Article can be accessed online at http://www.publishingindia.com

Weather Derivatives – A Need for Indian Farmers?

Prantik Ray*

Abstract

Weather affects the performance of many industries/ sectors. The notable examples are agriculture and energy. The weather sensitivity sometimes results in huge financial losses. Financial engineering thus came up with solutions like weather insurance and weather derivatives.

Weather Insurance products have been targeted at and sold to the farmers of India – but the success of these remains questionable. The reason for the failure could be attributed to lack of clarity/ awareness about the product, infrastructural issues and inherent issues with the category of insurance products.

Weather derivatives, in comparison, are a new class of products. Though, they are virgin to Indian soil, these have been successful abroad. Weather derivatives are regarded a better, low-cost, sustainable alternative system of agriculture risk management. These contracts can be designed with good deal of flexibility to help farmers manage drought risk by making a payment when rainfall in a given period goes below a certain pre-agreed level. Besides the developed countries, these contracts are already in operation in some developing countries, too, for instance, Morocco, Mexico, Ukraine, Mangolia, and Romania due to their numerous advantages. The derivatives cover events with highly probability or low risk – which insurance does not cover. Also, the problems of adverse selection and moral hazard are not seen in derivatives.

This paper aims to compare and contrast the concepts of weather insurance and weather derivatives. Taking a cue from the episode of weather insurance, the article suggests ways that might lead to the success and widespread acceptance of weather derivatives in India.

Keyword: Weather, Derivatives

Introduction

There is great need for low cost, efficient risk management instruments for the rural sector in developing countries. As observed by Hess, Richter and Stoppa (2002), "The economies depend heavily on weather conditions, and experience frequent weather hazards, such as drought, floods and windstorms. These factors typically affect most households and companies in the same area at the same time." Moreover, it is reported that all businesses face up to 70 percent weather risk of some sort (Lettre, 2000).

Though services sector is the largest contributor to Indian GDP, agriculture still employs the largest number of individuals in the country. So, agriculture and related occupations should be shielded from uncertainties and downsides to protect the interests of the economy as a whole. The agricultural sector faces a major threat from weather conditions like no other. In fact the Indian agriculture is famously referred to as "Monsoon fed." The rainfall deficit by a few inches leads the central bank of the country changing reserve ratios several times over the next year. The rain deficit or drought in 2009 is an excellent example for this. The lack of rain led to spiralling prices and hence inflation touched new highs. In a 1998 testimony to U.S. Congress, former commerce secretary William Daley stated, "Weather is not just an

* Faculty, Finance Area, XLRI, Jamshedpur, Jharkhand, India. Email: prantik@xlri.ac.in

environmental issue; it is a major economic factor. At least $1 trillion of our economy is weather-sensitive[1]." Same is the case in India - "It has been estimated that in India as much as 20 percent of the GDP is wiped out whenever there is a bad monsoon - which generally happens every five years or so in India (Vashishtha, Vol. 8, no.2, 2007)".

Also, agriculture is the major driver of socio economic development. It leads to the holistic development of the rural mass. But, changes in weather conditions should not create havoc in the lives of farmers as it would affect overall development.

Weather based Products

World Bank Report, 2008 on Indian agriculture attributes the poor performance of agriculture sector to abundant subsidies that Govt. provides the farmers for[2]. This hampers investment in the sector thus affecting technological improvement and access. This implies that it is better to introduce and advocate to farmers, methods to guard themselves from weather irregularities rather than waiving their loans later.

Financial engineers have devised a tool to combat weather irregularities. Any individual/group of individuals whose source of income fluctuates with irregularities in weather can hedge their risks by entering into insurance contracts or put/call options. The first option is weather insurance and the second form is the weather derivatives.

Rainfall insurance as a product has been provided in India in the past but cannot be called a major success. It has not liberated the farmers as is still widely seen as a CAT-based (catastrophic) product.

