# Gestion Actif-Passif en assurance : Partie I

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# Plan

- Introduction

- La nature des passifs d'assurance

- Les grands équilibres bilanciels d'une compagnie d'assurance

- Outils « classiques » de la gestion actif-passif

- Valorisation des actifs financiers et des passifs d'assurance

# Introduction

- ALM = Asset Liability Management.
- ALRM = Asset Liability Risk Management.
- BSRM = Balance Sheet Risk Management.
- BSRM = Economical Balance Sheet Risk Management

**Plan DAY1**

- Introduction
- La nature des passifs d'assurance
- Les grands équilibres bilanciels d'une compagnie d'assurance
- Outils « classiques » de la gestion actif-passif
- Valorisation des actifs financiers et des passifs d'assurance

Normes : French GAAP, SII, MCEV

Actifs : Placements financiers

Passifs : Provisions Techniques, Fonds Propres, valorisation.

RISK MANAGEMENT : IDENTIFICATION, QUANTIFICATION, GESTION, SUIVI

MODELES ALM.

# Introduction

- L'objectif de ce cours est de présenter la théorie et la pratique de la gestion actif-passif (ou ALM : Asset Liability management) des entreprises d'assurance.

- La gestion actif –passif a été toujours au cœur du métier de l'assureur mais elle a connu un développement rapide au cours des 20 dernières années.

- La sophistication des instruments financiers, le développement des outils de modélisation, les nouvelles exigences des parties prenantes (régulateurs, mais aussi actionnaires, analystes financiers, agences de notation et mêmes assurés) y ont fortement contribué.

- ALM s'inscrit désormais dans une approche plus globale de gestion des risques *(approche dite ERM: « Entreprise Risk management »),* par opposition à l'approche classique « par silos ».

- Par conséquent, ce cours aura comme objectif d'élargir la vision de la gestion actif-passif au-delà de la simple adéquation entre les actifs et les passifs d'un scenario économique central et soulignera l'importance de la prise en compte des interdépendances entre les risques.

- De même, la cohérence globale entre ALM, normes comptables, allocation d'actif, gestion de l'exigence en capital et gestion des produits sera abordée.

- De manière générale, une plus grande attention sera accordée à l'assurance vie où la problématique ALM est plus complexe. Toutefois, le cours sera complété par des exemples Non vie ou santé& prévoyance.

# The importance of Risk management : is the insurance industry different from the others ?

In the insurance sector, the **production process is inverted** : the policyholder pays a certain premium before potentially receiving **a contingent** claim payments later.

In contrast, an “ordinary” firm invests an initial amount in order to acquire inputs (e.g. raw materials). The raw materials are transformed and sold to the customers.

❑ **This feature explains why the ALM management of an insurance company relies on a prospective view and on stochastic modeling techniques. In fact, short- term cash flows are of limited use as a means of understanding of the business model.**

❑ However, whether the life insurance industry is fundamentally different from the banking industry is debatable (see [1]). At this stage, we notice :

- There are similarities between some life insurance guarantees and the financial options.
- The insurance (even non life) policy could be seen as a *contingent loan :* the policyholders lend an amount (the premium) to the insurer. The policyholders will be reimbursed in the case of claim (contingent loss).
- However, in contrast to the insurance firms, commercial banks can create money under a fractional-reserve banking system (most of the systems worldwide).

# The importance of Risk management :is the insurance industry different from the others ? (2)

Because of this inverted production cycle :

- The insurance industry is **regulated in order to protect the customer.**
- The regulators require the **insurer to lock a capital**. The amount of the capital depends more or less on the risk profile (Solvency I vs Solvency II vs economic capital). Note that even on a completely unregulated market, the insurer will need to a lock a capital, but a different amount from the regulatory one.
- The risk can be **financed** through equity or hybrid debt, **mitigated**, **avoided** (risk selection), or **transferred** (e.g. reinsurance).
- The asset-liability management (ALM) requires a prospective and stochastic view .

# The importance of Risk management

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- Before discussing insurance ALM in ERM context, **it is worth recalling the importance of risk management and why risk management creates value.**

- This nontrivial question was debated in the sixties and in the seventies. In fact, **the Modiagliani-Miller theorem (1958) states that under the following "perfect market" assumptions** :

  (i) neutral taxes;

  (ii) no capital market frictions (i.e., no transaction costs, asset trade restrictions or bankruptcy costs);

  (iii) symmetric access to the credit markets (i.e., firms and investors can borrow or lend at the same rate);

  (iv) firm financial policy reveals no information,

**the firm value does not depend on its corporate structure.**

- Consequently, many risk management activities and the risk transfer cannot add value, since the value of the firm cannot by changed through financial transactions.

- This conclusion is also in line with the CAPM (Capital Asset Pricing Model, Sharp 1964). Under the assumption of "perfect" markets, the company should not focus on the idiosyncratic risk (i.e. company-specific) but only on the systematic (or beta) risk.

- The intuitive reason is that the CAPM assumes the shareholders can always reduce the specific risks themselves through a diversification w/o cost.

- **Although theoretical, these conclusions are important. These frameworks show that the Risk management matters precisely because the assumptions of the Modigliani-Miller theorem and CAPM are partially violated in practice.**

# Why does Risk management matter ?

The Modigliani-Miller theorem shows why Risk management matters in reality :

- **Transaction costs**
- **Asymmetric information**
- **Bankruptcy costs**

# ALM and ERM (Enterprise Risk Management) (1)

**Over the last decade, a new approach emerged : Enterprise Risk management (ERM)**

**ERM is essentially driven by the following changes:**

- Inherent complexity of the risks, illustrated by high –profile corporate failures
- Pressure from the stakeholders (shareholders, regulators, analysts, rating agencies….)
- Move from “silo” to “global” (or “holistic”) approach
- Increasing sophistication of quantitative models combined with “qualitative” tools
- Risks are seen not only as a threat, but also as an opportunity

# ALM and ERM (Enterprise Risk Management) (2)

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**However, various definitions of ERM are available.**

These definitions provides insightful information on the organizations' philosophies and ambitions (see words in bold letters) :

***CASACT (see [4])*** *: ERM is* ***the discipline*** *by which an organization in* ***any industry*** *assesses, controls,* ***exploits****, finances and monitors risks from* ***all sources*** *for the purposes of increasing the organization's short- and long term value* ***for its stakeholders.***"

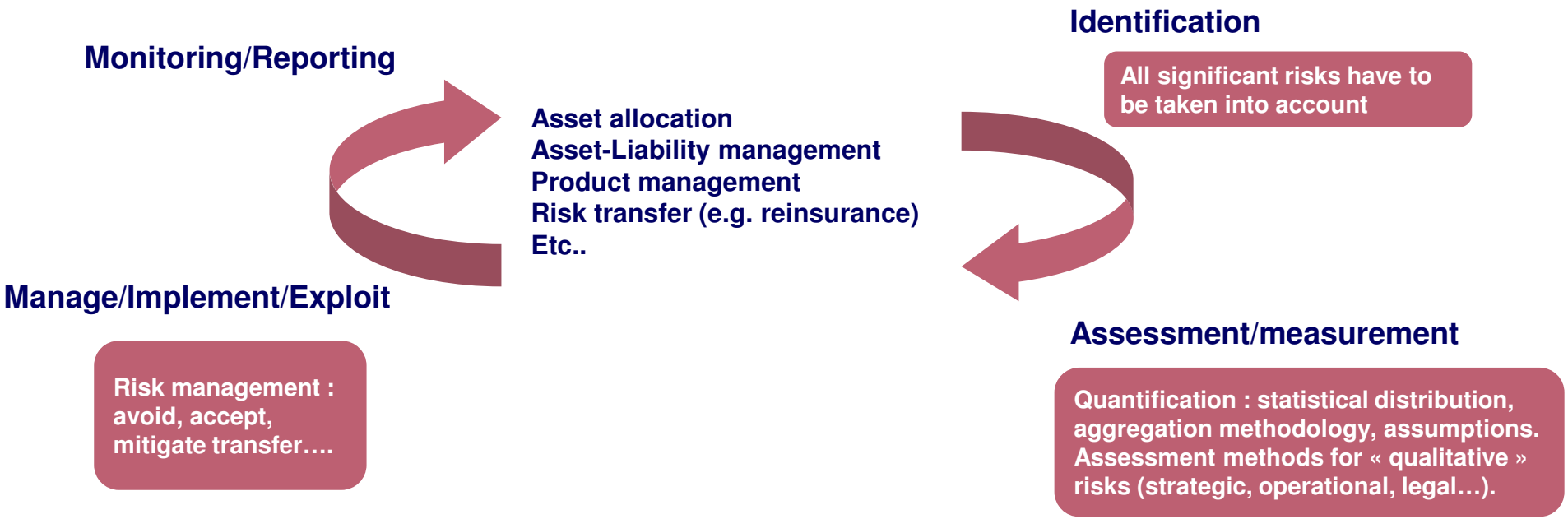
***COSO (see[5]):*** *ERM is a* ***process****, effected by an entity's board of directors, management, and other personnel,* ***applied in strategy setting and across the enterprise****, designed to identify potential events that may affect the entity, and manage risk to* ***be within the risk appetite****, to provide* ***reasonable assurance*** *regarding the achievement of entity objectives"*

***S&P (see[6])*** *: S&P defines risk management as the* ***process*** *companies use to* ***identify and monitor*** *significant risks and* ***to set limits*** *for these risks that reflect their* ***risk appetite, competencies, and resources****. Enterprise risk management extends these core risk management processes so they can be* ***adopted consistently across all risks*** *and in a way that supports the company's* ***overall corporate strategy****.*

**ALM should be embedded in this broader ERM approach.**

# Asset allocation and the Risk management cycle

The asset allocation needs to be embedded in an integrated risk management framework.




*Asset allocation and ALM are just two of the several dimensions under consideration in each step.*

*Solvency II requirement scan be mapped to each component of the risk management cycle.*

# Asset allocation and the Risk management cycle (2)

**Besides quantitative techniques, operational, strategic and business risks have to be considered as well. Some illustrative examples of potential loopholes in the risk management framework are :**

## ❑ Liquidity risk

The Traditional quantitative frameworks consider that all assets can be sold immediately which may not be the case in distressed market.

From ALM life insurance perspective, liquidity risk is important since in some cases the local regulation or the contractual clauses allow the policyholders to require the immediate payment of liability cash flows.

The traditional tools need to be complemented by stress and reverse stress scenarios in order to avoid an erroneous view on the risk-reward asset balance.

## ❑ Model risk

In general, tail correlations are key for the assessment of the capital need. Tail correlations between various risk factors (not necessarily only related to the market risk) can be easily under estimated.

A classic illustrative example is a pandemic scenario combining the following effects:

- equity market drop, widening spread motivated by fears about the long term economy trends,
- payments of death and disability benefits and/or payment of medical expenses,
- issue with the employees' availability leading to operational losses.

Another example is not modeled future guarantee resulting in under-priced products and an erroneous view of the risk taking capacity on the asset side.

# Definition of ALM in the insurance sector

- **Various definitions of ALM in the insurance field are available:**

*INTERNATIONAL ASSOCIATION OF INSURANCE SUPERVISORS [see 7]*

*"Asset-liability management (ALM) is the practice of managing a business so that decisions and actions taken with respect to assets and liabilities are* ***coordinated.*** *ALM can be defined as the ongoing process of* ***formulating, implementing, monitoring and revising strategies*** *related to assets and liabilities to achieve an organisation's* ***financial objectives****, given the organisation's* ***risk tolerances and other constraints".***

*From [see 8 ] "Asset & liability Management (ALM) is the practice of managing an insurer so that* ***actions taken with respect to assets and liabilities*** *are* ***designed to address the broad set of financial risks inherent in their joint behaviour.***

- **The key concepts are highlighted. The "ERM" logic is visible.**

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# L'origine des passifs d'assurance

**Les passifs d'assurance (la valorisation de l'engagement net de l'assureur**

**vis-à-vis de l'assuré)**

**naissent**

**des GARANTIES et OPTIONS du CONTRAT d'assurance**

**La connaissance des contrats est PRIMORDIALE, INDISPENSABLE et (quasi) PREALABLE à l'ALM.**

# Life insurance : the nature of the financial guarantees

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- The “market consistent” valuation approach is a common tool in Life insurance.
- In fact, various guarantees sold to the policyholders represent financial options. For example (French Life Insurance market) :
  - Minimum guaranteed rate (MGR, “Taux minimum garanti”)
  - Contractual profit sharing (« Participation aux bénéfices (PB) contractuelle »)
  - Regulatory minimalprofit sharing (« Participation aux bénéfices minimale »)
  - Lapse/surrender features (partial/ total)
  - The right to invest additional premiums
  - Switching option (« Droit d’arbitrage entre support Euro et support UC des contrats multisupport ») between the Euro and the UL support in the so called « multisupport » products
  - Option of future conversion into annuity
  - Death guarantee for Unit- linked contracts , or more generally all GM*B

**These guarantees represent financial *« options »* :**

**The policyholder has the right but not the obligation to surrender, switch, invest an additional premium and so on..**

- In addition, the liabilities of the standard “French” saving products depend on the discretionary bonus policy (“taux servi”, above the regulatory & contractual profit sharing). The insurer’s bonus policy depends on the competitive pressure which is particularly difficult to model.

# Life insurance : the nature of the financial guarantees (2)

- Most of the traditional European life contracts offer a combination of Minimum Guaranteed rates and some kind of profit sharing.

- In addition, various complex GM *B guarantees are offered through UL products on different markets (US, Japan, some developments in Europe):

  - Guaranteed Minimum Death Benefit (GMDB)
  - Guaranteed Minimum Accumulation Benefit (GMAB)
  - Guaranteed Minimum Withdrawal Benefit (GMWB)
  - Guaranteed Minimum Income Benefit (GMIB)

- GM*B are not common on the French market where saving “multisupport” products and retirements products (e.g. “Madelin”) are sold. Floor death guarantees for Unit-linked are common (“garantie plancher en cas de décès”).

