Weather Derivatives

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Introduction

According to the Chicago Mercantile Exchange (CME), it is estimated that 20% of companies in the US are directly affected by the weather. Some directly, some indirectly. For example, a vineyard can suffer catastrophic losses during a cold growing season. In the same vein, a power utility would prefer a very hot summer and cold winter to increase power consumption and thus the sale of their product.

A New Type of Derivative

Many derivatives have been created over the years to hedge against unwanted risk, for example commodity futures take the uncertainty out of prices for farmers, currency futures can hedge interest rates and index futures are a main tool of portfolio managers for hedging against big swings in market prices. Following the development of these more ‘vanilla’ derivatives, more exotic derivates entered the market, most notably weather futures. Quite simply, a weather derivative is a futures contract written on the weather in a given time period. Usually the ‘weather’ we’re referring to is expressed in temperature. In most contracts this is expressed by the ‘Heating Degree Days’ or ‘Cooling Degree Days’, the former being the number of days during the contract in which the temperature exceeds some ‘strike temperature’ and the latter being the number of days where the temperature falls under the strike temperature.

Example – CME HDD Future

As an example, people can buy and sell futures based on the CME's Heating Degree Day Index or (in the summer months) Cooling Degree Day Index. The contracts are futures in the traditional sense, however the HDD Index and CDD Index measure temperature in a specific region, instead of, say, a commodity price or interest rate. The contract specifications are similar to other futures, they have an expiry date, strike price (expressed as a value of the HDD or CDD index). But, in addition they specify the region, since weather can vary all over the country.

Insurance?

Now, common question would be: Why can’t industries purchase insurance to protect them from weather problems, we have all heard about hurricane insurance or crop protection for farmers, what makes this different? The main difference is that insurance is traditionally written in the form of disaster insurance. Insurance policies are there to protect against events which could destroy an entire yield, for example, a hurricane or drought. But there exists no insurance policy to protect a summer tourist resort from, say, receiving 15% less customers during a cold summer. Any insurance policy would not only be extremely complicated, but the process of proving, possibly in a court setting, that the weather directly caused that 15% percent drop in revenues’ could be legally impossible. Thus, simplicity is one of the most attractive features of a weather future. There is no requirement on the part of the contract holder to show he was negatively affected by the weather – the contract payout is simply calculated and made by the owing party.

Additional Benefits

Again, looking at the CME, we see another strong benefit to weather futures and that is that they are not subject to counterparty risk. They are in fact cleared through the CME Clearing House, who serves as counterparty to each trade. Thus there is no possibility of default on the contract. In addition, the futures are traded on the CME Globex electronic platform, which offer full access and price transparency to anyone connected to it. So, regardless of the size of the trade, the best price will always be offered. Finally, the futures are available to trade nearly 24 hours a day, five days a week on the Globex electronic platform.

Modeling Temperature

An example of a simple payoff function for a weather future over a period of n days would be: k*max {Hn-K, 0} where: Hn is the number of Degree Days, K is strike # of degree days and k is some fixed constant which refers to the payout per Degree Day above the strike. To clarify, a Degree Day is either a Heating Degree day (where the temperature exceeds some pre-defined average temperature) or a Cooling Degree Day (where the temperature is less than some pre-defined temperature) depending on which contract you buy. Note, that if a particular day is a Heating Degree Day than it is not a Cooling Degree Day and vice versa.

Modeling Temperature

In equation form, we have that
Hn = # of HDD during our time period of n days.
= where HDDi = R is the pre-defined reference temperature, which defines whether the day is a heating day or cooling day.

In terms of modelling, we have to fix a short period of time, say, n=30 to do our modelling. Because, if we take, say, 1 year, obviously the temperature will take on many different values and we will need to have multiple values of R. In addition, we model for a fixed region, not the entire country, since, for example, Umeå has much different weather than Göteborg.

Modeling Temperature

So we have a formula for the payoff function for the period (of n days) in question. The only issue now, is to have a model for T_i, the temperature (average) on day i . In Jan's notes, he suggests a model for the temperature describing the temperature process as Fractional Brownian motion.

This model is:

$$T_t^m = A + Bt + C\sin(\omega t + \varphi)$$

where $\omega = 2\pi/365$

φ, A, B and C are constants.