Diversification

Consideration on Modelling aspects & Related Fungibility and Transferability

October 2013

CRO FORUM

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1 Executive Summary

The policy responses to the financial crisis (e.g. higher loss absorbency, recovery and resolution, effective risk appetite frameworks, backstop capital requirements, stress testing etc.) have posed a number of questions about insurers' ability to measure and recognise diversification and its effects.

In 2005, the CRO Forum published a paper 'A Framework for incorporating diversification in the solvency assessment of insurers'[1]. This paper set out detailed analysis and proposals for the identification and recognition of diversification benefits in regulatory solvency assessments.

In light of the questions around diversification and recognition of its benefits, this paper supplements the 2005 paper with additional analysis on:

- practical considerations around modelling capabilities;
- principles to assist companies with setting model correlations, calibrations and parameterisation;
- clarification around fungibility and transferability and the role these factors play in models; and
- context of wider developments including ORSA, stress testing, scenario analysis and risk appetites to help recognition of fungibility and transferability of capital.

The intention is to:

- provide a basis for companies to evaluate and justify their treatment of diversification identified within their modelling;
- assist communication with supervisors in respect of the approach taken to modelling of diversification benefits;
- enable greater understanding around the ability to recognise the effects of identified diversification; and
- support improved cooperation to promote recognition of diversification within regulatory solvency assessments and mitigate the risk of arbitrary restrictions being imposed.

On this basis, the paper sets out the following:

- On the modelling approach, the factors that are likely to affect the modelling of diversification including, model structure and non-separability, level of granularity and its impact on how diversification is implicitly or explicitly captured, dependency modelling, model parameterisation, validation and benchmarking;
- Five principles to assist with the setting of model correlations, calibrations and parameterisation being:
    1. Expert Judgement should be utilised and incorporated in a structured and documented way;
    2. Parameterisation should utilize as much relevant data as practicable;
    3. Estimation of dependency relationships should take into account tail behaviour;
    4. Material dependencies should be identified and their impact on capital should be appropriately explained; and
    5. Model Users should understand how diversification assumptions impact the model outcomes.

[1] Available on CRO Forum website: http://www.thecroforum.org/a-framework-for-incorporating-diversification-in-the-solvency-assessment-of-insurers/

- A clear distinction between fungibility and transferability to highlight how fungibility can be demonstrated for the purposes of recognising diversification in economic capital models and that transferability is relevant for the assessment of liquidity rather than economic capital modelling;
- Consideration of the factors that are commonly raised as challenges to the principle of fungibility, such as legal structure, recognition of assets, intra-group arrangement, partial holdings and policy and shareholder restrictions; and
- An assessment of the regulatory context that assesses diversification and the recognition of diversification benefits, particularly how different regulatory developments should inform understanding of the ability of companies to recognise diversification and enable a flexible approach that avoids concentration and delivers policyholder protection.

Diversification is at the heart of insurance business and risk management. Fostering improved risk management, measurement and resilience are the best solution to many of the challenges posed by the financial crisis and maintain policyholder protection. The CRO Forum continues to believe that the ability of regulatory solvency assessment to recognise diversification benefits provides a key tool in meeting policyholder protection and financial stability objectives.

2 Introduction

2.1 Purpose of this paper

The purpose of the 2005 paper was to inform the debate on the issues surrounding the treatment of diversification in the solvency assessment of insurers and to redress the imbalance in the recognition of diversification effects (see also Appendix 1). Many of the principles set out in the 2005 paper were adopted into the Solvency II framework that was agreed in 2009, particularly the support for the development of internal models as tools to capture diversification effects. Some of the concepts were also incorporated into the International Association of Insurance Supervisors (IAIS) core principles for enterprise risk management[2].

The continuing regulatory dialogue on establishing global solvency assessment standards following the financial crisis means that diversification and its benefits remain an area of debate and challenge.

Following the financial crisis, two broad themes have emerged around the recognition of diversification benefits:

- Questions on how to satisfactorily and objectively measure diversification effects with the onus being on the industry to provide evidence of its existence and magnitude, particularly where an internal model is used; and
- Questions around the ability to demonstrate the fungibility of resources needed to realise diversification benefits.

The purpose of this paper is:

- to re-emphasise how principles and findings of the 2005 paper apply to address these themes;
- to set out steps and additional principles based on best practice to help companies promote the recognition and understanding of diversification within their business; and
- to suggest enhancements and explanations that can enable these themes to be addressed.

2.2 The scope of this paper

This paper has a similar scope as the 2005 paper of focusing on risk diversification or the spreading of an insurance portfolio over a variety of exposures, rather than only a few selected areas.

Measurement of risk is necessary but not sufficient alone to take credit for the benefits of diversification; appropriate practices, organisational structures and internal controls are required.

The insurance industry has been using a number of analytical and statistical approaches to capture the relationships between different types of risks as part of their risk management and to manage the exposure from a spread of different types of exposure. This paper will consider how these relationships and the adequacy of the resulting capital in stressed conditions can be quantified effectively.

[2] Insurance Core Principle 16, http://www.iaisweb.org/Insurance-Core-Principles-material-adopted-in-2011-795

Part 1 Consideration on modelling aspects

This paper is divided into two separate sections. Part 1 focuses on the approach to modelling of diversification that underpins principles 1, 2 and 4 from the 2005 paper. These principles provide a foundation for identifying diversification and that credit should be given for diversification that is measured and managed. In this paper, we look in more depth at:

- How the different approaches adopted to model diversification of risks can affect the observed level of diversification; and
- Principles that can assist companies with setting model correlations, calibrations and parameterisation to provide credible dependency assumptions underpinning the diversification within their business.

Part 2 Fungibility and transferability

Part 2 considers the ability to recognise the benefits of diversification building on Principles 3, 4, 5 and 6 from the 2005 paper. These principles looked to emphasise the risk management and measurement benefits from recognising diversification benefits rather than relying on excess capital. The principles focused on risk transfer and capital mobility as tools to enable benefits of diversification to be realised. In this paper, we look to clarify this area by considering:

- The difference between fungibility and transferability;
- Ways of demonstrating fungibility;
- How fungibility is addressed when modelling the economic view of a group, including modelling approaches and consideration of common factors raised in challenge to the principle of fungibility; and
- Implications of regulation and benefits of supervisory cooperation outlined in principle 6 from the 2005 paper.

Through this analysis, the paper aims to address the two broad themes affecting the discussions on diversification in the on-going development of solo and group solvency assessments standards. On this basis, the intention is that the discussion in this paper should help companies justify, recognise and promote recognition of observed diversification benefits in regulation and as a central part of risk management.

The intention being to reinforce the importance of:

- fostering improved risk management and measurement as the best solutions to the challenges posed by the financial crisis and policyholder protection; and
- the recognition of diversification benefits in regulatory standards as a means of meeting policyholder protection, financial stability objectives and promoting resilience.

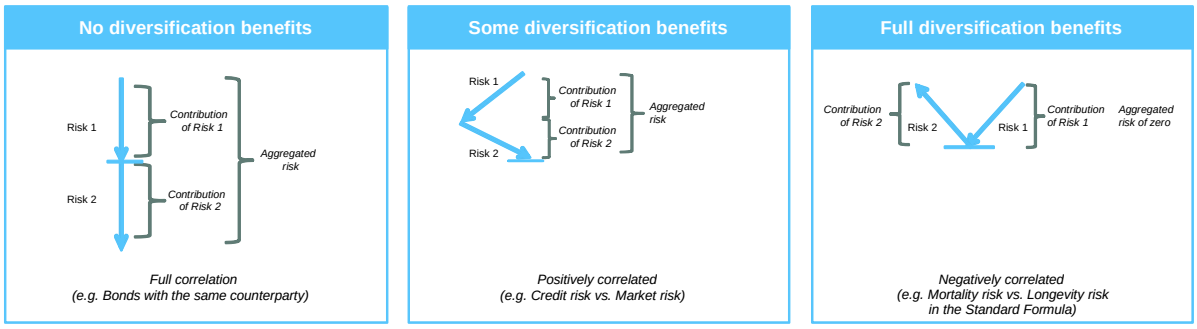
3 Part I – Consideration on modelling aspects

3.1 Introduction to diversification

As noted earlier, diversification is central to insurance business. In finance, diversification means reducing risk by investing in a variety of assets[3].

For European insurance companies, diversification is usually the process of diluting Asset Liability Management (ALM) exposure with insurance risks, financial risks and operational risk. Risk diversification, or the concept of spreading risks is reflected in the figure 1 below.

Figure 1: Graphical representation of some diversification examples



The size and timing of insurable events (death, motor accidents, natural catastrophes, etc.) for individual exposures are uncertain, and the downside risk to the individual of an uninsured event is often significant. The fundamental service that insurers provide is giving individuals and businesses a way of reducing their exposure to individual risks, increasing their ability to plan and invest with confidence for the future. This topic has been explored in detail in a number of publications including the recent paper from the European Financial Services Round Table (EFR)[4].

Insurers manage the type and amount of risk in their portfolio by pursuing diversifying strategies, including:

- Pooling similar and sufficiently independent risks – usually similar in terms of the characteristics of the risk subjects, but this pooling could occur over time as well;
- Pooling dissimilar risks – by writing a diversity of insurance products across different market segments and geographies, an insurer can decrease the likelihood of experiencing adverse results for large blocks of its book at any given time;
- Combining opposite risks to provide internal hedges – for example, the insurer can sell policies that contain features resulting in a risk exposure when interest rates are low, as well as policies whose value to the insurer increases when interest rates are low;
- Limiting risk concentrations in a similar way to that used by individuals and businesses when they seek to reduce exposure – this can be achieved by either limiting the underwriting to

[3] Diversification benefit for an insurance company can be expressed mathematically as a percentage of capital: (1 - ECT / Σ ECi) where ECT is an aggregate economic capital total for an insurance company and ECi is an economic capital on a standalone basis for each risk i.