# Life insurance guarantees (1) :illustrative examples

- **Minimum guaranteed rate (« Taux minimum garanti » )**

- **0% net guaranteed in the recent products:**

  *« Les versement en euro font l'objet d'une garantie…*

**This guarantee is also required by « Code des assurances ». Note that even such low guarantees induce a cost for the insurer in a low interest rate environment.**

- **Lapses ("rachat") :**

  ***«*** *Vous pouvez à tout moment demander le rachat total de votre contrat et recevoir la valeur de rachat de votre contrat. La valeur de rachat de votre contrat est égale à la valeur atteinte sur le contrat, telle que définie à l'article « Calcul des prestations », diminuée des avances consenties (principal et intérêts) et non remboursées ainsi que des éventuelles primes restant dues »*

- **Profit- Sharing**

  *« Le taux de participation aux bénéfices effectivement attribué au titre de l'exercice précédent est égal à 85 % du rendement net réalisé dans le fonds en euros diminué des frais de gestion, il ne peut être inférieur au taux minimum annoncé en début d'année »*

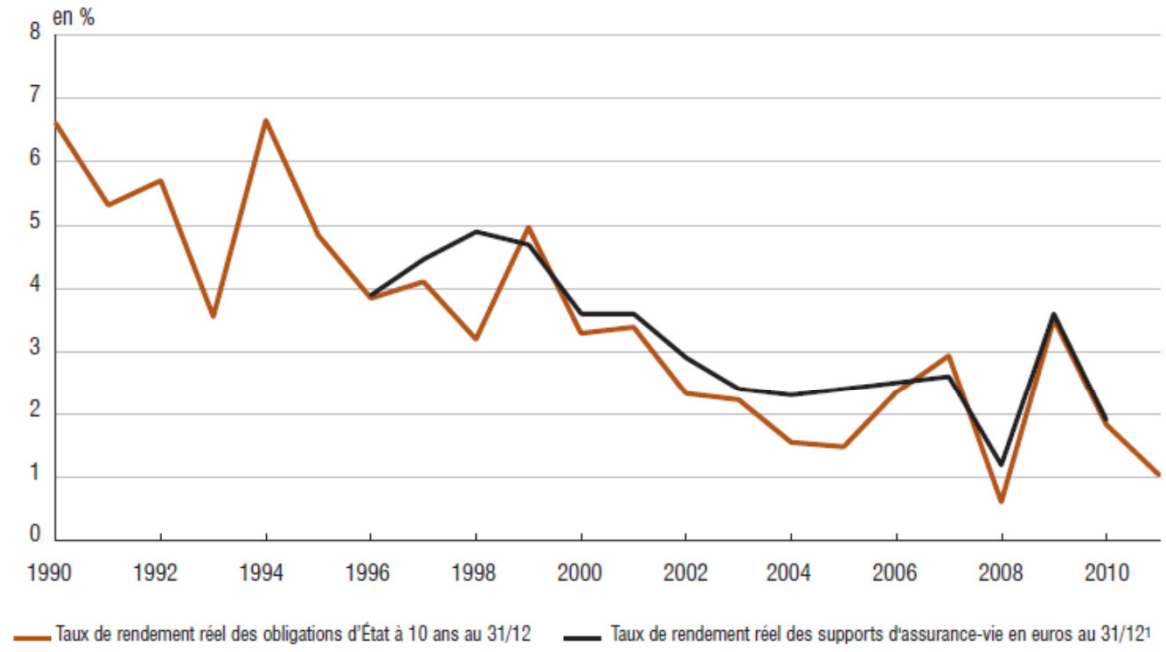
- **Optional flexible premiums :** *« Les versements libres sont possibles à tout moment »*

- **Optional future conversion into annuity**

# Life insurance guarantees : past developments

- In addition to the regulatory and the contractual profit sharing, the French insurance companies can serve a discretionary (or « commercial ») rate.
- This implicit option is correlated to interest rates and in combination with the potential lapses represents also a financial option.

2. Rendement réel des obligations d'État à 10 ans et des supports d'assurance-vie en euros




1. Les données de rendement des assurances-vie ne sont pas disponibles pour l'année 2011.
Champ : France.
*Sources : Caisse des dépôts et consignation et Banque de France. Autorités de contrôle des assurances et des mutuelles (Acam) et Fédération française des assurances (FFSA).*

# The nature of “non hedgeable” guarantees : life and non life business

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- In the beginning, the insurance has been focused on the following risk drivers :
  - mortality (death capital), longevity (annuities)
  - disability risk (morbidity) and medical expenses
  - non life risks (eg fire, motor , third party liability etc.. etc…,

- These risk are “**non hedgeable**” in the sense that there is no deep and liquid market (although there are some mortality and longevity bonds traded).

- As a consequence, we can not rely on the risk-neutral valuation approach.

- In this case, the liability are valued through an indirect approach : Cost of capital.

- The capital amount is based on the capital required for the given lines of business (i.e. under Solvency II it corresponds to the SCR w/o the hedgeable market risk).

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# FR GAAP vs bilan économique

- La logique du FR GAAP est une logique de valorisation basée essentiellement sur le coût historique et la **prudence** comptable.

- A fur et à mesure du développement de la norme, des éléments correctifs (exemple: « Provision pour risques d'exigibilité, PRE) ont été ajoutés, visant à rendre la norme à la fois plus « économique » **et prudentielle**.

- Néanmoins, la logique rétrospective du FR GAAP reste assez différente d'une **approche économique prospective de valorisation (et notamment de celle de Solvency II : introduction d'une notion de valeur de marché ou Market Consisten Valuation)**.

- Pourquoi étudier les règles FR GAAP dans le cadre de la gestion actif-passif ?:

  - Pour certaines sociétés, le FR GAAP reste une contrainte managériale et doit être intégrée.
  - En assurance vie, les règles de participation aux bénéfices contractuelles ou réglementaires sont basées sur un résultat financier et/ou technique issus FR GAAP. Dès lors, ces règles ont un impact sur le Best Estimate.
  - Le résultat fiscal est très proche du résultat FR GAAP, l'impôt est une composante importante dans la valorisation des fonds propres.
  - Car le bilan French Gaap est le point de départ incontournable et de référence à déformer pour construire un bilan économique : **connu et habituel pour tout le monde (management, régulateur).**

Voir [9] pour plus de détails sur le lient entre gestion actif-passif et provisions FR GAAP.

# FR GAAP vs bilan économique

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***Pour plus de détails, se référer aux rappels présentés en cours***

❑Valorisation des actifs :

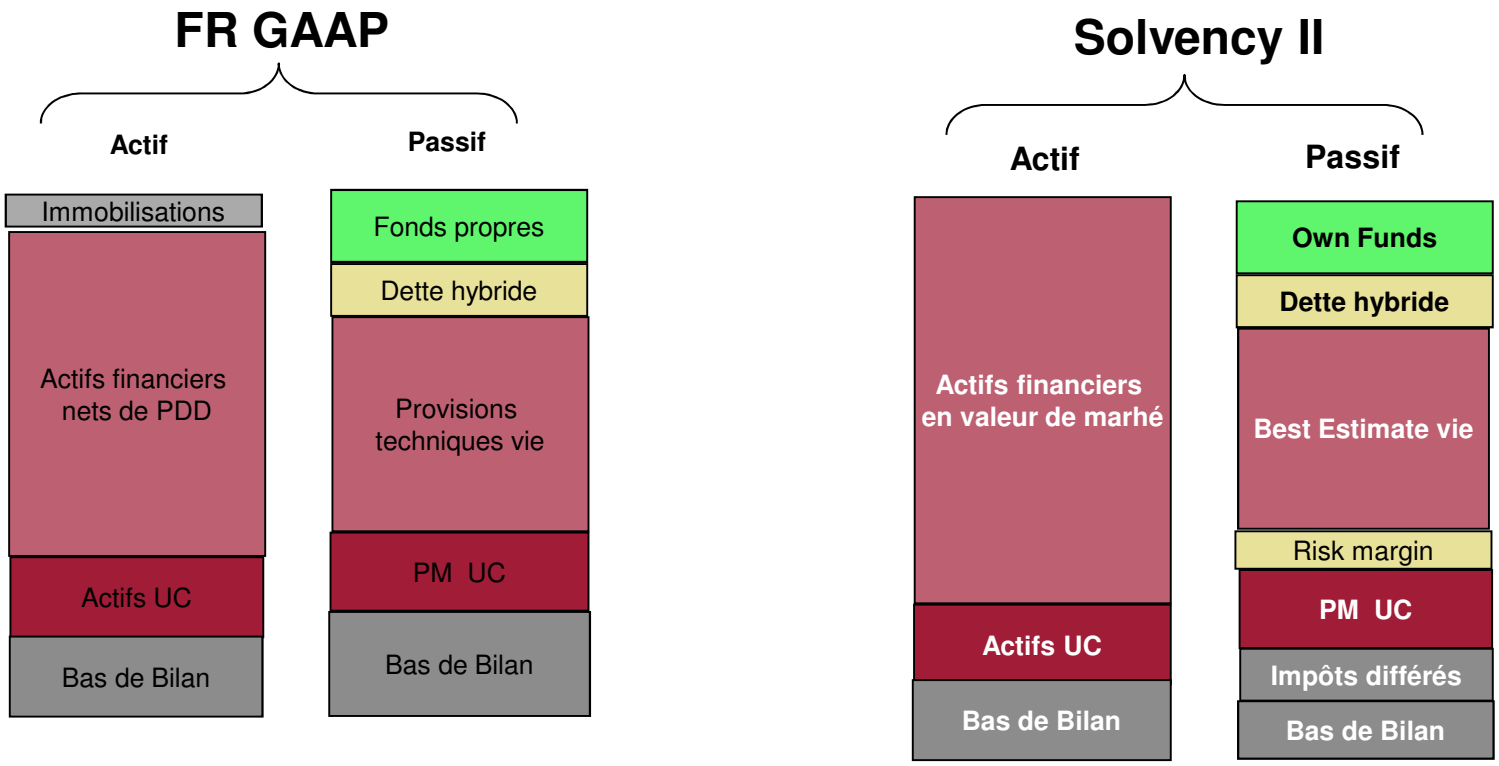
- Amortissement surcote/décote pour la plupart des obligations
- Action et OPCVM au coût historique (mais règles de PDD et PRE, voir ci-dessous)
- Etc…

❑ Valorisation des passifs (voir ci-dessous)

# FR GAAP vs bilan économique en assurance vie

*Pour plus de détails, se référer aux rappels présentés en cours*

*Pour le lien avec le bilan IFRS, voir le cours [35]*



# FR GAAP : La Provision Mathématique (PM)

- Inscription dans les comptes d'une évaluation des engagements contractés par les assureurs envers les assurés.

- En vie, le poste PM représente environ 90% du passif. Différents principes de valorisation sont appliqués selon la nature des provisions :

  - *Principe comptable* **: les engagements sont évalués avec une table réglementaire et actualisés au taux défini à la souscription**
  - *Principe coût historique* **: les engagements sont comptabilisés à leur coût historique**
  - *Principe économique* **: les engagements sont évalués avec une table d'expérience et actualisés avec un taux d'intérêt.**

- Des provisions spécifiques existent si les taux descendent en dessous du taux d'actualisation à la souscription.

- Pour les Unités de comptes, les engagements sont comptabilisés à la valeur de marché des placements en représentation. Mais des provisions complémentaires peuvent être constituées en cas de garantie plancher.

# La Provision pour Sinistre à Payer : PSAP

- La PSAP constitue le pendant de la PM en Vie et représente, dans le bilan d'un assureur non-vie, plus de la moitié du passif.

- La PSAP correspond à la valeur estimative des dépenses, tant internes qu'externes, nécessaires au règlement des au règlement de tous les sinistres survenus et non payés.

- En FR GAAP, elle doit être calculée de façon prudente.

- L'entreprise peut choisir une méthode dossier à dossier (évaluation par le gestionnaire du montant restant à payer et estimation de la charge de tardifs) ou des méthodes statistiques (fondées sur l'évolution historique de la sinistralité par branche d'activité) pour évaluer la provision.

# La Provision pour Participation aux Excédents

- Via les clauses de participation aux bénéfices, les compagnies s'engagent à reverser une part des bénéfices qu'elles réalisent chaque année.

- Les compagnies peuvent décider de différer dans le temps (sur 8 ans), le versement de ces bénéfices attribués aux assurés et d'en lisser la distribution.

- Elles peuvent ainsi doter la PPE.

- Il s'agit donc d'une réserve de lissage qui permet de piloter la façon dont la compagnie souhaite distribuer les produits financiers qui appartiennent aux assurés sur plusieurs années.

- Les reprises de réserve ne peuvent être utilisées que pour verser une rémunération au-delà du taux minimum garanti des contrats.

**Buffer important économiquement : valorisation des fonds propres, sensibilité des fonds propres aux facteurs**

# La Réserve de Capitalisation

- L'objectif de cette provision est d'empêcher les entreprises d'extérioriser et de distribuer les plus-values obligataires en bas de cycle des taux d'intérêt et d'appauvrir en termes de rendement comptable le stock.

- Réserve de lissage, elle vise donc à amortir les effets de mouvements de taux d'intérêt et favorise une gestion Buy & Hold.

- En cas de cession d'un titre dans un contexte de baisse des taux, la réserve est dotée à hauteur de la plus-value réalisée. Dans le cas inverse c'est une reprise de réserve qui vient compenser la moins-value (dans la limite de la réserve).

- Depuis 2010, un impôt est applicable aux plus ou moins-values obligataires et donc s'applique avant dotation/reprise de la réserve.

**Buffer important économiquement : valorisation des fonds propres, sensibilité des fonds propres aux facteurs**

# La Provision pour risque d'exigibilité : PRE

- Cette provision technique a pour fonction de permettre à l'entreprise de faire face à ses engagements en cas de moins-value latente des actifs non amortissables.

- Elle est calculée de façon globale sur la poche des actifs classés en R332-20 (actions, fonds, etc…).

- La moins-value globale de la poche est provisionnée.

- Un amortissement du provisionnement est possible : par tiers ou depuis 2009 sur une durée, de maximum 8 ans, égale à la duration du passif.

- La valorisation en coût historique de l'actif est respectée puisque la valorisation des titres à l'actif de change pas.

**Mécanisme procyclique fort: valorisation des fonds propres, sensibilité des fonds propres aux facteurs**

# La Provision pour risque de Dépréciation Durable : PDD

- Contrairement à la PRE, cette provision est une provision financière (comptabilisée à l'actif, en déduction de la valeur comptable).

- La PDD se calcule ligne à ligne.

- Elle a pour but de venir compenser un risque de ne pas recouvrer une moins-value durable sur un titre constatée depuis une période prolongée ou de provisionner un risque de défaut avéré sur un titre obligataire.

