Impact analysis of the change in bodily injury regulation in Spain

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December 2015

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Contents

Abstract

Keywords:

MTPL, bodily injuries, motor, Spain, Baremo, atypical losses, P&C reinsurance, cost overview, capital requirement

The regulation setting the compensation for motor third party bodily injuries in Spain will change on January 1st, 2016. A significant increase is expected, with important consequences for insurers. In order to anticipate this change for AXA in Spain, we have reviewed different studies aiming at understanding how the new regulation would impact costs, depending on the type of injuries, characteristics of the victims, etc…

After having understood how costs were going to evolve, we have re-assessed historical losses observed by AXA Spain with the new regulation, in order to measure the impact it would have on the result, on reinsurance needs, and on capital requirement.

Résumé

Mots clés :

Responsabilité civile auto, dommage corporels, auto, Espagne, Baremo, pertes atypiques, réassurance non-vie, panorama des coûts, besoin en capital

La réglementation fixant le montant des compensations accordées aux victimes dans le cas de dommages corporels auto en Espagne changera à partir du 1er janvier 2016. On attend un impact significatif, qui aura des conséquences importantes pour les assureurs. Afin d'anticiper ce changement pour AXA en Espagne, nous avons revus différentes études ayant pour but de comprendre comment la nouvelle réglementation impactera les coûts, en fonction du type de dommage, de la nature des victimes, etc…

Après avoir étudié l'évolution attendue des coûts, nous avons ré-estimé le coût que des dommages corporels observés lors des précédentes années chez AXA en Espagne aurait avec la nouvelle réglementation, afin de mesurer l'impact que ce changement aura sur le résultat, les besoins de réassurance, et les besoins en capital.

Executive summary

Keywords:

MTPL, bodily injuries, motor, Spain, Baremo, atypical losses, P&C reinsurance, cost overview, capital requirement

Note:

AXA is a leading multinational insurance company headquartered in Paris, and present in around 60 different countries over the world. It is a multiliner insurer, with significant portfolio in Life and Savings (L&S), Property and Casualty (P&C), Health and International Insurance. In 2014, AXA's gross revenues reached €92bn, of which 32% were P&C revenues. Within P&C revenues, motor is an important activity for AXA, and consequently a significant risk to monitor, due to its potential impact on the volatility of earnings, and on capital requirement.

Motor Third Party Liabilities (MTPL) is a liability insurance, mandatory in mature markets, guaranteeing that the insurer will indemnify the traffic losses, created by the person who caused the traffic accident, to the victim. Thus, MTPL insurance gives the road user assurance that the damage he/she creates will be indemnified and that the person who caused the damage must not indemnify it himself/herself. On the other hand, mandatory MTPL insurance gives the victim confidence that the losses caused to him/her will be indemnified.

Motor third party losses are comprised of:

- Material losses (e.g. damages to a car)
- Bodily injuries: damages to the physically hurt victims

Bodily injuries are an important risk for AXA, as the indemnity paid to victims can be sometimes worth several millions. For this reason, it is important to properly quantify this risk. AXA Global P&C, subsidiary of the Group in charge of piloting non-life insurance for the whole Group, is in charge of monitoring and modeling MTPL risks, notably in the context of its role of reinsurance coordinator for the Group.

In this report, we show first a panorama of the cost of motor bodily injuries claims, in 19 different entities of AXA Group. These 19 entities, representative of the diversity of the Group, can be split in three different groups, according to AXA's classification:

- Mature markets (Belgium, France, Germany, Greece, Italy, Luxembourg, Spain, Switzerland, UK, and AXA Corporate Solutions)
- Central and Eastern Europe entities (Czech Republic, Poland, Slovakia and Ukraine)
- Other emerging markets (Gulf, Hong Kong, Malaysia, Nigeria and Turkey)

Compensations for bodily injuries are function of various parameters, such as the age of the victim, the severity of the injury, the presence or not of relatives, the relationship of dependency between the victim and its relatives, income of the victim, local legislation, etc… In order to compare the level of costs between countries, we study costs for four scenarios aiming at being representative of the diversity of potential situations. Two scenarios involve a 30-year-old man with one surviving spouse and two children. The other two scenarios involve an 8-year-old child, with two surviving parents. For each of the two victims, we consider the case of death, and quadriplegia.

The analysis of costs reveals important discrepancy from one country to another, though a certain homogeneity within each of the three groups considered (mature markets, CEE countries, and other emerging markets).

Looking at the average level of costs between all countries, it can be observed that costs are higher for the quadriplegia scenario vs. the death scenario (for both victims). The less costly scenario is the death of the 8-year-old child, as costs are in this case only moral damages for the parents. The second less costly scenario is then the death of the 30-year-old man, where costs include in addition of moral damages an important part aiming at compensating the level of earnings for surviving members of the family, as the victim is considered as the homemaker of the household. Finally, quadriplegia scenarios have a comparable cost for both the 30-year-old man and the child, but explained by different factors: for the child, costs are primarily driven by future costs of expenses and personal care, while for the man, costs are driven principally by the loss of earnings for the family.

In terms of country groups, it can be observed that mature markets allow for the highest level of compensations, followed by CEE countries and then other emerging markets. Generally, the sophistication of the indemnity calculation increases with the maturity of the country: in mature countries, compensation is calculating frequently by taking into account the future life of surviving members of the family and can be paid as annuity, while in less mature countries compensation are more often a basic amount paid as a lump sum.

We have confirmed this ranking of costs of indemnities by country, by doing an analysis of the correlation between cost of claims versus economic development of the country. To model the economic development, we have as a proxy used the insurance penetration (insurance GWP / GDP), the wealth (GDP per capita) and the human development index (HDI). In all cases, we observe a correlation between costs and development.

This overview of costs allowed us to identify that in Spain, the level of costs is lower than countries comparable in terms of development, notably the part aiming at compensating the future life of victims and relatives (loss of earnings, future costs of personal care and health expenses). A new regulation ("Baremo") will become in force in January 2016 in Spain, with main purpose of offering a more adapted compensation for victims of bodily injuries notably as compared to other European countries.

Through a review of different impact studies produced by Aon, QBE, Swiss Re and AXA Spain, we estimated that the new Baremo will induce an increase in costs of 55% for death, 100% for severe injuries, and 20% for lighter injuries.

In order to estimate the consequences of this increase for AXA Spain (in terms of results, reinsurance needs and capital requirement), we have then modeled the potential amount of costs expected for 2016 with both the current and the new regulation. This modeling was performed using the atypical losses modeling methodology developed by AXA Global P&C and the Group Risk Management.

This methodology uses historical losses observed in the past by AXA Spain to determine:

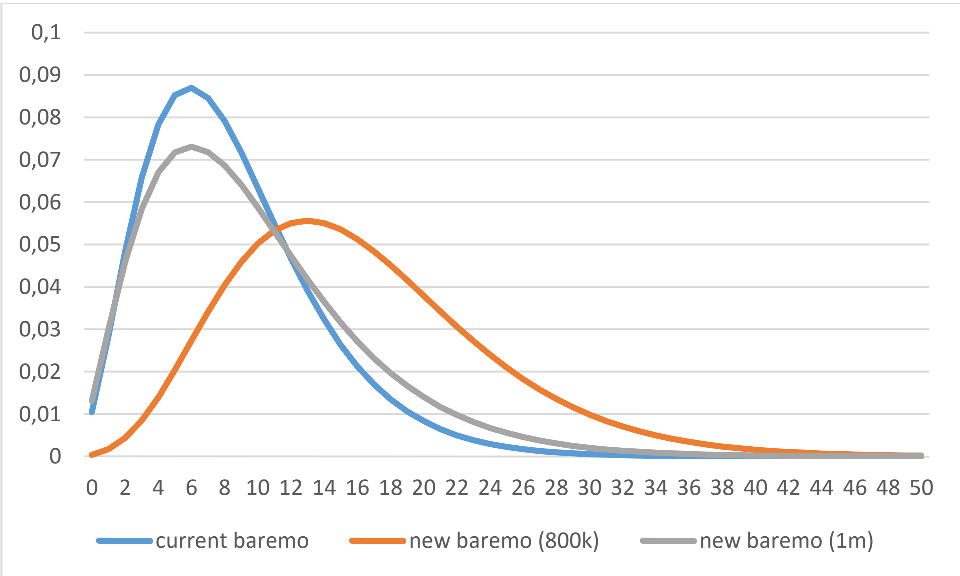
- An atypical threshold (amount above which losses are modeled)
- A law of frequency (number of losses expected each year above the atypical threshold)
- A law of severity (expected amount of each loss above the atypical threshold)

As historical losses were determined using the current Baremo, the first step consisted in re-evaluating the costs with the new Baremo, using the expected inflation by type of injuries (death, severe and lighter injuries).

The second consisted in retreating historical losses on an as-if basis: as if losses occurred on the first of January 2016. In practice, it means adjusting for inflation using consumer prices indicators, and developing claims (taking into account the IBNR effects) until the ultimate amount.

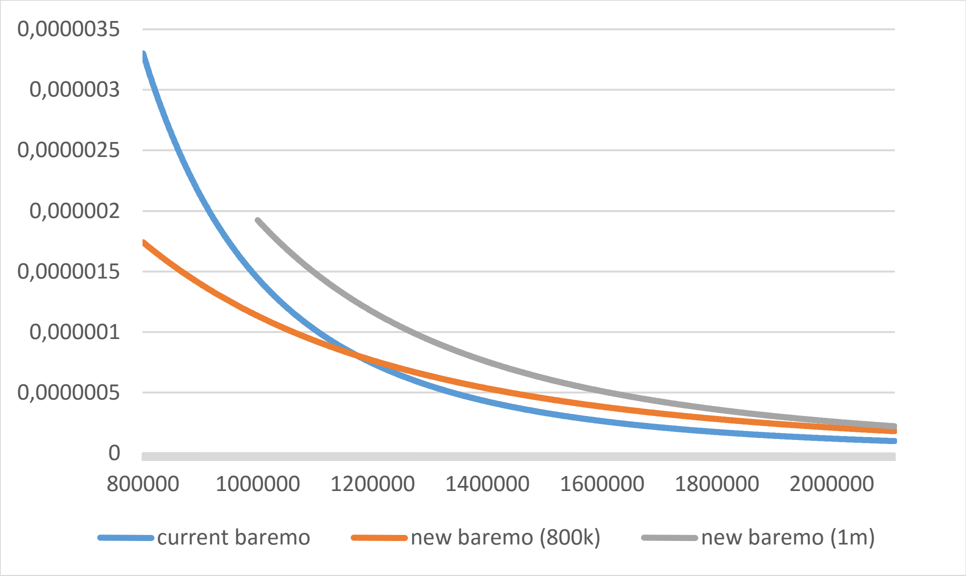
The third step consisted in determining the atypical threshold, i.e. threshold above which losses are material enough to be important individually for AXA. Losses below this threshold are considered attritional in the AXA Risk Management environment, and more important losses are considered catastrophes. The threshold is determined using the Hill estimator, and then the Hill plot method, the Cheng & Peng estimator, and the Bootstrap method to find the optimal threshold. We selected a threshold of €800k for losses calculated with the current Baremo, and two potential thresholds of €1m and €800k for losses calculated with the new Baremo: the €1m threshold seemed more adapted to the data, but only using the same threshold of €800k would allow a proper comparison with data from issued of the current Baremo.

The fourth step consisted in estimating the law of frequency for each of the sets of data. We have tested two different laws for each set of data: the Poisson law, and the Negative Binomial law. In all the cases, we have retained the negative Binomial law as more adapted vs. observed historical losses (in terms of observed mean and variance). A visual representation of the selected distributions can be observed in the figure below.



As can be observed, the average frequency (number of atypical losses expected) is higher with the new Baremo when the threshold is the same than the current Baremo. This can be explained by the fact that historical losses below the threshold with the current Baremo were estimated over the threshold with the new Baremo. Using a higher threshold naturally reduces the frequency.

The last step was the determination of the severity law: this is done by testing the fit of different potential distributions (Lognormal distribution, Generalized Pareto distribution, Right Truncated Pareto distribution and Weibull distribution). In all cases, we retained a Generalized Pareto distribution, as can be seen on the graph below.



As can be observed, the severity is lower with the current Baremo as compared to the new one, reflecting the increase in costs due to the new regulation. The severity naturally increases when the threshold is set to a higher number.

After having determined the parameters necessary to model motor bodily injury claims in 2016 for AXA Spain, we have simulated 10000 years of losses, that allowed us to determine the average and variance of losses, for each scenario, with and without reinsurance cover. Reinsurance was modeled as a simple excess of loss (€4m in excess of €1m).

Finally, the impact on capital requirement (SCR) was estimated using a Solvency II-like model: the additional capital requirement necessary to cover the atypical losses was calculated as the 99.5% percentile of retained losses (after reinsurance) plus cost of reinsurance. Results of the analysis are summarized in the table below.

	Current Baremo	new Baremo 800k
SCR (no reinsurance)	40 295 263 €	74 424 266 €
SCR (reinsurance)	32 870 816 €	46 911 968 €
Difference	7 424 447 €	27 512 299 €

As can be observed, the capital requirement is increasing in all cases with the new Baremo, with or without reinsurance. The analysis suggests that the reinsurance cover allows to reduce by €7m the capital requirement with the current regulation, vs. €27m with the new one.

This analysis allows to have an estimate of the magnitude of the impact of the new regulation in Spain on AXA's metrics. We estimate that this change in regulation will require a new estimation of the atypical threshold (threshold over which losses are considered atypical), an adapted reinsurance cover, and will inevitably require additional capital requirement.

Résumé

Mots clés:

Responsabilité civile auto, dommage corporels, auto, Espagne, Baremo, pertes atypiques, réassurance non-vie, panorama des coûts, besoin en capital

Note:

AXA est un assureur français, parmi les leaders mondiaux de l'assurance, présent dans une soixantaine de pays dans le monde. C'est un assureur mixte, avec un portefeuille important en Vie et Epargne, Dommages, Santé, et Assurance Internationale. En 2014, le chiffre d'affaires brut d'AXA était de €92 milliards d'euros, dont 32% en assurance dommages. Au sein de l'assurance dommages, l'automobile est une activité importante, et par conséquent un risque significatif qui doit être suivi de près, à cause de son impact potentiel sur la volatilité du résultat et sur les besoins en capital.

La responsabilité civile auto est une assurance obligatoire dans les pays matures, qui garantit que l'assureur indemnisera toute victime des dommages générés par la personne qui a causé l'accident. Par conséquent, cette assurance garantit à chaque usager de la route que les dommages potentiels qu'il/elle pourrait créer seront indemnisés, sans qu'il/elle n'ait à les payer. D'un autre point de vue, cette assurance garantit à toute victime potentielle qu'elle sera bien indemnisée en cas d'accident.

Les dommages indemnisés par la responsabilité civile auto sont principalement de deux natures :

- Dommages matériels (par exemple dégâts sur la voiture)
- Dommages corporels : blessures liées à l'accident

Les dommages corporels représentent un risque important pour AXA, car les indemnités payées aux victimes peuvent atteindre plusieurs millions d'euros. Pour cette raison, il est primordial de pouvoir correctement quantifier ce risque. AXA Global P&C, filiale en charge de piloter l'activité Dommages pour l'ensemble du Groupe, est responsable du suivi et de la modélisation de ces risques, notamment dans le cadre de son rôle de coordinateur de la couverture de réassurance.

Dans ce rapport, nous commençons par présenter un panorama des coûts des dommages corporels dans 19 entités du Groupe AXA. Ces entités, représentatives de la diversité des pays dans lesquels AXA est présent, peuvent être séparées en trois groupes différents (selon la classification interne utilisée par AXA) :

- Les pays matures : Belgique, France, Allemagne, Grèce, Italie, Luxembourg, Espagne, Suisse, Royaume-Uni, et AXA Corporate Solutions
- Les pays d'Europe Centrale et de l'Est (République Tchèque, Pologne, Slovaquie et Ukraine)
- Les autres marchés émergents : Golfe, Hong Kong, Malaisie, Nigeria et Turquie

L'indemnisation des dommages corporels est fonction de nombreux paramètres, tels que l'âge de la victime, la sévérité des blessures, la présence de proches, la relation de dépendance entre la victime et ses proches, le salaire de la victime, la législation locale, etc… Afin de comparer le niveau de coûts entre différents pays, nous étudions quatre scénarios représentatifs de la diversité des situations potentielles. Dans deux scénarios, la victime est un homme de trente ans avec une femme et deux enfants en tant que proche. Dans les deux autres scénarios, la victime est un enfant de huit ans, dont

les proches sont les deux parents. Les deux types de scénarios étudiés sont la mort de la victime, ou la tétraplégie.

L'analyse comparative des coûts révèle des différences matérielles entre les pays, même si une certaine homogénéité peut être observée à l'intérieur de chacun des trois groupes considérés (pays matures, pays d'Europe Centrale et de l'Est, autres marchés émergents).

En regardant le niveau moyen des coûts entre tous les pays, on peut observer que les coûts sont plus élevés pour le scénario de tétraplégie par rapport au décès (quelle que soit la victime). Le scénario le moins coûteux est le décès de l'enfant de huit ans, car dans ce cas les seuls coûts sont des dommages moraux pour les parents. Le second scénario le moins coûteux est ensuite le décès de l'homme de 30 ans, et là les coûts incluent en plus une part importante dédiée à compenser la perte de revenus pour les membres survivant de la famille, car la victime est considérée comme le principal apporteur de revenu du foyer. Enfin, les coûts des scénarios de tétraplégie sont comparables pour l'homme de 30 ans et l'enfant de huit ans, mais s'expliquent de manière différente : pour l'enfant, les coûts sont principalement liés aux dépenses futures (soins, accompagnement au quotidien, santé) avec une plus longue espérance de vie ; alors que pour l'homme, la plus grosse partie des coûts est dédiée à compenser la perte de revenus du foyer.

Au niveau des groupes de pays, on peut observer que les pays matures octroient le plus haut niveau d'indemnités, suivis par les pays d'Europe Centrale et de l'Est (CEE), puis enfin par les autres pays émergents. De manière générale, la sophistication dans le calcul de l'indemnisation augmente avec la maturité du pays : dans les pays matures, l'indemnisation est fréquemment calculée en prenant en compte la vie future des membres de la famille, et peut être payée sous forme d'annuités, alors que dans les pays émergents, l'indemnisation est souvent plus basique et payée sous forme de montant forfaitaire.

Nous avons pu confirmer ce classement des indemnités par pays, en faisant une analyse de la corrélation entre le niveau des indemnités et le développement économique du pays. Pour modéliser le développement économique, nous avons utilisé la pénétration de l'assurance (primes d'assurance divisées par le PIB), la richesse (PIB par habitant) et l'indice de développement humain (IDH). Dans tous les cas, nous observons bien une corrélation entre niveau des indemnités et développement.

Ce panorama des indemnités nous a permis d'identifier qu'en Espagne, le niveau des coûts est significativement plus simple que dans des pays d'un niveau de développement comparable, notamment en ce qui concerne la part destinée à compenser la vie future de la victime et de ses proches (perte de revenus, coûts des soins futurs). Une nouvelle législation (« Baremo ») devrait être mise en place en Janvier 2016 en Espagne, avec pour but principal d'aligner le système de d'indemnisation des victimes sur ce qui est fait dans les autres pays d'Europe.

A travers une revue de différentes études d'impact faites par Aon, QBE, Swiss Re et AXA en Espagne, nous avons estimé que la nouvelle législation induira une augmentation des indemnités à hauteur de 55% en cas de décès, 100% en cas de blessures graves, et 20% pour les blessures plus légères.

Afin d'estimer les conséquences de cette augmentation pour AXA en Espagne (en terme de résultat, de besoins de réassurance, et de besoin en capital), nous avons modélisé le niveau des coûts potentiels pour l'année 2016, avec le système actuel et avec la nouvelle législation. Cette modélisation est effectuée en utilisant la méthode de modélisation des pertes atypiques développée par AXA Global P&C, et le service de Gestion du Risque d'AXA.

Cette méthode utilise les sinistres historiques observés par AXA en Espagne, afin de déterminer :

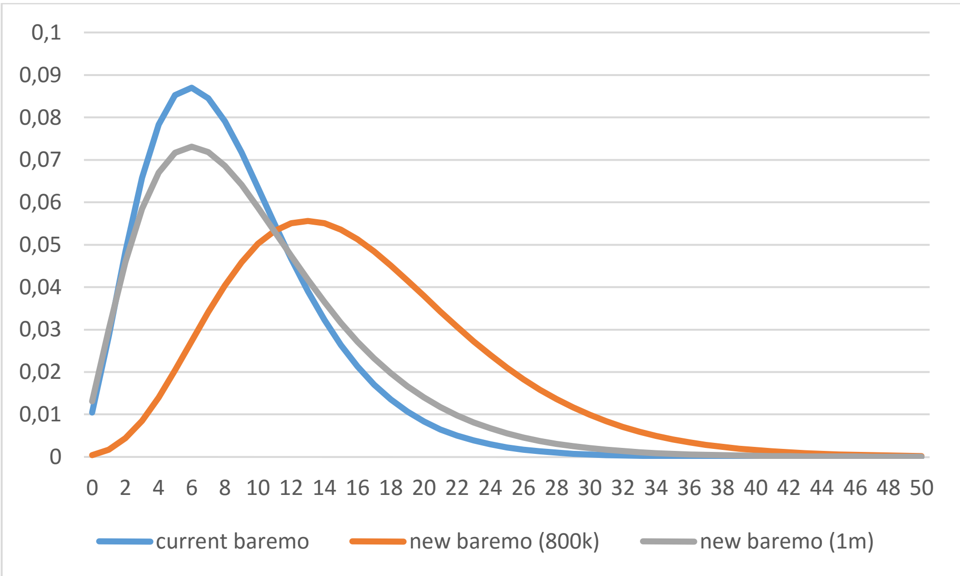
- Un seuil atypique (montant au-delà duquel les sinistres sont modélisés)
- Une loi de fréquence (nombre de sinistres attendus chaque année au-dessus du seuil atypique)
- Une loi de sévérité (montant attendu de chaque sinistre au-dessus du seul atypique)

Comme les sinistres historiques sont basés sur le « Baremo » actuel, la première étape de la modélisation consista à réévaluer les indemnités avec le nouveau « Baremo », en utilisant l'inflation attendue par type de blessure (décès, grave, légère).

La seconde étape consista à retraiter les sinistres historiques comme s'ils avaient eu lieu le premier janvier 2016. En pratique, cela revient à prendre en compte l'inflation, et à développer les sinistres (en prenant en compte l'impact IBNR) jusqu'au coût ultime.

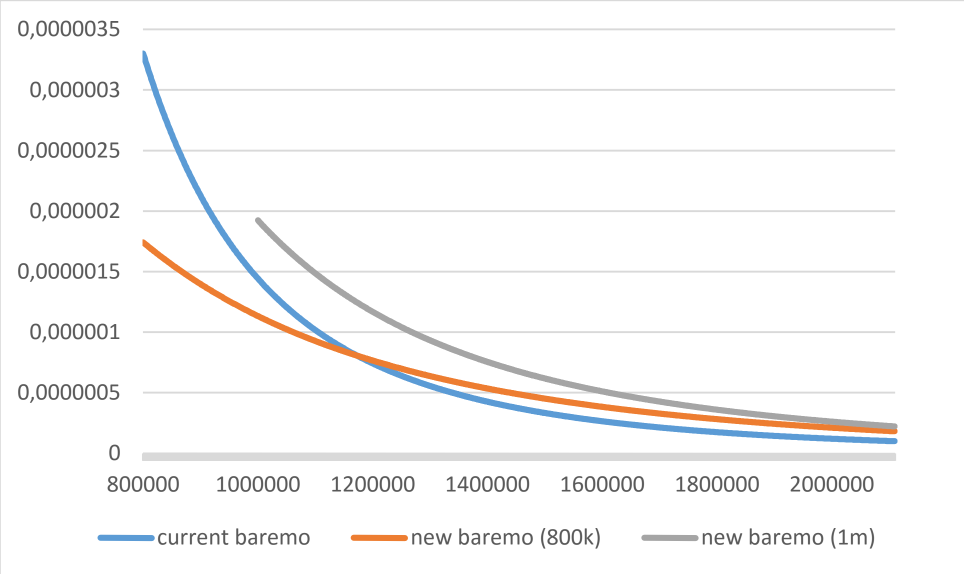
La troisième étape consista à déterminer le seuil atypique, montant au-delà duquel les sinistres sont suffisamment importants au niveau individuel pour compter pour AXA. Les sinistres en deçà de ce seuil sont considérés comme attritionnels dans l'environnement de gestion du risque d'AXA, et ceux bien plus importants sont considérés comme des catastrophes. Le seuil est déterminé en utilisant l'estimateur de Hill, et la méthode de représentation graphique correspondante, l'estimateur de Cheng & Peng, et la méthode de Bootstrap. Nous avons sélectionné un seuil atypique de €800,000 pour les sinistres liés au Baremo actuel, et deux seuils potentiels de €1,000,000 et €800,000 pour les sinistres recalculés avec le nouveau Baremo : le seuil le plus élevé correspondait mieux aux données, alors que celui de €800,000 permet une comparaison avec les données du Baremo actuel.

La quatrième étape consista à estimer la loi de fréquence pour chacun des jeux de données. Nous avons testé deux lois différentes pour chaque jeu de données : loi de Poisson et loi Binomiale Négative. Dans tous les cas, nous avons retenu la loi Binomiale Négative comme étant la plus adaptée par rapport aux sinistres historiques (en terme de moyenne et variance). L'illustration ci-dessous permet de comparer les différentes distributions retenues.



Comme on peut l'observer, la fréquence moyenne (nombre de sinistres atypiques attendus) est plus élevée avec le nouveau Baremo (quand le seuil atypique est le même). C'est expliqué par le fait que certains sinistres historiques sous le seuil atypique avec le Baremo actuel passent au-dessus du seuil après l'inflation correspondant au nouveau Baremo. En utilisant un seuil plus élevé, on voit que la fréquence moyenne diminue).

La dernière étape est la détermination de la loi de sévérité : c'est réalisé en testant l'adéquation de plusieurs distributions potentielles (Lognormale, Pareto Généralisée, Weibull, Pareto tronquée à droite). Dans tous les cas, nous avons retenu la loi de Pareto généralisée, comme on peut l'observer sur le graphique ci-dessous.



Comme on peut l'observer, la sévérité est plus faible avec le Baremo actuel par rapport au nouveau, ce qui reflète bien l'inflation attendue avec la nouvelle législation. La sévérité augmente comme on peut l'attendre quand le seuil fixé est plus élevé.

