Chapter 3

ART INSTRUMENTS FOR WEATHER RISK MANAGEMENT

3.1. Introduction

This chapter discusses in detail about the development of ART (Alternative Risk Transfer) instruments, its suitability and potential market for India. The introduction of weather derivatives to the market, weather derivatives contracts, applicability as risk hedging tool are discussed. Further the chapter discusses about weather risk, management, pricing weather derivatives and weather risk markets.

In index insurance, payments are based on an independent measure highly correlated with farm-level yield or revenue outcomes. Unlike traditional crop insurance that attempts to measure individual farm yields or revenues, index insurance makes use of variables exogenous to the individual policyholder—such as area-level yield or some objective weather event or measure such as temperature or rainfall—but have a strong correlation to farm-level losses.

3.2. Alternative Risk Transfer Instruments

Alternative Risk Transfer is the use of techniques other than traditional insurance and reinsurance to provide risk bearing entities with coverage or protection. The field of alternative risk transfer grew out of a series of insurance capacity crises in the 1970s through 1990s that drove purchasers of traditional coverage to seek more robust ways to buy protection.

The concept of alternative risk transfer (ART) defies a precise definition. One reason for this is that the range of risk products that can reasonably be defined as ART have expanded over time as product innovation continues. ART is not one product, but rather a way of doing business. It is generally accepted that there are two segments in the ART market—risk transfer through alternative carriers and risk transfer through alternative products. The market for alternative carriers (i.e. risk bearers) consists of self-insurance, captives, risk retention groups, and pools. Alternative products include finite risk reinsurance, runoff solutions, committed
capital, multiline, multiyear products, multi-trigger programs, structured finance and new asset solutions, and capital market solutions for weather risk (Hartwig and Wilkinson 2007).

Insurance industry has realized that though conventional risk transfer solutions are almost always favoured (when available at viable pricing levels), it becomes essential to investigate the value of non-conventional solutions and to focus on the benefits that can be derived from these solutions. ART, as the name suggests is basically an alternative risk transfer mechanism as differentiated from traditional methods of risk management. It would involve financing of risks through means other than traditional insurance or reinsurance. ART solutions aim at increasing the efficiency of the risk transfer, broadening the spectrum of insurable risks and tapping the capital markets for additional capacity. ART methods allow a company to dedicate its capital to its core business and, thereby, generate a higher return. Important factors influencing the expansion of ART solutions include the risk management culture, the importance of the capital market for corporate financing and impact of the regulatory structures. The aim of ART is to effect optimized risk transfer at optimal price, through a combination of insurance and other capital market instruments.

Traditional insurance contracts are usually yearly contracts whereas ART products are generally tailor made solutions. Traditional covers are complete risk transfer contracts of indemnity on insurable pure risks. ART products often cover risks not considered suitable under traditional insurance and also may not take care of full or complete transfer of risk but are simply a means of funding for risks. Where limited capital poses a constraint in traditional risk management, ART route provides solutions. ART is a true enterprise risk management approach that focuses on protection of value creation process and not on indemnification of much narrowly defined loss as in case of traditional insurance. It also avoids high transaction costs as also uncertainties with regard to quantification and thus, legal fees. Product innovation in the alternative risk transfer (ART) market is said to have started from deficiencies of traditional insurance or banking products. Single-line annual
coverage got developed into multi-line, multi-year coverage, single -trigger insurance became multi-trigger insurance and pre-loss funding concepts got transformed into contingent capital post-loss funding concepts.

3.2.1 Key features of ART Solutions
- Tailored to specific client problems
- Multi-year, multi-line cover
- Spread of risk over time and within the policyholder's portfolio.
- Risk assumption by non-(re) insurers

Essentially, ART market is broken into three areas- captives, tailored solutions and capital market solutions. A few distinguishing attributes common to most ARTs are:

- **Capital** - ART involves drawing capital from different sources like banks, capital market, insurers and in the process affords opportunity for arbitrage between the price and products available in the market.
- **Convergence** - Financial deregulation allowing vertical integration and economies of scale in the insurance, banking and investment institutions are driving ART market growth.
- **Characteristics** - ART deals are multidisciplinary as it draws from experience in insurance, risk modeling, capital market, investment banking, taxation, law and actuarial profession. ART mechanism involves integrated risk management over a longer time horizon involving multiple contracting parties.

3.2.2. The participants in ART market
- Risk takers and investors such as reinsurers, life assurers, bank traders, capital market investors.
- Protection seekers like insurers, reinsurers and bank traders.
- Intermediaries like insurance brokers and investment bankers.
3.2.3. **Major benefits of ART**

The benefits of an Alternative Risk Transfer (ART) solution will naturally depend upon the objectives of the individual entities but, typical benefits include:

- Increased underwriting capacity and capital for insurers
- More efficient use of existing capital
- Broader choice of coverage and earning stability for corporate
- Protection from catastrophic risks for the society at large
- Increased business through risk transfer and enhanced depositor and shareholder value.
- The opportunity to enter into transactions otherwise outside the regulatory guidelines for insurance business.
- Protection of the balance sheet (and the shareholders) from credit risk
- Cash flow protection / risk smoothing over time
- Diversification over portfolio and time

3.2.4. **Types of ART**

The two broad segments in ART market are risk transfer through (1) alternative carriers and (2) alternative products. Self-insurance, captives, pools come under the first category while multiline products, CAT bonds, securitization, derivatives and finite risk products fall under the second category.

3.2.4.1. **Securitization**

Securitization is the transformation of a non-liquid asset into a security. For example, a group of consumer loans can be transformed into a publically-issued debt security. A security is tradable, and therefore more liquid than the underlying loan or receivables. Securitization of assets can lower risk, add liquidity, and improve economic efficiency.

The Pool of Assets for securitization should have the following characteristics:

- Assets are to be suitable for trading
- Volume should be sufficiently large and homogenous to facilitate statistical analysis
- A stable history of rates, defaults, delinquencies, prepayments etc
- Sufficient diversification--for example, geographic and socio- economic--to reduce vulnerability to economic stresses
- Basic lender’s credit quality standards that are capable of being evaluated and approved by rating agencies and specialized financial guarantee companies
- Assets must be transferable and unencumbered

Securitization of debt, or asset securitization as is more often referred to, is a process by which identified pools of receivables, which are usually illiquid on their own, are transformed into marketable securities through suitable repackaging of cash flows that they generate. Securitization, in effect, is a credit arbitrage transaction that permits for more efficient management of risks by isolating a specific pool of assets from the originator's balance sheet. Further, unlike the case of conventional debt financing, where the interest and principal obligations of a borrowing entity are serviced out of its own general cash flows, debt servicing with asset backed securities (ABS) is from the cash flows originating from its underlying assets.

Securitization can help to resolve reinsurance market inefficiencies in several ways:

a. Risks that are correlated within insurance and reinsurance markets may be uncorrelated with other risks in the economy. For example, the risk of property catastrophes such as hurricanes and earthquakes leads to covariability of risk within the reinsurance industry, but such risks are largely uncorrelated with the economic forces that drive securities markets. Hence, if these risks can be passed directly to securities markets, it may be possible to significantly reduce the covariability loading in the premium. The low covariability with other investment risks also make the contracts attractive to investors for purposes of diversification, potentially permitting risks to be transferred at relatively low cost in comparison with reinsurance.

b. In comparison with the total volume of securities traded in capital markets, the equity capital of insurers and reinsurers is miniscule. In addition, the
largest projected insured loss events are also very large relative to the total
capitalization of the insurance industry. Modeling firms have estimated that a
$100 billion event in Florida or California has a probability of occurrence in
the 1–2 percent range. Such events are large relative to the capacity of the
global reinsurance industry but would be less than 0.5 of 1 percent of the
value of stocks and bonds traded in the United States alone. Hence, it is likely
to be much more efficient to transfer such risks directly to securities markets.

c. Securitized financial instruments can significantly reduce or eliminate the
credit risk (insolvency risk) inherent in reinsurance policies.

3.2.4.2. Securitization of Insurance Risks

The securitization technique is adopted in order to transfer insurance and
reinsurance risks to the capital markets, so that investors are substituted in place of
the traditional risk-bearers such as reinsurers. This can be achieved due to the fact
that capital markets can provide a greater risk-bearing capacity than the reinsurance
markets. This is particularly the case for low-frequency, high- severity exposures
that often prove difficult to insure or reinsure.

The main advantage of securitization compared with traditional reinsurance is that
additional capacity can be realised via the capital markets. For policyholders,
securitization solutions have the advantage that they do not run any credit risk –
unlike traditional reinsurance - since the capital is made available before the loss
occurs and is invested in safe, short-term securities.