- L'écart entre la valeur de réalisation et la valeur de recouvrabilité doit être provisionné.

- Les seuils généralement utilisés sont une baisse de –X% constatée depuis plus de Y mois.

# La Provision pour Aléa Financier : PAF

- La PAF a pour but de compenser une baisse du taux de rendement de l'actif.

- Constituée dès lors que le montant total des intérêts techniques et du montant minimum de participations aux bénéfices rapporté aux PM est supérieur à 80% du taux de rendement de l'actif.

- L e montant de la provision est alors égal à la différence entre les PM de l'inventaire et les PM recalculées avec un taux d'actualisation égal à 80% du taux de rendement comptable des actifs.

- Pour mémoire, le taux de rendement comptable de actifs correspond au rapport des produits nets comptables des placements augmentés des plus-values comptables sur cession, nettes de moins-values, nettes d'amortissement sur le montant moyen des placements.

- La PAF constitue une marge de prudence, mais elle n'est pas prospective.

# La Provision Globale de Gestion : PGG

- La PGG vise à compenser une mauvaise tarification des contrats et garantir la capacité de l'assureur à gérer les contrats.

- Elle est dotée à hauteur de l'ensemble des charges futures non couvertes par des chargements sur primes ou par des prélèvements sur contrats.

- Elle se calcule de façon prospective via la projection de comptes de résultat. Les marges négatives sont ensuite actualisée avec un taux prudent.

# La provision pour Garantie Plancher

❑Les contrats en Unités de Compte (UC) peuvent comporter des garanties en cas de décès ou en cas de vie consistant à garantir un montant minimum du capital au bénéficiaire.

❑Hors les UC sont comptabilisés à la valeur de marché des supports en représentations.

❑Une provision doit être constituée afin de s'assurer que l'assureur sera en mesure de délivrer les garanties offertes, même en situation adverse des marchés financiers.

Deux méthodes sont envisageables :

- une méthode déterministe : provisionnement des capitaux sous risque
- une méthode stochastique, dite « méthode des puts » correspondant à de l'évaluation d'option

# Lien avec Solvabilité II

- La comptabilisation au coût historique dans le bilan FR GAAP conduit à la mise en place de provisions venant **compenser les limites de la méthode : sous-tarification, risques de marché durable, etc** …

- Les méthodes de provisionnement sont le plus souvent déterministes.

- Solvency II introduit la notion de valeur de marché à l'actif et de Best estimate+ Risk margin au passif.

- En conséquence, dans un bilan Solvency II, tous les postes « provisions techniques » disparaissent pour laisser place au Best Estimate (BE).

- Le BE correspond à l'estimation des flux de trésoreries futurs des contrats d'assurance (primes périodiques, sinistres, intérêts et PB versés, frais) pondérés par leur probabilité d'occurrence et actualisés, et donc couvre le champ de chaque provision existant jusqu'à présent.

- L'assureur va désormais se placer dans un **environnement prospectif**, le plus souvent stochastique, afin d'afficher au bilan une vision **économiqu**e des ses engagements selon les paramètres préconisés par Solvency II (e.g. courbe d'actualisation, reconnaissance des primes futures selon le principe de « time boundary »).

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# Basic traditional techniques

**As discussed previously, one of the key ALM objectives is the adequacy between the assets and the liabilities.**

## Traditional approach : Deterministic scenario

A traditional ALM tool consist in performing a single deterministic scenario and analyzing the asset and liability cash-flows. The scenarios are essentially used in order to assess/manage the interest rate risk.

In this context, 2 useful tools based on the expected cash flows under “base” or stressed scenario are :

- **Liquidity gap**
- **Duration gap**

Although the stochastic techniques are widely used in Life business, the deterministic scenario analysis is still a valuable tool in the following cases:

- Communication tool for the decision makers
- Non life business
- Stress-scenarios and reverse scenarios analysis in order to complement the Economic capital calculations (VaR 99.5%, ES 99%), see later.

# Basic tools : duration (1)

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## Duration ("modified duration") (see [3] for details) :

Duration is a simple tool largely used in asset management, and by extension in ALM (in banking and in insurance sector).
Assume $i$ is the compounded, while $\delta$ is the continuous interest rate; $e^{\delta} = 1 + i$

$$(1) \qquad D(P) = -(1/P)(dP/di) = -d\ln(P)/di$$

Where *P* is the price of the instrument (e.g. a bond).

Note that the definition is very general, and it is valid for cash flow dependent on the interest rate, including or excluding embedded interest rate options, etc. It is also applicable if *P* is valued through stochastic valuation techniques.

For a small $\Delta i$ ; the duration is approximated through : $\left(P(i+\Delta i) - P(i)\right)/P(i)$

For that reason, the duration is often interpreted intuitively as the increase( resp. decrease) of the market price (in bps) following a parallel decrease (increase) of interest rate by 1 bps.

If the change of the interest rates is expressed in bps per year, the unit of the duration is « years ».

See [3],[10] for details.

# Basic tools : duration (2)

SwissLife

## Duration viewed as a weighted average time to maturity :

Assume the cash flows do not depend on the interest rates and interest rate curve is flat.

The present value is given by $P = \sum_{k=1}^{n} CF_k /(1+i)^k$

Therefore, $D(P) = \left( -1/(1+i) \sum_{k=1}^{n} k /(1+i)^k \right) / P$

This duration is called “modified” because of the term $1/(1+i)$ .

Sometimes a “non modified” version is used (i.e. w/o the term above) corresponding to the original concept introduced by Macaulay (1938) :

$$D_{Macaulay}(P) = D(P)(1+i)$$

The Macaulay duration and the modified duration are identical in case of a continuous compounding.

The “weighted average time to maturity” definition cannot be applied straightforwardly to “stochastic” cash flows. As a consequence, in this case the definition (1) is used.

# Basic tools : duration (3)

SwissLife

•For investment instruments (or liabilities) with fixed cash flows, the modified duration can be computed analytically. For example :

- **For 0 coupon bond** : $P = F/(1+i)^n \quad D(P) = n/(1+i) \quad D_{Macaulay}(P) = n$ (intuitive)
- **For a perpetual bond** $P = coupon/i \quad D(P) = 1/i \quad D_{Macaulay}(P) = (1+i)/i$ (it is not infinity)

• The modified duration (resp. Macaulay duration) of a portfolio of assets is given by the weighted average (to the market value) of the modified durations (resp. Macaulay durations) of each asset composing the portfolio :

$$D(P) = \sum_{k=1}^{n} D(P_k) \qquad \omega_k = P_k / \sum_{j=1}^{n} P_j = P_k / P$$

•**Advantages of the duration concept : overall an intuitive tool, easy to implement.**

•**Drawbacks : first order term in the Taylor's expansion, captures adequately a significant part of the interest rate risk only if the instrument is simple (e.g. bonds).**

# Basic tools : convexity (1)

**Definition (Convexity):** $C = (1/\mathrm{P})(\mathrm{d}^2 P / dr^2)$

The convexity is expressed in “periods squared”.

Back to the Taylor's expansion :

$$\Delta \mathrm{P/P} = -\mathrm{D}\,\Delta r + 0.5\,C\,(\Delta r)^2$$

In other words, the duration captures the first order effect and the convexity captures the second order effect regarding the sensitivity of the value to changes in the interest rates.

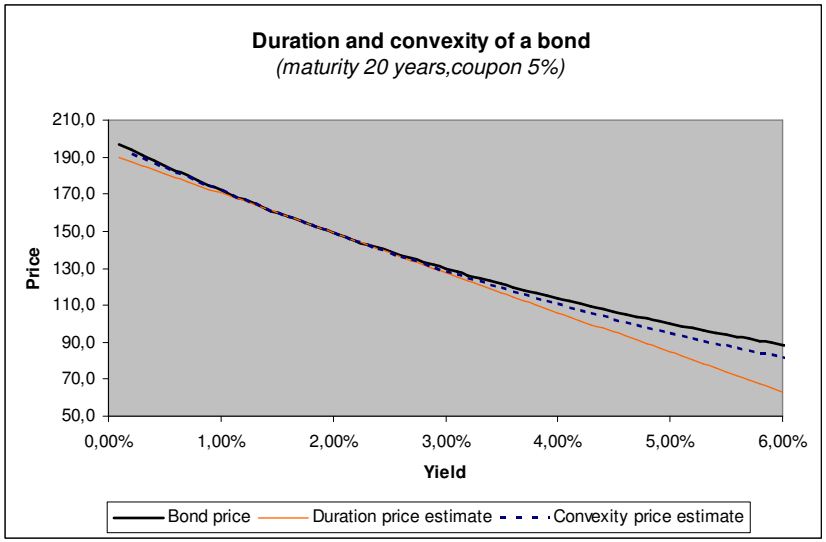
•The convexity of a 0 –coupon bond is $D(P) = n(n+1)/(1+i)$

•The convexity is an important concept in ALM (see next chapters).

See [3],[10] for details.

# Basic tools : convexity (2)

Example : convexity of a bond



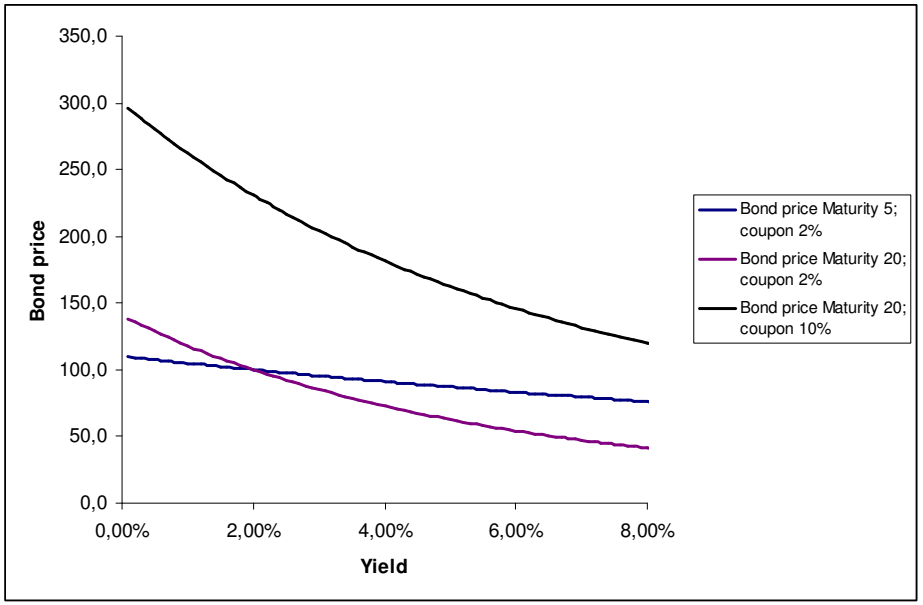

•The inclusion of the convexity (second term of Taylor's expansion) leads to a better estimate of the price sensitivity to the interest rates.

•Later on, we will discuss the liability convexity which is usually larger than the asset convexity.

**Some stylized facts about duration and convexity :**

- ❑ Shorter maturities,
- ❑ Higher coupons,
- ❑ Higher yields,

have a shorter duration and a lower convexity.



# Basic ALM adequacy tools: the duration gap based on a single economic scenario

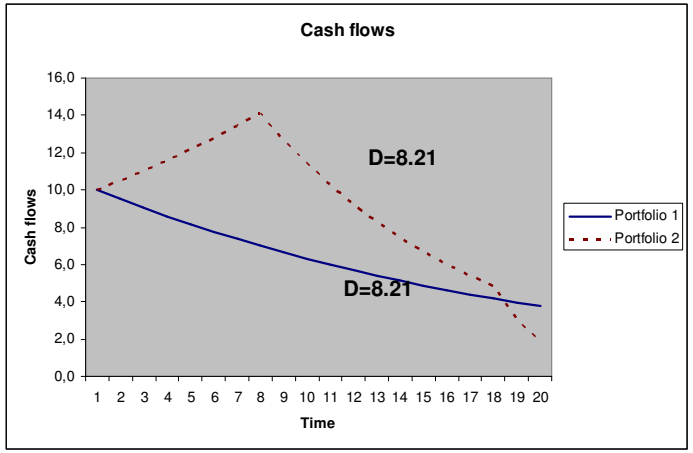
- The duration gap is defined as

*Duration gap= Duration Liability – Duration Asset*

- Similarly to the bond duration, the duration gap measures the 1st order sensitivity of the economic worth.
- Usually a modified duration is applied.
- A "weighted" duration gap is often used because the liability amount does not take into account the shareholders' equity

***Duration gap= Duration Liability *(Market value Liab/Market value Assets – Duration assets)***

- **Key ideas :**
  - A positive duration gap means that the economic worth will decrease if the interest rates decrease and vice versa.
  - The duration gap is only a 1st order proxy of the insurer's interest rate risk. This measure should be considered with caution, especially if derived from a single scenario because of the liability convexity (esp. in life business) and the model uncertainties.
  - A duration gap close to 0 does not imply that the asset and the liability cash flows match perfectly. Two portfolios with exactly the same duration of 8.21 years are shown in this example.



# Les gaps de trésorerie (liquidity gap) (1/2)

- Le rôle du gestionnaire ALM est de s'assurer d'une bonne adéquation des flux issus du portefeuille d'actifs (tombée de coupons, remboursements, dividendes) avec les flux issus du portefeuille des assurés (échéances, rachats, décès, rentes, rentes incapacité-invalidté, paiement de sinistres en non vie).

- Le niveau d'adéquation visé dépendra de l'appétence au risque de l'entreprise.