The Weather Derivatives product is still not legally cleared in the country. The amendment to the Forwards Market Commission (FMC) bill is pending before the parliament[3]. FMC Amendment Bill has been cleared by the Cabinet on 16th September 2010 and put up in the Lower House of the Parliament. Currently derivatives whose underlying is an intangible cannot be traded in the exchange unless a change in the Forwards Contract Regulations Act (FCRA) is enacted. This prevents trading on HDD (heating degree days) or NCDEX rain (rain index maintained by NCDEX). Once the amendment is passed, India will soon see a great deal of activity given its dependence on monsoons. It is worthwhile mentioning here that Weather Derivatives as a product is not only useful to farmers. It is a boon to food and food processing industry, amusement parks and energy companies. In fact many authors clearly attribute the rise of Weather Derivatives to energy companies.

"The history of weather derivatives dates back to the mid 90.s, when deregulation of the energy and utility industries started in the U.S. In the deregulated environment, energy merchants quickly realized that weather conditions were the main source of revenue uncertainties. Weather affects both short-term demand and long-term supply of energy. The close association between the short-term demand for energy and weather conditions created a natural impetus for the development of weather derivatives." (Melanie Cao, 2004)

In summary, farmers will no doubt be the greatest benefactors if Weather Derivatives is administered effectively. But going by the history of the developed countries which have successfully introduced Weather Derivatives, one can expect the weather – affected industries to be present in full attendance.

Weather Derivatives

The concept was first developed in the United States when energy companies were deregulated. Their only way to differentiate from competitors and earn stable revenues was to eliminate weather uncertainties[4]. The first contract was struck by Aquila Energy in July 1996 when it structured a dual-commodity hedge for Consolidated Edison Co. This contract included a weather related clause. Aquile would pay Consolidate Edison Co. if the temperature was below a specified level.[5] The Chicago Mercantile Exchange introduced the first exchange-traded weather futures contracts in 1999.

1 http://www.investopedia.com/articles/optioninvestor/05/052505.asp

2 http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/EXTSAREGTOPAGRI/0,,contentMDK:20273764~menuPK:548214~pagePK:34004173~piPK:34003707~theSitePK:452766,00.html

3 http://economictimes.indiatimes.com/markets/commodities/FMC-to-get-more-teeth-funds-as-Cabinet-clears-commodities-bill/articleshow/6569348.cms

4 http://www.investopedia.com/articles/optioninvestor/05/052505.asp

5 http://en.wikipedia.org/wiki/Weather_derivatives#History

Weather Derivatives can be defined as "An instrument used by companies to hedge against the risk of weather-related losses." The investor who sells a weather derivative agrees to bear this risk for a premium[6]. More simply put it is a risk management technique that minimises downfall in case of a negative event.

The instrument can be compared with any kind of derivatives right from simplest commodity derivatives to structured products like credit derivatives. In this case, it would be interesting to strike a similarity with a Credit Default Swap (CDS) which is a kind of credit derivative

A & B enter into a CDS. A is the protection buyer. B is the protection seller. The reference obligation or asset is Company X. When X defaults/goes bankrupt, A will be affected due to its transactions with X. So, A seeks protection against credit default and in order to get this protection A makes periodic payments to B and when default/bankruptcy of X happens, B compensate A for the same.

Striking a similarity with Weather Derivatives, A & B enters into a Weather Derivatives. A seeks protection and B is the seller of the protection. A pays a specified amount to B. A is affected by low rainfall (which is equivalent of the X Company in the CDS case). When the trigger event happens, i.e. rainfall below a specified level (similar to bankruptcy in the previous case) B will compensate A.

The underlying in the case of Weather Derivatives are intangibles. The commodity derivatives may be physically or cash settled. But physical settlement is not possible in this case (Hess, 2003). Underlying asset maybe rain, temperature or snow, which is difficult to price directly.

