

Internal Assessment for Underwriting Risk to Estimate the Solvency Capital Requirements Applied to Egyptian Non-Life Insurance Companies

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Abstract

the aim of this research is to estimate the solvency capital requirements and financial planning for the underwriting risk with application to non-life Egyptian insurance companies using the partial capital Model. Additionally, this research calibrates the underwriting risk using the undertaking-specific Parameters (USPs) as input for own Risk and solvency assessment (ORSA) in order to estimate the key volatility of risks, which enhances the Enterprise Risk Management (ERM) framework for Egyptian non-life insurance companies. Finally, this research aimed to test the quality of the capital model, determine the one-year change and quantify the one-year reserve risk as a portion of the ultimate risk (emergence risk), which are considered the important steps towards validation the reserving risk of capital model and understanding the reserve risk assessment from ultimate to the one-year reserve risk. This paper suggested partial capital model using the statistical-analytic methods, Mathematical methods and Scenario shocks based on the excel calculations with the help of a supported tool of solvency II called Quantitative Impact Study5 (QIS5). The authors selected value at Risk (VAR) with 99.5% over one-year time horizon, which is consistent with solvency II. This research will be guide for the future decisions on assessment of underwriting risks and integrate the capital model into of any insurance company's ERM plan.

Keywords: Internal Capital Model, Solvency II, own Risk and solvency assessment (ORSA), underwriting risks, solvency Capital requirements (SCR).

I. INTRODUCTION.

The reform of financial Regulatory authority (FRA) in Egypt in 2009 by merging all financial non-banks sectors, which created the need for ERM framework for these sectors. ERM has been the center of attention in the risk management world, where ERM helps in management of all the risks facing on an organization (both financial and non-financial). ERM framework enhances company's financial position and protects shareholders. Additionally, a lack of a suitable ERM can make many financial problems due to inadequate capital, which leads making the insurer insolvent or overestimation of Solvency Capital requirement (SCR).

The Solvency II project was launched by EIOPA (European Insurance and Occupational Pensions Authority) in the early 2000s in order to overcome limitations in insurance regulation in Europe, survive business and be able to pay liabilities to the shareholders and assure stability against any unexpected adverse fluctuation, with a 99.5% confidence level over a one-year time horizon and 1- to 200-year event occurrence frequency. The Solvency Capital requirements can be calculated using **a standard formula** or **partial** or **full internal models**. (cadoni, 2014).

Solvency II framework included quantitative and qualitative aspects of risk focusing on the following: (Lavelle et al, 2010)

- **Pillar I** (Quantitative requirement): Current-looking of solvency capital requirement.

- **Pillar II** (Qualitative requirement): It focuses on the ERM. It can be stressed that own Risk and Solvency assessment (ORSA), which represents the company's own view of required capital.
- **Pillar 3** (Market discipline): Disclosure and transparency.

The internal capital model is a key component of the company's future ERM and assessment of own risks. It can be defined as "a risk management system developed by an insurer to assess the overall risk profile, to model risks, and to estimate the economic capital requirements". Additionally, the internal capital model is used to assess the overall solvency needs (OSN), calculate the solvency capital requirements and meet ORSA requirements. On the other hand, the partial internal model is defined as "quantifying certain risk modules using the internal models, while the other risks are calculated using the standard approach". (Hill, 2008).

In order to obtain supervisory approval of the internal Capital under solvency II, the following tests in article 120 to 125 must be satisfied model according to Solvency II Directives (Anzar et al, 2012):

- Use tests.
- Statistical quality standards.
- Calibration standards.
- Profit and loss attribution.
- Validation standard Model.

In order to assess the impact of the standard formula with the internal models on the solvency capital requirements, EIOPA has conducted a series of Quantitative Impact Study (QIS5). Solvency capital requirements for non-life insurance companies are classified into: Market risk, Credit risk, Non-life underwriting risk and operational risk. This research will concentrate on the non-life underwriting risk, which represents the significant risk for the non-life insurance companies.

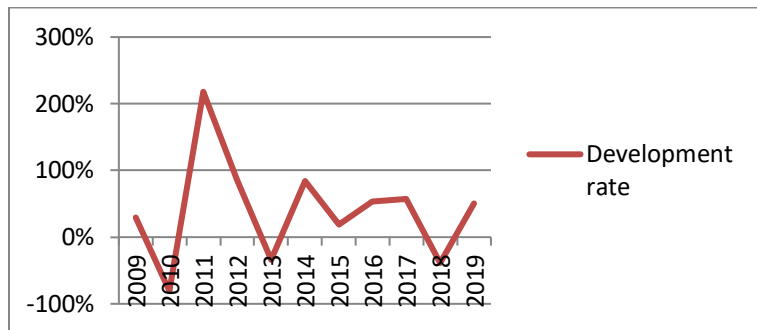
The underwriting risk is defined as "the uncertainty in the results of insurers related to existing insurance and reinsurance obligations, as well as to the new business expected to be written over the following 12 months". Additionally, non-life underwriting risk module consists of: The premium risk, the reserve risk (attritional losses), large losses and non-life catastrophe risk. Solvency II takes into considerations the one-year reserve risk, which is only the risk of the technical provisions in the Solvency II Economic balance sheet and arises from movements in the reserves and the risk margin. (Scott, 2020).

Now a day, the Egyptian insurance sector is growing with the economic growth of the country. According to the solvency for insurance companies, the Egyptian insurance supervision law specified that the total assets of insurance company should exceed its liabilities with 20% of earned premium and 25% of incurred claims (**Law no.1981**). FRA doesn't specify the approach in order to determine the r solvency capital requirements. Additionally, the Egyptian non-life insurance company doesn't efficiently manage all types of the risks, where the risk management is focused only on claim frequency and severity, ignoring the dependencies among risks, which give an incomplete image of ERM framework.

