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# Estimating Risk Margin For General Insurance Sector In The Saudi Insurance Market

Ahmed Mohamed Farhan[1], Raed Ali Alkhasawneh[1], Waheeb Hassan Yassin Gadour[1], Khaled Alsaeed Qamar[1], Mostafa A. Radwan[1], Saadaby Mohammed Ali Dafaalla Abdalla[1], M. Sh. Torky[2], S. A. A. Alhatemi[2], Hasnaa Attia Hamed Mohamed[1] and Fatma Yousef Elshinawy[2]

## Abstract

*The research aimed to estimate the fair value of the risk margin paid by policyholders, and to examine the significance of its balanced relationship with the rate of return on the cost of risk capital requirements, which is proportional to the amount of risk borne by shareholders in exchange for their unlimited liability for insurance obligations. To achieve the research objective, an actuarial model was proposed to estimate the value of the risk margin based on the standard rate of the cost of capital, which is consistent with the requirements of the Second Solvency Agreement. As well as designing a quantitative measure to measure the impact of diversification in the insurance portfolio on the value of the risk margin, and then the impact on the prices of insurance products. The practical application of the proposed model dealt with the data available for a sample of insurance companies operating in the Kingdom of Saudi Arabia. The application[1] also included all the insurance sectors (vehicles, property and accidents, and health). The research found that the actual rate of the cost of capital requirements is higher than the standard rate imposed by supervisory and regulatory bodies, as Saudi insurance companies resort to non-financial hedging to avoid the risk of fluctuations in the values of obligations, which results in higher prices and, consequently, lower demand for insurance products. The research also found that the significant differences arising between the risk margin and the corresponding optimal estimation values for obligations are due to the difference in the interest rate taken as a basis for estimating each of them. The inverse relationship between the diversification risk margin rate and the value of the risk margin directly affects the volume of premiums collected, which is reflected in the prices of insurance products, and thus the demand for insurance. The researchers recommended the necessity of estimating the risk margin based on the degree of risk in the insurance portfolio, and trying to achieve diversification in the insurance portfolio, because it has a direct impact on reducing the degree of risk, and thus reducing the value of the risk margin, which reflects positively on the possibility of reducing capital requirements to confront these risks.*

***key words*** *Risk margin - capital requirements - capital cost approach - diversification strategy - optimal estimation of liabilities - solvency agreement - insurance companies - Kingdom of Saudi Arabia.*

## Introduction

Increasing risk rates negatively affects insurance companies' estimates of the size of capital requirements necessary to cover expected obligations, which has made those responsible

[1] College of Applied Studies and Community Service, Imam Abdulrahman Bin Faisal University, P.O. Box 1982, Dammam 31441, Saudi Arabia.
[2] College of Business Administration, Imam Abdulrahman Bin Faisal University, P.O. Box 1982, Dammam 31441, Saudi Arabia.
*Author to whom correspondence should be addressed: amfmohamed@iau.edu.sa

for applying the principles of the Solvency II Agreement pay more attention to the risk margin element, since it aims to absorb unexpected deviations in the value of obligations. Actuarially, the risk margin represents the difference between both technical provisions and the optimal estimate of liabilities, considering estimating the value of insurance liabilities using the market value, so that it is consistent with the interest rate used in estimating the risk margin. The market value of the obligations depends on the amount required to be paid to transfer all insurance claims to another insurer, or the amount that the underwriter will accept the risk and pay as consideration for paying all insurance obligations. As it is difficult to directly estimate the technical provisions that make up the payment of obligations, the risk margin is estimated using one of the methods that is consistent with the requirements of the Second Solvency Agreement, known as the cost of capital approach, which requires that the risk margin be more flexible to change with the interest rate, in order to absorb Change in the market value of liabilities (Gambaro, 2023) (Barigou, 2019).

The actuarial foundations of the capital cost approach for estimating the risk margin are based on the principles of the Solvency II Agreement, and although it represents one of the traditional methods imposed by the law, it required more developmental actuarial tools to be compatible with modern evaluation methods in financial markets, especially in light of the lack of Having complete information about the financial market. Insurance companies rely on the cost of capital approach in particular when evaluating non-hedgeable risks. The development in estimating capital requirements according to the capital cost approach has witnessed two stages. The first reflects the estimation of capital from a purely financial point of view, relying mainly on the determinants of the financial market, where the regulator chooses a general framework for the financial market, then adds the capital requirements, which reflects the requirements for making investment decisions in the market. This stage reflects the application of the theory of making investment decisions within the framework of the financial market. This method does not take into account the estimation of the risk margin, which reflects the degree of risk to which the capital is exposed. As for the second stage, it considers the provision of mechanisms that include both financial and insurance risks to estimate capital, in light of what is known as partial hedging of capital risks. Based on the company's proposed financial strategy and insurance risks, capital requirements are determined (EIOPA, 2018) (Meyers, 2017) (Pelkiewicz, 2020).

Capital risks result from the risk borne by shareholders resulting from insufficient technical allocations, which may lead to an inability to meet the full value of claims, and thus, as a result of their unlimited liability, shareholders are forced to finance the payment of insurance claims in the event of insufficient allocations, and a deficit in claims payments occurs. Insurance. This required the intervention of the regulator and those in charge of enacting the laws regulating insurance to determine the extent of shareholders' commitment to bear the amount of this deficit, by regulating capital requirements. Where the obligations of shareholders or shareholders are limited to capital requirements, because they provide the minimum required from shareholders to pay the deficit with insurance claims (Albrecher, 2022) (Chiang, 2022).

