Bringing a forward-looking perspective into liability modelling

Liability Risk Drivers
Forward-looking modelling (FLM) is used to anticipate future outcomes of business for the re/insurance industry in the light of economic, societal, legal and other dynamics.
Foreword 3
Driving an industry-wide paradigm shift 5
Forward-looking modelling 6
The LRD model landscape 7
The LRD model and its components 11
Loss experience analysis 20
Indicator retrieval 22
Loss scenario and potential loss event 25
Portfolio definer 31
Other applications 33
Conclusion 36
Foreword

The re/insurance industry has traditionally used historical data to assess current and future risk exposures. But in today’s fast-changing environment, the past is no longer a good predictor of future casualty exposures because risks are becoming increasingly globalised, complex and interconnected. As a result, insurers need to develop new tools and forward-looking approaches to better assess future risks.

Such forward-looking approaches can be challenging in casualty business, and particularly in liability, due to their long-tail nature and exposure to changes in the risk landscape. It can also be difficult to pinpoint all of the risk drivers. To identify and understand the impact of new social, technological and legal trends driving casualty risk, Swiss Re has developed the Liability Risk Drivers™ (LRD). The first of its kind in the industry, this forward-looking model offers an effective approach to better understanding and rating long-tail risks.

A future-oriented risk assessment model, the LRD allows us to extend the basis for liability costing beyond historical data and to include the actual risk factors driving liability. As such, it enables better assessment and management of risks in markets and/or segments with no loss history or where the loss history cannot be used to gauge future exposure. LRD provides a sound basis for sustainable casualty business, especially in emerging and fast-changing markets.

With LRD, we assess our risk and help clients identify, quantify and price the accumulations in their portfolio. Working together, we can manage our liability exposures and make the world more resilient. We are smarter together.

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Liability Risk Drivers

The LRD model landscape
Driving an industry-wide paradigm shift

Few products in reinsurance are as challenging to model as liability with its long-tail nature and its susceptibility to changing technological, economic, legal and societal conditions. Modelling liability catastrophes and risk accumulation is especially difficult because historical loss information – if it exists at all – does not really say much about future exposures, and because new risks keep emerging on the horizon. At the same time, the need for transparency around accumulation potential in liability books will continue to grow with the increasing interconnectedness and complexity of liability risks.

With the introduction of the LRD model, Swiss Re is driving an industry-wide paradigm shift to forward-looking modelling in liability. Instead of starting out from statistics of past claims, Swiss Re’s proprietary Liability Risk Drivers™ (LRD) modelling approach operates with loss scenarios. The scenarios are used to build potential loss events which run through the environment or the jurisdiction in which the risk originates – e.g. the location of the premises or of the customers – to evaluate the risk drivers, such as the economic or legal environment. This new approach allows us, for instance, to anticipate the impact of a given change or a trend in a risk driver without having to wait for claims to emerge. It also allows results to be transferred from data-rich to data-poor contexts, from developed to high growth markets.

The LRD approach enables us to improve risk selection and generates a competitive advantage for both Swiss Re and our strategic clients.

Swiss Re is driving an industry-wide paradigm change from retrospective modelling to FLM in casualty business.

We are currently extending the LRD model to liability catastrophes as a basis for a bottom-up, forward-looking approach to risk accumulation. To do so, we need to capture the exposure on every single risk we have in our book. Our goal is to have a system in place which, in addition to supporting our risk selection and pricing efforts, helps us to make strategic decisions based on accumulation risk appetite, much like the approach we already apply for natural catastrophes.
Forward-looking modelling

Traditional costing approaches typically focus on correlations between loss and exposure data. They tend not to consider risk accumulation, risk contagion or liability catastrophe issues in the portfolio. Likewise, they don’t sufficiently consider loss generating mechanisms and loss drivers, which are essential when entering new markets or when market conditions change. Can we expand our approach beyond traditional rating methods by applying findings from behavioural economics and catastrophe modelling approaches? Will this allow us to price commercial risks better?

This brochure confirms that this can indeed be achieved using forward-looking modelling as a complement to the traditional methods. Swiss Re’s forward-looking model for liability business serves as an example to explain the details of this approach.

Forward-looking models (FLM) serve to anticipate future outcomes – for example, the characteristics of future losses – by reflecting the mechanics and processes that drive them. They go beyond a mere roll-forward of past experience and have the built-in flexibility to evolve and take into account current and future changes. They are validated and trained through an understanding of historical experience, which forms a subset of what the model can predict. This allows the model to be applied in situations with and without relevant historical experience.

Forward-looking models go beyond predictive models by acknowledging a structured cause-effect chain. The findings from predictive modelling can thus be transferred from data-rich contexts into the future and to other contexts where experience and data is sparse, for instance in high growth markets. FLM anticipates future outcomes of re/insurance risks in changing economic, societal, technological, and legal conditions, and is becoming a preferred approach to accurately predicting liability risk.

The parameters of an FLM are known as risk drivers, and most, if not all of them can be observed directly. They are parameterized from other sources than ultimate monetary past loss amounts. Such sources include validated insights of underwriters and claims adjusters as well as macro-economic data and other external data sources. This construction allows the model to focus on relevant loss data rather than being obliged to utilize any available loss data. Since an FLM explicitly reflects the structured cause-effect chain, it can be developed in a modular way which in turn allows extensions by adapting only the corresponding module instead of having to start from scratch.