Figure 1**Error! Reference source not found.**, describes the development rate of the profit/loss insurance for the Egyptian non-life insurance companies during the period from 2008/2009 to 2018/2019 based on FRA annual insurance report, we notice that there are high fluctuations in the development rate of the profit/loss insurance from year to another. There is a significant decline in the underwriting profit/loss for the Egyptian non-life insurance companies in 2010, 2013 and 2018. These fluctuations might be due to inappropriateness in the strategies of underwriting process and investment strategies. The underwriting risk (reserve & premium) module is an important component of the solvency capital requirements for non-life insurance companies and according to the published working paper by A.M. Best (2001) summarized that the insolvency for non-life

insurance companies come from the reserve risk. Moreover, this report illustrated that integrated ERM into the capital model for insurance companies is a one of the Lessons learned from the financial crises 2007-2008.

Figure 1: The Development rate of profit and loss for non-life insurers¹.



II. LITERATURE REVIEW

McNeil et al (2009) illustrated the strategies of integration the economic capital model in order to enhance (ERM) and its importance for the regulatory capital frameworks. Moreover, it estimated and allocated the required capital in order to develop and strengthen ERM framework within the undertakings.

Krvavych (2013) illustrated that using internal models are not only calculation of the regulatory capital requirements, but also providing greater insight into company's risk profile and enhancing ERM Framework. Additionally, It concluded that model can be used assess the efficiency of company's capital requirements, enhance shareholder surplus and the integrating internal capital model into ERM plan of the insurer helps in meeting regulatory requirements.

Vania R.Elias (2013) aimed to assess the overall solvency needs for non-life insurance companies with a view to their specific risk profile and estimate the undertaking specific parameters (USP) for reserve risk. For this purpose, the researcher estimated the ultimate reserve risk by using Mack chain Ladder, Boot chain ladder and Munich chain ladder and calculated the MSEP using the Merz-Wüthrich method. It concluded that he insurer should select the suitable methods that consist with its own data.

Clemente and savelli (2013) estimated the solvency capital requirement of premium and reserve risk. For this purpose, it used a risk theoretical simulation model applied in order to estimate risk capital requirements of insurance risk. Additionally, comparison had been performed between an internal risk model using collective risk model and Solvency II standard formula. It concluded that the choice of the stochastic model and the one-Year approach are the key approaches need to be investigated in order to perform assessment, with consistent with Solvency II.

Bermudez et al. (2013) formulated the internal capital model as a joint measurement of reserve and premiums risks in order to determine the solvency capital requirement (SCR). The author calculated SCR for the underwriting risk using the standard formula solvency II. Alternatively, the SCR for the underwriting risk was calculated using Monte Carlos simulations with one-year time horizon, using copula to measure the dependencies between lines of business. This research concluded that SCR by using the standard Solvency II approach overestimated the capital by using the proposed capital model. Moreover, modifications of the correlation matrix assumptions have a significant effect on SCR calculations.

Kočović and Koprivica (2018) proposed a partial internal model for measuring premium risk in order to calculate SCR of non-life insurance companies. This research helped in overcoming the limitations in the fixed-ratio dynamic methodology for determining SCR of non-life insurers. For this objective, this research suggested partial internal model, which was based on the full probability distribution of total claim amount. It

¹ Based on the "Annual Statistical report for Egyptian insurance market", Financial Regulatory Authority (FRA) in for the financial year 2018/2019.

concluded that the proposed model can determine the solvency capital requirement and its allocation, as well as enhancing the risk management framework.

Zarina et al, (2019) illustrated the factors that affect the capital and the strategies in order to strengthen the risk management and capital management by using one of the most suitable models: a standard formula with or without USP, a partial internal capital model and a full internal capital model. Moreover, it illustrated the components of internal capital models under the Solvency II. It concluded that the new risk assessment methods should be updated in order to develop internal capital models. Moreover, the regulators should cope with the requirements according to articles from 120 to 125 of the Solvency II Directive 2009.

III. CONCEPTUAL FRAMEWORK AND RESEARCH METHODOLOGY.

This research was applied to one of major non-life Egyptian insurance companies based on triangle of cumulative paid and incurred claims from 2011-2019 between different LOB of this company ,earned premiums and net reserves for each LOB for last 12 months. This triangle is adjusted by: Large Losses, Adjustment of the diagonal to reflect 12 months, Inflation adjustment, and Exchange rate and Actuarial judgments.

3.1 The solvency Capital Requirements for the underwriting Risk.

The portfolio loss function of the underwriting risk is a combination of different functions: **Attritional losses, Large Losses and CAT losses.**

A. Attritional losses:

The researchers quantified the loss function of the attritional losses (premium and reserve) with the help of a Log Normal distribution. The solvency capital requirements for premium risks with VAR_{99.5%} under solvency II QIS5 is determined by:

$$N_{pr} = 3 \times \sigma \times V. \quad (1)$$

Where,

σ = the volatility from the Merz-Wüthrich algorithm (premium risk factor).

V = the volume measure of the net earned premiums for 12 month for each LOB.

Additionally, the solvency capital requirement for Reserve risk with VAR_{99.5%} is determined by²:

$$N_{re} = 3 \times \sigma \times V. \quad (2)$$

Where,

σ = the volatility from the Merz-Wüthrich algorithm (Reserve risk factor).

V = the volume measure of the net reserves for 12 month for each LOB.

B. Large losses:

Large Losses are modeled separately to respect the fat tails of the loss distribution. Large claims are based on the probability distribution of the aggregate claim amounts, which are derived from the severity (amount of individual claims) and frequency of (number of claims), According to the collective risk model:

$$S = \sum_{i=1}^N X_i \quad (3)$$

Where,

X_i = the individual claim amounts, which are independent and identically distributed random variables. The aggregate claim amount distributions functions can be derived by:

$$F_s(x) = P(S \leq x) \quad (4)$$

² The reserve capital requirements should take into considerations the discount factor for each LOB.