A few examples to elaborate the concept – BCCI may want to hedge the risk of rain on the day of a match which may lead to loss of revenue in the form of ticket refunds, sponsorship refunds. Parle Agro/ Frito Lay may want to limit the risk of quantity and quality of potatoes harvested as it may grossly affect its income from the chips category. In the above mentioned scenarios, the stakeholders may enter into Weather Derivatives to secure their earnings.

A main point to be noted here is that betting happens in weather related aspects in India and the volumes are phenomenal. This is illegal in the Indian context.[7] The amendment discussed previously would help Weather Derivatives to get traded in the exchange and thus make it more reliable.

Disadvantages of Weather Derivatives

Weather derivatives are triggered when a specific temperature or rainfall measurement is reached. But the problem of place of measurement persists. Say, a farmer in Sangli district of Maharashtra wants to ensure that his turmeric yield is not affected by rain/humidity. When he enters into a Weather Derivative based on NCDEXrain (rainfall index offered in India) – how truly will it reflect the ground conditions on his farm.

In fact, for weather products to be implemented – Govt and relevant private stakeholders do employ weather measurement units called weather stations. Say if a 1000 *1000 square km is divided into areas of 200*200 sq. Km and each is installed with a weather station – still the problem might not be resolved. The areas within the micro units may not record the same amount of rainfall. This problem gives rise to basis risk. This is one of persisting worries when it comes to Weather Derivatives [8].

The instruments are to be employed in several micro units to overcome Basis risk. That would bring in a lot of infrastructural issues. A greater investment and clarity is essential with respect to the reference weather station for each individual based on his place of residence.

Also, the exchange should collaborate heavily with meteorological department, private players to offer the product. A lot of research is also to be employed by the exchange – best practices and failures all over the world studied to provide a foolproof mechanism for the benefit of everyone.

The other problems are mainly practical – the main benefactors of Weather Derivatives ought to be farmers for several social purposes. But how are they to be educated about the product? How will it be made accessible to them if it is offered via a computer interface? Will the product gain acceptability among them and benefit them truly?

6 http://www.investopedia.com/terms/w/weatherderivative.asp

7 http://www.weather-risk.com/News/news240808.aspx

Pricing of Weather Derivatives

The main method used to price derivatives is the Black Scholes method. But, this concept fails heavily when it comes to weather derivatives. Black Scholes model assumes that the underlying is tradable which fails in the case of Weather Derivatives and hence cannot be used for Weather Derivatives.

The alternatives were thus thought of:

Initially when there was lack of models, the efficiency of market was trusted. Protection buyer usually estimates the loss given a particular scenario. He could derive a utility curve for a series of weather variables and thus arrive at a value he is willing to pay for a loss. The protection seller also takes into account his risk appetite, cost vs. benefit before deciding on the price. The protection seller also considers the premium paid and verifies if he would bear the risk for that amount of compensation offered.

Another simpler method employed is burn pricing which considers the payout of the derivative over the past to arrive at an expected price. Though it is quick and easy, it more often than not does not provide a reliable estimate.

