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Rainfall Index Based Futures: A Tool for Absorbing Systemic Monsoon Risk

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Abstract:

Purpose: *The purpose of this paper is to analyse the application and uniqueness of rainfall index-based futures for mitigating rainfall risk which impacts various segments of the economy including agriculture, banking & insurance, agro-processing, and power generation.*
Design/Methodology/Approach: *Research studies have shown that traditional insurance markets are unable to address the problem of rainfall risk adequately. There is need for a versatile financial tool to effectively absorb the rainfall risk.*
Findings: *The structure of Rainfall Futures Contract is presented using standard metrics as Excess Rainfall Days (ERDs) and Deficit Rainfall Days (DRDs).*
Practical implications: *The importance of basis risk in evaluating the feasibility and effectiveness of rainfall index-based futures is examined.*
Originality value: *Rainfall index-based futures represent an innovative financial product introduced by Chicago Mercantile Exchange.*

Keywords: *Rainfall Index Based Future, Excess Rainfall Days, Deficit Rainfall Days, Basis Risk, Rainfall risk markets.*

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1. Introduction

The rainfall risk markets can play an important role in achieving sustainable growth of the economy. The stakeholders of these markets are farmers, insurance and reinsurance companies, speculators, and others who want to hedge the rainfall risk as shown in Table 1.

Table 1. *Impact of rainfall on Stakeholders*

Sl. No	**Risk due to rainfall variability**	**Stakeholders**
1.	Risk of low Crop yield	Farmers
2.	Non-Performing Assets	Agri-Lending Institutions
3.	Delays in work and additional cost on construction	Construction Companies
4.	Reduced in power generation	Energy generation Companies
5.	Postponements, reduced attendance of public	Entertainment and Tourism industries
6.	Budget overruns for compensation and incentives	Governments
7.	Increased claims settlement	Insurance & Companies
8.	Reduction in production, Reduced demand, increased raw material costs	Agro-based Manufacturing Companies
9.	Reduced demand of weather sensitive products	Retail industries
10.	Budget overruns, delays in services	Transportation companies

Source: *Own study.*

Research studies have shown that traditional insurance markets are unable to address the problem of rainfall risk adequately. There is need for a versatile financial tool to effectively absorb the rainfall risk. Rainfall index-based futures represent an innovative financial product introduced by Chicago Mercantile Exchange. The rainfall index-based futures are the short term contracts and these can be made available for the full monsoon season on monthly basis and also for the season as a whole.

The structure of Rainfall Futures Contract is presented using standard metrics as Excess Rainfall Days (ERDs) and Deficit Rainfall Days (DRDs). The importance of basis risk in evaluating the feasibility and effectiveness of rainfall index-based futures is examined.

2. Review of Literature

The development of rainfall index-based derivatives like rainfall futures is still in its infancy stage and very little literature exists on the subject. Andrea Stoppa and Ulrich Hun (2003) suggested that if the rainfall risk has an observable relationship with the production variable, rainfall derivatives can be effectively used to manage the agri-production risk. Rainfall derivatives may facilitate an efficient transfer of systematic risk between different economic sectors, as well as hedge it in global rainfall risk market.

Andrea *et al.* (2003) concluded that rainfall derivatives are useful tool to mitigate the agricultural rainfall risk by laying the foundation for addressing weather risk by the reinsurance companies. If the governments support reinsurance companies, they can play an important role in helping countries to transfer their systemic rainfall risk and create the global weather risk pool. For this, governments should focus on development of weather risk markets by providing the required infrastructure for compilation and dissemination of quality rainfall data.

Patrick *et al.* (2005) shown that hedger faces the basis risk for exchange traded rainfall derivatives contracts and credit risk in the OTC market. He has suggested to take up the further research to frame the effective rainfall risk hedging contracts and develop widely acceptable pricing model. Travis (2007) concluded that weather futures can be easily used to hedge agricultural volumetric risk and it leads to increase the revenue to the farmers and other agri- businesses.

Barry *et al.* (2008) suggested that index-based rainfall risk transfer products were valuable instruments for addressing the problem of crop insurance failure. Index based risk transfer products are the simple contract designs with few asymmetric information having low transaction cost. These products can be used to create international rainfall risk pool. The rainfall index based futures facilitate hedging rainfall risk by a wide range of stakeholders. Insurance and reinsurance companies can also hedge their rainfall risk exposure using rainfall risk market.

Anjali (2012) analysed the emergence of weather derivatives in India as an alternative hedging tool for agricultural risk management and suggested the weather derivatives to be used to manage the agricultural risk because of their relevance, low cost, flexibility and sustainability.

