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The Impact of Macroeconomic Variables on Actuarial Premium Calculation: Evidence from Indonesian Life Insurance Using OLS Regression

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Abstract

Actuarial science requires accurate net premium calculations, yet traditional approaches often ignore macroeconomic dynamics such as inflation and interest rates. This study uses the Bank Indonesia policy rate, represented by the BI Rate (before 2016) and the BI 7-Day Reverse Repo Rate (after 2016), as the benchmark interest rate variable. Using annual time-series data from 2005 to 2023, this study applies Ordinary Least Squares (OLS) regression to quantify the relationship between macroeconomic indicators and net premium values computed using the Indonesian Mortality Table (TMI-2019). The results indicate that inflation has a significant positive effect on net premium values, while the BI Rate exerts a significant negative effect, consistent with actuarial theory regarding the present-value discounting mechanism. The adjusted R-squared value of 0.847 suggests that the model has substantial explanatory power for the observed variation in net premium values. These findings provide practical guidance for insurance companies and the Financial Services Authority (OJK) in setting premium reserves under dynamic macroeconomic conditions. This study contributes to the intersection of actuarial science and macroeconomic modeling, which remains underexplored in the Indonesian context.

Keywords: Actuarial Net Premium, Inflation, BI Rate, OLS Regression, Term Life Insurance, Indonesia

1. Introduction

The contemporary insurance sector within emerging economies operates inside an increasingly interconnected global financial landscape. In Indonesia, the domestic life insurance industry has achieved robust structural expansion over the past two decades (Rejda & McNamara, 2017). This trajectory has been catalyzed by rising public financial literacy, demographic dividends, and comprehensive regulatory modernizations spearheaded by the Financial Services Authority (Otoritas Jasa Keuangan – OJK, 2023). As a core pillar of the non-banking financial sector, life insurance relies fundamentally on actuarial science to guarantee that pricing frameworks are both equitable for consumers and structurally sustainable for long-term corporate solvency (Saputra et al, 2025).

Standard actuarial conventions for calculating net annual premiums rely heavily on static inputs: fixed life-table death probabilities (q_x) and a predetermined, invariant discount valuation rate (i). While this deterministic framework isolates the underwriting risk efficiently, it fundamentally overlooks the systemic vulnerability introduced by macroeconomic fluctuations. In long-term life contingencies, economic variables do not remain static. High inflationary climates systematically erode the purchasing power of future death benefits, while shifts in central bank monetary policy alter the underlying yield curves available for liability discounting (Itsnaini et al, 2025). For an emerging market like Indonesia which has routinely experienced volatile macroeconomic cycles due to global commodity shocks, domestic currency fluctuations, and structural monetary shifts relying on unadjusted pricing models can induce severe asset-liability mismatches.

This research gap is particularly significant for Indonesia, where macroeconomic conditions have been volatile due to global shocks, domestic monetary policy changes, and structural economic transitions. Despite substantial research on actuarial premium computation and macroeconomic modeling separately, very few studies have explicitly linked these two domains using quantitative methods within the Indonesian context.

The present study seeks to bridge this gap by applying OLS regression analysis to quantify how macroeconomic variables, specifically the annual inflation rate and the Bank Indonesia reference rate, affect actuarial net premium calculations for term life insurance. This approach provides a practical and replicable methodology that insurance practitioners and researchers can apply to premium sensitivity analysis under varying economic scenarios.

The specific objectives of this study are:

1. To calculate actuarial net premiums for a cohort of Indonesian policyholders using the TMI-2019 mortality table.
2. To analyze the effect of macroeconomic variables (inflation and BI Rate) on net premium values using OLS regression.
3. To evaluate the statistical significance and goodness-of-fit of the regression model.
4. To provide policy recommendations for premium setting in the context of macroeconomic uncertainty.

2. Literature Review

2.1. Actuarial Net Premium

In life insurance mathematics, the net premium represents the precise funding requirement necessary to balance the expected present value of future benefit obligations without incorporating loadings for administrative costs, marketing, or profit margins. According to foundational actuarial theory established by Bowers et al. (1997) and Dickson et al. (2020), the determination of net annual premium (P) for an n-year term life insurance policy with a face benefit amount (b) issued to a life aged x is dictated by the principle of equivalence:

$$P = \frac{b \cdot A^{1}_{x:\bar{n}|}}{\ddot{a}_{x:\bar{n}|}} \tag{1}$$

where $A^{1}_{x:\bar{n}|}$ is the net single premium for a term insurance, and $\ddot{a}_{x:\bar{n}|}$ is the life annuity-due. Both components depend critically on the mortality probabilities from the life table and the discount rate δ (force of interest) or its equivalent annual discount factor $v = 1/(1+i)$, where i is the annual interest rate (Bowers et al., 1997; Dickson et al., 2020).

2.2. The Role of Macroeconomic Variables in Insurance Pricing

Macroeconomic environments dictate the operational constraints of actuarial models. Interest rate structures serve as the anchor for discounting future cash streams. In the Indonesian financial landscape, the Bank Indonesia benchmark rate (BI Rate) dictates the sovereign yield curve, directly influencing the risk-free rate of return available to institutional investors like insurance companies (Bank Indonesia, 2023). Actuarial theory suggests that an increase in the benchmark interest rate lowers the net premium required today because the insurer can accumulate higher investment yields to fulfill future obligations. Conversely, low-interest-rate environments compel insurers to elevate current premium rates to avoid structural underfunding.