The frequency distribution is **the Poisson distribution** and the severity distribution often a **Pareto distribution**. The convolution of both functions results in the overall distribution of claims. From the definition, the cumulative distributions of a Pareto random variable distribution with parameters α and

$$F_X(X) = \begin{cases} 1 - \left(\frac{x_m}{x}\right)^\alpha & X \geq X_m \\ 0 & X < X_m \end{cases} \quad (5)$$

In this model, the authors used the 99.5% confidence level of the large losses, which are estimated by $VAR_{99.5\%}$ of the Poisson distribution with an average claim.

C. CAT losses :

CAT losses are modeled extra to respect the fat tails of the loss distribution. The researchers modeled the CAT losses with the help of a scenario analysis. Under QIS5 solvency II, the natural and Man-made catastrophe losses, the CAT aggregation capital requirement is determined by the following:

$$\sqrt{(UW - CAT)_{Nat\ capital\ charge}^2 + (UW - CAT)_{ManMade\ capital\ charge}^2} \quad (6)$$

The diversification benefit should be taken into considerations in order to reduce the solvency capital requirements and enhance the capital management.

The Total capital requirement for Premium & Reserve & Large losses and CAT losses with diversification is determined by the following equation:

$$\sqrt{\sum \begin{matrix} \text{corr matrix of each LOB} \times \text{SCR for the premium, reserve and Large Losses of each LOB} \\ \text{the SCR for CAT according to the row and column of corr matrix of each LOB} \end{matrix}} \quad (7)$$

3.2 Calibration of the underwriting risk.

Under Solvency II, reserve risk takes a different meaning from the traditional actuarial view. In other words, it replaces the ultimate reserve view with one-year reserve view. Additionally, it concentrates on the profitability of reserve held over a one year, which is known as the Claims Development Result (CDR). The volatilities of premium and reserve risk are key factors that affect the capital requirement. calibration underwriting risk has the benefit in allowing a better assessment of the underwriting risk based on the risk profile , determining the one-year volatilities of the premium risk $\sigma_{(prem, LoB)}$ and one - year reserve risks $\sigma_{(res,LoB)}$,assessing the own solvency needs, which is considered as input for ORSA model.

3.2.1 Methods for calibration of the model of the insurance risks.

Calibration the underwriting risk with USPs and quantifying the prediction uncertainty for a one-year reserve using the statistical software R package and Excel Calculations with the help of QIS5.

The authors used the following methodology to calibrate the model:

A. The Merz -Wüthrich to perform one-year calibration:

- It is considered as Analytical approach to predict cumulative development result (CDR) and analyze the prediction uncertainty, which is considered a prospective view for solvency purpose.(Mouatassim, 2017). Its assumptions are illustrated in details in the next section.

B. Undertaking specific parameters (USPs) QIS5, which is the first step in order to obtain capital requirements more calibrated on the risk profile accurately. **Table 1** illustrates the Actuarial methods of the calibration the underwriting risk factors according to the data of this company and actuarial adjustment.

Table 1: The Actuarial methods of the underwriting risk factors.

The premium Risk	The Reserve Risk
- Chain Ladder.	- (Merz-Wüthrich) method.
- Bornhuetter-Ferguson (BF).	- Chain Ladder Method.
- Additive Loss Reserving Method.	- Additive Loss Reserving Method

3.2.2 The assumptions of calibration premium and reserve risks methods by USPs.

The assumption of each methods are summarized as follow: (Robert Scarth et al , 2020)

A. The chain ladder method.

The assessment of the loss development factor, which is determined on the basis of cumulative incurred claims in the following manner:

$$\widehat{f}_j = \frac{\sum_{i=1}^{n-j} c_{i,j+1}}{\sum_{i=1}^{n-j} c_{i,j}} \tag{8}$$

Where,

- \widehat{f}_j : is the estimate of the development factor.
- $C_{i,j}$: cumulative inflation Adj. paid claims that have occurred in i^{th} period, and that are settled until the end of j^{th} period.

Then, apply the development factor to obtain the final ultimate claims paid occurred in i^{th} year

$$\widehat{c}_{i,ult} = \widehat{c}_{i,n} \cdot \widehat{f}_{ult} \tag{9}$$

Where ,

$$\widehat{f}_{ult} = \prod_{j=n}^{\infty} \widehat{f}_j$$

B. The Bornhuetter-Ferguson (BF) method.

This method combines the expected loss ratio method and the method of development of paid claims Adj. inflation. The final ultimate claims paid are estimated as follow:

$$\widehat{c}_{i,n}^{BF} = c_{i,j} + \widehat{c}_{i,n} \cdot \left(1 - \frac{1}{F_j} \right) \tag{10}$$

Where,

- $C_{i,j}$: the cumulative inflation Adj. Paid claims.
- F_j : the cumulative factor of development of claims ($F_j = \prod_{j=n}^{\infty} \widehat{f}_j$)
- $\widehat{c}_{i,n}$: the estimate of ultimate cumulative claims.

C. Additive Loss Reserving (ALR) Method.

The additive method (incremental loss ratio) is based on the development pattern for incremental loss ratios, which are estimated as follow :

$$\text{Incremental loss ratios} = \frac{\text{ultimate claims paid Adj.inflation}}{\text{the premiums}} \tag{11}$$

The incremental inflation Adj. premiums calculation takes into consideration the discount Factor.