Swiss Re already pioneered the use of forward-looking modelling for natural catastrophes and is now doing the same in the casualty industry by developing and applying its patented Swiss Re Liability Risk Drivers™ (LRD) model.
The LRD model landscape

The Swiss Re Liability Risk Drivers™ model is the insurance industry’s first explicitly forward-looking model for end-to-end pricing of liability business. It is covered by a US patent (US8639617B2, granted 28 January 2014), other patents are pending.1

The LRD approach

The LRD model consists of two main elements: loss scenarios and risk drivers. Rather than starting out from past losses, the LRD model builds up the expected loss from potential losses which can be in the past or in the future according to a set of loss scenarios. These potential losses are then subjected to the influence of key risk drivers both within (e.g. the type of product or the geographic extension of activities) and outside (e.g. the willingness to sue or the legal environment) the companies to be insured. Past loss experience is used as a testing environment to verify and – if mismatches are found – to understand and correct the model’s outcome. The LRD model has been calibrated and validated against reliable in-house and external exposure and loss data.

Swiss Re Liability Risk Drivers™ is Swiss Re’s proprietary and patented FLM approach for liability business. It reflects the cause-effect chain of liability losses using a scenario-based methodology, and quantifies the impact of the main drivers of liability business on loss frequency and severity.

The risk drivers are parameterized from sources other than ultimate monetary past loss amounts. Such sources include validated insights of underwriters and claims adjusters as well as macro-economic data and other external data sources. This construction allows the model to focus on relevant loss data rather than being obliged to utilize any available loss data. Due to its modular approach, the model can be extended by adapting only the corresponding module.

1 Patent application was filed in 2010.
The LRD model landscape consists of three main parts: the LRD model, the LRD indicator retrieval and the LRD loss experience analysis. The LRD model calculates the expected loss from exposure information using loss scenarios and risk drivers. The LRD indicator retrieval observes and forecasts the development of risk-driving properties of the world used as parameters by the model. The LRD loss experience analysis collects and analyses the relevant loss histories and corresponding exposures to back-test the model predictions. If there are any significant mismatches between a loss history and the corresponding model prediction for the past, the model structure and/or the relevant model parameters are corrected accordingly.

Swiss Re is gradually moving towards FLM as the best practice approach to addressing the risk of change.

At the time of writing, we use the model for costing and underwriting products for public and commercial liability risks of companies whose revenue does not substantially surpass USD 2bn. It covers the entire world. An extension to larger companies was started in 2014. The model is also used for costing reinsurance treaties in a growing number of countries. The map shows the quality of the model in 2015. A full risk driver model has been developed for the countries marked dark blue, whereas a simplified approach has been used for the countries marked light blue.

2 In the treaty renewals of 1 July 2015, commercial liability treaties were underwritten using LRD in Australia, Canada, China, France, Germany, Hong Kong, Italy, Korea, Malaysia, the Netherlands, Singapore and the US.
The LRD model will be extended to other lines of business (e.g., professional liability including medical malpractice, architects and engineers, E&O and D&O), large corporates and treaties underwritten worldwide. Moreover, in 2013 work began on incorporating a liability catastrophe model into the LRD model, allowing risk accumulation control and costing of liability clashes and contracts consistent with capacity and risk management.

The LRD model in a nutshell

The LRD model calculates the expected loss and other expected loss characteristics from risk and exposure information of the company or the portfolio to be re/insured.

It does not take into consideration any account-specific or market loss history, and does not contain any historical loss data. Instead, it builds up the expected loss from potential losses (loss scenarios) and risk factors which can be observed independently.

The model requires a number of parameters in order to work effectively. Most parameters, such as the cost of living in various countries, represent risk factors and can be obtained and forecast from other sources. Only a few parameters, such as the number of events potentially triggering third-party losses (the so-called base frequency), are obtained by comparing model predictions with past loss experience. Most model parameters can be observed directly and can be forecast and verified directly and independently of any overall loss experience. This allows the model to anticipate the effect of changes among risk drivers before they become manifest in observed losses or even statistically significant.
The LRD model and its components

LRD model objectives

The LRD model was developed with the following key qualities:

- The model has predictive power, i.e., it can be used to anticipate the effects of legal or societal or other changes on the expected loss.
- It is transferable, i.e., it translates findings from one context to another one by means of differentiating parameters to be changed.
- It can be used to estimate the expected loss in areas with insufficient historic loss information and no tariffs.
- It is transparent, i.e., it can quantify the impact of changing terms, conditions and risk factors.
- The model can also be used for purposes other than pricing, such as accumulation control, risk modelling or the securitisation of risks.

To meet these objectives, model design followed these principles:

It explicitly takes account of the risk-driving properties of the underlying risk rather than considering statistics reflecting past loss experience. The risk-driving aspects of the legal or societal environment for instance are explicitly incorporated into the model. In this way, the model accommodates expert judgement and data related to risk drivers instead of, or in addition to, loss data (which is used for back-testing).
**The LRD model and its components**

Only a minimum of rating input is required: the values of all risk drivers external to the companies or portfolios to be insured are already part of the model. For most internal risk drivers, the model calculates default values. The only mandatory rating input is provided in terms of commonly used rating variables:

- the size of risk in terms of revenues
- types of products and activities in terms of revenue split into industry classes
- geographic extension in terms of revenue split by industry into regions, countries, states, or territories

A modular design and subsequent gradual refinement allow users to obtain early feedback from the model.

**Key elements: risk drivers and loss scenarios**

Risk drivers and loss scenarios are the key elements of the LRD model.

