Parametric Insurance Coverages against natural catastrophe risks: a new risk transfer solution in a world of climate extremes

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Introduction to Catastrophe Risk
What is a catastrophe risk?

A catastrophe risk is related to a ***disaster****, which is « a serious disruption of the functioning of a community or a society at any scale due to* ***hazardous events*** *interacting with conditions of* ***exposure, vulnerability*** *and* ***capacity****, leading to one or more of the following: human, material, economic and environmental losses and impacts »*

Acts of God

They are injurious events that have been originated by the forces of nature

Primary Perils

less frequent with high loss potential including also secondary perils

- Well-monitored
- Very low frequency both at single insured unit and at portfolio level

Secondary Perils

relatively frequent and generate low-to medium-sized losses

- Less rigorous monitoring and not always explicitly modelled
- Weaker exposure data capture and claims tracking

Man-made catastrophes

They concern events directly linked to the activities of men that lead to huge injuries

- It may hit one or more insured units but also, in the worst case, a set of units
- Low frequency for the single insured unit and medium-high frequency balanced at portfolio level of an insurance company

Note : *from UNDRR Sendai Framework terminology on Disaster Risk Reduction*

"La Gestione dei rischi climatici e catastrofali, Stefano Miami

Insurability of Catastrophe Risk

Insurability Criteria – Berliner (1982) & Charpentier (2007)

		Criteria	
Large risks non-diversifiable (CLT)	**ACTUARIAL**	1. Randomness of loss occurrence 2. Maximum Possible Loss (MPL) 3. Average Loss per Event 4. Loss Exposure 5. Information asymmetry	Independence and predictability of loss occurrence Manageable Moderate Large enough Minimal moral hazard and adverse selection
Finding a fair price	**MARKET / ECONOMIC**	6. Insurance Premium 7. Cover limits	Cost recovery (insurer) and affordability (policyholder) Acceptable
Abnormal intensity of natural/hazard	**LEGAL**	8. Public policy 9. Legal restrictions	Consistent with social values Allows the coverage

→ Huge losses infinitive actuarial premium + Geographical correlation, CLT not applicable, Additional capital required + No adequate short-term insurance market + Climate change uncertainty → **Natural catastrophes are hardly insurable**

Note The impact of artificial intelligence along the insurance value chain and on the insurability of risks, Martin Eling, Davide Nuessle, Julian Staubli, The Geneva Papers on Risk and Insurance

Alterantive Risk Transfer Solutions

Alternative Risk Transfer Solutions

→ Parametric Solutions

Insurance-linked Securities (ILS)

- Catastrophe Bonds
- Catastrophe Futures
- Catastrophe Options
- Catastrophe Swaps

Traditional Reinsurance Products

Proportional

Non-Proportional

Stop Loss

$$X_{RE} = L_{AAD,AAL}\left(\sum_{r} L_{D,C}(X_r)\right)$$

$AAD - Annual\ Aggregate\ Deductible$

$AAL - Annual\ Aggregate\ Limit$

Excess of Loss per Event or CAT

$$X_{RE} = \sum_{e} L_{D,C}\left(\sum_{i^e} X_{i^e}^{e}\right)$$

$\boldsymbol{X_{i^e}}$ *denotes the claim cost of risk* $\boldsymbol{i}$ *associated to the event* $\boldsymbol{e}$

Excess of Loss per Risk or policy

$$X_{RE} = \sum_{r} L_{D,C}(X_r)$$

$\boldsymbol{Xr}$ *denotes the claim costs of risk* $\boldsymbol{r}$

$C = limit\ of\ the\ coverage$

$D = contractual\ fixed\ deductible$

Government Programs

Classification*:

1. Robust or poor regulation of the insurance market by the **public sector**;
2. **Mandatory** nature of insurance coverage;
3. Possibility that policyholders cover part of the risk (**mutuality**) inversely related to the amount of insurance premium

*Note: from Mysiak and Pérex-Blanco (2016) classification

Parametric Disaster Insurance
Definition and mechanism

From World Bank definition

Index or parametric insurance pays out benefits based on a pre-determined index for the loss of assets and investments as a result of weather or other catastrophe events