[4] EFR. (2012). How Regulation can preserve the contributions of financial institutions to economic growth. http://www.efr.be/documents/news/EFR%20growth%20report%2020121126.pdf

certain specific risks or classes of insurance or through risk mitigation by means of reinsurance, hedging and/or securitisation of the risks.

Diversifying strategies of insurers aim to reduce risk by exposing the insurer's portfolio to different areas that would react differently to the same event and thereby mitigating the aggregate exposure to a single source.

It is also recognised that not all risk can be diversified away. In response to this, insurers look to use various risk mitigation strategies to reduce their exposure to the risks and improve their resilience in stress scenarios. Techniques include reduction of concentration in single investments, hedging of interest rate risks, purchase of reinsurance, insurance linked securities and other techniques.

These activities can help insurers meet consumer and client demands in a resilient and robust way.

The recognition of the effects of risk diversification is critical for the purpose of rewarding strong risk management and discouraging risk concentration. In line with principles 1 and 2 of the 2005 paper, the next section considers the effects of modelling diversification and then looks to identify principles to help support the identified diversification between risk factors.

3.2 Model capabilities

This section considers how the model structure impacts economic capital results and the allowance for diversification benefits in particular.

Subsection 3.2.1 considers the different model structures which can be used for risk aggregation (top-down vs. bottom-up approach, one-level vs. multi-level approach, level of granularity, non-separabiltiy of risks and aggregation across portfolios or risks) and how the model structure influences the level of diversification recognised when aggregating risks. Subsection 3.2.2 considers briefly various models of dependency and Subsection 3.2.3 sets out different risk aggregation methodologies.

In considering the quantification of diversification benefits, clarity around the structure of the model can help to provide understanding and confidence in the output from the model and its use.

The aim of this section is therefore to provide an objective description and assessment of the various methods of capturing diversification benefits, including strengths and weaknesses, and factors which can help build understanding and credibility around methods used.

3.2.1 *Model structure*

Looking at the structure of the model there are a number of factors which have an impact on how diversification is quantified, including:

a. Level of granularity at which risks are defined;
b. Approach to risk aggregation used in the model;
c. Levels of aggregation;
d. Dimensions of diversification.

a. Level of granularity

The finer the level of risk classification (i.e. a more granular subdivision of risk) within a variance-covariance matrix, for instance, the lower the diversification within a risk category and the greater

the diversification between risk categories. An illustration of this would be non-life insurance risk where one could envisage either:

i. just one risk category for non-life insurance risk say in a variance-covariance matrix with other non-insurance related risks; or
ii. non-life insurance risk split further into broader groupings by line of business of P&C and other insurance risks together with the same non-insurance related risks.

All other things being equal scenario (i) would result in greater diversification within a risk category but lower diversification between risk categories than scenario (ii). Differences in approaches will generally yield differences in the economic capital figure given the complexity of reworking all of the various risk dependency interactions. Therefore, an increasing number of risk factors usually lead to an increasing overall diversification.

The level of granularity should typically reflect the nature of the risk profile. For example, a company with limited non-life risk exposure could consider modelling the diversification within this risk type in a less granular manner than a company where the risk profile is dominated by non-life risk exposure.

The structure of the model and the level of granularity also have impact on how the model captures the interaction between the payoff of assets or liabilities due to combined movements in risk drivers. For example, a liability might be driven by interest rate and longevity risk drivers. A granular model can directly capture the interaction between those risk drivers on the liability pay-off (low interest rates increase the impact of change in longevity). In a less granular model, which e.g. diversifies market and life risks only at an aggregate level, this interaction would to be reflected in a different manner (e.g. embedded in the estimation of the correlation parameter).

b. Top-down vs. bottom up approach

Different approaches to risk aggregation can be considered to be one of two types: top-down or bottom-up aggregation.

To illustrate this, we start by defining risk drivers a very granular level. Such risk drivers can then be grouped into less granular sub-risk groups, which can be further grouped into high-level risk groups such as market risk, credit risk, life insurance risks, non-life insurance risk and operational risk. For example, mortality risk is a sub-risk of life insurance risk, which contains several risk drivers (uncertainty level, uncertainty trend and volatility).

In a **top-down aggregation approach**, risk is measured on the sub-risk level such as market risk, credit risk, life insurance risks, non-life insurance risk and operational risk; subsequently, risk is aggregated and allocated using a model of risk aggregation. An example of a model that largely aggregates risk in a top-down manner is the standard formula in Solvency II.

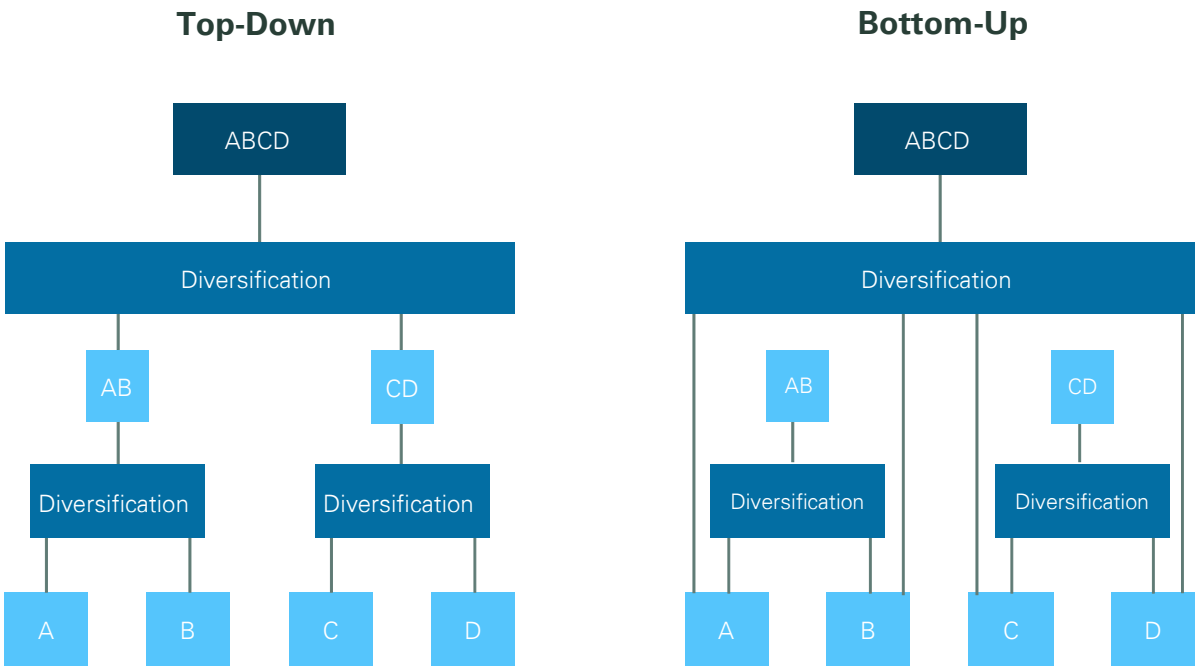
In a **bottom-up aggregation approach**, risk at sub-risk level is measured by aggregating bottom-up using a joint model of risk and correlations between the different risk-drivers. In this method, the different risk drivers for credit, market, life insurance, non-life insurance and operational risk are simulated jointly. Starting with the capital for each risk driver within an entity, the capital required at higher levels, such as entity-level or group-level is derived. It is important to notice that the bottom up calculation always has to start at quite a granular level.

Often models do not follow a pure bottom-up or a top-down approach in the modelling and aggregation of risk. Both approaches are valid. In practice it is often that a combination of both

approaches is being used. E.g. a bottom up risk aggregation for market risks in combination with a top-down approach to aggregate market risks with operational risk.

Below is a simplified diagram illustrating the bottom up approach versus the top-down approach.

Figure 2: Top-Down approach (left) versus Bottom-Up approach (right)



Correlation factors set at a lower level may be better supported by historical data and more stable over time than correlation factors set at a higher level.

An important analysis is to consider the risk drivers or events which could cause changes in the observed events. The correlation between sub-risks depends on the consequences of applying these risk drivers to the portfolio of business. While the portfolios of many direct writers are relatively stable year on year, it is good practice to review the validity of the sub-risk correlations. Consideration needs to be given to changes in the characteristics or mix of products which may have impact on dependencies.

Under both the top-down and the bottom-up methods, risks must be measured using a common time horizon. However, a key difference between the approaches is that, under the top-down method, one is usually concerned with specifying correlations on a broad basis between the different sub-risks. In contrast, the bottom-up approach requires the specification of all the underlying risk drivers of the sub-risks. Both methods have advantages and disadvantages which one needs to be aware of. Some advantages and disadvantages of the top-down approach versus the bottom-up approach are set out below.