We define a liability risk driver as anything which may have or is proved to have an influence on a liability loss in the broadest possible sense. The influence can be on the frequency of losses, their severity or on both simultaneously.

In a future re/insurance contract, the risk drivers can be macro-economic, societal, legal, or judicial by nature. Or they might be characterized by factors such as the size of a given company, the type of products, or the insurance terms and conditions. The exposure information representing the internal risk drivers is the model input. It comprises the size of risk together with its split by product/activity and country. It also contains information about re/insurance terms and conditions as well as optional information about the insured.

The LRD model breaks down the risk into different loss scenarios. A loss scenario represents a class of potential losses and combines the answers to the question “what could cause a loss?” with the responses to “what would be the effect of the potential loss?” including “who could be affected?”

The model generates potential losses from the loss scenarios based on the exposure information. These potential losses are then subjected to the various transformations an actual loss would undergo in the real world: from the cause to the effect, from the effect to the economic compensation, from the economic compensation to the awarded amount, from the awarded amount to the insured amount, and from the insured amount to the reinsured amount.
The LRD modules

The LRD model consists of modules which can be extended independently of each other. Seven modules are connected by a common scenario loss model representation reflecting potential losses, and they all answer a specific set of questions. Each module accommodates a number of risk drivers and derives the input information from the scenario loss models and the risk drivers. The scenario loss models are then modified and passed on to the next module. In the first three modules, the scenario loss models do not carry any monetary amounts but simply the counts of affected individuals and goods. This is denoted by the term “natural units”.

The chain of modules also reflects the steps the potential losses would undergo in the real world:

1. **Event generator**
   - Cause and effect of a potential loss
2. **Risk splitter**
   - Locations of the potential loss
3. **Risk discriminator**
   - Risk mitigation and other risk-driving properties of the insured company
4. **Price tag engine**
   - Economic compensation of the loss effect
5. **Legal system**
   - Influence of societal, legal and judicial risk drivers
6. **Wording filter**
   - Insurance coverage of the potential loss
7. **Aggregator**
   - Total re/insured expected loss
Event generator

The event generator determines the relevant potential losses and answers the following questions:

- What are the causes of a potential loss?
- What are the effects of the potential loss?
- Who is affected?

The event generator executes the following steps:

- Selection of the applicable loss scenarios according to their underlying risks (cause by type of product/activity and affected party) and their potential relevance for the intended line of business coverage (products or premises/operations liability and associated lines).
- Creation of a scenario loss model for each selected loss scenario. This represents the potential loss triggered by one event, such as a factory explosion, a faulty product batch, slip and fall on the manufacturer’s premises, etc.
- In addition to the underlying risk information, the generated scenario loss models derive information about their loss mechanism and the loss effect (number and nature of injuries and other damage) from the corresponding loss scenarios.

The effects of these events are expressed in natural units (e.g., the number of affected individuals) rather than in monetary amounts.

The following key liability risk drivers are part of the event generator:

- Internal risk drivers: *type of product/activity*, measured by breakdown of the company size (business volume) into industrial classes, represented by SIC major groups, custom industry groups or ISO industry classes.
Risk splitter

The risk splitter determines the location of the potential losses. It answers the following questions:

- Where does the potential loss occur (or where is the affected third party located)?
- How much business volume is exposed to the potential loss in a given location?

The risk splitter executes the following steps:

- Allocation of business volume to the different incoming scenario loss models according to the exposure split by location per type of product/activity.
- If the scenario loss models have business volumes in different countries, states or regions, identical scenario loss models are created for each location, and business volume is allocated accordingly.
- The frequency of the potential losses is determined by the risk driver “size of company” and some loss scenario properties.

The following key liability risk drivers are part of the risk splitter:

- Internal risk driver: geographic extension of activities, measured by the business volume per type of product/activity to the effective product destinations and to the locations of the own premises. These locations may be represented by countries, states, judicial venues and regions.
- External risk driver: size of economies (measured by GDP) and trade (measured by import/export numbers) to calculate weights for countries and regions such as Asia, European Union, Rest of World from the perspective of a particular country.
- Internal risk driver: size of company, measured by revenues or other proxies for business volume.
- External risk driver: relative reference revenue comparing equivalent revenues or other company-size proxies subject to inflation between countries and over years, measured by purchasing power parity.

Risk discriminator

The risk discriminator determines the impact of qualitative risk drivers related to the insured company. It answers the following question: How do the factors related to the insured company influence the loss frequency and/or severity?

The scenario loss model frequency and/or severity components are altered according to the influence of company-specific liability risk drivers. Among others, they are used to differentiate between “good risks” and “bad risks”.

The companies to be insured are differentiated according to their performance in relation to their peers in terms of:

- risks or benefits from “loss prevention” measures taken or not taken by the insured
- risks arising from the possibility of human error, i.e. the “human factor”
- risks or benefits arising from “new products and activities”
The following key liability risk drivers are part of the risk discriminator:

- **Internal/external risk driver: loss prevention**, measured by products and environmental certifications, **loss prevention measures** (used as internal risk driver) and **default loss prevention**, measured in the same way if the companies’ loss prevention measures are not known (used as external risk driver)
- **Internal risk driver: human factor**, measured by large-scale company structural changes, staff turnover as well as by the proxies workplace incidents indicator, recall statistics
- **Internal risk driver: new products and activities**, measured by the innovation factor determined from revenue, industry, and investment in R&D
- **Internal/external risk driver: government influence**, measured by the degree of effective control from government (internal risk driver) and the effect of government influence on the willingness to claim and the likelihood of an award (external risk driver)

**Price tag engine**

The price tag engine determines the economic compensation for the potential losses from the loss effects and their economic environment. It answers the following questions:

- What is the cost of the economic compensation resulting from the potential loss?
- What is the monetary exposure to the consequence of the potential loss?