1 — Collection of underlying data from provider

Data Cleaning

2 — Definition of the INDEX

- Objective
- Reliable
- Available
- Correlated

3 — Definition of the PAYOUT FUNCTION

- Triggering Event
- Type of payout

Advantages

- Transparency of payout trigger
- Lower dispute risk
- Faster payout
- No need for loss adjustment
- Lower expenses

Basis Risk

TYPE I
False Positive
Payout > Occurred Losses

TYPE II
False Negative
Payout < Occurred Losses

Note : SCOR, Parametric Insurance: a 360° View – Part One of Three, by Expert Views, April 2019

CASE STUDY: Weather-based Crop Insurance
Introduction to the Analysis

Weather-based Crop Insurance

The indemnity in based on realizations of a specific weather parameters measured over a specified period of time at a particular weather station

AIM of the Case Study

Replicating the functioning of a Weather Index Insurance Product (WII) based on a rainfall index aiming to protect Indian farmers' crop production against severe natural events

1

Prefeasibility Assessment

(1) Weather risks
(2) Type of crops
(3) Weather station locations
(4) Agro-climatic zones

2

Technical Feasibility

(5) Collection of data

(6) Index

Design of product

3

Field Implementation

(7) Trigger payout levels

Pricing contract premiums

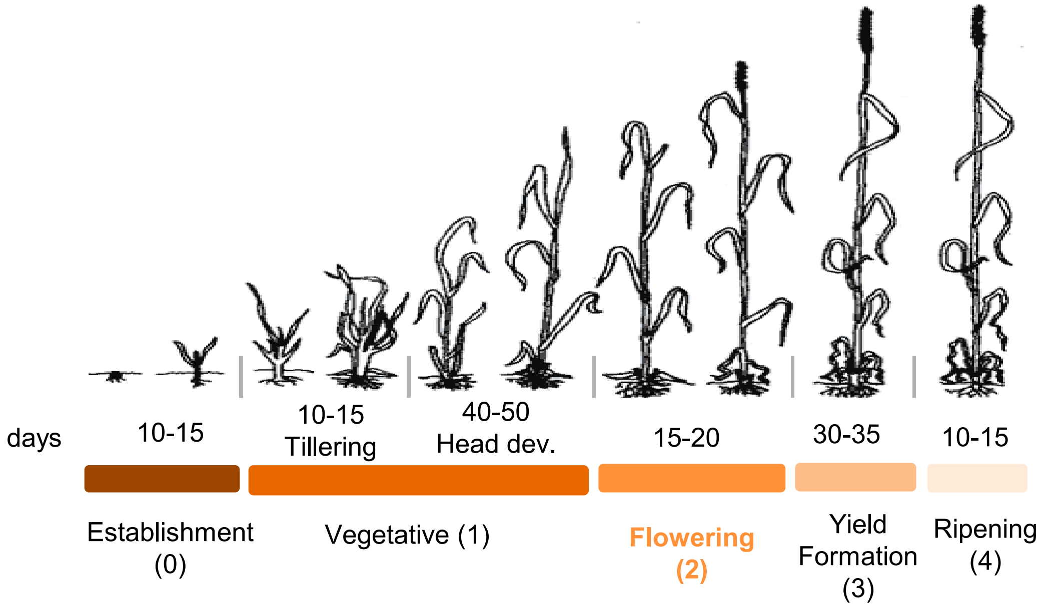
Note : The World Bank, «Weather Index Insurance for Agriculture: Guidance for Development Practitioners», by Agriculture and rural development discussion paper 50, November 2011

CASE STUDY: Weather-based Crop Insurance
Prefeasibility Assessment

(1) Weather risks Severe droughts or/and excess rainfall and the combination of the two events

(2) Type pf crops and Growth phases (by Large 1954) Growth

Winter Wheat Crop
- Sowing Period: 15th Nov. – 15th Dec.
- Harvesting Period: 15th Mar. – 15th May



(3) Weather station location

(4) Agro-climatic zones

INDIAN STATES selected
- **Uttar Pradesh** in North-West India
- **Madhya Pradesh** in Central India
- **Karnataka** in South Peninsula
- **Bihar** in East & North-East

Note : www.fao.org

CASE STUDY: Weather-based Crop Insurance
Technical Feasibility (1/4)

(5) Collection of data – CROP PRODUCTION

Source

Indian Government's Area Production Statistics (APS)