Shivakumar and Kotreshwar (2013) developed the general framework for creation of index-based Risk Transfer Products (RTP). The authors proposed a unique rainfall index as Monsoon Outcome Index (MOX) measured for each Meteorological Subdivisions (MSD). The statistical properties of these MOX values indicated the vast scope for launching new breed of rainfall risk market instruments for absorbing the rainfall risk.

Kotreshwar (2015) modified MOX and introduced Excess Rainfall Days (ERDs) and Deficit Rainfall Days (DRDs) as standard metrics for quantifying rainfall variability. The statistical analysis of these indices indicated the scope for launching rainfall index-based derivatives.

Ivana *et al.* (2016) conducted the empirical study to show the effectiveness and application of weather derivatives. They studied the relationship between yield of crops like grapes, corn, wheat, barley, soybean, etc. and the rainfall by using the variance and standard deviation as the statistical tool.

Kekre and Girish (2017), suggested that the success of the rainfall risk markets depend on the well-developed weather stations, efficient index structuring and creating the awareness among the farmers. Chengyi *et al.* (2018) opined that weather index futures can be a complement to the weather index insurance covering high probability events with low or medium risk. These weather index futures can also be used to protect not only the agricultural industry, but also the energy and utility companies.

Singh and Vashisht (2020) concluded that rainfall index is an excellent tool to hedge the rainfall risk. The rainfall index was the distinct asset class and it can be traded on an exchange as a tradable commodity because of its potentiality. The introduction of this tool attracts the hedgers and speculators to take part in trading rainfall risk.

Barath and Koreshwar (2020) analysed the rainfall indices as DRDs (Deficit Rainfall Days) and ERDs (Excess Rainfall Days) for selected meteorological subdivision by using the various statistical tools. The statistical properties of these indices have shown that there is an opportunity to design the rainfall derivatives to hedge the rainfall risk. Authors have shown that DRD & ERD values can be used as building blocks for designing the rainfall derivatives.

3. Rainfall Indexation

Rainfall indexation is the process of quantifying the excess or deficit rainfall at a particular location for the specified period. The rainfall index measures how much of actual rainfall vary from the standard rainfall or predetermined rainfall. The rainfall indexation discussed in this paper is based on a new set of rainfall index i.e., Deficit Rainfall Days and Excess Rainfall Days which were developed by Kotreshwar in 2015.

The underlying variable being rainfall, let R_i denote the rainfall (in millimeters) measured on i^{th} day, and R_x denote the average daily rainfall (in millimeters). The average daily rainfall, R_x should serve as the reference level of rainfall in millimeters. The value of R_x is based on the past rainfall data for any chosen length of the period. The standard underlying variable, then, would be simply the difference between the historical average value of rainfall (in millimeters) i.e., R_x and the actual value of rainfall (in millimeters) i.e., R_i.

As the standard underlying variable is measured in terms of millimeters on a daily basis, it can be denoted, symbolically, as DRDs (Deficit Rainfall Days) and ERDs (Excess Rainfall Days) on par with Heating Degree Days (HDDs) and Cooling Degree Days (CDDs) underlying a temperature derivative contracts. The DRDs generated on a given day i then, is given by:

$$DRD_i = Max. \{R_x - R_i, 0\} \quad (1)$$

Similarly, ERDs generated on a given day i is given by:

$$ERD_i = Max. \{R_i - R_x, 0\} \quad (2)$$

In equations (1) and (2) above, it can be seen that the number of DRDs/ERDs for a specific day is just the number of millimeters that the rainfall deviates from a reference level.

Then the number of accumulated DRDs and ERDs for a defined period will be:

$$DRDs_n = \sum_{i=1}^{n} DRD_i \quad (3)$$

$$ERDs_n = \sum_{i=1}^{n} ERD_i \quad (4)$$

For example, if the historical average daily (HAD) rainfall is 20mm for the particular location/MSD, DRDs and ERDs can be determined as shown in Table 2.

Table 2. *Daily ERDs and DRDs*

Days		1	2	3	4	5	6	7	Total DRDs/ERDs(mm) for the week
HAD		20	20	20	20	20	20	20	
ADR		21	18	25	17	27	30	12	
ERDs		01	0	05	0	07	10	00	23
DRDs		0	02	0	03	0	0	08	13

Source: *Author's own calculation (all figures are hypothetical).*

Table 2 shows the Excess Rainfall Days and Deficit Rainfall Days in millimetres for seven days and at the end for the weak. Given the historical average daily rainfall as 20mm and the actual daily rainfall as 21mm, there is an excess rainfall of 1 mm. On the second day the actual rainfall is 18mm and results in deficit rainfall. Each mm of excess rainfall is denoted as one ERD and each mm of deficit rainfall is denoted as one DRD. Accordingly ERDs and DRDs stood at 23 and 13 respectively for the whole week. Similarly, determination of monthly DRDs and ERDs is shown in Table 3.

