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INTRODUCTION TO PARAMETRIC SOLUTIONS

Almost as soon as human societies began to develop and interconnect, (re)insurance was developed to provide cover for goods and trade. Throughout the centuries, (re)insurance products have evolved to become increasingly sophisticated. In recent years, the rise of modelling capability, product innovation and data availability have led to the development of solutions with an augmented range of perils and exposures.

What if the (re)insurance industry could provide cover for previously uninsurable risks, in any part of the world and with fast and transparent payouts? While the novel characteristics of parametric products are progressively making them a staple of modern (re)insurance, they are often surrounded by misconceptions that make them appear more complex than they really are. In this article, we describe the main concepts of parametric products and explore their areas of application.

PARAMETRIC (RE)INSURANCE: A STRATEGIC TOOL FOR THE MITIGATION OF NATURAL CATASTROPHE AND WEATHER RISK

MARKET OVERVIEW

The current market is mainly driven by public and industrial sectors, such as Energy and Agriculture, which are exposed to weather uncertainty risks. Indices are typically constructed around precipitation, temperature, wind speed, quake magnitude and hurricane category.

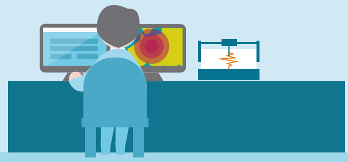
Sector	Risk Factor	Consequences
Public Authorities	Storm, flood, quake	Emergency and rescue expenses, infrastructure damage costs
Agriculture	Drought, temperature	Impact on yields
Energy	Rainfall, temperature, wind, sunshine	Production capacity
Construction	Temperature, wind	Interruption, extra costs and late penalties
Travel & Leisure	Rainfall, snowfall, temperature	Customer satisfaction
Transportation	Ice, snow	Access, cancellations
Sports & Events	Rainfall	Cancellations

A PAYOUT-BASED PRODUCT

What is traditionally meant by "insurance"? It is typically defined as the relationship between an insured and an insurer over the protection of the insured against uncertain losses, in exchange for a premium. Insurance traditionally provides indemnity: if a loss occurs, the insured submits a claim to the insurer, who indemnifies the insured for the loss sustained following a loss assessment by a claims adjuster.

A parametric product, on the other hand, does not rely on the assessment of the loss by a loss adjuster prior to payout, but on the observation of exogenous parameters.

SCOR The Art & Science of Risk | P&C



WORLD BANK DEFINITION

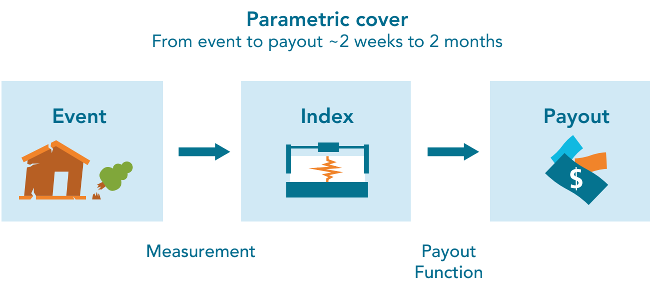
Index or parametric insurance pays out benefits based on a pre-determined index for the loss of assets and investments as a result of weather or other catastrophe events. In contrast, traditional insurance relies on assessments of the actual damage.

In other words, for a parametric transaction, the payout does not solely depend on the actual assessment of the insured's incurred losses, but is rather linked to an external, observable variable. This has the following advantages:

- transparency of payout trigger,
- lower dispute risk,
- faster payout,
- no need for loss adjustment,
- resulting lower expenses.

While it is interesting to compare traditional indemnity insurance to parametric cover, the two products can sometimes be used in complementary ways:

- parametric cover can fill the protection gap left by insurance products such as deductibles and uninsured business interruptions,
- it can provide revenue protection in addition to damage insurance for agriculture and electricity providers.