Shareholders expect a return because they bear this type of risk, resulting from legislation that requires them to maintain sufficient capital to pay any shortfall that may arise from increased liabilities, which is referred to as risk capital. The expected return on capital requested by shareholders, and regulated by insurance legislation, is divided into a risk-free return, and an additional return that is paid as compensation for bearing the risk of unlimited liability to shareholders, which represents compensation for risk capital, and is referred to as the capital cost premium, or risk premium, and is This additional cost is charged to policyholders through what is known as the risk margin. A state of balance must be achieved between what shareholders demand as a risk premium, and what policyholders pay in return as a risk margin. What helps to balance this relationship is following risk management strategies, such as trying to diversify risks within the insurance portfolio. This relationship has been adopted through the cost of capital approach to calculate the risk margin (Niehaus, 2022) (Waszink, 2013).

Although the cost of capital ratio is an important measure for insurance companies, as it represents the minimum rate of return that an investor requires to compensate for the risks associated with the investment, which insurance companies must calculate to make informed investment decisions and maintain financial stability, this may be It is difficult, especially for companies operating in inefficient financial markets, such as the financial market in the Kingdom of Saudi Arabia. These markets are characterized by the absence of some financial instruments or the limited availability of market information, which may make it difficult to accurately measure the risks and returns of investments. Therefore, insurance companies operating in this type of market must deal with these challenges when trying to evaluate their assets and liabilities, which may affect their financial stability and the risk management strategies applied. As a result, determining the appropriate cost of capital ratio for these companies is a complex and difficult task. This requires researchers and decision makers in insurance companies to develop more models that address the nature of the equilibrium relationship between both the average cost of capital that shareholders receive, as compensation for the additional risks they bear, and as compensation for the capital they spare as a means of risk management. Insurance obligations, and the risk margin borne by policyholders, is charged to the net risk premium, which is directly reflected in achieving the principle of fair pricing.

The research aims to "determine the fair value of the risk margin paid by policyholders, which achieves a balanced relationship with the rate of return on the cost of risk capital requirements and is also proportional to the amount of risk borne by shareholders in exchange for their unlimited liability for insurance obligations." This main objective reflects a set of sub-objectives, which include calculating both the actual value of the cost rate of capital requirements and the risk margin for the various insurance branches, to examine the extent to which fairness is achieved in pricing insurance products, which requires presenting a model to estimate the value of the risk margin using the standard cost rate. For capital, which is consistent with the requirements of the Solvency Agreement. As well as an attempt to develop a quantitative measure to measure the impact of diversification in the insurance portfolio on the prices of insurance products, through its direct relationship and the risk margin.

**Literature Review**

The current presentation of previous studies aims to identify the most important attempts and scientific foundations that have been made to estimate the risk margin, as well as the mechanisms for calculating the cost of capital requirements for insurance companies, and to identify the most important obstacles that researchers have faced to estimate these variables, and thus identify the pillars of the research gap from which the research begins. Perhaps one of the most important studies that dealt with estimating the risk margin using the cost of capital approach is the study (Floreani, 2011), which aimed to estimate the cost of solvency capital requirements, which was calculated based on the value at risk measure. This is within the framework of the Solvency II agreement, which requires that insurance liabilities be evaluated using the optimal estimation approach, in addition to an appropriate risk margin. The research finds that the uniform cost of capital applied to future capital requirements should be constant. This makes the Solvency II Agreement's requirements for estimating the risk margin consistent with the principles of financial economics. Floreani noted that the uniform cost of capital depends on the systematic risk of contractual liability, which is the uniform rate risk. The VaR alone, or the reserve risk register, is not sufficient to price the risk margin, but unsystematic risks must also be priced, as well as taking into account the expected cost of unexpected deviations in the risk margin. A uniform cost of capital must be relied upon across the various branches of insurance. The uniform cost of capital should also depend on the size of the insurance portfolio. The smaller and less diversified the insurance portfolio, the lower the uniform cost of capital.

The researcher recommended that insurance companies should pay special attention when relying on the requirements of the Solvency II agreement for capital allocation, product pricing, or any other administrative purposes, as applying these

requirements could lead to underestimating the value of the insurance obligation, which may have unrelated systematic risks, hedgable, or long-term, risks. The mix of insurance products may exacerbate losses if the company is exposed to systemic crises. Waszink (2013) relied on the recommendations made by Floreani, where he focused on analyzing the actual and desired characteristics of the capital cost input, with the aim of determining the risk margin when evaluating insurance obligations. He explained that the cost of capital method fails to provide accurate values for the risk margin, as well as the cost rate of capital requirements for long-term obligations. This is because they do not have an upper limit on capital requirements, nor a maximum value of liability, and they do not have fixed values over units of time. He showed that using the risk-free rate to discount the cost of capital reduces the efficiency of estimating an accurate value of the risk margin.

As for liabilities with long maturities, using the risk-free discount rate can lead to inconsistent and unpredictable results, such as a risk margin that exceeds the required capital. Waszink found that the cost of capital ratio could be relied upon to be an appropriate rate of discount, by assuming that the maximum unexpected loss was equal to the SCR. This provides an upper limit to the risk margin in relation to the effective risk-free rate. Which prompted (Meyers, 2017) to use the Monte Carlo simulation model for random loss reserve to simulate a Bayesian Markov chain, with the aim of simulating the future cash flows of insurance liabilities. Using sets of model parameters, where all future cash flows were represented, the cost of capital risk margin was calculated. The researcher also presented a model for using the MCMC output in order to calculate the risk margin for one year, as well as during a specific time period. The effect of diversification on the risk margin was also taken into account. Meyers estimated the cost of capital required to cover the risks associated with general insurance, and also estimated the amount an insurer would have to set aside as incentives to take on more future risks. Unexpected risks that could affect the value of general insurance were also identified. The amount of risk margin that the company must maintain to cover these risks has been estimated. It took into account current economic factors and future estimates of financial risks. These factors were used in formulating the risk margin estimation model. This helped insurance companies identify risks and estimate the costs associated with them more accurately and effectively.

