*Srivathsan Karanai Margan**

# Overcoming Basis Risk in Parametric Insurance

*Parametric insurance products are available for more than two decades now. These products do not indemnify pure loss like traditional insurance contracts but make a near-automatic payout of a pre-defined amount when the parameter, index of parameters, or pre-modeled loss related to a risk event reaches a pre-determined threshold. The parameter or index that acts as a proxy for the actual sustained loss is an important determinant for the success of a parametric product. Any mismatch between the actual loss and parametric payout that arises due to issues in the parametric structure is termed as basis risk. The presence of basis risk reduces the effectiveness of parametric insurance as a risk management tool, creates a perception of parametric insurance being a poor substitute for indemnity insurance, and prevents its widespread adoption. This article discusses the types and sources of basis risk and the means for overcoming it.*

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## Basis Risk and its Sources

Parametric insurance, also called index-based insurance, has been offered for more than two decades to cover natural catastrophes and weather-related risks such as hurricanes, excess rainfall, tornadoes, floods, and earthquakes. These products are predominately provided in developing countries for agriculture insurance. A parametric insurance structure comprises (i) a causal risk event, (ii) a parameter or index that serves as an objective measure for the intensity of the event or loss, (iii) a threshold value exceeding which a payout is made, (iv) amount to be paid, and (v) method of payment. Unlike the traditional indemnity-based insurance products that compensate for pure loss, parametric contracts make a near-automatic payout of a pre-defined amount when the parameter, index of parameters, or pre-modeled loss related to a risk event reaches a pre-determined threshold. As the parameter or index acts as a proxy for the actual sustained

* *Insurance Domain Consultant, Tata Consultancy Services Limited. Email: srivathsan.km@tcs.com*

loss, it is the most important part of a parametric product. Any inaccuracy or mistake that happens while structuring a parametric product could result in a mismatch between the actual loss and the parametric payout, which is known as basis risk.

The basic type of parametric insurance is pure parametric. These products follow a binary cut-off approach in which the specified amount is paid purely based on the occurrence of a trigger event of a specific intensity regardless of the financial loss suffered by the insured. In case the event occurs but with lesser intensity than what is specified, no payout is made. In pure parametric products, an imperfect correlation between modeled and sustained loss could result in bi-directional basis risk events. For example, an insured who sustains actual financial loss may not receive a payout because the event trigger value was not exceeded, whereas another insured who did not sustain any financial loss may receive a payout just because the event trigger value was exceeded. The former is called adverse or insured party basis risk and the latter is known as perverse or insurer basis risk.

**Table 1: Types of Basis Risk**

| | Insured suffers loss | Insured does not suffer loss |
|---|---|---|
| **Payout is made** | Well-designed parameter or index, and model matching risk event and loss exposure | Type-1 error or false-positive that results in perverse or insurer basis risk |
| **Payout is not made** | Type-II error or false-negative that results in adverse or insured party basis risk | Well-designed parameter or index, and model matching risk event and loss exposure |

Basis risk could occur due to a misstep at any stage of structuring a parametric insurance product such as arriving at a parameter or index that reflects the intensity of the risk event, accurately correlating the intensity of the risk event to the actual financial losses, selecting the right value of the parameter or index as a threshold to trigger the payment, and defining the terms of the contract. The basis risk in parametric structures could be categorized based on the sources from which they arise. The sources could be brought under two broad categories: geographical and reference-index related. The most prominent sources of basis risk are mentioned in Table 2 below.

The presence of insured-party basis risk has a negative effect on the perception of parametric products. The easiest way to address the concerns could be to reduce the value of the event- trigger thereby making a large majority of the insured eligible for a payout. However, this will cause an increase in insurer basis risk and is against the basic principles of insurance. It will result in a reduction of yield for investors forcing insurers to increase the premiums, and in turn, make the products unaffordable.