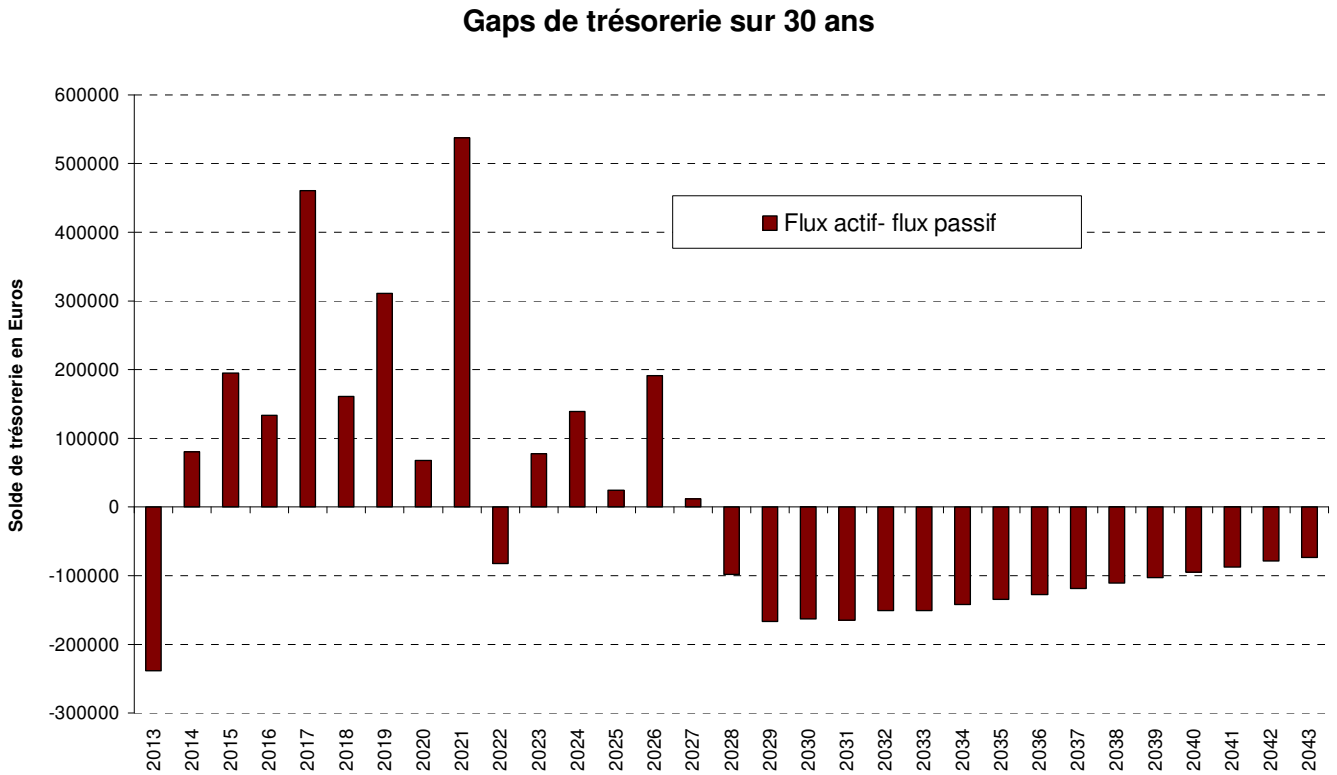
- Les trésoriers appellent « gap de liquidité» la différence entre les flux actifs et passifs pour des intervalles de temps définis. Cette mesure donne une idée sur les risques de liquidité et de taux auxquels une compagnie est exposée.

- La plupart des flux ne sont pas déterministes, il est nécessaire de faire des hypothèses pour étudier les projections des flux (taux de rachats, taus de croissance des dividendes,…). Une fois ces hypothèses fixées, les flux peuvent être projetés et comparés.

- Des stress scénarii de liquidité restent un outil important malgré le développement des techniques de projections stochastiques car celle-ci tiennent modélisent rarement les risques de liquidité.

# Les gaps de trésorerie (liquidity gap) (2/2)

**Exemple théorique**




Ce type d'indicateur permet d'orienter les investissements d'aboutir à un bon adossement des flux et éviter un risque de liquidité.

En revanche, il est nécessaire d'étudier plusieurs scénarii économiques afin de capter les interdépendances.

# Le ratio de financement (1/2)

- Le ratio de financement est défini comme le rapport de l'actif en valeur de marché et de la valeur actuelle des engagements de l'assureur au taux du marché.

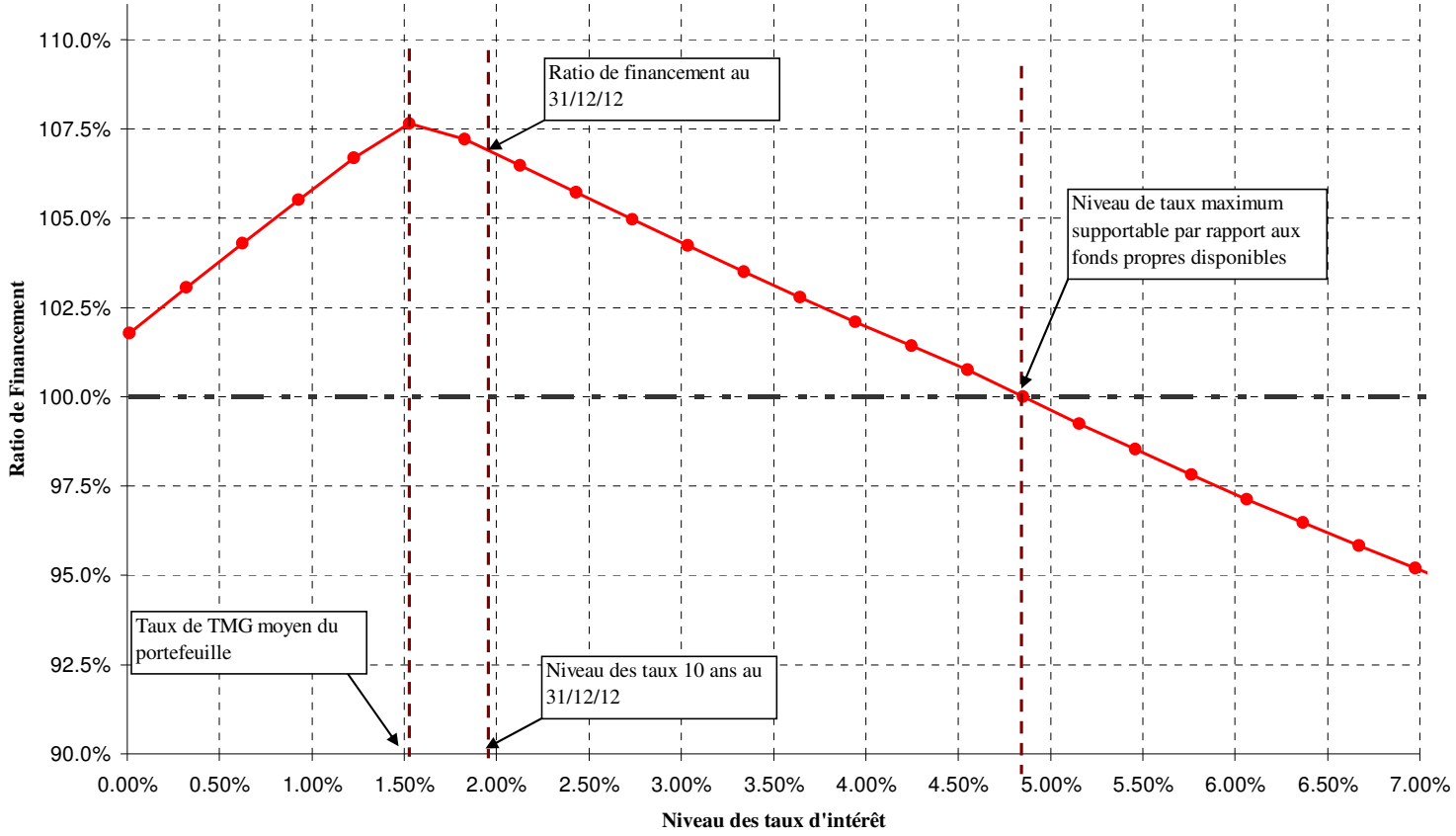
- Le ratio de financement doit être supérieur à 100% (corresponds à des « own funds » au sens de Solvency II positifs).

- Traditionnellement, le ratio de financement à calculé dans un référenciel déterministe.

- Dans une perspective ALM, il est intéressant de mesurer la sensibilité du ratio aux différents facteurs de risques, et notamment aux niveaux des taux.

# Le ratio de financement (2/2)

**Evolution du ratio de financement**
Revalorisation minimale à Max(TMG, Taux marché)




Exemple théorique largement inspiré de [9].

Cet exemple traduit dans une certaine mesure la convexité des passifs (voir chapitres suivants).

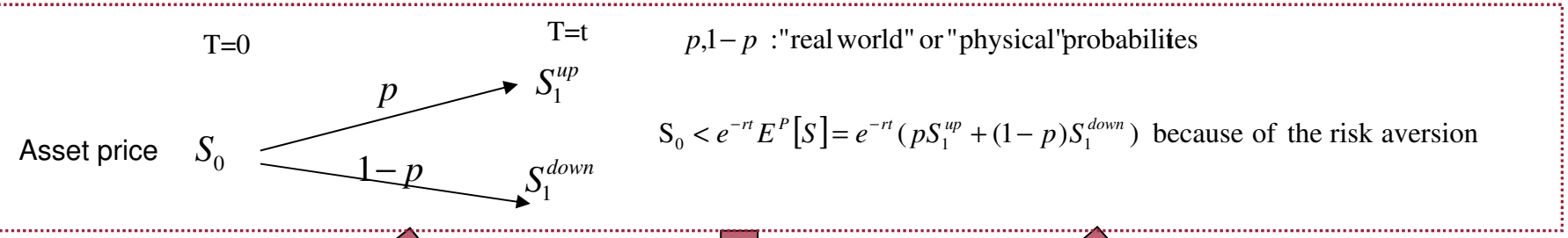
# Plan

- Introduction
- La nature des passifs d'assurance
- Les grands équilibres bilanciels d'une compagnie d'assurance
- Outils « classiques » de la gestion actif-passif
- Valorisation des actifs financiers et des passifs d'assurance

# Recall : « market consistent » valuation principles

SwissLife

- The purpose of this chapter is not to present extensively the “market consistent” valuation and the “risk-neutral” techniques.
- However, these methods play a key role in the assessment of the available economic worth. Therefore, it is crucial to understand the underlying assumptions, the limitations and the areas of applicability. The presentation is based on [10].
- In theory, there are 3 methods to achieve the “market consistency” and to represent the investors’ risk aversion:




**Risk neutral valuation**

Discount at the risk free rate **r** and adapt the probabilities (« risk neutral »)

$$S_0 = e^{-rt} E^Q[S] = e^{-rt}(qS_1^{up} + (1-q)S_1^{down})$$

where Q is the “risk neutral” probability

**Widely used for MCEV purposes and valuation internal models**

**Deflators**

Discount at a state -dependent rates **d**

$$S_0 = e^{-d_{up}t} pS_1^{up} + e^{-d_{down}t}(1-p)S_1^{down}$$

**Active academic research is on-going.**

**Utility functions**

“Measure” the utility of the cash flows :

$$S_0 = e^{-rt} E^P[U(S)]$$

**Only of theoretical interest**

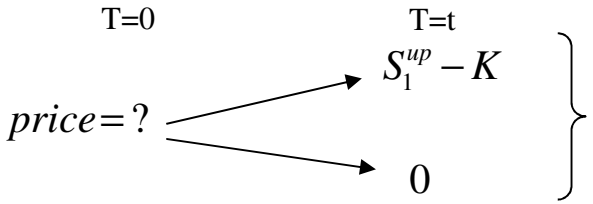
# « Risk neutral » valuation : why does it work ?

SwissLife

**•A fundamental result : under some assumptions, the "risk neutral" valuation (i.e. under probability Q) provides the market value of an option.**

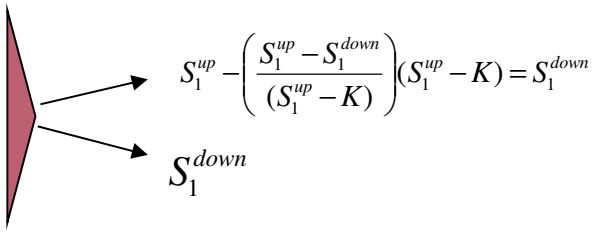
**"No arbitrage" principle**

Consider the following instrument :




**•Let us consider the following portfolio at t=0 :**

- Short of k options, where $k = \frac{S_1^{up} - S_1^{down}}{(S_1^{up} - K)}$ ; Long of 1 underlying asset




- The strategy leads to a deterministic pay-off at t=1.**The return from t=0 to t=1 must be the risk-free rate, because of the "no arbitrage" assumption.**

$$S_0 - k\ price(call) = e^{-rt} S_1^{down} \qquad price(call) = \frac{S_1^{up} - K}{(S_1^{up} - S_1^{down})}(S_0 - e^{-rt} S_1^{down})$$

Let $q = \frac{S_0 e^{rt} - S_1^{down}}{S_1^{up} - S_1^{down}}$ ⇒ $price(call) = q\, e^{-rt}(S_1^{up} - K)$

If $S_1^{up} = uS_0 \quad S_1^{down} = dS_0$ ⇒ $q = \frac{e^{rt} - d}{u - d}$ ⇒ $price(call) = q e^{-rt}(uS_0 - K)$

*Cet exemple n'est qu'un rappel; le cours ISFA « Modèles financiers et analyse de risque dynamique en assurance » fournit une présentation exhaustive du sujet.*

# « Risk neutral » valuation : why does it work (2)

**"Risk neutral" :**

$$S_0 = e^{-rt} E^Q[S] = e^{-rt}(qS_1^{up} + (1-q)S_1^{down})$$

$$S_0 e^{rt} - S_1^{down} = qS_1^{up} - qS_1^{down}$$

$$q = \frac{S_0 e^{rt} - S_1^{down}}{S_1^{up} - S_1^{down}}$$

$$price(call) = e^{-rt} E^Q[CF_t]$$

$$price(call) = e^{-rt}\left[\frac{S_0 - S_1^{down}}{S_1^{up} - S_1^{down}}(S_1^{up} - K) + 0\left(1 - \frac{S_0 - S_1^{down}}{S_1^{up} - S_1^{down}}\right)\right]$$

$$price(call) = e^{-rt}\left[\frac{S_0 - S_1^{down}}{S_1^{up} - S_1^{down}}(S_1^{up} - K)\right]$$

$$price(call) = q\, e^{-rt}(S_1^{up} - K)$$

If $S_1^{up} = uS_0$ $S_1^{down} = dS_0$

$$q = \frac{e^{rt} - d}{u - d}$$

$$price(call) = q e^{-rt}(uS_0 - K)$$

**The price based on the « no arbitrage » approach and the price based on the « risk neutral » valuation approach are identical.**

**Moreover, if there is no arbitrage opportunities and the market is complete, the "risk neutral probability" is unique.**

**Attention : risk –neutral probabilities are relevant only for valuation, not for risk measurement (ES, VaR) (see next chapters).**

**For risk measurement, physical (or "real world") probabilities are relevant.**

# « Risk neutral  valuation » : approche intuitive

SwissLife

• **Le fait qu'une valorisation en probabilité "risque neutre" permet d'obtenir le prix des instruments financiers peut paraître paradoxal.**

• **Or, la valorisation "risque neutre" des garanties du passif est un outil très important en assurance vie, et utilisée dans le cadre de la MCEV et de la construction du bilan SII (voir pages suivantes).**

•**Dès lors, il est important de comprendre intuitivement l'approche afin de pouvoir communiquer au sein de l'entreprise et auprès des décideurs.**

***Les agents économiques sont averses au risque, pourquoi la valorisation sous la probabilité « risque neutre »  permet-elle d'obtenir le prix de marché?***

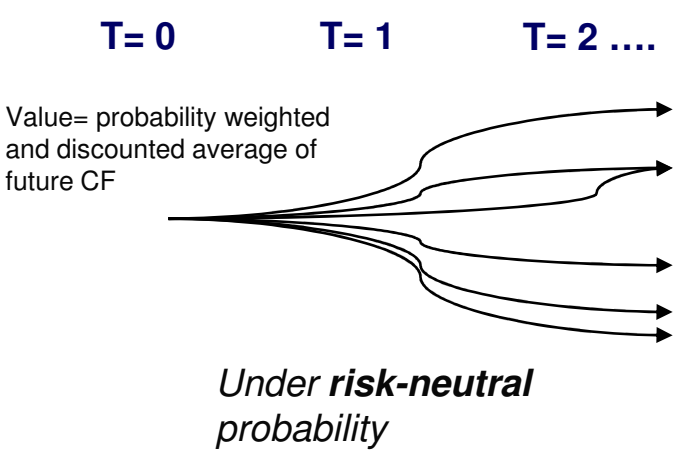
**->** Nous valorisons l'option financière en fonction du prix du sous-jacent (c'est-à-dire en termes « relatifs »).