3.2.4.3. Insurance derivatives

A financial derivative can be explained as a financial instrument based upon another
more elementary financial instrument. Insurance derivatives are financial
instruments whose value is determined by the performance of an insurance-specific
index (underlying). For example, the index may be based on claims development for
certain risks. Purchasing an insurance derivative allows any loss ensuing from an
unfavourable index performance to be offset by the gain in value of the derivative
instrument. This makes it possible to stabilise the loss costs or the expected returns.
No two insurance securitization transactions are the same, as each has unique features. However, it is possible to categorise such deals into two main types, Catastrophe Securitization and Non-Catastrophe Securitization.

### 3.2.4.3.1. Catastrophe Securitization (CAT bonds)

Historically, the capacity to finance catastrophic risk was limited by the claims paying ability of insurers and reinsurers or by the insured's ability to retain (or pool) that risk. Today, the ability to securitize catastrophe risk unlocks the vast potential of the global capital markets.

Investors in catastrophe bonds benefit not only from the relatively high yields offered on these securities, but also from the additional diversification that results from the fact that catastrophic risk is essentially uncorrelated with financial risk (e.g., fluctuations in interest rates or the stock market). Investors must balance the advantages of high yield and greater diversification with the risk assumed.

Insurers, reinsurers, and corporations interested in securitizing catastrophic risk usually enlist the aid of one or more intermediaries, including investment bankers, reinsurers, and brokers. Funds raised from investors are used to establish a "special purpose vehicle" (SPV), which is similar to a captive. The SPV then issues a reinsurance policy to the insurer or corporation transferring (ceding) the risk, which pays a premium to the SPV. This formal reinsurance structure is necessary so that the transaction is formally recognized for tax and regulatory purposes.

Depending on how the deal is structured, investors face the prospect of losing some or all of the investment income produced by the bond—and even some of the principal—in the event of a catastrophic loss. During the policy period, the capital raised from investors is held in trust in a conservative, highly liquid portfolio. Tapping into the capital markets allowed insurers to diversify their risk and expand the amount of insurance available in catastrophe-prone areas.

Catastrophe bonds have been used to cover a wide variety of exposures, Earthquakes (both in the United States and Japan). The issuance of bonds is
becoming an increasingly popular option for transferring non-catastrophe risks as well. Examples include risks arising from the issuance of life insurance policies, acquisition costs, auto residual (i.e., post-lease) value, and mortgage loans. Power failures and sport events are among the risks covered by catastrophe bonds. Federation Internationale de Football Association (FIFA), worked with Credit Suisse First Boston and other banks to develop and issue $260 million in cancellation bonds in August 2003 covering the 2006 World Cup in Germany. The arrangement covers FIFA's losses in the event the World Cup competition cannot be completed (or rescheduled) due to a variety of events, including terrorism.

The majority of CAT Bonds have been issued in relation to infrequent catastrophic events, such as hurricanes and earthquakes, hence, the name CAT bonds.

**3.2.4.3.2 Non-catastrophe Securitization**

It involves insurance risks that have a higher frequency of occurrence and as a result are more predictable. Types of insurance and reinsurance risks that are suitable for this approach include motor, life, health and property insurance.

**3.2.4.4. Finite Risk Solutions**

Finite-risk solutions represent a type of ART where individual risks are spread over time. This is distinct from traditional insurance or reinsurance where the transfer of risk takes place through pooling with a large number of similar risks.

Finite-risk solutions have the following characteristics:

- The transfer of risk from the policyholder to the insurer is limited (finite). In other words, finite-risk solutions contain a significant element of risk-sharing between the client and the insurer.
- Because finite-risk solutions rely on the smoothing and diversification that occurs with time, policies are usually written on a multiyear basis.
- Costs to the policyholder are primarily a function of individual experience. Much of the premiums not used to fund claims are repaid to the policyholder.
at the end of the policy period. In this sense, finite-risk solutions are similar to retrospectively rated policies.

- Investment income earned during the policy period is factored directly into the premium calculation. Because of the multiyear nature of finite-risk policies, the time value of money can have a considerable influence on premium.

Finite-risk solutions also can be blended with traditional forms of risk transfer. Such blended solutions are gaining in popularity with clients. The blending of finite and traditional approaches permits coverage that smoothes out annual fluctuations in claims costs, while also eliminating the financial risk associated with catastrophic perils.

3.2.4.5. **Insurance Linked securities (ILS)**

It is a general term that covers different instruments designed to pass life and non-life insurance risks on to the financial markets. They range from ILS in the strict sense of the term to contingent capital, cat bonds, cat swaps, cat options, sidecars, collateralized quota shares, and industry loss warranties. Some observers would probably also include under the ILS banner specialist hedge funds and certain derivatives, such as weather or climate derivatives.

Insurance risk securitization remains marginal compared with the businesses of insurance and reinsurance. However, it has undergone rapid growth in response to major loss events such as Hurricane Andrew in 1992, World Trade Center terrorist attacks in 2001, and Hurricanes (Katrina, Rita, and Wilma in 2005). After each of these disasters, the capital of reinsurers were seriously weakened and the usual means of rebuilding capacity—i.e., new company formation through initial public offerings, seasoned equity issues, and capital increases—were not sufficient to enable the market to rebuild to previous levels of capacity. In fact, ILS provided much of the additional risk capital that was unavailable through the usual channels. In 2007 and the first half of 2008, insurance and reinsurance companies continued to issue ILS even though the loss ratio for these years was moderate. Initially conceived as a supplement for rebuilding capacity exhausted by exceptional
disasters, ILS seem to have gradually carved out a place for themselves in the insurance and reinsurance landscape.

3.2.4.6. Captives

A captive is an insurer or reinsurer owned by a corporation or an association of businesses for which the primary business is not insurance. The principal distinguishing feature of a captive is that the insured (generally the captive's owner) exercises direct control over the insurer (captive). Under traditional arrangements, the insured (a policyholder of the company transferring risk) has no influence over the operation of the insurer. In this sense, captives may be viewed as a form of self-insurance.

Captives may be owned by one entity or several and they may insure the risks of organizations other than their major owners. Wholly owned captives are companies established by large corporations to finance or administer their risk financing needs. If such a captive insures only the risks of its parent or subsidiaries, it is called a "pure" captive.

Captives are the oldest form of an alternative risk transfer vehicle, dating back to the 1950s and account for substantial share of world’s commercial insurance market. Large corporations account for 80 percent of the captive market.

3.2.4.7. Multiline/Multiyear Products

The concept of blending experience across multiple lines over a period of time is intuitively appealing (Cummins 2009). The multiyear nature of the policies also produces an additional smoothing effect (over time). The volatility of results over a period of several years will generally be less than over shorter intervals. Policyholders benefit from multiline/multiyear products because loss costs will generally be more stable over a period of several years. Bad years will likely be balanced out by good ones. Premium stability is another advantage.

Integrated multiyear/multiline products (MMPs) provide several key advantages for clients. First, they allow clients to take advantage of the risk consolidation within
their own portfolio of risks. They also combine uncorrelated risks into an insured portfolio, allowing for efficient risk transfer and avoiding over insurance.

3.2.4.8. Multi-trigger Products

Coverage under a traditional insurance policy is "triggered" when the policyholder suffers a loss as the result of an event caused by an insured peril. As the name suggests, multi-trigger coverage require more than one triggering event. The first event is insurance-related (e.g., an earthquake or fire), while the second is often a noninsurance event (e.g., a specified increase in interest rates or decline in the stock market index). Payments for losses from the insurance risk are only paid if the second event or risk is triggered.

Multiple-trigger products (MTPs) are attractive to corporations whose earning power is heavily affected by fluctuations in commodity prices, exchange rates, or interest rates. Large, well-capitalized corporations with a relatively high risk appetite are especially well suited. Insurance risks, which usually would be retained by the company, could become a severe financial problem if coupled with another adverse economic event. A hedge for the combined risk can be provided by defining a trigger that is highly correlated with the company's profits. The remote likelihood of the simultaneous occurrence of two uncorrelated events means that coverage can be provided relatively cheaply.

3.2.4.9. Contingent Capital

Risk is generally transferred or financed before the occurrence of a loss event. Contingent capital represents one way of financing a loss after the event has occurred. Contingent capital may be particularly useful in financing low frequency/high-severity exposures. Contingent capital is similar to a line of credit except that access to the capital is conditional (contingent) upon the occurrence of (i) an insured event and (ii) an impact of a predetermined size on some measure of company financial performance (such as certain financial statement items). If both (i) and (ii)
occur, then the company is assured of a cash infusion in the form of a loan at its
time of greatest need. Put options (which give the owner the right to sell at a
predetermined price) on a company's own stock also can be used in the case where
item (ii), the financial trigger, is the company's stock price. While contingent capital
solutions can provide liquidity to a company when it needs it the most, possibly
even sparing it from insolvency, the financial impact can still be severe. Risk is not
actually transferred but is instead merely spread over time, nor is risk diversified
across other lines or pooled with other policyholders.