Après avoir déterminé les paramètres nécessaires à la modélisation des indemnités de sinistres corporels en 2016 pour AXA en Espagne, nous avons simulé 10000 années de sinistres, ce qui permet de déterminer la variance des coûts pour chaque scénario, avec et sans couverture de réassurance. Nous avons modélisé la couverture de réassurance par un traité en excédent de sinistres (€4m en excès de €1m).

Pour finir, l'impact sur les besoins en capital (SCR) a été estimé en utilisant un modèle similaire à Solvabilité II : le capital nécessaire pour couvrir les pertes atypiques a été calculé comme le 99.5% centile des pertes retenues (après réassurance), plus le coût de réassurance. Les résultats de l'analyse peut sont résumés dans le tableau ci-dessous.

	Baremo actuel	**Nouveau Baremo 800k**
SCR (sans réassurance)	40 295 263 €	74 424 266 €
SCR (avec réassurance)	32 870 816 €	46 911 968 €
Différence	7 424 447 €	27 512 299 €

Comme on peut l'observer, le besoin en capital augmente dans tous les cas avec le nouveau Baremo, avec ou sans réassurance. L'analyse suggère que la couverture de réassurance permet de réduire de €7m le besoin en capital avec la régulation actuelle, et de €27m avec la nouvelle.

Cette analyse permet d'estimer l'impact de la nouvelle régulation en Espagne sur certaines métriques utilisées par AXA. Nous estimons que ce changement de législation nécessitera de recalculer le seuil atypique, de considérer une nouvelle couverture de réassurance, et qu'il induira quoi qu'il arrive une augmentation du besoin en capital.

1 Introduction

1.1 AXA Group

1.1.1 Overview of the Group

AXA is a leading international insurance company headquartered in France. It operates in 59 different countries and employs around 161 000 persons to serve 103 million clients.

It is a multiliner insurer, with significant portfolio in Life and Savings (L&S), Property and Casualty (P&C), Health and International Insurance. In addition, AXA also operates in Asset Management (notably with its subsidiaries AXA IM and AllianceBernstein).

In terms of exposure, AXA is mostly exposed to Western Europe (with France as the biggest portfolio), but also has important exposure in the North America and Asia-Pacific, as well as growing exposure in South America, Middle East and Africa.

The Group AXA has existed under various names in the previous century, and was finally named AXA in 1985. Since then, the Group has experienced an exponential growth mainly by acquisition, notably with the incorporation of UAP (France), the Equitable (US), Winterthur (Switzerland) and various smaller sizes deals.

1.1.2 Key figures

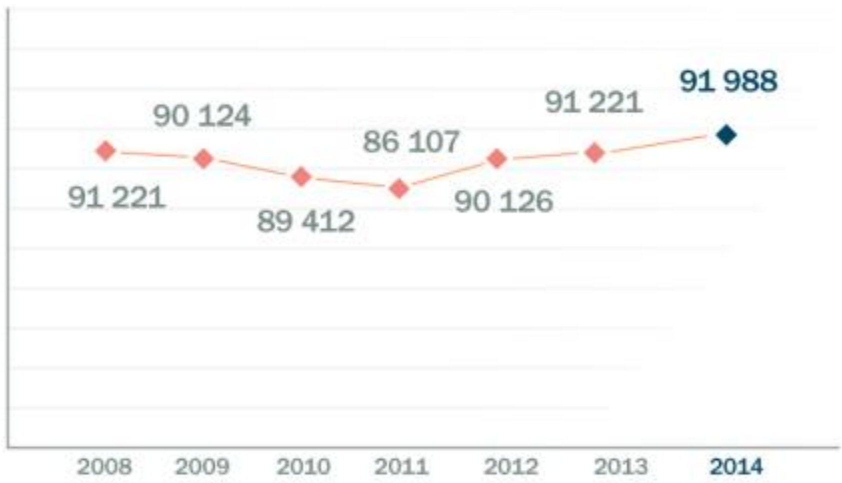


Figure 1-1. Revenues (million of euros)

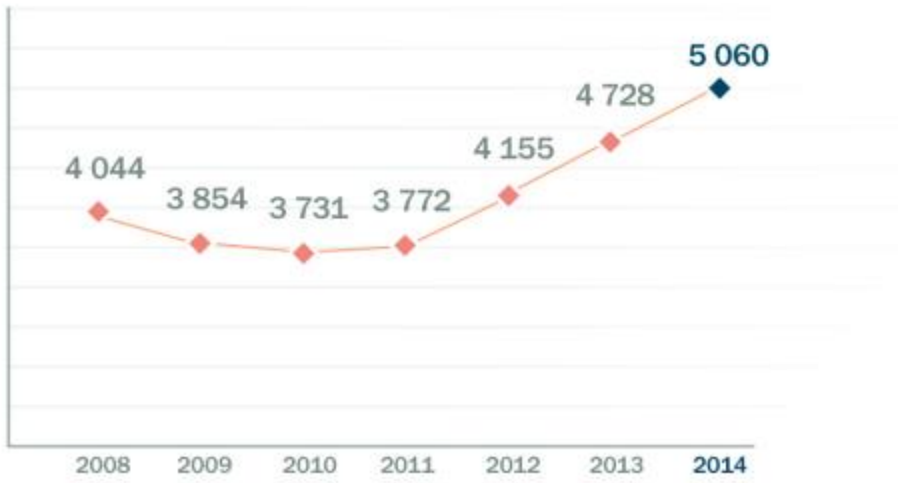


Figure 1-2. Underlying Earnings (millions of euros)

The split of gross revenues and underlying earnings by lines of business gives an idea of the weight of P&C activities (focus of this report) in the Group:

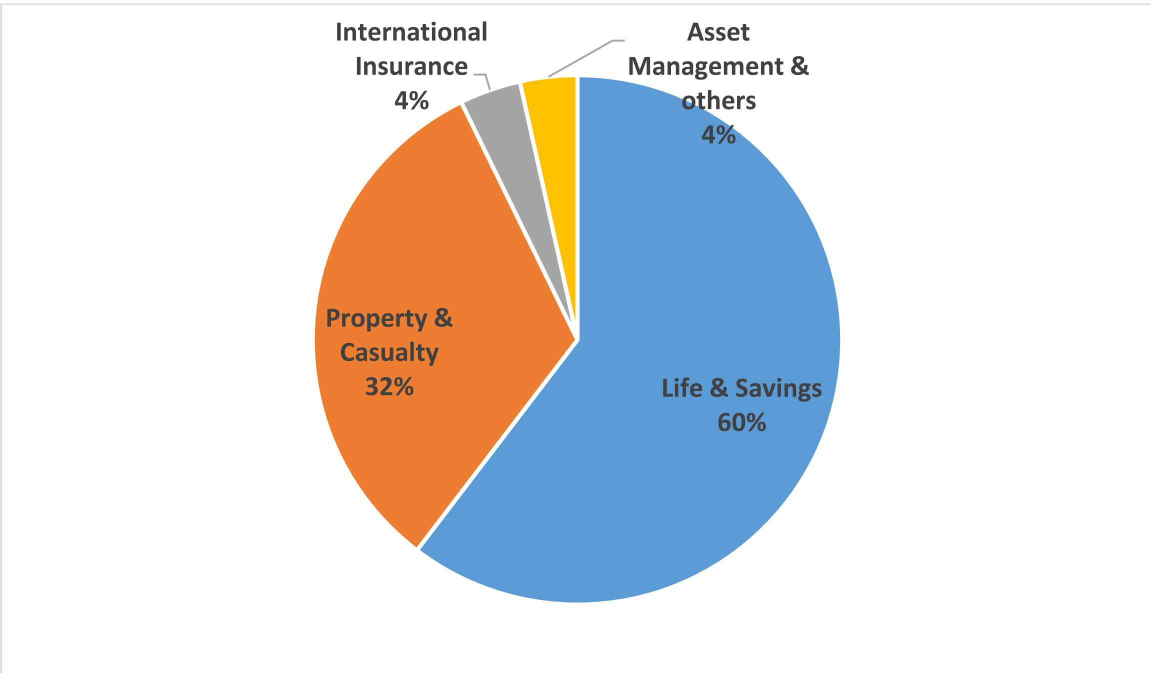


Figure 1-3. Split of the gross revenues by lines of business (AXA, 2014 results)

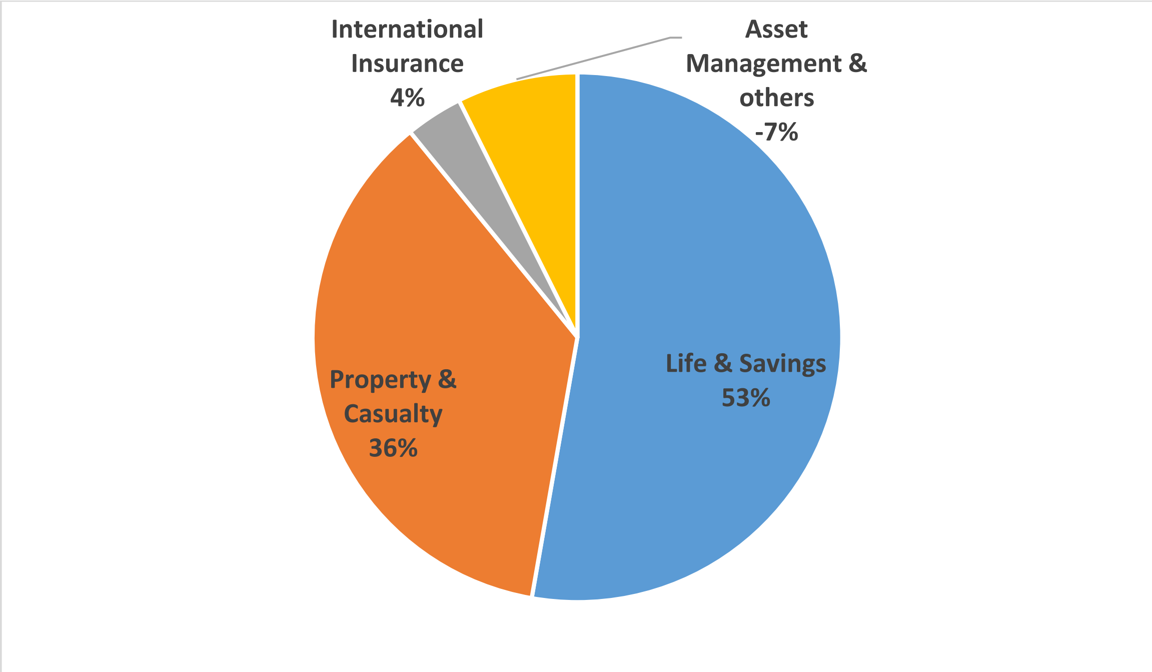


Figure 1-4. Split of the underlying earnings by lines of business (AXA, 2014 results)

1.1.3 Group organization

AXA is organized in a matrix way:

- The different operational entities in each country, reporting to the Group
- There are three Global Business Lines (P&C, L&S and Health), reporting to the Group, and designed to be centers of expertise for AXA. The Global Business Lines are in charge of defining the global strategy for each product lines (optimization of the geographical footprint, management of expertise in the Group, sharing of best practices between entities, etc…)
- AXA Group headquarters (the GIE) is in charge of coordinating the Group on major transversal functions: Strategy and Finance, Human resources, Marketing, Operations, etc…

1.2 AXA Global P&C and motor third party bodily liabilities

1.2.1 AXA Global P&C's mission

Subsidiary of AXA created in 2010, AXA Global P&C's mission is to pilot non-life insurance for the whole AXA Group. In addition to the role of coordinating the activities, AXA Global P&C is also in charge of managing the reinsurance of P&C activities for the Group and for local entities, and buy the adequate coverage from external reinsurance providers.

In order to determine the level of risk the Group is ready to keep, AXA Global P&C has to evaluate how much it is exposed by its portfolio of contracts, in coordination with the Group Risk Management department. Each type of risk has to be modeled as precisely as possible in order to be able to optimize its impact on the Group's earnings and capital requirements.

1.2.2 Motor third party liabilities – bodily injuries

Motor third party liability (MTPL) insurance is a liability insurance, mandatory in mature markets. In these countries, all motor vehicles participating in road traffic and subject to registration in traffic register must have valid MTPL insurance.

Based on the motor third party liability insurance, the insurer will indemnify the traffic losses, created by the person who caused the traffic accident, to the victim. Thus, MTPL insurance gives the road user assurance that the damage he/she creates will be indemnified and that the person who caused the damage must not indemnify it himself/herself. On the other hand, mandatory MTPL insurance gives the victim confidence that the losses caused to him/her will be indemnified.

Motor third party losses are comprised of:

- Material losses (e.g. damages to a car)
- Bodily injuries: damages to the physically hurt victims

Motor third party bodily injuries are an important risk for AXA, as the indemnity paid to victims can be sometimes worth several millions. It thus differs from other motor damages which are more in the magnitude of thousands of euros.

It is thus one of the risks which is precisely monitored and modeled by AXA Global P&C, in the context of its role of reinsurance coordinator for AXA Group.

2 Overview of motor third party bodily injury costs at AXA

2.1 Context of the study

2.1.1 AXA context

Third party costs are an important part of motor costs within AXA. They include both bodily injury costs and material costs. The share of these two categories can vary significantly from one entity to another within AXA Group.

The split of third party costs between bodily injury and material costs is not reported by entities to the Group within AXA, and thus it is complicated to have a precise view on the contribution of each entity on bodily injury costs, notably to size reinsurance needs.

At Group level, AXA Global P&C needs to model for each year the estimated amount of bodily injury costs:

- In order to buy the reinsurance coverage
- To calculate the risk capital

For these reasons, there is a need to better understand how the bodily injury costs are determined from one entity to another, and anticipate how these costs might evolve in the future years.

2.1.2 Purpose of this overview

To answer this need, AXA Global P&C launched a survey in the beginning of 2015 to all the P&C entities of the Group. The purposes of the study were to:

- Get an overview of bodily injury costs in the different AXA entities
- Understand the drivers of costs for each entity and for different scenarios
- Identify the different potential drivers of future inflation
- Anticipate potential changes of bodily injury costs in case of harmonization between the different countries

2.2 Description of the study

2.2.1 Scope of countries

Nineteen AXA entities participated to this survey. These entities can be split in different groups based on their geographical footprints, and according to AXA's classification.

- **AXA Corporate Solutions**: the International Assurance entity of AXA, aiming at delivering insurance solutions for large corporates. AXA Corporate Solutions operates through its network in 150 countries

- **Mature entities**:
    - AXA Belgium
    - AXA France

- AXA Germany
- AXA Greece
- AXA Italy
- AXA Luxembourg
- AXA Spain
- AXA Switzerland
- AXA UK

- **In Central and Eastern Europe (CEE)**
  - AXA Czech Republic
  - AXA Poland
  - AXA Slovakia
  - AXA Ukraine

- **Other emerging markets**
  - AXA Gulf
  - AXA Hong Kong
  - AXA Malaysia
  - AXA Nigeria
  - AXA Turkey

For practical reasons, AXA Corporate Solutions will be classified in the rest of this paper with mature entities, as most of its revenues are generated in Western Europe which is considered a mature market within AXA.

2.2.2 Different scenarios considered

Four different scenarios (2x2) were considered, including two victims and for each, two potential scenarios.

The victims considered were either:

- An 8-year-old child, considering the parents as main relatives
- A 30-year-old man, considering as relatives his spouse and two children

The following potential scenarios had to be considered for each victim:

- Death of the victim
- Quadriplegia of the victim

For calculation purposes, it was assumed that the accident occurred on the first of January, 2015.

2.2.3 Costs information collected

For each of the four scenarios, the entities had to fill an estimate of the associated third party motor liability costs. These costs were reported using six main different categories:

- **Loss of earnings:** this category encompasses the loss of current and future earnings of the victim, as well as the loss of potential future professional opportunities for the victim
- **Home and vehicle adaptation costs**: this category regroups all potential costs required to adapt the victim's environment in case of disability (scenario of quadriplegia only)
- **Damage to indirect victims and non-patrimonial damages**: pain and suffering paid to family members or special compensation for employer, or pain and suffering prejudice for the victim
- **Health expenses:** encompasses current and future health expenses
- **Personal care**: care expenses in case personal assistance is required by the victim (e.g. from a nurse or physiotherapist)
- **Legal & other**: legal costs and other specific costs not fitting in the previous categories

2.3 Comparative analysis of figures

2.3.1 Overview of total costs

Looking at the four different scenarios, the average costs calculated over the different entities were the following ones, as illustrated in the figure below.

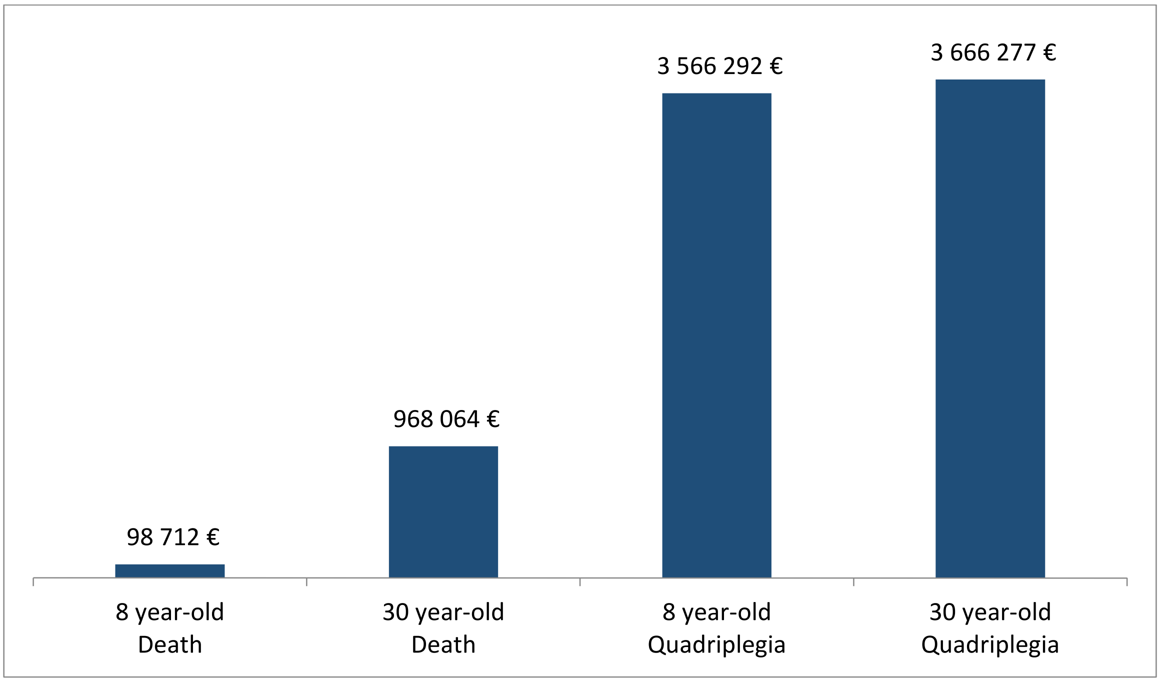


Figure 2-1. Comparison of average costs for each scenario

While these average costs reflect very different realities in each entity, it gives a first overview of the relative importance of each scenario, as can be evidenced by the split of costs for each scenario:

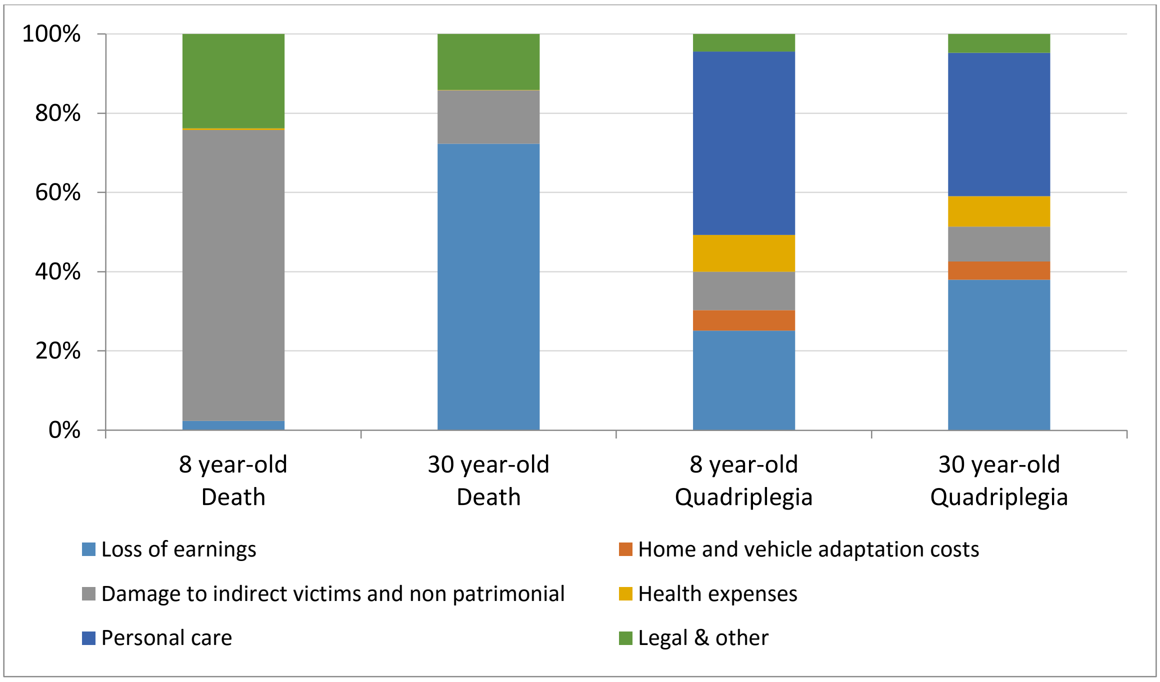


Figure 2-2. Repartition of costs by category for each scenario

From this first analysis, we can draw some initial conclusions, first between death and quadriplegia scenarios:

- In the two death scenarios, total costs are driven by the loss of earnings (66%)
- In the two quadriplegia scenario, total costs are driven primarily by personal care (41%), and then loss of earnings (32%).

Within the **death scenarios**, it is interesting to notice that:

- The **loss of earnings** logically has a more important weight for the 30-year-old man, as the loss is estimated for the family (the spouse and two children).
- For the 8-year-old victim, the most important item is the **damages to indirect victims**
- The total cost is significantly higher for the 30-year-old man (968k€) as compared to the child (99k€).

Within the **quadriplegia scenarios**, we can observe that:

- The **loss of earnings** logically has a more important weight for the 30-year-old man, as the loss is estimated for the family (the spouse and two children).
- The **personal care costs** are more important for the 8-year-old child, as this category is thus influenced by the fact that the child has a higher life expectancy.
- The total cost is relatively similar for the two victims, as the higher loss of earnings for the 30-year-old victim is compensated by the higher personal care for the 8-year-old child.

Another interesting analysis is related to the share of items related to the future life of the direct and indirect victims:

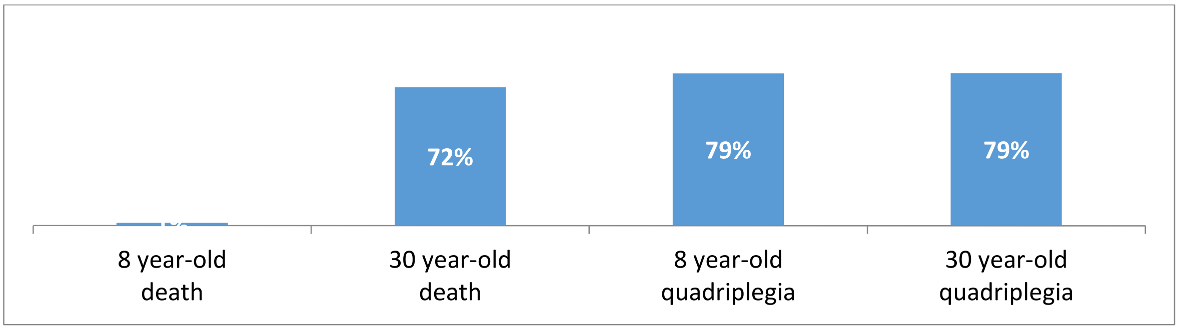


Figure 2-3. Share of items related to the future life of victims

Such costs include the loss of future earnings and professional opportunities covering for the needs of the victim's relatives, as well as personal care and future health expenses.

As expected, the share of future costs is higher for quadriplegia scenarios vs. death scenarios (as in addition to earnings compensation, personal care costs and future health expenses are added).

Within the **death scenarios**, the 30-year-old man scenario has a higher share of future items, reflecting the loss of earnings for the victim's relatives (while the death of the 8-year-old victim does not induce loss of earnings for the relatives).

For the **quadriplegia scenarios**, the share of future items is equivalent for both victims, as the higher loss of earnings for the 30-year-old man is compensated by higher personal care and health costs for the younger victim.

2.3.2 Comparison by country group

After having looked at costs on average for all entities, it is interesting to differentiate the analysis between the different country groups (corresponding to AXA classification):

- Mature entities
- Central and Easter Europe (CEE)
- Other emerging countries

The following analysis compares the average costs by country group and aims at identifying any similarities or difference depending on the scenario considered.