Table 3. *Monthly DRDs and ERDs*

Month	June	July	August	September	DRDs/ERDs for the whole season
HAD	20	18	25	30	

ADA	12	20	23	32	
ERDs	0*30=0	2*31=62	0*31=0	2*30=60	120
DRDs	08*30=240	0*31=0	2*31=62	0*30=0	302

Source: *Author's own calculation (all figures are hypothetical).*

Table 3 Shows the Excess Rainfall Days and Deficit Rainfall Days for the month of June, July, August and September. For the month of June, historical average daily rainfall is higher than the actual rainfall resulting in deficit rainfall and hence there shall be no ERDs but DRDs equal to 240 (8 x 30). After calculating monthly DRDs and ERDs, cumulative DRDs and ERDs for the season are shown which stood at 302 and 120 respectively.

4. A Model Rainfall Futures Contract

Basically, a rainfall index based futures contract is a derivative whose value depends on the underlying index. The rainfall index-based futures contracts cover the rainfall variability like excess rainfall or deficit rainfall. This contract is based on the measurable indices i.e., ERDs and DRDs. These contracts are standardised contracts like stock index futures traded on organised stock exchange.

All the contract details are defined in the contract specification and have a predetermined expiry period over which the underlying rainfall index is calculated. The term of the contract may be for a week, month or for whole season like south west monsoon season. A model Rainfall index based futures contract involves specification of the following terms:

1. **Contract Size:** The contract is simply an index number that needs to be converted into a monetary value by a 'multiplier' which for instance is 15 for SENSEX. The multiplier is called lot size of the contract. This is necessary for determining the value of a futures contract. The chosen multiplier may be any sum, say Rs 1000. This means that contract size is 1000 times the DRD/ERD index points. If the DRD index is 150 points, the contract value is 1,50,000.
2. **Product Description:** Empirically derived value of DRD/ERD indices are the products for each specified MSD or any other region or city.
3. **Tick Size:** It is the predetermined decimal applied to each index point. For instance, if the decimal is decided to be 0.1, then the tick size of the contract will be (=Rs 1000*0.1=Rs.100 per contract).
4. **Mode of Settlement:** The mode of settlement is compulsorily on cash basis. This is because DRD/ERD indices are not physically deliverable.
5. **Contract Month:** As core part of monsoon covers a period of 4 months from June to September, these monthly contracts are ideal for trading rainfall index based futures .

6. **Ticker Symbols:** As the underlying for rainfall index based futures is either DRD or ERD index, the ticker symbol could be DRDX or ERDX as the case may be.

Based on the terms described above, a model Rainfall index based futures contracts for North Interior Karnataka (NIK) Meteorological Subdivisions (MSD) can be designed as shown in Table 4.

Table 4. *A Model Rainfall Index Based Futures Contract (Specifications)*

1. Contract Size	Rs. 1000* times the respective DRD/ERD index.
2. Product Description	DRD/ERD Index for NIK
3. Tick Size	0.1 Index point (=Rs100 per contract)
4. Contract Months	June, July, August, September (4 months)
5. Settlement Procedure	Cash Settlement
6. Position Limit	All months combined: 10000 contracts
7. Pricing Unit	Rs. Per index point (1 index point= 1MM of rainfall
8. Ticker Symbols	DRDX / ERDX

Note: **Assumed figure.*
Source: *Own study.*

4.1 Basis Risk

Rainfall derivatives are designed to eliminate the moral hazard and adverse selection problems underlying traditional crop insurance. But the presence of basis risk in a rainfall derivative poses a challenge. In financial derivatives generally basis risk arises where there is a difference between spot price and futures price. But in rainfall derivatives, basis risk arises under three circumstances.

First, it occurs where the imperfect correlation between the recorded rainfall and actual rainfall in specific place. Secondly basis risk exists in the over the counter markets because rain gauge places are not registered in the exchange and finally it occurs where recorded rainfall in one area doesn't exactly equal the underlying rainfall value used in the rainfall index-based futures contract. If the recorded and actual rainfall is too far from each other, there exists a higher level of basis risk.

So, hedger must be aware of basis risk when hedging the rainfall risk. The basis risk can be reduced by installing more and more rain gauge stations to collect the rainfall data. Reduced basis risk increases the hedging effectiveness of rainfall derivatives.

4.2 Unique Features of Rainfall Index Based Futures

RIFs are endowed with several unique features that merit their introduction for absorbing systemic monsoon risk for the benefit of a wide range of stakeholders. They are similar to the stock index futures in design. Like stock index futures, RIFs can be offered on weekly or monthly basis covering the whole monsoon season and settled only through the cash. One important merit of RIFs is their transparency. They are not amenable to insider trading and manipulation as they are based on the rainfall index representing natural rainfall pattern which is beyond human control.