One of the most important studies that discussed the impact of the international accounting standards IFRS 17 on assessing the risk margin of life insurance companies, the study presented by (Chevallier, 2018), which aimed to unify and improve accounting reports for life insurance companies and evaluate insurance obligations on the basis of risk adjustment, to allow for uncertainty in cash flows arising from insurance contract obligations. It also presented a visualization of the changes in estimating insurance liabilities compared to IFRS 4, as it focused on disclosing the confidence level used to determine non-financial risk adjustment, as well as disclosing the technique used, and the confidence level corresponding to the results of that technique. Chevallier also addressed the definition of risk margin, and its role in evaluating the insurance capacity of life insurance companies. He defined it as the amount that is added to the insurance value to cover the company's excessive or unexpected risks. He also analyzed the concept of the probability of risk margin adequacy, and how it is calculated under IFRS 17. This probability is used to determine whether the current risk margin is sufficient to cover expected future risks. He proposed a method that could be applied to a life insurance contract to estimate the level of trust. The simulation model was based on two main risks present in a life insurance portfolio, namely interest rate risks, and biometric risks (mortality, longevity, morbidity, etc.). He recommended the need to pay attention to the possibility of adequate risk margin in assessing insurance capacity and achieving financial sustainability for life insurance companies. To examine the impact of measuring investments at fair value on the financial solvency of insurance companies.

As a result of the fact that the current actuarial methods used to evaluate insurance liabilities are not sufficient, Barigou (2019) proposed a new framework for estimating insurance liabilities, which considers both actuarial requirements and financial market determinants, by integrating market-based discount rates and evaluating the impact of

investment returns. Financial insurance obligations. The proposed framework provides a more accurate and fair assessment of insurance liabilities and can help insurance companies better manage their risks. Barigou explained the inadequacy of the current actuarial methods used to evaluate insurance obligations, as they do not take into account the changing nature of obligations, as well as the challenges facing insureds in assessing the current value of insurance obligations. The study uses a new model to determine the total value of insurance obligations in continuous time, where the value of insurance obligations is determined based on the analysis of financial data and information derived from financial markets in continuous time, through the use of an interactive analysis between information derived from financial markets and actuarial estimates. Barigou concluded that assessing fair prices depends on current interest rates and expectations regarding the cost of risk and inflation, and also requires determining the present value of future payments that will be made to policyholders. He also pointed out that evaluating fair prices is a challenge for insurers, especially when the obligations are long-term and complex, as this requires obtaining financial market evaluations to ensure the validity of the results. Evaluating fair prices for insurance liabilities can also be used as a tool to improve risk management, improve the financial performance of insurance companies, provide opportunities to improve the efficiency of operations, reduce capital costs, and can be used as a tool to improve risk management strategy and improve customer experience in the insurance industry. In addition, asset management requires determining an appropriate investment strategy, distributing assets in a balanced manner according to risks and returns, and must be consistent with applicable legal and regulatory requirements.

In continuation of the work done by (Chevallier, 2018), and to determine both the capital requirements and the value of assets suitable for insurance products, (Deelstra, 2020) presented a study that dealt with the mechanisms of designing a portfolio of insurance assets, which have a financial nature in the life insurance industry, through Develop a new and effective method to evaluate these products. It depends on three stages to evaluate these products, which include risk analysis, determining capital requirements, and determining the value of assets appropriate to the product. Therefore, this model is used to determine the value of financial and actuarial insurance obligations based on analysis of financial statements and information derived from financial markets. Deelstra pointed out that this new method can improve the accuracy of evaluating and pricing hybrid financial and insurance products, and improve risk management strategies, which is reflected in the positive impact of the financial performance of insurance companies.

One of the studies that focused on the impact of the Solvency II Agreement on estimating the risk margin is the study (Pelkiewicz, 2020), which explained the concept of the risk margin and its role in evaluating the insurance capacity of companies. The regulatory framework for the Solvency II Agreement was also reviewed, as it represents a framework for insurance in the European Union that aims to improve governance and risk management for insurance companies. He reached a design for the risk margin within the framework of the Solvency II agreement, and evaluated the factors that affect it. The focus was on several aspects such as evaluation methods, the required size of the margin, and the variation in implementation between companies. He also found that the most important challenges facing risk margin design under the Solvency II Agreement framework are the complexity and difficulty of predicting future risks. The strengths of this design were highlighted, such as enhancing transparency and improving risk management. Some suggestions were also made to improve the design of the risk margin, such as ensuring its compatibility with the requirements of different companies and improving evaluation methods.

In the same direction as that addressed by (Chevallier, 2018) (Alzobaidy, 2020) presented a study aiming to demonstrate the impact of the IFRS 17 standard on the value of the assets and liabilities of insurance contracts, and to explain the analysis of these impacts on the margin of financial solvency in Iraqi insurance companies, which helps companies in Responding and dealing positively early with these influences and adapting to them. This model was presented through a comparative approach between the European

Union and the Iraqi environment, and a study of the impact of measurement models on financial solvency. The research reached several conclusions, the most important of which is the existence of a relationship between measurement models according to IFRS 17 and capital adequacy in insurance companies. He recommended the necessity of designing simulation programs for regulators and financial analysts to facilitate the interpretation of differences in financial solvency resulting from technical operations in insurance companies and separating them from those resulting from changing measurement models used in accordance with IFRS 17 standards.