### 3.2.5. Risk financing through Reinsurance and Securitization

The traditional mechanism for transferring and managing risks in the insurance
industry is reinsurance. However, it is seen that securitized alternatives such as
bonds, options, and swaps have become available. Here the advantages and
disadvantages of reinsurance and securitization and an analysis of whether
reinsurance and securitization are appropriately viewed as substitutes, complements,
or some combination are brought out.

Cummins and Trainar (2009) conclude that the two approaches (reinsurance and
securitization) are generally complements but may be substitutes for certain types of
risk, such as the risk of large catastrophes. The traditional risk warehousing model
whereby risks are diversified internally by an insurer or reinsurer continues to be a
powerful approach to financing risk but works best when risks are numerous and
statistically independent and where maximum probable losses are relatively small.
With many, relatively small, independent risks, the amount of equity capital
required is also relatively small, such that the cost of capital tends to be low and the
price of insurance is close to the expected loss plus the expense loading.

Correlation among risks may both dramatically increase the amount of equity
capital required to support the risk warehouse and raise the cost of capital. The
effects are even more dramatic for risks that are not only correlated but highly
skewed. Risks with large maximum probable losses also stress the capacity of traditional insurance and reinsurance markets. For such risks, securitization may be the most efficient solution.

As the costs resulting from covariability, skewness, and high potential losses increase, securitization begins to substitute for reinsurance, but for the very highest level of risk reinsurance may be uneconomic and hence reinsurance and securitization are complementary. However, for larger, more correlated risks, securitization begins to compete with reinsurance, and securitization may be the only solution for the largest, most catastrophic risks.

Another dimension, complementary between reinsurance and securitization relates to credit risk. Insurance-linked bonds generally are fully collateralized, providing the hedger with a high degree of protection against the risk of default. By contrast, reinsurance substitutes diversification for collateralization when it comes to hedging the risk. But the diversification offered by reinsurance is only efficient as long as a substantial number of the reinsured events do not occur at the same time.

Securitization corrects for the inefficiency of the reinsurance market linked to the heterogeneity of the primary insurers, combined with the incomplete nature of reinsurance contracts.

In addition to its ability to pool relatively predictable, uncorrelated risks, the reinsurance market also has the advantage of maintaining long-term relationships between reinsurers and insurers. For the more predictable risks, at least, the reinsurance market remains open at all times, while the securitization market has been marked by sharp discontinuities, depending on economic conditions, and there have been times, including the financial crisis of 2008, when the securitization market closed down entirely. Reinsurance therefore is expected to remain the dominant player in markets that are not very opportunistic, in the sense of shifting risk management strategies in response to relatively small price differences.

Client relationships are the bread and butter of diversified reinsurers, as opposed to specialized, monocline reinsurers, which have generally developed opportunistic
strategies largely based on the securitization of the commodity they sell. The long-term relationships allow the efficient sharing of information between insurers and reinsurers and allow new information to be incorporated in reinsurance pricing.

3.2.6. Potential of ART for India

As corporate customers start demanding more innovative and customized solutions for risk management and ever increasing need for corporate to deliver shareholder value, it is likely that in future demand for ART products will be on rise and demand for solutions and products will grow steadily. Vastness of the country, ever increasing losses on account of natural disaster, growing size of risks & accumulations, entry of new insurers in the Indian market, enhanced shareholders’ concerns, corporate governance issues and convergence of financial services are going to be the drivers of ART in India (Godbole, 2004).

3.3. Financial Contracts on Weather Variables

In this context, a definition of financial weather contract is necessary before looking at how ART is used for mitigating weather.

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 a weather variable, measured at a stated location" (Anshul and Surendra 2006).

Ghiulnara, et al (2010), Weather is more than an element of the environment; it is a major economic factor. Weather affects economies worldwide, having a serious impact on revenues and earnings. Until now, there was nothing a business could do about its weather exposure.

Risks originating from natural events sometimes lead to unexpected negative impacts on a project’s cash flows or value. In order to face these risks and to attract financing, it is necessary to mitigate the risks in a way that diminishes the probability of appearance of such events. One way to manage weather risks is to use
weather derivatives. It is important that the various market participants (farmers, consumers, financial intermediaries, etc.) understand the benefits and risks associated with weather derivatives (Sharma and Vashishtha, 2007).

A financial weather contract can take the form of a weather derivative (WD) or of a weather insurance (WI) contract. While the differences between the two types of contracts might be important from regulatory and legal viewpoints, from an economic perspective both instruments share the common feature of being triggered by an underlying weather index.

According to Bhaskaran (2004), a weather derivative is distinct from weather insurance. An insurance policy protects against a risk. But to be entitled to a claim, the policyholder must have incurred the loss and be able to prove it. The Insurer will not automatically settle the claim. Further, an insurance policy is given for loss due to an event that is often not defined precisely. As against this, a derivative contract is enforceable on the happening of an event whether or not a loss is incurred. Moreover, a derivative contract is structured on an event that is defined minutely. Finally, an insurance contract is always bilateral, whereas a derivative contract can be both bilateral and exchange-traded. It is therefore, possible to hedge with and speculate through a weather contract, which is inconceivable in an insurance policy. Thus, although a weather derivative resembles an insurance policy and protects the downside risk, it is not an insurance contract.

In many ways, the weather market represents a frontier of convergence between the insurance market and the broader financial markets. As the market grew, it quickly attracted involvement not just of other energy traders but also of insurers and reinsurers, investment banks, and hedge funds. Although the insurance industry was accustomed to providing coverage for more catastrophic risks than the seasonal weather variations covered by the weather market, it found the weather market attractive for two reasons. First, there was a close similarity between weather derivatives and traditional 'mother nature' insurance products covering property damage and business interruption, and second there was a strong overlap between
the skills needed to participate in the weather market and the insurance industry's core actuarial and risk management expertise. At the same time, investment banks and commercial banks saw weather derivatives as a financial risk management product that they could cross-sell along with other financial products for hedging interest rate or currency risks. Finally, some commodity traders and hedge funds saw opportunities to trade weather on a speculative basis, or to take advantage of arbitrage opportunities relative to other energy or agricultural commodities. Today, all three sectors - energy trading, insurance, and the capital markets - are well represented in both trading and origination activities.

To address the needs of non-energy end-users, and to advance the variety of weather risk management capabilities available to all market participants, the range of products available in the market has been greatly expanded via continued innovation. Weather transactions today can be structured to cover almost any type of weather variable (temperature, rainfall, snow, wind speed, humidity, etc.), to have terms from as short as a week to as long as several years, and to have potential payouts ranging from a few tens of thousands of dollars for small risks to as much as $100 million or more for much larger exposures.

3.3.1. Weather Risk

Weather risk can be defined as the uncertainty in earnings and cash flow on account of weather volatility. Electricity companies, users of electricity, super markets, cold chains, travel and hotel industry, farmers and agro processing industries are a few names that come to one's mind immediately wherein weather risk is pronounced. Agricultural production, for instance, depends on the time of arrival of monsoon, normal levels of precipitation, normal length of monsoon etc. Any change in the pattern of rainfall affects the volume of agricultural production. A prolonged rain or a shortfall in rainfall will affect the production volumes. It follows, therefore, that if variability in rainfall can be structured into a contract, it should be possible for the farmer to protect himself against a downside risk in production volumes (and his income) by selling and/or buying rainfall futures. It should be remembered that a
fall in production will increase the spot and futures price. But the increase in price may not be sufficient to compensate the loss in volumes. Hence, there is need for a weather derivative. Similarly, if a company's raw material is agricultural produce, whose price is a function of market arrivals, it can hedge itself by a put or call on rainfall derivative, which will be a proxy to market arrivals. No doubt, these companies have access to commodity markets. But, weather derivative is a more specific hedge and not a mere price hedge.

Weather risk has some specificity compared to other sources of economic risk: in particular, it is a local geographical risk, which cannot be controlled. The impact of weather is also very predictable: the same causes will always lead to the same effects. Moreover, weather risk is often referred to as a volumetric risk, its potential impacts being mainly on the volume and not (at least directly) on the price. This explains why hedging of weather risk via the trading of commodities futures is difficult and imperfect. For example oil futures price does not depend solely on demand (cold winter) and can be high even if demand is low in case of a war for instance.

Weather risk is unique. It is volume related in the sense that weather has more to do with yield changes/losses and volumes than price changes. It has certain attributes that set it apart from commodity price risks and other risks. Whereas commodity markets have spot and physical markets, weather has no such attributes. The pricing of weather derivative is therefore not a function of spot or physical market. The price is either bilaterally decided or based on demand and supply issues. Often, price is decided by the financial implications of the buyer of contracts. To this extent these derivatives are not efficient in price discovery.