Period

1

From 1997 to 2010 used for **Average Yield** and **Average Production**

$$Yield = \frac{Production}{Area}$$

2

From 2011 to 2019 used for calculating **Payout**

Reference Period		Bihar	Karnataka	Madhya Pradesh	Uttar Pradesh
1997- 2010	**Avg. Yield**	2.00	0.82	1.73	2.73
1997- 2010	**Sigma**	0.26	0.20	0.16	0.18
1997- 2010	**CV**	0.13	0.24	0.09	0.07
1997- 2010	**Avg. Production (t)**	**4,2m**	**0,26m**	**7,2bn**	**25,5m**
2011 2019	**Avg. Annual Price in € 2011-2019***	196	196	196	196
2011 2019	**Avg. Prod. Value in € 2011-2019**	**825,4m**	**50,9m**	**1,4bn**	**5bn**

*It has been obtained as the average summary value of the single 2011-2019 annual averages previously obtained from the "Wheat Monthly Price – Euro per Metric Tons" – from www.indexmundi.com

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CASE STUDY: Weather-based Crop Insurance
Technical Feasibility (2/4)

(5) Collection of data – RAINFALL DATA in mm

Source

Meteorological Department (IMD)

Period

1
From 1961 to 2010 used for **Long Period Average (LPA)** for a given region

2
From 2011 to 2019 used for calculating **Payout**

Performance measurement

It will be measured in terms of its departures from its LPA, calculated over 30-50 years

Reference Period

Reference Period		India	Bihar	Karnataka	Madhya Pradesh	Uttar Pradesh
	Max	1,401 in 1999	1,660 in 1987	1,095 in 1997	3,032 in 1961	2,473 in 1971
	Min	947 in 1972	629 in 2010	473 in 2010	874 in 2000	938 in 1997
	LPA	**1,164**	**1,167**	**737**	**2,051**	**1,750**
1997- 2010	**Sigma**	103	207	133	388	363
1997- 2010	**CV**	0.089	0.178	0.181	0.189	0.208
1997- 2010	**m-d**	1,060	960	603	1,663	1,386
1997- 2010	**m+d**	1,268	1,375	870	2,439	2,113
1997- 2010	**Skewness**	-0.04	-0.29	0.47	-0.18	0.07

CASE STUDY: Weather-based Crop Insurance
Technical Feasibility (3/4)

(6) Index – RAINFALL DATA

Main steps of the analysis

1 Calculating the LPA for each of the four selected states on **annual** and **seasonal** basis

2 Assuming the **Normal Distribution** of rainfall time series

3 Calculating different **Categories of Rainfall** according to the ratio: $\frac{Observed\ Rainfall\ Value}{LPA} - 1$

(7) Field Implementation

Rainfall Category	Departure from Normal	Payout Structure CASE A *SOFT*	Payout Structure CASE B *HARD*
Large Excess (LE)	60% or more	75%	75%
Excess (E)	20% to 59%	25%	10%
Normal (N)	-19% to +19%	0%	0%
Deficient (D)	-20% to -59%	25%	10%
Large Deficient (LD)	-60% to -99%	75%	75%
No Rain	-100%	100%	100%

Note : www.hydro.imd.gov.in

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CASE STUDY: Weather-based Crop Insurance
Technical Feasibility (4/4)

(6) Weather Index – Construction

Weather Index is linked to **cumulative rainfall** measured in **mm** fallen in each of the four selected Indian states.

Three indexes are proposed:

Total Annual Rainfall Index

$$Payout\,\%_i \sum_{t \epsilon (year)} \alpha < \left(\frac{Obs.\,Rainfall\,Value}{LPA} - 1\right) < \beta$$

Total Seasonal Rainfall Index

$$Payout\,\%_i \sum_{t \epsilon (year\ for\ each\ season)} \alpha < \left(\frac{Obs.\,Rainfall\,Value}{LPA} - 1\right) < \beta$$

Weighted Annual Seasonal Rainfall Index

$$Payout\,\%_i \sum_{t \epsilon (year\ for\ each\ season)} \alpha < \left(\frac{Obs.\,Rainfall\,Value}{LPA} - 1 * \omega_j\right) < \beta$$