Given the importance of analyzing the cost of capital for insurance companies, Chiang (2022) presented a study that examined the impact of unexpected liabilities on the cost of capital. He pointed out that unexpected obligations cause an increase in the degree of uncertainty, and thus the inability to adequately predict, which leads to an increase in the cost of capital. We relied on a mathematical model that uses automated programming to analyze data and estimate unexpected liabilities in a more accurate way. The model uses mathematical induction theory and probability theory to estimate the cost of capital for insurance companies. The cost of capital was determined based on limited information about insurance contract liabilities, incorporating various factors such as the required rate of return and potential risk. It was concluded that using the proposed model could contribute to improving the accuracy of evaluating unexpected liabilities, and thus reducing the cost of capital for insurance companies. It also helps improve risk management and improve the financial performance of insurance companies and can be used as a tool to determine the levels of reserves needed to meet future insurance obligations.

While Barigou (2021) discussed a multi-level evaluation strategy for current interest rates, and expectations related to the cost of risk and inflation, where the evaluation is updated periodically according to the needs of insureds. He pointed out that the methodology for evaluating fair prices at multiple levels allows evaluations to be updated regularly, which results in improving their accuracy and reliability, and this methodology can be applied to various types of insurance obligations. The lack of accurate evaluations of insurance obligations can lead to high capital costs and facing challenges in providing new insurance products, but this can be avoided by evaluating fair prices periodically and accurately. He used a new model to improve the evaluation of insurance liabilities. This model consists of two steps to evaluate insurance liabilities. The first relies on future estimates to determine the costs of insurance liabilities, and the second uses the present value of insurance liabilities. The cost of capital is determined using the Capital Asset Pricing Model, taking into account various factors such as expected returns and potential risks. This model is used to determine reserve levels necessary to meet future insurance obligations, improve investors' understanding of insurance companies and improve confidence in them.

As for examining the equilibrium relationship between policyholders, shareholders, and the regulator, (Albrecher, 2022) presented a study conducted within the framework of the concept of the average cost of capital (CoC) of the insurance company. He pointed out that to balance the risks in this equilibrium relationship, the increase in capital is higher than the value of the “optimal estimate of liabilities,” which entails that insurance policyholders pay the price of this amount of capital. The option of implied limited liability for shareholders was also discussed. The approach to supply and demand prices in incomplete markets was relied upon to evaluate the illiquid liabilities in the insurance portfolio. The researcher concluded that sensitivity analysis of the equilibrium relationship would lead to a similar adjustment in the values of capital cost rates. Negative rates of this equilibrium relationship may also appear, due to negative interest rates. This phenomenon has been attributed to several reasons, such as an insufficient capital requirement from the regulator, and a similar possibility of misuse of shareholders' limited liability. In the same direction as the study of (Waszink, 2013), (Gambaro, 2023) presented a study that aims to estimate the value of the risk margin, by defining the concept of the cost of capital. Capital has been described as the amount required to cover unexpected changes in future regulatory capital from the present time to the time the liabilities mature.

The cost of capital is therefore the risk margin (RM) component allocated to cover future RM risks, not to cover changes in the best estimate of the cash flows of liabilities. The factors affecting determining the capital cost, such as the required rates of return and the cost of debt and equity used to finance the company, were reviewed. The importance of capital cost in assessing the company's future need to cover risks and achieve capital efficiency was also highlighted. A new time-consistent dynamic assessment formula for the Additive-SCR (ASCR) risk scale was proposed. Where ASCR represents the total expected capital requirements for the period from present to maturity of liabilities. By applying the model, he found that for long-term liabilities, the cost of capital can reach a quarter of the value of the risk margin.

By reviewing previous studies, it is clear that they focused on the factors affecting the estimation of the value of the risk margin, which is used in pricing insurance products. It addressed the cost of capital requirements, as well as the interest rate used in estimation, and the impact of both the Solvency Agreement and IFRS 17 standards on estimating the value of the risk margin. Despite the rich scientific basis provided by these studies, they did not address the impact of the bilateral equilibrium relationship between the risk margin and the average cost of capital on the pricing of insurance products, nor did each of these studies address the specific impact of insurance activity on the risk margin. Studies that dealt with the application of the insurance sector in the Kingdom of Saudi Arabia were also rare, despite it being one of the most important and emerging sectors with strong momentum in the Arab region and the Middle East. From the above, the researcher has established the features of the research gap under study, which deals with the attempt to estimate the risk margin for the insurance sectors under study, by relying on indicators of the equilibrium relationship between both the risk margin and the cost rate of capital requirements.

**Hypotheses**

The research is based on a basic hypothesis that indicates “the existence of a balanced relationship between the rate of return on the cost of risk capital requirements, which shareholders bear in exchange for their unlimited responsibility for insurance obligations, and the risk margin borne by policyholders, in the form of an addition to the value of the risk premium.” To test the validity of this hypothesis, a set of hypotheses have been put forward that will be subject to study and analysis. as follows:

H1: “There are no statistically significant differences between the average cost of capital requirements, which is borne by shareholders, and the risk margin that is charged to the value of the risk premium, at a significance level of 5%”.

H2: “There is no linear relationship between the logarithm of the risk margin and the optimal estimate of insurance liabilities, at a significance level of 5%”.

H3: “There is no significant effect of the diversification strategy of the insurance portfolio on the value of the risk margin for the insurance branches under study, at a significance level of 5%”.

H4: “There are no significant differences between the actual value and the estimated value of the risk margin using the proposed model, for each of the insurance activities in question, at a significance level of 5%”.