Par conséquent, l'aversion au risque des agents n'a pas d'importance car elle est déjà intégrée au prix de marché du sous-jacent.

# The well-known « nested simulations » issue

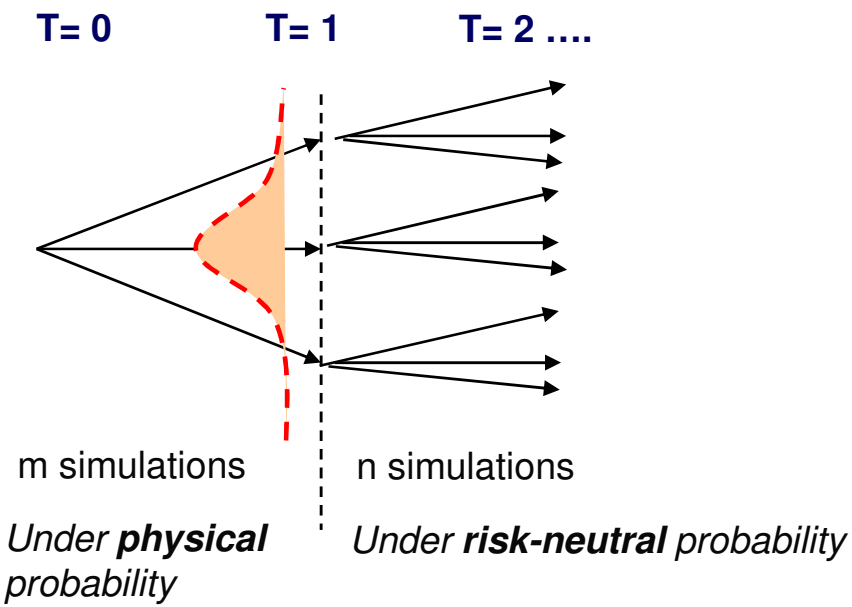
- In contrast to MCEV which deals with the valuation at t=0, the solvency requirements under Solvency II are based on the distribution at t=1 (unless a standard formula is used; in this case the VaR of the distribution at t=1 is approximated through standardized shocks at t=0) .

***Valuation concept (e.g. MCEV)***




*Under **risk-neutral** probability*

***Solvency requirement : based on the distribution at t=1***



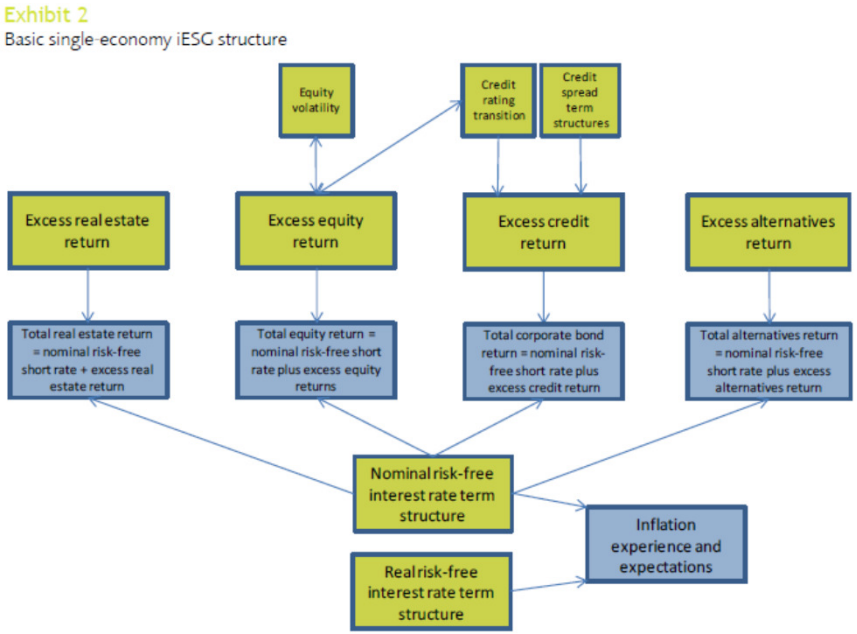

*Under **physical** probability*

*Under **risk-neutral** probability*

# Recall : valuation of liability guarantees : ESG 's

- In Life business, the **complex nature of the liabilities** require a stochastic valuation approach.
- **Therefore**, an ESG (economic scenario generator) is needed. For the purpose of this lecture, we recall some basic principles .
- Overall, the stochastic processes may be inspired by the economic theory, statistical approaches or a mixture.

Example of ESG architecture –example from [11]:




***Voir les liens avec les cours ISFA dans "Bibliographie".***

# Market consistent ESG's: equity

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***Voir les liens avec les cours ISFA dans "Bibliographie".***

Equity returns (see [3], [10])

- Loosely speaking, a Markov process is a process the conditional probability distribution of future states of the process depends only upon the present state,

- In other words, the prices change randomly and independently from the situation at t-1, t-2, because the exogenous data (e.g. news about the economic perspectives) are flowing randomly and are immediately taken into account by all investors.

$$dS_t / S_t = \mu\, dt + \sigma\, dW_t$$

- Lognormal returns (consequence of the geometric Brownian motion assumption) are consistent with this idea.

$$\ln(S_T / S_0) = \phi\left[\left(\mu - \sigma^2/2\right)T,\ \sigma\sqrt{T}\right]$$

- However, there is statistical evidence that equity returns are not always lognormally distributed with constant volatility (example : extreme movements). Consequently, other models have been developed.

# Market consistent ESG's: equity (2)

SwissLife

Introduce stochastic volatility

The basic idea is that markets are exposed to different degree of uncertainty over time. Periods with high uncertainty are leading to high volatility (in our simplistic example, investors are "over reacting " to any good or bad news ) and vice versa.

- GARCH

- Regime-switching (Hardy): eg $S_{(t+1)}/S_t$ is switching between 2 "regimes" of volatility with transitional probabilities p:

$$LogN(\mu_1, \sigma_1^2)(regime\ 1) \underset{p_{(2,1)}}{\overset{p_{(1,2)}}{\rightleftarrows}} LogN(\mu_2, \sigma_2^2)(regime\ 2)$$

- Heston

- Merton

etc…

It is important to keep in mind that for risk measurement purposes, the model quality regarding the tails is key, while for valuation purposes a slightly lower quality might be acceptable.

# Market consistent ESG's: Interest rates (1)

SwissLife

Difference between interest rate and equities stochastic processes

- Because of the basic features of instruments traded (bonds), geometric brownian motion is not appropriate for interest rate modeling.
- In theory, nominal interest* rates are expected to show "mean reversion" at least because :
  - On the long run, interest rate cannot increase boundlessly, because very high interest rates will jeopardize economic activity, resulting ultimately in a decrease of the interest rates.
  - **Despite some phenomena on the very short term, interest rates can not decrease below 0 because the economic agents have the option to withdraw the investment in convert it into paper money.**


Black swan undergoing !

  - On the one hand, nominal interest are linked to the real interest rates (because the central bank tend to control the inflation). On the other hand, the long term Real interest rate depends on the economic growth (and depends ultimately on the technical progress and demographic growth which are limited).

- This theoretical concept is supported **to some extent** by statistical evidence.
- In addition, interest rates have a term structure.
- Given the insurers' typical strategic asset allocation, interest rate modeling is crucial.

*) Basically Nominal interest rates= real interest rates + inflation

# Market consistent ESG's: Interest rates (2)

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**Interest rates : stochastic processes (an overview)**

**Short rate models**

**Forward rate models**

**LIBOR and swap market:**

**Equilibrium -type**

**« No arbitrage » -type**

$$dr_t = a(b - r_t)\,dt + \sigma (r_t)^{\gamma}\, dW_t$$

Mean reversion to b with « speed of adjustment» a.

If γ=0.5 -> **Cox –Ingersoll Ross**, if γ=0 -> **Vasicek**

**Pro's : simple and reflecting basic features**

**Con's : difficulties to match with the observed term structure**

**Other issues (eg negative interest rate with Vasicek possible).**

**Ho Lee:**

$$dr_t = \theta(t)\,dt + \sigma_t\, dW_t$$

**Hull White :**

$$dr(t) = [\theta(t) - a(t)\,r(t)]\,dt + \sigma(t)\,dW_t$$

θ and α constant – the Vasicek model

θ has t dependence – the Hull-White model

θ and α also time-dependent – the extended Vasicek model

**Pro's : easy to match the term structure (actually it is θ(t) : an input of the model). Therefore appropriate for market consistent valuation.**

**Hull- White takes into account mean reverting**

**Con's : In general, no closed formulas …**

Heath-Jarrow-Morton
**(voir cours ISFA)**

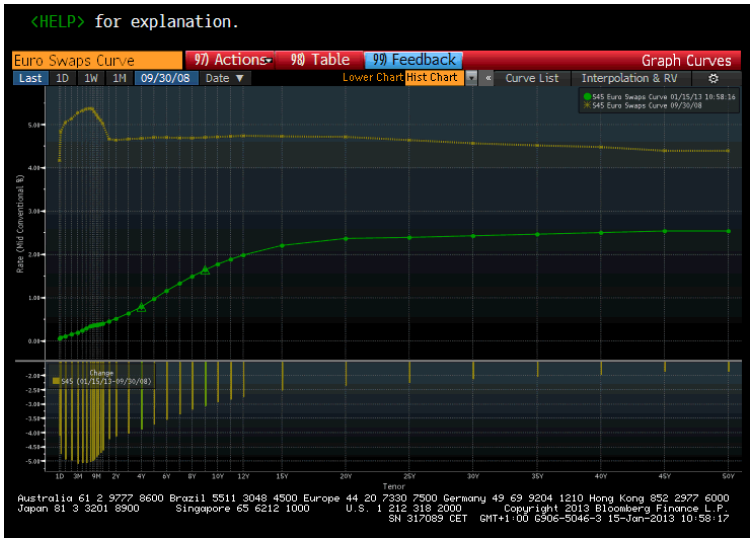
**Voir cours ISFA.**

*)Basically Nominal intrest rates= real interest rates + inflation

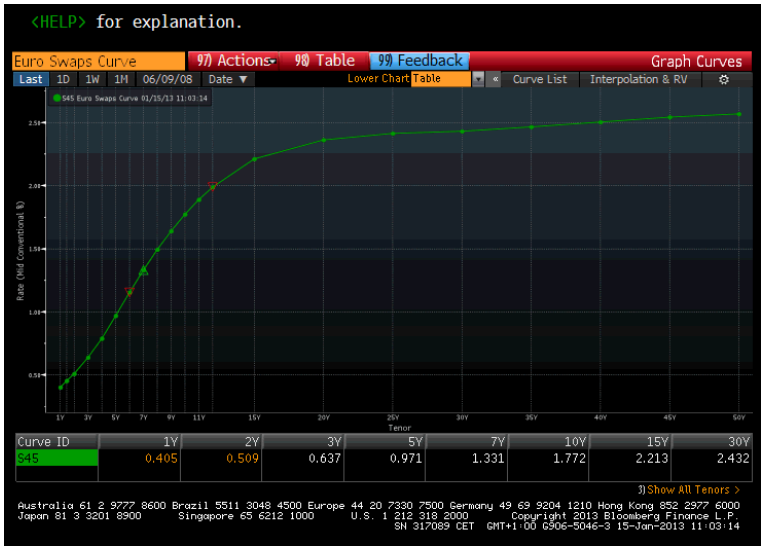
# Zoom to « no arbitrage models » (1)

- **Basic idea :** instead of modeling short rates, start with the initial curve term structure and model the deviations.
- Historical examples of such deviations :

## « Flattening »




## «Steepening »




## «Inverted »


Source : Bloomberg

# Zoom to « no arbitrage models » (2)

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• **The extended 2 factor Black –Karasinski** is widely used in MCEV field :used to model nominal interest rates for both Market Consistent and Real World calibrations. Provides an exact fit to the initial yield curve and short term interest rates are lognormally distributed, therefore the rates are positive.

•The number of factors reflects the number of noise sources. It allows the model to capture more complex behavior of the interest rates.

$$short\ rate\ d\ln(r(t)) = \alpha_1\left(\ln(m(t) - \ln(r(t))\right)dt + \sigma_1 dW_1$$
$$long\ rate\ d\ln(m(t)) = \alpha_1\left(\mu - \ln(m(t))\right)dt + \sigma_2 dW_2$$

$W_1\ et\ W_2$ are 2 independent Brownian motions

It can be shown that the short rate, conditionally on t=0, has a lognormal distribution. **Therefore the short rate is always positive.**


Black swan undergoing !