Volumetric risk is imprecisely compensated by the price variation in the futures position. Usually, when subject to some risk, it is possible to hedge against it by contracting some insurance policies. But, this is not really a possibility for weather risk for two main reasons: First it is more a high frequency – low severity risk but also the same weather event can generate economic losses for some agents and
some gains for others. As an example, we can think of a tourist place. If it rains one day during the summer, this is a bad day for providers of outside activities but this will not lead to tremendous losses. On the contrary, if the whole season is cold and wet, this could lead to the bankruptcy for some local businesses. Some rain in this case could be interesting for coffee shops and indoor businesses. Therefore, weather risk is a risk that is part of everyday life, having limited economic consequences on an everyday basis but with some huge potential consequences in its accumulation or repetition. Insurance is not a well-suited solution, as it could be for dramatic weather events such as hail, storm, or drought. To deal with this risk, some financial contracts depending on weather conditions (temperature, rainfall, snowfall etc.) were created and introduced on the financial market 10 years ago and are known as weather derivatives (Pauline Barrieu and Olivier Scaillet 2010).

The weather market has quickly expanded beyond the U.S., both in terms of the types of risks being addressed and the nationalities of firms involved in the market. Countries in which weather transactions have been completed include the U.S., the U.K., Australia, France, Germany, Norway, Sweden, Mexico, and Japan.

3.4. Management of Weather Risk

The website www.wrma.org covers basics of weather risk management, trading in weather risk etc. The same is as below.

Weather challenges a wide spectrum of businesses: utilities, transportation, construction, municipalities, school districts, food processors, retail sales and real estate are simply a start to a long list of sectors whose revenues, costs and financial performance are sensitive to weather. Cold winters result in high heating bills which pressure the budgets of school districts and erode the margins of real estate property operators. Adverse financial impacts result from adverse weather. The weather risk market makes it possible to manage the adverse financial impact of weather through risk transfer instruments based on the weather element – temperature, rain, snow, wind, etc. – which affects revenues, costs or margins. In its simplest form an enterprise affected by weather pays a premium to a risk taker who assumes the risk,
defined in terms of a weather element, posed by adverse weather. In exchange for
the premium the risk taker, under certain pre-defined circumstances, will pay the
buyer an amount of money which corresponds to the loss or cost increase caused by
the weather.

Adverse weather creates adverse financial conditions, which can be managed by
financial instruments or insurance policies built around the weather element to
which the buyer is exposed. The outcome of purchasing the risk transfer instrument
is to limit the adverse impact of weather on the buyer’s economics and to finance
the consequences of adverse weather conditions when and if they take place. Insurers, banks, financial houses, specialist companies and exchanges make their
business in assuming weather risks from those with natural exposures, often through
brokers and other intermediaries.

3.4.1. Trading of Weather Risk
A wide range of capital providers make markets in weather risk per se. The
existence of this market makes it possible for risk takers in the risk management
market to manage their portfolios of weather risk business and for market
participants to find value in the dynamics of the market itself. A risk taker, who has,
for example, accumulated weather exposures around Chicago, may be able to sell a
portion of these exposures to a counterparty who is looking for Chicago exposures
or to exchange a portion of these exposures for weather exposures in South Africa,
Belgium or Japan in order to diversify its business. Beyond this level of trading is
the identification of anomalies within the weather space itself – e.g. aberrant
behavior of climatological regions which normally are statistically correlated –
which provide the opportunity to create value from the trading of weather risk. This
trading activity creates value, increases diversity, restructures weather risk as it
exists in the market and facilitates market efficiency within the realm of the weather
risk business generally.

Over the last two years the cross trading of weather and commodities has grown
significantly, adding a new component to the trading of weather. The two markets
compliment and supplement each other in a variety of circumstances. For example,
risk takers may develop exposures in the upper mid west to low precipitation (e.g. drought insurance) which may be managed in part by the purchase of calls on wheat prices given that drought usually results in lower than expected supply which usually drives up prices. Commodity traders can stand this thought process on its head to manage their price positions. There are a variety of such combinations in which the two markets interact. Additionally, it is possible to combine weather risk and weather-related commodity risk in bundled or triggered structures which will respond, for example, if winter weather is both exceptionally cold and the spot price of natural gas is unusually high. The combination of weather and related commodity risk adds depth and breadth to the weather market and is the source of innovative products being offered in the native risk management arena. The scope of this trading extends to areas beyond energy and agricultural commodities into stocks and also into new risk areas, particularly environmental risks such as emissions and carbon.

The weather trading market is created by financial houses, trading organizations, specialist companies, hedge funds, banks, insurance companies and exchanges, often in conjunction with intermediaries. Trading transactions are effected almost exclusively on a derivative basis in a wide variety of structures (e.g. swaps, collars, floors, caps, straddles, puts, calls, etc.), over the counter, on exchanges or via specific weather based indices.

3.4.2. Structuring Basics for weather risk management

There are a few fundamental steps common to every weather risk management process for buyers with natural exposures to weather:

a. Identify the critical weather variable or variables
b. Identify the impact of the weather variables on revenues, margins, profits and/or costs.
c. Identify a reliable, neutral source of historical data and current recordings of the weather variables (usually a government agency such as the National
d. Identify the date period during which the weather variables’ influence is operative (e.g. hot weather influences air conditioning use primarily in the summer).

e. Quantify the relationship between changes in the weather variables and changes in the financial parameter affected by weather.

f. Establish sensitivity to the changes in the financial parameter and translate the sensitivity into terms of the weather variable.

This process is not always straightforward, and it normally is an iterative process. Data quality and availability often are major issues, and the weather exposures of each business segment – e.g. utilities, retail, transportation or municipalities – may have its own idiosyncrasies. Nonetheless, in virtually all cases these steps are fundamental to assessing the weather risk and structuring a weather risk management solution to manage a concern’s natural exposure to weather. They underlie the case studies below, which are offered generally to illustrate some of the structures under which weather risk is transferred.

Embedded in weather risk analysis is the recognition that in most cases weather risk is a volumetric risk. Variations in winter temperatures are the major determining factor in variations in the volumes of gas consumed for ambient heating. Amounts of rainfall are a significant determinant of crop yield. Snowfall reflects the masses of snow which have to be cleared from roads and runways. The economic limit is developed by applying costs – historical, projected or budgeted – onto the changes in volumes linked to the changes in weather.

Essentially there are three types of weather risk programs, based on:

a. **Aggregate measures** of weather variables over a defined period, such as average temperatures, cumulative degree days total snowfall, total rainfall. Aggregate based programs respond to the total of the values of the weather variable – e.g. 40 inches of total snowfall in a season.
b. **Adverse Days**, where an adverse day is defined in terms of a weather variable, such as days in which the average temperature is less than 0°C, or rainfall totals exceed 1.5 cm. Adverse day programs respond to the number of days which are characterized by the adverse condition – e.g. 10 days in the winter in which the maximum temperature is less than 15°F.

c. **Adverse Events**, in which the program responds to the occurrence of a weather condition – e.g. a day on which the maximum recorded wind speed exceeds 50 mph during the term of the agreement.

The analysis of weather variables and their relationship to financial parameters will identify the type of program which corresponds to the risk.

### 3.4.2.1. Aggregate Measures of Weather: Cool summer and Ice Cream Sales:

Aggregate measures of weather, precipitation and temperature preeminently, affect the demand for (and supply of) a variety of products. Much attention has been devoted to the role of temperature. Utilities, for instance, have been the main purchasers of aggregate temperature structures. For example, if winters are warm less natural gas is consumed for ambient heating. Cool summers similarly imply less electricity consumption for air conditioning. For utilities aggregate temperature usually is determined by the number of Degree Days: Heating or Cooling Degree Days being the difference, respectively, between 65°F and the day’s average temperature. The result of this daily computation can be summed – i.e. aggregated - over a defined period to establish whether a season is unusually warm or cool. Temperatures are measured at a pre-agreed weather station, in the U.S., usually administered by the National Weather Service.

Utilities are not the only sector for which demand is sensitive to weather. Food, beverages, apparel, chemicals, agriculture, leisure/sport are sensitive to seasonal aggregate measures of weather such as precipitation or temperature.

As an example let us consider the business of ice cream. Assume that a dairy in the Chicago area reviews its annual sales and sees that peak season sales in the summer are affected by weather. In cool summers sales drop off, in hot summer’s sales peak.
The more are the CDDs, warmer the summer, greater the sales; conversely, the fewer are the CDDs, cooler the summer, lesser the sales. If the dairy pegs its production to summer temperatures, it may find that its sales in cool summers become critically short if the summer is 10% cooler than average during the critical ice cream consumption period. At this level of temperature revenues become insufficient to support the business and inventory costs become burdensome.

