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WEATHER DERIVATIVES: A STUDY ON NEED AND IMPEDIMENTS IN INDIA

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Abstract: Weather whims do not fall under the brackets of uncommon phenomenon, however, may be obscure. Many industries and sectors are affected by the weather. Unpredictable changes in weather might result in financial losses that may range from paltry to substantial. To help hedge against possible risks, derivative instruments called as weather derivatives come to play, that are based on atmospheric changes. Such weather instruments are relatively new instruments in the derivatives market, having been introduced in the US for the first time in 1997. Later, these instruments began to achieve traction in other developed as well as developing countries, such as, the UK, Australia, France, Germany, Norway, Sweden, Mexico, and Japan. However, the concept couldn't get in the Indian field to play. This paper entails the need for weather derivatives in Indian context, their usability in the three sectors- primary, secondary and tertiary, along with deterrents and efforts as prerequisites for their future application.

Index Terms: Weather derivatives, insurance, India

I. INTRODUCTION

A derivative is a financial instrument that does not have its own value but whose value is driven from the underlying asset. The underlying asset could be stock, bond, any commodity, index, currency, etc. and even derivative itself. In case of weather derivatives, the underlying asset is the weather, which has no direct value. It could be used for risk-reduction to mitigate the risk of adverse or unforeseen weather conditions.

Weather being an uncontrollable factor, posses risk to different businesses, but such weather-related risks can be controlled by using weather derivative instruments. According to statistics provided by various meteorological research agencies, more than 80% of global commercial activity is dependent on weather (Choksi, 2012). It is anticipated that around one-seventh of the economy in the United States is vulnerable to weather risk (Ramkumar, 2018). Almost every industry is influenced by the weather in some way and the impact, obviously, varies depending on the type of firm, region, and climatic change (Ramkumar, 2018). Numerous market participants have begun to enter the markets that trade in weather, and many more in the risk management industry could benefit from the weather market's patterns.

A substantial part of the Indian economy, which is heavily reliant on agriculture, would be vulnerable to weather risk. Though, weather throws a range of obstacles, it also opens up a lot of prospects. Trading weather information could be useful in hedging risks. Beside than that, it may be a novel product in management of a portfolio (Ramkumar, 2018).

Even though the physical perils posed by weather occurrences cannot be removed, the financial risks can be mitigated by employing weather derivatives effectively (Hyman, 2001). Aside from temperature and precipitation, businesses are also subject to a variety of other weather concerns. It is not necessary for the weather to be catastrophic to have a detrimental effect on cash flow; it is at times enough for it to be unusual, unseasonal, or unforeseen (Berlage, 2013). In the long run, the development of new weather derivatives to manage these other risks will become more significant (Paul, 2013).

1.1 The Concept of Weather Derivatives

Weather derivatives are financial contracts that can be utilized by businesses or individuals to mitigate the risk of poor or unexpected weather situations. These are also financial derivatives with a difference that the underlying asset, which could be rain, temperature, snow, wind or a combination of two or more, has no direct value to price the weather derivative, unlike other derivatives. The weather derivative contracts are tied to the weather indices and these weather indices are created by the help of the weather information provided by meteorological stations. This means that the meteorological stations' role is crucial and hence, the data manifested must be reliable to the best level possible.

The financial market related to weather, as per the Weather Risk Management Association (WRMA), has two main key aspects: managing the financial repercussions of harsh weather for those having direct exposure to weather, and commercial dealing in weather, both on its own and in concomitance with a wide range of commodities.

Like any other financial derivative contract, the weather derivative contracts can be in the form of Futures, Forwards, Options and Swaps. And, the indices on which these contracts are based may be based on any of the following as mentioned by Datta (2018).

[1] **Temperature**- The most common types of temperature based indices used heating degree days (HDD) and cooling degree days (CDD), where the base temperature is regarded as 18 degree Celsius or 65 degree Fahrenheit, worldwide. Some may also be utilizing normal departure index (NORDIX) which denotes how "normal" or "strange" a given year or occurrence is whilst collating it to the long-term average for the region or area under examination. Apart from these, simply, maximum, minimum or average daily temperatures are made use of.