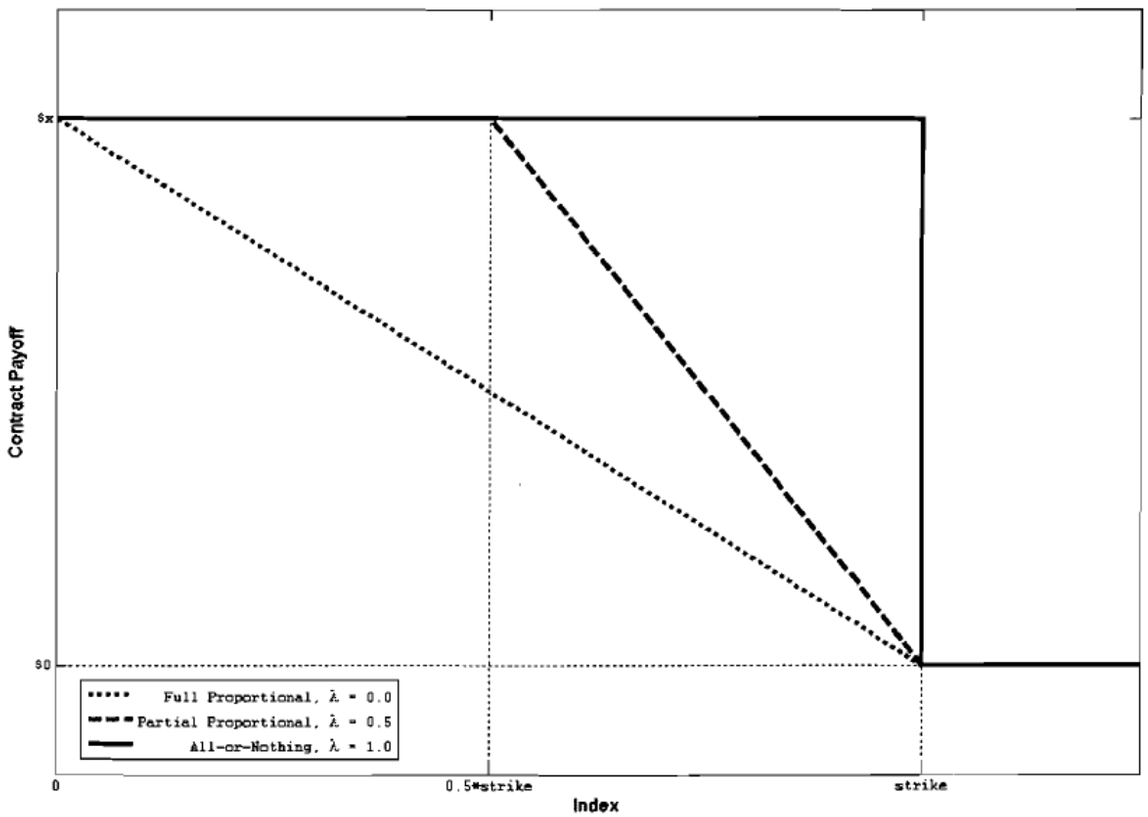
Next, pricing could be arrived at based on several indices available already. The most popular ones are HDD, CDD. In India, we've the rainfall index that is quoted as NCDEXrain. Every index is constituted in some prescribed manner and daily quotes are available. Pricing models are built on the indices using statistical methods available.

One such method is explained below (Barnett, 2004). A Weather Derivative contract is entered into. The payoff is as follows:

$$f(i \mid x, i^*, A) = x \times \begin{cases} 0 & \text{if } i > i^*, \\ \dfrac{i^* - i}{i^* - A_i i^*} & \text{if } A_i i^* < i \le i^*, \\ 1 & \text{if } i \le A_i i^*. \end{cases}$$

"In other words, the contract triggers (i.e., starts to pay) whenever the index i falls below a specified strike i*,

Fig. 1: Payoff Structure of an Elementary Contract



with indemnity proportional to the difference between the index and the strike. The maximum indemnity (equal to $x) is paid whenever the index falls below the limit Ai*, where 0<A< 1. Thus, an elementary contract can be uniquely identified by three parameters: strike, limit, and maximum indemnity." (Barnett, 2004).

Another more scientific method of pricing would follow numerical weather prediction models – mathematical models use weather variables as inputs[8]. Wave patterns, hurricanes can also be predicted today with remote sensing and GIS techniques.

Index

Weather indices have been framed in the past and have been implemented to serve as references for the evolution and flourishing of weather derivatives. The most common and oft quoted one is the heating degree days (HDD)/ cooling degree days (CDD).