A SIMPLE EXAMPLE

A city buys a parametric insurance policy to cover emergency expenses for an earthquake, with the following terms and conditions:

- limit: eur 100m,
- index: magnitude of an earthquake within a perimeter of 50km from a pre-determined coordinate in the center of the city,
- payout function:

Magnitude	0 ≤ M < 5	5 ≤ M < 6	6 ≤ M
Payout (€ million)	0	50	100

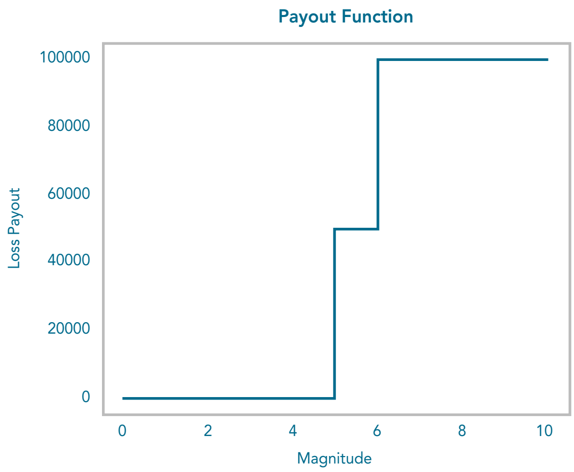
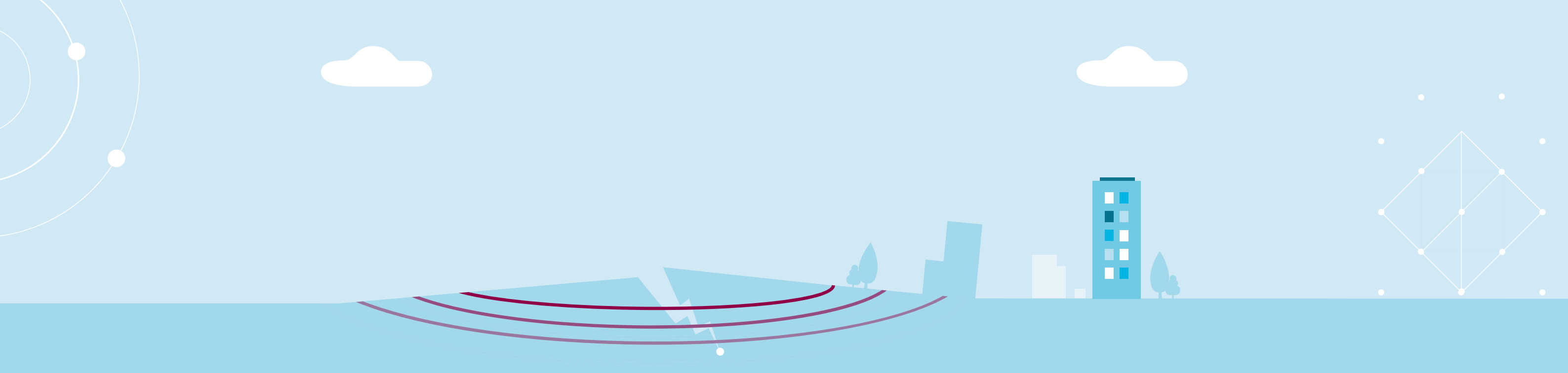


FIGURE 1: CONTRACT PAYOUT AS A FUNCTION OF THE EARTHQUAKE MAGNITUDE

Source: SCOR

Suppose the following frequency table is provided:

Magnitude	0 ≤ M < 5	5 ≤ M < 5.5	5.5 ≤ M < 6	6 ≤ M < 6.5	6.5 ≤ M <7
Frequency	0.09%	0.08%	0.06%	0.01%	0.005%
Loss (€ million)	0	50	50	100	100



Defining L(x) as the function associating the payout with the magnitude x, the expected loss of the contract is then €85,000.

This example illustrates a purely parametric product, which has limits compared to a more traditional insurance product.

The amount to be paid can be calculated immediately after receiving information about the magnitude of an earthquake, rather than estimating indemnity amounts.