[2] **Precipitation**- An index based on precipitation is employed for the areas where rain or snow are prominent to the weather derivatives market participants who wish to hedge from weather related risks. Indices of such derivatives contracts are based on rainfall and snowfall levels.

[3] **Wind**- Several weather derivatives contracts are also based on wind speed along a specific direction, wind farm output and variance, that is, variability is the wind.

The risks that industries confront differ, as do the sorts of indices that they use. For instance, the energy industry are exposed to temperature risk and so is the beverage industry, whereas agriculture businesses are, mostly, exposed to rainfall risk and so is the transportation business, ski resorts are exposed to snowfall risk and likewise. However, it is observed that maximum of the weather derivatives contracts are based on temperature based weather indices, indicating the lion's share of 98%, while those based on rain, snow and wind merely account for 0.9%, 0.5% and 0.2%, respectively (Choudhary & Nair, 2017). And, the utmost used underlying is the Degree Days, specifically, Heating Degree Days (HDD) and Cooling Degree Days (CDD).

The HDD index employed during winter months and gauges the cold waves. A higher index indicates a colder day, showing higher demands for heating as a corollary and vice versa. Therefore, it can be computed as:

HDD= (0, Base temperature- Actual temperature), i.e.,

HDD= (0, 65° F- T)

This means that the payoff would be zero in case the actual day temperature is more than base temperature and in case the actual day temperature is lower than the base temperature, the payoff would be the difference between the two.

The CDD index, per contra, is made use of during the summer months and measures the heat. A higher index denotes a higher temperature, indicating more demand for cooling and vice versa. It can be computed as:

CDD= (0, Actual temperature- Base temperature), i.e.,

CDD= (0, T- 65° F)

This means that the payoff would be zero if the actual day temperature is less than the base temperature and it would be the difference between the two if the actual day temperature is more than the base temperature.

All weather derivative contracts delineate the following essentials:

[1] The location of the contract,

[2] The underlying

[3] The strike price, that is, the predetermined price at which the derivative contract will be bought and sold at the time of execution of the contract

[4] The expiration date, that is, the last day the derivative contract is valid

[5] Notional value, indicating the total amount of the underlying

1.2 Presence and Acceptance of Weather Derivatives in Other Countries

Notwithstanding the interest in weather derivatives, Hamisultane (2008) brings out that their headway has not been as swift or impactful as envisaged. He further indicates that the exit of major players like Enron, Aquila, and El Paso reduced the quantity of transactions, leading to diminishing market liquidity. Nevertheless, many countries have introduced weather derivatives due to a growing attention towards climate-related risks has fueled demand for financial products that safeguard against severe weather and climate-related effects.

The US is not only the first one to trade in weather related instruments but also witnesses the preponderance of weather derivatives transactions, both exchange traded and OTC traded. In 1997, Koch Energy and Enron signed the first official agreement on weather derivatives (Cao, Li & Wei, 2003). And, the first standardized future contracted was introduced in September, 1999 and was traded on the Chicago Mercantile Exchange (Leggio & Lien, 2002). With temperature based futures and options, the Chicago Mercantile Exchange Group provides centralized clearing and eliminates counter party risks along with price risk management, price transparency, liquidity, making it cost effective for the participants to deal in such products. The weather is expected to affect about 20% of the US economy (Chicago, 2006) and 70% of businesses' financial results are linked to weather conditions (Smith, 2000), indicating that there is a tacit demand for financial shielding against weather-related perils. Weather derivatives have been said to be the swiftly growing derivatives market, as per the CME (Chicago, 2006). Further adding that the major end users of weather derivatives have been utility companies; agricultural markets, on the other hand, have a lot more historical data than utilities. As a corollary, weather derivatives are increasingly being used to cover agricultural commodities and livestock. Weather futures contracts might be used to simply offset much of the risk in agricultural commodity volume, resulting in higher revenues for farmers and others in the agricultural industry.

In Canada, weather derivatives were started to be used by farmers as a way to manage weather related risk, especially in the higher crops like seed. Although weather derivatives were focused quite late by farmers, they were first developed in 1990 as a method for the energy sector to protect against temperature-based demand variations. Other businesses, including retail and tourism, such as ski

resorts, soon adopted them as well. In 1998, a non-energy company, a Canadian snowmobile company, became one of the first to employ derivatives. Since then, energy industry participants have traded standardized weather contracts on established exchanges, and interest in non-standardized agreements addressing specific weather risks is expanding at a rapid pace.