HDD/ CDD is defined with respect to a predetermined base which is 65 F. These were initially employed for energy businesses but later adapted to the Weather Derivative segment as well. In a particular day the max and min temp are recorded, average computed. The average of high-low temperatures is subtracted from the base temperature to arrive at HDD. The pricing of weather derivatives in summer is based on CDD and winters on HDD. The cumulative excess over base price is calculated for a month and then multiplied by the value specified in the contract if there arises a contractual obligation. It is to be noted here that contractual obligations are tested using HDD/CDDD in the first place. There would be a problem in adapting HDD as such internationally. This is due to the fact that the base temperature employed in U.S. (65 F) is the temperature required to normally heat a home in the country and may not be universally true.

NCDEXrain is a rainfall based measurement index. This was commissioned by NCDEX for display and disseminating information[9]. NCDEX Rainfall Index indicates the percentage of cumulative normal expected rainfall that has materialised (i.e. actually rained). The resultant figure is multiplied by 1000 to represent a number. All rainfall data is made available by India Meteorological Department (IMD) & National Collateral Management Services Ltd. (NCMSL)[10]. The rainfall index was launched for Mumbai in June 2005. In 2006, the index was extended to cover Bangalore, Erode, Guntur, Kottayam, Ganganagar, Karimnagar, Murshidabad, Rajkot, and Ujjain (Ravikumar, 2008). A high index would mean that compared to cumulative long period, the rainfall has been more in quantity.

Weather Insurance

Weather Insurance can be defined as "A financial product that insures individuals/corporations against variations in weather". It identifies the perils (weather variations) that could lead to loss, correlations identified and studied in depth to create a product structure. A common reference such as a transparent index is set up. Back testing is done to make sure that the payouts are adequate to compensate for the loss. Also, historical data is studied (actuarial data) to arrive at prices. ICICI Lombard is the main player in the Indian scenario and it claims its settlement policy to be hassle free. The insurance provider automatically reimburses at the end of season based on weather station data.

Example –

"Orange crop suffers yield losses in case adequate rainfall is not available for flowering or if there is a dry spell subsequent to flowering. 782 farmers (7% of all the Orange cultivators in the district) were provided a cover for 613 acres for a sum insured of Rs. 18.3 mn by ICICI Lombard"[11]

Weather Derivatives vs Weather Insurance

1. The fact that Weather Derivatives are market administered makes it more efficient. Price is determined by market factors rather than being fixed by insurance companies which incorporates its administrative costs.
2. Weather Insurance is priced using actuarial information whereas Weather Derivatives need not necessarily incorporate historical weather movements. This method is in fact useful as every weather cycle may

8 http://en.wikipedia.org/wiki/Numerical_weather_prediction
9 http://www.weather-risk.com/News/news240808.aspx
10 http://www.ajmeras.com/ajmeras/faqcommodity.aspx#16
11 https://www.icicilombard.com/rural-insurance/weather.html

not be a repetition of the past. So, when Weather Derivatives can incorporate immediate predictions of meteorological departments it is a better mechanism of risk measurement.

3. Weather Derivatives do not encounter the problems of moral hazard and adverse selection as against Weather Insurance.
4. There is no lag due to administrative purposes in case of Weather Derivatives. The necessity of submitting claims on the occurrence of the obligatory event is rendered irrelevant. Due to this, the subjectivity is also eliminated. The insurance officer may inspect the amount of losses and quantify the amount to be paid. This is not the case with Weather Derivatives. Irrespective of losses/damages, the obligatory event triggers full payment. This is not an inefficient mechanism as the protection seller takes this into account while designing a premium and he is not exploited.
5. Weather Derivatives may be affected for partial events like continuous rainfall of 6 cms for 5 days. However, Weather Insurance contracts are typically for catastrophic events – the ones that create havoc or heavy losses. Weather Insurance products for high loss, low probability events but Weather Derivatives can be even for low loss, high probability events too.
6. Premium payments are to be made periodically, policy documents need to be administered/updated, lapses to be followed up in case of Weather Insurance whereas Weather Derivatives comes across as a "one time" product.