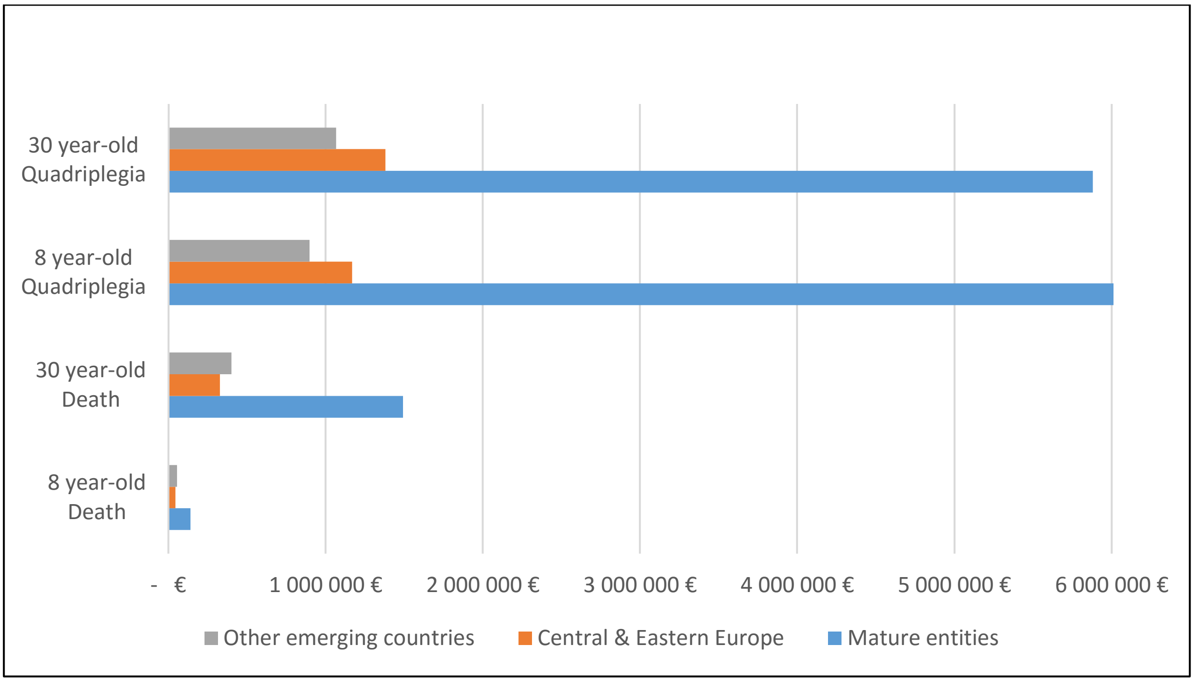


Figure 2-4. Average costs by country group for each scenario

For the four different scenarios, looking at the average costs for the three different country groups (mature entities, Central & Eastern Europe, other emerging countries) reveals important discrepancies:

- In **mature entities**, costs are on average higher than for the rest of AXA Group, for teach of the four scenarios.
- In **CEE**, costs for the quadriplegia scenarios are below the ones from mature entities, but above those of other emerging countries. On the other hand, costs for the death scenarios are the lowest ones.
- The costs of **quadriplegia** scenarios in CEE and other emerging countries are higher for the 30-year-old man than for the child, while it is the opposite in mature scenarios.

Looking at both quadriplegia scenarios (which are the costliest ones overall), it is interesting to look at the split of costs by category, for each country group.

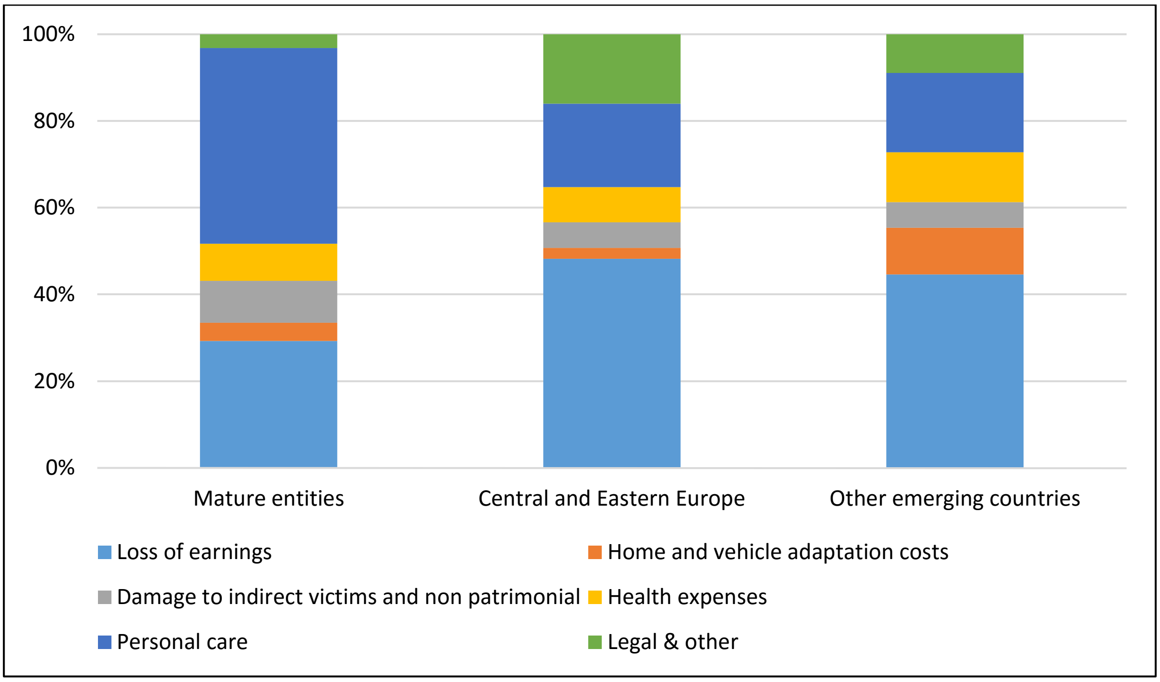


Figure 2-5. Repartition of costs by category – quadriplegia scenarios

The costs of personal care are the main driver for mature entities, while in CEE and other emerging countries, costs are mainly driven by the loss of earnings.

Another interesting analysis is the share of items related to the future life of direct and indirect victims:

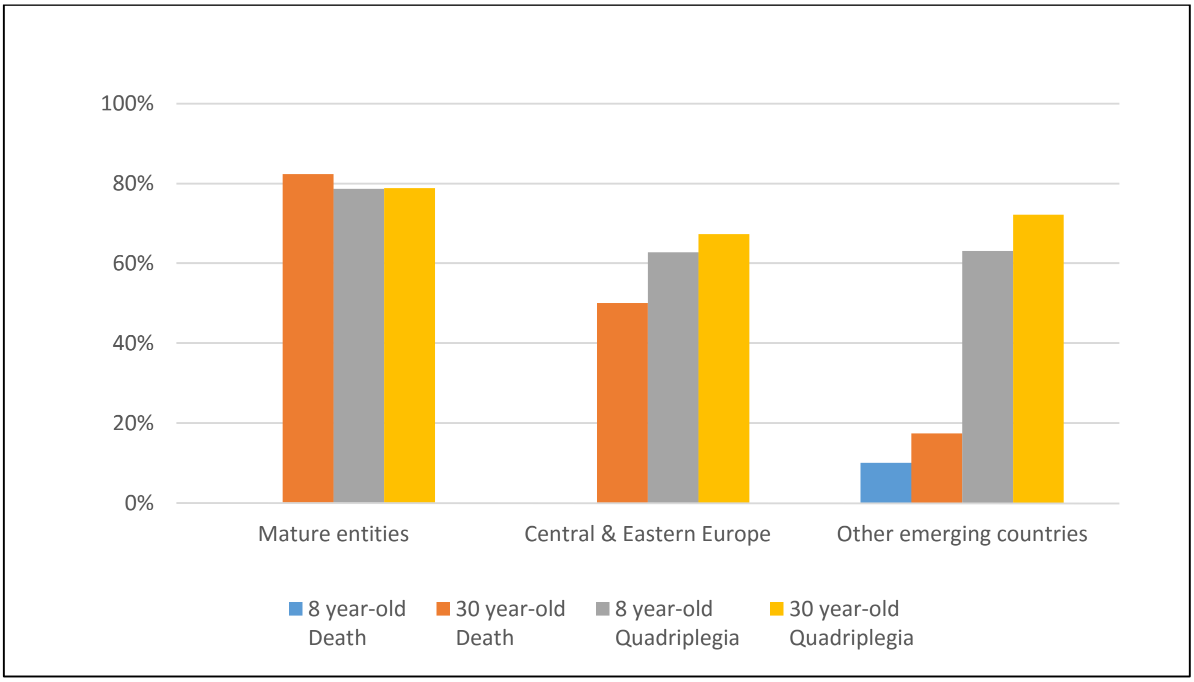


Figure 2-6. Share of items related to the future life of victims by country group

- **Mature entities** have the higher share of future elements in the costs, except in the scenario of death of the 8-year-old victim where the share is zero.

- While in **mature entities** and **CEE** no element refers to the future life of the victims for the **death of the 8-year-old child**, some costs are associated to this item in other emerging countries.

After having looked at these statistics for each group, it is interesting to go at the country level, and see if there are some differences between the geographical groups.

2.3.3 Zoom on mature entities

The group of mature entities is the largest group, and includes countries all located in Europe (with the particular case of AXA Corporate Solutions).

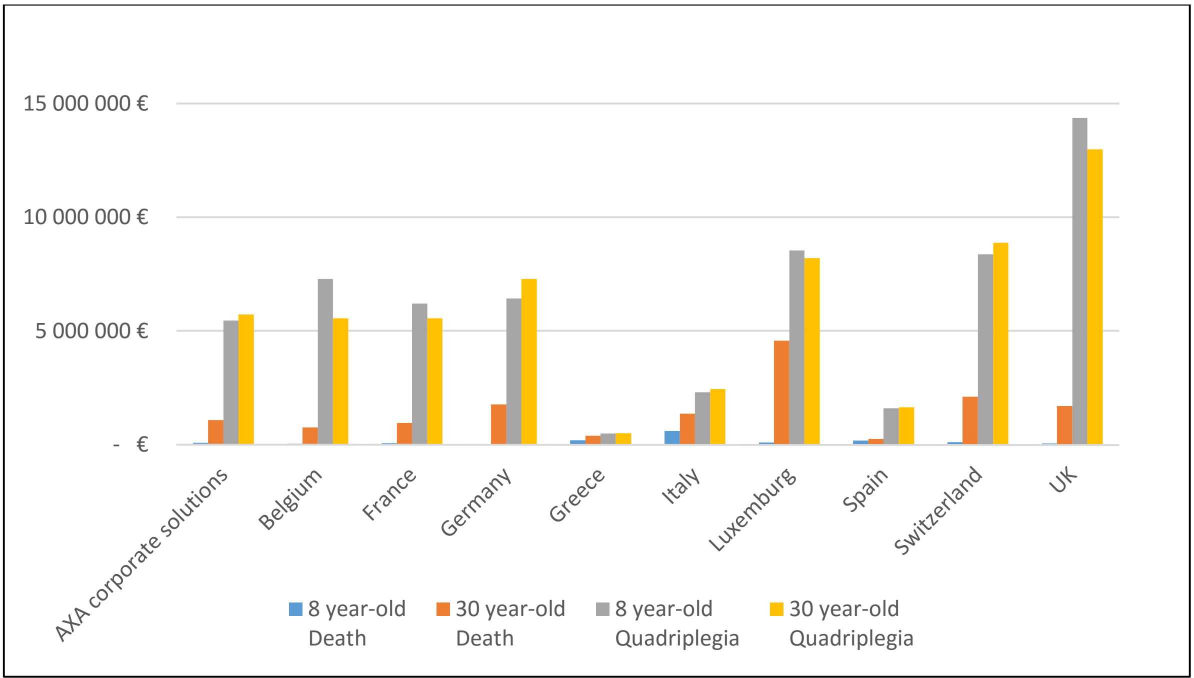


Figure 2-7. Total costs by entity for each scenario

This category shows quite homogenous results, with some notable exceptions:

- In **Greece**, **Spain** and **Italy**, the level of costs for quadriplegia scenarios is significantly lower than in other countries. On the other hands, these three entities have submitted the highest level of costs for the scenario of death of the 8-year-old child.
- In the **UK**, costs are significantly higher than in other countries for the quadriplegia scenarios.
- **AXA Corporate Solutions** reported levels of costs very similar to the other countries of the group, comforting the choice to include them in this bucket.

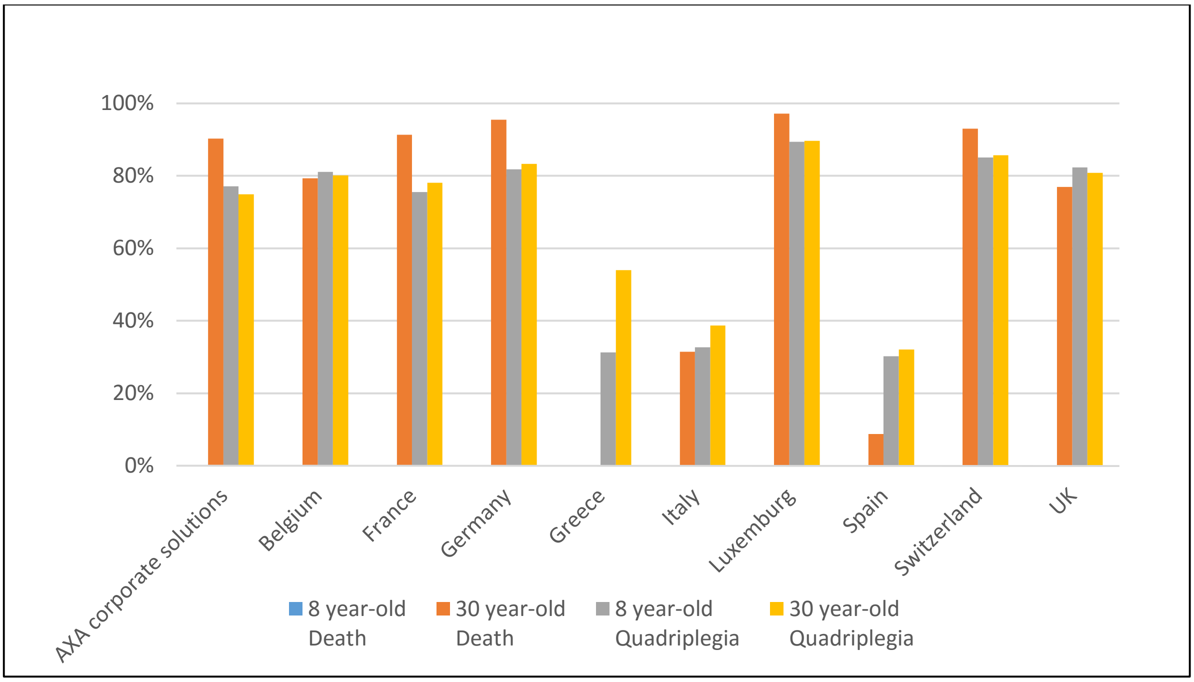


Figure 2-8. Share of future items in the total costs

Looking at the share of future items in the total costs, we can see some homogeneity in the results: for most countries, the share of future items is between 70% and 100% for all scenarios (except in case of death of the 8-year-old victim where future items are 0 in all countries). There are some notable exceptions:

- **Greece**, **Spain** and **Italy** have reported a lower share of future items
- For **Greece**, there are no future costs in case of the 30-year-old death scenario, meaning that the loss of earnings for indirect victims is not considered in the calculation of the compensation.

2.3.4 Zoom on CEE entities

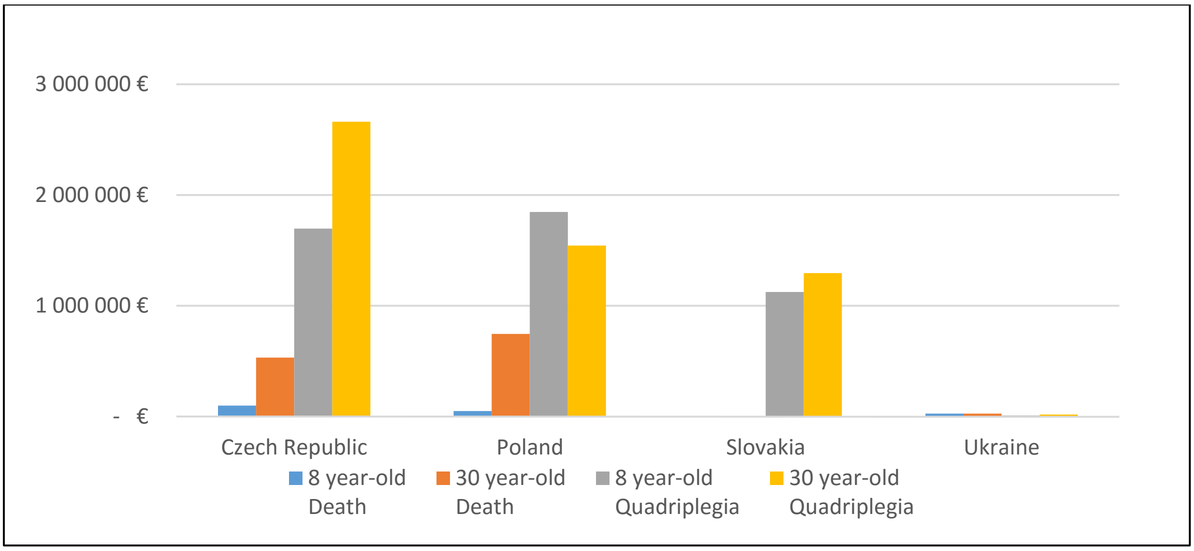


Figure 2-9. Total costs by entity for each scenario

This category shows quite homogenous results, and not far from the results of mature entities. Some notable observations could however be made:

- In **Ukraine**, overall costs are the lowest ones, significantly lower than in other countries.
- Costs for the death scenarios are very low in **Slovakia**, while quadriplegia costs are comparable with other countries.

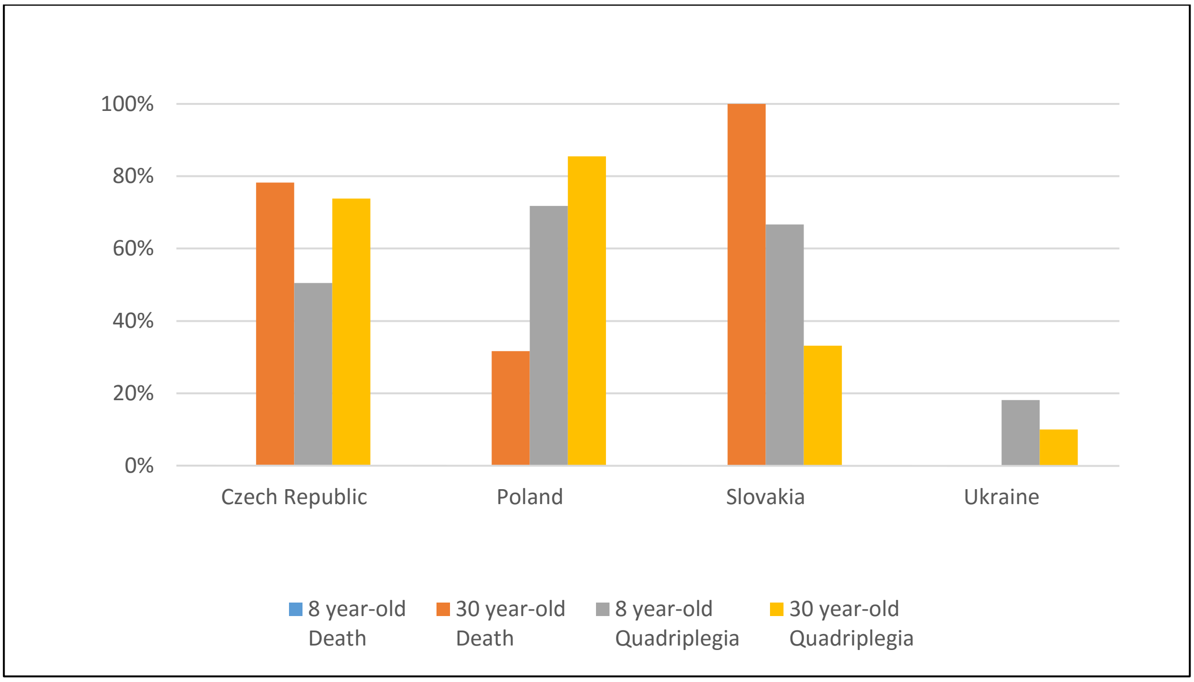


Figure 2-10. Share of future items in the total costs

Looking at the share of future items, results show significant discrepancies:

- **Ukraine** shows levels of future items below 20% for all scenarios (0% for death scenarios)

- In **Poland,** the level of future costs is relatively low for the death scenario (32%) while it is 78% in **Czech Republic** and 100% in **Slovakia**.

2.3.5 Zoom on other emerging entities

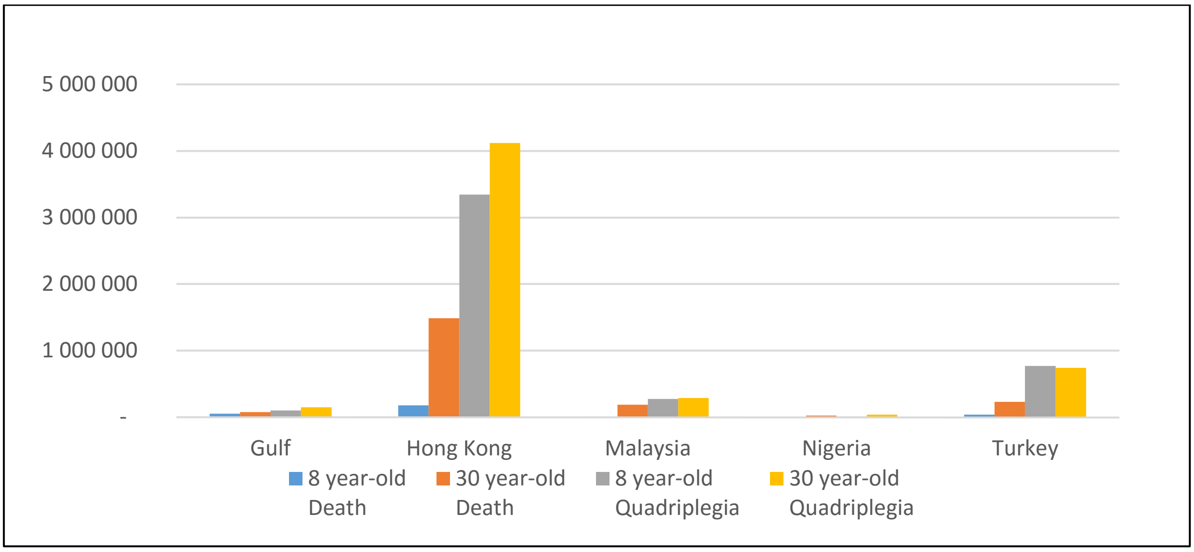


Figure 2-11. Total costs by entity for each scenario

This third category seems to be the most heterogeneous:

- In **Hong Kong**, level of costs seems comparable to the average level in mature entities.
- **Turkey** shows cost levels lower compared to mature and CEE entities, but significantly higher than remaining entities (Gulf, Malaysia, Mexico, Nigeria).

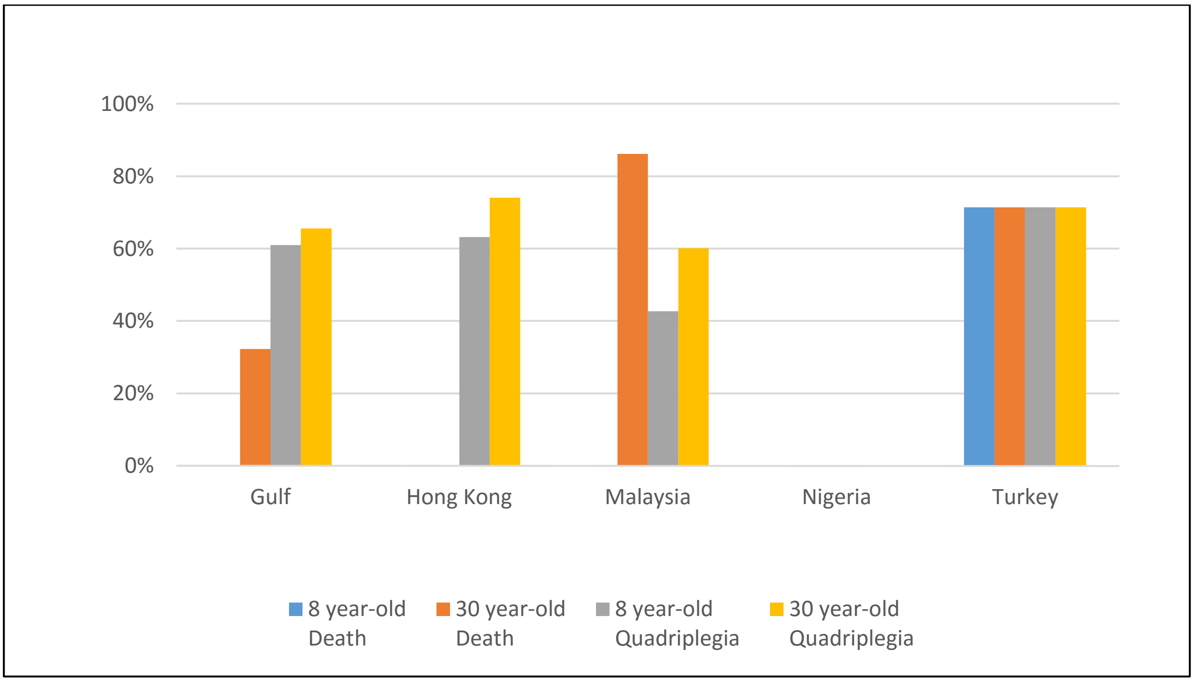


Figure 2-12. Share of future items in the total costs

Finally, looking at the share of future items in the costs of each scenario reveals important differences:

- In **Nigeria**, there are no future costs for any of the four scenarios.
- In **Turkey,** the share of future costs is the same for the four scenarios.

2.4 Conclusions of this overview and zoom on the specific case of Spain

2.4.1 Conclusions of the comparison by country

The comparative study of costs for these four scenarios among twenty different entities highlighted important differences. The analysis based on AXA groups of countries suggested that these groups were relatively adapted to identify similarities between the entities, with notable exceptions:

- **Hong Kong** having levels of costs close to the one in mature countries,
- **Spain, Italy and Greece** having low levels of costs as compared to other mature countries
- **Turkey** having level of costs higher than other countries of the emerging group.

We have tried to understand if the level of costs for these scenarios could be linked to parameters specific to each country (e.g. economic development, richness, insurance penetration, etc…). In order to do so, we have represented on a graph the level of costs by country in function of different parameters:

- **Insurance penetration:** this indicator is expressed as a percentage, representing for a country the total insurance gross written premiums (GWP) of a year divided by the gross domestic product (GDP). It represents how much money is spent on insurance compared to the value created in the country, and it is a good indicator of how much the insurance markets are developed.
- **GDP per capita:** this indicator, is expressed as a value (in euros in this analysis), is a good indicator of the economic development of the country. It represents how much value is created each year and per citizen of the country.
- **Human Development Index:** this is a composite indicator (using life expectancy, education and income per capita indicators) used to rank countries in terms of human development. This indicator aims at balancing the pure economic ranking by some elements related to human development (education, life expectancy) and could presumably help explain the differences in bodily injury costs we have observed.

For this analysis, we have only used the 30-year-old victim’s scenarios, as they were costlier in almost all cases.

