LISBOA SCHOOL OF ECONOMICS & MANAGEMENT

MASTER OF SCIENCE IN ACTUARIAL SCIENCE

MASTERS FINAL WORK

INTERNSHIP REPORT

ANALYSIS OF THE REINSURANCE TREATY FOR A WORKER'S COMPENSATION PORTFOLIO

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Acronyms

APS: Associação Portuguesa de Seguradoras

ASF: Autoridade de Supervisão de Seguros e Fundos de Pensões

IPP: Permanent Partial Incapacity

IPA: Permanent Absolute Incapacity

IPATH: Permanent Absolute for the usual work Incapacity

ITA: Temporary Absolute Incapacity

ITP: Temporary Partial Incapacity

FAT: Worker’s Compensation Fund

LoB: Line of Business

LTA: Long term Assistance

P&C: Property and Casualty

VaR: Value-at-Risk

WsC: Worker’s Compensation

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Abstract

This report resumes the analysis of the sustainability of Worker's Compensation within the internship at Allianz Portugal. The legal framework of the business is primarily explained as it is important to understand the business specifications.

Models and assumptions used, by the Company, in the calculation of technical provisions for Worker's Compensation will be detailed. The main focus of this paper will be in the analysis of the Excess of Loss reinsurance treaty that covers costs from Worker's Compensation and its impact in the technical result. The analysis is based on the Collective Risk Model and statistical indicators, such as Value-at-Risk, skewness coefficient, variance and expected value.

Keywords: Worker's Compensation, Claim, Mathematical Reserves, Aggregate Loss, Chi-square goodness of fit test, Reinsurance, Excess of Loss, Retention limit, Premium, Value-at-Risk.

1. Introduction

Portugal is one of the few countries where Worker's Compensation insurance is compulsory, contracted by the employer to an insurance company with strict rules to be applied, followed by the Portuguese Insurance Regulator (ASF). All employers and self-employees are obliged to insure the risk (all employees) in an insurance company.

In the Portuguese market, Worker's Compensation (WsC) is a line of business with one of the highest negative technical result. This means, Worker's Compensation is not a sustainable line of business for most companies.

Although the negative result originated from Worker's Compensation is mitigated by the profit of other lines of business, it is a major concern for most companies to reduce its costs.

The main cause for the negative results is the high loss ratio, which is the ratio between claim losses and earned premiums. Worker's compensation is a line of business with long duration benefits which causes an increase on volatility and difficulties on the predictability of the claim costs.

The Portuguese market is very competitive, which means the companies do not have a great margin to increase the price. Therefore in order to enhance the Worker's Compensation's profit the main focus of the insurance companies is to reduce losses without increasing prices.

Our main objective is to analyze the Worker's Compensation losses, in order to improve its results.

During the internship in Allianz Portugal we performed several validations and studies to ensure the reserves were being correctly calculated and allocated. The main objective is to prevent being too much conservative, but at the same time to make sure we have all future losses covered.

In order to decrease the volatility of losses, Worker's Compensation is covered by an Excess of Loss reinsurance treaty. We will take a closer look to the Worker's Compensation reinsurance treaty and its assumptions with the purpose of minimizing the costs without increasing the risk excessively.

Our final goal is to measure the impact in the Worker's Compensation technical result of changing the retention limit of the Excess of Loss treaty.

To analyze the distribution of the aggregate losses covered by the reinsurance treaty we will apply the Collective Risk Model and the Normal Power and Translated Gamma approximations.

For the sake of confidentiality and data protection, calculations presented are based on modified data.

2. Worker's Compensation in Portugal

Worker's Compensation is one of the most important lines of business in the Portuguese insurance market given that it is considered as a social risk, although it is managed as a private insurance and therefore it is the insurer company's responsibility.

Throughout the years, new laws have been implemented in order to increase the claimant's rights and the employer's obligations and, therefore, also the respective insurer's responsibilities. On the other hand, in the current economic context, the decrease in the companies' number of workers causes a need to allocate the employees in additional tasks, which will increase the exposure of these workers to accidents and consequently will increase the insurer's losses. From the insurance market's point of view this social context will reduce the intentions of increasing the prices in this LoB (Line of Business), resulting in a significant liability for the insurance companies and its economic results.

Being a compulsory insurance, Worker's Compensation represents a significant part of the Non-Life business. According to the APS (Associação Portuguesa de Seguros) Technical Analysis from December 2013, in the Portuguese market WsC represents 13.6% of the Non-Life business and 10.9% of the entire business, in terms of earned premiums. In Allianz Portugal, WsC represents 18.4% of the total Non-Life earned premiums and 14% of the entire business. It is one of the LoB's with higher loss ratio, which, in 2013, has increased +1.8% in the Company. In the Portuguese market, according to APS, despite the increase of the loss ratio in 2011 and 2012, in 2013 it has decreased by 5.7%.

Another characteristic of the Worker's Compensation line of business is that there is a Worker's Compensation Fund (FAT) managed by ASF and financed by the Portuguese Insurance Companies (based on a % of the Insured Capital and a % of the Annuities). This fund ensures: a) the payment of benefits that are due from an accident at work where, for reasons of economic incapacity objectively characterized in legal proceedings for bankruptcy or equivalent process, or recovery process from the company or if by reason of absence, disappearance and inability to identify, cannot be paid by the responsible entity; b) the payment of the insurance premiums from companies that, as part of a recovery process, are unable to do so, upon request made by the Manager of the company; c) the payment of pensions updates and the updates of supplementary obligations in charge of the insurance undertaking and d) placing the rejected risks in an insurance company.

2.1 Risks Covered

Worker's Compensation is characterized by assuming the entire risk of any accident occurring at the workplace and at working time that causes, directly or indirectly, personal injury, functional disorder or disease resulting in reduction of working or earning capacity or even death.

It is understood by workplace any place in which the worker is, as a result of work, or to which he addresses and is subject to review by the employer. It should be understood by working time the normal working hours, the time that precedes the beginning of work, the time that follows it, and even normal or compulsory interruptions.

The employer is not responsible for the accident damages in case it:

- is caused by the victim or results from non-compliance of the security conditions established by the employer entity or provided by law;
- occurred by force majeure: It is considered force majeure when the accident arise from inevitable forces of nature, which are independent of human intervention, and not derived by the risk created by the working conditions, neither by a service ordered by the employer and in situations

of clear danger, such as a storm that devastates a city, lightning or earthquake to reach the area where the employee was.

3. Worker's Compensation in the Company

In Allianz Portugal, depending on the employer, there are different types of Insurance: workers in the private sector, self-employed workers or public servants. We can also divide the WsC contracts into two types, Fixed Premium or Variable Premium contracts. For a Fixed Premium contract, we know the exact number of workers and the amount of the insured salary of each of them. The Proposal of the Fixed Premium Insurance should refer specifically to the amount of each received income by time unity (month, day or hour/week), so that it is possible to calculate financial allowances in case of an accident. For a Variable Premium Contract, when the contract covers a variable number of employees, also with variable insured salaries, the Company will regularly update the insured persons and their respective retributions, in accordance with the delivered payslips.

We can also divide the Workers Compensation policies into two types, self-employed or employer's policies. In the self-employed policies the employee is both the policyholder and the insured person, in which case there is only one insured person per policy. In the employer's policy the policyholder is the employer and the insured people are the employees, hence one policy may cover several insured people.

3.1 Benefits

After the accident occurrence, the claimant is entitled to three different types of benefits, depending on the disability originated from de accident:

- Pension;
- Long Term Assistance;
- Other benefits (including medical care necessary to recover the professional activity).

The benefits' calculation is based on the salary with a minimum value set by Portuguese legislation, on the number of days of disability and the percentage of disability.

In case of Temporary disability (partial or total), a daily allowance linked to the salary and to the number of days of disability is attributed. In some cases, there is an additional payment to cover the professional rehabilitation.

A Life term annuity (in general paid on a monthly basis) based on the percentage of disability and salary is paid to claimants who are declared to be permanently incapacitated. A capital allowance for the adaptation of the household, if necessary, is also provided. In some cases, there is also an additional payment to cover 3rd person assistance, professional rehabilitation, high percentage of disability and home adaptations. In case of IPP (Permanent Partial Incapacity) less than 30% and annual pension not exceeding the value of 6 x RMMG (guaranteed monthly minimum wage), a mandatory remission of the life term annuity is applied and the benefit will be paid as a lump sum.