3.3 Merz and Wüthrich Analytical approach

Merz and Wüthrich derived analytic formulae for the (**prediction uncertainty**) of the cumulative development result (CDR), which is considered as the one-year uncertainty of claims. This method is based on Mack’s model. This approach gives analytic expression for the mean Square Error Prediction (MSEP) of the CDR within Mack’s model. Also, it has a similar separation in process variance term and parameter estimation uncertainty as Mack’s formula. The Mack formula estimates this conditional MSEP in the distribution-free CL model at time $t = I$ by

$$\text{MSEP}^{\text{MACK}}_{C_{i,j}/D_I} = \sum_{j=I-1}^{J-1} \frac{S_j^2}{(F_j \widehat{CL}(I))^2} \left[\frac{1}{\widehat{CL}(I)} + \frac{1}{\sum_{l=1}^{I-j-1} C_{i,j}} \right] \quad (12)$$

This method gives an estimate of the one-year risk, which is consistent with the estimate of the ultimate risk given by Mack’s formulas. However, they cannot allow for dependence between the lines. (England et al, 2019)

3.3.1 The assumptions of The Merz-Wüthrich method

The assumptions of this approach can be summarized as following: (Wüthrich, 2008)

- Cumulative payments $C_{i,j}$ in different accident years $i \in \{0, K, I\}$ are independent.
- $(C_{i,j})_{j \geq 0}$ are Markov processes and there exist constants $f_j > 0$, $\sigma_j > 0$ such that for all $1 \leq j \leq J$ and $0 \leq i \leq I$.

3.3.2 The Definition of Mean Square Error Prediction

The MSEP is defined as the prediction error, which can be approximated using the formula:

$$\text{MSEP} = \text{process variance} + \text{Estimation variance} \quad (13)$$

At time I , then, we have information D_I and our goal is to predict the random variable $C_{i,j}$, which defined as :

$$\text{MSEP}_{C_{i,j}/D_I}(\widehat{CL}, J) = [E(C_{i,j} - \widehat{CL}, J) / D_I] \quad (14)$$

Because \widehat{CL}, J is D_I -measurable this can easily be decoupled into process error (variance) and parameter error:

$$\text{MSEP}_{C_{i,j}/D_I}(\widehat{CL}, J) = \text{VAR}(C_{i,j} / D_I) + (E[C_{i,j} / D_I] - (\widehat{CL}, J))^2 \quad (15)$$

3.4 The claim Development result

CDR is defined as” the movement from the opening estimate of ultimate claims to the closing estimate of ultimate claims”. The CDR for origin period I , which is calculated using the formula (Scarth et al, 2020):

$${}_i \widehat{CDR}_{n-I+1} = {}_i U_{n-i+1} - {}_i U_{n-I+2} \quad (16)$$

Where,

- U_{n-i+1} : Opening Estimate of Ultimate.
- ${}_i U_{n-I+2}$: Closing Estimate of Ultimate.

The quantification of the prediction uncertainty for the observable CDR at the end of the accounting period is given by (Wüthrich, 2008):

$$\text{MSEP } \widehat{CDR}_{i(1+I)/D_I}(0) = E[(\widehat{CDR}_{i(1+I)} - 0)^2 / D_I] \quad (17)$$

This previous conditional MSEP gives the short-Term prospective solvency in order to hold margin risk capital for possible negative deviations of CDR.

3.5 Undertaking Specific Parameters methodologies

The Calculations of USPs use different mathematical and statistical methods. According to solvency II QIS5, the authors summarized the following methods to calibrate the risk factors based on the risk profile using USPs, which facilitate the ERM of the insurers. (CEIOPS, 2010)

Method 1:

The following relationships should take into considerations:

1. The behavior of losses is formulated as:

$$R_{Y,LoB} = V_{Y,LoB} + \sqrt{V_{Y,LoB}} \beta_{LoB} \epsilon_{Y,LoB} \quad (18)$$

Where,

- $V_{Y,LoB}$: the volume measured according to LOB in calendar year Y.
- β_{LoB} = Constant proportion for the variance of the best estimate for claims outstanding in one year + the incremental claims paid over the one year by LoB.
- $\epsilon_{Y,LoB}$ = An unspecified random variable with distribution with mean.

2. The estimator for β_{lob} is estimated by:

$$\hat{\beta}_{lob} = \sqrt{\frac{1}{N_{LoB}-1} * \sum \left(\frac{(R_{Y,LoB} - V_{Y,LoB})^2}{V_{Y,LoB}} \right)} \quad (19)$$

Where,

N_{LoB} = the number of data points available by LoB. The volatility of risk factor can be calculated using the following equation:

$$\sigma_{(U, lob)} = \frac{\hat{\beta}_{lob}}{\sqrt{PCO_{lob}}} \quad (20)$$

Where,

- The parameter value $\hat{\beta}_{lob}$ is the Constant of proportionality for the variance of loss by (LOB).
- PCO_{lob} = the best estimate for claims outstanding by LoB.

Method 2:

This method is based on Merz-Wüthrich methodology. The MESP of the claims development result (CDR) over the one year should take into consideration in this approach. The volatility of risk factor can be calculated using the following equation:

$$\sigma_{(U, lob)} = \frac{\sqrt{MSEP}}{PCO_{lob}} \quad (21)$$

However, PCO_{lob} : the best estimate for claims outstanding by LoB estimated via the Mack Model, which consistent with the Merz -Wüthrich method.

Method 3:

This method is similar to Method 2. However, PCO_{lob} : The best estimate for claims outstanding by LoB estimated via the Chain Ladder method.

IV. Main results of application the proposed model to Egyptian non-life Insurance Company.**4.1 The solvency capital requirements for the attritional losses of premium and reserve risks with the VaR99.5%**

In this section, we will illustrate the attritional losses of the underwriting risks for each LOB as shown in **table 2**. The authors calculate the volatility of the premium and reserve risks for attritional losses from Merz - Wüthrich methodology, taking into consideration the discount factor.