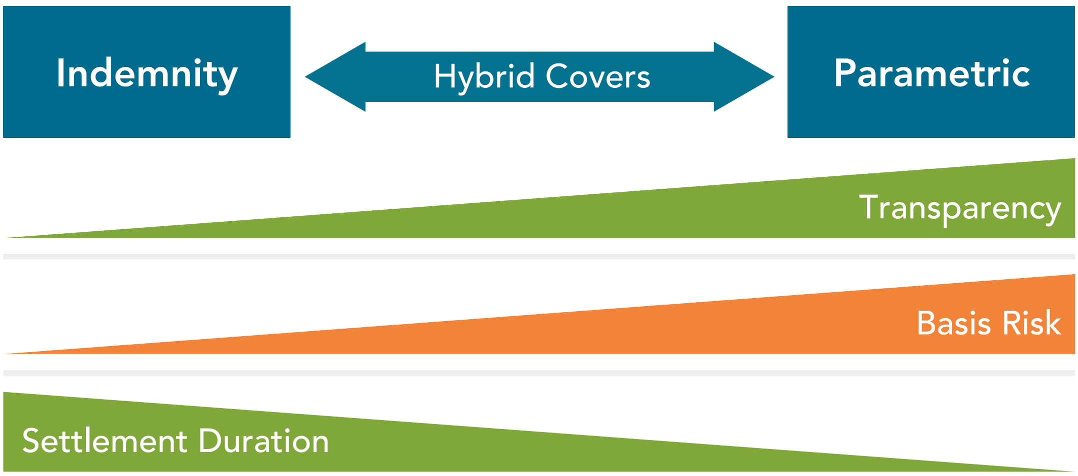
But the strictness of the trigger can prevent some loss payments when there has actually been some damage. For example, if an earthquake with a magnitude of 4.9 happens in the city center, it could cause some actual damage, but because the parametric product has not been triggered, this damage would not be covered. Equally, the parametric product would not provide any cover for loss sustained due to a high magnitude earthquake happening 55km away.

On the other hand, the same contract could trigger a payout in circumstances where no damage is caused. For example, an earthquake with a magnitude of 5.1 that happens 49km away in an unpopulated area would still trigger the parametric cover, even if it has only caused very little damage. Similarly, the index used in the example is only partially suitable for modelling the earthquake. The model considers only the magnitude of the event, whereas elements such as depth of epicenter, type of wave, distance to population or infrastructure centers are crucial for an accurate characterization. In this case, an indicator such as peak ground acceleration would provide a more accurate trigger.

BASIS RISK POSES A KEY TECHNICAL CHALLENGE TO THE DEVELOPMENT OF PARAMETRIC PRODUCTS

So where is the catch? By reducing settlement times and increasing settlement transparency, parametric covers might seem like the perfect product. While those characteristics are true, parametric covers also entail the issue of basis risk (where payout does not match the insured's actual losses).

Parametric covers are not a silver bullet and need to be used in situations where their advantages are used best. However, Basis Risk is an integral part of a parametric product and needs to be dealt with accordingly.



WHAT IS BASIS RISK?

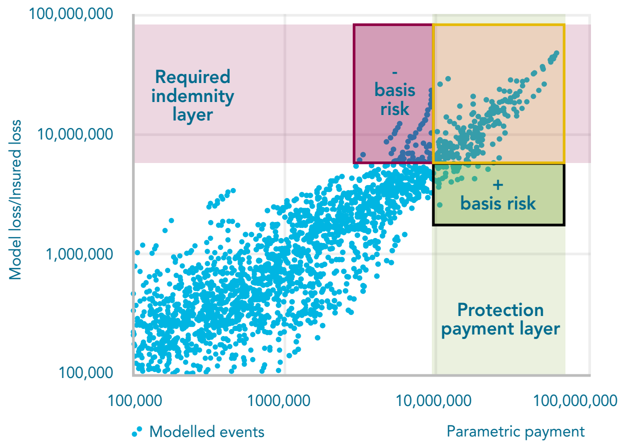
In its most basic definition, basis risk is the mismatch between the payout on a contract and the actual losses suffered by the policyholder.

It should be understood that basis risk is an inherent part of parametric products, simply because the payout is based on exogenous parameters and not on actual losses suffered by the insured. But the magnitude of the basis risk involved can vary significantly, depending on the accuracy of the modelled losses and the quality of the product design.

Basis risk can be classified into two types:

- **type I (false positive):** the product provides more payout than occurred losses,
- **type II (false negative):** the product does not provide sufficient payout to cover occurred losses.

	Occurred Losses	No Loss
Payout	Well designed	Type I (false positive)
No Payout	Type II (false negative)	Well designed



CASE STUDY: HOW A THOROUGH ANALYSIS OF THE POLICYHOLDER'S NEEDS, COMBINED WITH ADVANCED MODELLING, CAN MITIGATE BASIS RISK

We will present basis risk and the methods used to minimize it through a request for parametric cover from the fictional state-owned electricity utility company EoM (Electricity of Mapau) in South-East Asia.

The country is composed of two main islands, with a large city on each island. EoM wants to buy typhoon coverage for its power grids. A parametric cover might be ideal for the situation, as the country wants to use insurance for costs associated with emergency expenses and repairs.