A partial remission of the pension can be requested to the court in case of IPP greater than 30% and pension overlap not smaller than 6 times the RMMG at the remission date. In order to be partially redeemed it is also necessary that the capital of remission is not greater than the pension calculated on the basis of a IPP of 30%. In case the Court authorizes the partial remission, a lump sum is paid immediately as well as the first payment for the remaining pension.

In case of Death, the beneficiaries will receive an allowance to cover funeral expenses and a monthly pension in similar conditions to the permanently disabled pensioners. Possible beneficiaries are the spouse, descendants and/or parents (depending on the household if dependent) and children under 18.

In cases of a severe permanent damage situation (e.g paraplegic, prosthesis, etc), in addition to the life term annuity, the worker has the right to a lifetime assistance for medical expenses.

The calculations for each type of benefit are shown in Appendix 1.

3.2 Reserves Calculations

Depending on the type of benefits we can define two categories: Long term (Long Term Assistance and Pensions) and Short term (Other benefits). Long term reserves calculation is based on Life techniques whilst short term reserves are calculated using Non-Life techniques.

Mathematical Reserves to cover Pensions are determined according to life actuarial techniques, including mortality assumptions. We can distinguish two types of mathematical reserves, redeemable and non-redeemable. The redeemable reserves are calculated for the pensioners where the obliged remission is applied and therefore the benefit will be paid as a lump sum. The non-redeemable reserves are calculated to cover the future payments of a pension with no remission. The present value of a unitary benefit is obtained from actuarial tables, with the following technical basis, which differ for each type of pension:

Non-redeemable ("Não Remíveis"):

- Interest Rate: 4%
- Expenses: 2%
- Mortality Table: 25%GKF80+75% GKM95

Redeemable ("Remíveis"):

- Interest Rate: 5.25%
- Expenses: 2% (over 4 years)
- Mortality Table: TD88/90

The interest rate and mortality table used in the redeemable mathematical reserves is set by law. Therefore we are obliged to use the 5.25% rate in these cases. However for the non-redeemable pensions the interest rate can be adjusted according to each company's portfolio. For accounting purposes this Company applies the 4% rate. However for reinsurance reporting we apply a 2% interest rate. This assumption is due to the reinsurance's sunset clause (which will be explained in section 3.3). The liabilities covered by reinsurance are calculated anticipating the future costs and will be settled at the end of the fifth year after the claim occurred. Since we predict that the interest rates will decrease in the next five years, we already assume a lower interest rate in order to avoid the need of adjustments in the ceded costs if we change the interest rate assumptions in the future.

For each pensioner the actuarial table is obtained accordingly to his/her family relation, pension, age, if he/she is incapable or conditioned and clinic situation and percentage of disability of the victim. Each actuarial table is calculated using monthly annuities that depend on the nature of the pensioner, as shown below:

i. Victims: $\ddot{a}_x^{(12)} \approx a_x + \frac{13}{24}$

ii. Orphans: $\ddot{a}_{x:\overline{25-x|}}^{(12)} \approx \ddot{a}_{x:\overline{25-x|}} - \frac{11}{24}(1 - {}_{25-x}E_x)$

iii. Partners/Parents: $\ddot{a}_x^{(12)} + \frac{1}{3} \cdot {}_{65-x|}\ddot{a}_x^{(12)}$

where:

$${}_{k-x}E_x = v^{k-x} \cdot {}_{k-x}p_x$$

$$a_x = \sum_{k=1}^{\omega=117} v^k \, {}_kp_x$$

${}_kp_x = P(T_x > n) = S_x(n)$ where T_x is the future lifetime of an individual aged x.

Finally the mathematical reserves are obtained by multiplying the Pension benefit by the corresponding annuity.

Long term assistance (LTA) is associated to victims with injuries that will need medical assistance for life. This covers the medical costs that are not regular payments, but are long term benefits.

The reserves, as well as the average annual payment are calculated depending on the type of lesion of the victim. Every year a study is conducted in order to revise the average costs by lesion, based on the information available in the respective year. In 2013 the average costs were obtained based on the average payments between 2010 and 2013.

LTA reserves are associated to life techniques, including mortality assumptions, cash-flows discounting and capitalization and follow the technical basis below:

- Interest Rate: 4%
- Inflation: 1%
- Expenses: 2%
- Mortality Table: 120% (25%GKF95+75% GKM95)

The present value of benefits is calculated using a whole life annuity paid once a year:

$$\ddot{a}_x = \sum_{k=0}^{\omega=117} v^k \, {}_kp_x$$

During 2013, the technical basis were analysed and the mortality table changed from 25% GKF80 to 25%GKF95, the inflation rate decreased from 2.5% to 1% and a 2% rate for expenses was included.

In order to calculate the amount we need to provision for each claim, we assume that a claim corresponding to a certain type of lesion will benefit from the average cost once a year. Therefore the Long term Assistance reserves are the product between the average cost of the corresponding lesion and the whole life annuity.

We also need to calculate the reserves for the **Other Benefits** (medical expenses, lost salaries, etc.). In these other benefits we also need to provision for the payments that we are obliged to pay to FAT (Worker's Compensation fund). These reserves are included in the Short Term WsC and are estimated using Non-life techniques, similar to the other P&C (Property and Casualty) LoBs. In this Company we use a Chain Ladder Method to estimate the net reserves for P&C LoBs.

The Chain Ladder (together with the Bornhuetter-Ferguson) is one of the most commonly-used methods to estimate the outstanding claims. The Chain Ladder, unlike the Bornhuetter-Ferguson, assumes that the development factors are different for each development year. The advantage of this method is that its predicted outstanding claims are highly responsive to changes in the observed incurred claims. On the other hand this could be seen as a disadvantage, as it causes the model to be too sensitive (in *Neuhaus, W. Outstanding Claims in General Insurance, Loss Reserving Lecture notes*).

As far as WsC Short Term concerns, in this Company, we used only the triangle of Paid claims for the evaluation of the ultimate, with the only exception for the series of the year 2000 where we used the actual incurred claims value due to its particular nature as a mixture of older series.

When we have evaluated the Loss development method on the Paid triangle we have used a pure Chain Ladder but we have introduced for the 3 first factors some manual values that could help us to recover the future development, taking into consideration the increase of the settled claims' rate that we have been observing in the past years in this line of business.

3.3 Worker's Compensation Reinsurance Structure

Worker's Compensation is covered by an Excess of Loss treaty where the Reinsurer shall indemnify the Company with the sum that exceeds the amount of the underlying retention (M) in respect of each and every loss or series of losses arising from the same event. However the cover granted by the Reinsurer shall in no case exceed the specified limit of liability (L).

Definition of Loss Occurrence

For reinsurance purposes, “Loss Occurrence” shall include all individual insured losses which arise directly from the same cause and which occur during the same period of time in the same area, without consideration of the number of policies affected.

Coverage of the agreement

The agreement covers the mathematical reserves corresponding to pensions in respect of permanent incapacity and death. Mathematical reserves corresponding to additional pensions in respect of full salary are also covered.

The following capital allowances are also included:

- Death capital, equivalent to 12 times the minimum monthly wage,
- Capital allowance for higher disability (IPP superior to 70%), equivalent to 12 times the minimum monthly national wage multiplied by the % of the IPP
- Allowance for the adaptation of the household, whenever necessary and in case of an IPP superior to 70%, until 12 times the minimum monthly national wage.

Therefore, the following are excluded:

- Temporary incapacity;
- Medical, transportation and repatriation expenses;

- Funeral expenses;
- Rehabilitation costs;
- Legal costs and Lawyers' fees of any kind;
- All other expenses.

Reinsurance cover

The reinsurance treaty assumes an underlying retention of the reinsured of 400,000 EUR (M) per risk/event and a limit of liability of the reinsurer of 22,100,000 EUR (L) in excess of 400,000 EUR. Additionally the agreement also has an annual aggregate limit of 44,200,000 EUR.

The premium that the company is obliged to pay is calculated as a percentage of the gross earned premiums, 0.475%, with a minimum of 189,000 EUR payable in four equal instalments at the end of accounting quarters.

Sunset clause

The Reinsurer's liability is limited to five years as from the year of occurrence. Cases which have not yet been resolved by this date must, upon agreement with the Reinsurer, be capitalised to the extent of the anticipated permanent incapacity for work based on the doctor's testimony, and settled with the former. The remission of the Reinsurer's liability is final. Therefore, any subsequent liability deriving from claims which are not yet known or from an alteration of the mathematical reserves will not be covered.

4. Risk Modelling

Risk theory allows us to build and study mathematical models suited to the needs of the insurance business. The analysis may be performed using the Collective Risk Model or the Individual Risk Model.