Top-Down versus Bottom Up approach	
Advantages	**Disadvantage**
The top down approach is more intuitive to understand and conceptualise.	Correct Top-level correlations depend on exposure to risk factors. E.g. exposure in A, B, C and D drives the "right" diversification between AB and CD.
Limits the number of dependencies that need to be estimated (e.g. no need to estimate A-C correlation).	More approximate than a bottom up approach, a lot of the finer relationships are not captured.
Facilitates a step-wise (and potentially not central) calculation process. E.g. firstly calculating AB and CD and in a second step ABCD.	Can lead to inconsistencies in the overall diversification calculation.
Easier to make the whole correlation matrix internally consistent, Positive semi-definite (PSD)	Less conducive to decision making at a more granular level.
	Can have limitations for risk management when direct interactions between sub-risks become relevant (e.g. exposure A and C) whereby diversification is only captured indirectly.

Current risk aggregation models range from very simple models which add sub-risks together to linear risk aggregation, and in some cases, risk aggregation is done using copula models or integrated models. Also, some insurance companies may use a combination of bottom-up and top-down approaches to risk integration.

There are various approaches to model diversification using linear correlation at solo level. For example, it is envisaged that diversification in the standard formula for Solvency II will be based on a base correlation matrix within each risk class (market, life, non-life, health, default) and a top level correlation matrix between these risk classes. However, insurers' internal models tend to follow a bottom-up approach which uses a correlation matrix that combines all risk types. The quantum of diversification identified through the approach used for the internal model is not relevant to any assessment of the quality of the modelling by the insurer.

c. Multi-level vs. one-level approach

In Filipovic's paper[5], multi-level and one-level approaches are compared. In particular, Filipovic deals with multi-level aggregation issues by comparing the Solvency II Standard Formula for Solvency Capital Requirement (SCR) aggregation methodology on two levels (intra then inter-risk modules) to an aggregation approach based on a global correlation matrix of all risk factors. It gives important insight into the possible differences between the diversification assumptions between the standard approach and internal models. The conclusions drawn from Filipovic's studies are the following:

- Two-level risk aggregation method that relies on a correlation matrix common to the whole market cannot generally reproduce a true bottom-up risk aggregation approach. Inter-module correlation matrices are necessarily entity specific.

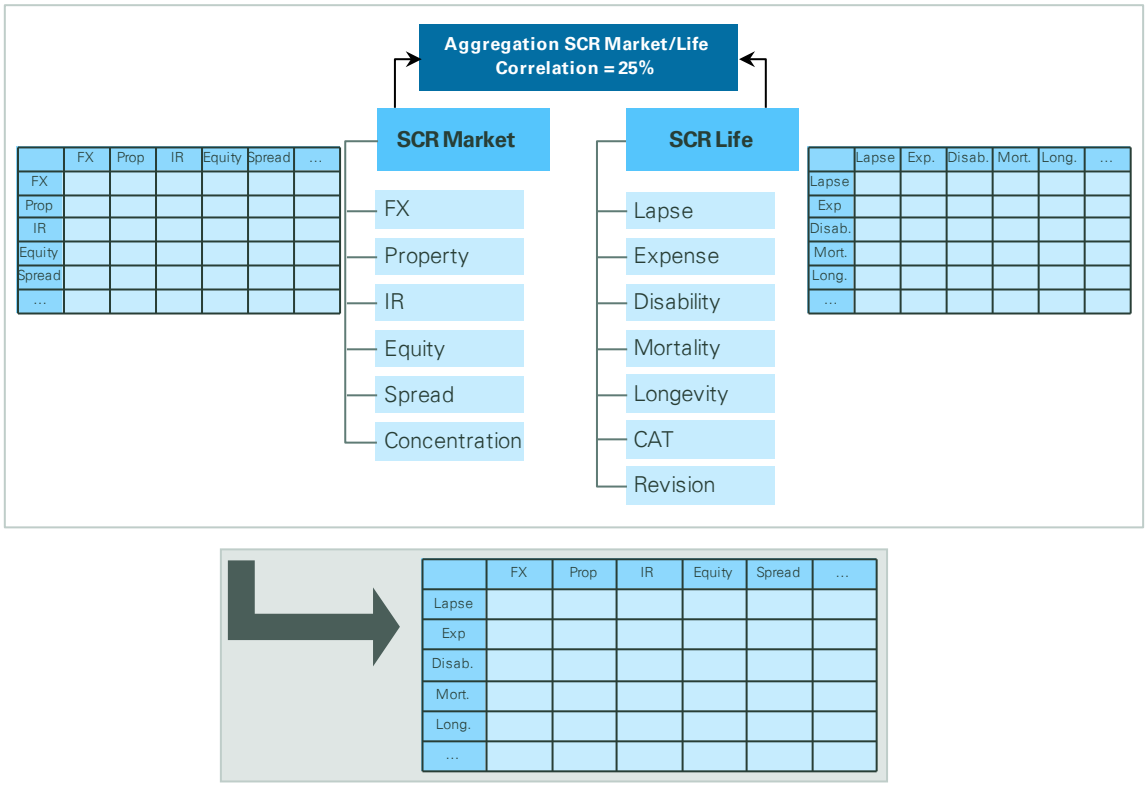
[5] Filipovic, D. (2008). Multi-Level Risk Aggregation. Vienna Institute of Finance.

- A minimal correlation matrix can be derived from risk factors contained in different modules. This matrix is implicit to the company. The term "minimal" means that correlation coefficients are as small as possible.

Filipovic's work allows going from a multi-level aggregation approach to a one-level aggregation approach (i.e. the demodularisation approach). It may also serve as a benchmark for comparison of standard and internal correlation specifications.

The figure below displays the implicit correlations between sub-risks derived when applying the de-modularisation approach.

Figure 3: Demodularisation approach



Note that this demodularisation approach allows the identification of key pairs of risks in terms of dependence, which is useful when considering Principle 4 in Section 3.3.

d. Dimensions of diversification

Insurers may aggregate risks on one or more of several broad levels. Intra-risk aggregation is carried out across exposures within an individual risk type, such as market risk. Inter-risk aggregation refers to aggregation across the individual risk types, for example to combine measurements of life risk and market risk. Aggregation across portfolios is performed through the simultaneous application of the defined methodology to all portfolios within an entity. Finally, within groups, risks may be aggregated into a consolidated measure across entities.

3.2.2 *Modelling dependence*

In risk modelling, there are usually two main components that are considered: (i) the marginal risk distribution for each risk and (ii) the dependency structure that links these risk distributions. The focus of this section is on how to model the dependency structure between risks recognizing that the modelling of the margins may impact the level of diversification when aggregating risks.

The words 'dependency' and 'correlation' are widely used interchangeably. Quite often linear correlation is used in situations when insurers need to measure the strength of dependency between two random variables. Actually, it is important to keep in mind that linear correlation is simply a special case of dependency. It quantifies a linear relationship between two random variables while dependency deals with any kind of relationship. Dependence between two random variables can be very strong, but such a relationship does not need to follow a linear pattern.

One of the reasons for the popularity of correlation in finance is that it can be used in variance-covariance matrices with elliptic distributions to form a tractable tool. However, in reality, a lot of financial risks that are dealt with in economic capital modelling are not adequately described by an elliptic distribution. Some of these risks exhibit greater skewness and heavytailedness than is described by an elliptic distribution, especially in non-life insurance or operational risk, and so relying solely on correlation as a measure of dependency between risks can be very misleading.

Moreover, by definition, linear correlation is a constant scalar factor. As the period since the financial crisis has shown, the dependence structure between random variables can change drastically with the value of the underlying variables themselves. Under stressed market conditions, the implied correlations between various assets classes turned out to be significantly higher than had been observed historically. This drawback of linear correlations can be overcome by calibrating the correlation parameter in such a way that it incorporates information on tail behaviour.

There are several methods that could be considered to analyse tail behaviour. Examples of such methods are:

- Adverse quadrant correlation: Linear correlation estimate calculated solely based on those observations out of the entire sample where the joint observation of both factors lie in the "adverse quadrant", i.e. the quadrant where both factors change in a direction that implies an adverse event from a Profit and Loss (P&L) perspective;
- Adverse period correlation: Linear correlation estimate calculated solely based on those observations out of the entire sample that occur within a historical time period which represents a time of adverse market conditions;
- Rolling Correlation: Linear correlation measure calculated for a fixed-length historical window (e.g. one or two years) of observations over time. The results is a time series of trailing estimates which can highlight periods of higher average dependency between risk types; and
- Tail dependency analysis: Mapping process which estimates correlation parameters by comparing simulated Gaussian distributions with the empirically observed joint distribution of a risk factor pair with respect to their tail dependency. For this purpose one can use the Tail concentration function that calculates the probability of two variables exceeding a given percentile divided by the probability of such event if the two variables were perfectly correlated.

In this context it is also important to note that the frequency of observations has an impact on the dependency. E.g. using daily, weekly, monthly or quarterly returns can impact the results. Linear correlations between market risk variables potentially show increased tail dependency when analysing monthly or quarterly returns in comparison with daily or weekly returns.

In Embrechts et al[6], the limitations of linear correlation as a dependence measure are highlighted, particularly when we leave the multivariate elliptical distributions. Alternative dependence measures derived from copulas, such as rank correlations and coefficients of tail dependence, are defined and discussed. Rank correlations are mainly of interest to calibrate copulas to data, while tail dependence is an important concept since it addresses the phenomenon of joint extreme values in several risk factors, which is one of the major concerns when aggregating risks. For more details about these modelling concepts, we refer to Embrechts et al (2005) and Embrechts et al (2002).

Although tail dependency need to be incorporated in the model, it should be highlighted that there is no one fit to all solution. There are many ways of how tail dependencies can reasonably be taken into account and they should fit into the whole model structure and calibration/modelling. At the end each company should be able to demonstrate how this feature is addressed in the model.