The price tag engine executes the following steps:

- The economic cost, ie the money needed to compensate the damage arising from the loss consequences, is calculated from the loss consequence. For this calculation, the price tag engine uses macroeconomic values such as the cost of living, wages, and trends such as medical cost inflation etc.
- The variability of the economic cost is calculated from the variability of the loss process and the variability of the economic circumstances of the affected parties.

The module uses the following liability key risk drivers:

- **External: compensation components** for defined injuries and defined expenditure types
- **External: macro-economic trends**, measured by wage inflation, medical cost and general price inflation indices
- **External: cost of living**, measured by personal consumption expenditures

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3 Not shown in picture on p. 13. Some other risk drivers are also omitted from this text for better readability.
Legal system

The legal system engine determines the liability award from the economic damage to be possibly compensated. It answers the following question: How do the factors related to the economic, legal, judicial or societal environment influence the loss frequency and/or severity?

The scenario loss model frequency and/or severity components are altered according to the influence of liability risk drivers.

The liability risk drivers in the legal system module are related to the legal, judicial, and societal environment of the potential claimants. The potential losses are transformed from “what happened” to “what is awarded” (regardless of what is insured). In particular, the following aspects are considered:

- The risk driver types of liability determines the applicable laws and legal practices
- The risk drivers liability laws and pain & suffering determine the relationship between the value compensating the damage and the sum awarded by court decision or by out-of-court settlement
- The risk drivers liability laws and government influence establish the link between the number of claims potentially qualifying for compensation and the number of claims awarded (in court or out of court)
- The risk driver likelihood of mass tort litigation determines the effects of elements of the legal system and legal practice which favour or inhibit the possibility for individuals to file claims jointly or for associations to file claims on behalf of groups

This module uses the following key liability risk drivers:

- External risk driver: pain & suffering, measured by average awards to compensate pain and suffering for defined injuries
- External risk driver: liability laws, measured by results from a questionnaire sent to market experts for each country, amended by risk-driver data analysis and ad-hoc studies
- Internal/External risk driver: types of liability, measured by percentage of turnover by product sold to the final consumer without further processing (internal risk driver), and the applicable liability regime based on industry, market and the position in the value chain (external risk driver)
- External risk driver: likelihood of mass tort litigation, measured by results from questionnaires sent to experts
- Internal/External: government influence, measured by the degree of effective control of the government or a government official over a company (internal risk driver) and different answers to the liability laws questionnaire in case of effective government control of the company and lacking separation of powers in its home country (external risk drivers)
Wording filter

The wording filter determines the insured and the reinsured loss from the insurable loss using the re/insurance terms and conditions such as limits, deductibles, sub-limits, lines of business, endorsements, exclusions, and claims trigger. It answers the following question: Which part of the loss is covered by re/insurance given the covering terms and conditions?

The elements of scenario loss models are filtered according to the wording definitions, inclusions, exclusions and limitations. The input scenario loss models reflect the losses as they need to be paid by the insured company, the output scenario loss models reflect the losses as they are covered and likely to be claimed from the insurer and/or reinsurer.

In all modules before the wording filter, the potential losses are modelled irrespective of any insurance potentially covering them. In the wording filter, the insurance conditions are explicitly applied to the elements of the scenario loss models:

- The severity components and the frequency are adjusted according to limits and deductibles.
- The frequency is adjusted according to the defined claims trigger conditions.
- Account is taken of some key coverage extensions and/or exclusions.
- Account is taken of common clauses such as the claims series clause.

This module uses the following key liability risk drivers:

- Internal: limits and deductibles, measured by the selection of the policy form, limits, deductibles, aggregate limits, sub-limits, and exclusions/extensions.
- Internal: claims trigger, measured by a selection of triggering conditions.

Aggregator

The aggregator is the final module in the model. It creates frequency and severity distributions from the scenario loss model properties and combines all scenario loss models to produce an expected loss or other observable aspects the user is interested in, such as expected loss split by industry, frequency, severity distribution or shortfall. During this process, it applies the insurance and reinsurance terms and conditions from the wording filter module to the generated distributions.

The aggregator answers the following questions:

- What is the total insurable, insured, and reinsured expected loss?
- Which part of the insurable or insured loss is covered by insurance and reinsurance?

The aggregator module does not explicitly contain any risk drivers but applies several of the terms and conditions from the wording filter module. This is because severity distributions are needed for limits and deductibles, and some terms and conditions, such as aggregate conditions, can only be applied once scenarios have been combined and aggregated.
Loss experience analysis

Earlier chapters demonstrated how LRD is able to generate a numerical estimate of the expected loss for a single risk or for a portfolio of risks without using past losses. However, this does not mean that loss experience is not used at all. On the contrary, the analysis of past losses is fundamental to LRD. Then how does loss experience come into play? To start from an obvious statement: A good model should at least predict what has already happened. In LRD, loss data is used to back-test, verify and challenge the model’s prediction.