To model our risks we will use a Collective Risk Model, because, instead of the Individual Risk Model, this model allows an evaluation of the portfolio on a more global basis and, being an open model, it allows the entrance and exit of policies.

To model the aggregate loss random variable S per period of time, we need to know the severity distribution, X_i, and the distribution for the number of claims in our portfolio, N, in the same period of time:

$$S = \sum_{i=1}^{N} X_i \ , where\ S = 0\ if\ N = 0$$

$$and\ \{X_i\}_{i=1,2,\ldots} are\ i.i.d. random\ variables\ and\ independent\ of\ N.$$

4.1 Hypothesis tests

We used the χ^2 goodness-of-fit test to study the fitness of different distributions to our portfolio data. In order to test the hypothesis that N has a given distribution function with r unknown parameters $\theta_1, \cdots, \theta_r$, we start by classifying our sample in $m+1$ classes, numbered from 0 to m. Let n_k as the number of observations in class k and $p_k(\theta_1, \cdots, \theta_r)$ as the probability that N takes values in class k, with $k = 0, 1, \cdots, m$, then when the hypothesis is true the statistic below is asymptotically distributed according to a χ^2 with $m - r$ degrees of freedom.

$$\chi^2(\hat{\theta}_1, \cdots, \hat{\theta}_r) = \sum_{k=0}^{m} \frac{\left(n_k - n \cdot p_k(\hat{\theta}_1, \cdots, \hat{\theta}_r)\right)^2}{n \cdot p_k(\hat{\theta}_1, \cdots, \hat{\theta}_r)},$$

where $(\hat{\theta}_1, \cdots, \hat{\theta}_r)$ are the maximum likelihood estimators, based on the classified data and n is the sum of all n_k.

The maximum likelihood estimators are obtained maximizing in $\theta_1, \cdots, \theta_r$ the following likelihood function or the corresponding log-likelihood function:

$$L(\theta_1, \cdots, \theta_r) = \prod_{k=0}^{m} [p_k(\theta_1, \cdots, \theta_r)]^{n_k}$$

$$l(\theta_1, \cdots, \theta_r) = \ln(L(\theta_1, \cdots, \theta_r)) = \sum_{k=0}^{m} n_k \cdot \ln(p_k(\theta_1, \cdots, \theta_r))$$

For continuous distributions we could also have used the Kolmogorov-Smirnov or the Anderson-Darling tests.

4.2 Portfolio and data used

For the purposes of this report we will model the aggregate loss covered by reinsurance. This means that our random variable X represents the costs (mathematical reserves calculated with a 2% interest rate and cumulative payments) of the claims that originated permanent disabilities or deaths, and N represents the number of claims in our portfolio that satisfy these conditions.

When modelling the number of claims per policy we used as sample the policies in force in 2013 and for those policies we considered the claims occurred in that year. We chose the year of occurrence 2013 because the reinsurance treaty under consideration is related to claims occurred in that year.

Portfolio characteristics as at 31st December 2013:

Portfolio characteristics	Employer's	Self-employed	Total
Number of policies	55,406	13,702	69,108
Number of insured people	279,579	13,702	293,281

Due to some inconsistencies in the data, some of the Employer's policies had no information about the number of insured people. Therefore, we have excluded these policies from the sample used for the analysis:

Sample used	Employer's	Self-employed	Total
Number of policies	55,004	13,702	68,706
Number of insured people	279,556	13,702	293,258

As the number of excluded policies is very small, we confirm that our sample is reliable and reflects adequately our portfolio.

Significance of the Sample	Employer's	Self-employed	Total
Number of policies	99.3%	100.0%	99.4%
Number of insured people	100.0%	100.0%	100.0%

In the sample used in our analysis all claims registered correspond to distinct loss occurrences, since no loss occurrence reported in 2013 originated more than one claim.

In order to analyse the individual loss per claim, we considered the ultimate cost of the claims occurred in 2013. The amounts covered include the accumulated payments plus the mathematical reserves calculated, as mentioned in chapter 3.2, with a 2% interest rate.

4.3 Distribution for the number of Claims

Our portfolio is divided into two sub-portfolios where employer's policies belong to sub-portfolio 1 and self-employed policies belong to sub-portfolio 2.

For all random variables, the same period of time (one year) was considered.

Let N_i be the total number of claims of a randomly selected policy from sub-portfolio i and $N_{i,k}$ be the total number of claims per policy with k insured people from sub-portfolio i. Additionally let K_i be a random variable denoting the total number of insured people in a policy taken out randomly from sub-portfolio i and M_i be the number of claims per insured person from a policy in sub-portfolio i. In sub-portfolio 2 every policy has one and only one insured person, therefore $Pr(K_2 = 1) = 1$.

Negative Binomial vs Poisson

Given that in our portfolio we observe policies with a variable number of insured people, it is convenient to model the number of claims with an infinitely divisible distribution (see Definition 6.17 in Loss Models, third edition page 140). The Negative Binomial and the Poisson are two examples of infinitely divisible distributions.

Negative Binomial	**Poisson**
$p_x = \dfrac{r \cdot (r+1) \cdots (r+x-1) \cdot \beta^x}{x!\,(1+\beta)^{r+x}}$	$p_x = \dfrac{e^{-\lambda} \cdot \lambda^x}{x!}$
$P(z) = [1 - \beta(z-1)]^{-r}$	$P(z) = e^{\lambda(z-1)}$
$E[N] = r \cdot \beta$	$E[N] = \lambda$
$Var(N) = r \cdot \beta \cdot (1+\beta)$	$Var(N) = \lambda$
$\mu_3 = r \cdot \beta \cdot (1+\beta) \cdot (1+2\beta)$	$\mu_3 = \lambda$

For the purpose of this analysis we assumed for the random variable K_i, with $i = 1,2$ the respective empirical distribution at 31st of December of 2013.

Let $N_{i,k}$ be the number of claims per policy, and assume that $M_{i,j}$ (number of claims per insured person in sub-portfolio i) are independent and identically distributed to M_i. To model N_i, we define:

$$N_{i,k} = \sum_{j=1}^{k} M_{i,j}$$

Given that both Poisson and Negative Binomial distributions are infinitely divisible, we can demonstrate that if $M_i \sim Negative\ Binomial\ (r_i, \beta_i)$ then $N_{i,k} \sim Negative\ Binomial\ (r_i k, \beta_i)$ and if $M_i \sim Poisson\ (\lambda_i)$ then $N_{i,k} \sim Poisson\ (\lambda_i \cdot k)$.

Let $P_X(z)$ be the probability generating function of an integer random variable X, then:

$$P_{N_{i,k}}(z) = E[z^{N_{i,k}}] = E[z^{M_i}]^k = [P_{M_i}(z)]^k = [1 - \beta_i(z-1)]^{-r_i k}$$

$$P_{N_{i,k}}(z) = E[z^{N_{i,k}}] = [P_{M_i}(z)]^k = e^{\lambda_i \cdot k \cdot (z-1)}$$

for the Negative Binomial and Poisson, respectively.

Let $f_{N_i}(j)$ be the probability function of the random variable N_i:

$$f_{N_i}(j) = \Pr(N_i = j) = E[\Pr(N_i = j|K_i)] =$$

$$= \sum_{k=1}^{d} \Pr(N_i = j|K_i = k) * \Pr(K_i = k) =$$

$$= \sum_{k=1}^{d} f_{N_{i,k}}(j) * \Pr(K_i = k)$$

$$where\ d\ is\ the\ maximum\ number\ of\ insured\ people\ in\ one\ policy.$$

We then applied the χ^2 goodness-of-fit test to study the fitness of the probability function $f_{N_i}(j)$ to the number of claims per policy in our portfolio using the Poisson and the Negative Binomial distributions, and obtained the following results:

Type of Policy	Distribution	Estimated parameters		Chi-square Statistic	Degrees of Freedom	p-value
Sub-portfolio 1	Poisson	$\hat{\lambda}$	0.0035	66.22	6	0.0000
	Negative binomial	$\hat{r}$	0.0185	9.54	7	0.2163
		$\hat{\beta}$	0.2020			
Sub-portfolio 2	Poisson	$\hat{\lambda}$	0.0066	0.30	2	0.8599
	Negative binomial	$\hat{r}$	94.5492	0.30	1	0.5808
		$\hat{\beta}$	0.0001			

For the employer's policies, it is clear that the distribution function using the Negative binomial fits better our portfolio than the one with the Poisson distribution. However for the self-employed policies, the best fit is with the Poisson distribution, as we would already expect as the sample mean and variance are similar.