**Drawbacks :** No closed formulas for 0-coupons bonds. For pricing a binomial tree approach is used.

**Advantages :** Can be used not only for valuation, but also for real-world projection. Asymmetry captured.

•**Note that some companies are switching to the Libor model.**

# Zoom to inflation modelling

SwissLife

- The inflation can be derived from the difference between nominal and real interest rates

$$I(t+1)=I(t)e^{r_{nominal}-0.5(r_{real}(t+1)-r_{real}(t))}$$

- **Real interest rates could be modeled though a 2 factor Vasicek for example :**

$$dr_1(t)=\alpha_1\left(r_2(t)-r_1(t)\right)dt+\sigma_1 dW_1$$
$$dr_2(t)=\alpha_2\left(\mu-r_2(t)\right)dt+\sigma_2 dW_2$$

are 2 independent Brownian motions

**Drawback :** note that with this process negative short rate could occur.

**Advantages :** analytical solution for the price of 0-coupon bond.

# Modeling of interest rates : some practical problems

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- Even though the issue with the negative rates is specific to the Vasicek model, most of the interest rates models can lead to scenarios with extremely high interest rates.

Example :

*Extreme interest rates might leads to numerical issues in the ALM projection engines due to the very low discounting factor.*

*exp(-100%*40 years)= 0.00000000000000000004 and exp(-1000%*40 years) is considered as 0 -> numerical issues in the code.*

- Practical solution for valuation (easy but no necessarily market consistent) : cap the rates to some extreme but still plausible rate (eg 50% or 100% per year).

# Modeling of interest rates : calibration of the volatility

- The implicit volatility is derived from the observed market prices for swaptions

Example as of 31.12.12 (extract from the MCEV report of an insurance company).

5.1.2 VOLATILITY ASSUMPTIONS – Volatility assumptions for the year-end 2011 and 2010 calculations are derived from market data as at 31 December 2011 and 2010.

The interest rate volatilities are based on implied volatilities of at-the-money receiver swaptions. The tenors are 20 years for the euro and the US dollar and 10 years for the Swiss franc.

5.1.2.1 SWAPTION IMPLIED VOLATILITIES AS AT 31 DECEMBER 2011

| Economy | 1 year option | 2 year option | 5 year option | 10 year option | 15 year option | 30 year option |
|---|---|---|---|---|---|---|
| Switzerland | 53.3% | 47.3% | 39.5% | 45.3% | 45.2% | 31.4% |
| Euro Zone | 38.5% | 35.3% | 30.3% | 28.7% | 29.3% | 23.3% |
| United States | 40.2% | 36.9% | 32.2% | 28.4% | 27.4% | 32.8% |

# Spreads

- **Key question**

*Pour plus de détails, se référer aux rappels présentés en cours*

- **Spread risk, Migration risk, Default Risk**

*Voir les liens avec les cours ISFA dans "Bibliographie".*

# Correlations

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*Pour plus de détails, se référer aux rappels présentés en cours*

*Voir les liens avec les cours ISFA dans "Bibliographie".*

- **Key question**
- **Modeling tool : copulas , but difficult to calibrate.**
- **Often a Gaussian copula is used but may not be appropriate….**

# Real estate

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*Pour plus de détails, se référer aux rappels présentés en cours*

- **Usually, a Brownian motion is assumed by default.**

*Voir les liens avec les cours ISFA dans "Bibliographie".*

- **Issues with representing long cycles.**

- **Issues with data, since the markets are not liquid and not comparable.**

# Life insurance : valuation through closed formula

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- In the late nineties, the academic research focused on the valuation of life insurance liabilities through closed formulae.

- This approach require many simplifications, but gives insight into the key life insurance mechanisms.

- For educational reasons, we will briefly discuss one of these papers. Other papers developed further this idea in the nineties (**[18], [19], [20] )**

- At present, insurers apply Monte Carlo techniques (see next chapters).

- The Monte Carlo techniques are also used for MCEV (Market Consistent Embedded Value) computations, the framework which replaced around 2005-2008 the TEV (Traditional Embedded Value).

# Some models with closed formulae : an example

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## Briys and de Varenne (1997) :

**Balance sheet at t=0**

| Assets | | Liabilities and Equity | |
|---|---|---|---|
| Assets | $A_0$ | Equity | $E_0 = (1-\alpha)A_0$ |
| | | Liabilities | $L_0 = \alpha A_0$ |
| **Total** | $A_0$ | | $A_0$ |

$\alpha$ : proportion of initial assets financed by equity

**Liabilities :**

L* : minimum guaranteed liability

$\delta$ : participation coefficient

Cash flows paid at time T (in fact the model is single period).

**•Shareholder's payoff :**

-Insolvent company $\quad E_T = 0 \;\; si \;\; A_T < L_T^*$

-Only the guaranteed rate is paid $\quad E_T = A_T - L_T^* \;\; si \;\; L_T^* \le A_T < \frac{L_T^*}{\alpha}$

-Profit sharing is higher than the guaranteed rate $\quad E_T = (1-\delta\alpha)A_T - (1-\delta)L_T^* \;\; si \;\; \frac{L_T^*}{\alpha} \le A_T$

**The equity and the liability are viewed as contingent claims -> can be solved using option pricing :**

$$E_T = \underbrace{\max[0, A_T - L_T^*]}_{\text{European Call Option}} - \underbrace{\delta\alpha \max\left[0, A_T - \frac{L_T^*}{\alpha}\right]}_{\text{European Call Option}}$$

European Call Option
maturity T
Strike $L_T^*$

**Interpretation :** shareholders have a limited liability in case of default

European Call Option
maturity T
Strike $\frac{L_T^*}{\alpha}$

**Interpretation** :Potential profit sharing

$$L_T = \underbrace{L_T^* P(t,T)}_{\text{Risk free part}} - \underbrace{Put_E(A_T, L_T^*)}_{\text{The SH can default (option)}} + \underbrace{\delta\alpha C_E\left(A_t, \frac{L_T^*}{\alpha}\right)}_{\text{Profit sharing option}}$$

# Illustration with a simplified « saving » product

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- Based on the same idea, let us a very simple product :

A « saving » product (simplified view of a GMAB-like product, lapses not allowed, ..)

- Profit sharing rate=85%, Minimum guaranteed rate=2.5%, Premium=1 000€, Maturity=5 years, risk free rate 5Y=3%
- Asset allocation : 20 % equity, 80% (zero-coupons) « risk free » bonds, maturity 5 years
- Pay-off t=5

$$Pay-off_{t=5} = \text{Premium}(1+2.5\%)^5 + \text{Premium}\max\left(85\%\,\text{Value\_assets}_{t=5} - (1+2.5\%)^5;0\right)$$

$$Pay-off_{t=5} = \underbrace{\text{Premium}\,(1+2.5\%)^5}_{} + \underbrace{\text{Premium}\,\max\left(85\%\,\text{Value\_assets}_{t=5} - (1+2.5\%)^5;0\right)}_{}$$

⇒ **ZCB maturity 5 Y, nominal 1**

⇒ $w_1 = \text{Premium}\,(1+2.5\%)^5$

$$\text{Premium}\max\left(85\%\left(20\%\,S_{t=5} + 80\%\left(1+riskfree\_rate_{5Y}\right)^5\right) - (1+2.5\%)^5;0\right)$$

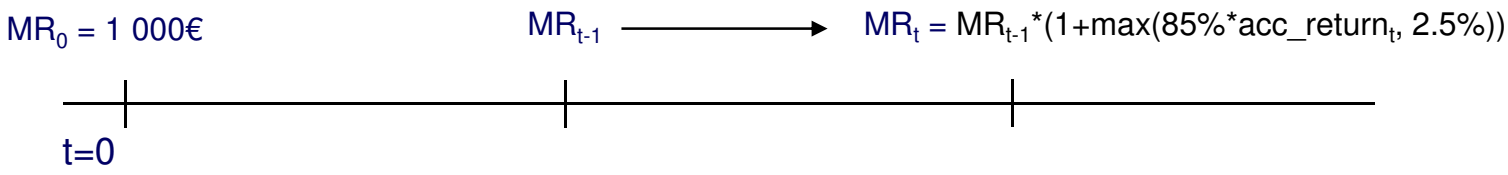
$$85\%\;25\%\;\text{Premium}\max\left(S_{t=5} - \frac{(1+2.5\%)^5 - 85\%\;80\%\left(1+riskfree\_rate_{5Y}\right)^5}{85\%\;20\%};0\right)$$

It is a call with maturity 5 Y, strike =2.14, underlying asset 100% equity

$w_2 = 85\%\;20\%\;\text{Premium}$

# « Path dependency » and the role of the accounting rules

- **In fact, the product described above is not the French « Euro » saving product.**
- The « profit sharing » rules (règle de « PB mini » ou « contractuelle ») introduces a « path dependency ».
- Mathematical reserves (if neglecting the loadings) of a product with a 2.5% minimum guaranteed rate (MGR):




- At the maturity date, and if neglecting the loadings, the PH will receive the Math.reserves at the end of 5Y:

$$MR_5 = MR_0 \prod_{t=1}^{5} (1 + \max(85\% * \text{accounting return}_t, 2.5\%))$$

- Each year, the policyholder benefits from an option on the « accounting return » of the invested assets.
- The « accounting return » is not identical to the economic return and increases the complexity of the model.
- Overall, the role of the French GAAP is significant because the profit sharing rules (regulatory or contractual) are based on the “accounting” French GAAP return.
- **The valuation of this instrument is not possible through closed formulas in all cases…**

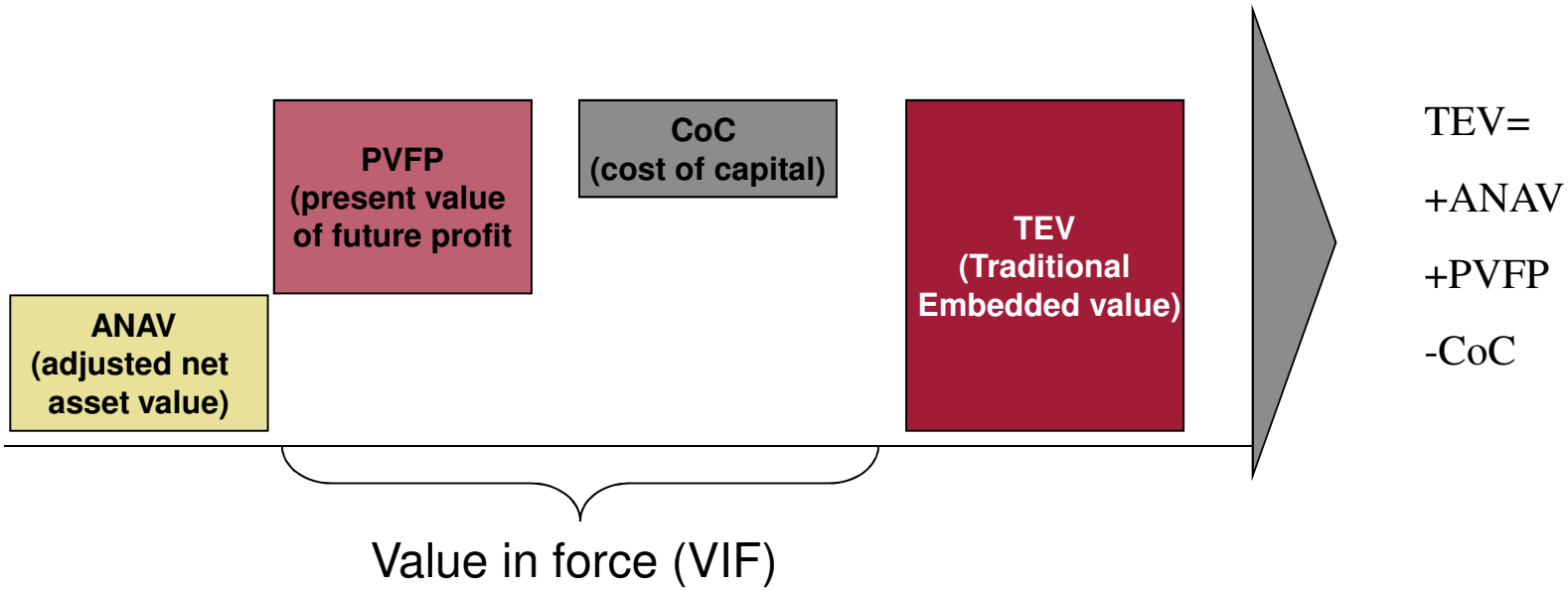
# Liability valuation : TEV (Traditional Embedded Value) approach

•EV measures the value that the shareholders own in an insurance enterprise (ie “consolidated value of the shareholders’ interests in the covered”).

•From the late nineties to 2004/2005, what we call currently the TEV approach (called during this period simply EV) was widely used by Life insurers.

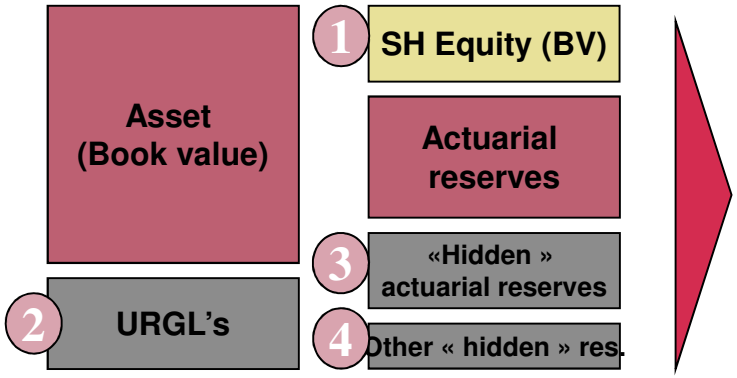
**Main characteristics :**

- New Business is not considered
- “Top-down “ approach : 1 deterministic projection; the cash flows are discounted using interests rates above the risk-free rate
- An explicit “Cost of capital” component



# TEV components : ANAV

**Generic Economic Balance sheet :**




\+ 1

\+ 2 3 4

-Potential profit sharing of 2) 3) 4)

-Elimination of items included in PVFP

-Taxes

**=ANAV**

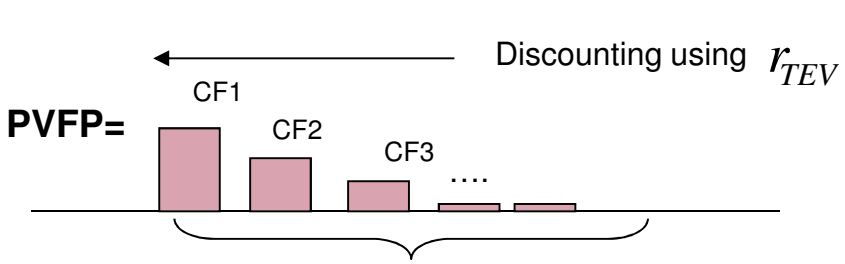
* CFO Forum documents

# TEV components : PVFP

- Valuation based on 1 unique deterministic projection, discounted using an interest rat above the risk free rate :

$$r_{TEV} = r_{riskfree} + beta * riskpremium$$

- The lapse rates are deterministic and do not depend on the market conditions.
- Often, the Asset-Liability interactions are modeled in a simplistic way.
- No explicit assessment of the Cost of Financial options& Guaranties and the Cost of Non Headgeable Risks. (mortality, longevity, lapses, etc.., see next page). These cost ares assessed implicitly through the discounting.