**Methodology, Analysis and Results**

The applied framework of the research aims to test and analyze the hypotheses under study, which reflect the mechanisms for applying the proposed model for estimating the risk margin, which includes a set of stages. The first of these stages is to calculate the actual value of the cost rate of capital requirements from the data under study, and to examine the significance of the deviations of the cost rate. About the standard rate of solvency agreement requirements. The second stage deals with calculating the actual value of the risk margin for the various insurance branches, and testing its proportionality to the cost of capital, which reflects the fair pricing of insurance products. While the third stage of the proposed model focuses on describing the relationship between the cost of capital

requirements in accordance with the Solvency II Agreement, and the risk margin, and examining the significance of the deviations between each of them, which may be in the interest of shareholders, when the cost of capital requirements is less than Risk margin, or in the interest of policyholders if the opposite occurs. Then comes the fourth stage, which aims to estimate the value of the risk margin using the standard cost of capital rate and analyze the deviations between the value of the actual and estimated risk margin. The proposed model also provides mechanisms for examining the significance of risk margin deviations depending on the nature of insurance activity, which is included in the fifth and final stage of the proposed model, which aims to examine the significance of the presence of moral deviations between the ratio of the risk margin to the value of the optimal estimate of obligations based on the results of the work of the insurance branches in question. the study. To test the research hypotheses, we relied on a quarterly time series of data on general insurance branches, with a group of insurance companies operating in the Kingdom of Saudi Arabia. The Eviwes14 statistical program was also used to determine the parameters of the proposed models and test the research hypotheses.

**Actual rates of cost of capital and risk margin**

Companies operating in the Kingdom of Saudi Arabia adhere to the standard rate of cost of capital, recommended in the Solvency II Agreement. The burden of the cost of capital is transferred to policyholders by adding a risk margin to the value of the net premium or risk premium. This directly affects the estimate of the value of premiums for each of the different branches of insurance, which represents the expected value of claims, in addition to the risk margin, which reflects the value of unexpected fluctuations in insurance claims. This entails the necessity of maintaining sufficient capital to cover both expected claims and unexpected fluctuations in these claims. When estimating the value of the risk margin, one must rely on an interest rate equal to the standard interest rate based on which the cost of capital requirements is calculated, so that this does not result in an unjustified increase in insurance premiums (Chevallier, 2018). This is reflected in the first hypothesis of the research, which indicates that "there are no significant differences between the average cost of capital requirements, which is borne by shareholders, and the risk margin that is added to the value of the risk premium, at a significance level of 5%." To test this hypothesis, the researchers present the following proposed model to estimate both the actual values of the cost of capital requirements and the risk margin. We relied on data for each of (written premiums - claims - volume of losses - technical allocations) for each of the various insurance branches, for a group of insurance companies operating in the Saudi insurance market, during a time series starting from the first quarter of 2015 AD to the second quarter of 2024 AD. By relying on the values of the parameters of the actual distribution of the data under study, it is possible to reach the proposed probability distribution of the variables, as the descriptive statistics of the data were examined, as well as the value of the skewness and kurtosis coefficients of the data under study, and through the graphical form representing the probability distribution of the data, the researchers proposes to rely on the distribution Gauss to reflect the probability distribution of claims, as it is one of the distributions that is proportional to the size of large businesses, whose individual future risks are characterized by having a long tail, as they have rare probabilities of realization, or small probabilities of realization. The central limit theorem also allows the value of claims to be approximated to the Gaussian distribution, as it takes the same form as the long-tailed probability distribution, which is consistent with the probability distribution of insurance claims. (Alzobaidy,2020) (Gambaro,2023) .Therefore, the expected value of claims is equal to:

$$E(Y) = \mu + \sigma\varphi^{-1}(P) = F^{-1}(P) = C$$

Through the previous function, it is clear that the expected value of claims is equal to the Gaussian distribution parameter μ, which reflects the average of the actual values of claims, in addition to the risk measure $\sigma\varphi^{(-1)}$ (*P*), which indicates unexpected fluctuations

in the value of claims, and can be estimated by Relying on the value of the standard deviation of the normal cumulative distribution function of the risk measure P, which is equal to the value of capital requirements $C$ (Waszink, 2013), Albrecher, 2022). Thus ($Y$) follows a Gaussian distribution with mean μ and variance $\sigma^2$, and hence the risk scale parameter for claims $Y$ is equal to: -

$$p(Y) = VaR(Y) \ \rightarrow Security\ Level \ \ (where\ \ p \in \left(\frac{1}{2}, 1\right))$$

The value of the net premium or risk premium can also be estimated by relying on the probability distribution of claims, and the risk premium function takes the following form:

$$E(P) = E(Y) + \ \alpha\sqrt{Var(Y)} = [\mu + \ \sigma\varphi^{-1}(P)] + [E(Y) - \mu] = \ E(Y) + \sigma(p,\gamma)$$
$$= F^{-1}(p) - \frac{1}{\sqrt{2\pi\sigma^2}} \int_{-\infty}^{F^{-1}(p)} (F^{-1}(p) - y)\, exp\left(-\frac{(y - \mu - \gamma\sigma)^2}{2\sigma^2}\right) dy$$

The prior function indicates that the expected value of premiums equals the expected value of claims plus the risk measure α, which can be denoted by the loading factor of premiums with the standard deviation of claims. As for the risk value σ (p, γ), it increases with the exponential risk parameter γ, and Solvency II rules stipulate that the highest value of the risk parameter is equal to 0.15, and it is symbolized by the symbol $\gamma_o$ (Alzobaidy, 2020) (Floreani, 2011). Therefore, the exponential distribution function of the risk parameter takes the form:

$$\alpha\sqrt{Var(Y)} = \sigma(p,\gamma) \approx \chi(P,\gamma_o) \quad where\ \gamma_o = 0.15\ [Solvency\ II]$$