Hence we will consider the following distributions:

$$N_{1,k} \sim Negative\ Binomial(\hat{r}k, \hat{\beta})\ and\ N_{2,k} \sim Poisson(\hat{\lambda}k)$$

When we look at the probability function of N_1 and N_2, we observe that there's a higher probability of a policy from sub-portfolio 1 to have more than one claim, than a policy from sub-portfolio 2. This is explained by the higher exposure to risk of an employer's policy, given that these policies may have more than one insured person, increasing the probability of one of them having an accident.

	Employer's policies $i = 1$	**Self-employed policies $i = 2$**
$f_{N_i}(0)$	0.9860	0.9934
$f_{N_i}(1)$	0.0116	0.0066
$f_{N_i}(2)$	0.0016	0.0000
$f_{N_i}(3)$	0.0004	0.0000
$f_{N_i}(4)$	0.0002	0.0000
$\sum_{x=5}^{\infty} f_{N_i}(x)$	0.0003	0.0000

Let N be the total number of claims in our portfolio in a year. Since N_1 and N_2 are two random variables referring to different policy contracts, we assume these random variables are independent. This means that:

$$E[N] = E[M_1] * n_1 + E[M_2] * n_2$$

$$Var(N) = Var(M_1) * n_1 + Var(M_2) * n_2, \qquad since\ Cov(N_1, N_2) = 0$$

$$\mu_3(N) = \mu_3(M_1) * n_1 + \mu_3(M_2) * n_2, \qquad since\ Cov(N_1, N_2) = 0$$

where n_i is the total number of insured people in sub-portfolio i and $i = 1,2$ and $M_1 \sim Negative\ Binomial(\hat{r}, \hat{\beta})$ and $M_2 \sim Poisson(\hat{\lambda})$.

Hence we calculated the following results:

	Employer's policies	**Self-employed policies**	**Total**
$E[N]$	1047	91	1138
$Var(N)$	1258	91	1349
$\mu_3(N)$	1766	91	1858
γ_N	0.040	0.105	0.037

In one year, we expect to have 1138 new claims in our portfolio that may be covered by reinsurance.

4.4 Distribution for the individual losses

In order to model the distribution for the individual losses for pensioners with permanent disabilities, we started by testing the fitness of some positive continuous distributions: Lognormal, Gamma and Pareto.

Gamma, Lognormal and Pareto Distributions

We considered the Gamma distribution with shape parameter α and scale parameter θ; the lognormal distribution with log-scale parameter μ and shape parameter σ; and the Pareto with scale parameter θ and shape parameter α.

	Gamma	**Lognormal**	**Pareto**
$f(x)$	$\frac{\left({x}/{\theta}\right)^{\alpha} \cdot e^{-\frac{x}{\theta}}}{x \cdot \Gamma(\alpha)}$	$\frac{1}{x \cdot \sigma \cdot \sqrt{2\pi}} exp\left(-\left(\frac{ln(x)-\mu}{\sigma \cdot \sqrt{2}}\right)^2\right)$	$\frac{\alpha \cdot \theta^{\alpha}}{(x+\theta)^{\alpha+1}}$
$E[X]$	$\alpha \cdot \theta$	$exp\left(\mu + \frac{\sigma^2}{2}\right)$	$\frac{\theta}{\alpha - 1}$
$Var(X)$	$\alpha \cdot \theta^2$	$exp(2\mu + \sigma^2) * (\exp(\sigma^2) - 1)$	$\frac{\alpha \cdot \theta^2}{(\alpha-1)\cdot(\alpha-2)}$

Weighted distributions

Finally we tested some weighted distributions using a Gamma, a Lognormal and/or a Pareto and found one that adjusted better our sample. The density function of the considered distribution is given by:

$$f(x) = \hat{p} * f_{Gamma(\hat{\alpha}_1,\hat{\theta}_1)}(x) + (1-\hat{p}) * f_{Gamma2(\hat{\alpha}_2,\hat{\theta}_2)}(x)$$

The maximum likelihood parameters obtained with some of the simulations performed are below:

Distribution	Estimated parameters		Chi-square Statistic	Degrees of Freedom	p-value
Gamma	$\hat{\alpha}$	0.049	10.978	8	0.2029
	$\hat{\theta}$	82,605.188			
Lognormal	$\hat{\mu}$	6.942	11.523	8	0.1738
	$\hat{\sigma}$	1.873			
Pareto	$\hat{\alpha}$	1.390	13.328	8	0.1010
	$\hat{\theta}$	2,981.267			
Weighted Gamma + Gamma	$\widehat{\alpha_1}$	4.182	6.676	5	0.2459
	$\widehat{\theta_1}$	2,624.691			
	$\widehat{\alpha_2}$	1.230			
	$\widehat{\theta_2}$	58,064.194			
	$\hat{p}$	0.964			

Using the weighted distribution of two Gammas we would have the following:

	Weighted Distribution
$E[X]$	13,173
$Pr(X > 400{,}000)$	0.000065
$Pr(X > 22{,}500{,}000)$	0

In cases when a single event originates several claims, for reinsurance purposes, the aggregation of these claims should be treated as an individual loss. Therefore, we added a Single-parameter Pareto distribution for severities higher than 200,000€, in order to define a probability for these cases that originate exceptionally high individual losses.

The Single Pareto density function is given by:

$$f_{SinglePareto(\alpha,\theta)}(x) = \frac{\alpha \cdot \theta^{\alpha}}{x^{\alpha+1}}, \qquad x > \theta$$

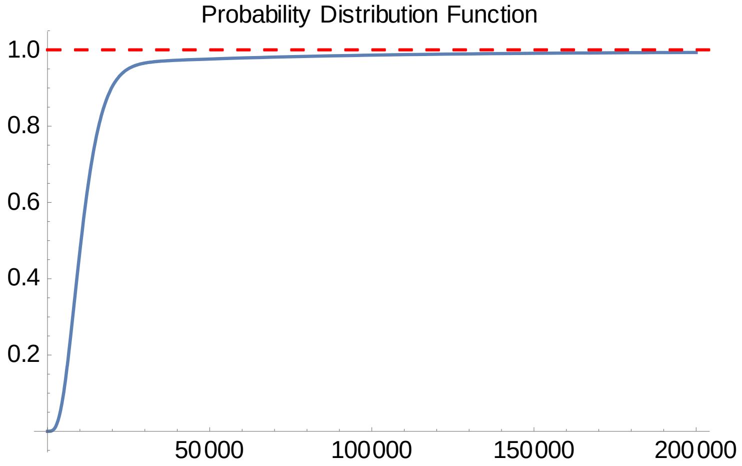
Therefore, the final selected distribution is as follows:

$$f(x) = p_2 * \left(\hat{p} * f_{Gamma(\widehat{\alpha_1},\widehat{\theta_1})}(x) + (1-\hat{p}) * f_{Gamma(\widehat{\alpha_2},\widehat{\theta_2})}(x)\right) + (1-p_2) * f_{SinglePareto(\alpha,\theta)}(x)$$

Where the chosen parameters for the Single-Pareto are:

$$\alpha = 4 \ ; \ \theta = 200{,}000 \ ; \ p_2 = 0.99$$

And the distribution function is represented by:



The moments for the chosen distribution can be obtained using the following formulae:

$$E[X^k] = p_2\left(p * E\left[{X_{Gamma1}}^k\right] + (1-p) * E\left[{X_{Gamma2}}^k\right]\right) + (1-p_2) * E\left[{X_{Pareto}}^k\right]$$

$$Var(X) = E[X^2] - E[X]^2$$

$$\mu_3[X] = E[X^3] - 3E[X^2]E[X] + 2E[X]^3$$

Finally, we obtained the following results:

	Selected Distribution
$E[X]$	15,708
$Var(X)$	1,028,271,833
γ_X	10.08

We conclude that our individual loss random variable is positively skewed, which means that most of our claims originate lower losses. The average cost per claim is 15,708€.

According to this distribution the Value-at-Risk of an individual claim is:

$$VaR_{0.95}(X) = 137{,}226.5$$

$$VaR_{0.99}(X) = 208{,}537.1$$

$$VaR_{0.999}(X) = 366{,}489.4$$

Which is less than the retention limit M set by the reinsurer. This means that more than 99.9% of the claims will not exceed the retention limit. The probabilities of reaching the limits of the reinsurance treaty are very small:

$$Pr(X > 400{,}000) = 0.0007$$

$$Pr(X > 22{,}500{,}000) = 6.24295 \times 10^{-11}$$

As the probability of reaching the limit L is very small, we will strict our analysis to the impact of changes in the retention limit M and not the liability covered limit L.