Cash flows (CF's) =
+ Premium
+Interest income
–Benefits
–Increase act.reserves
–Alloc. to participation
–Tax

$$PVFP = \sum_{i=1}^{n} \frac{CF_i}{(1 + r_{TEV})}$$

# TEV components : CoC

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- CoC represent the cost of holding a capital.

$$CoC = \sum_{i=1}^{n} \frac{RqC_{i-1} * (r_{TEV} - r_{riskfree} * (1 - tax))}{(1 + r_{TEV})^{i}}$$

*Difference between the RDR (risk discount rate) and the return of the invested RqC= cost*

*Sometimes, instead of the risk free rate, the expected investment return of assets backing the capital is used.*

where RqC is the amount of required capital assumed at time i.

- Usually, the Solvency I required capital was used as a basis, or alternatively 120 % or 150 % of this amount.

# TEV : main disadvantages

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## RDR (Risk discount rate)

• The risk premium of the RDR represents a compensation for the uncertainty of the future cash flows. Although the concept is theoretically relevant, it raises practical challenges.

• Obviously, the risk premium depends on the underlying risk. As a consequence, it should depend on the company, on the portfolio, even on the LOB (line of business).

• During the TEV-era (from the late nineties to 2005-2008), Life insurers released TEV reports w/o really answering the question how exactly the RDR was derived. In fact, the rate was often based on expert judgment and on the market practice justified by the observed equity premiums.

•In general, the RDR was only adjusted from one year to another for the changes of the risk free rate.

## Projected investment return

•Under TEV, increasing the risk of the asset allocation is leading to a higher expected return and higher TEV, because usually the RDR is not adjusted.

•As a consequence, the underlying valuation of the liabilities is not necessarily “market consistent”.

## Cost of Financial and Non Financial Guarantees

•If the guarantees are not activated within the deterministic projection, the cost is not explicitly captured . The RDR implicitly captures the cost, but in an inaccurate way (see next slide).

# Valuation in Life Business: why a stochastic approach is needed ?

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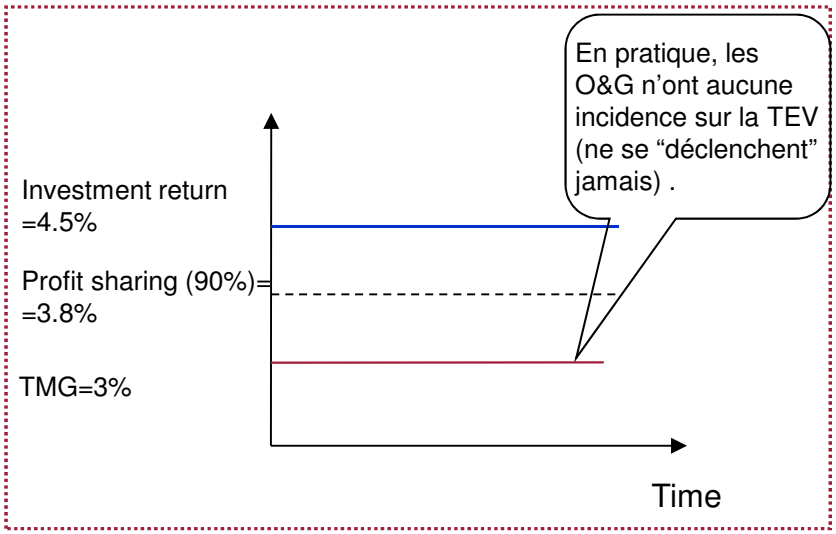
- As already highlighted, life insurers offer various guarantees to the policyholders.

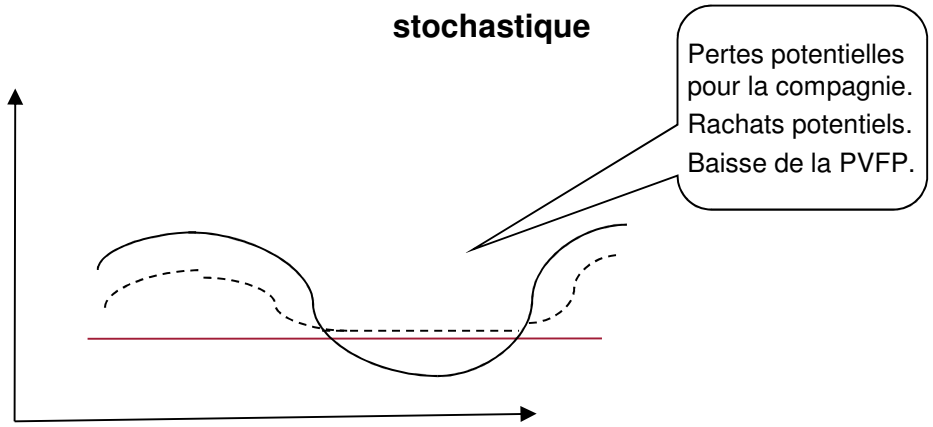
- Most of these guarantees can be analyzed using the tool of the financial theory. These guarantees are asymmetric :
  - the policyholder has the right but not he obligation to surrender or to switch between Euro and UL;
  - he is benefiting from the profit sharing mechanism, if the reinvestment return increases, and form the Minimum Guaranteed rat (MGR) in case of market shock.

- The TEV does not capture adequately the cost, as illustrated below :

**Vision TEV (illustrative)**




**Vision réaliste : nécessité d'un modèle stochastique**



# “Market consistent liability valuation” (1)

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•The market consistent valuation techniques in general, and especially the Monte Carlo computational methods, are relatively recent in the insurance sector.

•Although many decision makers are aware of the principles, it is worth discussing some potential misunderstandings/ erroneous interpretations (for the further details, see [15])

• The MCEV answers one specific question : *« From sharehoders’ point of view, what is the value of the company, including the cost financial options & guarantees on the liability side, given the market prices of the financial instruments observed.».*

•In particular, MCEV does not treat the question of the required economic capital.

• The MCEV approach does not necessarily imply Monte Carlo simulations. As seen previously, for some guarantees a closed formula approach is possible( eg GMAB).

# “Market consistent liability valuation” (2)

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- **The “risk neutral valuation” implies that the average asset** yield of the stochastic scenarios is the risk-free rate. Sometimes, it is suggested that the guarantees (eg. minimum guaranteed rates) have to be “adjusted” (ie lowered).

In fact, the only difference between “real world” and “risk-neutral” valuation is the probability of the different scenarios. The guarantees are identical in the “real” as in the “risk neutral” world (similarly, we do not adjust the strike of the B&S formula).

**A “risk neutral scenario” concept does not exist, only the scenario probabilities are “risk neutral”.**

- It was also argued that MCEV is not consistent with the idea of “mean reverting” diffusion process of the assets.

In reality, the existence of a “mean-reverting” phenomenon does not have any impact on **the valuation** of the liabilities (in contrast with the capital requirements).

One of the key characteristics of a market-consistent valuation is that it reproduces market prices. So, in valuing an equity or equity option, the possible outcomes are weighted by the probability of occurrence and by a discount factor which implicitly reflects investors’ aversion to a loss.

# Simple illustrative example (1)

- Assume a theoretical product with the following cash flow payments under a given scenario i:

$$Liability_{\ i} = Math.res_{\ 0} \prod_{t=1}^{n} (1 + \max(MGR, 1 + 90\% I(t)))$$

*MGR=minimum guaranteed rate*

Assume the loadings cover exactly the internal expenses : both are neglected

We model the investment return as follows : $dI(t) = rdt + \sigma dW_t$

- ***Theoretical liability value under CEV :*** $Liability_{\ CEV} = Math.res_{\ t=0} (1 + 90\% r)^n / (1 + r)^n$

- Assuming that a single premium of 100 is invested at t=0, we perform 10 000 Monte Carlo simulations with r=3%, sigma =4%, n=20.

$$Liability_{\ MCEV} = \left( \sum_{i=1}^{10000} Liability_{\ i} \right) / 10000$$

# Simple illustrative example (2)

Sigma =4% with 90 % profit sharing

| MGR | CEV | TVOG | MCEV |
|---|---|---|---|
| 0,0% | 5,7 | -8,9 | -3,2 |
| 1,0% | 5,7 | -14,6 | -9,0 |
| 2,0% | 5,7 | -22,7 | -17,0 |
| 3,0% | 0,0 | -28,1 | -28,1 |
| 4,0% | -21,3 | -22,3 | -43,6 |

Sigma =3% with 90 % profit sharing

| MGR | CEV | TVOG | MCEV |
|---|---|---|---|
| 0,0% | 5,7 | -4,2 | 1,4 |
| 1,0% | 5,7 | -8,4 | -2,8 |
| 2,0% | 5,7 | -15,1 | -9,5 |
| 3,0% | 0,0 | -19,8 | -19,8 |
| 4,0% | -21,3 | -13,5 | -34,8 |

Sigma =3% w/o profit sharing

| MGR | CEV | TVOG | MCEV |
|---|---|---|---|
| 0,0% | 44,6 | 0,0 | 44,6 |
| 1,0% | 32,4 | 0,0 | 32,5 |
| 2,0% | 17,7 | 0,0 | 17,7 |
| 3,0% | 0,0 | 0,0 | 0,0 |
| 4,0% | -21,3 | 0,0 | -21,3 |

**Some remarks** :

- These simple tests show why a stochastic risk neutral valuation is needed : under CEV, the MGR cost is nil unless r>MGR.
- A 0% guarantee has also a TVOG
- The TVOG arises from the asymmetrical combination of the Minimum guaranteed rate and the Profit-sharing mechanism.
- The higher the asset volatility, the larger the TVOG effect is. It is important to understand that this occurs because we are performing a valuation of guarantees.
- Naturally, this mechanism does not imply the company should not invest in risky assets, but only that we cannot take into account any future performance above the risk free rate before its actual materialization.

# “Market Consistent Embedded Value “ : standard introduced by the CFO Forum

- **CFO Forum :** founded in 2002, with representation from major European insurers.

- Members (as of Feb 2013)


- Developed an unified standard for Life insurance. There is an intermediary version called EEV (European Embedded Value), but this presentation will focus on the latest MCEV guidelines.

- Most recent MCEV guidelines release : October 2009

# MCEV : principles [see 16]

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*Principle 1: Market Consistent Embedded Value (MCEV) is a measure of the consolidated value of shareholders' interests in the covered business. Group Market Consistent Embedded Value (Group MCEV) is a measure of the consolidated value of shareholders' interests in covered and non-covered business.*

*Principle 2: The business covered by the MCEVM should be clearly identified and disclosed.*

*Principle 3: MCEV represents the present value of shareholders' interests in the earnings distributable from assets allocated to the covered business after sufficient allowance for the aggregate risks in the covered business. The allowance for risk should be calibrated to match the market price for risk where reliably observable. The MCEV consists of the following components:*

- *Free surplus allocated to the covered business*
- *Required capital; and*
- *Value of in-force covered business (VIF).*

*The value of future new business is excluded from the MCEV.*

*Principle 4: The free surplus is the market value of any assets allocated to, but not required to support, the in-force covered business at the valuation date.*

*Principle 5: Required capital is the market value of assets, attributed to the covered business over and above that required to back liabilities for covered business, whose distribution to shareholders is restricted.*

# MCEV : principles (2)

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*Principle 6: The value of in-force covered business (VIF) consists of the following components:*

- *Present value of future profits (where profits are post taxation shareholder cash flows from the in-force covered business and the assets backing the associated liabilities) (PVFP)*
- *Time value of financial options and guarantees as defined in Principle 7*
- *Frictional costs of required capital as defined in Principle 8*
- *Cost of residual non hedgeable risks as defined in Principle 9*

*Principle 7: Allowance must be made in the MCEV for the potential impact on future shareholder cash flows of all financial options and guarantees within the in-force covered business. The allowance for the time value of financial options and guarantees must be based on stochastic techniques using methods and assumptions consistent with the underlying embedded value. All projected cash flows should be valued using economic assumptions such that they are valued in line with the price of similar cash flows that are traded in the capital markets.*

*Principle 8: An allowance should be made for the frictional costs of required capital for covered business. The allowance is independent of the allowance for non hedgeable risks.*

*Principle 9: An allowance should be made for the cost of non hedgeable risks not already allowed for in the time value of options and guarantees or the PVFP. This allowance should include the impact of non hedgeable non financial risks and non hedgeable financial risks.An appropriate method of determining the allowance for the cost of residual non hedgeable risks should be applied and sufficient disclosures provided to enable a comparison to a cost of capital methodology.*

*Principle 10: New business is defined as that arising from the sale of new contracts and in some cases increases to existing contracts during the reporting period. The value of new business includes the value of expected renewals on those new contracts and expected future contractual alterations to those new contracts.*
*The MCEV should only reflect in-force business, which excludes future new business. The value of new business should reflect the additional value to shareholders created through the activity of writing new business.*

# MCEV : principles (3)

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*Principle 11: The assessment of appropriate assumptions for future experience should have regard to past, current and expected future experience and to any other relevant data. The assumptions should be best estimate and entity specific rather than being based on the assumptions a market participant would use. Changes in future experience should be allowed for in the VIF when sufficient evidence exists. The assumptions should be actively reviewed.*

*Principle 12: Economic assumptions must be internally consistent and should be determined such that projected cash flows are valued in line with the prices of similar cash flows that are traded on the capital market. No smoothing of market or account balance values or unrealised gains is permitted.*

*Principle 13: VIF should be discounted using discount rates consistent with those that would be used to value such cash flows in the capital markets.*

*Principle 14: The reference rate is a proxy for a risk free rate appropriate to the currency, term and liquidity of the liability cash flows.*

- *Where the liabilities are liquid the reference rate should, wherever possible, be the swap yield curve appropriate to the currency of the cash flows.*
- *Where the liabilities are not liquid the reference rate should be the swap yield curve with the inclusion of a liquidity premium, where appropriate.*

*Principle 15: Stochastic models and the associated parameters should be appropriate for the covered business being valued, internally consistent and, where appropriate, based on the most recent market data. Volatility assumptions should, wherever possible, be based on those implied from derivative prices rather than the historical observed volatilities of the underlying instruments.*

# MCEV : principles (4)

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***Principle 16: For participating business the method must make assumptions about future bonus rates and the determination of profit allocation between policyholders and shareholders. These assumptions should be made on a basis consistent with the projection assumptions, established company practice and local market practice.***

***Principle 17: MCEV results should be disclosed at consolidated group level using a business classification consistent with the primary statements, with clear description of what business is covered by MCEVM and what is not. Except where they are not considered material, compliance with the MCEV Principles is compulsory and should be explicitly disclosed.***

# MCEV : overall perception, financial and sovereign debt crisis 2008-2012

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- In 2006-2007, the financial community welcomed the MCEV was by and considered as a progress in understanding the life insurance business model and the value creation.

