

Weather Derivatives-Pricing and Design Issue in India

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Introduction:

In the last decades, agricultural policies of certain countries focused on adopting and strengthening the crop insurance programmes. Traditional agricultural insurances schemes are known to be plagued by the problems of asymmetric information and systemic risks and consequently, in order to be operated needs substantial government support. In supporting such programmes, the intention of the policy makers is usually to provide more market oriented policy instruments – reducing producers' incentives to rely on free disaster aid and compared to disaster relief intervention, to attain more efficient and equitable use of the resources. Given such policy orientation, a significant number of innovative and sophisticated insurance programmes were tested and developed. The most advanced experiences are those of Canada and USA, where producers can chose between a vast array of policies, including level multi-peril revenue and income products and area based multi-peril revenue and income schemes.

In this line of thinking, innovations in the energy markets suggest the possibility of addressing the agricultural risk factors by issuing derivatives on weather elements. Such instruments appear particularly attractive, as asymmetric information and loss adjustment issues do not affect them. From an agricultural policy perspective, the possibility of adopting the programmes of this kind could represent significant progress in terms of cost saving and market transparency.

India being agriculture based economy; it can easily adopt weather derivatives. Agriculture in India contributes around 30% of GDP and more than 50% of agriculture depends upon rainwater irrigation. Thus, we can easily conclude that rainfall is very much related to the market. Weather derivative with rain index may come handy to the market. There are different weather derivatives and the most prominent among them are Heating Degree Days (HDD). But for the discussion, here in this paper, we will talk about rain index and in the next two section we will see the methods of pricing Weather derivatives and the design of the contract. But before going to the issue of pricing and designing we would first like to define the Weather Derivative.

Definition: A financial weather contract can be defined as a “weather contingent contract whose payoff will be in an amount of cash determined by future weather events. The settlement value of these weather events is determined from a weather index, expressed as values of weather variable measured at a stated location.”

A financial weather contract can take any form of a weather derivative or of a weather insurance contract. The difference between these two is that in traditional insurance contracts, indemnities are paid only after actual damages are quantified by proper loss adjustment, and not simply upon the occurrence of the specific state of nature. This is an important difference that, according to the specific circumstances, can make one of the instruments more attractive than the other. And here we will discuss weather derivative only.

Pricing:

The pricing of weather derivatives is, of course, another issue. One cannot buy or sell the underlying, be it sunshine or rain. Position have to be hedged with offsetting positions and one cannot create a risk-free portfolio by combining the derivatives with its underlying (as done for

other derivatives). Weather contracts are based on forecasting, so the information on past weather behaviors and an understanding and an understanding of the dynamics of the environment is essential. Now here comes the toughest part as the weather derivative that can be traded will have longer maturity than the data available for forecasts. So to fit a proper distribution is the critical issue. Stephen Jewson in his paper take the weather outcomes as normally distributed and even Mark Davis in his paper tried to fit lognormal distribution which is based on normal distribution itself. They both made a good attempt and give us the base to fit the distribution for forecasting and hence pricing issue. We can use the method used by S. Jewson for estimating the index variance. There are two methods, which allow us to combine probabilistic forecasts and climatological models in such a way as to calculate accurate estimates of the distribution of the index without assuming independence between the forecast and post-forecast periods. Accurate estimates of the index distribution then allow us to calculate accurate prices for WDs. The two methods are pruning and grafting. To explain each method in detail is out of scope of our paper.

Once we calculate the index variance we can use this to pricing linear and nonlinear contracts. Robert Henderson gives a simple overview of pricing theory, according to him actuarial approach to pricing can be done by

$$\text{Price}_{\text{Bid}}^{\text{Offer}}(t) = D(t, T) \{ E(P) \pm F_{\text{Bid}}^{\text{Offer}}(R(P, CP)) \}$$