Mexico had also launched weather derivatives witnessing the instrument's pros and had also used weather indexes to reinsure crop insurance in the past. The Mexican agricultural insurance programme (Agroasemex) used weather markets to reinsure a portion of its multiple crop insurance plans in 2001. By Using temperature and rainfall based weather indices, considering several major production regions, a weather index that was in accordance with the experience pertaining to loss with crop insurance in Mexico was constructed. This reinsurance approach using weather instruments has proven to be effective in the country and the traditional reinsurance was found to be less efficient.

Europe is also gaining speed in the growth of participants and contract types in the weather market. Most growth has been evident in France and the United Kingdom, followed by Scandinavia and Germany, as well as Sweden. Over time, there has been an improved availability of weather related information provided by eight UK and three European sites. Howbeit, the majority of European trades are still over-the-counter (OTC) instead of exchange traded contracts. A report by Weather Risk Management Association (WRMA) in 2002 portrayed that while temperature-related hedge remained the most prominent; the share of contracts for rain, snow, and wind had climbed. However, in Europe, weather derivatives have been less popular than insurance schemes. But they are regarded as efficacious for protecting against the risk associated with weather unpredictability, and they may become even more appealing in future climates featured by higher fickleness and frequency of harsh weather. Considering the stretched out list of businesses that are exposed to risks associated to weather, Norway also incorporated weather derivative instruments in the financial markets. Various firms in the area of energy production and consumption, supermarkets, agriculture and leisure are making use of weather derivatives to protect themselves from revenue-draining weather. Although, weather data is provided by well established meteorological stations, there are still discrepancies in weather related data (Undli & Schatvet, 2018), therefore, the users cannot have complete reliability over such information. But it is suggested by numerous studies that the careful usage of weather derivatives would prove to be beneficial.

Weather derivatives have been successful to intrigue other parts of the world. Asia has experienced an upsurge in this field; however, weather derivatives in Asian countries are underdeveloped. The first agreement, in Asia, on wind speed was made for a wind power plant. Specifically, in Japan, the majority of transactions have come from non-energy sectors, with banks serving their role for intermediation between end users and weather risk management companies. Weather risk management approaches, such as weather derivatives, appear to be in demand, according to several perspectives, in developing countries such as China.

Numerous deals in Australia have engaged power retailers. Undoubtedly, the energy and power sectors have benefited the most from the weather derivatives. Weather derivatives have given cover against losses caused by excessive heat, in case electricity prices may skyrocket.

Not just the above mentioned countries, but various others have commenced the use of weather derivative products at some levels or are planning to launch them considering uncertainties and losses to individuals and businesses that can be attributed to weather. Even though the market development internationally is laggard, the consideration and acclimatization of weather derivatives in different countries prove that the pavement of growth will continue to build up.

II. LITERATURE REVIEW

Jose, Nidhusha & Nirmalran (2021) looked into the machine learning methods for making predictions about rainfall relating to the arena of weather derivatives. For this purpose, they used rainfall amount in mm, on monthly basis, from year 2009 to 2019 and applied linear regression and polynomial regression for forecasting monthly rainfall.

Ray (2016) in his research work compared weather insurance and weather derivatives and provided inputs that might lead to acceptance and proper usage of weather derivative instruments in India, as they are popularly used and traded in other developing counties.

A study by Arora (2013), examined the state of risk management in Indian agriculture, as well as assessed the effectiveness of weather derivatives as risk management instruments and the basic structure needed for hedging purposes.

Climate change, according to Hurduzeu & Constantin (2008), is one of the factors that has had a significant impact on economic development. They suggested that management of risks related to weather are among the major concerns by Government and large corporations and also highlighted agriculture as a vital sector of the economy, emphasizing the need of using weather derivatives in this field.

Sharma & Vashishtha (2007) looked at the potential for risk hedging with weather derivatives in India's agriculture and power sectors. According to the findings, traditional risk hedging instruments and approaches have proven to be expensive and inadequate for a large country like India. Weather derivatives, according to the study, may be more adaptable, manageable, and effective for the Indian economy.