Analysis determines that the dairy’s loss of revenues and increased costs are approximated by a linear relationship between summer coolness (fewer CDDs), expressed in terms of $/CDD. The dairy elects to take to market a structure, based on this analysis, which begins to pay the dairy when the seasonal CDD total is less than 680 CDDs (10% less than the 20 year average) and will pay at the rate of $/CDD less than 680 CDDs until the seasonal CDD total amounts to 375 CDDs, beyond which point it no longer will respond. The 375 CDDs represents the coolest recent summer (1992). Under this structure, for each seasonal aggregate CDD less than 680 CDDs the dairy would receive $. The maximum payment would be (680 CDDs – 375 CDDs = 305 CDDs) x $/CDD. In this way the dairy would receive a payment which offsets its loss of revenues and its increased costs due to adverse summer weather. If the aggregate total of CDDs during the summer exceeded 680 CDDs the dairy would receive no payment, reflecting the conclusion of its analysis that if the summer was warm enough to result in 680 CDDs during the critical ice cream consumption period the dairy would be able to meet its basic financial targets.

3.4.2.2. Aggregate Measures of Weather: Precipitation – Agriculture

Farmers in certain parts of the southern United States desire to plant crops as early as possible in the season. If they are unable to plant early in the season they have to switch their planting strategies and they lose the opportunity to plant two crops. The critical factor is rainfall. If there is excessive rainfall early in the season farmers cannot work the soil and may not be able to move equipment onto their fields because of the soft ground. Excessive rainfall creates additional expense and lost income.
A farm cooperative offered a program to its members backed by a weather risk structure. If rainfall exceeded 9.5 inches in total in the months of February and March the farmer would receive a single payment based on lost income and extra expense due to the inability to till and plant in the early spring. Based on this structure the program would have paid to the farmers nine times in the last 50+ years.

From the two examples above it is clear that the logic of aggregate structures translates well to temperature and to precipitation exposures. Aggregate measures of weather risk apply to many other enterprises:

a. Insufficient rainfall requires increased sprinkling of golf courses and other recreational facilities.

b. Snowfall totals affect the cost of maintaining highways in the winter.

c. Combinations of snowfall and temperature are critical to ski resort revenues and the sale of ski-related apparel and equipment.

d. Average wind speeds relate to the general efficiency of wind turbine generated electrical power.

e. The combination of rain and temperature play a meaningful role in determining the demand for lawn fertilizer and swimming pool treatment chemicals.

3.4.2.3. Adverse Day Count: Agriculture – Corn (Maize) Yields

Temperature is one of the weather variables to which corn (maize) yields are sensitive. Excessive cold at germination and excessive heat in the phases before harvest reduce yields. Any party dependent on the volumes of corn harvested – farmer, grain elevator operator, agricultural credit bank – may look to manage a significant portion of the yield risk by managing the temperature risk through a weather risk management structure.

Taking the various elements into account, such as local climate, farming practices and seed varieties the buyer brought together the following critical information:
• Season: April 15 – October 31, in which cold temperature risk prevailed up to the middle of June and hot temperature risk commenced towards the middle of June.

• Expected (Average) Cold Days: 5 days with average temperature < 32ºF

• Expected (Average) Hot Days: 3 days with average temperature > 95ºF

• Impact of early season cold: loss of x bushels of grain equivalent to $20,000 revenue of harvested corn for each Cold Day.

• Impact of mid-late season heat: loss of y bushels of grain equivalent to $30,000 revenue of harvested corn for each Hot Day

• Historical maximum number cold days: 15

• Historical maximum number hot days: 13

Possible Structure
Type: Count of Adverse Days

• Adverse Days: Section A: Cold Days: Days with average temperature < 32ºF

• Section B: Hot Days: Days with average temperature > 95ºF

• Risk Period: April 15 – October 31

• Section A: April 15 – June 14

• Section B: June 15 – October 31

• Attachment (Deductible/Priority): Section A: 5 Cold Days

• Section B: 3 Hot Days

• Limit: Section A: 10 Cold Days

• Section B: 10 Hot Days

Amounts Payable, in total up to a maximum of $500,000 subject to the limitations below:

Section A: $20,000 per Cold Day after the fifth Cold Day in the Section A Risk Period, up to a maximum of $200,000 with respect to Section A.

Section B: $30,000 per Hot Day after the third Hot Day in the Section B Risk Period, up to a maximum of $300,000 with respect to Section B.

Measurement of Temperature As recorded by the NWS at the Weather Station,
during the Risk Period and reported by the National Climatic Data Center.

**Premium:** t b d

### 3.4.2.4. Adverse Events

The concepts of Adverse Events and Adverse Days are closely related. Adverse Days operate on the assumption that a certain number of days with weather conditions defined as adverse will take place during a given period. The risk management practice is to make reasonable allowance for the occurrence of such Adverse Days and to secure protection from an unusual number of Adverse Days occurrences. The reasonable allowance usually is the deductible, and the purchase of protection against the excessive condition relieves the buyer from making physical or financial allowance for the contingency. Adverse Events in the strictest sense imply that the buyer cannot tolerate the presence of the adverse condition at all.

**Examples:**

Rainout of a day, in a test cricket match of a World Series game or of a semi-final Grand Slam tennis match, means rescheduling, with increased costs for the promoter and venue and loss of audience and advertising efficacy for advertisers.

High winds during a week in which a contractor is dependent on cranes to complete a work process.

Adverse temperatures/precipitation on the day, when spraying fertilizers, herbicides or insecticides to the crops.

Adverse Event programs are structured to respond by paying the reasonably established amount of the increased costs and/or revenue loss associated with the Adverse Event taking place.

The logic of Adverse Events brings some participants in the weather risk market to offer capacity for Extreme Weather Events, of which hurricanes and typhoons are examples of prime current interest. The thought process is similar to other adverse events, in that programs are structured with respect to storms of a given strength afflicting a pre-defined area. Payments may be in relation to the strength of the
storm (e.g. wind speed or category). At present the capacity in the weather market for extreme weather event risk is relatively limited.

3.4.2.5. Further Notes

Weather risk management structures based on Aggregate Measures, Adverse Days and Adverse Events encompass the great majority of program structures used for weather risk management purposes. Among the other structures are forecast risk protections, which provide compensation if the buyer organizes its activities according to weather forecasts which, in the event, turn out to be wrong. Newly emerging, particularly in Europe, are weather-indices. Parties with weather risk can buy or sell a position on the index, in a way analogous to the trading of positions on securities indices. Indices have been developed for specific European business segments, such as warm weather indices in the summer for brewers. Another important development is the appearance of bundled weather and commodity structures. Dual trigger programs with a temperature trigger and a commodity price trigger are a basic example of such structures. They respond when there is both an adverse weather condition and an adverse price environment and focus on combinations which present the gravest risk management challenges to buyers who are sensitive to both price and to weather. Dual trigger programs operate most effectively in environments in which the commodity is a liquidly traded commodity.

Each segment of business or government, each exposure, each weather variable all have their individual characteristics around which weather risk management programs can be molded. As importantly, the weather risk management program can be tailored to meet the buyers pertinent risk management objectives which may different from one situation to another. For example: the sales of apparel retailers may be sensitive to seasonal weather, but weather conditions on critical sales days may be a significant exposure as well. Aggregate measures of temperature or precipitation over a period may respond most closely to the former concern, and an adverse day structure (heavy snow on weekends before Christmas) or an adverse event cover (weather on a critical sales day) may respond to the latter. Weather risk management programs also can serve to manage exposures that are less obvious.
One of the largest weather risk transactions has been an adverse day structure based on cold days that provides support to a government mandated fund which pays the wages of construction workers who are unable to work because of inclement weather. These examples and this discussion are intended as a starting point for those interested in managing the weather risk affecting their business and civic responsibilities.

3.4.3. Weather risk Market

The market of risk takers offering to accept the transfer of native weather risk is made up primarily of insurance companies, banks, the desks of utilities active in the weather business. Buyers can also avail themselves of exchange contracts, including index based contracts. In some cases participants in the risk management segment of the market make their chief business out of assuming third party risk (e.g. insurers and banks). Others, such as utilities, may take on such risk as diversifiers to their own, native risk.

Transaction sizes vary widely in accordance with the risk parameters of the buyers. Small and medium sized commercial and industrial buyers may require limits in the tens of thousands of dollars or hundreds of thousands of dollars. Dealing effectively with such small limit transactions requires a high level of automation and systematic means of standardizing products which nonetheless are tailored to the buyer’s circumstances. For larger enterprises limits between $10 million and $30 million are common, and larger enterprises also are well positioned to purchase multi-year agreements. The largest transaction in the market is syndicated and has an annual limit well in excess of $100 million.