- In December 2008, the CFO forum published a press release supporting a review of the interest rate curve and implicit volatilities used because of the turbulent financial markets.

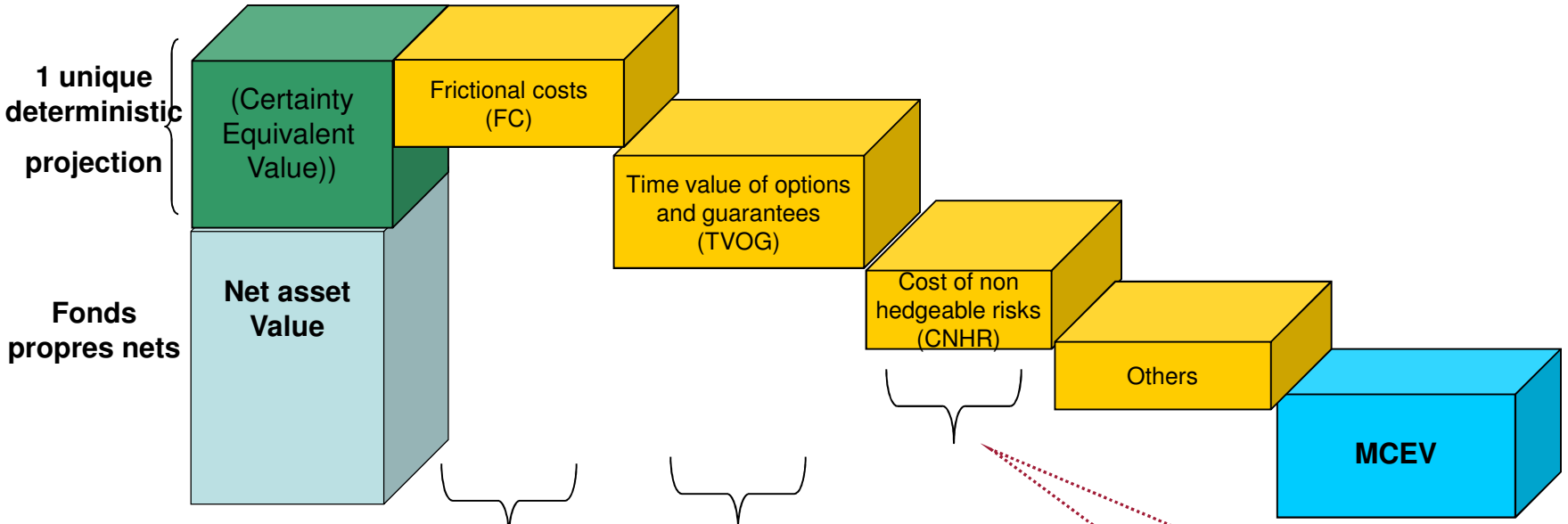
- MCEV as of 31.12.08 released by the insurance companies were hardly comparable. Many companies introduced a liquidity premium and averaged (smoothed) implicit volatilities based on different methodologies.

- In December 2009, the CFO changed the Principle N14, allowing the use of a liquidity premium.

- In addition, there are on -going academic debates on the nature and the rationale of the liquidity premium. Most of the “pro’s and con’s” presented are essentially similar to the arguments regarding the Solvency II CCP (countercyclical premium).

- See [XX].

# Market Consistent Embedded value (MCEV) : components




**« Frictional costs »**

Has a different meaning from the CoC under TEV.

« FC » is only the tax effect on the investment return of assets backing the Shareholder equity and the investment fees. In a world w/o taxes and investment costs, the effect is nil.

**« TVOG »**

Corresponds to the difference between:

- Certainty Equivalent Value (deterministic scenario)
- PVFP

**«CNHR»**

Market consistent approaches value the "financial" O&G (MGR, profit-sharing…).

Other guarantees are « non hedgeable » (e.g. mortality, longevity, deviation of the expense ratio).

The cost of theses guarantees is estimated through a CoC approach.

Le passage consiste à **supprimer la mesure simpliste du coût du risque dans la TEV** (actualisation à un taux > taux sans risque, Cost of capital), pour la remplacer par une mesure plus fine du coût des **O&G financières (TVOG),** tout en tenant compte **des risques démographiques** et des **coûts résiduels (FC).**

# Focus on Life business

The Life Best estimate requires usually a complex valuation model even for companies applying the standard formula.

1

**Economic conditions**

Asset allocation

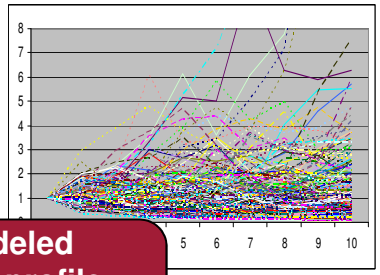
2 **Financial guarantees, profit sharing etc..**

***Cost of O&G***

Lapses, « arbitrage » (switch Euro/UL, conversion into annuity…)

Characteristics of the products (loadings, commissions, financial guarantees, guaranteed rates, insurance risks).

3



**Interactions modeled Valuation and risk profile assessed through stochastic scenarios**

Expenses

4

Biometric risks (mortality, longevity)

5 **Strategic Asset allocation**

Policyholder's behavior

This general scheme is valid for many life saving or retirement products on major European markets.

**The management acts to various extent on 1) 2) 3) 4) and 5) with a "feedback loops".**

**The asset allocation is one of these decision levers.**

As a consequence, the risk-return balance of a given asset class cannot be fully assessed w/o taking into account the overall balance sheet strength and the interdependencies between assets and liabilities.

# MCEV : Value of New Business (1)

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● Although not directly related to ALM,( but important for the ORSA process and the steering of the company, see next chapter), the Value of New Business is an import concept within the MCEV framework.

●Value of New Business (VnB) is defined as follows [ see]:

***Principle 10: New business is defined as that arising from the sale of new contracts and in some cases increases to existing contracts during the reporting period.***

***The value of new business includes the value of expected renewals on those new contracts and expected future contractual alterations to those new contracts.***

***The MCEV should only reflect in-force business, which excludes future new business. The value of new business should reflect the additional value to shareholders created through the activity of writing new business.***

●The *Appraisal value* is defined as :

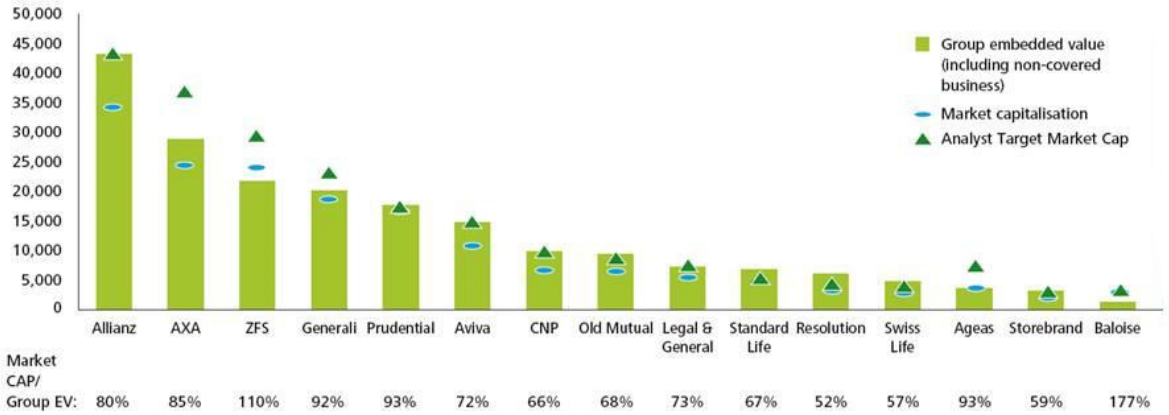
| Appraisal value = MCEV + multiple (eg 3) x VnB |
|---|

The appraisal value is used in corporate finance and M&A deals, the multiple depends on the perception of the potential for future New Business growth.

# MCEV : Appraisal value

**During the crisis, the implicit multiples were low, the market capitalizations were even below the MCEV (as of 31.12.10, Deloitte study, see [17] :**

Group embedded value vs. market capitalisation (£m)




| | Allianz | AXA | ZFS | Generali | Prudential | Aviva | CNP | Old Mutual | Legal & General | Standard Life | Resolution | Swiss Life | Ageas | Storebrand | Baloise |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Market CAP/ Group EV: | 80% | 85% | 110% | 92% | 93% | 72% | 66% | 68% | 73% | 67% | 52% | 57% | 93% | 59% | 177% |

Source: Companies' disclosure and Deloitte analysis

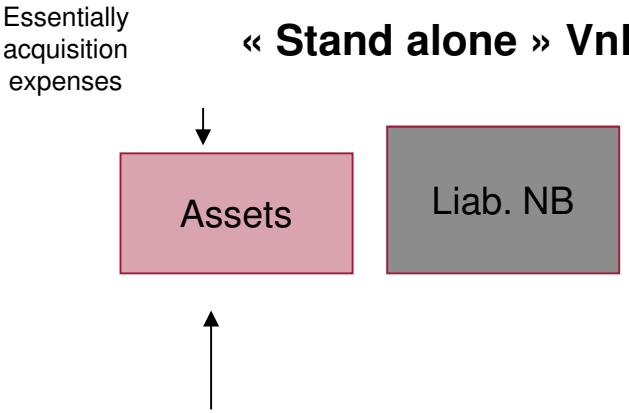
Note:
- Market cap as at 31 December 2010.
- Lloyds Banking Group, KBC (bankassurer), Munich Re (reinsurer) and Groupama (mutual) were excluded from this analysis as their market cap is not directly comparable to embedded value.
- Aviva, Generali, Legal & General, Old Mutual, Prudential, Resolution, Standard Life, Storebrand analyst target based on Thomson Reuters.
- The analyst target for Allianz is based on Commerzbank report, AXA and CNP is based on Societe Generale report, Ageas is based on KBC report, Swiss Life and Baloise is based on Deutsche Bank report and ZFS is based on Collins Stewart report.

# VnB : 2 different theoretical views

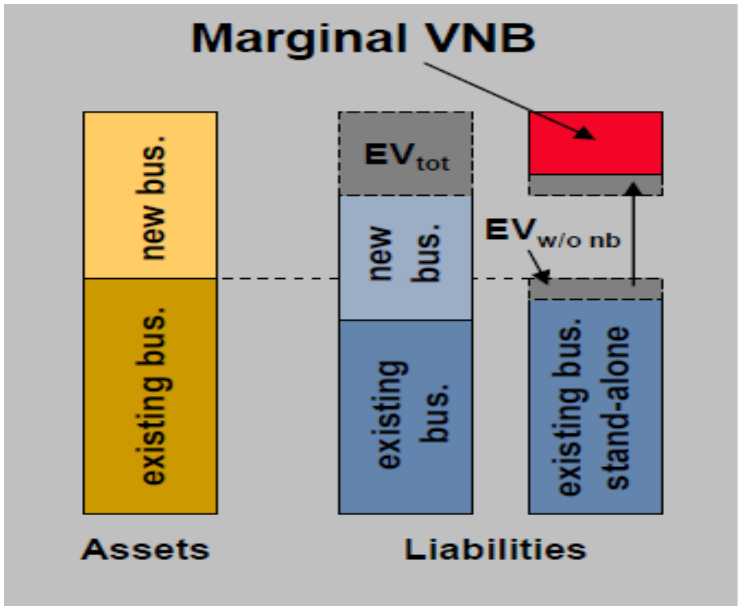
## Answers to different questions :

- **« Stand-alone » approach :** the value of the NB as if the contracts are underwritten by a fictive company with an « empty » balancesheet but with indicators (eg expense rates) are derived from the « going concern » principle.
- **"Marginal" approach** : the change in MCEV induced by the underwriting of the New Business. In practice, it is the difference between 1) a valuation of the stock w/o NB of the year and 2) a valuation with NB.

### « Stand alone » VnB




- Only investment of the NB, no or limited URGLS' (depending on the investment date and the approach ("point of sale" or "end of period")
- All buffers at nil (exemple Fonds de PB, Réserve de capitalisation)



# VnB methodologies : pro's and con's

| | "Stand alone" | "Marginal" |
|---|---|---|
| **Avantages** | • Intuitive<br><br>• Relatively simple from operational point of view (no cross effects between In force business and New Business) | • Usually consistent with the decision taking process (« marginally » regarding a given context).<br><br>• Natural component of the MCEV Movement analysis (also valid for SII own funds). |
| **Drawbacks** | • Might be inappropriate regarding the decision making within a given context (the company's decisions are usually « marginal »).<br><br>•Does not fit the New business step in the Movement analysis : an additional bridge is needed | • Less intuitive, the analysis of the changes for marginal VnB is challenging.<br><br>• Insights into the potential cross- effects between stock and New Business |

# ANNEXES

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SwissLife

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