Chen, Roberts & Thraen (2006) investigated the weather derivatives' potential. Weather derivatives, according to the study, can serve as a backup to abatement technology. Furthermore, the study found that employing them both at the same time is advantageous than making use of them separately.

Stoppa & Hess (2003) examined rainfall index insurance in agriculture policies using weather derivatives, with a focus on Morocco. They came to the conclusion that weather derivatives could be useful in addressing the general element of agricultural risk, signifying potential uses in the unveiling of different agricultural risk systems.

According to Agarwal (2002), a derivative product provides greater benefits than an insurance policy in a way that weather derivative not only gives coverage, but also other possibilities such as 'trade feasibility' and 'flexibility.'

III. NEED FOR WEATHER DERIVATIVES IN INDIA

Although the concept of weather derivatives has gained attention around the world, their growth is still at the nascent stage. And, when it comes to India, the development and launch of weather derivative products still remain in the discussions and feasibility research.

Agriculture accounts for a large portion of India's GDP and has the greatest growth prospects of all the industries due to its high risk of weather exposure. Agriculture still provides a living for more than half of the India's population and considerable percent of total employment. As a result, they are exposed to a significant amount of weather danger. Even a paltry increase in temperature might cause a undesirable decrease in net revenue at the farm level. Variations in temperature and precipitation can have an impact on crop/plantation yields, lowering farmers'/growers' earnings. A poor monsoon affects the country's productivity, poor farmers' anguish, which leads to suicide in some parts of India, negatively affecting the country's GDP, and the stock market. Although, the government launched various insurance schemes like Comprehensive crop insurance scheme, Experimental crop insurance, National Agricultural Insurance Scheme, etc. but all of the schemes proved little as these schemes did not cover majority of crops, resulted in high claim amounts, there was lack of awareness among farmers are some of the reasons among others; and therefore, got discontinued. Pradhan mantri fasal bima yojana was introduced in 2016 covered a lot of crops and natural calamities and continues to be in effect. Still the problems have not been completely phased out, necessitating the development of a new instrument to offset weather related risks.

Although insurance protects against losses caused by natural disasters, it does not cover market risk caused by climate change. Also, insurance requires good amount of premium to be paid which cannot be easily afforded by every person who wants to hedge against weather risk, be in any sector. In such a case, weather derivatives, like any other derivative product, can show to be useful and act as an alternate hedging instrument. They are widely utilized in other countries for hedging weather-related exposures in industries such as energy, agriculture, and plantations.

Not just agriculture, but other businesses in the field of construction, energy, manufacturing, retailing, transportation, etc. are directly or indirectly affected by the whims of weather. Weather derivatives could be a good way to protect against the wish of Nature, which could contribute to reduced agricultural production. This would be valid for individual farmers as well as for a broader group of farmers. The similar case could be made for a variety of other industries where sales and income are weather-dependent. Hedging via weather derivatives is advantageous for such businesses since it decreases earnings volatility.

IV. WEATHER DERIVATIVES FOR INDIAN PRIMARY, SECONDARY AND TERTIARY SECTORS

Weather derivatives, though, have not been practically used in India, but the theoretical scope indicates a promising outlook. The usability of these instruments in different sectors for risk mitigation might be an attractive factor to consider their launch in the Indian economy.

The Indian economy is agriculture based. When the monsoons are unfavourable in India, it is believed that up to 20% of the country's GDP is lost (Choksi, 2012). Rapid agrarian developments remain critical for jobs, livelihoods, and food security (Finance Ministry, 2015). Because the watering supplies in India are not fully developed, farming is majorly dependent on rainfall. Agriculture output is ruined if the rain falls short, or if it pours furiously. While considering temperature, concerns remain prevalent. For instance, a temperature that is much high than required has the negative effect on a yield's efficiency.

Although, crop insurance was introduced in India in 1985, it does not cover all the crops and the states even till date. Moreover, crop insurance better befits and is designed for big-scale disasters such as floods and earthquakes that affect a vast region, with no coverage at the smaller or individual level, for example, someone has a bad crop due to insufficient irrigation facilities and a late monsoon, that farmer will not be reimbursed under the insurance scheme. As an advantage of the introduction of weather derivatives, all farmers, whether working on small scale or large scale, may protect themselves against unpredictably changing weather conditions. These are several key points of difference that highlight the significant gap where weather derivatives can be quite beneficial. Also, unlike certain hindrances in the execution of insurance schemes such as red-tapism (Kumar, 2016), weather derivatives are comparatively more transparent (Choudhary & Nair, 2017).