4.5 Aggregate loss distribution

Let S be the random variable that represents the portfolio's aggregate loss:

$$S = \sum_{i=1}^{N} X_i$$

The first three central moments and skewness coefficient of the aggregate loss S are obtained by the following formulae:

$$E[S] = \mu_S = E[N] \cdot E[X]$$

$$Var(S) = {\sigma_S}^2 = E[N] \cdot Var(X) + Var(N) \cdot E[X]^2$$

$$\mu_3[S] = \mu_3[N] \cdot E^3[X] + 3 \cdot Var(N) \cdot E[X] \cdot Var[X] + E[N] \cdot \mu_3[X]$$

$$\gamma_S = \frac{\mu_3[S]}{\sigma_S{}^3}$$

We obtained the following results for these measures:

	Aggregate Loss
$E[S]$	17,872,805
$Var(S)$	1,502,914,996,666
γ_S	0.2446

There are some approximations that can be used for large portfolios where the first few moments for the severity can be obtained, while the severity distribution is unknown. In cases when the skewness is small ($\gamma_S < 0.1$), the Normal approximation can be used. However, for larger values of γ_S, this approximation causes significant errors, especially on the tail of the distribution. For larger skewness coefficients, the appropriate approximations are the Normal Power (NP approximation) and the translated Gamma.

<u>NP Approximation</u>

The NP approximation is based on the *Edgeworth series* for the distribution function H of a random variable Z, where

$$Z = \frac{S - \mu_S}{\sigma_S}$$

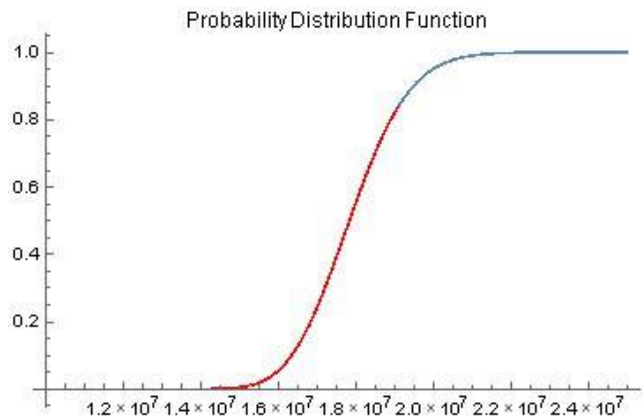
The approximation of the distribution function of S can be obtained by the following formula (for the proof see *Centeno, Teoria do Risco na Actividade Seguradora* pages 70, 71):

$$F(s) \approx \Phi\left(-\frac{3}{\gamma_S} + \sqrt{\frac{9}{\gamma_S{}^2} + 1 + \frac{6}{\gamma_S}\frac{s - \mu_S}{\sigma_S}}\right)$$

The NP approximation can only be applied if:

$$\frac{s-\mu_S}{\sigma_S} > 1$$

The probability distribution function for the aggregate loss is represented below, where the red line represents the values where the NP approximation cannot be applied.



Using the NP approximation we can obtain the Value-at-Risk:

$$VaR_{0.95}(S) = 19{,}974{,}541$$

$$VaR_{0.99}(S) = 20{,}945{,}287$$

Translated Gamma

The translated gamma approximation consists on approximating our random variable S to a random variable $k+Y$, where k is a constant and Y is a gamma distributed random variable with parameters α and θ. We assume that the translated gamma distribution has the same mean, variance and skewness coefficient as the random variable S that we are adjusting. Therefore the parameters k, α and θ are calculated using the following formulae:

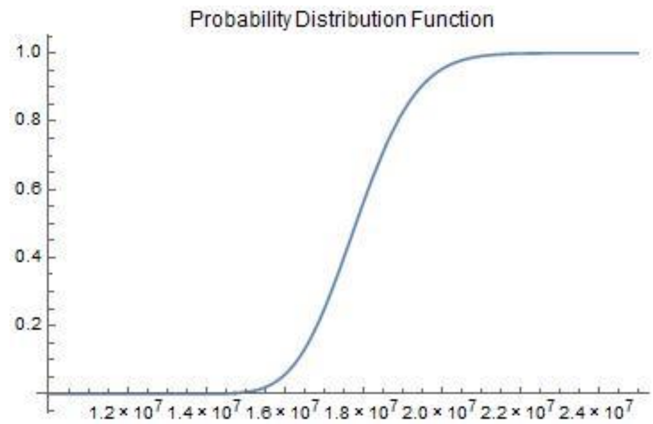
$$\mu_S = k + \alpha \cdot \theta \Rightarrow \hat{k} = \mu_S - \frac{2\sigma_S}{\gamma_S}$$

$$\sigma_S{}^2 = \alpha \cdot \theta^2 \Rightarrow \hat{\theta} = \frac{\sigma_S \cdot \gamma_S}{2}$$

$$\gamma_S = \frac{2}{\sqrt{\alpha}} \Rightarrow \hat{\alpha} = \frac{4}{\gamma_S{}^2}$$

We obtained the following results for the parameters and distribution function:

	Translated Gamma parameters
$\hat{\alpha}$	66.834
$\hat{\theta}$	149,957
$\hat{k}$	7,850,506



Using the translated gamma approximation we can obtain the Value-at-Risk, at 95% and 99%:

$$VaR_{0.95}(S) = 19{,}970{,}876$$

$$VaR_{0.99}(S) = 20{,}943{,}119$$

As expected, the values obtained using each approximation are similar.

5. Reinsurance analysis

5.1 Retained and ceded losses

Let $Z(M,L)$ and $Y(M,L)$ be random variables that represent the ceded and retained losses of an individual claim covered by an Excess of Loss reinsurance:

$$Z(M,L) = \min(L,(X-M)_+) = \begin{cases} 0 & if\ X \le M \\ X-M & if\ M < X \le M+L \\ L & if\ X > M+L \end{cases}$$

$$Y(M,L) = X - Z(M,L) = \begin{cases} X & if\ X \le M \\ M & if\ M < X \le M+L \\ X-L & if\ X > M+L \end{cases}$$

The k-th moment of the individual ceded and retained losses are:

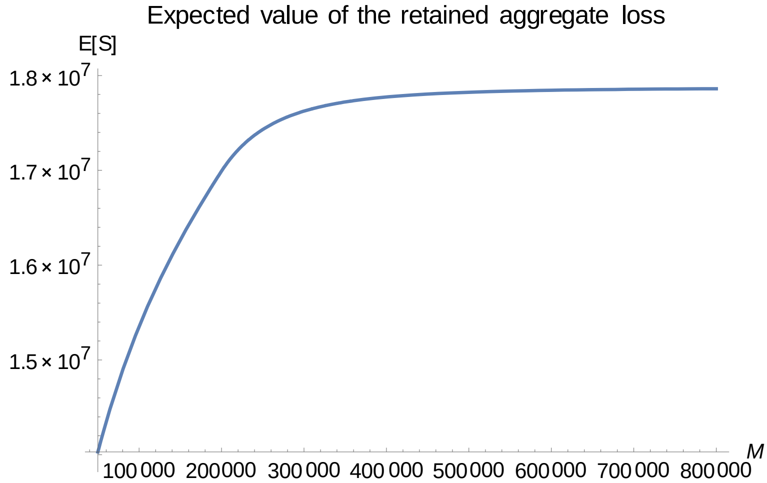
$$E\left[\left(Z(M,L)\right)^k\right] = \int_M^{M+L} (x-M)^k dF_X(x) + L^k\left(1-F_X(M+L)\right)$$

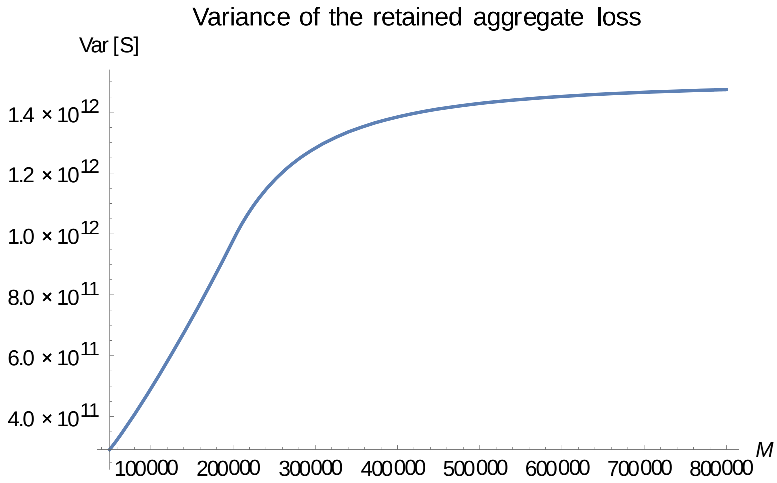
$$= k\int_M^{M+L} (x-M)^{k-1}\left(1-F_X(x)\right)dx$$

$$E\left[\left(Y(M,L)\right)^k\right] = \int_0^M x^k dF_X(x) + M^k\left(F_X(M+L)-F_X(M)\right) + \int_{M+L}^{\infty} (x-L)^k dF_X(x)$$

$$= k\int_0^M x^{k-1}\left(1-F_X(x)\right)dx + k\int_{M+L}^{\infty} (x-L)^{k-1}\left(1-F_X(x)\right)dx$$

In order to analyze how the changes in the retention limit M will affect the aggregate retained loss we calculated the expected value, variance and skewness coefficient of the aggregate loss as a function of M.