3.2.3 *Risk aggregation methodologies*

Risk aggregation is at the core of insurance and so central to company's economic capital modelling efforts. This involves the aggregation of individual risk measurements using a model for aggregation. The model for aggregation can be based on a simple linear aggregation or using a more sophisticated model.

The linear aggregation model is based on aggregating risk, such as value at risk (VaR) or expected shortfall (ES), using correlations and the individual VaR or ES risk measures. The copula model, for instance, aggregates risk using a copula for the co-dependence and the individual risk profit and loss simulations. The copula model allows greater flexibility in defining the dependence model than the linear risk aggregation.

The main approaches are considered below with a brief discussion of their advantages and their disadvantages.

Simple summation: This simple approach involves adding the individual risk economic capitals. Typically, this is perceived as a conservative approach since it ignores potential diversification benefits and produces an upper bound to the true economic capital figure. Technically, it is equivalent to assuming that all inter-risk correlations are equal to one and that each risk component receives equal weight in the summation. Moreover, no data is required to calibrate this approach and the communication of the results is easy. However, this approach does not recognise or allow for meaningful interactions between risks.

Fixed diversification percentage: This method is essentially the same as the simple summation approach with the only difference that it assumes a fixed level of diversification deduction from the overall capital figure. The final figures are highly dependent on the chosen percentage. This method is easy to implement, to communicate and recognises some diversification. However, it also does not capture non-linearity and does not recognise or allow for meaningful interactions between risks or changes in risk exposures.

[6] Embrechts, P., Frey, R. and McNeil, A. (2005). Quantitative Risk Management: Concepts, Techniques and Tools. Princeton University Press.

Embrechts, P., McNeil, A., & Straumann, D. (2002). Correlation and Dependence in Risk Management: Properties and Pitfalls. Risk Management: Value at Risk and Beyond . (D. M, Hrsg.) Cambridge University Press, Cambridge.

Variance-covariance matrix: The approach allows for interactions across risk types. However, these interactions are assumed to be linear and fixed over time. It has also to satisfy certain conditions (positive semi-definiteness) that are sometimes ignored in practice. Although this method is relatively simple to understand, to implement, to calculate and to communicate, it implies that the underlying risk distribution functions are elliptically distributed (no allowance for skewness for instance) and the correlation factors are sensitive to the underling risk distribution functions. Eventually, the overall diversification benefit depends on the size of the pair wise correlations between risks.

Copulas: This is a much more flexible approach to combining individual risks than the use of a covariance matrix (allowance for skewness, non-linearity and heavytailedness). The copula is a function that combines marginal probability distributions into a joint probability distribution. The choice of the functional form for the copula has a material effect on the shape of the joint distribution and can allow for rich interactions between risks. The challenges of this approach are: (i) that copulas require the estimation of the distributions for all underlying risk categories; (ii) computation power via Monte Carlo simulations can be quite demanding; (iii) the results can be subject to fluctuations due to the parameter estimation uncertainty; and (iv) the communication of the results can be more challenging.

Integrated model: Common underlying drivers of risk are identified and their interactions are modelled. Simulation of the common drivers (or scenario analysis) provides the basis for calculating the distribution of outcomes and economic capital risk measure. Applied literally, this method would produce an overall risk measure in a single step since it would account for all risk interdependencies and effects for the whole portfolio.

Theoretically, this approach is appealing and intuitive. It is possible to represent the "real world" and to capture hence the non-linearity effects through the structural risk interactions. However, this method is demanding in terms of input and in terms of computing power. Additionally, parameterisation related to the structural risk interactions and transparency/results communication may prove a challenge.

For several of the above aggregation methods the basis for the dependency relationships is one (or more) correlation matri(x)(ces). Above it is already mentioned that such matrices in most methods should satisfy certain conditions, known in algebra as positive semi-definiteness (PSD). When estimating a matrix through simple linear correlations this is often satisfied by construction, but when using other methods or including expert judgement in setting dependency relationships one has to ensure that the resulting matrices are still PSD. Typically there are two type of methods to adjust a matrix to ensure it is PSD:

- Methods that change all correlations, but find the closest PSD matrix. A well known algorithm often used is the Rebonato and Jackel[7] algorithm that essentially performs the PSD transformation by setting negative eigenvalues of the matrix to zero; and
- Methods that change a sub-set of the correlations to find the closest PSD matrix. This avoids changes to the most important dependency pairs, but as a drawback might generate bigger changes to other dependencies in order to achieve a PSD matrix. An example is the algorithm developed by Qi and Sun[8] .

[7] Rebonato, R. and Jackel, P. (1999). The most general methodology to create a valid correlation matrix for risk management and option pricing purposes, The Journal of Risk, 2(2).

[8] Qi, H.D & Sun, D. (2006). A quadratically convergent Newton method for computing the nearest correlation matrix. SIAM J. Matrix Anal. Appl., 28(2):360–385.

3.3 Correlations, calibration and parameterisation

While the existence of diversification is broadly accepted, the challenge is around the reliability of its quantification.

In the previous section we considered the model approaches that can be used by insurers to analyse the interactions between the different risks that they are exposed to. As noted, within a capital model, it would be relatively straightforward to assume that each variable moves either independently or in perfect lockstep. This would misstate the degree of diversification (overestimating it in the former case, and underestimating it in the latter). More typically, variables are partially correlated, and require that appropriate structures and parameters be carefully established to model these relationships.

The method used to develop suitable parameters will vary based on how inter-relationships (dependencies) are reflected and captured in the model (variance/covariance matrix, copula, structural approach, some combination, etc.).

Whatever approach is taken, the following five principles can help guide the development and demonstration of credible dependency assumptions.

1. Expert Judgement should be utilised and incorporated in a structured and documented way;
2. Parameterisation should utilise as much relevant data as practicable;
3. Estimation of dependency relationships should take into account tail behaviour;
4. Material dependencies should be identified and their impact on capital should be appropriately explained; and
5. Model Users should understand how diversification assumptions impact the model outcomes.

1. Expert judgment should be utilised and incorporated in a structured and documented way

Since historical data will typically be insufficiently credible on its own, the judgment of subject-matter experts (SMEs) is an important supplement to any model. SME input should be used in a structured – though not necessarily mathematical – way. Subjective overrides of indicated results may be appropriate in lieu of incorporation via more formal statistical inference. In either case, however, consideration should be given to the appropriate level of documentation on the approach taken and the reasoning of the SMEs that might be needed should a knowledgeable third party need to understand the method used and the justification of key decisions made based on a review of the material.

Although expert judgment plays a role in almost all parameterisation work, it is particularly critical in assessing tail correlation, where the data is sparse. Expert judgement can leverage well known economic relationships to imply the relationship between risk factors and how these risk factors might behave in extreme scenarios. Credibly measuring dependency levels over the entirety of the distribution is already a challenge and gauging correlation among the worst 1% or 0.5% of scenarios is generally not possible based on only historical data alone. Also with respect to the available data, its relevance (e.g. structural historical changes) and how to use the data (whether you look at e.g. monthly, quarterly or annual returns) typically requires expert judgement.

When the dependency modelling is relying more on expert judgement and less on observed observations this may also impact the granularity of the modelling and the level of precision of

parameters set. For example, based purely on expert judgement, it may only be possible to classify dependencies as high, medium or low.

However, depending on the available information and its quality one can propose to use Bayesian inference which combines prior information (e.g. guidelines from regulators), observations and expert opinion in order to estimate a dependence measure and determine the estimation uncertainty. The combination of different sources of information can significantly reduce the parameter uncertainty compared to the use of only one source.

2. Parameterisation should utilise as much relevant data as practicable

Dependency levels are notoriously difficult to measure accurately. Many observations may be needed to yield an identifiable indication of correlation, but even then is unlikely to by itself provide a clear picture of dependence in the most adverse scenarios (i.e. "tail correlation") which tend to drive the calculation of required capital typically based on high confidence levels.

Consideration should also be given to the fact that circumstances of a product, portfolio or business may change over time, rendering older data partially or fully obsolete. For these reasons the historical results of two marginal variables by themselves will generally not provide an entirely reliable indication of dependency levels.

As such, it will be useful to benchmark results against those for similar variables for which internal or external data is available. Expert judgment or mathematical techniques can be used to /provide credibility to observed historical results and the remainder to one or more benchmarks.

Economies also go sometimes through structural changes making historical observations less relevant (or perhaps more relevant in other cases). For example hyper-inflation has occurred in many countries (e.g. Germany) although this may not be relevant due to a different economic structure or monetary policy. Similarly emerging markets at some point can mature with structurally lower growth rates impacting many market risk drivers in such markets. Expert judgement is therefore also relevant to see how structural economic changes impact the relevance of historical market data.

3. Estimation of dependency relations should take into account tail behaviour

Dependency between risk factors can differ between "normal" and more "extreme" market circumstances. Typically some dependencies can become stronger when markets are volatile. E.g. stock markets are globally stronger correlated in extreme negative scenarios.

When estimating dependency relationships it is important to take into account such behaviour in tail events considering that we are interested in the behaviour in such scenarios. The drawback is that the number of observations for tail events are typically quite limited. However, there are several ways to take this into account in the estimation of the dependency parameters.

4. Material dependencies should be identified and their impact on capital should be appropriately explained

Sensitivity testing can show which dependencies have the most material impact on capital calculations. As there are typically many risk drivers, the materiality of the dependency in the overall calculation can help to focus the modelling and validation efforts.