$\gamma_o$ indicates the highest value of the exponential distribution parameter for the risk measure, considering that the risk measure in the case of preferring the limited liability option for shareholders decreases to ($p < 0.795$). While in the case of unlimited liability for shareholders, the value of the risk measure rises and reaches ($p > 0.5$), which is the norm in Saudi insurance companies. Through the previous functions, it is possible to arrive at the estimated value of the risk margin, RM, and the solvency capital requirements, SCR, based on the Gaussian distribution of claims, as evidenced by the following functions (Meyers, 2016):

$$RM \ = P - \ \mu = \ \sigma_\chi(P,\gamma_o)$$
$$SCR = \sigma(\varphi^{-1}(P) - \chi(P,\gamma_o))$$

The previous functions reflect the estimated value of both the risk margin, which represents the difference between the premiums collected and the estimated value of claims, as well as capital requirements, and thus the estimated value of the cost of capital rate can be arrived at, which is reflected by the following function.

$$R_{COC} = \frac{RM}{SCR} = \ \frac{\sigma\chi(P,\gamma_o)}{\sigma(\varphi^{-1}(P) - \chi(P,\gamma_o))}$$

The previous relationship refers to the cost of capital ratio, which represents the ratio of the estimated value of the risk margin to the capital requirements under Solvency II. By applying the time series of the variables under study, the following table had arrived.

**Table No. (1):** Actual values of risk margin, capital requirements, and average cost of capital for the data under study ($P = 0.95$)

| Insurance company | Branch | $RM$ $\sigma\chi(P,\gamma_o)$ | $SCR$ $\sigma(\varphi^{-1}(P)-\chi(P,\gamma_o))$ | $R_{coc}$ | Variation |
|---|---|---|---|---|---|
| **United Cooperative Insurance** | Vehicles | 0.143 | 2.577 | %5.53 | 0.343 |
| | Property and casualty | 0.141 | 2.383 | %5.93 | 0.443 |
| | Healthy | 0.140 | 2.639 | %5.32 | 0.293 |
| **General Gulf** | Vehicles | 0.141 | 2.459 | %5.74 | 0.393 |
| | Property and casualty | 0.149 | 2.554 | %5.85 | 0.423 |
| | Healthy | 0.138 | 2.692 | %5.13 | 0.253 |
| **Buroj Insurance** | Vehicles | 0.141 | 2.503 | %5.61 | 0.363 |
| | Property and casualty | 0.143 | 2.389 | %5.96 | 0.443 |
| | Healthy | 0.146 | 2.864 | %5.08 | 0.233 |
| **Malath Cooperative Insurance** | Vehicles | 0.156 | 2.797 | %5.57 | 0.353 |
| | Property and casualty | 0.143 | 2.375 | %6.03 | 0.463 |
| | Healthy | 0.141 | 2.685 | %5.26 | 0.273 |
| **Taeawuni** | Vehicles | 0.159 | 2.816 | %5.66 | 0.373 |
| | Property and casualty | 0.154 | 2.614 | %5.89 | 0.433 |
| | Healthy | 0.152 | 2.932 | %5.17 | 0.253 |

It is clear from Table (1) that the proposed model for estimating the average cost of capital, based on the value of both the risk margin and the cost of capital requirements, has succeeded in arriving at the actual values of the average cost of capital for the study period for each of the different branches of insurance. By examining the values contained in the table, it becomes clear that the cost of capital rate is higher than the standard rate, which is followed in accordance with the Second Solvency Agreement. By examining the values contained in the table, we find that an increase in the value of the cost of capital rate above the standard rate of 6%, has resulted in an increase in the value of the risk margin, which was charged to the value of the net premium (risk premium), and therefore it can be said that Saudi insurance companies resort to Non-financial hedging to avoid the risk of fluctuations in the values of obligations, which results in an increase in the prices of insurance products.

Based on the previous results, it is possible to reject the first hypothesis of the research and accept the alternative hypothesis, which states that there are significant differences between the average cost of capital requirements, which is borne by shareholders, and the risk margin, which is charged to the value of the risk premium, at a significance level of 5%.

**The proposed model for estimating the risk margin RM**

The proposed model provides mechanisms for estimating the value of the risk margin calculated based on the capital cost approach for general insurance, which requires an accurate estimate of the value of the technical provisions, which indicate the insurer's responsibility for unexpected losses. The value of the technical allocations must be equal to the optimal estimate of the risk margin. The optimal estimate is based on the estimated

value of the weighted average future cash flows, which takes into account the time value of money, as well as the risk-free interest rate. Therefore, the value of the risk margin can be estimated by determining the cost of providing the solvency capital requirements necessary to pay the insurer's obligations, taking into account achieving harmony between the different risks that are covered, and thus calculating the risk margin in an independent manner for each of the different branches of insurance (Meyers, 2017) (Albrecher, 2022).

It must be considered when building the model that the supervisory and control bodies in the Kingdom of Saudi Arabia require insurance companies to price insurance products based on a standard capital cost rate equal to 6%, which is stipulated in the principles of the Second Solvency Agreement. This directly affects the estimation of the value of the risk margin, on the basis of which the prices of insurance services are calculated. The following is a presentation of the proposed functions for estimating the value of the risk margin based on a standard cost of capital rate, with the aim of testing the third hypothesis of the research, which examines the extent to which there are significant differences between the estimated values of the risk margin taken as a basis for pricing insurance products and the actual values. Actuarial principles for estimating the risk margin indicate that it represents the difference between the premiums collected and the claims, as a tool for managing the risks of fluctuations in the values of claims over the estimated values, which is borne by policyholders as an addition to the price of the policy, in exchange for shareholders bearing the additional amount of capital held to confront these fluctuations. This is what we refer to as the cost of capital. Actuarially, there must be a balance between each of them, in order to achieve the principle of fair pricing (Gambaro, 2023) (Waszink, 2013). The following presentation shows the proposed model for deriving the estimated value function and risk margin.