Several loss data sets are analyzed from different sources: reinsurance clients’ submissions, in-house data, insurance associations worldwide, such as the Gesamtverband der Deutschen Versicherungswirtschaft (GDV). In a few cases, much more detailed loss data from reinsurance clients was used for specific markets. Market curves (frequency and severity distributions) have been developed for specific markets with different degrees of granularity (eg by industry and/or by loss type) depending on what the loss data set allows.

The goal of back-testing is to check if the model predicts these curves and if not, to find out why. An analysis of mismatches allows targeted improvements, thus avoiding ad-hoc parameters being tweaked. The fundamental step here is to set the model in the past environment so that its predictions can be compared with past experience. To do so, past values are assigned to the model’s risk drivers (see Indicator retrieval). In other words, the model is “set to the past”. This comparison can also be used to calibrate certain model parameters which are difficult to obtain by direct observation (for instance the likelihood that a specific reference company of a given size in a given country operating at a given time in a specific segment produces a loss) so that the model is able to reproduce the corresponding loss experience. However, this procedure has been used to determine only very few country-independent parameters.
One of the fundamental properties of LRD is its predictive power, i.e., the ability to anticipate future outcomes. This was verified by checking the so-called model transferability. The model calibration procedure described above was not executed for all markets covered by LRD. Instead, in a first step, the model was calibrated for Germany because this country has very good loss data available and was one of the pilot countries used to develop the model.

Then, in a second step, the parameters describing the German environment were substituted for those describing other environments (e.g., Spain, Australia, Hong Kong). The model then generated market loss severity distributions without using any specific loss experience from these countries.

In a third and final step, the model’s predictions were compared with distributions from past loss data. In many cases, the distributions generated by LRD (without using the local loss experience) matched the past experience (see figure). Where the match was not good, a reason could be identified (for example, a missing risk driver).

This characteristic of the forward-looking model is extremely important because it allows business properties to be transferred from data-rich to data-poor contexts, e.g., from more advanced to emerging markets, from the past to the future. Where the model’s predictions were not in full sync with past experience, either new drivers explaining the differences were introduced or assumptions were corrected. At all events, as soon as a new set of data is available, LRD improves its predictive power and the quality of its predictions.
Indicator retrieval

Indicator retrieval (IR) is a fundamental part of the Liability Risk Drivers model. It denotes the process of periodically collecting and critically reviewing worldwide quantitative and qualitative information on the liability risk drivers.

As already described in the modelling chapter, the two most important risk drivers are the economic and legal environments. The price tag box retrieves numerical and economic values that transform a potential victim into an economic loss. An economic loss refers to the damages paid to compensate the claimant for loss or injury. The damages paid aim to restore the position claimants would have been in if the loss had not occurred. The victims are classified in three categories: reversible injury, irreversible injury and fatality (further refinement by degree of injury is possible). For each category, we retrieve information on the expected loss of earnings this victim will suffer, the cost of medical treatment the victim will need and an indication of nursing expenses for life-long home care.

Irreversible injury – The amount and its composition differ greatly from one country to the next
The legal system is broken down into several steps reflecting the path a plaintiff would follow from suffering a loss to receiving the compensation. The journey starts with the decision to take action against the wrongdoer. In this case, the information retrieved from each country is the percentage of those who would take action against the wrongdoer in case of a specific loss scenario. This information also takes account of societal and cultural elements and therefore can vary significantly from country to country.

Other steps evaluate such aspects as the possibility of claimants joining together in class actions, whether claimants follow the out-of-court or the in-court path, the local liability regime (ie strict vs negligence) or the presence of punitive damages. Information is retrieved on a worldwide basis. The IR process is used to assess each societal, economic, legal, and judicial context (for instance a country) for the past and future. The ultimate values (in case of changes and trends, the risk drivers are reflected in time series) feeding the model are the result of the combination of scientific evidence (usually derived from statistical studies or studies publicly available, for instance on a country’s health care costs or number of class actions per year) with Swiss Re expertise.

IR is also a logical way to reflect expected and/or observed changes and trends, for example of a societal, economic, legal or technological nature in LRD. In case of a change, the corresponding indicators are modified to reflect the expected change. Using a corresponding IR, several “change scenarios” or “trend scenarios” describing the different ways in which a change or a trend is expected to happen can also be developed and reflected in LRD. In this way, the loss scenarios running through the “new” environment enable the anticipation of the effect that a given a change will have on the re/insurance business down to the single contract, without having to wait for claims to emerge as a result of an observed change. This is the essence of the forward-looking modelling methodology used in LRD.

In conclusion, the indicator retrieval is the way the outside world is reflected in the LRD model. The generic loss scenarios become specific loss events, they “learn” about the future world by running through – for instance – specific economic and legal environments, and thus become the losses likely to occur in the future.

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4 In case of strict liability, the claimant does not have to prove that the defendant was negligent.
Loss scenario and potential loss event

The LRD model not only contains the numbers related to losses it predicts and the factors influencing them, but it also links them to the narratives. It therefore goes beyond mathematical concepts and parameters. This enables the model users to relate the model results to real situations, and the model developers to determine or confirm model parameters directly from observations independent of any loss experience. Most LRD parameters correspond to directly measurable properties in the real world. This facilitates expert elicitation both to bridge data gaps and for forecasts.

General characterization of LRD loss scenarios

Loss scenarios are a central element of the LRD model. Each of them represents a group of potential losses as if they had happened in the real world, sharing parts of their narrative. For instance, a loss scenario relates to explosions during production of chemicals with a heat and pressure wave causing property damage and bodily injury, and with the release of hazardous substances causing bodily injuries and environmental damage.