The explanation of material dependencies should consider the main drivers of those dependencies.

Dependency drivers may be captured and applied explicitly to affected variables or defined via a copula or similar approach.

There are a number of benefits that can be identified from understanding the explicit drivers of dependency and considering their impact on relevant marginals. These can include:

- Increased understanding of the causes of dependency and their effects; and
- Potential for improved credibility in levels of tail correlation. In particular, to the extent that the modelled correlation driver contains extreme events, and/or that the marginals to which the drivers are applied react in extreme ways, tail correlation is the probable outcome. This can make the result easier to defend.

Back-testing against historical results can be helpful when comparing modelled outputs that have been aggregated to a higher level. For example, examining simulated ranges of loss ratios for a company as a whole speaks to the veracity of both the risk and dependency parameters. However, observations are likely to be in the body of the distribution with only very limited information on the tail.

5. Model users should understand how diversification assumptions impact model outcomes

As noted earlier, although the existence of diversification may be accepted, the concept and calculation can be relatively opaque and difficult to understand for many stakeholders although diversification assumptions can sometimes significantly impact model outcomes and therefore business decisions.

The nature of the assumptions made and the main limitations should be communicated to model users, in particular also to the management level that makes strategic decisions taking into account model outcomes. Sensitivities to key (diversification) assumptions or other measures that indicate the uncertainty in model outcomes can implement above communication.

When setting risk tolerance and appetite the firm should consider model risk related to key assumptions such as diversification benefits.

3.4 Observations

Computed diversification benefits are influenced by many factors of the aggregation process, which may complicate the understanding of diversification benefits. However the following messages are coming out of our discussion:

- **Model structure and non-separability**: Classifying risk exposures into different risk categories is a common approach to risk measurement. An assumption made is that risks can be clearly separated. In reality, risk exposures in these different buckets may have some interactions, which the model may or may not capture depending on its granularity. Therefore, usual methods that classify risks into different buckets and aggregate through common distribution assumptions may lead to significant misestimation of risks or misestimation of diversification benefits. In addition, this classification of risks may also hinder appropriate management of the risks, as the bucketing may lead management to ignore certain important risks or risk interactions.
- **Level of granularity impacts how diversification is implicitly or explicitly captured**: The level of granularity within the risk aggregation approach is a crucial factor that affects the management and measurement of diversification benefits. Regarding risk measurement, the level of granularity of the aggregation method influences the calculation of diversification

benefits. One should also be careful when comparing the stand-alone risk factor shocks and the diversification between two models that use a different level of granularity. E.g. the Solvency II standard formula assumes 100% correlation between all equities and therefore does not allow for diversification within equity risk. However, the equity shocks are calibrated based on a diversified equity index, so some level of equity diversification is already embedded within the calibrated shock. On the other hand a model with multiple equity risk drivers might assume some level of diversification between these risk drivers, which does not necessary imply a lower equity risk capital. More in general the structure and the granularity of the model drive how diversification is recognised in the model. Typically, the more the aggregation approach differentiates portfolios or activities according to dimensions such as geography, business unit/legal entity level, risk type or product type, the more explicit diversification will be shown. Obviously, one has to be careful to recognise sufficiently the tail dependencies across all such dimensions to not overestimate diversification benefits.

- **Model structure and level of granularity need to fit the business profile**: Obviously the level of granularity and sometimes even the model structure are driven by the business profile. Risks that are more material for the business are typically captured in a more granular manner. Also elements such as geographical diversification might become more important to capture when a company has significant international activities across multiple markets.
- **Dependence modelling**: An inappropriate modelling of a dependence structure could result in an incorrect calculation of diversification benefits, despite the fact that the individual capital components themselves may be quite reasonable. In modelling dependencies it is important to consider how risks behave in tail events.
- **Model parameterisation**: Parameterisation of the variables used to model dependence structures is often difficult. Many issues arise, not only in the estimation of parameters themselves e.g. correlation factors in the use of the variance-covariance matrix, but how these parameters evolve over time as a result of changes in economic indicators, business cycles or underwriting cycles. The use of expert opinion is usually necessary as totally determinative data is rare and the decisions may materially affect the computed diversification benefits.
- **Modelling and validation efforts need to be driven by materiality**: Given the large number of risk drivers that capital models typically have, it is important to be aware which dependencies are the most material and focus the parameterisation and validation efforts especially on those dependencies.
- **Model comparison and benchmarking to the Standard Formula**: Given that models can have a different structural approach and level of granularity one should be careful when comparing the diversification benefits shown (explicitly) by various models. Regulators tend to make comparisons with the Solvency II Standard Formula (SF). However, this has to be done with care as the SF is a particular (top-down) approach with limited granularity and therefore the correlation parameters as well as the diversification benefits may not be directly comparable with internal models used by insurance companies.

On this basis, the following conclusions can be drawn:

- Diversification ratios are an unreliable basis for comparison between companies given the scope for different structural approaches taken in modelling;
- Diversification should not be taken as a basis for assessing the validity of a model;
- Consistent use of confidence levels are needed to assess relationships between risks; and
- Expert judgement plays an important role irrespective of the structure of approach taken in modelling and understanding the dependency between risks.

4 Part II – Fungibility and transferability

4.1 Introduction

Part I of this paper set out the modelling considerations related to the identification and calculation of diversification benefits. This section considers the recognition of diversification benefits in economic capital modelling particularly in the context of insurance groups.

For a solo entity, the amount of diversification benefits are uniquely determined by the entity's portfolio mix. For an insurance group, which consists of a number of insurance entities, diversification benefits include the balance of risks across the different solo entities. This is based on an economic view of the group as a single economic entity where all assets and liabilities are fungible.

4.2 Fungibility and transferability

The 2005 paper referred to capital mobility and risk transfer as relevant components in the recognition of diversification benefit. However, it is the principle of fungibility that underpins the ability to consider an insurance group as a single entity under an economic view.

Fungibility means that an element of own funds in one of the entities can be used to absorb any kind of losses within the group, regardless of where these commitments arise. Fungibility relates to the ownership of the assets or liabilities and the ability to determine how they are used. In this sense, fungible capital can be dedicated to any purpose. In economic capital modelling, the starting assumption is that there is full fungibility of assets and liabilities. Unfortunately, the concept of fungibility is often confused with the concept of transferability.

Transferability, on the other hand, refers to the actual ability to transfer own funds from one undertaking to another within the group within a certain timeframe. The transfer of own funds will increase or decrease the own funds in solo entity without increasing or decreasing the group own funds. On this basis, transferability captures the timing and legal constraints affecting the availability of particular assets or liabilities and is particularly relevant to considerations of liquidity management. It does not capture ownership and, therefore, is not relevant to the question of whether a group has sufficient assets to meet liabilities to a confidence level under an economic view.

A number of transferability requirements has been incorporated into the regulatory solvency assessment which adds to the confusion between fungibility and transferability. As a result, diversification benefits can be restricted from the regulatory solvency assessment on grounds (transferability) that are not relevant to the economic view of the resilience of the group.

Transferability within a group supports the ability of the group and its entities to meet liquidity needs across the group. The capital provides resilience to withstand shocks to be able to meet commitments to policyholders and other creditors. Ultimately, fungibility and transferability deal with different issues regarding the resilience of a group in terms of capital and liquidity respectively across the group.

4.3 Demonstrating fungibility

The guidelines, such as those being considered under Solvency II, place specific requirements to assess whether own funds eligible for the solo capital requirement are able to effectively be made available to cover the Group capital requirements. However, both fungibility and transferability are

mentioned as necessary criteria in forming their view on availability. An example criteria is the time feature of 9 months within which the own funds should be made available.

Being conscious of these guidelines, this paper considers a pure economic view where there should be no restrictions on fungibility since, in an economic approach, the economic value of capital can always be monetised (through a sale as a last resort). This argument is valid even in times of stress since a sale will remain feasible. In Solvency II this is incorporated in the requirement use an "exit value approach" which calculates market values in times of stress. From this perspective, there should be no arbitrary barriers imposed by supervisors on fungibility and transferability should be considered separately in connection with liquidity assessments.

The starting principle is that under normal market conditions, in an arms-length sale of the business from one insurer to another, value is attached to all assets and liabilities. Therefore, ultimately all capital in a legal entity within a group can be considered as available and fungible in support of the realisation of diversification benefits.

In a stressed economic environment, the value of expected future profits may be reduced, forcing down the potential 'sale value' of the business under consideration. This is likely to be the case for particular types of risk exposure within the entity. Different parts of a diversified business will be affected in different ways. Therefore, assets or liabilities within the legal entity or across the group could be used to change the relative risk profile of an entity or the group.

Potential solutions can help to demonstrate that sale values under stressed conditions for particular parts of the business are still sufficient to cover capital requirements both within entities and across the group.

Examples of options available that can ensure fungibility include:

- **Intra-group loans**: this can be in the form of loans or guarantees;
- **Reinsurance**: reinsurance arrangements can be used to transfer risk and related capital requirements between insurance undertakings; Reinsurance can be both internally between legal entities within the same company as well as externally;
- **Options to monetise future profits/dividends**: this is an option to monetise value in force (VIF); funding is often provided by an investment bank or fund;
- **Contingent loans**: a loan can be obtained from a bank, with repayments contingent on future surplus emergence; and
- **Simplifying legal structures through a branching structure**: this is an option were profits are automatically available with no obligation to keep capital in excess over reserves locally.