**Table 2: Sources of Basis Risk**

| Sl. | Source of Basis Risk | Description |
|---|---|---|
| 1 | Geographical basis risk or spatial basis risk | • Geographical basis risk is the most common source of basis risk.<br>• It is caused because of the displacement between the place where the index is measured and where a loss event occurs and/or the spatial variability of weather conditions.<br>• For example, too much rain could flood a farmer's land, whereas not much rain is observed at the weather station.<br>• The basis risk is directly proportional to the increase in displacement. |
| 2 | Product basis risk or local basis risk | • Product basis risk occurs due to incorrect parameterization of the index resulting in a low correlation between the weather variables for the insurance payout and the economic losses.<br>• For instance, the functional relation between crop yields and weather is very complex and difficult to relate.<br>• The actual loss could occur because of reasons that are not related to weather, such as complex crop growth patterns, pest, disease, soil type and degradation. |
| 3 | Contract design basis risk | • Contract design basis risk is related to the design of the parametric insurance product.<br>• This arises when the parameters of the contract are incorrectly set or when it is difficult to set them due to other major constraints.<br>• The constraints could be related to the choice of weather variable, specific index for the chosen weather variable, and/or methods of payout.<br>• For example, crop loss occurs due to lack of rainfall or dry spells, but the index does not consider them as risks and hence a payout is not triggered. |

| | | |
|---|---|---|
| 4 | Temporal basis risk | • Temporal basis risk arises due to the mismatch in the timing of the loss event considered.<br>• For example, the loss caused by lack of rainfall or excess rain could vary depending on stage of crop development.<br>• The difference could also arise based on whether the season starts sooner or later than the norm, planting decisions of farmers, and short/long cycle crop types considered. |

While defining any parametric structure, arriving at the accurate trigger-parameter or index for an event and a reliable way to monitor it are the two most important activities. Considering that the parameter or index is a mere proxy for the modeled loss, there is always a possibility that the actual loss could deviate. This makes basis risk extremely difficult to eliminate, but still, it can be reduced with appropriate methods.

## Reducing Basis Risk

The insurance industry has been continuously improving parametric structures to minimize the sources of basis risk. As the drivers of basis risk differ from one parametric structure to another, for reducing them, a more detailed understanding of the sources of uncertainty related to each structure is required. After identifying the source of basis risk, it is important to quantify the uncertainty to make necessary improvements to the parametric structure by adopting an appropriate mix of the methods listed below.

## Increased Measurement

The simplest way to reduce the most common geographical basis risk is to increase the monitoring and validation process by proportionately increasing the density of measurement stations. The risk is also reduced by designing contracts with two-scale triggers in which one trigger is at a larger scale, say the district-level, and another trigger is at a lower geographical scale which is nearer to the location specified by the policyholder. Statistical methods such as inverse distance weighting, where the weights depend on the distance to the reference station, or optimal regional diversification, in which a comprehensive portfolio of parametric structures is used for different locations also help to reduce geographical basis risk.

## Modeled Loss and Model Efficiency

The product basis risk in pure parametric structures is addressed by following a modeled loss instead of merely looking only at the value of the event that triggers it. In this method, the loss is modeled based on the trigger, and the correlation between the risk event and loss is quantified. However, this requires long-term data availability regarding the changes in the index and the value at risk to arrive at an index that closely correlates to the risk. The introduction of a participatory structuring process that involves meteorological experts, implementing partners, and farmers reduces the mismatch between modeled and sustained loss. Further, continuous monitoring of the index design, validation, and improvement mitigate basis risk. For contract design, and temporal basis risks, understanding the other influencing factors, such as soil, water, farming practices and the design index trigger that reflects the variation of yield sensitivity to extreme events, helps to mitigate basis risk. The magnitude of basis risk is also reduced by developing different indices for each crop type by modeling the loss for each event separately.

## Cat-in-a-box Structure

Cat-in-a-box is the most popular of all parametric insurance structures. The basic version of the cat-in-a-box parametric structure would trigger a payout if an extreme weather event meeting the minimum pre-agreed intensity threshold occurs in a pre-agreed area, which can take the form of a square, rectangle, or circle. These products follow a "double-trigger" method where the first trigger is a catastrophe occurring within the box and the second trigger is the catastrophe meeting the minimum pre-agreed intensity threshold. High basis risk will still exist in this structure as it does not consider the impact at the insured's location. These first-generation cat-in-a-box solutions focused on reducing the basis risk when the potential loss was difficult to assess or when the measurements needed for index-based solutions were not easily available.

To illustrate the cat-in-a circle structure, let us consider a parametric structure that protects the insured from the losses caused by a cyclone. The parametric structure restricts that only a cyclone that passes within 100km of the location specified (first trigger) by the policyholder will be treated as a qualifying risk event. Any cyclone whose track misses the location by more than 100km will not result in a payout, regardless of the wind speed. When this requirement is met, the payout will be triggered based on the wind speed of the cyclone (second trigger) inside the 100km circle. If the reported wind speed is below 100 km/hr., no payout is triggered, whereas wind speeds above 100 km/hr. will trigger a payout of $500,000.