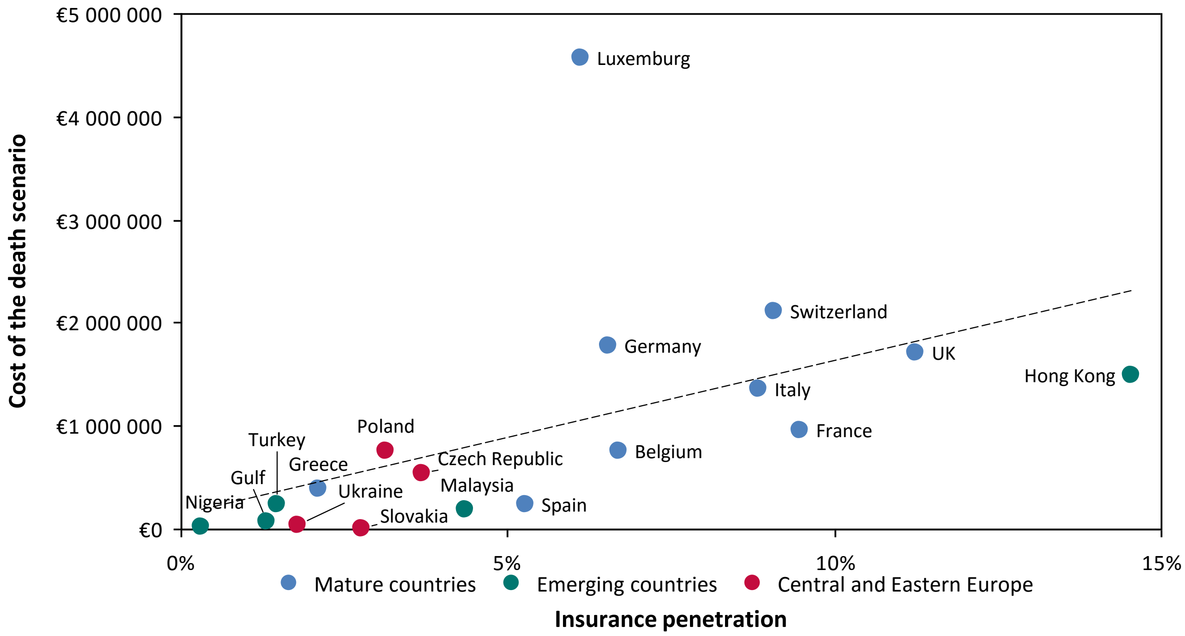


Figure 2-13. Cost of the death scenario in function of the insurance penetration by country

This first analysis shows that the costs related to the death scenarios increase with the insurance penetration, in a linear way. Apart from the case of **Luxembourg**, which is quite far from the expected figure, all countries are relatively close to the linear regression.

Considering all countries, the coefficient of determination (R^2) related to this linear regression is 0.27, which is quite low. When removing Luxembourg from the sample, the coefficient is 0.66.

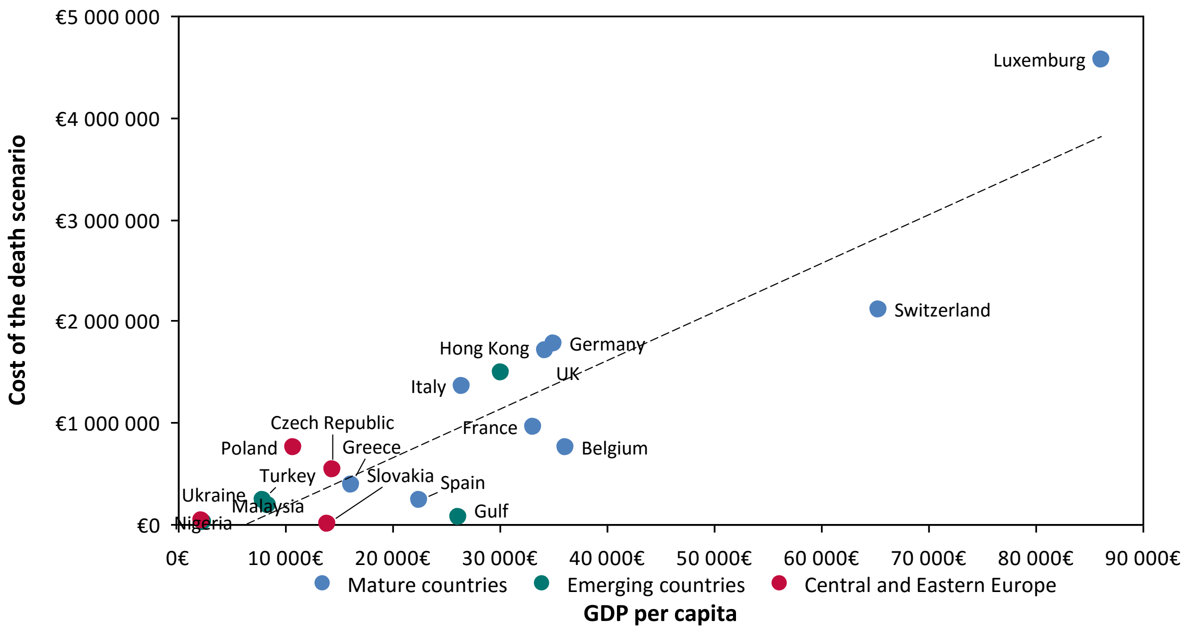


Figure 2-14. Cost of the death scenario in function of the GDP per capita by country

Same results can be obtained with an analysis in function of the GDP per capita. Results seem to fit even better with the linear regression model. A R^2 equal to 0.82 confirms this.

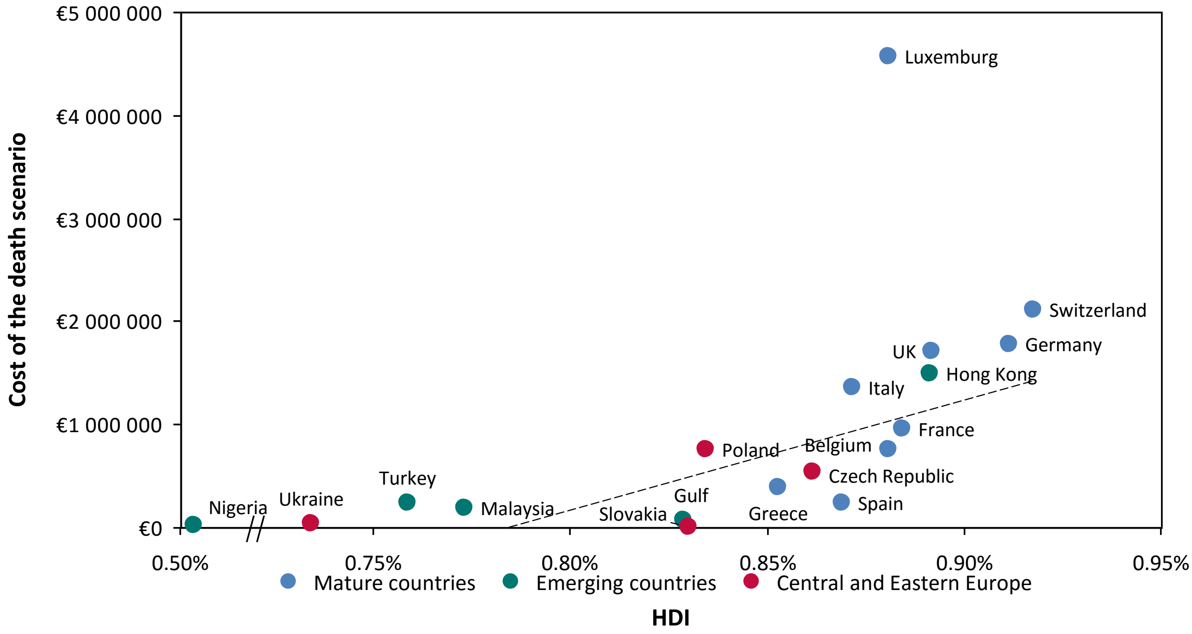


Figure 2-15. Cost of the death scenario in function of the Human development index

The analysis in function of the HDI is more complex, as for the set of countries considered HDI values are quite close one to each other: apart from Nigeria with a HDI of 0.50, all countries have HDI comprised between 0.73 and 0.92.

For the corresponding linear regression, the R^2 coefficient is 0.22, which is the less explicative as compared to the insurance penetration or the GDP per capita.

GDP per capita is thus the most explicative parameter in this case. Similar results are obtained if we look at the quadriplegia scenario, as evidenced on the figure below.

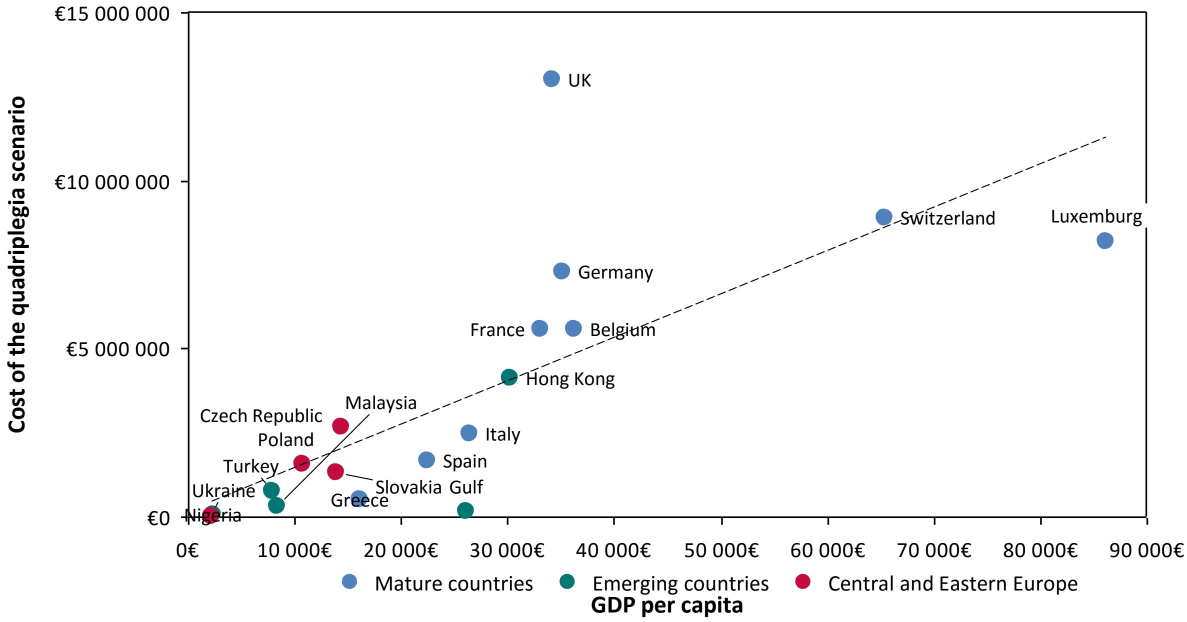


Figure 2-16. Cost of the quadriplegia scenario in function of the GDP per capita by country

Looking at the quadriplegia scenario, the R^2 obtained associated to linear regressions with the same three parameters were the following ones:

- **GDP per capita**: 0.55
- Insurance penetration: 0.49
- HDI: 0.32

These results mean that there is a link between the level of value produced by a country (or purchasing power) – which can be a proxy for the economic development of a country – and the average cost paid by an insurance company in case of death or severe injury.

2.4.2 The specific case of Spain

As evidenced by the previous analyses (notably figures 2-7 and 2-8), Spain reported a lower level of costs as compared to other countries of the same group (mature countries). This can be further evidenced when looking at the linear regressions in function of the GDP per capita (figures 2-14 and 2-16): in both cases, Spain is under the estimated line.

These results reflect a reality in Spain, as the regulation currently applied in Spain ("Baremo") for the calculation of bodily injury costs is considered outdated.

A new regulation will be applied from January 1, 2016, in which the methodology to calculate costs has been reviewed.

In the context of the cost comparison done in the current section of this report, we have also collected from AXA Spain the costs that will apply to the four different scenarios, with the current and the new regulations.

We have performed a comparative analysis of the costs with the old and the new regulations.

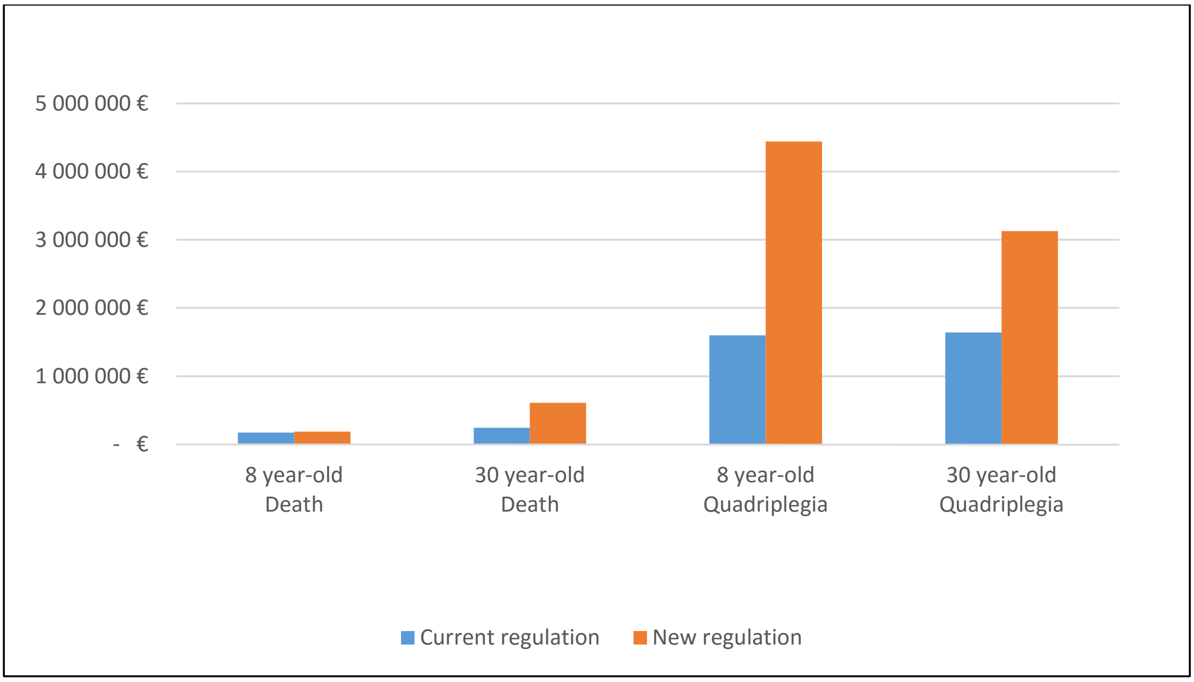


Figure 2-17. Impact of the new regulation on the costs per scenario

This first graph shows that the total level of cost increases for each of the four scenarios considered with the new regulation. The increases are significant for all scenarios, except for the scenario of death of the 8-year-old victim, where the costs remain stable:

Scenario	Old regulation	New regulation	Increase (%)
8-year-old death	170 038 €	184 800 €	9%
30-year-old death	241 975 €	608 543 €	151%
8-year-old quadriplegia	1 598 658 €	4 442 497 €	178%
30-year-old quadriplegia	1 641 378 €	3 127 035 €	91%

Table 2-1. Overview of cost increases due to the new regulation in Spain

For a better understanding of this evolution, it is necessary to look at the evolution of each category of costs. We have chosen to focus on the two scenarios where the cost increase is the most important: death of the 30-year-old man and quadriplegia of the 8-year-old victim.

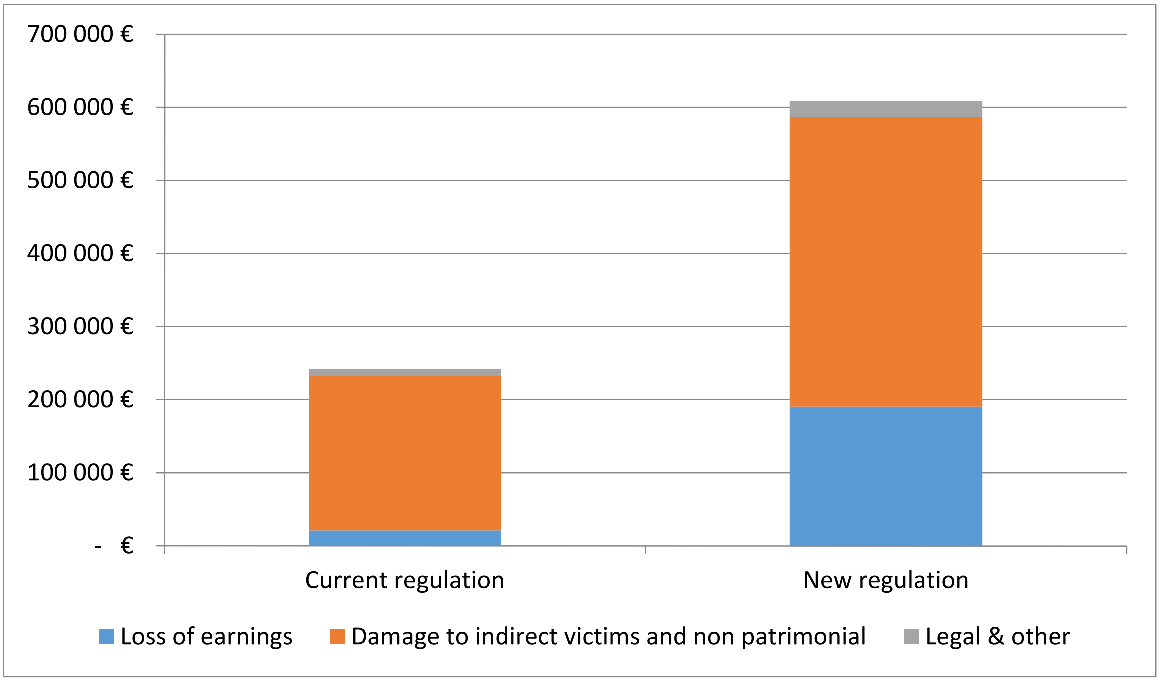


Figure 2-18. Impact of the new regulation – Scenario of death for the 30-year-old victim

For the scenario of death of the 30-year-old man, the increase is explained by a strong increase of damages for indirect victims (prejudice) and the amount aiming at compensating the loss of earnings. Both are calculated taking into account how the entourage of the victim (spouse and children) is composed.

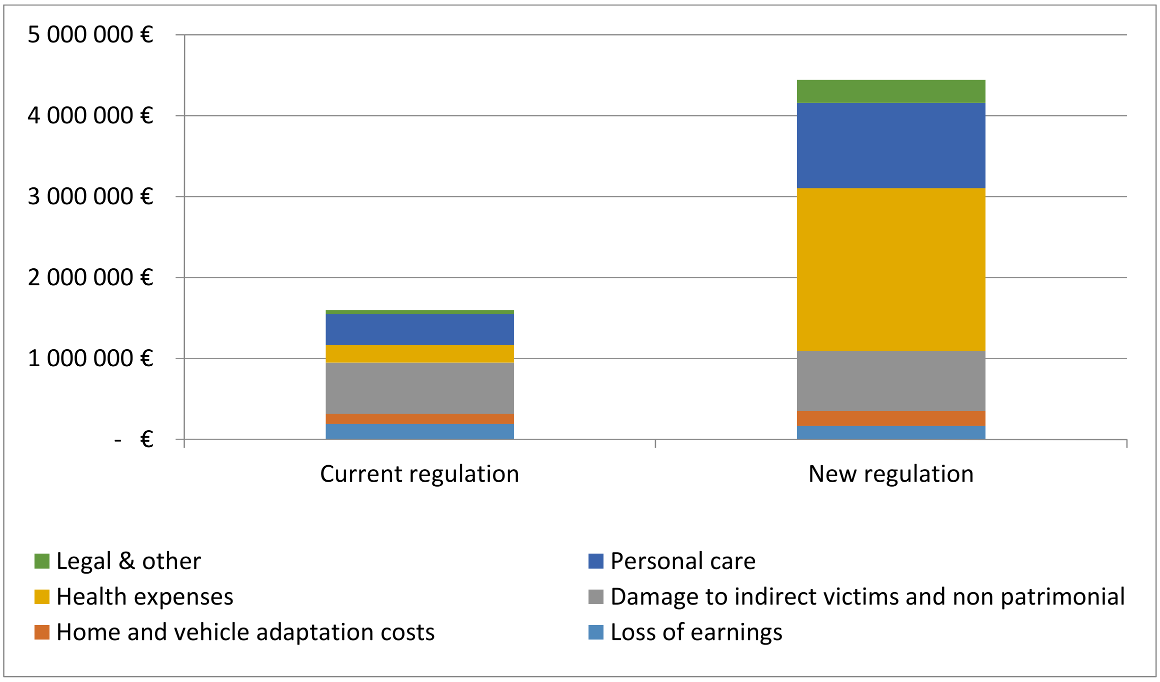


Figure 2-19. Impact of the new regulation – Scenario of quadriplegia for the 8-year-old victim

For the scenario of quadriplegia of the 8-year-old man, the increase is driven by the amount of care and health expenses, while the amount aiming at compensating the damages for relatives, adaptation costs and loss of earnings remain stable.

These results provide a first overview of the change of regulation related to bodily injury costs in Spain, and how it will affect the costs paid by AXA. We will now in the third section of this report explore the details of this regulation change, and estimate more precisely how this change will impact AXA’s reinsurance needs.

3 Change in the bodily injury regulation in Spain

3.1 General context

In Spain, the assessment of harm and damage caused to car accident victims is guided by a regulation (current *Baremo*). This Baremo defines the amount to be allocated to victims or relatives after an accident, in function of:

- Severity of the injury: death or permanent lesions (rated from 1 to 100)
- Age of the victim
- Familial status: spouse or not, children (minor or adults), parents, siblings
- Income of the victim
- In case of permanent lesions: moral damages, necessary adjustments of housing and/or vehicle, etc…
- Duration of a potential hospitalization

In practice, the Spanish system has been criticized both by victims and the insurance industry. One of the reasons for these complaints was the rigidity of the system that generated abuses in some cases and underestimation of compensation to the victims in other cases. This can notably be evidenced by the comparison with other systems in Europe.

In the previous section of this report, we have seen that the level of costs allocated to death of quadriplegia victims was lower in Spain as compared to other European countries. This is notably due to the share of costs related to future elements of the life of the victim or its relative (future health expenses and care, loss of earnings, damages to indirect victims).

A new text has been prepared by a college of experts, and was presented to the Spanish legislature in 2015. As the text has been voted, it shall enter into force on January 1, 2016. This text presents a much more granular methodology to calculate indemnities as compared to the current system, depending on many parameters. For this reason, insurance players have found difficult to estimate the impact of the new regulation on their annual claims amount.

In this section, we will briefly introduce the main changes induced by the new Baremo, and review different impact analyses performed by various actors aiming at estimating the impact of the new regulation.

3.2 Main changes of the new regulation

In general, the new Baremo allows a more individualized compensation than the old one and is based on the idea of a full compensation of the victim. It now clearly distinguishes between pure financial loss and moral damage. Most importantly, the new "Baremo" grants substantially higher compensation amounts for severely injured and death cases. In addition, it broadens the circle of beneficiaries by including also close dependents.

The new Baremo is much more precise and complex than the current one. In practice, the document summarizing the amounts to be taken into account for each specific case is 465 pages long for the new Baremo, versus only 6 pages for the current one.

3.2.1 Comparison of the old and new systems for death

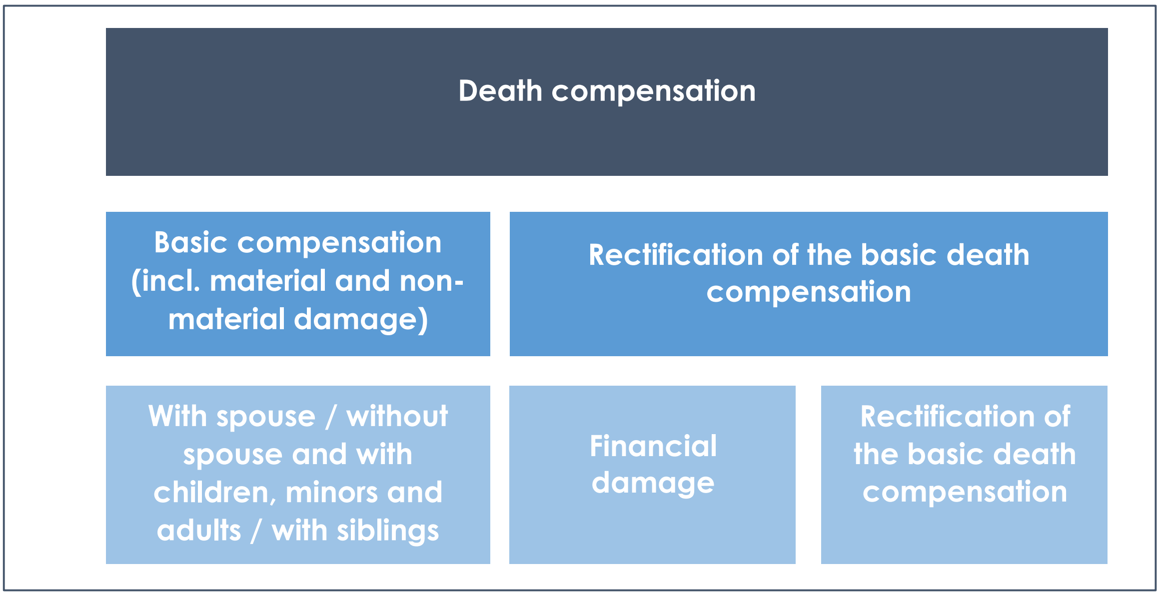


Figure 3-1. General principle of the death compensation (current Baremo)

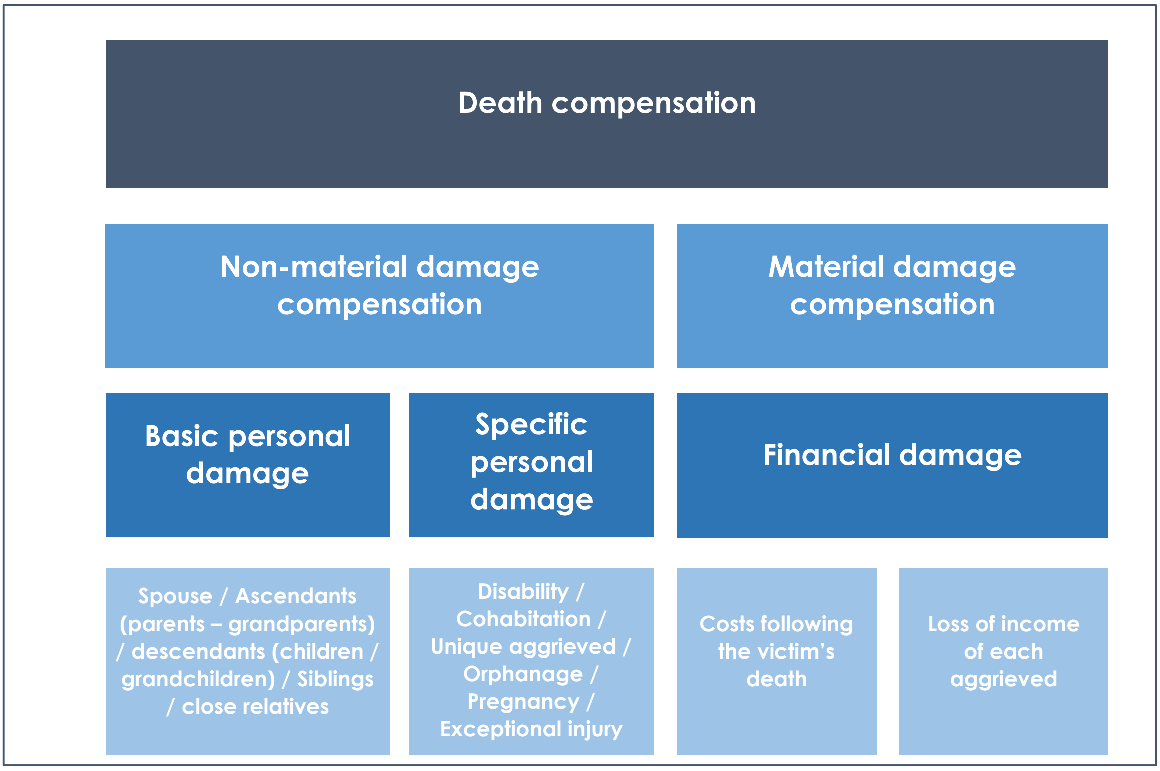


Figure 3-2. General principle of the death compensation (new Baremo)

The new Baremo makes official the notion of two different types of damages:

- **Material** (patrimonial) **damages**: emotional damage to indirect victims caused by the death of a relative, with different levels of loss based on the link between the relatives and the victim

- **Non-material** (non-patrimonial) **damages**: loss of income and financial costs caused by the death of the victim (i.e. funerals), calculated individually for each indirect victim.