Melanie *et al.* (2003) opined that as long as the risk market is incomplete, there is a scope for the new instruments to improve the risk return trade off. The relationship between weather derivatives and other conventional financial assets shows the relatively lower correlation and it suggests that the weather derivatives like RIFs can be an excellent diversification vehicle.

5. Conclusion

Rainfall index-based futures represent an innovative financial product designed to absorb the systemic monsoon risk. These are the short term contracts and can be made available for the full monsoon season on monthly basis and also for the season as a whole. A Rainfall Futures Contract can be structured using standard metrics like Excess Rainfall Days (ERDs) and Deficit Rainfall Days (DRDs) as building blocks.

Basis risk forms an integral part of RIFs as hedging tools. RIFs are endowed with several unique features that merit their introduction and development for the benefit of a wide range of stakeholders.

The development of a market for RIFs requires an elaborate research and regulatory support, apart from creating awareness and product knowledge and providing reliable data from the meteorological sub divisions.

References:

Andrea Stoppa, Ulrich Hess. 2003. Design and Use of Weather Derivatives in Agricultural Policies: The Case of Rainfall Index Insurance in Morocco. International Conference, Capri, Italy. Retrieved from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.631.7422&rep=rep1&type=pdf.

Anjali Choksi. 2012. Emergence of Weather Derivatives-Feasibility in Indian Context. ZENITH International Journal of Business Economics & Management Research, 2(5). http://zenithresearch.org.in/.

Barry J. Barnett., Oliver Mahul. 2007. Weather Index Insurance for Agriculture and Rural Areas in Lower Income Countries. American Agricultural Economics Association, 1241-1247. https://doi.org/10.1111/j.1467-8276.2007.01091.x.

Bharath, V., Kotreshwar, G. 2020a. Evaluating Rainfall Risk Profile of Indian Subcontinent Based on Index Metrics. Indian Journal of Finance and Banking, 4(2), 38-50. https://www.cribfb.com/journal/index.php/ijfb/article/view/700.

Bharath, V., Kotreshwar, G. 2020b. Rainfall indexation for evaluating rainfall risk profile of

Indian subcontinent. Indian Journal of Finance, 14(12), 38-50.

Chengyi, Pu., Yueyunchen, Xiaojun, P. 2018. Weather indexes, index insurance and weather index futures. Insurance Markets and Companies, 09(1), 2616-3551. http://dx.doi.org/10.21511/ins.09(1).2018.04.

Dileep N., Bharath, V., Kotreshwar, G. 2021. Innovative Alternatives for Crop Insurance: Rainfall-Index-Based Insurance and Futures. International Journal of Banking, Risk and Insurance, 9(1). http://publishingindia.com/IJBRI/56/innovative-alternatives-for-crop-insurance-rainfall-index-based-insurance-and-futures/10922/16327/.

Harendra Singh, Anil Vashisht. 2020. Use of rainfall derivative to hedge rainfall risk in agriculture sector in India. Journal of Xi'an University of Architecture & Technology, 7(5), 2280. http://www.indianjournaloffinance.co.in/index.php/IJF/article/view/156483.

Ivana Stulec, Kristina Petljak, Tomislav Bakovic. 2016. Effectiveness of weather derivatives as a hedge against the weather risk in agriculture. Agric. Econ. Czech, 62(8), 356-362. doi: 10.17221/188/2015-AGRICECON.

Kotreshwar, G. 2015. Securitisation of Rainfall Risk in India: Designing Rainfall Derivative Contracts Based on Standard Metrics. Paper presented in International Conference on Emerging Trends in Finance Accounting, SDM-IMD, Mysuru, India.

Melanie Cao, Anlong Li, Jason Wei. 2003. Weather Derivatives: A New Class of Financial Instruments. https://dx.doi.org/10.2139/ssrn.1016123.

Patrick, L., Brockett Mulong Wang, Chuanhou Yang. 2005. Weather derivatives and weather risk management. Risk Management and Insurance Review, 8(1), 127-140. http://dx.doi.org/10.1111/j.1540-6296.2005.00052.x.

Shivakuamr, D., Kotreshwar, G. 2013. Trading in weather risk transfer products-Reengineering rainfall indexation. International journal of business and management invention, 2(2), 33-41. http://www.ijitee.org/download/volume-8-issue-5/.

Travis, L. Jones. 2007. Agricultural Applications of Weather Derivatives. International Business & Economics Research Journal, 6(6). http://dx.doi.org/10.19030/iber.v6i6.3377.

Vedenov, Dmitry V., Barnett, Barry J. 2004. Efficiency of Weather Derivatives as Primary Crop Insurance Instruments. Journal of Agricultural and Resource Economics, Western Agricultural Economics Association, 29(3), 1-17. DOI: 10.22004/ag.econ.30916.