In addition, the disposal or partial disposal of an entity could be undertaken in order to make capital available at group level. However this will have implications for the diversification within the group going forward.

In considering each of the options set out above, the following factors are relevant:

- Strategic implications: some of the options set out above, in particular disposal or partial disposal of entities, may not be in line with the business model of the Group;
- Costs: all of the above options involve some costs and usually necessitate foregoing a proportion of future profits; there may also be some direct expenses incurred in implementation;

- Availability in a stress scenario: a different level of confidence can be attached to the availability of each of the above options in a stress scenario. This would include consideration of the extent that risk has been transferred and the associated counterparty exposure; and
- Difficulty of implementation: legal, regulatory and tax impacts notably can be studied for each of the above options.

There are a number of historical transactions across the industry where capital has effectively been available from a subsidiary undertaking to the group. These have largely been through either the disposal of an entire line of business or undertaking, or monetisation of future profits through a reinsurer.

4.4 Challenges to fungibility in the economic view of the group

Different issues can by their design appear and impose restrictions e.g. capital within a ring-fenced fund may not be fully fungible due to the incorporated profit sharing mechanism. However building on the ways to demonstrate fungibility, an economic view can generate an economic value that takes any restrictions into account. As a result restrictions are incorporated into the economic value. This can allow the overall level of risk to be considered independently of the legal structure of the group. This is mainly due to the fact that under an economic view all parameters influencing the value of an item (no matter if it is a subsidiary, participation, an asset vehicle, etc.) should be taken into account in order to obtain the economic value. As noted earlier, this would include legal, time and costs implications. For example in case of profit sharing mechanisms the profits not available for the shareholder, (i.e. attributable to the policyholder) will result in higher liabilities and therefore reduce the economic surplus representing the economic value.

Applying economic principles, the economic value of an item can always be monetised. Examples of this were discussed in more detail above. Hence if modelled correctly there should be no restrictions on fungibility. By monetising economic surplus the group can expect to generate the funds needed to cover losses within the group. This supports the key driver for the recognition of group diversification that different risks can represent natural hedges within a group, i.e. between its subsidiaries.

Below we apply the reasoning of an economic view to several factors usually present within a group in order to illustrate this principle. However, it should be noted that with regard to economic models there should be no obligation to formally conduct such argumentation as an economic model builds on the economic value, i.e. taking all factors with its characteristics into account. The factors include:

a. Legal structure
b. Recognition of assets
c. Intergroup arrangements
d. Partial Holdings (minority interest, joint ventures and participations)
e. Policy and share holder restrictions (Own fund)
f. Tax

Each of these factors will be discussed below.

a. Legal Structure

Legal structure describes the organisational structure in terms of the legal forms of the respective companies included in a group. Due to the legal form of a company, there may exist some restrictions concerning the fungibility between those entities.

However, fungibility from a group perspective is usually a bottom up process, meaning that in case capital is needed by one subsidiary, the capital is usually moved from other subsidiaries to the group and then allocated to the subsidiary in need. Therefore it is sufficient to look at the parent-subsidiary relationship when assessing possible restrictions resulting out of the legal structure.

Under an economic point of view and as noted in Section 4.3, the legal structure alone does not impose any constraints as the economic value of the subsidiary (according to the participation rights of the parent undertaking) takes this into consideration. As noted above, the economic value can be fully attributable to the parent undertaking as it can usually be monetised, e.g. by selling the entity or taking up a loan on this value.

As a result the parent undertaking can use this economic value to cover losses incurred by any subsidiary independent of the detailed legal structure. The legal structure itself therefore does not impose any restrictions (regulatory view is considered in section 4.7).

b. Recognition of assets

Another factor to consider is the fungibility of assets and liabilities making up own funds and the ability of different subsidiaries to recognise these assets and liabilities.

An example of this arises under Solvency II and the value of expected profits in future premiums (EPIFP). The available capital is determined by the economic value of future cash flows at the solo entity level set by how the contract boundary is defined. The contract boundary looks to identify the cash flows that arise from the receipt of future premiums. Under an economic view, future profits attributable to the entity have to be included in the present value of the entity. Hence it is included in the surplus of the respective entity and available for monetisation at group level.

c. Intergroup arrangements

Intergroup arrangements are the mechanisms that enable the group to move assets and liabilities within the group whether between the group and its subsidiaries as well as among subsidiaries themselves. Examples can include letters of credits, given guarantees, internal loan agreements etc. But as the group is treated as one economic unit intergroup agreements of any kind should already be captured. This is to avoid any double counting on group level. Consequently such arrangements do not impose any restrictions concerning the recognition of diversification.

d. Partial Holdings

Partial holdings are where a parent undertaking does not fully own a subsidiary, e.g. in case of minority interests, participations, affiliated enterprises etc. Economically, the value of an entity is given by its economic equity which is attributable to the respective owners of the company according to their share in that company. As the economic equity more or less represents the difference of assets and liabilities this relates one to one to the shareholders of the company. Their respective share can be interpreted as proportional owning rights of the assets and liabilities of the company. Hence the only risk related to the proportional share in that company is effectively carried by the respective shareholder and any diversification effects at group level are also related to that share. Consequently this argument also applies to the capital, i.e. only the proportion of the owned share can be taken into account at group level, but this share again can be sold.

e. Policyholder and shareholder restrictions

There are specific ring-fencing arrangements in different jurisdictions to protect policyholder funds that need to be considered. The specific design of ring fencing depends on the legal or contractual

arrangements but usually has some sort of limit concerning the sharing of profit/losses between policyholder and shareholder or the usage of assets.

At first glance this appears to be a restriction concerning transferability. Concerning the aspect of profit sharing between shareholder and policyholder, profits stemming from assets contained in the ring fencing arrangement are attributable to the policyholder up to a certain amount. Under an economic view this however immediately results in higher liabilities reflecting the additional future benefits for policyholders. Therefore the remaining excess of assets over liabilities stems from the shareholder part. Again this economic value can be monetised and is be suitable to cover losses elsewhere in the group. A major portion of ring-fenced funds relate to life insurers that write with-profit business, pension contracts and Protection and Indemnity Associations.

f. Tax

In the event of taxable temporary differences stemming from deviating recognition values of assets or liabilities in the Solvency II balance sheet and its tax base, deferred tax assets or deferred tax liabilities occur. As these balance sheet items are derived in accordance with the local tax regimes of subsidiaries the question arises if those items in one subsidiary can be used by the group to cover losses in another subsidiary. In such a case the subsidiary in question is not directly affected by the capital need of another subsidiary. Hence the deferred tax assets (DTA) and deferred tax liabilities (DTL) values should not change due to this circumstance and under the economic view the excess of assets over liabilities represents the economic value of the subsidiary attributable to the group. As the DTL is a liability which has to be paid with high probability one cannot alter this value. The question remains if the DTA can be seen as available or if it has to be removed from the excess of assets over liabilities at group level. As the subsidiary calculates the DTA and DTL based on its individual situation which is not affected by the capital need of another subsidiary the DTA represents an asset for that subsidiary. If this DTA is valuable for that subsidiary it has to be included in the economic value of the entity. Additionally in order to recognise these items within the balance sheet they have to be recoverable. As the parent undertaking can monetise this value as part of the economic value of its subsidiary e.g. by selling the subsidiary for its economic value or taking out a loan, the DTA is fungible.

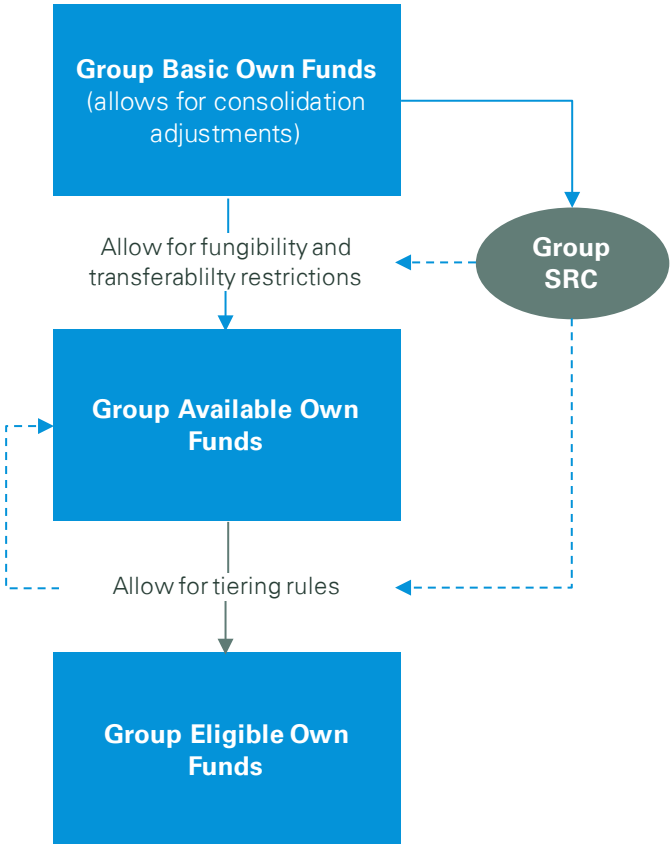
Above examples show that under a pure economic view no arbitrary fungibility restrictions should be imposed.

However regulation can impose some transferability requirements, for example under the current Solvency II regulation, which have to be fulfilled for an item to be considered fungible. In addition some items e.g. surplus funds are identified as not transferable. As a general rule of thumb all items not explicitly identified as not transferable/fungible by regulators can be seen as fungible up to their economic value.