Table 2: Solvency Capital requirements of the attritional Losses

Line of Business	Net Earned Premium (last 12 months)	Net reserves	Premium Risk Factor	Reserve Risk Factor (Merz-Wüthrich)	Capital Requirement Premiums	Capital Requirements of Reserves
Fire	1,279,611,963	1,431,869,559	15.8%	31.1%	606,479,003	976,745,530
Marine Cargo	253,364,425	214,672,359	5.5%	27.8%	76,009,328	132,838,583
Inland Transport	76,949,760	37,291,833	10.9%	52.8%	25,061,014	47,650,584
Marine Hull	177,991,484	150,672,472	10.3%	56.6%	55,020,237	189,197,682
General Accidents	680,921,696	478,220,373	11.3%	32.2%	231,092,289	351,282,324
Engineering	221,003,629	590,366,045	9.8%	36.2%	66,301,089	444,811,434
TPL-Old	0 EGP	1,275,943,644	0.0%	21.9%	- EGP	515,314,091
TPL-New	242,502,795	633,175,560	14.2%	18.3%	103,242,285	265,369,430
Comprehensive	1,311,591,317	334,017,756	5.8%	10.8%	393,477,395	92,804,540
Aviation	122,618,058	299,764,359	9.7%	48.3%	36,785,417	324,756,096
Oil & Petrol	774,329,319	1,039,763,712	15.7%	81.1%	364,172,567	1,937,947,294
Medical	602,920,007	47,767,575	47.0%	55.7%	849,800,269	67,188,362
Total undiversified capital	5,743,804,453	6,533,525,247	15.1%	0%	2,807,440,893	5,345,905,951

4.2 The Capital requirement for the large losses are Calibrated by VAR99.5% of the Poisson distribution with an average claim

In this section, the authors modeled the large losses separately to respect the fat tails of the loss distribution using the Poisson distribution. It calculated λ of poisson distribution for the net large losses.

The poisson λ 99.5% quantil (empirical determined) is estimated by $= 99.5 \sigma + Z$ value of log normal distribution. The capital requirements from frequency losses for LOB = **Average single large losses (net) x Poisson Lambda 99.5% (Net)**.

Finally, the capital requirements for the large losses (net) are **750,445,520 EGP** and the Total capital requirement for Premium & Reserve & Large losses with diversification are shown in **table 3**.

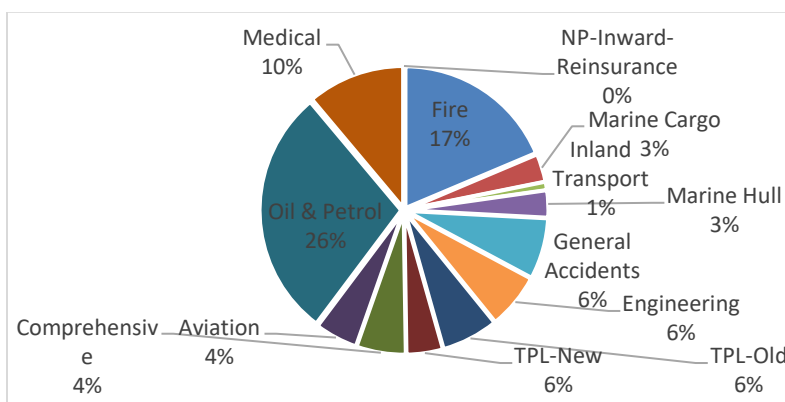
Table 3: The Solvency capital requirements for Premium & Reserve & Large losses

Line of Business	Capital Requirement Premiums	Capital Requirements Reserves	Capital Requirements Reserves for Large Losses	Correlation P/R/Large Losses	Capital Requirement Premium & Reserves & Large Losses (net)
Fire	606,479,003	976,745,530	165,961,774	50%	1,484,763,393
Marine Cargo	76,009,328	132,838,583	99,535,296	50%	253,407,759
Inland Transport	25,061,014	47,650,584	15,428,761	50%	73,842,408
Marine Hull	55,020,237	189,197,682	39,177,845	50%	245,632,909
General Accidents	31,092,289	351,282,324	75,499,991	50%	554,663,034

Engineering	66,301,089	444,811,434	42,614,848	50%	505,313,305
TPL-Old	0 EGP	515,314,091	0 EGP	50%	515,314,091
TPL-New	103,242,285	265,369,430	0 EGP	50%	329,358,847
Comprehensive	393,477,395	92,804,540	0 EGP	50%	447,161,751
Aviation	36,785,417	324,756,096	73,771,663	50%	388,432,431
Oil & Petrol	364,172,567	1,937,947,294	238,455,341	50%	2,280,311,895
Medical	849,800,269	67,188,362	0 EGP	50%	885,308,681
Total undiversified	2,807,440,893	5,345,905,951	750,445,520	50%	8,903,792,363
Diversification Benefit					2,861,298,207
NL P&R&LL Risk					6,042,494,156

The LOB capital requirement split for Premium& Reserve & large losses are shown in the **figure 2**, which is illustrated that underwriting Risk capital requirements without CAT risks for each LOB are followed by: oil & petrol (26%), fire (17%), Medical (10%), General Accidents (6%), Engineering (6%), TP-old and TP-New (6%), Aviation & comprehensive (4%), Marine Cargo & Marine Hull (3%), Inland Transport (1%), NP-Inward-Reinsurance (0%), Island Transport (1%).

Figure 2: The LOB capital requirement split for Premium& Reserve & large losses



4.3 The Capital requirement for the CAT losses are calibrated by VAR 99.5%

Table 4 , presents the results of CAT capital requirements using the scenario analysis and **equ.6**, with the help the Excel sheet calculations under solvency II QIS5.

