are used for three reasons: to hedge against unwanted financial risk; to speculate in the hope of financial gain; or to benefit from asymmetry in information or circumstances via arbitrage. Derivatives are commonly used as a market-based instrument to transfer risk from one party that is exposed to risk, to another that is considered able or willing to bear it.

There are several types of derivatives; one of the most commonly used, called an option, is a contract that gives the owner the right, but not the obligation, to exercise the contract at a specific condition of the underlying index, called the ‘strike’ by a deadline called the ‘maturity date’. Options come in different types. A ‘call’ option gives the contract owner a pay-off if the underlying index is above the strike by the maturity date, while a ‘put’ option gives the contract owner a pay-off if the underlying index is below the strike by the maturity date.

Options are further distinguished by the conditions under which they can be exercised. A “European” option can only be exercised at the maturity date, while an “American” option can be exercised prior to the maturity date. Thus, a European put option will generate a pay-out to the owner only if the underlying index is below the strike at the maturity date, while an American call option could, if the owner so decided, pay-off if the underlying index is above the strike at any time before the maturity date.

Here we provide an example of a European put option, based on forecasts of sea surface temperature (SST) that can be exercised at a maturity date to give a $100 pay-out for each degree the summer SST deviates *below* 18 °C. Crucially, aquaculture companies who wish to further adapt to climate change would use the up-front payment to invest in efforts such as selective breeding to develop more thermally tolerant fish, or relocation of production facilities to cooler, open-ocean offshore operations (Hobday and Poloczanska, 2008). If ocean conditions at maturity remained *below* the 18 °C threshold the contracted aquaculture company would be obliged to make a pay-out to the contract owner or investor, but would be compensated by the upside benefit of not incurring the risks and costs associated with a higher SST. By contrast, if summer temperatures rise *above* the 18 °C threshold, a contracted aquaculture company would not be obliged to make a pay-out. Instead, it would benefit from the investment made in adapting to higher water temperatures.

Pricing climate derivatives

The price at which a derivative is traded relies on several components: an underlying index or asset price forecast, the pay-out and exercise conditions, the strike and the lifetime or length to maturity.

Underlying index

Models that capture the processes governing the dynamics of the underlying index could provide reliable probabilistic forecasts, and thus accurate derivative prices (Caballero et al., 2002; Little et al., 2014). Climate models simulate the physical processes that influence atmospheric and oceanographic quantities such as temperature, pressure and precipitation at large spatial and temporal scales (Stock et al., 2011), and have been used to project future climates and inform climate adaptation planning and risk assessment (Stock et al., 2011; Holz et al., 2010; Tabor and Williams, 2010). At short time and small spatial scales, models disagree and their predictive power is much debated (Stott et al., 2010; Maslin and Austin, 2012; Whetton et al., 2012). Technically, climate model forecasts could be used to price a derivative, but their use is complicated for two reasons. First, general circulation models (GCMs) used to project future climate scenarios have coarse spatial resolution (e.g. 2 × 2 degrees; Stock et al., 2011) with forecasts for adaptation plans typically needed at a finer regional scale (Jewson et al., 2005). Most aquaculture sites in Tasmania, for example, occur in regions within a radius of about 10 km, and there is great habitat diversity among sites. Second, climate risk modelling and derivative pricing require probabilistic forecasts (Whetton et al., 2012; Dessai and Hulme, 2004), such as those from ocean and weather forecasting, (e.g. Oke et al., 2008) while many GCMs are deterministic. Down-scaling (Pielke and Wilby, 2012), employing multiple models (Hobday and Lough, 2011) and estimating uncertainty address these issues and provide a basis for climate risk modelling and derivative pricing.

The underlying index for this example was defined as the average annual summer (Jan., Feb., March) SST in the D’Entrecasteaux Channel of south east Tasmania (43.05°S, 147.18°E). Model forecasts for SST were obtained from the Climate Futures for Tasmania (Grose et al., 2010) based on an ensemble of 12 GCM forecasts consisting of two IPCC Emission scenarios (A2, B1) and six different GCMs (CSIRO-Mk3.5, GFDL-CM2.0, GFDL-CM2.1, ECHAM5/MPI-OM,