$$RM = R_{COC}\,.SCR = C - E[Y] = VaR_p(Y) - E[Y]$$
$$= inf\{\gamma \epsilon R: P[Y \le \gamma] \ge p\} - (\mu + \sigma\varphi^{-1}(P)\,)$$
$$= F^{-1}(p) - (\mu + \sigma\varphi^{-1}(P)\,)$$
$$= \frac{1}{1-p}\int_p^1 VaR_\alpha(Y)d_\alpha - (\,\mu + \sigma\varphi^{-1}(P))$$
$$where\ \left[M \approx \{Q_\gamma|\gamma| \le \gamma_o\}\right], Q_\gamma(dy) \approx \frac{1}{\sqrt{2\pi\sigma^2}}exp\left(-\frac{(y-\mu-\gamma\sigma)^2}{2\sigma^2}\right).dy$$
$$= sup_{Q\in M}\,E_Q[Y \wedge C] - \left(\mu + \sigma\varphi^{-1}(P)\right)$$

The previous functions reflect the estimated value of the risk margin, which is equal to the product of both the cost of capital ratio and the capital requirement. Or the difference between both regulatory capital and the expected value of claims. The value of capital can be estimated using the expected value of the value at risk $VaR_{p(Y)}$, where the company must maintain capital that contributes to facing the risks resulting from the risks $p$, for which $Y$ claims arise. According to the principles of the Second Solvency Agreement, the insurer must accumulate obligations in Homogeneous groups of risks. And with the lowest number of insurance lines, when calculating technical provisions. This indicates that the total risk margin for all insurance lines represents the sum of the risk margin for each of the different insurance lines individually. Where the optimal estimate of the obligations and sufficient capital requirements to face the possible uncertainty of these obligations, Co, is calculated at the end of the calendar year ($t = 0$), and Co will be invested in investment funds with a risk-free interest rate of return i. At the end of the following year ($t = 1$), the insurer will adjust the optimal estimate of liabilities based on the results achieved for the previous year and estimate updated requirements for capital C1 to cover liabilities. The positive difference between each of the new requirements C1 and the previous year's capital requirement Co.(1+i) is received by shareholders, while shareholders will bear the difference if this difference is negative (Floreani, 2011) (Barigou, 2019). Therefore, the average cost of capital for the risk margin and the optimal estimate of liabilities equals:

$$R_{COC} = R_{COC(T)} = C_o - \sum_{t=1}^{u+1} \frac{C_{t-1}.(1+i) - C_t}{(1+r)^t} = (r-i).\sum_{t=0}^{u} \frac{C_t}{(1+r)^t}$$

$$E_{Best} = \frac{U_s}{(1+i)^t} = \frac{exp(u_{s,t} + \sigma^2)}{(1+i)^t}$$

$$R_{ACOC(i)} = R_{COC(i)} \cdot \frac{R_{COC(T)}}{R_{COC(1)+\cdots\ldots\ldots\ldots\ldots+R_{COC(L)}}}$$

$$marginal\ cost\ of\ capital\ risk\ margin = Combined\ Risk\ Margin - Cost\ of\ capital\ risk\ margin$$

$$R_{COC(i)} = R_{COC(T)} - R_{COC(-1)}$$

$$Diversification\ Credit = 1 - \frac{Combined\ Risk\ Margin}{Total\ Standalone\ Risk\ Margin} = 1 - \frac{R_{COC(T)}}{R_{ACOC(i)}}$$

The following table shows the results of estimating the risk margin for a number of homogeneous risk groups, relying on both the written premiums and the claims paid for the five companies under study. The value of the aggregate risk margin was reached for three general insurance branches. The table also shows the proposed model for arriving at the values of the individual risk margin for insurance branches, as well as the aggregate risk margin, the share of the margin allocated to the branch of the aggregate margin, the marginal cost of the capital cost risk margin, and the diversification rate resulting from the insurer's reliance on a risk portfolio with a homogeneous group of risks, which is What we refer to as (Diversification Credit) (Meyers, 2017) (Albrecher, 2022).