According to the Economic Survey 2016-17 report, India suffered annual losses of $9-10 billion as a result of weather extremes. Nearly 80% of these losses are still uncovered under the insurance policies. In this regard, the government has been making efforts for doubling farmers' earnings. The Economic Survey 2017-18 warned that changes in climate might cut annual agricultural revenues in India by 15% to 18% on average, and up to 20% to 25% in non-irrigated areas in the years to come. Notably, over 52 percent of India's total agricultural area is still unirrigated or rain-fed. Plus, India is extremely susceptible to climate (Panagariya, 2009). This ambiguity necessitates adequate preparation for possible unpredictable weather variability, indicating towards the introduction and usage of weather derivatives in India to combat changes in temperature, rainfall, snowfall, and other factors.

The secondary sector, in India, is no less important than the primary sector and serves as the backbone for various developments, providing employment opportunities to around 14% of the total workforce in the country and contributing about 27.6% of the country's GDP (Ministry of Finance, 2015). While talking about the tertiary sector, India ranked ninth in overall GDP and tenth in service GDP among the top 15 countries with the most impressive general GDP in 2011. The tertiary sector accounts for around 57% of GDP and employs 34% of the workforce. Weather can affect both of these sectors negatively, as stated by (Kumar & Yalew 2012). Apart from directly affecting these two sectors, weather changes may have a bearing on these sectors at different stages, like disturbance or problems caused during the supply or delivery of raw goods from the primary sector, disruptions in the efficiency and effectiveness as well as in the mobility of labourers (Viswanathan & Kumar 2015), via markets that also suffer from the weather whims.

Howbeit, such impacts can be implicated to be small but the fact that these small losses are uninsurable and therefore, cannot be indemnified. The impact, in general, might be significant, negatively impacting the firm's profitability. By using weather derivatives instruments, corporations may not only hedge against adverse situations, but they can also profit from them.

V. IMPEDIMENTS OF WEATHER DERIVATIVES IN INDIA

Academics, the press, and financial professionals in Western countries have paid weather derivatives a considerable interest, but the product hasn't gotten the same consideration in India, although many researches have been carried on the product's need and utility in many economies throughout the world that includes India.

Such markets require a firm foundation and tough regulatory support, which India lacks in this area. Apart from computation of value of weather derivatives in accordance with the heating/cooling degree days (HDDs/CDDs), the fact that rainfall and abnormal monsoon trends are the most important factors here, a weather index that is a combination of both temperature and precipitation would be required to be formulated, adding to the complexities.

However, Indian statutes do not identify weather as a commodity, preventing trading. Furthermore, financial firms are prohibited from participating in commodities trading as stated under the legislation, so even if weather derivatives are introduced, the market will be less in action. Financial institutions' involvement could lead to improved hedging and discovery of price. According to news sources, CME, which already sells weather products in its home country, is eager to enter the Indian market, however, a lack of adequate infrastructure and historical time series data supplying meteorological information is a significant barrier (Datta, 2018).

5.1 Prerequisites to bring Weather Derivatives in India

In 2016, the Statutory Board of India (SEBI) had announced for allowing trading of weather derivatives but a large number of requirements fall in the way of bringing weather derivatives in Indian financial markets, all of which need to be catered to.

[1] For making weather derivatives functional in true sense, it is imperative that weather related data be available and bona fide.

[2] Infrastructural developments entailing computer based small stations at all levels is a prerequisite. Government role is vital for creation of such intricate infrastructure and weather station network. (Seth, 2008)

[3] The overall growth of the weather derivatives market would be aided by the convenient, quick and economical accessibility of meteorological data (Stern and Dawkins, 2004).

[4] In the countries where weather derivatives are in existence, such products are traded on both- the recognized exchanges and the OTC markets, serving the need of the participants as per desire. In India, as well, both platforms would be needed to be developed concurrently, to offer standardized and customized products for hedging (Gupta, 1997).