Table 4: Solvency Capital requirements of CAT risk

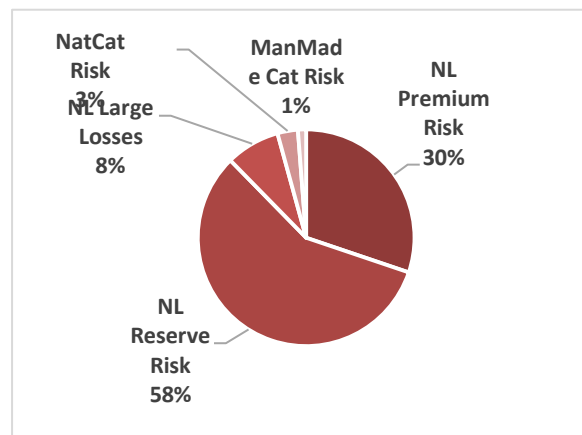
	Net capital requirements
CAT Capital requirement without diversification	396,710,328 EGP
Cat diversification benefit	91,478,557 EGP
Cat Capital requirements with diversification	305,231,771 EGP

From the previous table, the net CAT capital requirement without diversification is estimated by **396,710,328 EGP** and the CAT Capital requirement with diversification is estimated by **305,231,771 EGP**. This means that the average diversification impact reveals a **30%** reduction for CAT capital requirements. **Table 5** summarizes the non-life underwriting risk solvency capital requirements with diversification using **equ.7** and **figure 3** illustrates the composition of non-life underwriting risks split without diversification.

Table 5: The non-life underwriting risk solvency capital requirements

Risk module	Capital Requirement
NL Premium Risk	2,807,440,893 EGP
NL Reserve Risk	5,345,905,951 EGP
NL Large Losses	750,445,520 EGP
Nat Cat Risk	283,434,220 EGP
Man Made Cat Risk	113,276,107 EGP
Risk from P/R & Large Losses	6,042,494,156 EGP
Nat CAT & Man Made Risks	305,231,771 EGP
Total undiversified Capital Requirements	9,300,502,691 EGP
Diversification Benefit	3,174,567,443 EGP
Solvency Capital Requirements with diversification	6,125,935,248 EGP

Figure 3: The composition of non-life underwriting risks



The above figure illustrated that the reserve risk represents **58%**, which is the most critical risk in the non-life underwriting risk capital requirements. On the other hand, the CAT risk represents **4%**, which is the least critical risk in the Non-life underwriting capital requirements.

4.4 A correlation sensitivity analysis and stress test of non-life underwriting risk on the estimation of the solvency capital requirement.

Dependencies estimation becomes a key point in the estimation of the SCR under the Solvency II framework. In this section, the researchers measured the dependence within the risk categories of underwriting risks (attritional and large losses) by using the sensitivity analysis and the correlation matrixes between LOB. The sensitivity of premium, reserve and large losses volumes between LOB should take into consideration: average claims, the aggregation risk capital of Premium, Reserve and Large Losses, discount factor of reserve, premium and reserve risk factors and net earned premium (last 12 months). The effect of sensitivity analysis and stress test of the reducing Premium, reserve and large losses by **large amounts** (nonlinear effects) by using the sensitivity matrix of premium, reserve and large losses risk factors on the non-life underwriting capital requirements portfolio is shown **in table 6**.

Table 6: Non-Linear effects of sensitivity analysis on the estimation of the solvency capital requirements portfolio

The basic scenario of the capital requirements				Non-Linear effects of sensitivity analysis estimation portfolio			The Portfolio
LOB	Premium Risk	Reserve Risk	Large losses	Premium Risk	Reserve Risk	Large losses	Total capital requirements
Fire	606,479,003	976,745,530	165,961,774	253,255,536	473,195,802	59,915,878	786,367,216
Marine Cargo	76,009,328	132,838,583	99,535,296	28,901,575	58,476,801	37,781,181	125,159,557
Inland Transport	25,061,014	47,650,584	15,428,761	9,486,756	21,464,450	4,954,194	35,905,401
Marine Hull	55,020,237	189,197,682	39,177,845	19,840,296	88,426,981	13,295,548	121,562,824
General Accidents	231,092,289	351,282,324	75,499,991	92,214,808	161,321,924	26,186,634	279,723,367
Engineering	66,301,089	444,811,434	42,614,848	22,846,384	214,312,773	13,907,925	251,067,083
TPL-Old	0 EGP	515,314,091	0 EGP	- EGP	250,284,032	0 EGP	250,284,032
TPL-New	103,242,285	265,369,430	0 EGP	38,205,263	124,622,601	0 EGP	162,827,863
Comprehensive	393,477,395	92,804,540	0 EGP	176,367,210	35,017,447	0 EGP	211,384,658
Aviation	36,785,417	324,756,096	73,771,663	12,531,490	154,554,043	25,222,041	192,307,575
Oil & Petrol	364,172,567	1,937,947,294	238,455,341	140,770,271	1,017,694,864	87,317,437	1,245,782,572
Medical	849,800,269	67,188,362	0 EGP	393,869,660	24,036,121	0 EGP	417,905,780

As shown in the previous tables, there is a significant decrease (more than 50%) in the premium, reserve and large losses capital requirements after the non-linear correlation sensitivity analysis to measure the dependency structure between LOB and underwriting risk volatilities. Therefore, the dependency between lines of business is a key component of internal capital model and the dependency between the premium and reserve risks have a significant effect on the Solvency capital requirements.

4.5 Sensitivity and stress tests for the Premium and Reserve risks for each Line of Business.

In In this section, we will illustrate the sensitivity of premiums and reserve risks between LOB by using Macro excel sheet calculations, which used in determining the Technical result and mitigation strategies for the underwriting risk as shown in **figure 4** and **figure5**³.