Where $D(t, T)$ is present value,

$E(P)$ is the expected payout,

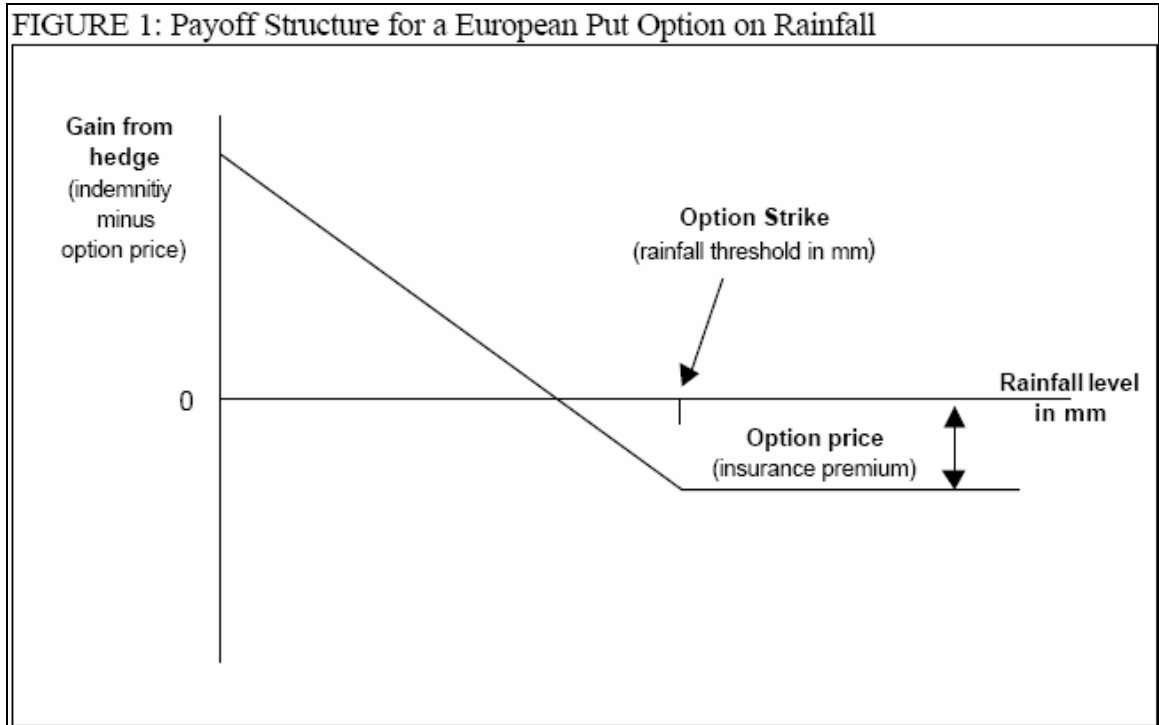
$R(P, CP)$ is the risky payout, which is the function of CP- current position.

Design:

In order to develop WDs, the weather variable must be measurable, historical records must be adequate and available, and all parties involved in the transaction must consider such measures objective and reliable. The existence of a complex relationship between the product and the weather factor must be carefully explored. For agricultural production the relationship is not always as straightforward since differences in products, crop growth phases, soil textures, etc. have different responses to the same weather factor. Also, the more skilled and advanced the cultivating techniques, the greater the entrepreneurial influence on yields the smaller the portion of variability generated by the specific weather elements.

The crucial issue for application of WDs at the agricultural production level lies in the actual presence of a clear and satisfying relationship between the weather factor and the production variable. In order to be able to be successful, the WD must be able to explain a very high portion of the variability in production, losing otherwise its attractiveness as a hedging device. Hence appropriate identification of the relationship between production and the weather variable is very important

The structure of the Weather Derivative proposed in the world bank feasibility study is that of a European put option, where the option price is the cost of the derivative for the producer and the strike is the rainfall threshold below which an indemnity is triggered.



As mentioned above in designing a weather derivative for hedging weather risk at the production level, particular attention must be placed in capturing the relationship between weather factors and the specific product.

In trying to address yields variability through a rainfall weather derivative the working hypothesis is that rainfall is the main determinant of crop yield and that drought is the quasi-exclusive source of risk.

In this framework, the objective of the design phase is to capture the rainfall yield relationship is the most accurate way possible.

The optimization problem adopted in order to select index weights can be described as follows. Effective rainfall in period 'i' is defined as

$$r_i = \max [r_i^*, CAP_i] \text{ -----(1)}$$

where r_i^* is actual rainfall in period i,
 CAP_i is amount of rainfall in period I beyond which additional rainfall does not contribute to increased yield.

The rainfall index for year t is defined as a weighted average effective rainfall

$$R_t = \sum_{i=1}^m w_i r_{it} \text{ ----- (2)}$$

Where m is the total number of period in growing season, w_i is the weight assigned to period i of the growing season and r_{it} is the effective rainfall in period i for year t. The weights w_i can be chosen to maximize the sample correlation between the rainfall index and yields using data on rainfall and yield.

Payout procedure: The rainfall derivative for crops is structured to pay out when rainfall (R_t) in the crop year is below a specified threshold (T). The payment is proportional. The value of R_t is calculated by summing the value obtained multiplying rainfall in each period I of year t by specific weights assigned to every period I (equation 2)

The indemnity is triggered according to the following function

$$\text{Indemnity} = \begin{bmatrix} 0 & \text{if } R_t \geq T \\ \frac{T - R_t}{T} & \text{if } R_t < T \end{bmatrix} \times \text{Liability}$$

Conclusion:

With agriculture contributing to major portion of GDP in India and weather elements having prevalent and causal relationship with the production variables, weather derivatives can be effectively used to manage agricultural production risk.

From the experience of the other developed countries, it can also be observed that weather derivatives can be useful means for addressing the systemic portion of agricultural risk, leading to potential applications in the stand-alone or layer structures in the re-insurance of agricultural risk exposure.

Weather derivatives giving hedge against the agricultural risk happen to be cheaper and more effective than insurance schemes for agriculture. In order to support new developments in weather markets, at production or re-insurance levels, the regulators may also focus on providing infrastructure- in particular weather stations and free availability of weather data –and supporting transaction costs for ‘Weather Derivatives’ development.

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3. Robert Henderson: Pricing Weather Risk.
4. Mark Davis: Pricing weather derivatives by marginal value.

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