When M goes to L, the expected value tends to approximate to the expected value of the aggregate loss before reinsurance. The variance will increase with M, until it stabilizes. When M is too high, the probability of a claim reaching that limit is very small, and the amounts that will exceed it do not affect significantly the expected value and variance.

A positive Skewness means that the density distribution is right-skewed, which means that there's a higher probability for the lower values of the random variable. When the retention limit M increases, the aggregate retention loss becomes more positively skewed.

5.2 Approximation for the retained loss distribution

For the retained loss distribution we only calculated the Normal-Power approximation, since the results obtained using the translated gamma approximation are very similar.

<u>NP Approximation</u>

We also calculated a Normal Power approximation for the retained aggregate loss for each value of the retention limit M.

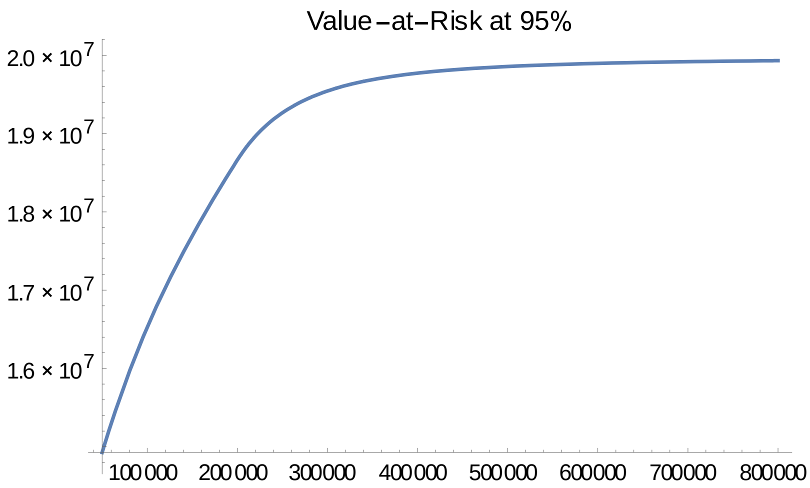
For a distribution function S obtained using the NP-Approximation, the Value-at- Risk can be found using the following expression:

$$VaR_\alpha(S) = \left[z_\alpha + \frac{\gamma_S}{6} \cdot ({z_\alpha}^2 - 1)\right] \cdot \sigma_S + E[S],$$

where z_α represents the α-quantile of a Standard Normal Distribution:

$$\Phi(z_\alpha) = \alpha$$

Using the NP-approximation, the Value-at-Risk, at 95%, for the retained aggregate risk for each M is represented by the following:



5.3 Premium and Profit analysis

Next we want to measure the impact of changes in the retention limit M in the technical result of Worker's Compensation business in the Company in 2013.

First let $P_{ceded}(M, L)$ be the ceded premium and $S_{retained}(M, L)$ the aggregate retained loss for a treaty with retention limit M and reinsurance limit L. Additionally, let $W(M, L)$ be a random variable such that:

$$W(M, L) = P_{ceded}(M, L) + S_{retained}(M, L)$$

Before proceeding it is important to explain how the premium ceded was obtained. A premium calculation principle is a rule that assigns to each risk a real non-negative number, depending only in the cumulative distribution function. The pure premium is the expected value of the aggregate risk, but usually the premium should be greater than the pure premium. The difference between the premium and the pure premium is denominated as security loading.

When we change the values of the reinsurance retention limit, the premium paid for the treaty needs to be adjusted as well. We considered the standard deviation premium principle, in which the loading is proportional to the standard deviation of the aggregate claims:

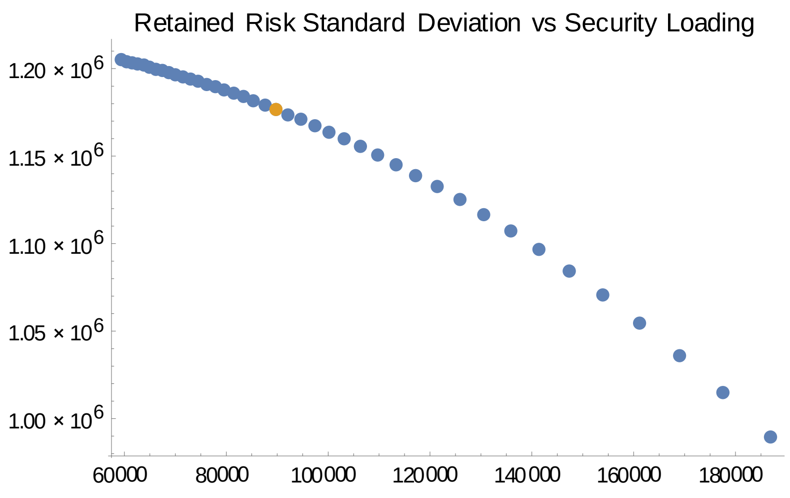
$$P_{ceded}(M,L) = E[S_{ceded}(M,L)] + \alpha\sqrt{Var\left(S_{ceded}(M,L)\right)}, \qquad \alpha \geq 0$$

We assumed that the reinsurer would request a fixed α for variations of the retention limit. Therefore we obtained α for the current minimum premium established in the treaty:

$$\alpha = \frac{P_{ceded}(400{,}000; 22{,}500{,}000) - E[S_{ceded}(400{,}000; 22{,}500{,}000)]}{\sqrt{Var\left(S_{ceded}(400{,}000; 22{,}500{,}000)\right)}}$$

$$\Rightarrow \alpha = 0.458132$$

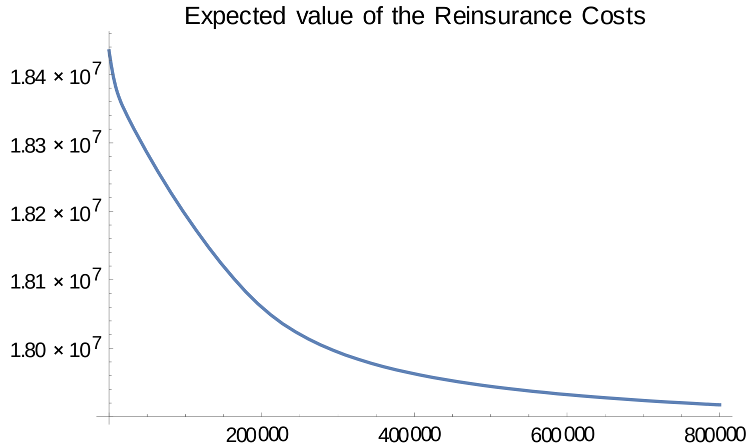
The following graph represents, for each M, the standard deviation of the random variable $S_{retained}(M,L)$ (retained aggregate loss) against the security loading for the premium ceded:

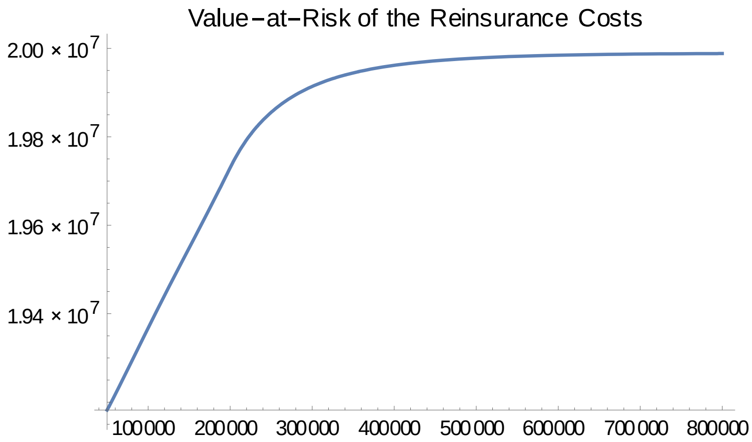


where the orange point represents the results for $M = 400{,}000€$.