The first response to the enquiry is to propose a cat-in-a-box approach. If a typhoon with sufficient "intensity" is observed going through a designated geographical area, the transaction will trigger a payout.

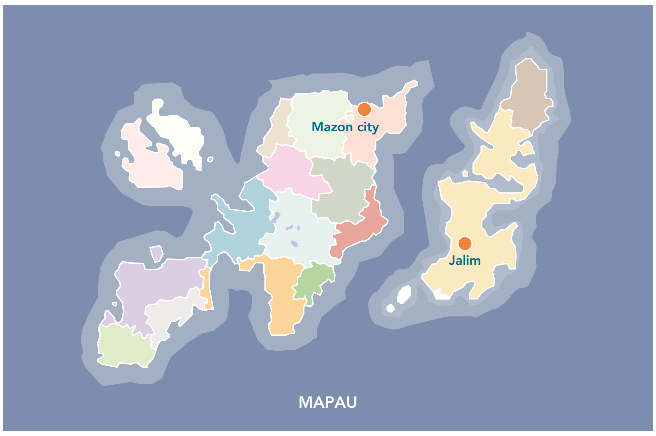


FIGURE 2: POLITICAL MAP OF MAPAU

Source: SCOR

In our case, the following parameters are selected:

Geographical area	200km radius around the middle point between Mazon City and Jalim.
Index	Maximum 1-minute average windspeed around the eye of the typhoon within the circle, measured in meters per second (m/s). Typhoon track data is provided by the Mapau Meteorological Agency
Payout	If the index indicates a value equal or higher than 35 m/s, then a payout of USD 30,000,000 is made.

Such cover is simple and robust, but suffers from several drawbacks:

- The selected geographical area is approximate and does not represent the reality of the insured values.
- Similarly, the simple design of the index could lead to major basis risk.
- The payout is binary (either the contract pays USD 30 m or nothing) and is not sufficiently tailored to the needs of EoM.

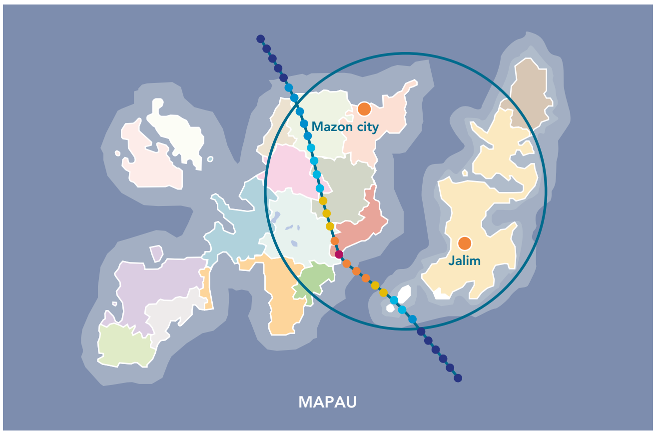
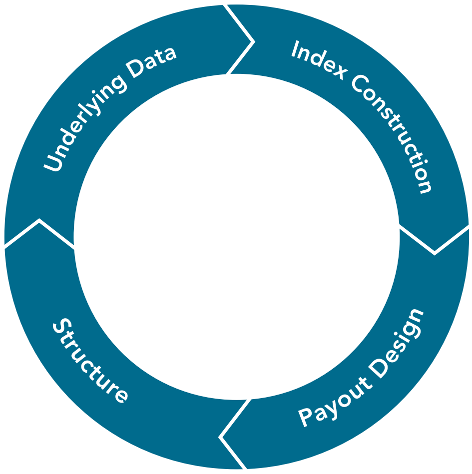


FIGURE 3: CAT-IN-A-BOX COVER WITH AN EXAMPLE OF TYPHOON TRACK CAPTURED BY THE "BOX".