4.5 Modelling Approaches

The figure below gives a conceptual overview of a methodology to derive group level own funds and recognisable diversification. We use the current Solvency II framework to provide context, a basis for illustration and examples of restrictions imposed on fungibility by regulation. Own funds are taken as the starting point for all calculations. The solvency requirement is referred to as the SCR. For the purpose of this paper, we use the SCR as set out in Solvency II being the *Value-At-Risk of the basic own funds of an insurance or reinsurance undertaking subject to a confidence level of 99.5% over a one-year period*. Note that, at Group level, Own Funds should allow for consolidation adjustments to avoid the double-counting.

Figure 4: Example: Adjustments to Solvency II Own Funds



In essence the available own funds are the basic own funds after allowing for the constraints (eligible own funds are the available own funds after any applicable tiering rules). The methodology considers the constraints on group available own funds. As shown in the diagram above, the determination of group available own funds uses basic own funds, SCR, constraints, and, indirectly, the tiering rules (as an example of regulatory restrictions or factors that should be considered) as inputs.

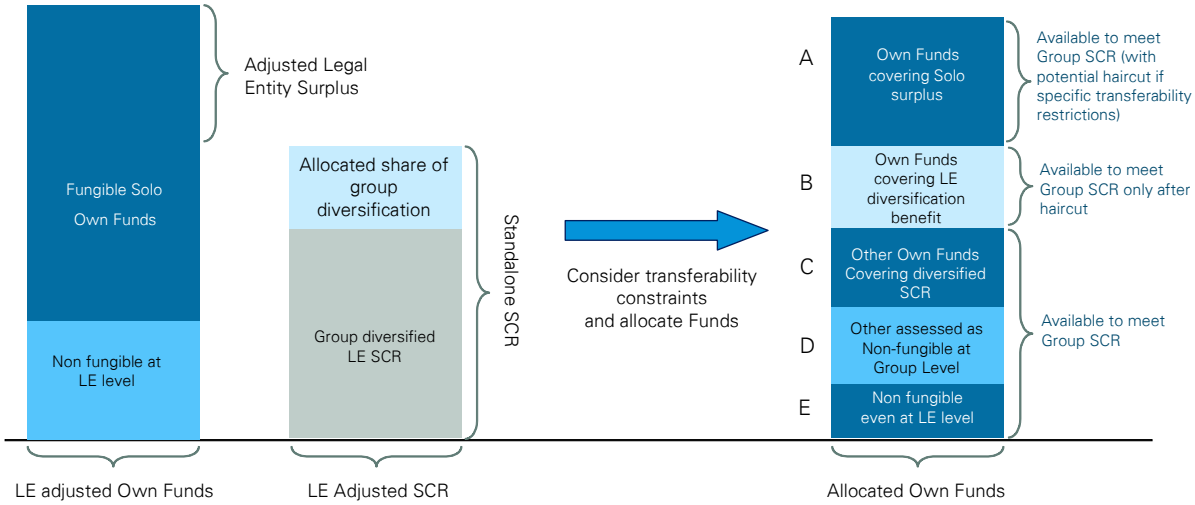
4.5.1 *General principles of calculation*

The Solvency II framework requires that the Group will assess if own funds available at solo level can also be made available at group level. In addition to the regulatory principles other assumptions may be considered:

- Some Own Fund items which are not directly transferable may be made available through sale.
- When Own Funds are not directly transferable due to local constraints, additional techniques are available that mean the capital is still fungible within the Group.

Haircuts can be a way of reflecting the cost of the imposed restrictions on these Own Funds items. The basic figure 5 illustrates this:

Figure 5: Example: the application of transferability restrictions

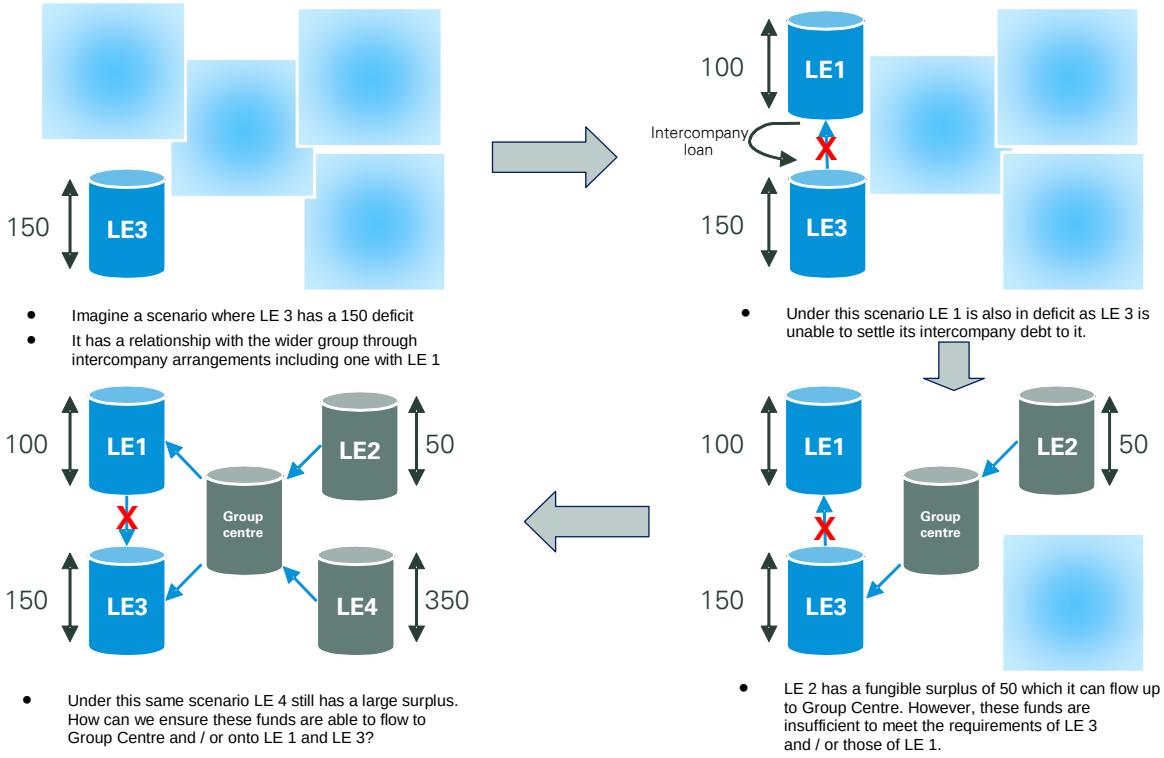


In this example, the Legal Entity (LE) Own Funds comprises of non-fungible and fungible capital. The LE Own Funds up to the level of the diversified SCR are always available to cover the Group SCR(C+D+E). The excess over LE standalone SCR (i.e. LE surplus) is fully available to cover the Group SCR if there are no specific legal or regulatory restrictions (A).

4.5.2 *Allowing for Intercompany arrangements*

Another modelling approach is to capture these issues in the calculation of the group solvency. This requires on one side to calculate the group SCR and on the other side to determine the amount of Own Funds within the group eligible to cover the group SCR. The underlying assumption is that some capital sitting in one entity may be used to help another entity. However this is not always possible due the fact that some capital may not be able to absorb some types of loss or may be prevented from being able to cover the loss. This is illustrated broadly in the figure 6 below:

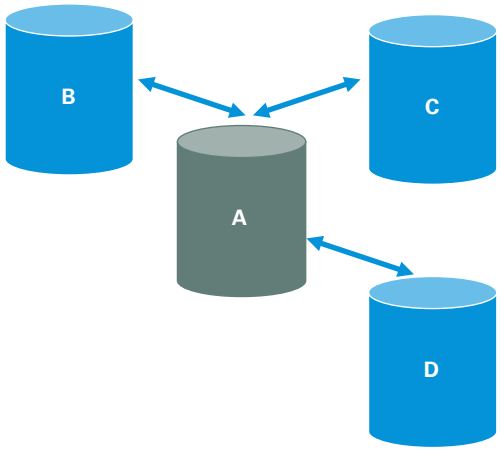
Figure 6: Stylised diagram of moving funds around a group



The above diagram is highly stylised and shows that some Legal Entities can be in surplus whilst others are in deficit. The point at which Legal Entities would go into "deficit" (shown as red in the figure above) depends upon the degree and nature of the stress applied, for example, it may be a Group 1-in-200 or, a weaker Group 1-in-x where the business would look for LEs to stay above their target capital (SCR + buffer). Hence these considerations address matters that might form part of a risk management framework.

A Group can conceivably set-up a network of agreements between businesses that give Group delegated authority to implement them up to a certain value. The Group capital model can be written to reflect the rules around these agreements.

Figure 7: Stylised diagram of agreements in place between companies in a group



For example, company A can call from B, C, and D if it requires capital in a given model run (see figure 7). It may be that this capital is taken equally from each of B, C, and D (if they are all solvent in this scenario) or it could call on capital no more than taking each down to a certain solvency cover, and, further, that it does this in a certain order such as A before C before D. That is, any rules governing how funds would be transferred would be written to reflect the specific business requirements and the agreements in place. Hence, when the stochastic model is run these rules are incorporated into each of the model runs and the resulting output reflects these having been factored into the model and stressed.