In 2015, the LRD model contained roughly 800 loss scenarios with a narrative. These scenarios are made to represent all potential losses which have some aspects in common resulting in products liability or premises and operations liability. In addition to the 800 main loss scenarios, there are three scenario types representing special cases.

Loss scenarios are a generalization of historic and potential losses. They are constructed in such a way that each real loss can be unambiguously matched to a corresponding scenario. To do so, each scenario contains three elements of the narrative. The first one is the cause, the second is the description of the mechanism and the third is the effect. The cause, for example, could be a chemicals manufacturer whose operations may potentially affect, say, neighbours or contractors. The description could be an explosion of a reactor within the chemicals manufacturing process, triggering the release of a heat and pressure wave and of hazardous substances. The effect could be represented by numerous physical injuries, some of them serious, as well as property and environmental damage.

The other scenario types are placeholders for unknown losses. The first represents the tail of the severity distribution, and the corresponding loss scenarios are intended as placeholders for as yet unknown large losses. Special loss scenarios of the second type represent very small (attritional) losses. They are so small that the narrative is not usually reported and therefore remains unknown. The third special type represents any other class of as yet unknown losses. These losses are neither too small nor too large. They simply have not yet occurred or have not yet been reported with sufficient detail.
The role of these three special scenario types decreases over time. The more we know about potential large losses, the less important the influence of the tail scenarios becomes. The more we know about small losses, the smaller the necessary allocation to the attritional scenarios. Eventually, the placeholders for any other unknown losses should disappear entirely.

All these loss scenarios are complemented by scenarios related to liability catastrophes, such as Deepwater Horizon in the Gulf of Mexico in 2010, asbestos or an inflation shock (see Other applications).

Role of loss scenarios in the LRD model

The loss scenarios are used to create potential loss events in the model as if they had happened in the real world. They connect the cause and effect of a potential loss event which interacts with all risk drivers as it would in the real world. To make connections between the risk drivers, the potential loss events retain all modifications made by the risk drivers during a calculation. For example, to determine when strict liability is applicable, we need to know whether the loss is a product liability loss or a premises and operations liability loss: in most jurisdictions, strict cause of action is not applicable for premises and operations liability.

Such relationships cannot be reflected directly on a loss severity curve. Instead, a potential loss event can hold the information that the damage was caused by a faulty product, which means that strict liability is applicable when sold to a consumer without further processing.

Besides making connections between risk drivers and providing a specific context for them, the loss scenarios also serve other purposes in the LRD model. They provide transparency on the kind of losses an account could produce, including potential losses arising from new risks. New kinds of losses can simply be included by adding new scenarios. Finally, a back-test on the LRD model is not only possible on the level of a curve relating to an undefined kind of loss. It can also, and much more specifically, be used in testing whether the real events are similar to what the LRD model would predict for a corresponding loss scenario.
Example of a loss scenario in the LRD model

The user of the LRD model determines the relevant properties of the risk to be re/insured and the covering terms and conditions, and then starts the model calculation. The applicable loss scenarios are determined at the beginning of the calculation. Each of them provides the scenery for hypothetical actors including plaintiffs, defendants, lawyers, and insurers in potential losses.

The way a loss scenario works and how it relates to the modules of the LRD model, is best explained by means of an example. Let us assume a fictitious company manufacturing chemicals in Germany and Malaysia.

The first step in the model is the event generator, which determines whether a loss scenario is applicable or not. Since the company causing a loss in our example is the chemicals manufacturer, the explosion scenario mentioned above is relevant for the risk to be re/insured.

Looking at the circumstances surrounding the selected potential loss event, we can answer three key questions following the event generator stage. These are:

- Who caused the loss? – *The chemicals manufacturer running its operations*
- Who is affected? – *Contractors, neighbours and the environment*
- What is the effect? – *Several people severely injured; some of them permanently; parts of buildings destroyed, environmental pollution.*

So far, the risk driver “type of products and activities” has been used to determine the applicable loss scenarios (among other aspects, the explosion and the release of hazardous substances). The next step is to determine where the potential loss will occur using the risk splitter. In the example of the company producing chemicals in Germany and Malaysia, the potential loss could occur in one of these countries. The potential loss with an undetermined location is split into two potential losses. One of them is located in Germany, the other in Malaysia. In this way, the risk splitter creates more specific potential losses.

- How frequently can an event of this kind be expected to occur for a company similar to the one causing the loss?

To determine the likelihood of the two potential losses, two risk drivers are relevant for the risk splitter: The risk driver “size of risk” determines the likelihood of both potential losses combined, and the risk driver “geographic extension” determines the applicable locations (Germany and Malaysia) as well as the relative likelihood of the loss happening in either location.

So far, we do not know any details regarding monetary damage, liability, insurance or reinsurance. However, the cause, the effect, and the location are known for each potential loss.
The next step is to determine the monetary amount of the potential losses, i.e., the economically justified compensation for the damage caused. This is the first time that monetary values are taken into account. In the example above, some of the potential plaintiffs are severely injured. In the price tag engine, the monetary compensation for assistance, for medical care, and for loss of earnings is used to determine how much money is needed to compensate each potential plaintiff for the damage suffered. These sums are not values from the past but instead represent expected future compensation amounts in a given future economic environment. With permanently disabled people, this means anticipating the needs of the injured for the remainder of their lives. The risk driver determining the economic compensation for defined injuries is called “cost of living.” Its indicators represent personal consumption expenditures for specific population groups. After completing the price tag engine stage, we know the monetary amount needed to compensate the damage caused by the potential losses.