We observe that when the security loading increases, and consequently the premium paid increases, the standard deviation of the retained aggregate loss does not decrease as much. We would need a great increase in the security loading to have a significant decrease of the volatility of the risk retained.

Next we calculated the expected value and Value-at-Risk, at 95%, of the reinsurance costs, $W(M, L)$, as a function of the retention limit M.





When the limit M increases, the expected value of the reinsurance costs decreases, due to a reduction of the ceded loading. However, the loss retained becomes more volatile and the probability of higher losses increases. Therefore the Value-at-Risk for the reinsurance costs increases.

If we subtract the random variable $W(M,L)$ to the gross earned premium, other costs and losses occurred from other Worker's Compensation pensions not qualified for reinsurance, we obtain the random variable $T(M,L)$ that represents the technical result of the entire WsC line of business.

With these results we observe that if we changed the retention limit from the current 400,000€ to 600,000€ we would increase the technical result in 0.37%, which represents an increase of 30,342€ in the year of change. And the Value-at-Risk of the retained aggregate losses would increase in 0.63%. If we changed the retention limit from 400,000€ to 500,000€ we would increase the technical result in 0.22%, which represents an increase of 18,325€ in the first year. And the Value-at-Risk for the retained aggregate losses would increase 0.43%.

6. Conclusions

Worker's Compensation is an important line of business, not only due to its mandatory nature, but also because it represents a significant part of the entire business.

Due to its mandatory nature, Worker's Compensation is object of several changes in the law. And companies should comply with several requirements from the Portuguese regulator. This means that the companies need to have additional care with this line of business.

Several studies and analysis are performed throughout the year in order to make sure that claims are well provisioned, and benefits are paid accordingly to the laws and regulatory requirements. We also perform impact studies to understand if the assumptions used by the Company are adjusted to our portfolio.

When choosing the universe of claims to analyze we chose the claims that occurred in the year 2013. The severities of these claims may suffer some variations in the future, and therefore the ceded costs will also change accordingly. Hence the ceded cost estimated in this report does not correspond to the final ceded cost of the claims occurred in 2013. However, it corresponds to the cost that we will observe in the technical result of the year 2013.

We could have chosen to model the number and severity of claims occurred in 2009 and we would have the ultimate cost covered by the reinsurer. Following the end of the fifth year, after the occurrence of a claim, the reinsurer settles an ultimate cost and the claim ceases to be covered by reinsurance. However the severities of claims that occurred in 2009 may not represent exactly the reality in 2013 due to changes in model assumptions and economic reality. Therefore, we couldn’t make the correspondence to the reality in the present-day.

For the severity random variable we verified that the selected distribution didn’t fit the sample very well. Hence if we tested other distributions or used additional hypothesis tests to verify the fitness of the distributions, we could have found one that fitted better.

Additionally, with a reliable database for extremely high claims that already occurred throughout the years, we could estimate the parameter p_2 of the selected distribution instead of assuming a given value.

The excess of Loss reinsurance treaty applied to Worker's Compensation has a retention limit very high. A huge part of the claims do not reach the retention limit, causing a cession rate very low.

With our analysis we observed that an increase of the retention limit could enhance our technical results, however we would be more exposed to the volatility of the business. From a conservative perspective, we should choose a lower retention limit even if it means a higher cost for the Company. Since a lower retention limit means an increase of the ceded premium. In a riskier perspective we could increase the retention limit to increase the net profit of the business, causing a more volatile retained loss.

For future studies we could analyze the impact of adding Long term assistance to the reinsurance treaty. Additionally we should also test if a lower liability cover limit L could decrease the ceded premium without increasing the retained risk as much.

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8.1. Appendix 1: Benefits Calculations

Disability	Benefits	Calculation
ITA – Absolute Temporary Disability	Daily compensation if the disability does not exceed 30 days	Gross monthly salary x 70% / 30 x nº of disability days
	Daily compensation if the disability > 30 days and =/< 12 months	Gross monthly salary x 70% / 360 x nº of disability days
	Daily compensation if the disability after 12 months	Gross monthly salary x 75% / 360 x nº of disability days
ITP – Partial Temporary Disability	Daily compensation if the disability does not exceed 30 days	Gross monthly salary x 70% x %IT / 30 x nº of disability days
	Daily compensation if the disability > 30 days	Gross monthly salary x 70% x %IT / 360 x nº of disability days
	Allowance for occupational rehabilitation (if it fulfils conditions)	Expenses amount up to 1.1 IAS/month for a maximum of 36 months
IPA – Absolute Permanent Disability	Lifetime Pension	Gross monthly salary x 80% + 10% for each dependent person (up to 20%)
	Additional benefit for 3rd person assistance (if clinically justifiable)	Monthly allowance up to 1.1 IAS (minimum 6h) x 14
	High permanent disability allowance	12 x 1.1 IAS in force at the time of the accident
	Residence rehabilitation allowance (if required)	Expenses amount up to 12 x 1.1 IAS in force at the time of the accident
IPATH – Absolute Permanent Disability for the Usual Work	Lifetime Pension	Gross monthly salary x [(70% - 50%) x IPP + 50%]
	Additional benefit for 3rd person assistance (if clinically justifiable)	Monthly allowance up to 1.1 IAS (minimum 6h - maximum 24h) x 14
	High permanent disability allowance	(1.1 IAS x 12) - (1.1 IAS x 12 x 70%) x IPP + (1.1 IAS x 12 x 70%)
	Residence rehabilitation allowance (if required)	Expenses amount up to 12 x 1.1 IAS in force at the time of the accident
	Allowance for occupational rehabilitation (if it fulfils conditions)	Expenses amount up to 1.1 IAS/month for a maximum of 36 months
IPP – Partial Permanent Disability	Lifetime Pension if IPP=/>30% or amount > 6 RMMG	Gross monthly salary x 70% x IPP
	Redeemable capital if IPP <30% and pension amount =/<6 RMMG	Gross monthly salary x 70% x IPP x rate corresponding to the age
	Additional benefit for 3rd person assistance (if clinically justifiable)	Monthly allowance up to 1.1 IAS (minimum 6h - maximum 24h) x 14
	High permanent disability allowance if IPP =/> 70%	12 x 1.1 IAS in force at the time of the accident x IPP
	Residence rehabilitation allowance (if required)	Expenses amount up to 12 x 1.1 IAS in force at the time of the accident
	Allowance for occupational rehabilitation (if it fulfils conditions)	Expenses amount up to 1.1 IAS/month for a maximum of 36 months

8.2. Appendix 2: Mortality tables

MT	Type of pensions	MT	Assumptions	
30	Non-Redeemable	Pensioner	25% GKF80+75% GKM95	
31		Pensioner under 14 year old	Interest rate	4.00%
32		Relatives in retirement age	V	0.9615385
33		widow	Charges	2.00%
34		Spouse, in retirement age under 65 year old		
40	Redeemable	Pensioner	(Table TD 88/90 - 5.25% enc 0%) + temporary income 4 Years (TD 88/90 5.25% enc 2%)	
41		Pensioner under 14 year old	Interest rate	5.25%
42		Relatives in retirement age	V	0.9501188
43		Spouse, in retirement age under 65 year old	Charges	2.00%

Age\MT	Pensions MT									LTA MT
	30	31	32	33	34	40	41	42	43	
0	24.402	16.249	24.652			18.744	14.023	18.832		30.982
1	24.336	15.857	24.596			18.864	13.853	18.958		30.852
2	24.267	15.449	24.537			18.837	13.559	18.936		30.718
3	24.196	15.025	24.477			18.804	13.246	18.908		30.580
4	24.121	14.584	24.414			18.766	12.915	18.876		30.438
5	24.044	14.125	24.348			18.726	12.565	18.841		30.292
6	23.964	13.648	24.280			18.683	12.197	18.804		30.142
7	23.880	13.151	24.209			18.637	11.809	18.764		29.987
8	23.793	12.635	24.135			18.588	11.400	18.722		29.827
9	23.703	12.099	24.059			18.537	10.970	18.678		29.663
10	23.609	11.541	23.979			18.482	10.516	18.631		29.494
11	23.511	10.960	23.896			18.425	10.039	18.582		29.319
12	23.410	10.356	23.810			18.365	9.537	18.530		29.140
13	23.304	9.729	23.720			18.302	9.008	18.476		28.955
14	23.194	9.076	23.627	13.807	13.879	18.237	8.452	18.421	11.982	28.765
15	23.080	8.397	23.530	13.318	13.392	18.169	7.868	18.363	11.584	28.569
16	22.994	7.702	23.463	12.827	12.905	18.100	7.253	18.304	11.166	28.410
17	22.906	6.979	23.394	12.317	12.398	18.030	6.606	18.245	10.728	28.247
18	22.814	6.226	23.322	11.785	11.870	17.961	5.927	18.188	10.269	28.079
19	22.718	5.441	23.247	11.476	11.566	17.894	5.214	18.133	9.996	27.906
20	22.618	4.624	23.169	11.275	11.374	17.826	4.462	18.078	9.811	27.727
21	22.513	3.773	23.088	11.172	11.280	17.757	3.671	18.022	9.707	27.541
22	22.404	2.886	23.002	11.157	11.278	17.685	2.837	17.965	9.675	27.349