This distinction was not formally included in the previous Baremo, which was mainly calculated as:

- A basic compensation aiming at covering both material and non-material damages
- Corrections of the basic compensation based on the individual situations

In practice, additional notions have been introduced in the new Baremo:

- Notion of cohabitation (or not) of the aggrieved with the victim in the calculation of non-material damage
- Unique aggrieved of its category (i.e. only child, only parent)
- Unique family aggrieved (i.e. only relative)
- Death of a single parent
- Basic financial damage (unspecific expenses)

3.2.2 Comparison of the old and new systems for disability

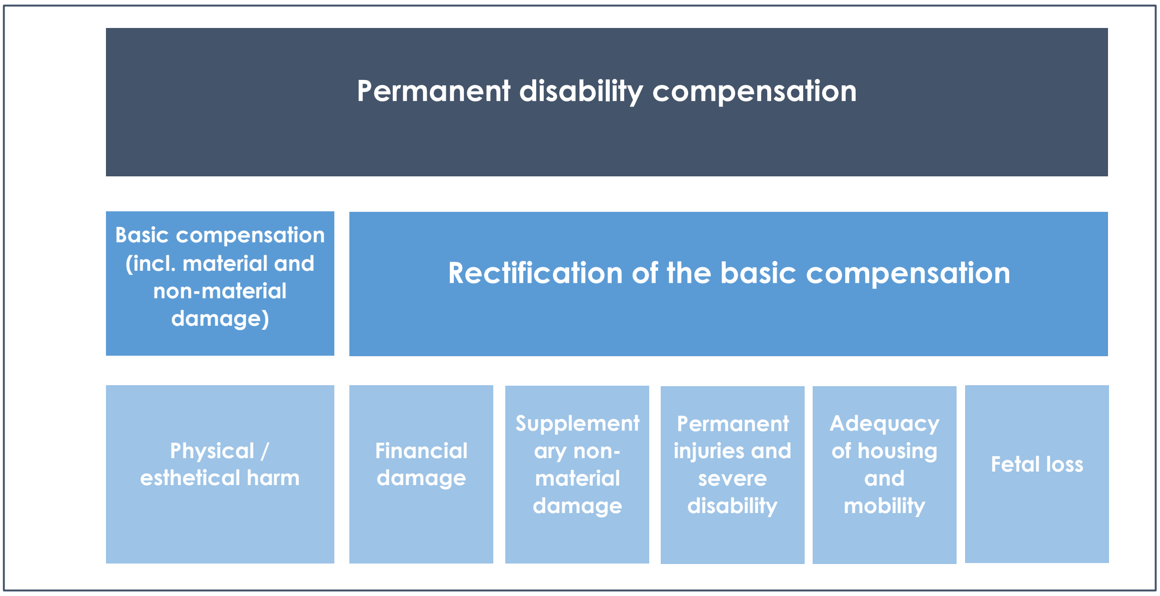


Figure 3-3. General principle of the disability compensation (current Baremo)

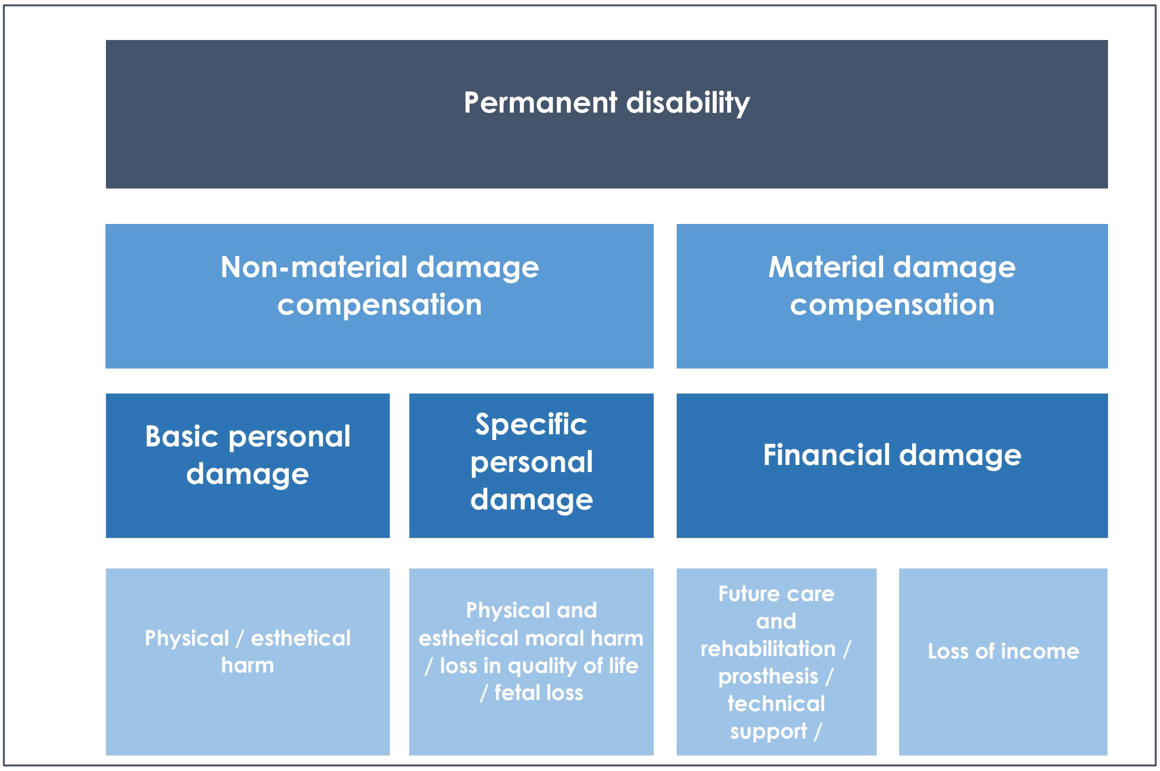


Figure 3-4. General principle of the disability compensation (new Baremo)

As for the death indemnities, the new Baremo makes a distinction between material and non-material damage, which are then estimated based on several criteria related to the victim and severity of the injury.

The current Baremo also works in the case of disability as a basic compensation plus some adjustments aiming at individualizing the amount to each case.

In practice, additional notions have been introduced in the new Baremo:

- Further healthcare linked to the disability
- Prosthesis and orthosis
- Rehabilitation
- Technical assistance

3.3 Review of different impact analyses

As explained below, the new Baremo is a much more precise and complex system as compared to the current one. It needs a lot of information on the victims and its relatives to be able to calculate properly the indemnity. In practice, it means that it is complex to estimate the impact of the new Baremo on a whole portfolio, as the parameters required to calculate the new indemnity are not easily available.

In order to overcome this difficulty, we propose to review different impact analyses that have already been performed by different actors (one broker and two reinsurers) of the Spanish market, and aiming at assessing the impact of the new Baremo on modeled data (using the different parameters necessary to the calculation as variables of the model).

We summarize here the results of different impact analyses performed by Aon, QBE and Swiss Re.

3.3.1 Summary of Aon's results

3.3.1.1 Methodology

50,000 cases have been randomly generated for this quantitative analysis to compensate for the impossibility of having all the necessary information on real cases. The cases were generated in order to be able to measure the impact of certain variables:

- For death: age of the victim and of the aggrieved, civil status, relationship of dependency, employment status, net salary level
- For permanent disability: in addition, lesion points (1-100) for physical and aesthetic harm

Once the sample of cases has been built, the indemnity amounts were calculated both with the current and the new Baremo. Results were then analyzed by relevant reference groups:

- For death: family status (married / single, with ascendants, with descendants, with siblings, with close relatives) and by employment status (employed, unemployed, student, homemaker or retired)
- For permanent disability: severity of the disabilities (0-50; 50-75; > 75 points) and employment status

3.3.1.2 Results – death

	By family status					By employment status				
	with descendants	with spouses	with ascendants	w/o spouses	w/o descendants	Retired	Homemaker	Economically active (employed)	Economically active (unemployed)	Student
Material damage	60.1%	48.7%	47.4%	36.1%	21.2%	64.7%	45.9%	45.8%	45.7%	11.4%
Non-material damage	238.9%	220.1%	144.5%	7.9%	62.5%	128.4%	226.0%	218.0%	158.7%	-57.0%
Total compensation	**79.2%**	**67.7%**	**57.9%**	**32.7%**	**26.2%**	**72.6%**	**65.6%**	**65.2%**	**57.2%**	**4.5%**

Table 3-1. Aon's simulation - variation due to the new regulation (death scenario)

These results illustrate that the expected change in death indemnity will be positive in all the cases studied (on average). In most cases, the increase seems to be stronger for non-material damages. While it's difficult to determine an average increase given the heterogeneity of each case, we consider that the range of average increase in death indemnity is around 40-60% based on these results.

3.3.1.3 Results - disability

	Scale of severity			By employment status				
	50-74	75-100	0-49	Student	Economically active (employed)	Economically active (unemployed)	Homemaker	Retired
Material damage	24.5%	10.7%	24.1%	11.7%	13.6%	13.5%	12.9%	29.6%
Non-material damage	1588.8%	217.1%	351.1%	603.9%	296.2%	296.1%	269.0%	163.3%
Total compensation	**136.2%**	**81.9%**	**49.7%**	**149.1%**	**82.4%**	**81.0%**	**76.8%**	**67.4%**

Table 3-2. Aon's simulation – variation due to the new regulation (disability scenario)

Again for disability indemnities, the increase seems to be positive on average for all the sub-groups considered here. In terms of severity, the amount for lighter injuries (0-49 lesion points) increases less than for more severe injuries.

The average increase in disability indemnity seems to be in the range of 80-120%.

3.3.2 Summary of QBE's results

3.3.2.1 Methodology

Two different fictional cases were used to simulate the impact of the new Baremo (with only the level of income varying between the two scenarios) in case of death.

For severe injuries, QBE's study consisted in analyzing 130,510 past losses, and assessed through both the current Baremo and the past Baremo. Assumptions were taken in order to fill the necessary information not available in the original losses database.

3.3.2.2 Results – death

First case:

- 40-year-old victim with €25,000 annual net income
- 40-year-old spouse (married for 20 years)
- Two children of 8 and 12 years old
- Two parents (without cohabitation nor economical dependency)
- 1 sibling (without cohabitation)

Second case:

- Same case but with €50,000 annual net income

	Case 1: €25,000 annual income			Case 2: €50,000 annual income		
	Current baremo	New baremo	variation	Current baremo	New baremo	variation
Expenses	4 000 €	6 400 €	60%	4 000 €	6 400 €	60%
Moral damage	230 070 €	373 750 €	62%	230 070 €	373 750 €	62%
Loss of revenues	23 007 €	144 063 €	526%	57 518 €	384 851 €	569%
Total	**257 077 €**	**524 213 €**	**104%**	**291 588 €**	**765 001 €**	**162%**

Table 3-3. QBE – variation due to the new regulation (death scenario)

The results here show an increase between 100 and 160%, but are only estimated for the very specific case of the victim being married with two dependent children, which cannot be considered representative of all other cases.

3.3.2.3 Results – disability

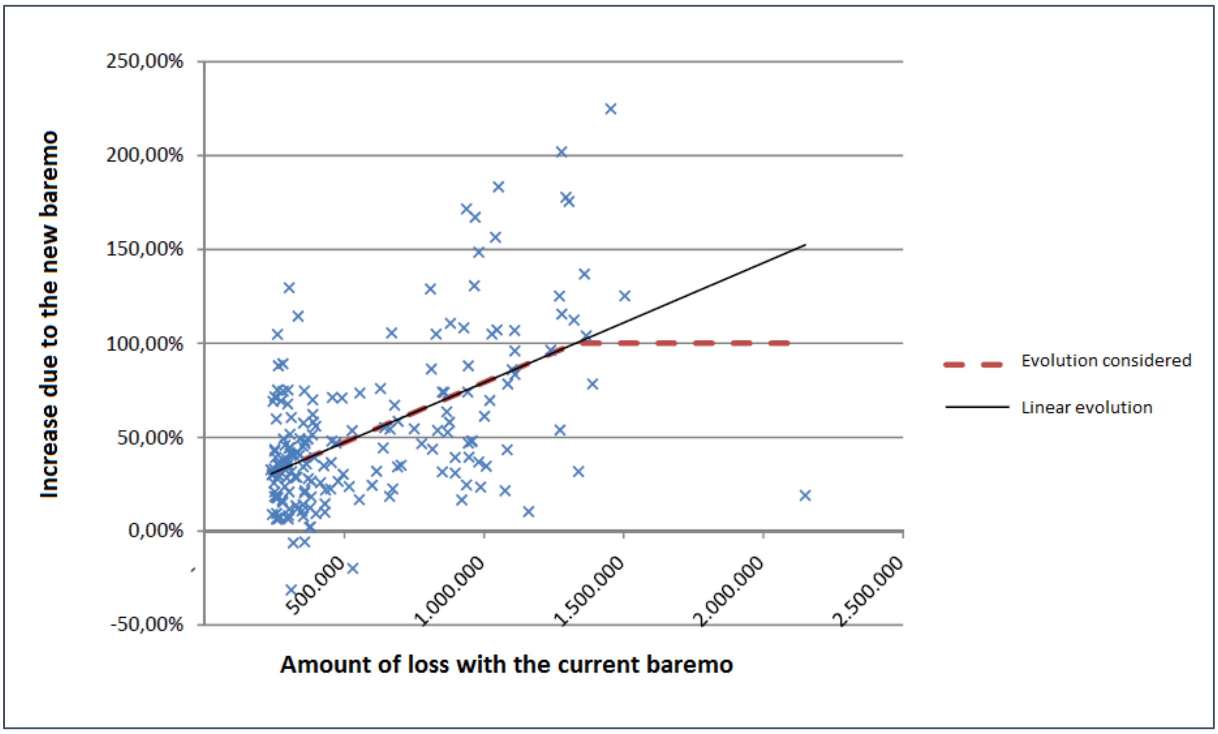


Figure 3-5. QBE – variation due to the new regulation (disability)

QBE has retained in its analysis a linear evolution of losses for amounts between 500k€ and 1.5m€, followed by a plateau at 100% for higher amounts.

3.3.3 Summary of Swiss Re's results

3.3.3.1 Methodology

Different scenarios were considered with the income, age of the victim considered as variables for the death case.

For severe injuries, one scenario was considered.

For midsize injuries, three different cases were considered.

3.3.3.2 Results – death

First scenario: 30-year-old victim with annual income varying from 10,000€ to €60,000

	By annual income					
	10 000 €	20 000 €	30 000 €	40 000 €	50 000 €	60 000 €
Increase	**7.1%**	**35.7%**	**55.2%**	**93.5%**	**150.0%**	**187.9%**

Table 3-4. Swiss Re's results – variation due to the new regulation (death scenario) by annual income

Second scenario: Victim with €30,000 annual income and age varying from 25 to 75 years old

	By age					
	25	30	35	50	60	75
Increase	**38.5%**	**77.8%**	**40.6%**	**25.0%**	**-9.1%**	**-24.2%**

Table 3-5. Swiss Re – increase due to the new regulation (death scenario) by age

Third scenario: 30-year-old victim with annual income of €25,000, married and two children: 47% increase

3.3.3.3 Results – disability

- **Severe injuries**: 30 year-old married with two children – 300% increase
- **Midsize injuries:**

	Number of points of lesion		
	25	50	75
Increase	**-20%**	**83%**	**163%**

Table 3-1. Swiss Re – increase due to the new regulation (midsize injuries) by number of points of lesion

3.3.4 Discussion on the results

The review of the three impact analyses performed by Aon, QBE and Swiss Re reveals the complexity of the new Baremo system, and how variable its impact can be with parameters such as the age or income of the victim.

In the next section of this report, we aim at estimating, for AXA Spain, the financial impact (in terms of reinsurance and capital requirement) of this change in regulation. This estimation will be based on the assessment of previous claims through the new Baremo. As we will not have all the necessary information to properly make this assessment (notably the age of the victims or nature of injuries), we will use average increase factors for death, severe injuries and lighter injuries.

In regards of the three impact analyses reviewed in this section, as well as the analysis of the results submitted by AXA Spain in the section 2.4.2 of this report, we have selected the following increase factors to be used for the rest of this analysis:

- For death costs: 55%
- For severe injuries: 100%
- For lighter injuries: 20%

With these factors we will now assess the impact of the increase in bodily injury costs on motor third party liability in Spain for AXA, based on historical claims data.

4 Application: estimation of the impact of the regulation change for AXA

4.1 General description of the methodology

In this section, we aim at measuring the impact of the new regulation (the new "Baremo") on MTPL bodily injury costs in 2016 for AXA Spain.

In order to do that, we will:

- Study historical claims of AXA Spain
- Estimate the impact of the new regulation on these historical claims
- Use AXA's methodology to model future losses in 2016, based on historical data

4.2 Analysis of AXA Spain historical claims

4.2.1 Description of the available data

AXA Spain shared with us a database including all the MTPL losses year by year, from 2004 to 2015, where each loss exceeded 500 000€. 452 points of observation were included in this database. For each loss, the database comprises the following details:

- Date of loss
- Policy and loss references
- Status (closed / open)
- Number of total victims – *not always reported*
- Number of victims split by severity of the injury (deaths / severe injuries / lighter injuries) – *not always reported*
- Amount of the loss split by severity (same categories than for the number of victims) – *not always reported*
- Development table: for each year from 2004 to 2015, paid amount, outstanding amount and total amount

Illustration

Date of loss	loss id	policy reference	Status	Number of victims	Nuber of deaths	Number of severe injuries	Number of lighter injuries	Amount - deaths	Amount - severe	Amount - lighter	Cost of claim	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
17/11/2004	SI14787	NC SI14787	Closed	N/A							Paid	57	20 023	608 621	608 621	608 621	608 621	608 621	608 621	608 621	608 621	608 621	608 621
											Outstanding	-	-	-	-	-	-	-	-	-	-	-	-
											Total	**57**	**20 023**	**608 621**	**608 621**	**608 621**	**608 621**	**608 621**	**608 621**	**608 621**	**608 621**	**608 621**	**608 621**
18/11/2004	S50802	11091185	Closed	2	0	1	1	0	330 197	7 882	Paid	161	31 067	31 067	31 067	31 067	31 067	31 067	31 067	31 067	331 865	331 865	331 865
											Outstanding	465 757	388 385	808 165	808 165	855 445	855 445	855 445	855 445	855 445	-	-	-
											Total	**465 918**	**419 452**	**839 232**	**839 232**	**886 512**	**886 512**	**886 512**	**886 512**	**886 512**	**331 865**	**331 865**	**331 865**
26/11/2004	SI14788	48170287	Closed	2	0	0	2	0	0	0	Paid	-	28 032	47 577	187 951	188 442	200 904	215 560	218 923	218 923	218 923	218 923	218 923
											Outstanding	122 360	386 867	521 623	381 249	448 250	435 787	-	-	-	-	-	-
											Total	**122 360**	**414 899**	**569 200**	**569 200**	**636 692**	**636 691**	**215 560**	**218 923**	**218 923**	**218 923**	**218 923**	**218 923**
03/12/2004	S45931	NC S45931	Closed	N/A							Paid	-	72 000	433 000	433 000	433 000	433 000	433 000	433 000	433 000	433 000	433 000	433 000
											Outstanding	9 000	806 000	-	-	-	-	-	-	-	-	-	-
											Total	**9 000**	**878 000**	**433 000**	**433 000**	**433 000**	**433 000**	**433 000**	**433 000**	**433 000**	**433 000**	**433 000**	**433 000**
03/12/2004	S65011	NC S65011	Closed	N/A							Paid	354	72 393	795 554	795 554	795 554	795 554	795 554	795 554	795 554	795 554	795 554	795 554
											Outstanding	-	-	-	-	-	-	-	-	-	-	-	-
											Total	**354**	**72 393**	**795 554**	**795 554**	**795 554**	**795 554**	**795 554**	**795 554**	**795 554**	**795 554**	**795 554**	**795 554**
04/12/2004	S42519	55193597	Closed	N/A							Paid	6 000	19 029	513 226	513 226	513 226	513 226	513 226	513 342	513 342	513 342	513 342	513 342
											Outstanding	840 853	1 142 040	-	-	-	-	-	-	-	-	-	-
											Total	**846 853**	**1 161 069**	**513 226**	**513 226**	**513 226**	**513 226**	**513 226**	**513 342**	**513 342**	**513 342**	**513 342**	**513 342**
05/12/2004	S65029	NC S65029	Closed	4	0	1	3	0	279 939	1 059	Paid	52	48 856	50 014	290 014	291 024	291 024	291 024	291 024	291 024	291 024	291 024	291 024
											Outstanding	762 977	597 520	596 362	28 364	27 354	27 354	-	-	-	-	-	-
											Total	**763 029**	**646 376**	**646 376**	**318 378**	**318 378**	**318 378**	**291 024**	**291 024**	**291 024**	**291 024**	**291 024**	**291 024**

Figure 4-1. Extract of AXA Spain's claims database

4.2.2 Data treatment

Our aim is to use this historical claims data to estimate the impact of the new regulation in Spain. In order to do that, we have as a first step needed to clean the data and for each claim estimate the split of losses by types of injuries (death / severe / lighter), as it has not been properly allocated for each loss.

4.2.2.1 Initial cleaning: inflation adjustment

In order to be able to analyze the losses from different years (2004 to 2015), the first step consists in applying an inflation factor to historical losses in order to convert all losses in 2016 amount. This allows to neutralize the time value of money effect (as the value of 1€ in 2004 is different from the value of 1€ in 2016). The following inflation table was used:

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
inflation	3,0%	3,4%	3,5%	2,8%	4,1%	-0,3%	1,8%	3,2%	2,4%	1,4%	-0,2%	-0,5%
multiplier to end of 2015	127,4%	123,7%	119,6%	115,6%	112,4%	108,0%	108,3%	106,4%	103,1%	100,7%	99,3%	99,5%

Table 4-1. 2004-2015 inflation used to retreat historical data

using data available on the OECD website (http://stats.oecd.org/): consumer prices index for Spain.

The multipliers m_k^{2015} to end of 2015 were calculated as follows:

$$m_k^{2015} = \prod_{j=1}^{2015-k+1} (1 + i_j)$$

Where:

- m_k^{2015} is the multiplier to be applied to losses occurred in year k in order to convert them to 2015 euros
- i_j is the inflation in year j

Each loss reported in the database in then converted into 2016 euro amounts, using the multipliers defined above. This simple method does not take into account the precise date of occurrence of losses within the year but is considered sufficient for this exercise.

With all amounts converted in 2016 euros, it is possible to determine some first statistics on this data set:

- The average unit costs of each type of injuries (calculated when possible):
  - For death: 125k€
  - For severe injuries: 571 k€
  - For lighter injuries: 52k€
- The weight of each type of injuries in the total amount of losses (calculated when the split was available)
  - For death: 7%
  - For severe injuries: 75%
  - For lighter injuries: 18%

4.2.2.2 Split by type of loss

For losses where the amount was not split by type of injuries, the following approach was applied to split:

- **According to the number of victims and weight of each type of injuries** (based on the calculation of the average unit costs for losses where all the details were available) – For losses where the number of victims by type of injuries was reported:
    - Average unit cost for death: 125k€
    - Average unit cost for severe injuries: 571k€
    - Average unit cots for lighter injuries: 52k€

In that case the amount of losses allocated to each type of injury is calculated as:

$$Losses_k = \frac{n_k\ Uc_k}{n_{death}\ Uc_{death} + n_{severe}\ Uc_{severe} + n_{lighter}\ Uc_{lighter}} Total\ cost$$

Where:

- $Losses_k$ represents the amount of losses of type k (death, severe or lighter injuries)
- n_k represents the number of victims of type k
- Uc_k represents the unit costs for a victim of type k
- $Total\ cost$ is the total amount of losses reported

- **According to the weight of each type of injuries** (calculated on average for other losses):
    - Total weight of death losses: 7%
    - Total weight of severe injuries losses: 75%
    - Total weight of lighter injuries losses: 18%

In that case the amount of losses allocated to each type of injury is calculated as:

$$Losses_k = w_k Total\ cost$$

Where:

- $Losses_k$ represents the amount of losses of type k (death, severe or lighter injuries)
- w_k represents the weight of losses of type k calculated previously
- $Total\ cost$ is the total amount of losses reported

loss i.d.		Nuber of deaths	Number of severe injuries	Number of lighter injuries	Amount - deaths	Amount - severe	Amount - lighter	Total cost
1	before treatment	2	2	1	?	?	?	3 500 000 €
	after treatment	2	2	1	605 956 €	2 768 006 €	126 039 €	3 500 000 €
2	before treatment	?	?	?	?	?	?	650 000 €
	after treatment	?	?	?	45 500 €	487 500 €	117 000 €	650 000 €

Table 4-2. Illustration of methodology used to allocate costs

After this first step, the data consists in 452 losses observations, split between death, severe and lighter injuries.