$\boldsymbol{i}$ *corresponds to Case A or Case B of the payout %*

$\boldsymbol{\alpha}$ *and* $\boldsymbol{\beta}$ *are the extremes of the rainfall categories depending on departure from Normal*

(7) Field Implementation

Three triggering events – actual rainfall has a departure from the Normal:

1. LE, E, D, LD, No Rain
2. Only LE and E
3. Only D, LD and No Rain

Weights

45% for JF	- *Winter Season*	Flowering Phase
25% for MAM	– *Pre Monsoon Season*	Harvest
5% for JJAS	– *SW Monsoon Season*	
25% for OND	– *Post Monsoon Season*	Sowing

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CASE STUDY: Weather-based Crop Insurance

Bihar – Total Annual Rainfall Index (1/3)

Year	Rainfall Annual	Obs / LPA	Categories	Payout %		Payout amount					
						Excess-Deficit		Excess		Deficit	
Annual LPA 1961-2010 = 1,168				Soft	Hard	Soft	Hard	Soft	Hard	Soft	Hard
2011	1,097	-6%	N	0%	0%	-	-	-	-	-	-
2012	1.032	-12%	N	0%	0%	-	-	-	-	-	-
2013	1,070	-8%	N	0%	0%	-	-	-	-	-	-
2014	1,061	-9%	N	0%	0%	-	-	-	-	-	-
2015	873	-25%	D	25%	10%	193	77	-	-	193	77
2016	1,158	-1%	N	0%	0%	-	-	-	-	-	-
2017	1,112	-5%	N	0%	0%	-	-	-	-	-	-
2018	861	-26%	D	25%	10%	187	75	-	-	187	75
2019	1,195	2%	N	0%	0%	-	-	-	-	-	-
TOTAL						**380**	**152**	**-**	**-**	**380**	**152**
Per 1 unit of production (in €)						**0.46**	**0.18**	**-**	**-**	**0.46**	**0.18**

$$25\% * 4{,}202{,}208 * 178.04$$

Avg Prod 1997-2010 (4,202,208) · **2018 Avg Annual Price** (178.04)

$$\frac{861}{1{,}168} - 1 = -26\%$$

→ -20% to -59%

$$0.46 = \frac{380}{825}$$

$$825 = 4{,}202{,}208 * 196.43$$

Avg Annual Price 2011-2019 (196.43)

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Results

Bihar JF – Total Seasonal Rainfall Index (2/3)

Year	Rainfall Annual	Obs / LPA	Categories	Payout %		Payout amount					
						Excess-Deficit		Excess		Deficit	
Seasonal JF LPA 1961-2010 = 21.212				Soft	Hard	Soft	Hard	Soft	Hard	Soft	Hard
2011	12	-43%	D	25%	10%	238	95	-	-	239	95
2012	21	-1%	N	0%	0%	-	-	-	-	-	-
2013	28	32%	E	25%	10%	247	98	247	98	-	-
2014	51	140%	LE	75%	75%	674	674	674	674	-	-
2015	15	-29%	D	25%	10%	193	77	-	-	193	77
2016	10	-53%	D	25%	10%	158	63	-	-	158	63
2017	1	-95%	LD	75%	75%	486	486	-	-	486	486
2018	0	-100%	No Rain	100%	100%	748	748	-	-	748	748
2019	31	46%	E	25%	10%	189	75	189	75	-	-
TOTAL						2,935	2,319	1,110	849	1,824	1,470
Per 1 unit of production (in €)						3.56	2.81	1.35	1.03	2.21	1.78

$$\frac{0}{21.212} - 1 = -100\%$$

$$100\% * 4{,}202{,}208 * 178.04$$

2018 Avg Annual Price

Avg Prod 1997-2010

$$3.56 = \frac{2{,}935}{825}$$

$$825 = 4{,}202{,}208 * 196.43$$

Avg Annual Price 2011-2019

Results

Bihar JF – Weighted Annual Seasonal Rainfall Index (3/3)