3.5. Weather Derivatives

Derivative contracts generally represent a contract to trade a specified quantity of an underlying asset, at an agreed price and time. The term “derivative” is used as they derive their value from movements in the price of an underlying asset. By making a payment to a separate company that will assume the financial weather risk for them, organisations are buying a type of insurance: the company assuming the risk will
pay the purchaser a pre-set amount of money that will correspond to the loss or cost increase caused by the disruptive weather. As such, risk exposure can be managed in a wide range of settings. Weather derivatives on the other hand, derive their value from climatic conditions such as temperature, snowfall, hurricanes or rainfall.

Bhaskaran (2004), defines weather risk as an uncertainty in the occurrence of normal weather conditions affecting each and every business enterprise either favorably or adversely. Weather derivatives come into play to hedge such weather risk. The growth that weather derivatives are able to accomplish is very high.

Weather derivative is more useful in utility/service industries and areas, wherein the commodity market is not specifically available. Let us take the example of deregulated and free economy where power is privatized. It is known that a cooler than normal summer could cause a fall in sale of power, making the unit power price to go up (cost of carry being added to all). Similarly, in a severe summer higher demand for power (presumed free play of demand and supply) should increase the prices. Naturally, a consumer will be affected, if the power price was to go up, albeit on account of weather changes. Individuals seldom complain about risk as they neither have a balance sheet to publish nor stakeholders to answer. But wherever people invest in businesses which use power, there would be the normal expectation that companies manage the variability in income on account of weather changes such that risk is reduced and profitability is maintained. Similar is the case of Air conditioners' manufacturers whose sales will be affected in the event of a mild winter thereby affecting the income. A milder winter may affect the income of a woollen hosiery company. A milder summer may affect the income of a travel company as people may not relocate to cooler locations. In all these cases, the impact of an adverse weather will be a higher cost of carry and/or lower income levels. It is possible to hedge these risks by taking position on temperature known as "degree day contracts".

Till recently, nothing much was thought or heard about derivatives, as business houses did not intend/know to protect the downside of income on account of
weather impact. As most of the utility companies were government-owned, the bottom-line were unimportant! But with the deregulation of economy, more particularly the deregulation of electricity and power sector, managing weather risks has become important. That is the reason the power/energy sector has driven the demand for weather derivatives. Electric companies are aware that, consumption of power and power production are highly correlated with weather. Equally true is that they find it difficult to price the energy higher, on account of bad weather or vary the price frequently. Therefore, the price fluctuations are loaded as fuel equalization/adjustment charges. In these circumstances, trading in weather derivatives could help the power company hedge such risks and, eventually, bring down power prices.

An equally important reason for the development of this market is the deregulation of capital, finance and insurance markets. The institutions in these markets have the need to manage weather related loan risks through weather derivatives. They have also brought pressure on business houses to professionally manage risk. In the financial market, a fully risk-hedged company is considered safe for doing business and issuing of loan and investing in equity. Take the case of insurance companies. As they have risks that can be naturally hedged in the weather derivative market, they will be eventually the biggest gainers. There is a possibility that reinsurance cost could be reduced, if weather derivatives market is used efficiently. Already, we have seen the introduction of "Catastrophe bonds and options" instead of insurance to manage risks. In a way, it is a message for the business houses. It is no longer fashionable to blame the weather for losses.

Weather derivatives are of great economic importance in that they allow participants to manage a very specific form of risk. While weather futures contracts currently make up a relatively small proportion of trading in derivatives markets, it is a sector that is experiencing rapid growth – particularly as more companies recognise the correlation between weather and profit.
Primarily, weather derivatives take the shape of a bilateral contract. It is thus possible for two people to agree to pay one another, certain sum of money depending on some meteorological conditions during the contract period. Weather derivatives are traded in exchanges. It is seen that exchanges have developed weather indices and allow trade on them. There are three most commonly used forms of weather derivatives. They are Call, Put and Swap. The call and put contract can revolve around a level of temperature (known as HDD and CDD contracts) or precipitation. The put is in operation, when the temperature (precipitation in case of a rainfall contract) is less than the strike and the call in action when the temperature (precipitation) is more than the strike. In a swap, depending on the situation, the buyer and the seller make payment to one another.

What are the risks in such contracts? The Primary concern is about the cost of risk management, which could be high, in the absence of depth in the market. The other concerns are about transparency and reporting standards. But, what is more crucial in weather derivative is the bilateral pricing of the contract and the benchmarking the event. When a buyer and a seller agree upon a fixed contract period, a weather index or number to serve as the basis of contract, the price or premium in case of bilateral contracts is, often decided, based on the financial position of the buyer and buyer's estimate of impact of weather on business. This could, at times, result in the premiums being higher, on account of information availability being different between the buyer and seller. No wonder, it is reported that there are many transactions, where companies have lost huge sums in premium. Often, the desire to take multiple hedges overcomes prudence, resulting in financial losses. As yet there are no set rules. With CBOT, LIFFE and other exchanges offering weather indices/contracts it is expected that there would be more standardization of contracts and bilateral contracts will be phased out. It is, however, time that certain exposure norms on derivatives is developed so that, failures on account of derivatives will be reduced. Stricter disclosure norms are also needed. This would bring the much-needed transparency in the system and financial statements.
Weather derivatives resemble a weather insurance policy. Before the launch of weather derivatives, it is necessary to consider, whether a robust commodity exchange could offer products that could manage these risks. There are certain advantages that would accrue to the parties due to weather derivatives, which are not available in the normal commodity futures market, such as absence of basis risk, one upfront premium and absence of intermittent cash flows. However, in a country like India, where deregulation process is still nascent, introduction of weather derivatives may have to wait. It would be ideal, if weather derivatives are introduced in a more mature market (Bhaskarn, 2004).
The development of weather derivatives market is in Table 3.1.

### Table 3.1: Chronology of main events on the weather derivatives market

<table>
<thead>
<tr>
<th>Year</th>
<th>Developments of weather derivatives market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-99</td>
<td>First weather derivative on a standardized market in the US (CME)</td>
</tr>
<tr>
<td>Oct-99</td>
<td>Launching of a new activity dedicated to weather derivatives: Goldman Sachs and Merrill Lynch decide to launch a new structure to attract institutional investors and to promote the weather derivatives market</td>
</tr>
<tr>
<td>Nov-99</td>
<td>Koch Energy Trading launches the first bond linked to climate</td>
</tr>
<tr>
<td>Mar-00</td>
<td>Enron and Koch use Internet technologies to promote transparency and to boost transactions</td>
</tr>
<tr>
<td>Oct-00</td>
<td>World Food Program: A research team from the World Bank explores the way to link climate and insurance, to help developing countries</td>
</tr>
<tr>
<td>Feb-01</td>
<td>Protection of fragile economies against weather risk: The World Bank and the International Finance Corporation take the initiative to propose governments and firms protection against weather risk</td>
</tr>
<tr>
<td>Jul-01</td>
<td>Six European banks enter the weather derivatives market</td>
</tr>
<tr>
<td>Jul-01</td>
<td>Partnership between Axa and Meteo France for the development of weather derivatives</td>
</tr>
<tr>
<td>Nov-01</td>
<td>Transaction: ABN AMRO makes a first deal on the weather derivatives market</td>
</tr>
<tr>
<td>Dec-01</td>
<td>Launching of new products: LIFFE launches futures based on temperature in three European cities</td>
</tr>
<tr>
<td>Mar-02</td>
<td>Clearing house: Powernext considers the possibility of creating a clearing house for weather derivatives on OTC markets</td>
</tr>
<tr>
<td>Jun-02</td>
<td>Enron crisis and decline of the weather derivatives market</td>
</tr>
<tr>
<td>Jun-02</td>
<td>Société Générale investment bank launches its first weather-linked bond</td>
</tr>
<tr>
<td>Feb-03</td>
<td>Standardization of weather contracts: ISDA makes rapid progress in standardizing weather contracts</td>
</tr>
<tr>
<td>Nov-03</td>
<td>Transaction: ABN AMRO sells a protection against weather risk. It is based on cold temperatures in Amsterdam. The contract is sold to “cold weather risk fund” administrators. This derivative was meant to provide support for the government-mandated fund that pays the wages of construction workers who are unable to work because of inclement weather</td>
</tr>
<tr>
<td>Jan-04</td>
<td>EDF hedges against risk of storm. The product is structured by CDC Ixis Capital Market</td>
</tr>
<tr>
<td>Jun-04</td>
<td>Increase in market liquidity thanks to hedge funds</td>
</tr>
<tr>
<td>Nov-05</td>
<td>Powernext and MeteoFrance launch temperature indices</td>
</tr>
<tr>
<td>Dec-05</td>
<td>Hedge funds contribute to market liquidity and to the development of the weather derivatives market</td>
</tr>
<tr>
<td>Apr-06</td>
<td>Weather derivatives in Ethiopia: An insurance contract is signed between the World Food Program and AxaRe</td>
</tr>
<tr>
<td>May-07</td>
<td>Metnext creation: Meteo France and Euronext create a joint venture specializing in weather derivatives</td>
</tr>
<tr>
<td>Sep-07</td>
<td>Merrill Lynch launches a protection for Italian farmers</td>
</tr>
<tr>
<td>Jan-08</td>
<td>Launching of a climate index by UBS</td>
</tr>
</tbody>
</table>

An important set of contracts traded on the Chicago Mercantile Exchange (CME) are temperature-based futures contracts. Contracts are offered for trade based on the temperature across a range of US, European and Australian cities such as Brisbane, Sydney and Melbourne.