Source: SCOR

To assess basis risk and optimally reduce its impact, SCOR has developed a framework designed around 4 elements:

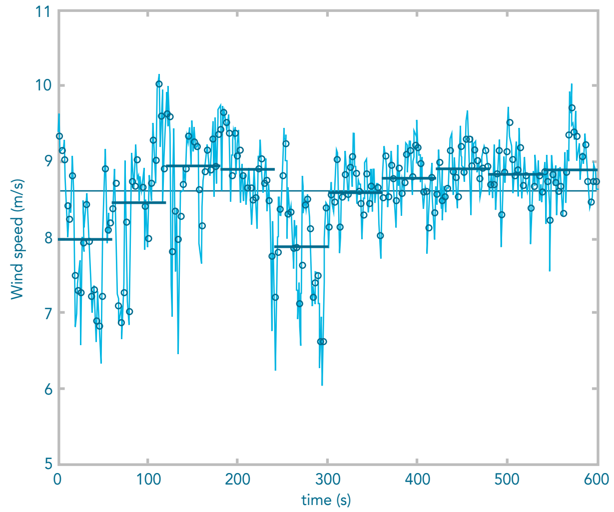
- **Underlying data:** can a relevant index be constructed with the available data? If not, can it be approximated with other data?
- **Index Construction:** is the index sufficiently correlated with the underlying risk? What is an acceptable trade-off between accuracy and simplicity, given the context of the inquiry? How quickly can the index be calculated and how trustworthy is the calculation?
- **Payout Design:** should the payout be a lump sum (binary payoff function) or should it be more complex?
- **Transaction Structure:** should the policy be a straightforward contract, or should it have additional components? (e.g. multi-year aggregate features).



UNDERLYING DATA

The Mapau Meteorological Agency has provided historical events with tracks over the past 20 years, with 2-minute average windspeed measures around the eye of the typhoon. While this data is good enough to build an initial model, several improvements can be made:

- **Cross-check with other sources to validate observations.**
- **Check if the available data is complete enough to provide accurate modelling.** A historical period of 20 years is typically not sufficient for such catastrophe events. We would ideally need at least 50 to 100 years of typhoon observations. Missing data points can be interpolated depending on the context.
- **Check the consistency of the data.** Could geographical context such as increased urbanization influences the measures? Have the measuring methodology or the tools changed over time, and has this been taken into account?
- **Can a backup measurement provider be found?** Ensuring that the index can be provided in a reliable way is essential for parametric cover.
- The 1-min average windspeed measure is prone to high volatility that can lead to both Type I and Type II basis risk. A 10-minute average measure is recommended for an accurate estimation of mean windspeed.



The thin curve is the 1-second mean, the open circles are the 3-second means, the thick horizontal bars are the 1-minute means and the horizontal line is the 10-minute mean.

FIGURE 4: ILLUSTRATION OF THE IMPACT OF THE AVERAGING PERIOD ON THE WINDSPEED OBSERVATIONS.

Source: WMO keynote by J. A. Knaff and B. A. Harper

By combining internal and public databases, significant improvements can be made to the underlying data used to model the transaction. Such a model leads to basis risk reduction by itself, but is more importantly the foundation for all the other basis risk reduction techniques.

INDEX CONSTRUCTION

The initial index is a "cat-in-a-box" index that, in a designated geographical area, checks if a typhoon is within the area and outputs the maximal 2-minute observed average windspeed. While such an index has the advantage of being simple, it may be enhanced as follows:

- **Make the index depend on insured values.** The initial index is location-independent as long as the measured typhoon is in the CAT circle. A first approach is to break down the coverage into N sub-regions (related to portfolio insured values) and use a locally weighted index:

$$I(t) = \sum_{i=1}^{N} w_i \max\{0, v_i(t)-t_i\}^{\alpha_i},$$

where v_i is the observed windspeed at location $i \in [1,N]$, w_i the weight of location i (proportional to the sum of insured values of region i), t_i the corresponding threshold and α_i an exponent representing the relation between the windspeed and the damage to the insured values.

The portfolio weights are usually straightforward to calculate, as they are proportional to the sum of insured values. The index is therefore tailored for the policyholder. On the other hand, the damage exponents α_i need to be calibrated. This is done by fitting a power function for each of the locations $i \in [1,N]$:

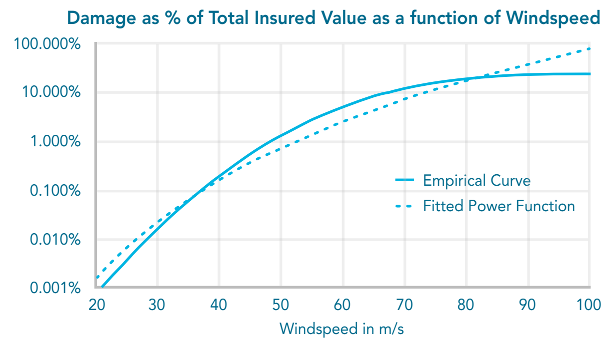


FIGURE 5: CALIBRATION OF DAMAGE FUNCTIONS.