Year	Rainfall Annual	Obs / LPA	Categories (a)	(a) x 45%	New (a)	Payout %		Payout amount					
								Excess-Deficit		Excess		Deficit	
Seasonal JF LPA 1961-2010 = 21.212						Soft	Hard	Soft	Hard	Soft	Hard	Soft	Hard
2011	12	-43%	D	-20%	D	25%	10%	238	95	-	-	238	95
2012	21	-1%	N	0%	N	0%	0%	-	-	-	-	-	-
2013	28	32%	E	14%	N	0%	0%	-	-	-	-	-	-
2014	51	140%	LE	63%	LE	75%	75%	674	674	674	674	-	-
2015	15	-29%	D	-13%	N	0%	0%	-	-	-	-	-	-
2016	10	-53%	D	-24%	D	25%	10%	158	63	-	-	158	63
2017	1	-95%	LD	-43%	D	25%	10%	162	64	-	-	162	64
2018	0	-100%	No Rain	-45%	D	25%	10%	187	74	-	-	187	74
2019	31	46%	E	21%	E	25%	10%	189	75	189	75	-	-
TOTAL								**1,609**	**1,048**	**863**	**750**	**745**	**298**
Per 1 unit of production (in €)								**1.95**	**1.27**	**1.05**	**0.91**	**0.90**	**0.36**

Weight JF 45%

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Results

Year	India	Bihar (B)	Madhya Pradesh (MP)
2011	N	N	LE
2012	N	N	E
2013	N	N	LE
2014	N	N	E
2015	N	D	E
2016	N	N	LE
2017	N	N	E
2018	N	D	E
2019	N	N	LE

Obs/LPA using India LPA on annual values for each states

	Total Annual Rainfall Index		Total Seasonal Rainfall Index JF		Weighted Annual Seasonal Rainfall Index JF = 45%		Total Seasonal Rainfall Index JJAS		Weighted Annual Seasonal Rainfall Index JJAS = 5%	
Year	B	MP	B	MP	B	MP	B	MP	B	MP
2011	N	N	D	LD	D	D	N	E	NO PAYOUT	NO PAYOUT
2012	N	N	N	N	N	N	N	N		
2013	N	E	E	LE	N	E	D	E		
2014	N	D	LE	LE	LE	LE	N	N		
2015	D	N	D	LE	N	E	D	N		
2016	N	N	D	D	D	N	N	E		
2017	N	N	LD	D	D	D	N	N		
2018	D	D	No Rain	D	D	D	D	N		
2019	N	E	E	D	E	N	N	E		
TOTAL	380	1,449	2,935	5,826	1,609	2,910	627	1,423		
Per 1 unit of production (€)	0.46	1.03	3.56	4.13	1.95	2.06	0.76	1.01		

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Conclusions

Emergency of natural disasters and innovation of parametric insurance coverages

Innovative alternative to traditional insurance, especially in times of hard insurance market

Role of parametric coverages

- Coverage of uninsurable risks worldwide
- Fast and transparent payouts based on external observable variables
- “basis risk” must be minimized through careful trigger decision

Current applications and future research

- To overcome limitations in data access, especially in developing countries
- Diverse applications, from micro-insurance to public authorities

THANK YOU!

Questions?


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APPENDIX

Parametric Disaster Insurance
Indemnity Insurance vs Parametric Insurance

	Indemnity Insurance	Parametric Insurance
Core legal requirements	Insurable interest proof of loss	Insurable interest
Nature of risk	Risk should be largely independent	Risk should be largely correlated
Payment determination	After the event loss assessment	Before the event pre-defined payments schedule
Actuarial determination	With independent risk, the risk of an insurance pool is less than the risk of the individual	Historic time series of events is combined with the exposure to develop an expected loss for the parametric structure
Trasparency	Can be challenged with complex exclusions	Can be fully trasparent
Moral hazard & adverse selection	The insured can influence the risk and will have more knowledge of the risk	The insured has no influence on payments but there can be adverse selection if sales closing is not properly set
Speed of payment	take time to complete loss assessment	made with a short-time period
Core limitation	Higher cost for loss assessment and mechanisms to control adverse selection and moral hazard	Poorly designed products can fail to meet the needs when there is a loss or may even pay when there is no problem for the client (basis risk)
Flexibility	Sometimes constrained by requirements for proof of loss**	Can cover a variety of financial risk that are difficult to prove use for business interruptions and good potential for the intangible economy

**The granularity level required depends on the jurisdiction selected

Note : Global Parametrics, Introducing Parametric Disaster Risk Financing