An incremental innovation to this parametric structure is to fragment the overall area of coverage into a grid comprising several zones based on the similarity of internal and external features. Separate models are created for each zone, and the index value derived for each zone is correlated with the outcomes in these homogeneous areas. The availability of high-resolution gridded data not only reduces the geographical basis risk but also provides reliable long-term data series to develop index-based contracts. The second-generation cat-in-a-box solutions refer to a comprehensive index-based trigger to capture the range of vulnerabilities within the defined area. As the basis risk could be more when the area that is covered by the parametric solution is heterogeneous, it is controlled by capturing the spatial heterogeneity in weather conditions, crop development, field conditions, and management practices, and appropriately factoring them in the parametric structure.

## Stepped Payout

The advances in data sourcing and analytics have helped to measure and qualify the intensity of the weather event at various locations. This has helped to reduce the basis risk by tracking the actual intensity of the weather event from several locations. This has consequently led to another innovation in the parametric payout, which is a stepped payout. A stepped payout allows partial payouts for a lower category storm and progressively higher payouts for stronger storms. In the cat-in-a-circle example cited above, a stepped structure could trigger differential payout depending on the intensity of the cyclone within the 100km radius. For example, a reported wind speed of below 100 km/hr. triggers no payout, wind speeds between 100-150 km/hr. and above 150km/hr. trigger payouts of $500,000 and $1,000,000 respectively.

## Partly Parametric Structures

In contrast to pure parametric products, a new breed of partly parametric products is being introduced. These products follow a hybrid model where the claim payout depends both on a parametric event trigger as well as an indemnity condition of reported loss. These products follow a two-phase, multi-tranche, or adjuster-triggered payout mechanism. In a two-phase payment, an initial lower sum is settled parametrically when the specific trigger threshold is exceeded, and the remainder is settled through traditional indemnification. In a multi-tranche model, the first payment happens on a parametric basis, however, the subsequent payments are made in multiple tranches that require varying degrees of loss assessment procedures. Adjuster-triggered depends on a human adjuster to verify if the parameter or index threshold has been met to initiate the parametric payout.

## Technology-led Revolution

Historically, the non-availability of reliable risk data has been a major limiting factor for the accurate modeling of parametric triggers. The advent and proliferation of new-age technologies in the last few years have changed the risk equation to the benefit of insurers. It has become a game-changer for the emergence of new channels for sourcing real-time data, means to transmit, store, analyze and derive insights from them. This is having a major influence on the way parametric products are reimagined. The subjectivity that prevailed in risk modeling due to the non-availability and opacity of individual risk behavior is changing. As insurers get more data on the individualized risk behavior, the traditional risk concepts that were propounded in an archaic era, when data was a scarce resource, are being revisited and redefined. Consequently, the possibility to break down risk into granularized coverages and objectively parameterizing them is increasing.

Parametric solutions are now introduced for several risks that were even deemed to be uninsurable earlier. The deluge of data from remote sensing satellites, drones, aerial platforms, and ground sensors, and the power of advanced machine learning algorithms to analyze such large volumes of data is providing insurers with deeper insights about the various attributes of the risks and these facilities increase their capacity to manage risk more efficiently. For example, Steel City Re, and Tokio Marine Kiln, developed a product for managing enterprise-reputation risk. The product pays out when the insured's reputational value metric falls below a certain threshold. Insurers are partnering with specialized technology providers to enrich parametric solutions. For example, AXA Climate has partnered with satellite technology firm VanderSat to derive parametric triggers linked to soil moisture levels.

The growth of internet-of-things sensors can be singled out as the most important catalyst for the dramatic reduction of basis risk and growth of parametric products. The geographical-bias risk is extensively reduced with the increasing possibility of sourcing data from the actual risk location itself. For example, FloodFlash, a UK-based Managing General Agent (MGA) models flood risk at a high resolution and sells property-specific parametric insurance. Flood height sensors are attached to a building and the payment is triggered when the water level rises to a pre-agreed depth. As the risk event trigger is based on data sources from within the risk location there is no displacement, and the resulting basis risk is negligible.

The availability of granular, high-quality, and real-time risk data along with machine learning-driven modeling techniques has armed insurers with a new capability to identify new parameters and derive new indices for both old and new risks. These sophisticated models mitigate the basis risk by accurately correlating between indexed-risk events and the sustained loss.