The next step is to determine liability arising from the damage:
- Do the injured parties or those who have lost property intend to take action against the party allegedly causing the loss, i.e., the potential defendant?
- Will they go to court or try to settle out of court?
- Which legal principles will be applied to establish liability? Can the plaintiffs claim under strict liability or do they need to demonstrate negligence by the defendant?
- Will the judge or jury establish liability given the evidence provided?
- Can they join a class or do they need to take action individually?
- If they can join a class, does this increase the likelihood of them taking action?

All these questions are relevant to determine how many of the individuals who have suffered a loss will receive an award. In the example of an explosion, more specifically the one in Germany, the number of plaintiffs, the severity of their injuries, and the fact they reside in Germany makes it quite likely that they will seek compensation for injuries and property damage. In other words, a degree of liability will be established. Some claimants will opt for an out-of-court settlement. And if they do, the size of the settlement may be different from that handed down by a court.

Ultimately, the courts need to determine the size of the award, which is subject to several influencing factors. First, they need to make assumptions about the future needs of the injured person. In the example above, the potential loss occurs in Germany, and the courts will make great efforts to estimate future needs as realistically as possible. Depending on the jurisdiction, the courts could be biased either in favor of the plaintiff or of the defendant. There are however other uncertainties in the award: How much judgmental freedom does a judge have? In Germany, this freedom will be limited, and the award will be quite predictable.

Note that the insurer not only has a duty to indemnify but also to defend. This has two effects: some of the cases will not be fully paid out, resulting in a reduced award, and then there is the question regarding who should carry the legal costs. In our example, the “loser pays” principle will apply, and legal costs will generally be much lower than the award. Finally, there are discretionary elements of the award, such as compensation for pain and suffering. In some jurisdictions, there will be punitive damages. In other contexts, there may be legal caps to the indemnity. In our example in Germany, there is a catalogue for the amount for pain and suffering, no legal caps apply, and punitive damages are not awarded.
In nine steps, the legal system module of the model has modified the potential loss from pure damage into an established liability award. These are
- willingness to take action
- court accessibility
- out-of-court award
- liability regimes
- mass tort litigation
- plaintiff-friendliness
- award uncertainty
- insurer’s defences
- discretionary elements of the award

These nine steps include three risk drivers: “liability laws”, “types of liability”, and “likelihood of mass tort litigation”.

The amount derived from the above process can be insured. This is where the wording filter module comes in. It applies the insurance limits and the reinsurance limits. It also can apply limits per line of business and exclude parts of the potential loss altogether, depending on the policy wording. For example, the potential loss described above involves sudden and accidental pollution damage whose contribution to the insured loss is removed in case of a total pollution exclusion. Clauses related to the definition of an occurrence, such as the claims series clause, can also be considered. The risk drivers here are called “limits and deductibles” and “claims trigger”.

Finally, the aggregator module combines all the potential losses and answers most relevant questions for the underwriter: What is the total reinsured expected loss given all the information I have and given the re/insurance structure I propose? What drives this loss?
Portfolio definer

Treaty portfolios are sets of risks which share certain properties and are therefore treated collectively. The straightforward approach to costing treaty reinsurance contracts would be to use individual policy bordereaux, ie lists of policies covering all the risks in the portfolio, including some of their properties. However, this information often is not available. This is the main challenge for applying a forward-looking model in treaty reinsurance.

Since currently the relevant information is not routinely available, no model has so far been developed based on such information. And since there has been no model that would use the additional information, there has been no point in asking for it. The portfolio definer has been developed to resolve this dilemma.

The portfolio definer produces a hypothetical portfolio composition, granular and specific enough to provide valid input to the LRD model which treats this hypothetical portfolio as a collection of individual risks.

The information fed into the portfolio definer is a mix of hard, soft and unstructured information. This mix alone usually is not sufficient to fully define the hypothetical portfolio composition. Instead, it is used to narrow down the background information about the economic composition of the underwriting territory to a hypothetical portfolio composition which is more specific and satisfies all conditions known to the underwriter. In addition to information on what is in the portfolio (eg industrial risks), there is also information on what is not in the portfolio. For example, the underwriter may know of exclusions or other constraints, such as the kind of companies that must not be ceded into the treaty. Often, the underwriter also knows the client’s underwriting focus – soft information which can be used to make the hypothetical portfolio composition even more specific.

The portfolio definer is only a temporary solution to bridge the information gap until all relevant information is reported to the reinsurance underwriter. In cases where the underwriter still has to rely on partial information – for example detailed information on peak risks only – the portfolio definer can still be used to create a hypothetical portfolio composition of the bulk of the risks, as specific as possible given the information available. The same is valid for all other risks the underwriter does not know in detail.
The output of the portfolio definer is concrete and allows the underwriter to challenge it directly by looking at the produced hypothetical portfolio composition. The underwriter can also challenge the potential losses which the hypothetical portfolio composition produces. For example, if an LRD calculation produces many pipeline losses although the underwriter suspects that pipelines are excluded from the treaty in question, he has a good reason to check the treaty wording for exclusions. Input into the portfolio definer can thus be refined and its output improved accordingly.

Such a review of the hypothetical portfolio composition is best conducted together with the client in the most relevant areas or where the underwriter is in doubt. This also serves to move the discussion with the client away from actuarial parameters to a more productive dialogue on the risks in the portfolio and on how to best protect it.