Figure 4: Sensitivity of premium risk

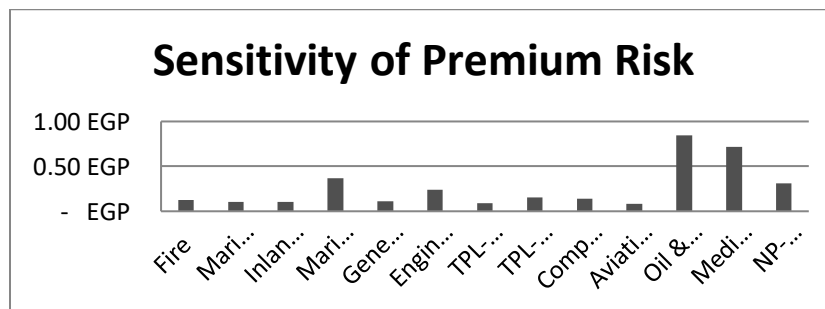
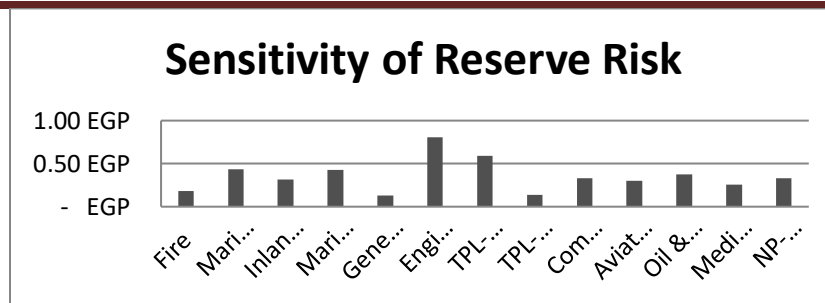


Figure 5: Sensitivity of Reserve risk

³ using the Expected combined ratio 80% and the weighted length of the development pattern ranged from 2-4 years according to LOB (i.e 1-2 year for property business and 2-4 years for casualty business)



4.6 Calibration the underwriting Risks

In this section , the authors calibrated the underwriting risk by using undertaking-specific parameters (USP) and Merz -Wüthrich Methodology, which reflect the risk profile of the own risks. Moreover, the CDR and the prediction uncertainty are the central aim of interest for the one-year reserve risk, which have to be analyzed. In addition to, studying possible shortfalls in the profit & loss statement need to be studied under solvency II requirements.

A. The Risk factor (volatilities) of the premium risk

The researchers calculated the volatility of the premium risks according to the different three methods as illustrates previously by using equ.8 to equ.11. The results are shown in tables 7and 8.

Table7: The loss ratios and the sigma of the premium risk based on the three methods

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019
Premium1 LR	26.6%	28.3%	21.8%	15.5%	24.1%	26.7%	18.8%	13.2%	13.6%
σ (CL method)	0.3%	0.5%	0.0%	0.3%	0.1%	0.4%	0.1%	0.4%	0.4%
Premium 2 LR	26.6%	28.3%	21.8%	15.9%	25.3%	29.2%	25.7%	19.1%	36.6%
σ (BF method)	0.01%	0.08%	0.12%	0.80%	0.00%	0.15%	0.00%	0.26%	0.88%
Premium 3 LR	26.6%	28.3%	21.8%	15.7%	24.2%	26.6%	19.2%	18.3%	21.9%
σ (ALR method)	0.15%	0.30%	0.0%	0.42%	0.03%	0.18%	0.11%	0.12%	0.00%

Table 8 : The volatility of the premium risk under 3 methods

Premium Risk Factor	
Premium Risk 1 Factor (CL)	5.43%.
Premium Risk 2 Factor (BF)	5.37%
Premium Risk 3 Factor (ALR)	4.05%

B. The Risk factor (volatilities) of the reserve risk.

The solvency II reserve view shifts the risk profile only to (CDR), the researchers calculated the volatility of the Reserve risks and CDR according to the different three methods as following:

- I. **Reserve Risk 1** (Merz –Wüthrich Method) : The researchers calculated the rooted MSEP of CDR over 1- year, ultimate claims and best Estimate claims outstanding under Merz- Wüthrich (Based on Mack CL), which the Relevant codes are available through the R package Chain Ladder as shown in table 9 .

Table 9: Best Estimate of claims outstanding and RMSEP of CDR

AY	Best Estimate claims outstanding	Ultimate Claims	Merz – Wüthrich RMSEP
2011	0	711,000,000	0
2012	200,293	729,000,000	72,351.83
2013	153,493.1	573,000,000	800,143.0
2014	11,225,778	392,773,660	9,301,528
2015	21,505,862.5	752,458,865	12,159,480
2016	50,534,265.4	816,705,868	9,845,789
2017	91,191,393.5	525,253,965	27,344,220
2018	123,255,653.8	250,005,972	63,634,680
2019	247,102,869.9	278,248,263	0
Total	545,731,793	5,028,446,593	123,158,191.83

Therefore, $\sigma_{(U, res1, lob)} = \frac{123,158,191.83}{545,731,793} = 23\%$.

II. **Reserve risk 2:** The risk factor of the reserve 2 is based on CL method (i.e Best Estimate of outstanding claims based on CL method). The researcher calculated one –year reserve view CDR and the reserve risk volatility 2 as shown in the **table 10**.

Table 10: The CDR ratio and the estimator of $\hat{\beta}$ of reserve 2

Year	2012	2013	2014	2015	2016	2017	2018
CDR ratio	-197%	-155%	49%	78%	97%	72%	140%
$(R_Y - V_Y)^2$	(3,120,666)	(36,851,358)	4,219,438	827,788	833,117	10,617,252	58,818,442
V_Y							

According to **equ.(20)** and **equ.(21)** , $\sigma_{(u, res2 , lob)} = 10.5\%$.

III. **Reserve risk 3:** The risk factor of the reserve 3 is based on ALR method. Similarly, the volatility of reserve risk 3 , $\sigma_{(u, res3 , lob)} = 8.9\%$.

Additionally, the above tables illustrated that there was a loss in the Profit & Loss statement in first two years. However, there was a profit in the P&L statement from 2014 to 2018. The researcher summarized the USP Risk factors (premium & Reserve) as shown in **table11**.