[5] The very important requirement, as mention by Seth (2008) is payment facilities. Use of internet, in such case, would make it easy to make payments and receive money, though it would require awareness and training activities at different levels.

[6] The weather derivatives regulating agency would have to conduct a significant number of researches at various levels in order to comprehend the requirements and obstacles more clearly.

[7] Further, information from various studies and related findings would be needed to be disseminated for proper understanding of the working of such a new concept as weather derivatives.

[8] Another element relates to the pricing of weather derivatives. There is no fixed pricing model for weather derivatives. In addition, the study conducted by Seth (2008) pertaining to farmers suggests that the pricing should be such that is affordable and does not push down the interest of investing or trading in weather derivatives. This applies to all the other participants as well.

[9] The willingness to pay by the participants, although, has been determined by several studies in case of India, but it is required to be investigated at a greater level, as such studies have been undertaken only in small and scattered regions by the researchers at a very small scale.

[10] There would be an emergence of advisors pertaining to investing in and hedging using the weather derivatives. This issue is of regulatory relevance as such advisors or consultants would be required to be prohibited from taking positions in these contracts so as to ensure that the fair advice is provided. (Seth, 2008)

[11] It would be critical to create an adequate regulatory and legal framework for weather derivatives in order for this segment of the derivatives market to thrive. Indecorous framework may lead to corruption, inequality in implementation and execution of policies and regulations, market failures, etc. There would also be a shift in the role of the Government from regulator to facilitator. Plus, diversion of the funds that are directed to subsidies must be considered by the Government. (Seth,2008)

[12] The regulatory mechanisms are defined and enforced by the government in majority of exchanges around the world, generally within the legislative statutes (Tsetsekos and Varangis, 2000). Weather derivatives in India could be treated similarly.

[13] Further, policies regarding international trading of such products would be required to be framed.

[14] There should also be scope for experimentation in innovative weather instruments in order to develop the products and the market better.

[15] Taxation concerns would also be needed to pay dire attention to. The tax treatment should be such that hamper the interest of hedgers and speculators. (Seth, 2008)

[16] The structuring of the weather derivative contracts is another issue like details about trade mechanics, role and criteria by the concerned parties among others.

[17] Option contracts are better in terms of management of risk, henceforth, it would be preferable to initiate with weather options (Thomas, 2002), which will increase the work of making the potential participants understand their concept as options are more complex than future and forward contracts.

[18] Another unavoidable point of concern mentioned discusses the credit information sharing that could guide in slumping the risks and costs. It's tough to get counterparty with an offsetting risk while dealing with extreme weather (Jajoo, 2011).

[19] Also, it would be prudent to start with minimum required regulations (Kolamkar, 2002) to promote participation.

VI. CONCLUSION

A weather hedge is based on a basic notion. It's a strategy to shield businesses from expensive rates or low demand and any other losses caused by unpropitious weather. Weather derivatives are, in this way, an extension of existing risk management techniques like futures, options and swaps (Geyser & Van der Venter, 2001). Weather derivatives have a number of advantages over other weather risk management measures, including the advantage over diversification by shifting the risk to a party who is better able to manage it, advantage over the contract situations by compensating for losses suffered, advantage over traditional weather insurance by offering a payout based on index value, without the need for a field visit to ascertain the loss, advantage over weather-based index insurance by not necessitating insurable interest and thereby, allowing for market speculations and finally, advantage over commodity futures by reducing the risk that the payoff to offset the weather related damage is deficient (Lazibat & Štulec, 2011).

In theory, usage of weather derivatives shows to positive implications. Not just the agricultural sector, that has a direct impact of weather changes, but other sectors are also affected by the whims of weather. This requires the need to assess the feasibility of weather derivatives thoroughly in India by the regulatory authorities. Plethora of challenges lie on the plate of the government and other concerned bodies pertaining to the launch of such products in India, that concern from spreading awareness about these instruments to a strong establishment of infrastructure of weather stations.

Furthermore, such risk management tools, particularly when available on the recognized exchanges, can facilitate cost-effective risk sharing among a wide range of participants—both commercial (ranging from farmers to big corporations) and non-commercial (those willing to take risks on the basis of facts and figures on the underlying weather component)—whilst fortifying the participants from possible default risk posed by the counter party, which is not in the case of trading in the Over-The-Counter markets.

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