How does the portfolio definer work?

The background information on the economic market composition stems from various sources: from country-specific statistical bureaus, commercial databases and to some extent also from a specifically created market model which predicts the economic composition of a given market. This information is used to determine a split of the total set of companies by their number, into industries, into the average revenue achieved in a given industry and into the distribution of companies within each industry by their size and revenue.

The portfolio definer looks at each industry within a given economy, checking whether the industry is not excluded from a treaty and whether all the hard and soft factors allow it to be included. If all these criteria are met, the next step is to determine the average revenue the relevant companies achieve in the industry considered. To do so, companies which are unlikely or impossible to be found in the portfolio are excluded from the industry revenue distribution before taking the average. Various factors, such as the client’s risk appetite or contractual stipulations, may be considered here.
Other applications

Swiss Re started to develop the LRD model for costing purposes, the main goal being to determine the expected loss related to products and general liability. However, its design also allows it to be used for other purposes, such as liability catastrophe modelling, risk accumulation control or reserving.

Other classes of casualty business

While the LRD model was originally intended for products liability and public liability including premises and operations liability, it was soon extended to include pollution, accidental and several related covers, and more lines of business could still be added. A proof of concept on medical malpractice and on errors and omissions has demonstrated that the LRD model for general (GL) and products liability (PL) can be extended to cover these lines of business without requiring a fundamental overhaul.

Some areas and lines of business are more closely related to products liability – which inspired the current structure of the LRD model – because the losses they address are more tangible. These lines include motor liability or professional indemnity of architects, for example. Other lines, such as directors and officers (D&O) liability, need larger extensions because the liability risk drivers in the LRD model for GL and PL generally relate to tangible losses. The financial valuation of intangible assets is second-tier to GL and PL but not to D&O. An LRD-like forward-looking model concept for D&O has shown that only one module needs to be added to LRD to also cover D&O and other financial lines.

The LRD model development started with medium-sized companies simply because very few or no losses had been recorded in this area. A model was therefore needed to make sound predictions. In the meantime, the model has been extended to a much wider range of entities – such as small companies ceded into reinsurance treaties and to large corporate risks in certain industries. Further options include extensions to car and truck drivers, individuals for private liability, governmental or non-governmental entities causing accidents, and losses to third parties. The risk driver concept can serve to explain the differences between all these entities.
Liability catastrophes and risk accumulation

A key extension of the LRD model is to predict liability catastrophes, i.e. events which may potentially cause policies to clash, triggering several policies at the same time. The loss histories are particularly volatile in this low-frequency, high-impact area which is subject to substantial change.

The LRD model differentiates between three types of liability catastrophes:

The first type of catastrophe concerns limited events that relate to losses which can be traced down to an isolated causing event, for example the explosion on the Deepwater Horizon platform in the Gulf of Mexico in 2006.

The second type concerns unlimited catastrophes. These could include scenarios similar to asbestos, for example Bisphenol-A—a widely used substance—causing developmental disorders by endocrine disruption. Catastrophes of this kind feature similar losses and mechanisms but are not caused by a common event.

The third type concerns systemic events caused by changes in the operating environment, for example runaway inflation or changes in life expectancy.

FLM is new to casualty, but well-established in natural catastrophe business.

Liability catastrophes, especially the unlimited ones, usually take a long time from causation to accusation and payout. Asbestos, for example, took more than 30 years to develop. An important extension to the model, the temporal evolution of the losses, has been implemented in order to make sure that LRD can be applied to liability catastrophes.

The forward-looking approach to liability catastrophes opens up an important area to quantitative modelling: casualty risk accumulation control and portfolio steering. Without a structured approach in place, it is very difficult to capture the mechanisms driving risk accumulation in quantitative terms. The new model approach for liability is similar to the one for natural catastrophe models, which facilitate risk accumulation control for property business. Understanding a portfolio enables underwriters to determine which policies will be triggered together if a liability catastrophe occurs.

The forward-looking approach for liability catastrophes is gaining momentum in the insurance industry, and various providers have started to search for a structural explanation to risk accumulation rather than a mathematical one. An event or an economic or legal development triggers several losses which then can be aggregated to determine the accumulated risk under the scenario.

Other uses

A forward-looking model can be used to calculate case reserves if the model is supplied with real loss data rather than potential loss data. In this case, the model allows users to find out how much money needs to be set aside to fulfil future liability obligations given a known physical outcome of the event. If the portfolio composition is known, the reserve adjustment related to a bulk of losses can be determined based on changes to the surrounding external factors.
Conclusion

Liability is indeed a challenging business: loss experience loses its value quickly in this line because the environment in which a loss occurs changes over its manifestation period and continues to change until the claim is settled and finally closed. Our forward-looking Liability Risk Drivers model offers a superior approach to meet this challenge. The first of its kind in the re/insurance industry, its predictive power allows us to anticipate the impact of economic, societal and legal developments on liability business. With our new model, we help our clients identify, quantify and price for the accumulations in their portfolio.

Services based on FLM allow Swiss Re and its clients to collaborate and grow confidently in emerging markets, and to improve risk selection through increased business transparency and a better understanding of risk.

The development of the model is by no means complete, and we are continuing to pioneer and expand it to a comprehensive liability model for costing and beyond. The LRD model will change the way the insurance industry deals with liability risks, and it makes Swiss Re an even stronger partner for our clients.