Solutions

From the above listing, it is clear that Weather Derivatives are a better mechanism to overcome the perils of weather abnormalities. But the problem of basis risk still exists. And, also awareness and acceptance by the rural mass is a problem. This can be solved by entry of Government/ public parties. A PPP could be formed in which Govt and private parties share the responsibility and revenues. As seen in the case of Morocco when the yield –crop insurance failed, it introduced weather products in the form of European options in coalition with World Bank. World Bank as an experienced player provided the expertise and this led to successful implementation (Hess, 2003). To eliminate the basis risk more weather stations are to be set up. Tamil Nadu government has already taken a proactive step and announced plans to set up 300 stations in the state. This ought to be done by other state governments too. Also, advancement in technologies can be employed. For e.g. in Alberts, Canada satellite images were used to monitor weather conditions – certain wavelength to capture the state of growth conditions of crops. In fact satellite images collected over time can be employed to compare temporal conditions. Another major factor to be considered is that weights have to be given to different phases of crop growth. This was carried out in the project by Moroccan Government in coalition with the World Bank (Hess, 2003).

Going ahead, India should clear the amendment bill in the parliament for Weather Derivatives to be exchange traded. Then, public private partnership would be helpful in delivering the product to the masses. Lastly, technological improvements like satellite images, remote sensing, and GIS could be used to overcome the inherent flaw in the product namely basis risk.

References

Andreas Miller, M. G. (April 2000). Weather Derivatives: A risk mangement tool for Weather sensitive industries. *The General papers on Risk and Insurance* , 25(2), 283-287.

Barnett, D. V. (2004). Efficiency of weather derivatives as primary crop insurance instruments. *Journal of Agricultural and Resource Economics* , 387-403.

Brockett, P. L., Mulong, W., & Chuanhuo, Y. (2005). Weather derivatives and weather risk management. *Risk Management and Insurance Review*, 8(1), 127-140.

CME group hurricane products. (2009, March 20). Retrieved November 28, 2010, from Marketswiki. Retrieved from http://www.marketswiki.com/wiki/index.php?title=CME_Group_Hurricane_Products&action=history

Dercon, S**. (**2002). Income risk, coping strategies and safety nets. World Institute for Development Economics Research Discussion Paper 2002/22, Oxford

ET bureau. (2010, september 17). FMC to get more teeth, funds as Cabinet clears commodities bill.

Hess, A. S. (June 23-26, 2003). Design and Use of Weather Derivatives in Agricultural Policies:the Case of Rainfall Index Insurance in Morocco. *International*

Conference- Agricultural policy reform and the WTO: where are we heading? Capri (Italy).

Hess, U., Richter, K., & Stoppa, A. (2002). Weather Risk Management for Agriculture and Agri-Business in Developing Countries," IFC, World Bank and Procom Agr, Rome, 2002, pp 01.

Hess, U., Richter, K., & Stoppa, A. (n.d.). Weather Risk Management for agriculture and Agri- business in developing countries. *Climate risk and the weather market* .

ICICI research centre. (2005). *Current Economic Statistics and Review - 30th weekly report.*

Lettre, J. (2000). Risk management solutions, weather insurance, weather derivatives. Research paper. *Financial Management,* Rivier College, Nashua, NH.

Melanie Cao, A. L. (January 2004). *Weather Derivatives: A New Class of Financial InstrumentsWeather Derivatives: A New Class of Financial Instruments.*

Mulong Wang, M.-M. W. (2010). Weather derivatives, price forwards, and corporate risk management. *Journal of Risk Finance*, 11(4), 358-376.

Ravikumar, P.H., MD and CEO, NCDEX. (2008, January 5). Mitigating weather risk in commodity markets.

Sean, D., & Campbell, F. X. (2000). Weather Forecasting for Weather Derivatives.

Turvey, C. G. (2001). Weather derivatives for specific event risks in agriculture. *Review of Agriculture Economics*, 23(2), 333-351.

Vashishtha, A. K. (2007). Weather derivatives: Risk-hedging prospects for agriculture and power sectors in India. *The Journal of Risk Finance*, 8(2), 112-132.