4.6 Regulatory cooperation

Having looked at how various factors can be addressed in the modelling and economic valuation, the challenge for firms and regulators is to avoid arbitrary restrictions that can unnecessarily trap capital in local entities and reduce the incentives to understand the benefits of diversification.

Coordination is a central theme to enable the benefits of diversification to be realised. The group supervision regime plays a key role in enabling this. There are a number of wider developments that are aimed at incentivising risk management by companies. These developments include global acceptance of the principles of ORSA, stress testing, scenario analysis and risk appetite. These initiatives provide supervisors and firms with significant additional information, expert analysis of the factors and economic valuation supporting the diversification analysis and the resilience of the group.

Therefore, these developments provide context for the solvency assessment and information that can enable diversification benefits to be realised. A key benefit is that it can avoid restrictions being imposed that can frustrate effective risk management and trap capital in particular entities undermining the benefits of diversification.

Local statutory requirements like the discounting effects (delta between book value reserves and Solvency II reserves including market value margin (MVM) after tax) or equalisation reserves or the effects of prudent reserving in statutory reporting are not explicitly listed in the Solvency II texts as non-fungible.

For example, some subsidiaries might be required to hold certain minimum capital requirements or cover reserves on a different basis to that used in the group computation (this can arise for non EEA subsidiaries in a Solvency II Group calculation) or local GAAP accounting may limit release of funds.

It will appear that these capital items may not be fully fungible since the capital cannot be transferred to cover losses elsewhere in the group. However, it is possible to demonstrate that 'restricted items' are fungible, as noted earlier.

Examples of restrictions that are incorporated into regulation are those in the current Solvency II framework and detail. The existence of group level diversification benefits is accepted under Solvency II as it is recognised that the group solvency capital requirement may be less than the sum of its solo SCRs. However the Solvency II framework is still far from looking at the group as a single economic entity as it would be justified under an economic model view.

Solvency II imposes restrictions that affect recognition of diversification benefits captured in the calculation of the group SCR. These are targeted at the factors likely to affect transferability rather than recognising the principle of fungibility.

Another example is where own fund items are only eligible to cover the SCR at group level if it meets the eligibility criteria at solo level but also additional group specific eligibility criteria. This deviates from an economic approach where all own fund items are available on the basis of fungibility and reflect the resilience of the group.

The regulatory view of transferability provides that the following criteria must be considered in assessing whether own funds eligible for the solo capital requirement are unable to effectively be made available to cover the Group capital requirements:

- The own-fund item is subject to legal or regulatory requirements that restrict the ability of that item to absorb all types of losses wherever they arise in the group;
- There are legal or regulatory requirements that restrict the transferability of assets to another insurance or reinsurance undertaking;
- Making those own funds available for covering the Solvency Capital Requirement of the participating insurance or reinsurance undertaking would not be possible within a maximum of 9 months.

The consequence of not meeting these criteria is a deduction from own funds and effectively a zero valuation for the purposes of the group calculation. Additionally requirements on the tiering of capital can add to the challenges and present further restrictions on fungibility.

These restrictions present arbitrary barriers that can undermine risk management, confuse the ability of a group to withstand shocks with liquidity requirements and present significant challenges for management and regulators in times of stress.

The coordination among supervisors together with the Pillar II developments provides a comprehensive picture that can support the economic valuation that underpins the recognition of diversification benefits and allows clear separation between issues of resilience/economic capital and liquidity. The understanding of this distinction will be for effective cooperation and coordination between supervisors and firms in times of stress.

5 Conclusions

Diversification is at the heart of insurance business and risk management. Fostering improved risk management and measurement is the best solution to the challenges posed by the financial crisis and policyholder protection. The CRO Forum continues to believe that the ability of regulatory solvency assessment to recognise diversification benefits provides a key tool in meeting policyholder protection and financial stability objectives. On this basis, this paper looks to provide a basis for:

- companies to evaluate and justify their treatment of diversification identified within their modelling;
- assisting communication with supervisors in respect of the approach taken to modelling of diversification benefits;
- enabling greater understanding around the ability to recognise the effects of identified diversification; and
- supporting improved cooperation to promote recognition of diversification within insurance solvency assessments and mitigate the risk of arbitrary restrictions being imposed.

Modelling

The paper identified factors that are likely to affect the modelling of diversification including, model structure and non-separability, level of granularity and its impact on how diversification is implicitly or explicitly captured, dependency modelling, model parameterisation, validation and benchmarking. Five principles are identified in the paper to assist with the setting of model correlations, calibrations and parameterisation being:

1. Expert Judgement should be utilised and incorporated in a structured and documented way;
2. Parameterisation should utilise as much relevant data as practicable;
3. Estimation of dependency relationships should take into account tail behaviour;
4. Material dependencies should be identified and their impact on capital should be appropriately explained; and
5. Model Users should understand how diversification assumptions impact the model outcomes.

The paper provided a clear distinction between fungibility and transferability to highlight how fungibility can be demonstrated for the purposes of recognising diversification in economic capital models and that transferability is relevant for the assessment of liquidity rather than economic capital modelling.

Consideration of the factors that are commonly raised as challenges to the principle of fungibility, such as legal structure, recognition of assets, intra-group arrangement, partial holdings and policy and shareholder restrictions were raised.

An assessment of the regulatory context that assesses diversification and the recognition of diversification benefits, particularly how different regulatory developments should inform understanding of the ability of companies to mobilise capital and enable a flexible approach that avoids concentration and delivers policyholder protection was given.

Fungibility relates to the ownership of the assets or liabilities and the ability to determine how they are used. In this sense, fungible capital can be dedicated to any purpose. In economic capital

modelling, the starting assumption is that there is full fungibility of assets and liabilities. Unfortunately, the concept of fungibility is often confused with the concept of transferability.

Applying economic principles, the economic value of an item can always be monetised. Hence if modelled correctly there should be no restrictions on fungibility. By monetising economic surplus the group can expect to generate the funds needed to cover losses within the group. This supports the key driver for the recognition of group diversification that different risks can represent natural hedges within a group.

6 Glossary of abbreviations

ALM	Asset Liability Management
CRO	Chief risk officer
DTA	Deferred tax asset
DTL	Deferred tax liability
EEA	European Economic Area
EFR	European Financial Services Round Table
EIOPA	European Insurance and Occupational Pensions Authority
EPIFP	Expected profits in future premiums
ES	Expected shortfall
IAIS	International Association of Insurance Supervisors
LE	Legal Entity
MVM	Market value margin
P&C	Property & casualty
P&L	Profit & Loss
PSD	Positive Semi Definite
QIS	Quantitative impact study
SCR	Solvency capital requirement
SME	Subject Matter Expert
VaR	Value at Risk
VIF	Value in Force

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8 Appendix, Summary of the 2005 paper and its six principles

Summary of the findings of the 2005 paper

In june 2005 the CRO Forum published a paper on diversification "A framework for incorporating diversification in the solvency assessment".

The purpose of the 2005 paper was to start an informed debate on the issues surrounding the treatment of diversification in the context of the development of Solvency II. Although diversification has always been necessary for all insurance it was poorly recognised in existing solvency assessments and regulation. The 2005 paper aimed to address the imbalance.

The 2005 paper argues for solvency assessments to take account of risk concentrations, risk dependencies and risk diversification both within and across entities of a group. This was justified on the basis that:

- Concentrations of risk can have very damaging effects on an insurer's solvency;
- Risk diversification plays a critical role in the economies of the insurance business and lies at the heart of the principles of the existence of the insurance industry – to bear risks that individual policyholders would be unable or unwilling to bear themselves;
- There is widespread and accepted evidence of diversification benefits;
- Recognition of these facts has led many insurance companies to dramatically improve their risk management capabilities (a factor that has helped the insurance industry to remain resilient through the financial crisis and generally act as a stabiliser through the volatile markets following September 2008); and
- the 2005 regulatory approaches do not adequately deal with diversification or promote continued enhancement in risk based decision making that will be informed by diversification.

Six principles were set out in the 2005 paper:

1. Incorporation of the effects of risk diversification into solvency frameworks is critical for the purpose of rewarding strong risk management and discouraging risk concentration
    - Risk diversification is a critical component of successful risk management for insurance companies;
    - Conversely, risk concentration is one of the major drivers of insurance company default;
    - Furthermore, diversification effects are uniquely determined by a company's portfolio mix and legal entity structure.
2. Diversification effects must be recognised when risk factors, their dependencies and the company's exposure to them are:
    - Identifiable;
    - Supported by empirical evidence, scientific research or expert opinion of causal linkages;
    - An active consideration in business decision-making;
    - And, where capital / risk mobility does not impose barriers to the diversification effects being realisable.

3. For the purpose of recognising diversification effects, capital mobility and risk transfer should be recognised if financial resources are available to back policyholder and other creditors' claims:

   - With sufficient economic value and;
   - As they fall due.

4. Capital requirements at the solo entity level should reflect:

   - The diversification effects within that solo entity;
   - The formalised support, where present, provided by transferability of capital between a Group and the solo entity, or an external party and the solo entity.

5. Capital requirements for an insurance Group must be assessed separately from those of the solo entities within that Group, and should reflect:

   - The diversification effects specific to that Group, taking any constraints to capital mobility into account;
   - The capital implications of both Group legal structure and any intra-group agreements.

6. Co-ordination between supervisors of local entities and Groups is essential to ensure an efficient, competitive European insurance market. This includes the coordination by a mandatory Lead Supervisor.

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The CRO Forum is supported by a Secretariat that is run by
KPMG Advisory N.V.

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