The most common of these contracts come in the form of either Heating Degree Day (HDD) or Cooling Degree Day (CDD) contracts. The payoff of these contracts is based on the cumulated difference in daily temperatures relative to $18^\circ$C over a fixed period such as a month. The fixed level of $18^\circ$C is the temperature at which the energy sector believes little heating or cooling occurs in households. The buyer of a HDD or CDD contract benefits from a positive payoff if cumulative temperature is below or above a specified level. While this nomenclature may seem counter-intuitive, heating (or cooling) occurs when temperatures are lower (higher).

Major participants in this market include utilities and insurance companies, whose costs and or revenues are dependent upon weather conditions. In an Australian setting, an electricity supplier normally provides its customers with electricity at a fixed price irrespective of the wholesale price in the National Electricity Market. However, the wholesale price of electricity can fluctuate wildly with extreme weather conditions. CDD contracts can provide a hedging tool for such fluctuations in electricity prices in the wholesale market during periods of extremely high temperatures. Similar arguments apply in the northern hemisphere, where utilities face risk from increased demand during periods of low temperatures and hence HDD contracts are a natural hedging tool.

Futures on traditional assets such as stocks, bonds, agricultural and most energy products are priced under the cost of carry approach. The logic of this approach is that there are two alternatives for obtaining the asset in question at some point in the future. These are either, borrow to purchase it now and store the asset, or agree to purchase the asset at that later date via a futures contract. Under the absence of arbitrage, the cost of both approaches should be equivalent. Hence the current cost of a futures contract is related to the current price of the asset and the cost of
borrowing and storing the asset. This arbitrage-free valuation approach is a simple yet common method for pricing many financial securities.

Weather derivatives have also gained research attention in academic circles as they represent unique pricing problem. The cost of carry method is based on the possibility of storing, or holding the underlying asset. (Financial securities such as stocks or bonds do not obviously required to be physically stored). However, in the case of weather contracts such as HDD or CDD, the underlying asset is not storable in any meaningful way.

As such, the cost of carry approach is not relevant and pricing is based on a discounted value of the payoff from the futures contract. A statistical model is required to generate the possible range of outcomes that the underlying weather index may take and subsequent payoffs ensuing from the derivatives contract. The discount rate will be market determined given the prices for contracts that the market will bear.

The differences between insurance and a derivatives market are provided in table 3.2.

Table 3.2 : Differences between an insurance and a derivatives market.

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Insurance market</th>
<th>Derivatives market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective of the market</td>
<td>Protection against risk</td>
<td>Protection against risk Exploitation of new financial opportunities</td>
</tr>
<tr>
<td>Nature of the product</td>
<td>Fine-tuned solutions Heterogeneity</td>
<td>Tradable on a secondary market irrespective of the nature and tradability of the underlying asset Sufficiently objective definition to allow for re-trading on a secondary market Sufficient homogeneity to allow for re-trading on a secondary market Has volatility, is uncorrelated with other financial assets, can be managed like other financial assets to pursue hedging or arbitrage strategies. Free circulation</td>
</tr>
<tr>
<td>Characteristics of the actors</td>
<td>Mutual identification (face-to-face relationships) Networks and personal recognition Monopoly on insurance products</td>
<td>Actors with different risk profiles Great number of actors</td>
</tr>
<tr>
<td>Nature of exchange</td>
<td>Interpersonal</td>
<td>Sufficiently impersonal for tradability on a secondary market to remain possible</td>
</tr>
</tbody>
</table>

3.5.1. Construction of Weather Derivatives Contracts

A weather derivative involves a buyer and a seller. They mutually agree on a contract period and weather index, which would serve as the basis of transaction. The contract is formulated by specifying the following parameters.

- **Contract Period**: It is now, internationally agreed that in weather contract, summer is from May to September and winter is from November to April. Contracts are structured within this broad classification.

- **Weather Station**: Any official weather station is identified, from where the data regarding temperature/rainfall etc would be collected. This will form the basis of other details to follow.

- **Definition of weather index**: For rainfall we can call it R which would be the underlying contract.

- **Strike (S)** indicating the strike level of rainfall or precipitation.

- **Tick (T)** which could be an agreed payment for a given change/variation in rainfall.

- **Premium**: This is arrived at mutually negotiated rates or decided by the exchange, in case of indexed trades.

With the above, the payment that the seller is bound to make will be decided as under.

In case of a call, payment would be: \( P_{(\text{call})} = T_{\text{max}} (R - S, 0) \)

For a put payment would be: \( P_{(\text{put})} = T_{\text{max}} (S - R, 0) \)

Which means that, in the case of a call, payment is made when the rainfall / precipitation is higher than the strike level mutually agreed upon and in the case of a put payment is made when the rainfall is lower than the strike.

In the case of a call, the seller of a contract receives premium, initially from the buyer. At the end of the contract period, the buyer will get payment if the rainfall is more for an amount equal to the excess rainfall i.e \( T (R - S) \). At times parties could agree upon a fixed sum and may not link it to the variation in the rainfall and the strike. In the case of a put, payment equal to \( T(S - R) \) will be made, if the rainfall is...
less than the strike. Here also, a fixed amount of payment can be agreed upon notwithstanding the rainfall variation to the strike. Given that variability of rainfall will affect the price and the farmer may have some losses, the derivative income should help to some extent.

A collar is a combination of a Call option and a Put Option. It entitles the buyer to a payout per unit of Weather Index in excess of the Call Strike. But it obliges the buyer to make a payout per unit of Weather Index below the Put Strike. If the value of the Weather Index ends up between the Call Strike and the Put Strike, no payout is due by either side. There is usually no premium for a Collar and all payments are subject to a Maximum Payout. The profile of Call, Put and Collar are provided in figures 3.1 to 3.3.

A Swap contract between two parties (A & B) requires no upfront premium. But, on the conclusion of the contract they pay each other (as if A has a call position and B has a put position) depending upon whether the strike was less or more than the actual weather index/number. But here it is essential that the parties take the opposite position and the premium on a call and a put is the same.

Figure 3.1: Profile for a call option

Source: www.corioliscapital.com/weather.html
Weather derivatives focus on day-to-day variations in weather conditions and not on one-off disasters such as hurricanes or cyclones that are taken care of by insurance. Day-to-day variations happen frequently and have a more subtle effect on the profitability of many businesses. For instance, a rise or fall in temperature may have
an effect on the sale of ice creams. Similarly, the amount of rainfall decides the fate of our crops and wind speed may affect the viability of a wind power project. Weather derivatives bring together those who want to hedge their risk and those who want to assume the risk. It makes trading of weather risk possible in the form of a financial instrument. A party willing to protect himself from the vagaries of nature transfers his risk to someone who is willing to play the role of an adventurous risk-taker by taking a fee. In case nature remains within its expected limits, the risk-taker earns a profit; however, in case of greater fluctuations, the risk-taker has to take a loss. The remarkable thing is that the profit or loss arising out of a weather derivative is not correlated at all with the trends in the financial market. Stock or bond markets may rise or fall together. But a rise or fall in the city temperature has nothing to do with the rise or fall in the stock market indices. A weather derivative remains unaffected by the general mood of the financial market. Investments that aren’t correlated have their own charm for some investors.

3.5.2. Valuation of weather derivatives

There is no standard model for valuing weather derivatives similar to the Black–Scholes formula for pricing European style equity option and similar derivatives. That is due to the fact that underlying asset of the weather derivative is non-tradable which violates a number of key assumptions of the BS Model. Typically weather derivatives are priced in a number of ways:

3.5.2.1. Business pricing

Business pricing requires the company utilizing weather derivative instruments to understand how its financial performance is affected by adverse weather conditions across a variety of outcomes (i.e. obtain a utility curve with respect to particular weather variables). Then the user can determine how much he is willing to pay in order to protect his/her business from those conditions in case they occurred based on his/her cost-benefit analysis and appetite for risk. In this way, a business can obtain a 'guaranteed weather' for the period in question, largely reducing the expenses/revenue variations due to weather. Alternatively, an investor seeking a certain level of return for a certain level of risk can determine what price he is
willing to pay for bearing particular outcome risk related to a particular weather instrument.

3.5.2.2. Historical Pricing (Burn analysis)
The historical payout of the derivative is computed to find the expectation. The method is very quick and simple, but does not produce reliable estimates and could be used only as a rough guideline. It does not incorporate variety of statistical and physical features characteristic of the weather system.