Source: SCOR

A power model has the advantage of being a simple model. But, as seen in Figure 4, it can be a crude approximation on tail events and can therefore still allow for significant basis risk. To reduce this risk, a more general approach to index modelling can be taken by performing a regression analysis, which in a formal way corresponds to a set of optimal w_i and f_i such that

$$I(t) \approx \sum_{i=1}^{N} w_i\, f_i(v_i),$$

where w_i is a weighting coefficient and f_i: $\mathbb{R} \rightarrow \mathbb{R}$ is a real-valued function.

As a general rule, a simpler model is more robust and better understood, but is less precise. A more complex model might have better predictive power, but the model becomes increasingly opaque ("black-box" effect) and runs the risk of being overfitted. This is a typical Data Science problem

and should follow the appropriate procedures: checking modeling assumptions, overfitting, data bias, and so on.

Compared to an approach using an industry standard model, creating an index tailored to a specific case has the advantage of providing full transparency and precision in terms of the location and amount of insured assets.

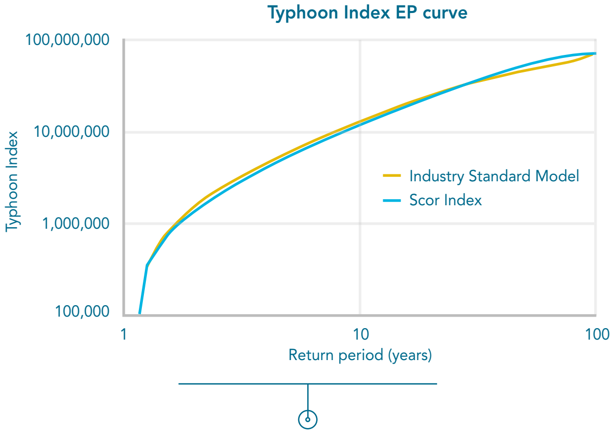


FIGURE 6: SCOR INDEX VS. INDUSTRY STANDARD MODEL OUTPUT.
Source: SCOR

PAYOUT DESIGN

The payout function translates the index into a nominal monetary amount. It has two characteristics: a condition to trigger the payout based on an index threshold, and the type of payout.

- **A well-chosen threshold.** The threshold value is selected to meet a concrete need and is usually proposed directly by the company looking for the cover. In cases where there is room for further optimization, the threshold can be calculated by transforming the index EP Curve into a loss EP Curve.
- **Additional trigger conditions.** A flexible way to reduce basis risk is to add more trigger conditions. These additional conditions could be an alternative index or an indemnity-related requirement, such as the observation of the actual losses. They can have two distinct effects:
  - An "and" additional trigger would provide the (re)insurer with additional protection against basis risk. This protects against Type I basis risk.
  - An "or" additional trigger gives the cover a second possibility to produce a payout and potentially reduces basis risk for the insured. This corresponds to protection against Type II basis risk.

TRANSACTION STRUCTURE

The structure of a transaction is not specific to parametric covers but is an essential element of any (re)insurance product. The simplest parametric cases are similar to a standard excess-of-loss contract, while more complex covers can become advanced cashflow management tools. Solutions for scenarios that involve addressing specific needs, or developing more complex structures, can be developed using structured products and the underwriting expertise of the reinsurer plays an important role in the efficiency of the structure.

OUTLINE

We have seen that parametric products may provide alternative types of protection, which replace indemnity uncertainty with model uncertainty. This comes with a set of trade-offs: while parametric covers are faster for payouts, more transparent and do not require loss adjustment, they are exposed to basis risk.

Basis risk can be an issue both for the protection buyer and the protection seller, i.e. where the product pays out despite there being no actual losses (Type I) or the opposite situation, where losses occur but there is no payout (Type II). Fortunately, multiple techniques are available to mitigate such risks, and advances in technology and modelling are further helping to improve the accuracy of parametric covers.

The increasing availability and quantity of data helps to build a well-fitted index and provide alternatives. The use of data science techniques can lead to more sophisticated indices and better tailoring, thereby significantly reducing basis risk. The choice of trigger conditions is a fundamental factor, and using dual triggers is a useful approach to reconcile a payout with the corresponding indemnity. Finally, a transaction can be adapted to better fit specific needs by incorporating structural elements.

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