4.2.2.3 Application of the inflation due to the new regulation

The second step consists in inflating the losses of the database to simulate the impact of the new regulation. In order to do that, multipliers were chosen based on the different scenarios studied in the section 3.1.2 of this report. The multipliers chosen were:

- For death costs: 55%
- For severe injuries: 100%
- For lighter injuries: 20%

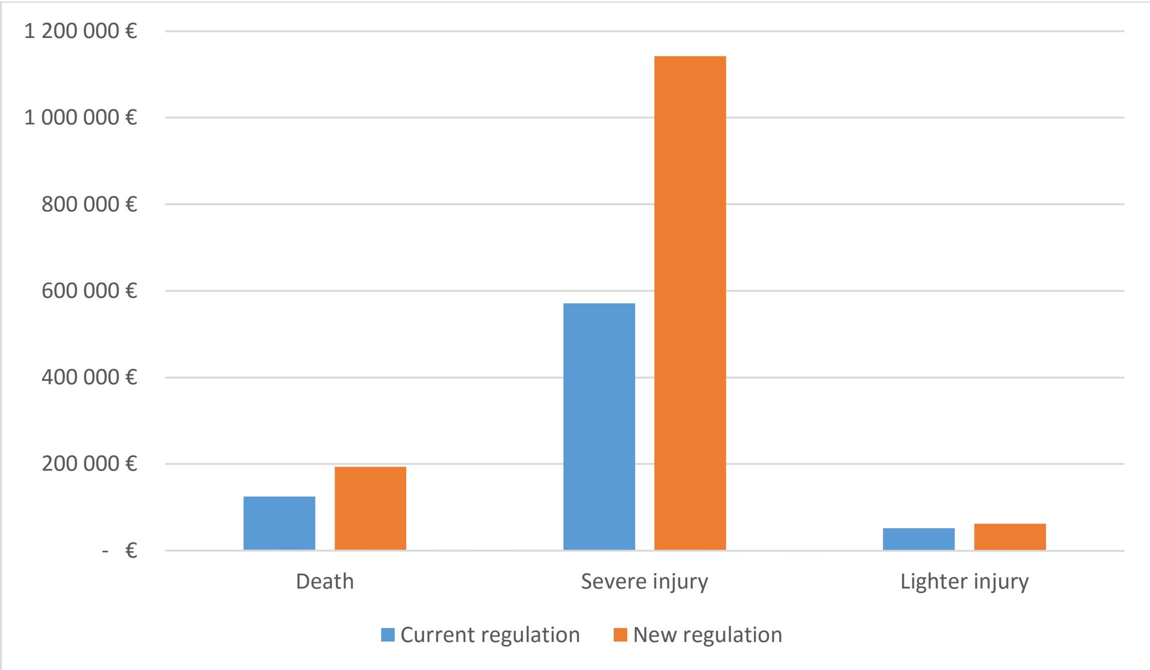


Figure 4-2. Evolution of the average unit costs after application of the new regulation

4.2.2.4 Application to claim development and cancellation of the inflation impact

We have used ultimate amounts of losses to refine the split between the different types of losses reported in the claims database, after having ensured that all the value of money was comparable for the different losses (use of inflation to convert all amounts in end of 2015 euros). The last step consists in:

- Cancelling the impact of inflation on all the losses (as in the next steps we will need to have historical amounts reported with historical values of money): this can be done by applying the reverse operation: each ultimate amount corresponding to an event occurred in year k is divided by m_k^{2015} previously defined.
- For each claim, recalculating the claim development pattern: the *paid, outstanding* and *total* amount of each year of development are adjusted proportionally to make sure that the *total* of the last reported year matches with the ultimate amount previously calculated.

4.3 Modeling of future losses

4.3.1 General description of the methodology

The goal here is to use the historical claims data of AXA Spain (from 2004 to 2015) in order to determine future losses to be expected in 2016.

These future losses will be estimated using the atypical loss modeling used in AXA. As opposed to the Solvency II classification where losses are defined either as natural catastrophes or not, AXA further expands this classification to distinguish between:

- **Attritional losses**: most common losses, with the highest frequency and lowest severity
- **Atypical losses**: major losses with lower frequency, in practice where the amount is above a threshold defined in advance
- **Catastrophe losses:** also considered as atypical losses but modeled using 3rd party models

We consider here that the losses observed in the previous section (4.2) to be more atypical than attritional, due to:

- a relatively low frequency: 452 losses in 11 years, or around 40 event every year
- an important severity by nature, as the database only included losses above 500k€

This analysis will thus consist in determining future losses expected in 2016:

- based on historical data ("as is"), i.e. without considering in inflation of costs due to the application of the new regulation
- based on historical data inflated (as described in section 4.2 of this report) to reflect the impact of the new regulation

We will then be able to measure the impact of the new regulation on losses expected for 2016.

The annual amount of atypical losses S^{Atyp} is estimated using a model based on a frequency x severity approach:

$$S^{Atyp} = \sum_{i=1}^{N^{Atyp}} x_i^{Atyp}$$

Where:

- N^{Atyp} represents the atypical loss frequency of the subject portfolio, meaning the number of atypical Losses per year,
- x_i^{Atyp} represents the individual atypical loss amount, where the x^{Atyp} are identically and independently distributed loss amounts.

As explained above, N^{Atyp} and x_i^{Atyp} will be assessed using the historical method (i.e. calibrated using the observed historical exposure).

In practice, the modeling of future losses (estimation of the frequency and severity parameters) is performed through a dedicated module developed by AXA's Group Risk Management department: Future Losses, which is a module for HARP (a software developed by AXA, that allows to use R modules through a user interface). In the following section, we will explicit the modeling performed by Future Losses for our two scenarios (current regulation and old regulation).

4.3.2 "As-if" retreatment and claims development

4.3.2.1 "As-if" retreatment

In order to use past claims data, and since a loss of €1 which occurred in 1990 is not worth €1 today, it must be revalued as-if it occurred today by taking into account claims inflation.

The goal is to revalue a historical loss as-if this claim occurred during the target year 2016 as shown in the following graph.

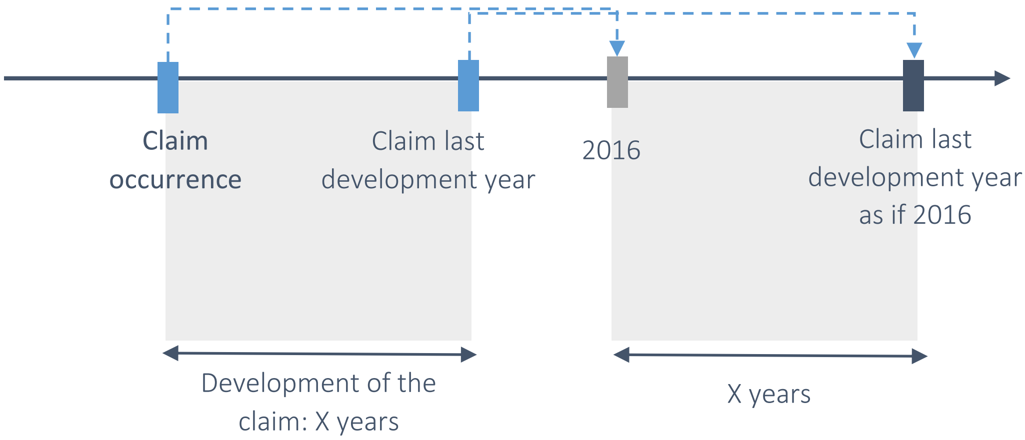


Figure 4-3. As-if » retreatment

The "as-if" treatment is only using the cost inflation (same factors than used in the previous section):

$$\tilde{x}_{i,j}^{k} = \tilde{x}_{i,j-1}^{k} + (x_{i,j}^{k} - x_{i,j-1}^{k}) \times \frac{I_{targetyear+j-1}}{I_{i+j-1}}$$

Where:

- $x_{i,j}^{k}$ denotes the cumulated individual amount of claim k which occurred in year i at development year j
- $\tilde{x}_{i,j}^{k}$ denotes the cumulated individual "as-if" amount of claim k which occurred in year i at development year j
- I_i denotes the claims inflation index at year i

4.3.2.2 Claims development

The amount of a claim evolves over time, from the date when the loss is reported to the closing date. The evolution of the amount over time is called development. Over time, a claim can:

- Evolve in amount especially in long-tailed Lines of Business such as Liability, which is the case we are considering
- Appear late if its year of reporting differs from its occurrence year.

Therefore, when assessing claims at the ultimate through the frequency and severity of a given target year, those effects, called IBNR (Incurred But Not Reported), must be taken into account. They are usually split into two components:

- The **IBNER** (Incurred But Not Enough Reported) which corresponds to uncertainty in the final amount of the claim.
- The **IBNYR** (Incurred But Not Yet Reported) which corresponds to the uncertainty in the number of claims related to one occurrence year.

4.3.2.3 Incurred But Not Enough Reported (IBNER effect)

Since the amount of a claim can evolve over time, the last observed amount of a claim is not necessarily its ultimate amount once the claim is definitely closed. This effect impacts the severity.

In the example below we assume that:

- The average time to close an Atypical claim is four years.
- A loss has been reported three years before the modeling date.
- As a consequence, the loss amount can evolve for one year to reach the ultimate amount.

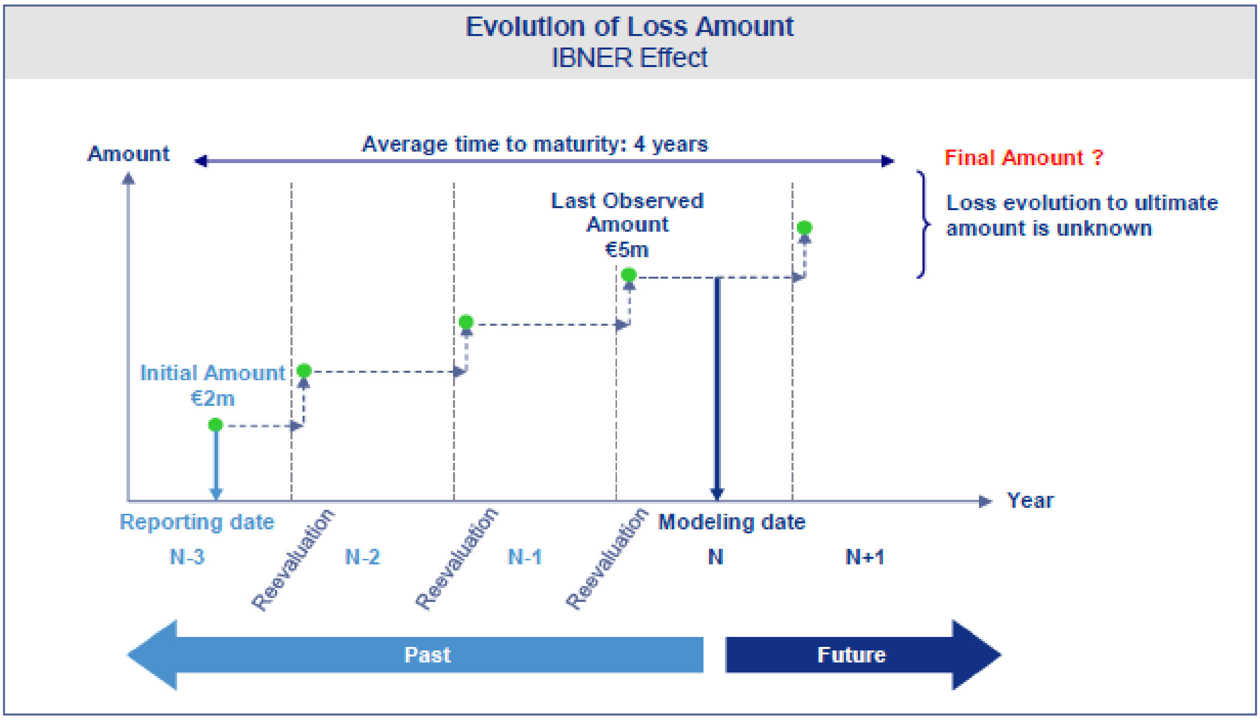


Figure 4-4. Evolution of atypical loss amount

4.3.2.4 Incurred But Not Yet Reported (IBNYR effect)

As an example, at year end, not all losses which occurred in the past year are declared. Typically, losses which occurred on December 31th, 2012 are not claimed instantly but during the year 2013. These losses are to be accounted for with the IBNYR when calculating the ultimate claims number related to year 2012.

The IBNYR effect corresponds to two possible cases:

- Case 1: Since the reporting date of a claim can differ from its occurrence date, the observed frequency can be different from the final one.
- Case 2: As seen with the IBNER effect, a loss amount can evolve over time. A claim below the Atypical threshold could hence increase in valuation at its closing date and become Atypical which will impact the final frequency of Atypical claims. Note that the inverse scenario is also taken into account: a claim which starts off being valued above Atypical threshold could end up below.

In the example below we assume that three Atypical Losses are observed at the modeling date. The time effect adjustments lead to:

- One additional loss due to a time lapse in notification, i.e. the IBNYR effect,
- One loss evolves above the Atypical threshold due to the IBNER effect. Therefore, the total modeled frequency is five losses per year.

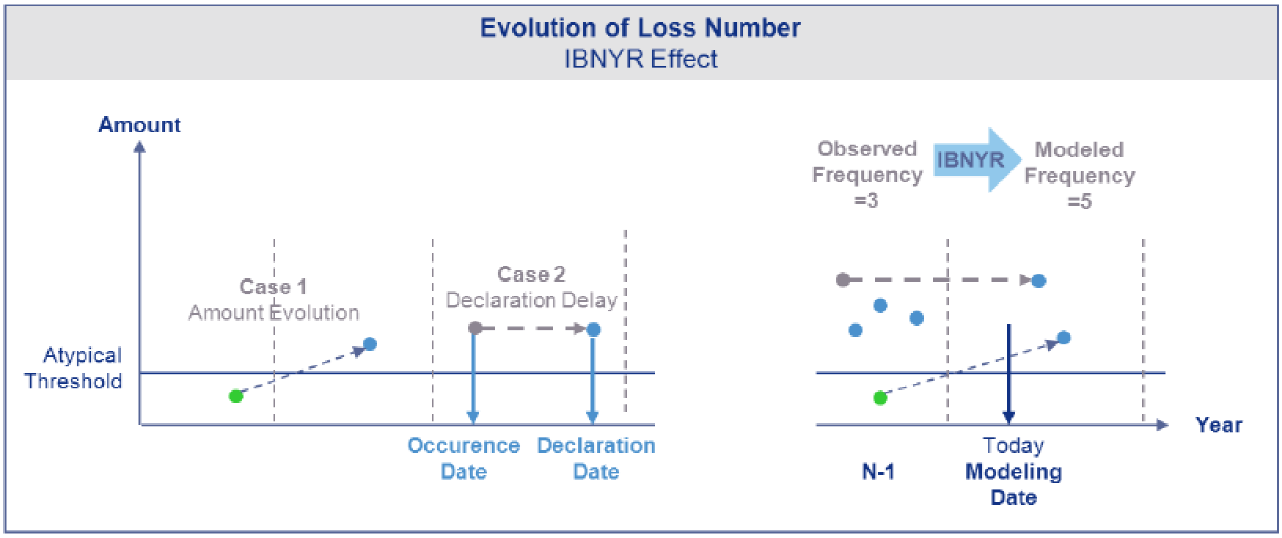


Figure 4-5. Evolution of atypical losses number

4.3.3 Determination of the atypical threshold

An important parameter of the future losses modeling is the atypical threshold: it is the amount above which losses are considered atypical (as opposed to attritional). In the example of the Spanish claim database, we have collected losses above 500k€, which imposes de facto to model threshold above 500k€.

As explained in the previous section of this report (4.3.2), the amount of each loss can evolve over time due to IBNR effects. For that reason, a loss lower than threshold in a given time can later overcome this threshold and become atypical. Reversely, a loss higher than the threshold can later decrease to a lower amount and become attritional.

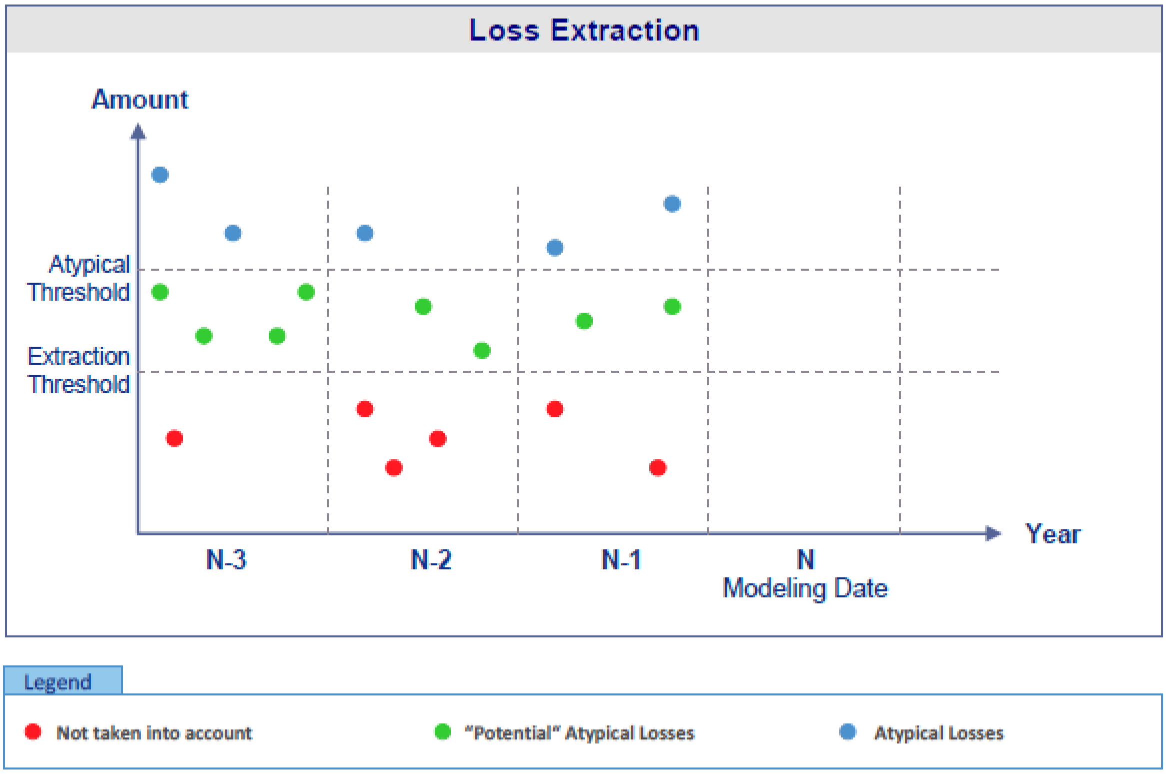


Figure 4-6. Illustration: impact of the atypical threshold on modeled losses

In the example above, we see that the number of atypical losses evolve from 2 in year N-3 to 1 in year N-2 and finally 2 in year N-1.

As illustrated, the choice of the atypical threshold will influence the severity and frequency parameters.

We used a combination of four different methods to select the atypical threshold:

- The Hill plot's method
- The Mean Excess function (MEF)
- Cheng & Peng method
- Bootstrap method

4.3.3.1 Hill plot

Suppose $F \in MDA^{1}(G_\xi)$, with $\xi \geq 0$, Hill plot's method is based on the Hill estimator (Hill, 1975) for the tail index of F

$$\hat{\xi}_{n,k} = \frac{1}{k}\sum_{i=1}^{k} \log X_{n,n-i+1} - \log X_{n,n-k}$$

where k is the number of exceedances (losses higher than the threshold).

[1] Maximum Domain of Attraction

The Hill plot's method consists of plotting $\left\{(\hat{\xi}_{n,k})\middle|k = 2, \dots, n\right\}$ and choosing the optimal k where the Hill plot is stable.

4.3.3.2 Mean Excess Function

The theoretical Mean Excess Function (MEF) for a random variable X is defined as the theoretical mean of excess of X over a threshold:

$$e(u) = E[X - u|X > u]$$

The MEF's method of determining the threshold is to use its specific form when X follows a Generalized Pareto distribution (GPD). Indeed, for a $GPD(\xi, \sigma)$, the corresponding MEF is linear with respect to the threshold u:

$$e(u) = E[X - u|X > u] = \frac{\sigma + \xi.u}{1 - \xi}$$

with $\xi > 1$ to ensure the existence of the theoretical mean.

Furthermore, for a GPD distribution function, conditioning by a higher threshold results again in a GPD with the same shape parameter. That is, if $X \sim GPD(\xi, \sigma, u_0)$, let's define $Y = X|X > u_1$with $u_1 > u_0$

Then, $Y \sim GPD(\xi, \sigma + \xi.(u_1 - u_0), u_1)$

It is straightforward that an empirical counterpart of the MEF can be defined with a sample of losses' amount $X_1, \dots, X_n$ by:

$$e_n(u) = \frac{1}{N_u} \sum_{i \in \Delta_n(u)} (X_i - u)$$

Where $\Delta_n(u) = \{i|i = 1, \dots, n;\ X_i > u\}$ and $N_u = card(\Delta_n(u))$

Since for a sample $X_1, \dots, X_n$ i.i.d with distribution function $F \in MDA(G_\xi)$, the Pickands-Balkema-de Haan Theorem ensures that the distribution function of excesses converges toward a GPD, then a graphical approach for selecting the optimal threshold is to plot

$$\{(u, e_n(u)|u = \min(X_i), \dots, \max(X_i)\}$$

and to choose u such that $e_n(u)$ is linear for $x \geq u$.

This method presents the advantage to be valid for a large class of distribution since the condition includes all MDA families. So, for all kind of generators in Future Losses, the MEF's plot is a suitable way of analyzing the Atypical threshold.

4.3.3.3 Cheng & Peng estimator

The Cheng & Peng method is based on asymptotic properties of the Hill estimator. Indeed,

If $k \to \infty$ and $\frac{k}{n} \to 0$ then $\hat{\xi}_{k,n} \xrightarrow{p} \xi$

In order to obtain an asymptotic normality of the Hill estimator, we assume the assumption that the survival function follows a second order equation:

$$1 - F(x) = c.x^{-\frac{1}{\xi}}(1 + b.x^{-\beta} + \theta(x^{-\beta}))$$

Where:

- F denotes the unknown distribution function of losses
- $c > 0, \xi \geq 0$
- $\beta > 0$ and $b \neq 0$

then

$$\sqrt{k(n)}.\left(\hat{\xi}_n - \xi\right) \xrightarrow{L} N\left(0, \xi^2\right)$$

Knowing that the Hill estimator has a Normal distribution for large thresholds, one can build asymptotic one-sided or two-sided confidence intervals of level for the shape parameter of the

unknown losses' distribution. This approximation allows the prediction of the region in which the shape parameter varies, with a predetermined confidence level.

$$\begin{cases} IC_1(\alpha) = \left[0, \hat{\xi}_n + \frac{z_\alpha.\hat{\xi}_n}{\sqrt{k}}\right] \\ IC_2(\alpha) = \left[\hat{\xi}_n - x_\alpha.\frac{\hat{\xi}_n}{\sqrt{k}}, \hat{\xi}_n - x_\alpha.\frac{\hat{\xi}_n}{\sqrt{k}}\right] \end{cases}$$

where:

- $z_\alpha = P(N(0,1) \leq z_\alpha)$
- $x_\alpha = P(|N(0,1)| \leq x_\alpha) = \alpha$

Cheng & Peng have developed, under the survival function second-order condition, an expansion for the Hill estimator which permits to assess the rate of convergence of the tail index's coverage probability. The theoretical optimal number of Atypical losses is the one which minimizes the absolute value of the coverage error term.

4.3.3.4 Bootstrap estimator

Recall $X_1, \ldots, X_n$ a sequence of i.i.d losses with unknown distribution function F and $\hat{\xi}_{n,k}$ the Hill estimator based on the k upper losses.

$$\hat{\xi}_{n,k} = \frac{1}{k}\sum_{i=1}^{k} \log\left(\frac{X_{n,n-i+1}}{X_{n,n-k}}\right) == \frac{1}{k}\sum_{i=1}^{k} \log X_{n,n-i+1} - \log X_{n,n-k}$$

The objective is to find the value of k which permits the best assessment of the tail behavior of losses data and therefore the more accurate Hill estimator. Given that the survival losses' function is of the following type (Hall & Welsh, 1985)

$$1 - F(x) = cx^{\frac{1}{\xi}}\left(1 + bx^{\frac{\rho}{\xi}} + \theta\left(bx^{\frac{\rho}{\xi}}\right)\right)$$

And

$$U(x) = \frac{1}{1 - F(x)}$$

Using proof provided by de Haan and Peng (1998 paper), we suppose that there exists a function $A(t)$, of constant sign and tends to zero as $t \to \infty$ such as:

$$\lim_{x\to\infty} \frac{\frac{U(tx)}{U(t)} - x^{\gamma}}{A(t)} = x^{\gamma}\frac{x^{\rho}-1}{\rho} \quad \rho \leq 0$$

Where ρ is the second order parameter. Then we have, asymptotically, the following distributional representation for the Hill estimator:

$$\hat{\xi}_{n,k} = \xi + \left(\frac{\xi}{\sqrt{k}}N(0,1) + \frac{1}{1-\rho}A(n_k)\right)^2 = \frac{\xi^2}{k} + \frac{A^2\left(\frac{n}{k}\right)}{(1-\rho)^2}$$

A suitable criterion could be the minimization of the asymptotic minimum square errors

$$AMSE(\hat{\xi}_{n,k}) = E\left(\frac{\xi}{\sqrt{k}}N(0,1) + \frac{1}{1-\rho}A\left(\frac{n}{k}\right)\right)^2 = \frac{\xi^2}{k} + \frac{A^2\left(\frac{n}{k}\right)}{(1-\rho)^2}$$

The task at hand is then to choose the value of that minimizes the of the Hill estimator. Therefore:

$$\sqrt{k_0}A\left(\frac{n}{k_0}\right) \to \frac{\xi(1-\rho)}{\sqrt{-2\rho}}, \text{ as } n \to \infty$$

Danielsson has shown that there exists a function of the second order parameter $D(\rho)$, such that the optimal number of Atypical losses is given by

$$k_0(n) = D(\rho)n^{\lambda}(1 + \theta(1))$$

Where:

- $\lambda = \frac{2\rho}{2\rho-1}$

The bootstrap's method is based on the fact that losses' subsamples have the same tail's behavior than the original losses data.

Let's consider a bootstrap sample $X_1^*, \dots, X_n^*$ with $n_1 < n$, generated independently from the empirical distribution function of the original losses $F_n(x) = \frac{1}{n}\sum_{i\leq n} 1_{\{X_i \leq x\}}$. We denote by $\hat{\xi}_{n,k}^*$the corresponding Hill estimator.