23	22.289	1.963	22.912	11.225	11.361	17.611	1.959	17.906	9.711	27.149
24	22.169	1.001	22.817	11.371	11.526	17.532	1.032	17.843	9.810	26.943
25	22.043		22.719	11.591	11.768	17.449	0.056	17.777	9.970	26.730
26	21.912		22.615	11.880	12.083	17.361		17.707	10.185	26.510
27	21.775		22.507	12.231	12.464	17.269		17.633	10.452	26.282
28	21.632		22.394	12.635	12.904	17.172		17.555	10.763	26.047
29	21.483		22.277	13.080	13.388	17.069		17.474	11.109	25.805
30	21.327		22.154	13.546	13.899	16.962		17.389	11.476	25.555
31	21.166		22.027	14.021	14.422	16.850		17.300	11.853	25.298
32	20.998		21.895	14.485	14.938	16.733		17.207	12.225	25.034
33	20.823		21.757	14.915	15.422	16.611		17.111	12.574	24.762
34	20.642		21.614	15.299	15.864	16.484		17.011	12.892	24.482
35	20.454		21.467	15.642	16.267	16.352		16.908	13.181	24.195
36	20.259		21.314	15.956	16.642	16.214		16.800	13.452	23.901
37	20.057		21.155	16.232	16.983	16.071		16.689	13.698	23.598
38	19.847		20.991	16.457	17.275	15.922		16.574	13.908	23.289
39	19.630		20.822	16.633	17.519	15.767		16.455	14.084	22.971
40	19.406		20.648	16.763	17.717	15.606		16.332	14.228	22.646
41	19.174		20.468	16.848	17.874	15.438		16.204	14.340	22.313
42	18.935		20.283	16.893	17.991	15.266		16.075	14.426	21.973
43	18.688		20.093	16.899	18.071	15.087		15.942	14.485	21.624
44	18.434		19.898	16.869	18.117	14.906		15.809	14.524	21.268
45	18.172		19.698	16.807	18.133	14.719		15.673	14.541	20.905
46	17.903		19.493	16.714	18.120	14.525		15.534	14.538	20.534
47	17.626		19.285	16.593	18.081	14.325		15.392	14.517	20.156
48	17.342		19.072	16.446	18.019	14.118		15.247	14.480	19.771
49	17.051		18.856	16.275	17.936	13.906		15.101	14.428	19.379
50	16.753		18.637	16.083	17.834	13.691		14.955	14.367	18.981
51	16.448		18.416	15.871	17.717	13.471		14.811	14.296	18.577
52	16.137		18.193	15.641	17.585	13.247		14.667	14.218	18.167
53	15.820		17.968	15.394	17.441	13.019		14.526	14.135	17.753
54	15.497		17.743	15.132	17.287	12.787		14.387	14.047	17.334
55	15.168		17.518	14.857	17.124	12.551		14.252	13.956	16.910
56	14.833		17.294	14.569	16.954	12.314		14.123	13.867	16.483
57	14.493		17.071	14.269	16.780	12.071		13.998	13.776	16.052
58	14.149		16.851	13.959	16.602	11.824		13.876	13.686	15.618
59	13.799		16.634	13.640	16.423	11.573		13.763	13.600	15.181
60	13.444		16.422	13.311	16.244	11.318		13.656	13.517	14.740
61	13.085		16.215	12.974	16.066	11.060		13.561	13.443	14.296
62	12.721		16.015	12.630	15.891	10.799		13.475	13.377	13.848
63	12.352		15.823	12.278	15.722	10.532		13.402	13.321	13.396
64	11.979		15.640	11.920	15.560	10.261		13.341	13.276	12.941
65	11.601		11.601	11.554	11.554	9.983		9.983	9.945	12.483
66	11.220		11.220	11.184	11.184	9.699		9.699	9.669	12.024

67	10.838	10.838	10.811	10.811	9.406	9.406	9.384	11.567
68	10.457	10.457	10.438	10.438	9.109	9.109	9.094	11.114
69	10.077	10.077	10.065	10.065	8.807	8.807	8.798	10.668
70	9.702	9.702	9.696	9.696	8.503	8.503	8.498	10.230
71	9.331	9.331	9.331	9.331	8.194	8.194	8.194	9.803
72	8.967	8.967	8.967	8.967	7.887	7.887	7.887	9.386
73	8.609	8.609	8.609	8.609	7.579	7.579	7.579	8.982
74	8.259	8.259	8.259	8.259	7.270	7.270	7.270	8.591
75	7.918	7.918	7.918	7.918	6.960	6.960	6.960	8.214
76	7.586	7.586	7.586	7.586	6.652	6.652	6.652	7.850
77	7.264	7.264	7.264	7.264	6.345	6.345	6.345	7.501
78	6.951	6.951	6.951	6.951	6.042	6.042	6.042	7.166
79	6.648	6.648	6.648	6.648	5.747	5.747	5.747	6.845
80	6.356	6.356	6.356	6.356	5.456	5.456	5.456	6.538
81	6.074	6.074	6.074	6.074	5.172	5.172	5.172	6.246
82	5.802	5.802	5.802	5.802	4.901	4.901	4.901	5.966
83	5.540	5.540	5.540	5.540	4.639	4.639	4.639	5.700
84	5.288	5.288	5.288	5.288	4.385	4.385	4.385	5.447
85	5.047	5.047	5.047	5.047	4.143	4.143	4.143	5.207
86	4.815	4.815	4.815	4.815	3.908	3.908	3.908	4.978
87	4.593	4.593	4.593	4.593	3.680	3.680	3.680	4.762
88	4.380	4.380	4.380	4.380	3.466	3.466	3.466	4.557
89	4.177	4.177	4.177	4.177	3.270	3.270	3.270	4.363
90	3.982	3.982	3.982	3.982	3.084	3.084	3.084	4.180
91	3.797	3.797	3.797	3.797	2.904	2.904	2.904	4.008
92	3.620	3.620	3.620	3.620	2.735	2.735	2.735	3.846
93	3.450	3.450	3.450	3.450	2.584	2.584	2.584	3.654
94	3.289	3.289	3.289	3.289	2.437	2.437	2.437	3.503
95	3.136	3.136	3.136	3.136	2.291	2.291	2.291	3.358
96	2.989	2.989	2.989	2.989	2.130	2.130	2.130	3.222
97	2.849	2.849	2.849	2.849	1.973	1.973	1.973	3.092
98	2.715	2.715	2.715	2.715	1.790	1.790	1.790	2.968
99	2.586	2.586	2.586	2.586	1.665	1.665	1.665	2.851
100	2.461	2.461	2.461	2.461	1.554	1.554	1.554	2.740
101	2.338	2.338	2.338	2.338	1.447	1.447	1.447	2.634
102	2.216	2.216	2.216	2.216	1.332	1.332	1.332	2.534
103	2.088	2.088	2.088	2.088	1.218	1.218	1.218	2.438
104	1.949	1.949	1.949	1.949	1.059	1.059	1.059	2.347
105	1.785	1.785	1.785	1.785	0.829	0.829	0.829	2.261
106	1.571	1.571	1.571	1.571	0.553	0.553	0.553	2.178
107	1.831	1.831	1.831	1.831	0.553	0.553	0.553	2.100
108	1.754	1.754	1.754	1.754				2.025
109	1.680	1.680	1.680	1.680				1.953
110	1.609	1.609	1.609	1.609				1.885

111	1.538	1.538	1.538	1.538	1.819
112	1.471	1.471	1.471	1.471	1.755
113	1.397	1.397	1.397	1.397	1.691
114	1.300	1.300	1.300	1.300	1.620
115	1.179	1.179	1.179	1.179	1.530
116	1.010	1.010	1.010	1.010	1.375
117	0.553	0.553	0.553	0.553	