Table 11: Risk factors of the underwriting risk

Premium Risk Factor	
Premium Risk Factor (CL) $\sigma (u, prem. 1 , lob)$	5.43%
Premium Risk Factor (BF) $\sigma (u, prem. 2 , lob)$	5.37%
Premium Risk Factor (ALR) $\sigma (u, prem. 3 , lob)$	4.05%
One-year Reserve Risk Factor	
Reserve Risk Factor (Merz-Wüthrich) $\sigma (u, res1 , lob)$	23%
Reserve Risk Factor (CL)) $\sigma (u, res 2 , lob)$	10.5%
Reserve Risk Factor (ALR) $\sigma (u, res 3 , lob)$	8.9%

The above table illustrates that the volatility of the reserve risk is greater than the premium risk and the

uncertainty of one-year is greater than the ultimate view. Moreover, the significance its risk profile deviates from the calculation of SCR according to the capital model.

4.7 Validation model.

Validation model is at the heart of designing internal capital model with the quantitative assessment risks. A good validation procedure assures that the calibration of model parameters is done accurately. (Dacorogna, 2017).

Testing the model to compute the one-year change is one of the important steps towards validating a model. The key validation techniques used in this research (Mouatassim, 2017):

- Comparing the measure of uncertainty from the corresponding one-year and ultimate distributions.
- Calculation the proportion of risk emerging for each origin period, which should be within 0% and 100%.

Using the statistical software R (the codes are available in chain ladder package) and Merz–Wüthrich formulas, ultimate claims and reserves by using Mack chain ladder model, the corresponding conditional MSEPs and conditional MSEPs of one year CDR and the risk emergence percentage, which is calculated as the one-year RMSEP divided by the ultimate RMSEP (capital over time method) are estimated as shown in the **table 12**.

Table 12: The uncertainty Estimation of Mack, Merz –wüthrich and the emergence

AY	Reserves	Ultimate Claims	Mack RMSEP	Merz-Wüthrich RMSEP	The Emergence %
2011	0	711,000,000	0	0	0
2012	200,293	729,000,000	72,351.83	72,351.83	100%
2013	153,493.1	573,000,000	801,914.5	800,143.0	99 %
2014	11,225,778	392,773,660	9,322,419	9,301,528	99%
2015	21,505,862.5	752,458,865	18,017,370	12,159,480	67.5%
2016	50,534,265.4	816,705,868	20,923,570	9,845,789	48%
2017	91,191,393.5	525,253,965	31,523,400	27,344,220	87%
2018	123,255,653.8	250,005,972	66,968,250	63,634,680	95%
2019	247,102,869.9	278,248,263	1,312,370,000	1,310,467,000	99%
Total	545,731,793	5,028,446,593	1,315,428,000	1,312,864,000	99.8

The previous table illustrated that the one-year CDR is lower than the traditional life time view. The solvency capital /risk margin for the CDR (prospective solvency II point of view) is estimated by **1,312,864,000 EGP** and the total uncertainty of total ultimate claims is **1,315,428,000 EGP** (long-term-view).

This comparison between the RMSEP of Mack and of RMSEP CDR and the emergence percentage are the key validation of the reserve risk for non-life insurance company. The emergence % figures all look reasonable – they were within the interval [50%, 99%] and all less than 100% (excepting year 2012) and greater than 50% (excepting year 2016). Generally, the model used in the reserving will affect the speed of risk emergence. This risk emergence is quicker and high in the recent and the oldest years, and lowest in the middle-aged origin period, which is called the “**smile curve**”. Consistent with this, the emergence percentages are higher for Mack’s model.

V.CONCLUSIONS

The purpose of this research paper was to estimate the solvency capital requirements for the underwriting risks of non-life insurance companies. Furthermore, it measured the dependencies between the lines of the business in order to investigate the effect of stressing the underwriting risks on the capital requirements portfolio, calibration the underwriting risk with undertaking Specific Parameters (USPs) with the help of QIS5, as input for ORSA in order to enhance the Enterprise Risk Management and assess the Own Solvency capital requirements (The Linkage between internal capital model and ORSA) and analyze the prediction uncertainty of a one-year reserve under solvency II regime. In summary, the findings of this research have procedures to

decision- making, financial planning and enhance ERM in insurance sector and support the actuarial department. First, the regulatory can obtain a high level understanding of the non-life insurance company's own risks from the capital model. Second, this capital model illustrated that the reserve risk represents 58%, which is the most critical risk driver in the non-life underwriting capital requirements. On the other hand, the CAT risk represents 4%, which is the least critical risk driver in the non-life underwriting capital requirements. Third, Calibration the underwriting risk factor with USP is considered as a one step in ORSA requirements, which assess the overall solvency needs (OSN) without approval from the regulatory. Fourth, it concluded that the reserve risk is the key volatility driver in the underwriting risk capital requirements. Fourth, the sensitivity of the premium and reserve risks have advantages in:

- I. Determining the Mitigation strategy of the non-life underwriting Risk.
- II. Taking action to increase premium rates and being more selective in the underwriting approach.
- III. Studying the causes of these volatilities of LOBs by the claims risk owner.

Fifth, analyzing the prediction uncertainty of CDR and comparing the measure of uncertainty from the one-year reserve view (Merz- Wüthrich) with ultimate view (Mack Model) in order to test the model to compute one-year reserve risk, which is a key step toward validation model. In addition to, this methodology helps in understanding the assessment of the reserve risk from one year to ultimate view, which is a key component in ORSA requirements.

Moreover, this paper helps in understanding “own their risk” and “own their rating. This research recommended developing internal capital model for the other material risk modules (i.e Market risk, Credit risk and operational risk) in order to estimate the economic capital model for the insurer and understand the “ own rating“, which helps in understanding the rating process

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