Considering the minimum square error for the subsample bootstrap's Hill estimator

$$MSE(\hat{\xi}_{n_1,k}^*) = E\left[\left(\hat{\xi}_{n_1,k}^* - \xi\right)^2\right]$$

the optimal number of Atypical losses for the bootstrap subsample is of the same form as the one corresponding to the original data with the same function $D(\rho)$ and parameter λ, as long as the subsample size n_1 is of the type $n_1 = \theta(n^{1-\epsilon}), 0 < \epsilon < 1$

$$k_0^*(n_1) = D(\rho)n_1^{\lambda}(1 + \theta(1))$$

Then,

$$\frac{k_0^*(n_1)}{k_0(n)} = \left(\frac{n_1}{n}\right)^{\frac{2\rho}{2\rho-1}} (1+\ \theta(1))$$

We can now use another subsample of different size n_2, to get rid of the second order parameter ρ

$$k_0^*(n_2) = \ D(\rho)n_2^{\lambda}\ (1+\theta(1))$$

Thus,

$$\frac{k_0^*(n_2)}{k_0(n)} = \left(\frac{n_2}{n}\right)^{\frac{2\rho}{2\rho-1}} (1+\ \theta(1))$$

And for every $\alpha > 1$,

$$\frac{[k_0^*(n_1)]^{\alpha}}{k_0^*(n_2)} = \left(\frac{{n_1}^{\alpha}}{n^{\alpha}} . \frac{n}{n_2}\right)^{\frac{2\rho}{2\rho-1}} \left(1+\ \theta(1)\right) = \left(k_0(n)\right)^{\alpha-1}\left(1+\theta(1)\right)$$

It is then enough to choose $n_2 = n\left(\frac{n_1}{n}\right)^{\alpha}$ to get independence in ρ. With $\alpha = 2$, $n_2 = \frac{n_1}{n}$ and we have

$$\frac{[k_0^*(n_1)]^2}{k_0^*(n_2)} = \left(k_0(n)\right)^1\left(1+\theta(1)\right)$$

We must then estimate the $k_0^*(n_i), i = 1,2$ to get an estimate of the number of Atypical losses in the original set of data. For this purpose, we need an initial value of k, denoted k_{aux}, such that $\hat{\xi}^*_{n,k_{aux}}$ is a consistent estimator of ξ. We can then introduce a minimum square error criterion measuring a quadratic distance between the bootstrap subsample Hill estimator and the Hill estimator based on k_{aux} exceedances:

$$MSE(n_i, k) = E\left[\left(\hat{\xi}^*_{n,} - \hat{\xi}^*_{n,k_{aux}}\right)^2\right], i = 1,2$$

It can be shown that $MSE(n_i, k)$ is minimal at a value $k_0^{**}(n_i)$ asymptotically equivalent to $k_0^*(n_i)$. Then, by replacing $k_0^{**}(n_i)$ by its empirical counterpart,

$$k_0^{**}(n_i) = \arg \min_{1 \le k \le n-1} Empirial\_MSE(\,n_i, k)$$

one gets an estimate of the optimal number of Atypical losses

$$\hat{k}_0(n, k_{aux}, n_1) = \left[\frac{\left(k_0^{**}(n_1)\right)^2}{k_0^{**}(n_2)}\right]$$

4.3.3.5 Threshold estimation – application to the current regulation

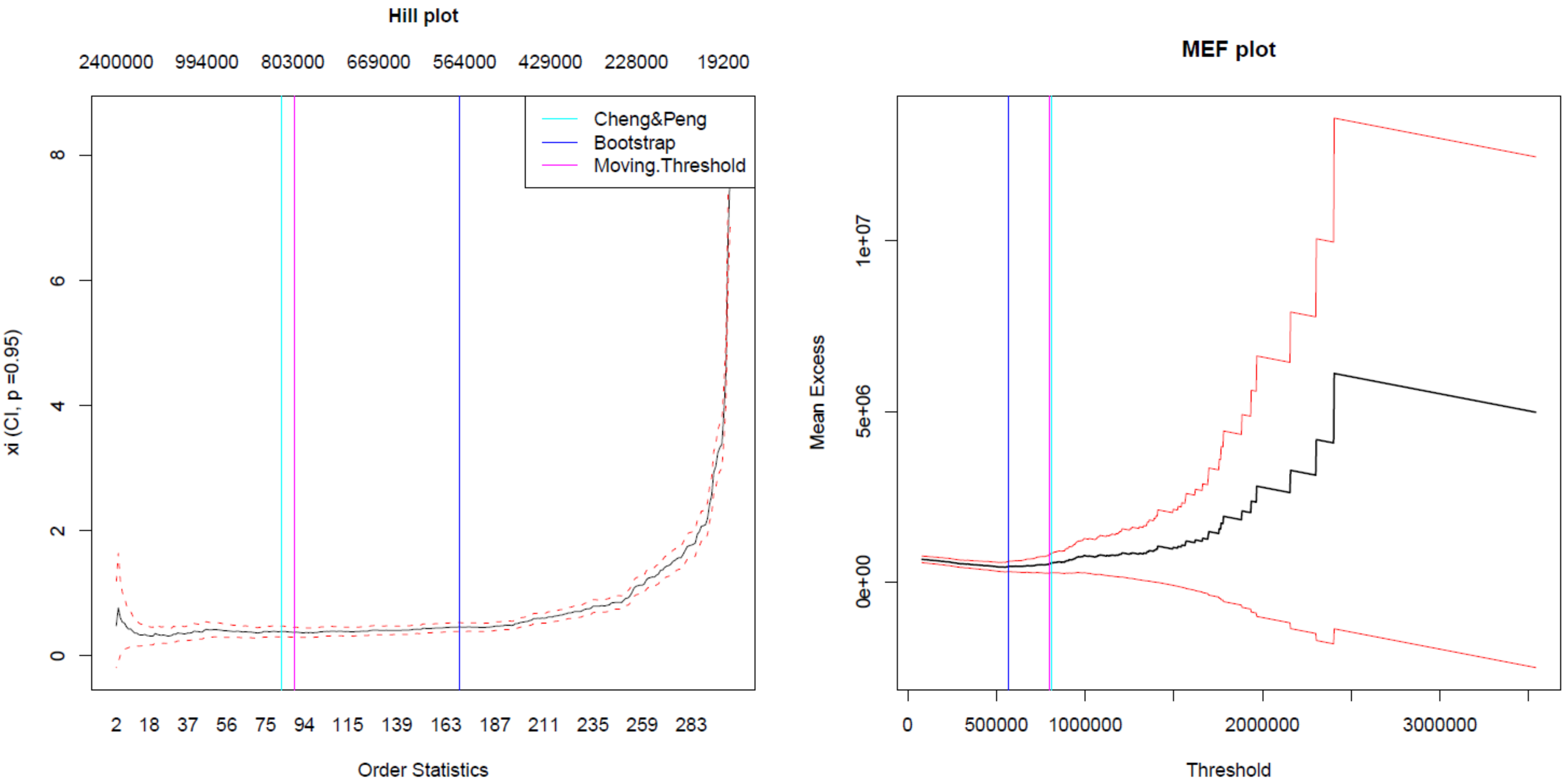


Figure 4-7. Estimation of the atypical threshold - current regulation

4.3.3.6 Threshold estimation – application to the new regulation

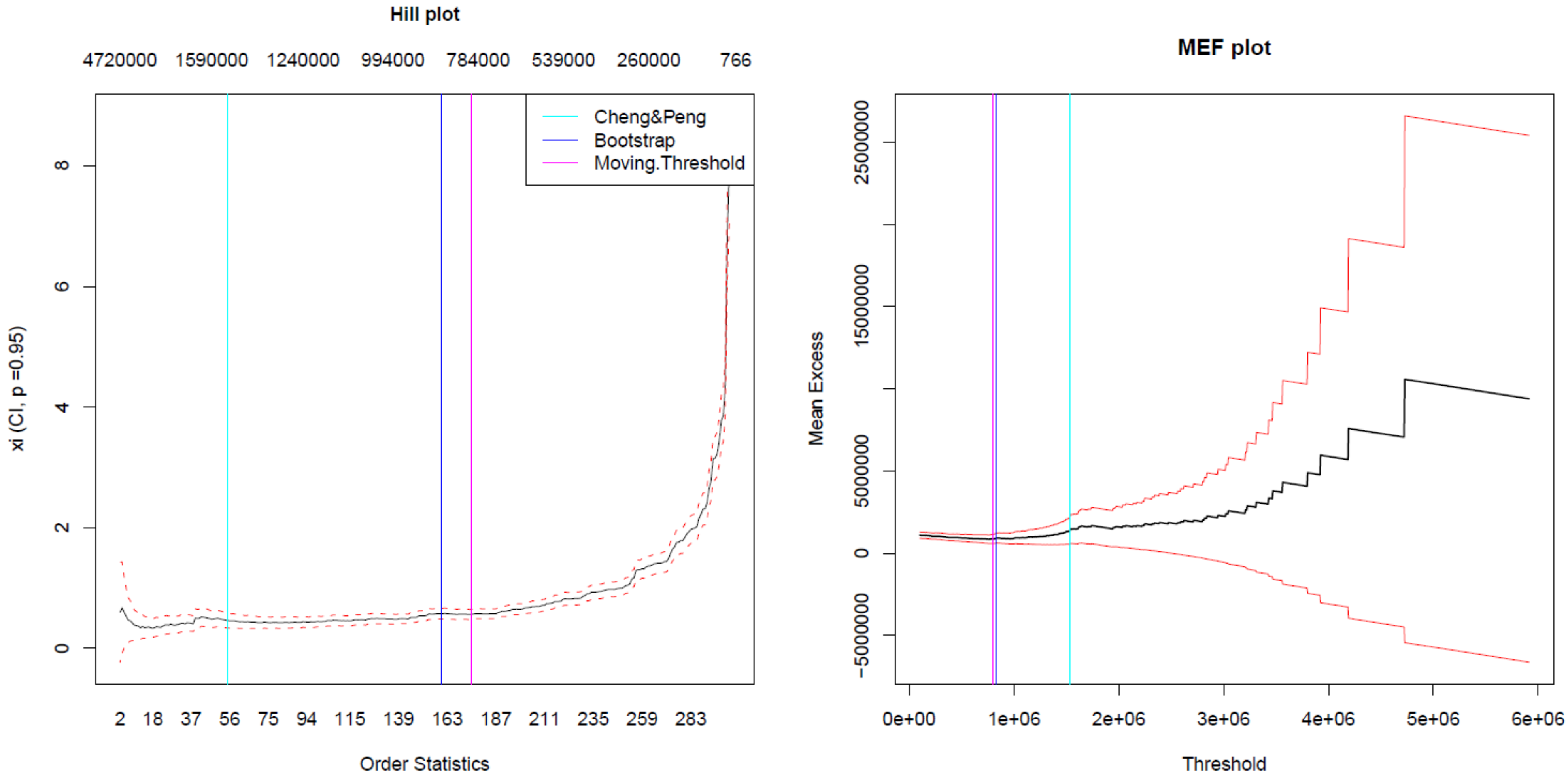


Figure 4-8. Estimation of the atypical threshold – new regulation

4.3.3.7 Discussion on the results

A study of the results provided by the four different methodologies previously presented give the following information:

- For the data based on the current regulation:
    - The atypical threshold estimated by the Bootstrap method is 566k€ with 170 exceedances
    - The atypical threshold estimated by the Cheng & Peng method is 811k€ with 83 exceedances
    - The use of the Hill plot (looking at the zone where the curve is flat) indicates that the threshold can be set between the two borders defined by Bootstrap and Cheng & Peng
    - The MEF method (identification of the zone where the curve is as stable and flat as possible) indicates that the ideal threshold is around 750k€

- For the data based on the new regulation:
    - The atypical threshold estimated by the Bootstrap method is 832k€ with 160 exceedances
    - The atypical threshold estimated by the Cheng & Peng method is 1,530m€ with 55 exceedances
    - The use of the Hill plot (looking at the zone where the curve is flat) indicates that the threshold can be set between the two borders defined by Bootstrap and Cheng & Peng
    - The MEF method (identification of the zone where the curve is as stable and flat as possible) indicates that the ideal threshold is around 1m€

These results must be used to set the atypical threshold, which will be the basis of the modeling of future losses.

In order to be comparable, we would like to select a common threshold for the losses modeled based on the current regulation, and the new regulation. We retain a threshold of 800k€ which seems adapted to both sets of data according the results above. As for the new regulation, the MEF and Cheng & Peng suggest that the ideal threshold is around 1m€, we propose to study a second scenario for the new regulation, where the atypical threshold is set to 1m€.

For the rest of this report, we will then consider the three following scenarios for the modeling of future losses:

- Scenario A: use of the data “current regulation” with an atypical threshold of 800k€
- Scenario B1: use of the data “new regulation” with an atypical threshold of 800k€
- Scenario B2: use of the data “new regulation” with an atypical threshold of 1m€

4.3.4 Frequency assessment

The second important parameter of the model is the frequency of atypical losses, i.e. the expected number of losses to be above the threshold determined earlier. We will in this section estimate by which law can the frequency be modeled, for the three scenarios (A, B1 and B2) mentioned above.

The aim of this section is to determine the law of N^{Atyp} used in the calculation of the total atypical losses presented earlier:

$$S^{Atyp} = \sum_{i=1}^{N^{Atyp}} x_i^{Atyp}$$

Where:

- S^{Atyp} is the annual amount of atypical losses,
- N^{Atyp}represents the atypical loss frequency of the subject portfolio, meaning the number of atypical losses per year,
- x_i^{Atyp} represents the individual atypical loss amount, where the x^{Atyp} are identically and independently distributed loss amounts.

4.3.4.1 Methodology

As previously detailed claim amounts are now on an "as-if" basis. Based on the claims development two matrices are created: $N = (N_{i,j})$ and $D = (D_{i,j})$.

For year i and development year j, $N_{i,j}$ is the number of new Atypical claims at year i and development year $j-1$. So $N_{i,j}$ is the number of claims which reach the threshold at the year of occurrence i. Mathematically,

$$N_{i,1} = \sum_{l=1}^{k_i} 1_{\{x_{i,1}^l \geq T\}}$$

$$N_{i,j} = \sum_{l=1}^{k_i} 1_{\{x_{i,j-1}^l < T\} \cap \{x_{i,1}^l \geq T\}} \text{ for } j \geq 2$$

Where:

- k_i is the number of losses occurred in year i
- T is the atypical threshold

Note that a claim can cross the threshold at multiple dates. For example, a claim can decrease in size and fall below the Atypical threshold between two dates.

For year i and development year j, $D_{i,j}$ is the number of new attritional claims which were Atypical at year i and development year j. In other words, it is the number of Atypical claims which fall under the threshold. So, the number of claims which are below the threshold at $D_{i,1}$ must be 0. Mathematically,

$$D_{i,1} = 0$$

$$D_{i,j} = \sum_{l=1}^{k_i} 1_{\{x_{i,j-1}^l \geq T\} \cap \{x_{i,1}^l < T\}} \text{ for } j \geq 2$$

We introduce $X = (X_{i,j})$ which is defined by $X = N - D$. It is the net number of claims which reach the threshold at year i and development year j. Mathematically, its cumulated version is written as

$$X_{i,1} = N_{i,1}$$

$$X_{i,j} = X_{i,j-1} + N_{i,j} - D_{i,j} \text{ for } j \geq 2$$

We also denote H_k the information at year k. The information of today is the triangle we have. To simplify, we will always write H which is the knowledge before the observation of a corresponding random variable ($k = i + j - 1$).

4.3.4.2 IBNYR coefficients

Let's take three assumptions for the following:

$\mathcal{H}_1$: We suppose that each year is independent. It means that, for two different years i_1 and i_2, the observation of $(X_{i_1,1}, \dots, X_{i_1,n})$ is independent of $(X_{i_2,1}, \dots, X_{i_2,n})$.

$\mathcal{H}_2$: For each year of occurrence i, and year of development j, knowing the past, $N_{i,j}$ is on average linear to the exposure of date i. The linear coefficient does however not depend on i. Mathematically,

$$\mathbb{E}(N_{i,j}|H) = \lambda_j E_i$$

This translates the main hypothesis of Schnieper's article: the number of new claims does not depend on the past history or on the current number of claims but on the exposure.

$\mathcal{H}_3$: For each year of occurrence i, year of development j, knowing the past, $D_{i,j}$ is on average linear to the number of claims which are above the threshold for the year of occurrence i and the development year j. The linear coefficient does not depend on i. Mathematically,

$$\mathbb{E}(D_{i,j}|H) = \delta_j X_{i,j-1} \text{ for } j \geq 2$$

Intuitively, if each claim at development year j has a probability δ_j to fall under the threshold, then the expected number is $\delta_j X_{i,j-1}$.

Since the coefficients $(\lambda_j)_{1 \leq j \leq n}$and $(\delta_j)_{2 \leq j \leq n}$are unknown, they are estimated as follows,

$$\hat{\lambda}_j = \frac{\sum_{i=1}^{n+1-j} N_{i,j}}{\sum_{i=1}^{n+1-j} E_i}$$

$$\hat{\delta}_j = \frac{\sum_{i=1}^{n+1-j} D_{i,j}}{\sum_{i=1}^{n+1-j} X_{i,j-1}}$$

These estimators are unbiased under $\mathcal{H}_1$, $\mathcal{H}_2$ and $\mathcal{H}_3$.

4.3.4.3 Projection of claims

According to the definition of X, N and D,and the hypothesis $\mathcal{H}_1, \mathcal{H}_2$ and $\mathcal{H}_3$, we have:

$$\mathbb{E}(X_{i,j}|H) = (1-\delta_j)X_{i,j-1} + \lambda_j E_i$$

In order to estimate the unknown part of the triangle, we introduce the estimators defined above.

$$\hat{X}_{i,j} = (1-\hat{\delta}_j)\hat{X}_{i,j-1} + \hat{\lambda}_j E_i$$

This iterative formula allows to estimate the ultimate value $\hat{X}_{i,n}$. This gives the ultimate frequency vector.

4.3.4.4 Mean and variance fitting

The estimator of the ultimate mean is

$$\hat{\lambda} = \frac{\sum_{i=1}^{n} X_{i,n}}{\sum_{i=1}^{n} E_i}$$

$$mean = \hat{\lambda} E_{n+1}$$

The estimator $\hat{\lambda}$ is the best weighted mean under the hypothesis $\mathcal{H}_1, \mathcal{H}_2$ and $\mathcal{H}_3$ and according to the assumption for the variance. Moreover, under the Poisson assumption, the estimator of the mean is efficient: the best unbiased estimator among all unbiased estimator.

For the variance, we assume that

$$Var(X_{i,n}) = \sigma^2 E_i$$

We deduce the estimator

$$\widehat{s^2} = \frac{1}{n-1}\sum_{i=1}^{n}\frac{(X_{i,n} - \hat{\lambda}E_i)^2}{E_i}$$

$$var = \widehat{s^2} E_{n+1}$$

4.3.4.5 Frequency fitting

To assess the frequency of Atypical losses, the empirical distribution built is then tested against two distributions in order to see which one fits best:

- The Poisson(λ) distribution
- The Negative Binomial(r, p) distribution

Fit of the distribution is assessed through a comparison of the mean and variance.

4.3.5 Severity assessment

Now that we have assessed the distribution for the frequency, the same exercise must be done for the severity.

4.3.5.1 IBNER Coefficients

The IBNER coefficients are computed as a basic chain ladder with individual claim amounts above an IBNER threshold. We denote $x_{i,j}^{k}$ the amount of a claim whose unique ID is and which occurred at year i viewed at development j. The basic chain ladder coefficient for development is given by:

$$\hat{\delta}_j = \frac{\sum_{i,k} x_{i,j}^{k}}{\sum_{i,k} x_{i,j-1}^{k}}$$

As we model losses above an atypical threshold, the chain ladder is derived with constraints:

$$\forall j, \quad \hat{\delta}_j = \frac{\sum_{i,k} x_{i,j}^{k}}{\sum_{i,k} x_{i,j-1}^{k}} \quad \forall j \forall k \mid x_{i,j}^{k} > T \;\&\; x_{i,j-1}^{k} > T$$

Where T is the IBNER threshold.

Since the drop/increase of the claim size which triggers a change of state of the claim (i.e. attritional vs Atypical) is already taken into account in the IBNYR, it is excluded from the IBNER analyses and therefore IBNER and IBNYR are consistent.

4.3.5.2 Severity fitting

The retreated ("as-if retreatment") and projected ("IBNER projection") Atypical losses are used to build an empirical distribution. Selecting the severity distribution corresponds to "fitting" this empirical distribution to a theoretical one.

Five distributions are available for the modeling of Atypical loss costs in the tool used by AXA:

- The empirical distribution
- The Lognormal distribution
- The Generalized Pareto distribution
- The Right Truncated Pareto distribution
- The Weibull distribution

The choice of the best fitting distribution is done:

- graphically with the help of the Q-Q plots
- numerically by comparing different distances (Kolmogorov-Smirnov and Cramér–von Mises).

4.3.6 Results

4.3.6.1 Scenario A – current regulation with €800k atypical threshold

For this scenario, the claims development and number of atypical losses observed are the following one:

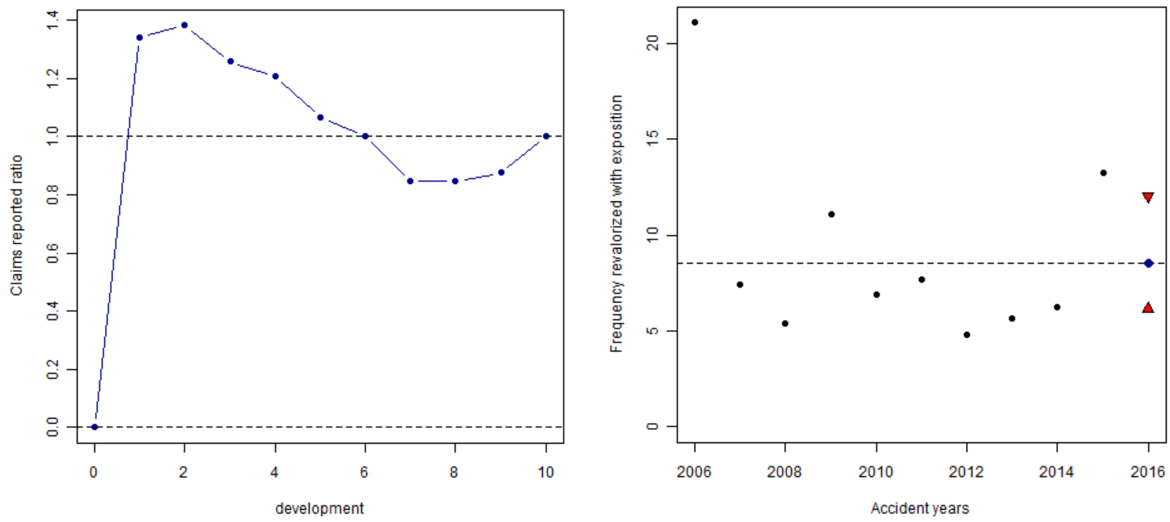


Figure 4-9. Claims development pattern and historical frequency (scenario A)

The empirical distribution of the frequency can be plotted:

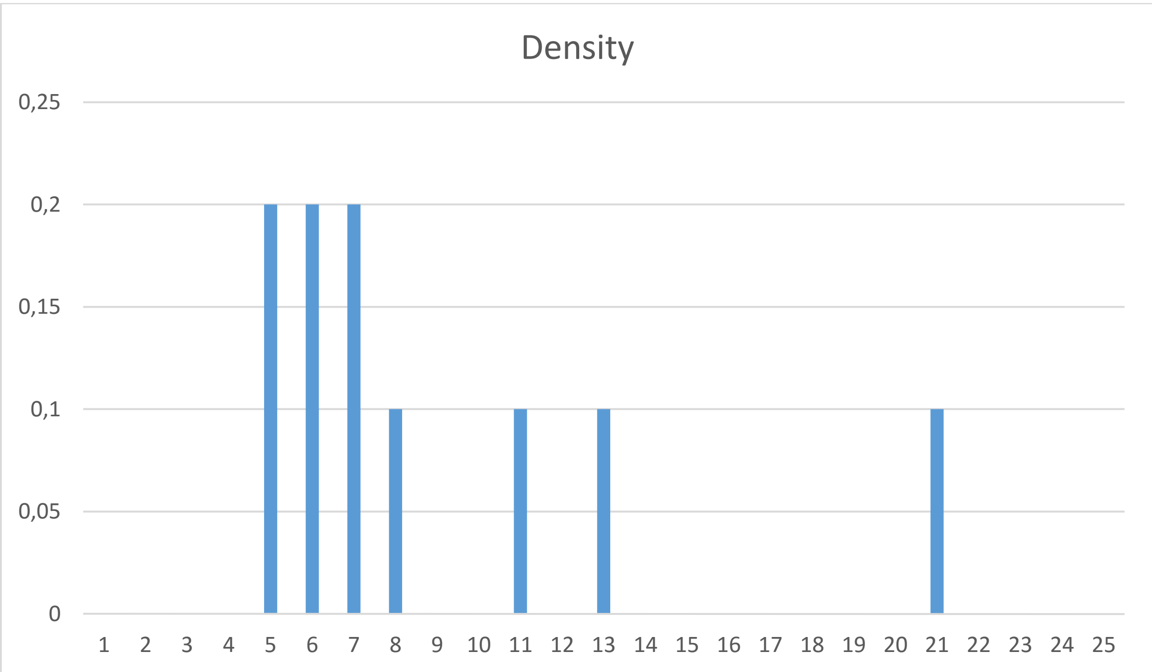


Figure 4-10. Density plot for the frequency distribution (scenario A)

The estimated mean and variance for the frequency are:

- Mean: 8.55
- Variance: 26.73

Given that the variance is higher than the mean, we chose to model the distribution with a negative binomial distribution (r, p). The parameters are:

- $r = 4.02$
- $p = 0.32$

For the severity, we chose a Generalized Pareto distribution (μ, σ, ξ), where:

- The location μ is equal to 800k€
- The scale σ is equal to 302 884€
- The shape ξ is equal to 0.42

4.3.6.2 Scenario B1 – new regulation with €800k atypical threshold

For this scenario, the claims development and number of atypical losses observed are the following one:

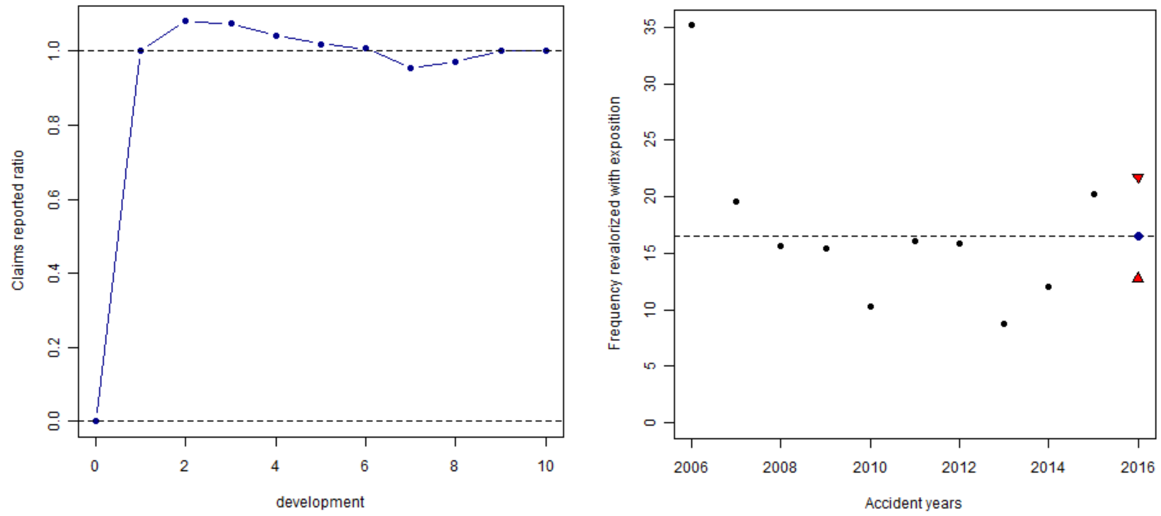


Figure 4-11. Claims development pattern and historical frequency (scenario B1)

The density of the empirical distribution of the frequency can be plotted:

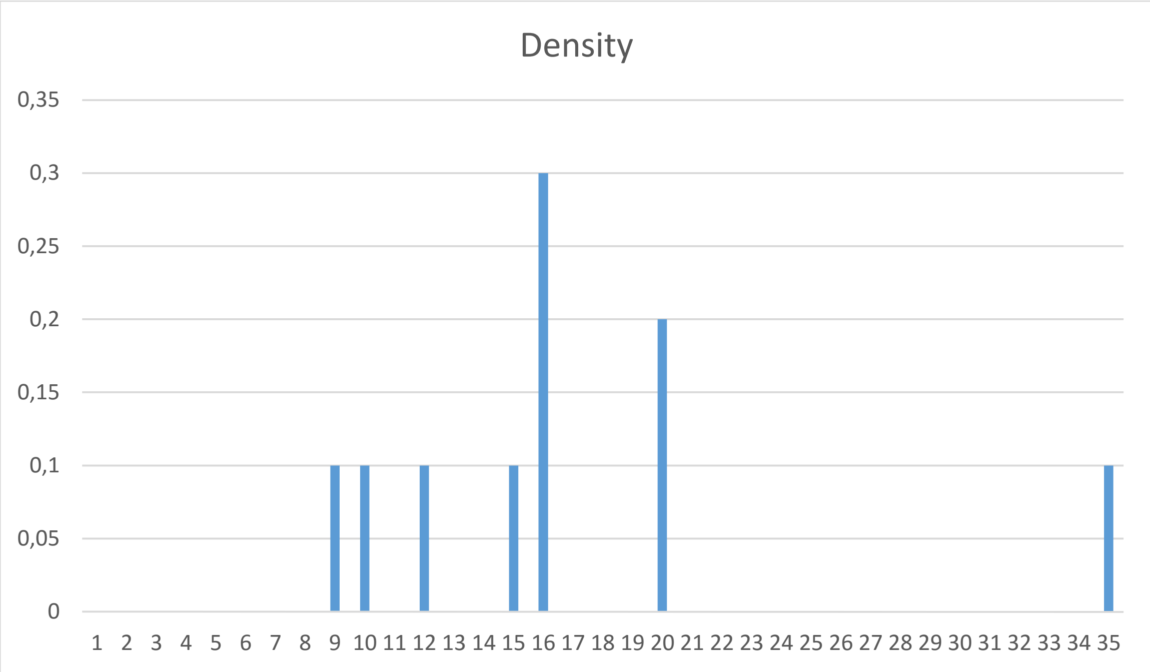


Figure 4-12. Density plot for the frequency distribution (scenario B1)

The estimated mean and variance for the frequency are:

- Mean: 16.56
- Variance: 61.22

Given the important difference between the mean and variance, we also chose to model the distribution with a negative binomial distribution (r, p). The parameters are:

- $r = 6.14$
- $p = 0.27$

For the severity, we chose a Generalized Pareto distribution (μ, σ, ξ), where:

- The location μ is equal to 800k€
- The scale σ is equal to 574 146€
- The shape ξ is equal to 0.30

4.3.6.3 Scenario B2– new regulation with €1m atypical threshold

For this scenario, the claims development and number of atypical losses observed are the following one:

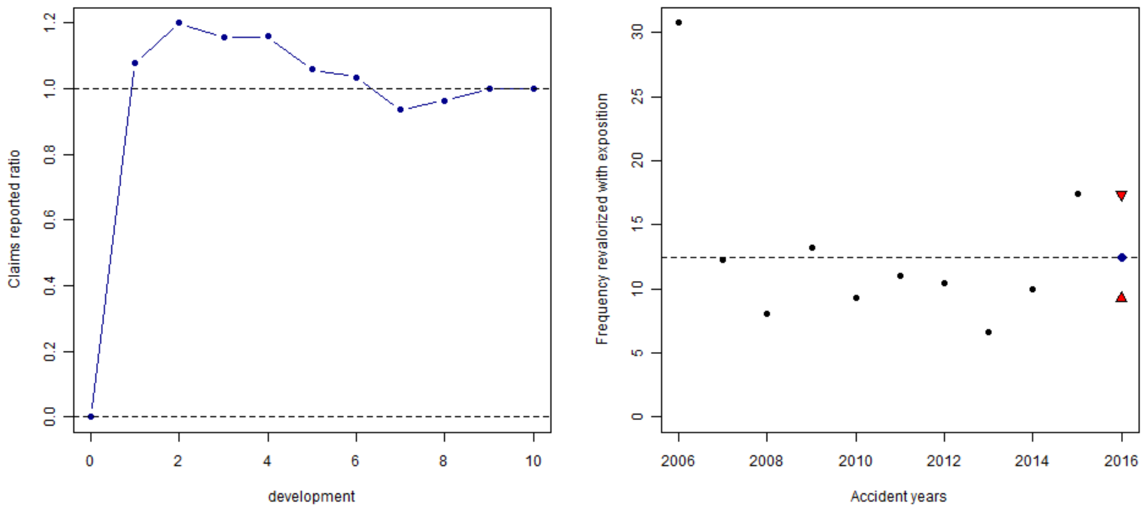


Figure 4-13. Claims development pattern and historical frequency (scenario B2)

The empirical distribution of the frequency can be plotted:

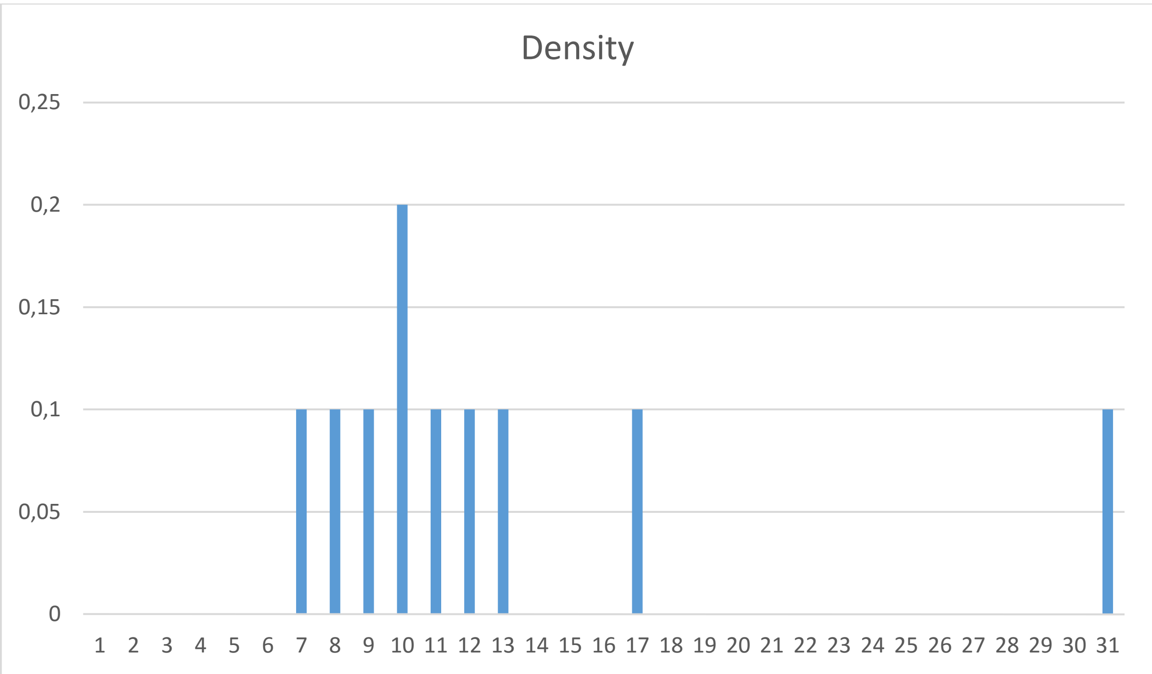


Figure 4-14. Density plot for the frequency distribution (scenario B2)

The estimated mean and variance for the frequency are:

- Mean: 12.44
- Variance: 52.77

Given the important difference between the mean and variance, we also chose to model the distribution with a negative binomial distribution (r, p). The parameters are:

- $r = 3.84$
- $p = 0.24$

For the severity, we chose a Generalized Pareto distribution (μ, σ, ξ), where:

- The location μ is equal to 800k€
- The scale σ is equal to 519 882€
- The shape ξ is equal to 0.39
-

4.3.6.4 Discussion on the results

Because in the three different scenarios considered, the frequency and severity distributions have been modeled using the same distributions (Negative Binomial and Generalized Pareto), we can easily compare the results obtained in each scenario.

Frequency:

In terms of frequency, we observe that the modeled frequency is the lowest for the scenario A (current regulation), and increases significantly with the new regulation. As expected, the frequency is lower when the threshold is set to €1m, as less losses are expected to reach that threshold.

	current Baremo	new Baremo (800k)	new Baremo (1m)
Mean	8.55	16.56	12.44
Variance	26.73	61.22	52.77
p	0.32	0.27	0.24
r	4.02	6.14	3.84

Table 4-3. Parameters of the frequency laws

The following graph compares the graphic representations of the frequency law for the three different scenarios:

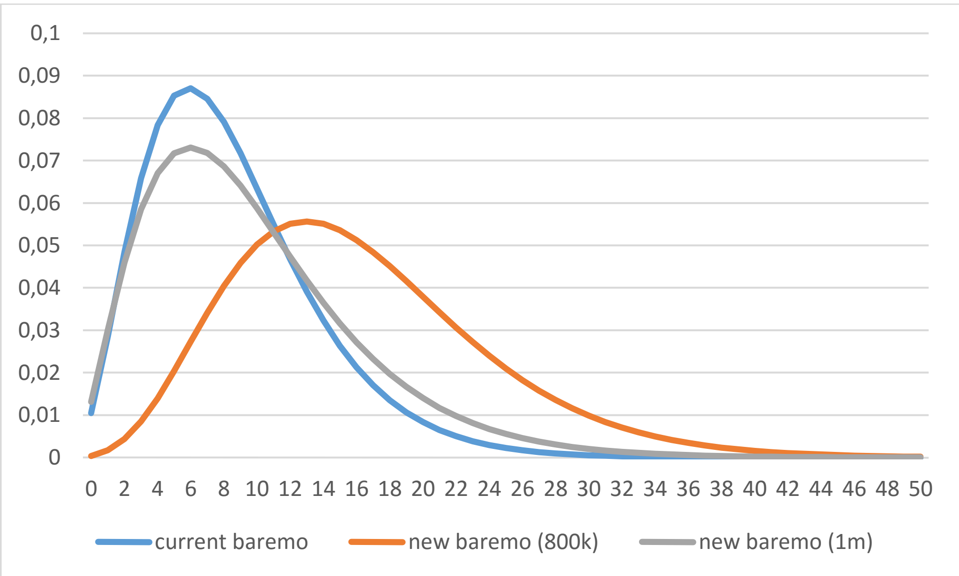


Figure 4-15. Comparison of the different laws of frequency modeled

Severity:

In terms of severity, as expected, the average atypical loss is lower for the scenario A (current regulation), and increase with the new regulation. The severity is higher when the threshold is set to €1m, as losses between €800k and €1m are not accounted for in the average.

The average severity and parameters of the severity law for each scenario are given in the following table.

	current Baremo	new Baremo (800k)	new Baremo (1m)
Scale	302 884 €	574 146 €	519 882 €
Position	800 000 €	800 000 €	1 000 000 €
Shape	0.42	0.30	0.39
Mean	1 323 675 €	1 616 852 €	1 852 996 €

Table 4-4. Parameters of the severity laws

The following graph compares the graphic representations of the probability distribution function for the three different scenarios:

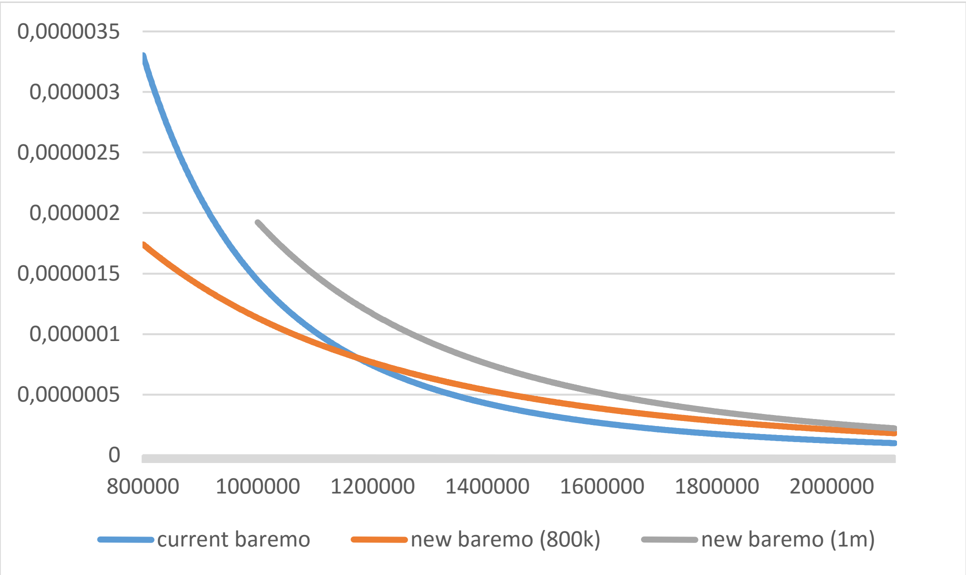


Figure 4-16. Comparison of the different laws of severity modeled

4.4 Analysis of the impact on capital requirements and reinsurance

4.4.1 General principle

In the previous section, we have estimated the parameters that allow to model MTPL atypical losses for AXA Spain for the year 2016, for three different scenarios:

- **Scenario A**: use of the data "current regulation" with an atypical threshold of 800k€

- The frequency is modeled as a Negative Binomial law $NB(r,p)$ with $r = 4.02$ and $p = 0.32$
- The severity is modeled as a Generalized Pareto law $GPD(\xi,\sigma,\mu)$ with $\xi = 0.42$, $\sigma = 303$k€ and $\mu = 800$k€

- **Scenario B1**: use of the data "new regulation" with an atypical threshold of 800k€
  - The frequency is modeled as a Negative Binomial law $NB(r,p)$ with $r = 6.14$ and $p = 0.27$
  - The severity is modeled as a Generalized Pareto law $GPD(\xi,\sigma,\mu)$ with $\xi = 0.30$, $\sigma = 574$k€ and $\mu = 800$k€

- **Scenario B2**: use of the data "new regulation" with an atypical threshold of 1m€
  - The frequency is modeled as a Negative Binomial law $NB(r,p)$ with $r = 3.84$ and $p = 0.24$
  - The severity is modeled as a Generalized Pareto law $GPD(\xi,\sigma,\mu)$ with $\xi = 0.39$, $\sigma = 520$k€ and $\mu = 1$m€

With these frequency and severity laws, it is possible to simulate potential atypical losses for 2016. We will simulate the atypical losses for the three different scenarios, and assess the impact of the new regulation on reinsurance and capital requirement.

4.4.2 Simulation of losses

For each one of the three scenarios (A, B1 and B2), we simulate 10000 years of atypical losses:

- Each year n ($n \in [\![1; 1000]\!]$), the frequency (number of atypical losses) N_{Atyp}^n is simulated with the Negative Binomial law
- The k^{th} atypical loss of year n, x_k^n ($n \in [\![1; 1000]\!]$ and $k \in [\![1; N_{Atyp}^n]\!]$) is simulated with the Generalized Pareto law:

With these simulations, we can have a look at some statistics:

	Current Baremo	new Baremo 800k	New Baremo 1m
Mean frequency	8.55	16.57	12.44
Var frequency	26.68	61.42	52.69
Mean severity	1 319 164 €	1 615 794 €	1 852 124 €

Table 4-5. Statistics of the simulated losses

This is in line with the statistics of the Negative Binomial and Generalized Pareto law that we had identified to model atypical losses for the three different scenarios.

4.4.3 Determination of a reinsurance cover

4.4.3.1 Principle

For these scenarios, we are going to model a reinsurance of the type excess of loss – (Per Risk XL). We will consider a reinsurance cover of €4m in excess of €1m.

It means that, for each loss:

- If the loss is higher than €1m, the reinsurance is triggered
- The amount between €1m and €5m is recovered (paid by the reinsurance company)
- Any amount below the threshold of €1m remains at the charge of the insurance company

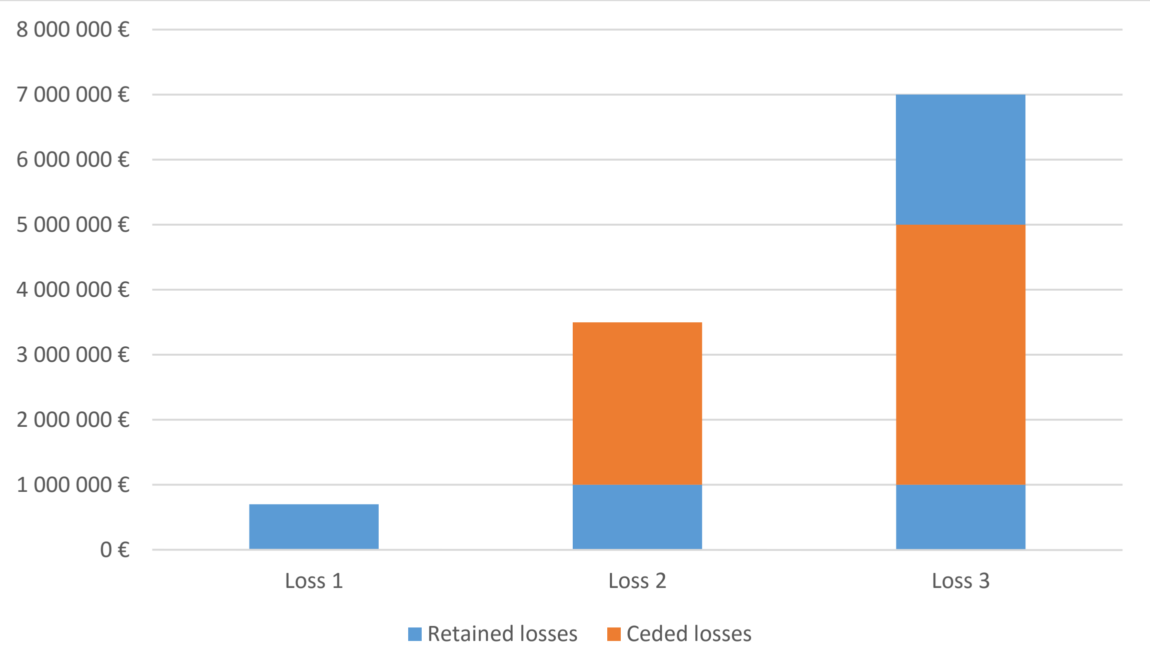


Figure 4-17. Example of reinsurance €4m excess of €1m

In the example above:

- For loss 1 of €700k, the reinsurance is not triggered
- For loss 2 of €3.5m, the reinsurance is triggered and the recovery is €2.5m (total amount less threshold)
- For loss 3 of €7m, the reinsurance is triggered and the maximum capacity of €4m is reached, so the recovery is €3m

For such a reinsurance cover, the pricing can be determined with the following formula:

$$\Pi_{technical} = \frac{\Pi_{pure} + \alpha.\ \sigma_{recovery}}{1 - \beta}$$

Where:

- $\Pi_{technical}$ is the technical premium paid by the insurance company to the reinsurance company

- Π_{pure} is the pure premium, determined as the mean recovery
- α is a safety coefficient applied by the reinsurer to cover for uncertainty. It is usually set to 20% (based on observations from AXA on motor reinsurance)
- β is a coefficient allowing for fixed expenses (set to 15% based on observations from AXA)

4.4.3.2 Application and results

We apply this reinsurance cover to all the losses simulated previously for the three scenarios.

We can easily monitor the impact of the reinsurance cover:

	Current Baremo	new Baremo 800k	New Baremo 1m
Average losses (no reinsurance)	11 274 103 €	26 765 629 €	23 035 054 €
Average retained losses	8 399 970 €	16 922 688 €	13 656 288 €
Average ceded losses	2 874 133 €	9 842 940 €	9 378 766 €
Price of the reinsurance cover	3 994 216 €	12 966 236 €	12 527 454 €
Cost of reinsurance and retained losses	12 394 186 €	29 888 925 €	26 183 742 €

Table 4-6. Results of the reinsurance cover

As expected, average losses increase from the current regulation to the new one, and are higher with a threshold of €800k (as more losses are accounted for).

The price of the reinsurance coverage increases consequently with the new Baremo, and is also higher when the threshold is set to €800k.

But the efficiency of reinsurance can not only be measured by the average cost of losses and reinsurance, but should also be measured through the impact on the volatility of results and capital requirement. This analysis is performed in the next section.

A KPI frequently used to assess the performance of a reinsurance coverage is:

$$K = \frac{Ceded\ result}{\Delta SCR_{gross\ of\ reinsurance} - \Delta SCR_{net\ of\ reinsurance}}$$

Where:

- $Ceded\ result$ is calculated as the cost of reinsurance less the recoveries (ceded losses)
- $\Delta SCR_{gross\ of\ reinsurance}$ is the additional capital requirement to cover for atypical losses, without reinsurance
- $\Delta SCR_{net\ of\ reinsurance}$ is the additional capital requirement to cover for atypical losses, with reinsurance

The reinsurance performance increases when the KPI K decreases, because:

- The reinsurance is better when the ceded result is low
- A bigger gap between SCR gross and net of reinsurance is a sign that the reinsurance cover allows to allocate less capital

4.4.4 Impact on capital requirement

In a Solvency II environment, the solvency capital requirement (SCR) for a given risk is defined as the VaR at 99.5% over one year. In practice, it means that it should correspond to the worst possible cost

(cost of reinsurance + retained losses), with a probability of 99.5%. Alternatively, this worst possible loss can be considered as the worst loss occurring once every 200 years.

We will then estimate the additional capital requirement necessary for AXA Spain to cover the atypical losses in 2016, for the three different scenarios considered, after and before use of the reinsurance cover.

With no reinsurance, the SCR is the VaR of losses.

With reinsurance, the SCR is the VaR of costs of reinsurance + retained losses.

	Current Baremo	new Baremo 800k	New Baremo 1m
SCR (no reinsurance)	40 295 263 €	74 424 266 €	78 447 861 €
SCR (reinsurance)	32 870 816 €	46 911 968 €	48 346 649 €
Difference	7 424 447 €	27 512 299 €	30 101 212 €

Table 4-7. Impact on capital requirement

We can observe that in all cases, the reinsurance has a positive impact on the calculation of the additional capital requirement: SCR is lower in all the cases with reinsurance as compared to no reinsurance.

The gain of capital (difference of capital requirement with and without reinsurance) is much higher for scenarios B1 and B2, highlighting the greater role of reinsurance in these two scenarios.

To measure the performance of these reinsurance covers, we calculate the KPI K defined in the previous paragraph

- For the current Baremo (scenario A): $K = 15\%$
- For the new Baremo with threshold of €800k (scenario B1): $K = 11\%$
- For the new Baremo with threshold of €1m (scenario B2): $K = 10\%$

It means that this reinsurance cover is most efficient for scenario B2 and B1 as compared to A. It can be explained mainly by the positive impact on capital requirement, as losses are considerably reduced by the reinsurance cover in case of adverse events with the new regulation, while reinsurance is less triggered with the current regulation.

It means that the cover €4m in excess of €1m is probably not perfectly adapted to the current Baremo, and suggests that a lower capacity could be have been used.

5 Conclusion

Motor third party bodily injury costs are an important risk for AXA, due to its important exposure to motor risk in various countries. As we have seen in the second section of this report, these costs vary a lot from one country to another, and can reach significant amounts of several millions in severe cases involving disability or loss of earnings for surviving family members.

The level of indemnity paid in case of the same bodily injury is different in each country and function of numerous parameters (age of the victim, relatives, income, severity of the injury, local legislation,) but we have observed that it is correlated to the economic development of the country, that can be measured in different ways (GDP per capita, insurance penetration, Human Development Index, …).

In Spain, the level of indemnities paid for bodily injuries has until 2015 been lower than in neighbor European countries, as a result of a simplistic regulation in place for several years. This gap will be reduced, as a new regulation will become in force in 2016 (new Baremo), aiming at reaching a level of indemnities adapted to the economic development of the country and comparable to other European countries.

The new regulation will trigger an increase of 50 to 100% of severe injury costs in Spain, which will have important consequences for AXA Spain in terms of reserves, pricing, results and capital requirements. In order to be prepared for these consequences, we have estimated the potential impact in 2016 it could have through the use of the atypical losses model used within AXA, on the basis of historical observed losses on the portfolio, that have been re-assessed through the new regulation.

We estimate that this change in regulation will require a new estimation of the atypical threshold (threshold over which losses are considered atypical), an adapted reinsurance cover, and will inevitably require additional capital requirement.

Appendices

List of the figures

List of the tables

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