## Future of Basis Risk

The nagging problem of data poverty that continuously stymied insurers from making quantifiable improvements to a parametric structure is becoming a thing of the past and a new era of data abundance is being ushered in. The powerful combination of data abundance with the right technologies is giving insurers the freedom to produce innovative parametric coverages that are tailored to the requirements of the insured. The practice of pursuing incremental changes to improve the accuracy levels of the proxies is shifting towards procuring data directly from risk-relevant sources and deriving causative insights. The variety of risks that are covered under parametric contracts is expanding from natural catastrophes or weather-related to all other types of risks.

Insurers are starting to offer parametric products for risks that are non-catastrophe related, intangible, emerging, or those which were previously considered uninsurable. Innovative parametric products cover intangible business opportunity losses due to loss of customer footfall following a terror alert. For example, Aon launched a new cover to protect the income streams of companies with large amounts of intangible assets, such as Uber or Airbnb. The product caters to events like terrorist threats, cyberattacks, transit strikes, or inclement weather that do not necessarily cause physical damage, but that can have cash-flow impacts on service-oriented businesses, like hotels, retailers, and transportation companies. The insured value in these products is modeled based on historic and average revenue.

Parametric products that have a binary cut-off event trigger and carry no inherent basis risk are being introduced. For example, Blink, an Ireland-based insurtech company, offers coverage for customers who miss a flight or experience a flight delay. Parametric structures are being applied over other innovative insurance models such as usage-based, on-demand, peer-to-peer, and microinsurance. In the tech-enabled connected landscape, continuous monitoring will lead insurers to the age of comprehensive management of risk and its prevention. As the losses from several hazards are effectively prevented, a major portion of the sustained losses is likely to be caused by fortuitous reasons. In such a connected landscape, any mismatch between the customer's experienced loss and the parametric payout in the new generation products could be attributable more to coverage gap rather than basis risk.

## References


- Gaurav, S. & Chaudhary, V. (2020), "Do farmers care about basis risk? Evidence from a field experiment in India", *Climate Risk Management*, 27, 100201.
- Goda, Katsuichiro, Franco, Guillermo, Song, Jie & Radu, Alin (2018) "Parametric Catastrophe Bonds for Tsunamis : CAT-in-a-Box Trigger and Intensity-Based Index Trigger Methods", *Earthquake Spectra*. 55. 10.1193/030918EQS052M.
- Lin, Xiao & Kwon, W. (2019), "Application of parametric insurance in principle/regulation-compliant and innovative ways. *SSRN Electronic Journal*. 10.2139/ssrn.3426592.
- Meenan, Conor (2017), "Unpacking Basis Risk". Retrieved from *https://www.rms.com/blog/2017/08/14/unpacking-basis-risk*
- Sengupta, R. & Kousky, C. (2020), "Parametric Insurance for Disasters" Retrieved from *https://riskcenter.wharton.upenn.edu/wp-content/uploads/2020/09/Parametric-Insurance-for-Disasters_Sep-2020.pdf*
- Singapore Reinsurers' Association (2020), "Parametric risk transfer : A solution to narrow Asia's protection gap. Retrieved from *https://sg-reinsurers.org.sg/sites/default/files/2021-01/sra-white-paper-parametric-risk-transfer-2nov2020.pdf*
- Singer, Andrew W. (2019), "The Evolution of Parametric Insurance". Retrieved from *http://www.rmmagazine.com/2019/04/01/the-evolution-of-parametric-insurance/*
- Skees, J., Murphy, A., Collier, B., McCord, M. & Roth, J. (2007), "Scaling up index insurance: What is needed for the next big step forward. Microinsurance Centre, LLC & GlobalAgRisk, Inc [online] Retrieved from *http://globalagrisk.com/Pubs/2007_Skeesetal_Scaling%20UP%20Index%20Insurance_KfW_dec.pdf*
- Stillwell, Kate (2021), "Claims' considerations for parametric insurance". Retrieved from *https://www.propertycasualty360.com/2021/01/13/claims-considerations-for-parametric-insurance/*
- Turner, Stuart (2020), "Parametric insurance policies: Do they have to be weather-related?" Retrieved from *http://edition .cnn.com/2009/LIVING/ wayoflife/09/14/mf.get.rich.off.weather/*
- Vyas, S., Seifert, V., Schaefer, L. & Kreft, S. (2019), "Climate Risk Insurance Solutions : Understanding the Drivers of Cost-effectiveness". Retrieved from *https://www.insuresilience.org/wp-content/uploads/2019/03/MCII-Discussion-Paper-3_Understanding-cost-effectiveness.pdf*


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