**Table (2):** Estimated value of risk margin and diversification rate according to insurance activity*

| Insurance company | Branch | Realized annual lossesS | Optimal estimation of liabilities Capital) Cost Requirements Cost) $E_{Best}$ | Change in the risk margin of capital $R_{COC(i)}$ | Risk margin allocated to the branch $R_{COC(1}$ | Marginal risk margin $R_{ACOC($ | Diver. Credi | Risk margin for capital $R_{COC(-}$ | The branch's share of the risk margin% |
|---|---|---|---|---|---|---|---|---|---|
| **United Cooperative Insurance** | Vehicles | 33835.11 | 13753.23 | 1148.54 | 2033.15 | 2562.57 | 21.4 % | 884.6 | 83.2 % |
| | Property and casualty | 78604.57 | 14405.83 | 206.62 | 378.96 | 782.44 | 53.4 % | 172.3 | 16.2 % |
| | Healthy | 2797.50 | 503.68 | 6.59 | 12.46 | 30.84 | 61.7 % | 5.9 | 0.6% |
| | **Total** | 115237.18 | 28662.73 | 1361.76 | 2424.56 | 3375.85 | 45.5 % | 1062.8 | 100.0 % |
| **General Gulf** | Vehicles | 16973.40 | 4109.83 | 147.88 | 277.03 | 449.46 | 39.7 % | 129.2 | 48.5 % |
| | Property and casualty | 39693.85 | 6392.31 | 140.52 | 277.11 | 401.35 | 32.0 % | 136.6 | 51.3 % |
| | Healthy | 772.37 | 129.10 | 0.70 | 1.18 | 8.46 | 89.0 % | 0.5 | 0.2% |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | 57439.63 | 10631.24 | 289.10 | 555.32 | 859.29 | 52.8% | 266.2 | 100.0% |
| **Buroj Insurance** | Vehicles | 678237.57 | 130241.01 | 2411.87 | 3717.44 | 11522.60 | 70.1% | 1305.6 | 27.9% |
| | Property and casualty | 2747369.38 | 342863.97 | 4681.37 | 7149.11 | 8065.43 | 11.8% | 2467.7 | 52.7% |
| | Healthy | 308711.59 | 32923.43 | 332.79 | 1239.46 | 3700.41 | 68.8% | 906.7 | 19.4% |
| | Total | 3734318.54 | 506028.42 | 7426.04 | 12106.01 | 23288.46 | 50.2% | 4680.0 | 100.0% |
| **Malath Cooperative Insurance** | Vehicles | 3938.57 | 553.86 | 0.19 | 2.18 | 10.64 | 82.2% | 2.0 | 4.8% |
| | Property and casualty | 43531.51 | 4782.05 | 9.94 | 17.83 | 36.88 | 53.5% | 7.9 | 19.0% |
| | Healthy | 158957.07 | 21515.20 | 16.59 | 48.24 | 534.26 | 94.1% | 31.6 | 76.2% |
| | Total | 206427.15 | 26851.11 | 26.72 | 68.25 | 581.78 | 76.6% | 41.5 | 100.0% |
| **Tawuniya** | Vehicles | 319289.35 | 49723.03 | 1669.19 | 2954.02 | 5205.41 | 44.7% | 1284.8 | 42.4% |
| | Property and casualty | 445738.07 | 52212.71 | 775.17 | 1290.71 | 2172.49 | 42.0% | 515.5 | 17.0% |
| | Healthy | 3139179.84 | 319501.46 | 1475.70 | 2706.86 | 13305.51 | 82.4% | 1231.2 | 40.6% |
| | Total | 3904207.27 | 421437.20 | 3920.06 | 6951.60 | 20683.41 | 56.4% | 3031.5 | 100.0% |

Table (2) shows the quantitative application of the proposed model to estimate the risk margin for each of the different insurance branches for a sample of insurance companies operating in the Kingdom of Saudi Arabia. By relying on the values of realized annual losses, the value of the optimal estimate of liabilities was calculated, which indicates the present value of net future cash flows. By applying the previous functions, the value of risk capital and the value of the change in the risk margin of capital were reached, which indicates the degree of increase in the amount of risk through increasing the value of the positive margin of capital risk. The value of the risk margin allocated to the insurance branch was also estimated and is based on the size of the capital held to deal with the risks allocated to the branch. Therefore, the risk margin allocated depends on the deviation in the degree of risk for the branch's insurance portfolio only, without considering the rest of the company's insurance branches.

Therefore, the value of the marginal risk margin was also estimated, which is based on both the capital reserved for the allocated risks in addition to the size of the deviation in the degree of risk, which will be covered by the total capital of the company, and at the level of all branches, and therefore the marginal risk margin is estimated based on the degree of risk in the branch's insurance portfolio, taking into account the degree of risk shared with the company's overall insurance portfolio. The value of the diversification risk margin rate was also estimated, which represents a rate complementary to the risk margin, the result of the diversification policy practiced by the company, and the extent of its impact on reducing the degree of risk, and thus reducing the value of the risk margin, which reflects the possibility of reducing capital requirements to confront these risks.

The column in Table (2) ($R_{COC\,(-1)}$) represents each insurance branch's share of the company's total risk margin, as the total value of the column represents the value of the risk margin. From the numbers in the table, it is clear that there is an inverse relationship between the diversification risk margin rate, resulting from relying on the risk diversification policy, and the value of the risk margin allocated to the branch. The greater

the degree of diversification in the risks of the branch's insurance portfolio, the more this leads to maintaining a smaller amount of margin. risks, thus reducing capital requirements. Therefore, the third hypothesis of the research can be rejected, and the alternative hypothesis can be accepted, which states that there is a significant effect of the diversification strategy of the insurance portfolio on the value of the risk margin for the insurance branches under study, at a significance level of 5%.

## Conclusion

The research dealt with the formulation of functions representing the proposed model to estimate the value of the risk margin and the cost rate of capital requirements, and based on the Gaussian distribution of claims, the actual values of the variables under study were arrived at. The applied results of the proposed model also indicated that there is a linear relationship between the logarithm of the risk margin and the logarithm of the optimal estimation of liabilities (capital requirements), for each of the different branches of insurance. Through the quantitative application of the proposed model to estimate the risk margin for each of the various insurance branches for a sample of insurance companies operating in the Kingdom of Saudi Arabia, the value of the optimal estimate of liabilities was calculated, which indicates the present value of net future cash flows. The value of the risk margin was estimated based on a standard cost of capital ratio, and the trend of these deviations was examined. Calculating the actual value of the risk margin for different insurance branches, testing its proportionality to the cost of capital, and then arriving at a clear picture of the extent to which fairness is achieved in pricing insurance products. The proposed model also provided mechanisms for examining the significance of risk margin differences depending on the nature of insurance activity and examining the significance of the existence of differences between the ratio of risk margin to the value of the optimal estimate of obligations based on the nature of insurance activity. In addition to developing a quantitative measure to measure the effect of the degree of diversification in the insurance portfolio on the value of the risk margin. The results of the practical application concluded that the significant differences between the risk margin and the corresponding optimal estimate of obligations are due to the difference in the interest rate taken as a basis for estimating each of them. The increase in the value of the charges corresponding to the risk margin is reflected in the demand for insurance products as a result of the parallel rise in prices. It was found that there is an inverse relationship between the diversification risk margin rate, resulting from relying on the risk diversification policy, and the value of the risk margin allocated to the branch.

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