3.5.3. Weather Derivatives market
The weather derivatives industry is relatively young. This derivatives sector began to develop in 1997, as a result of the severe weather events of El Niño. The El Niño events of 1996-1998 were the first such major climate forecasts that the meteorological community forecasted correctly. The El Niño winter of 1997-1998 was forecasted to be unseasonably mild. This caused numerous companies that had earnings tied to weather to realize the importance of hedging their seasonal weather risk. During this time, the insurance industry was in a position to make available a sufficient amount of capital to hedge weather risk. There were a large number of options with payouts tied to weather events that were written by insurance companies, which increased the liquidity. To further increase the size of the weather derivatives market and to remove the counter-party credit risk involved in over-the-counter weather contracts, the Chicago Mercantile Exchange (CME) introduced the first exchange-traded, temperature-related weather futures and options on September 22, 1999. The CME contracts give large and small investors the opportunity to hedge their weather-related risks using liquid, standardized contracts with the additional benefit of having access to the best available prices at all times. A significant advantage of the CME’s exchange-traded contracts is the presence of the CME Clearing House, which reduces counter-party credit risk by guaranteeing performance of both parties in a weather futures or options contract. The CME Clearing House acts as the buyer for every seller and the seller to each buyer, thus ensuring that each party honors their financial obligation.
There are two primary markets for exchange traded (standardised) weather derivative contracts that cover US, European and some Canadian cities. The two major exchanges that offer an automatic and standardised market for the trading of weather derivatives are:

The Chicago Mercantile Exchange (CME), has the largest weather derivatives market in the world. The exchange offers both futures and option contracts over a range of US and European cities.

London International Financial Futures and Options Exchange (LIFFE), in July of 2001, launched a series of contracts based on indices related to the daily average temperatures in London, Paris and Berlin. This organisation has been working with several technology companies to create an internet based trading platform for European weather derivatives.

The acceptance of weather derivatives has been slower in Europe than in the US market. One of the main reasons for this is the lack of a standardised weather-recording framework that exists across the Atlantic. This is as a result of the many individual countries that make up Europe who have vastly different levels of development, which has meant that it has historically been very difficult to obtain consistent, reliable data. The recent expansion of the European Union (EU) and the creation of a single European currency should greatly facilitate the propagation of unified procedures for data capture and analysis.

More recently Asia, and in particular Japan, have become a source of weather derivative demand as their energy markets gradually became deregulated. The first official transaction in Japan was during 1999 between Mitsui Marine and a local sporting goods manufacturer that consisted of an option over the snow depth recorded for the following winter season. Natsource Japan, a large energy-based broker, is one of the major promoters of weather derivatives in Japan and has created a measure, the Japan Weather Derivatives Index (JWDI), around which market participants can design weather risk management products. As well as this the company has created an interbank electronic exchange, the Japanese Weather
Exchange (JWX), on which the large financial organisations can transfer weather risk both within Japan as well as to the rest of the world.

The first weather derivative contract in Australia occurred in March of 1998 between United Energy Marketing and Utilicorp4, a US based energy utility. The contract called for a payout if the temperature rose above 35°C in Melbourne or 33°C in Sydney for 5 days or more during the summer months. As it turns out Sydney reached this level on 5 days and Melbourne on 6 days and hence the contract exercised at roughly 8 times the initial one-off premium paid.

According to WRMA survey, conducted by PricewaterhouseCoopers LLP (PWC) for the year 2010-11 brings out that the market for customized weather derivatives grew by nearly 30% with the overall market increasing by 20%. The total notional value for over-the-counter (OTC) traded contracts rose to $2.4 billion, while the overall market grew by $11.8 billion. Worldwide, temperature contracts remain the most traded customized weather hedge. Growth was also seen in rainfall, snow, hurricane and wind contracts, representative of increased end user participation from a wider variety of industries such as agriculture, construction and transportation. Geographically, the number of contracts traded rose in the US, Asia and Australia with Europe posting the biggest gains.

The growth in the customized weather derivatives market shows increasing participation from a wide variety of end users who recognize the value of actively managing their weather risk. The increased balance between the exchange-traded market and the OTC market demonstrates a greater interaction between market participants which creates a strong platform for future growth.

3.5.4. Examples of few Sectors affected by weather

a. Biofuels
In countries where the trend is to use more biofuels for transportation and power generation, weather risk management tools are essential. In the biofuels market, mitigating weather risk is a key to keeping biofuels operations viable. If the yield on a biofuels crop is less than expected due to lower than normal temperatures, a
weather risk product can be used. If the crop has been hedged using a temperature-related weather risk product, the dollar amount of the crop loss is offset by the payout of the weather hedge. While a weather hedge won't replace lost barrels of ethanol, it can help the biofuels producer to continue to operate instead of suffering what could be a crippling financial loss.

b. Weather Risk for winter
Winter weather including snowfall, ice and subzero temperatures have created challenges for businesses and municipalities. The unpredictability of winter weather creates uncertainty for companies to plan for energy uses, snow removal, and sand and salt costs – ultimately leading to budget overages and mounting costs throughout the winter season.

Major snowstorms are extremely costly, but with the prudent use of weather risk management tools – futures, customized contracts and reinsurance – businesses can protect profits and assist municipalities in managing their budgets. The cost of snow removal on roads and walkways has weighed heavily on towns and cities. By using a snowfall hedge to mitigate the weather risk, municipalities could prudently manage costs related to the storm. The level of service could remain high while the burden on taxpayers could be reduced or eliminated.

c. Snow Futures
Snow removal companies and salt/gritting companies are beginning to see the benefits of hedging the economic impact of snowfall and cold temperatures. U.S. salt companies are already using snowfall futures to hedge their winter financial risk exposure, thereby helping to smooth out revenues.

Snow futures and options contracts were launched on the CME Group’s Chicago Mercantile Exchange in 2006 for New York Central Park and Boston Logan International airport. In 2009, CME Group expanded the number of cities to include Minneapolis/St. Paul Airport, Detroit Metro Airport, Chicago O’Hare International Airport, and New York LaGuardia Airport. Snow futures and options can be traded on a monthly or seasonal basis. CME Group also offers binary options, which are
being used to lessen the economic consequences from below normal snowfall or above average snowfall.

d. Frost Day Certificates
In the UK, it is typically cold weather, not snow, that’s the primary culprit during the winter. Gritting companies are now using Frost Day Certificates as part of their risk management programs. Frost Day Certificates are a cost-control solution whereby purchasers receive an automatic payout if a predefined parameter for the number of frost days is met. This allows gritting companies to manage their costs when there’s an extended period of cold weather, resulting in increased demand for gritting.

e. Construction Industry
The European construction industry is also using Frost Day Certificates to offset the impact of cold weather on revenues. In The Netherlands, labor agreements prevent workers from working in freezing temperatures. If temperatures are below freezing at 10 am, construction worker aren’t allowed to be on construction sites and must be sent home with pay. If the freezing weather is extensive, the cost of wages and lost production could extremely detrimental to a company’s balance sheet. By using Frost Day Certificates, a construction company can minimize its financial risks. During the winter of 2010-2011, Dutch companies took out several million Euros in coverage to prevent losses from severe, sustained cold weather thereby protecting revenues from being adversely affected by the weather.

f. Outdoor Recreation and Tourism
Profits generated by outdoor recreation and tourism businesses, such as ski resorts, are tied to winter weather conditions. Weather derivatives can be used to offset the financial impact of warm weather and/or lack of snow on a ski resort. These financial tools would augment a ski resort’s artificial snowmaking efforts. A weather derivative can be employed for a set period of time, such as a busy period for the ski resort, when insufficient snowfall can cut into profits. Ski resorts use weather derivatives to hedge risk since traditional insurance products may not provide comparable coverage or are unavailable.
g. Traditional Energy
The energy industry has used weather risk management tools for a number of years. Utilities look at weather forecasting models to determine likely energy usage by consumers. It is very advantageous for utilities to correctly forecast energy demand. Should utilities come up short, they will need to purchase power on the spot market. That can be extremely expensive. However, a prudent utility will have used weather risk management tools to hedge that scenario.

h. Renewable Energy
Renewable are subject to the impact of winter weather as well. While not a daily occurrence, wind farms have been shut down due to icing on the turbines. With no power being produced, the owner of the wind farm likely will need to purchase power on the spot market to supply its customers. By using a weather risk management tool, the utility can mitigate the impact of purchasing replacement power at market rates.

3.6. Summary
In the above discussion it has been dealt with weather risk, its management, weather risk markets, ART instruments and weather derivatives. Amongst various weather parameters for Indian economy, rainfall plays a vital role. The rainfall risk management has been dealt in chapter 4.

3.7 References