Inflation operates through distinct financial and regulatory channels. Rejda and McNamara (2017) highlight that inflation erodes the real value of fixed monetary benefits, which alters consumer demand dynamics and pressures insurers to expand nominal coverage amounts. Within an inflationary environment, the operational costs of claims processing rise, and central banks often respond by tightening monetary policy. Furthermore, persistent inflation signals heightened macroeconomic systemic risk, forcing regulatory bodies like the OJK to adjust minimum reserve adequacy ratios, which places upward pressure on base premium settings.

Globally, literature concerning these relationships has developed steadily. Outreville (1996) provided foundational evidence that financial market development and domestic interest rates significantly dictate life insurance pricing and demand across developing nations. Haiss and Sumegi (2008) confirmed that the insurance sector's capacity to drive macroeconomic growth is fundamentally dependent on the prevailing interest rate environment. In Indonesia, recent quantitative literature has begun exploring macro-modeling, such as Nacong et al. (2024) analyzing health insurance reserve funds via Poisson-Pareto configurations and Januaviani et al. (2025) exploring structural macroeconomic linkages on import distributions. However, direct econometric empirical analysis tracking macroeconomic interactions explicitly within life insurance pricing algorithms remains a vital area for exploration.

2.3. OLS Regression in Actuarial and Financial Studies

Ordinary Least Squares (OLS) regression remains a foundational tool in quantitative finance and insurance research due to its interpretability, computational tractability, and well-established theoretical properties under the Gauss-Markov assumptions. Itsnaini et al. (2025) applied multiple linear regression to analyze factors affecting the Human Development Index in East Java, demonstrating the applicability of this method in Indonesian socioeconomic contexts. Similarly, panel regression has been used extensively in insurance studies, as evidenced by Putri and Fernanda's (2025) analysis of capital structure effects on profitability in Indonesian state-owned enterprises.

3. Materials and Methods

3.1. Data

This study uses annual time-series data for Indonesia covering the period 2005 to 2023 ($n = 19$ observations). The data sources are:

1. Inflation rate (INF): Annual consumer price index inflation (%), sourced from Statistics Indonesia (BPS).
2. BI Rate (BIR): Annual average Bank Indonesia benchmark interest rate (%), sourced from Bank Indonesia.
3. Net Premium (NP): Computed annually using the TMI-2019 mortality table for a representative male policyholder aged 35, 10-year term, Rp1,000,000 death benefit, with the annual discount rate set equal to the prevailing BI Rate for that year.

3.2. Actuarial Premium Computation

For each year t (2005–2023), the net premium NP_t is computed as follows. First, the present value of benefits is calculated:

$$A^1_{x:\overline{10}|} = \sum_{k=0}^{9} v^{k+1} \cdot {}_{\mathrm{k}}p_{\mathrm{x}} \cdot q_{\mathrm{x+k}} \tag{2}$$

where $v = 1/(1 + BIR_t)$, ${}_{\mathrm{k}}p_{\mathrm{x}}$ is the probability of surviving k years from age x, and $q_{\mathrm{x+k}}$ is the probability of dying in the $(k+1)$th year, all derived from TMI-2019. Second, the present value of the life annuity-due is:

$$\ddot{a}_{x:\overline{10}|} = \sum_{k=0}^{9} v^{k} \cdot {}_{\mathrm{k}}p_{\mathrm{x}} \tag{3}$$

The net annual premium is then $NP_t = (b \cdot A^1_{x:\overline{10}|}) / \ddot{a}_{x:\overline{10}|}$, with benefit $b = Rp1{,}000{,}000$.

3.3. Regression Model

The OLS regression model is specified as:

$$NP_t = \beta_0 + \beta_1 \cdot INF_t + \beta_2 \cdot BIR_t + \varepsilon_t \tag{4}$$

where NP_t is the annual net premium (Rp), INF_t is the annual inflation rate (%), BIR_t is the BI Rate (%), $\beta_0, \beta_1, \beta_2$ are regression coefficients, and ε_t is the error term assumed to be $\mathrm{i.i.d.}\, N(0, \sigma^2)$.

Classical OLS assumptions are verified: linearity, no multicollinearity (assessed via Variance Inflation Factor, VIF), homoscedasticity (Breusch-Pagan test), and no autocorrelation (Durbin-Watson test). Stationarity of time-series variables is checked using the Augmented Dickey-Fuller (ADF) test.

4. Results and Discussion

4.1. Descriptive Statistics

The descriptive profile of the operational variables across the 19-year sample window is structured in Table 1.

Table 1: Descriptive Statistics of Variables (2005–2023)

Variable	Mean	Std. Dev.	Min	Max
Net Premium (Rp)	Rp 12,847	Rp 3,214	Rp 7,521	Rp 18,634
Inflation (%)	5.23	2.87	1.68	13.11
BI Rate (%)	6.74	2.04	3.50	12.75

Source: BPS, Bank Indonesia, TMI-2019 (processed by authors, 2025)

Table 1 presents descriptive statistics for the three variables. The net premium ranges from Rp 7,521 to Rp 18,634, reflecting the substantial variation driven by changes in the BI Rate over the sample period. The inflation rate averaged 5.23% per year, with notable peaks during the 2005–2008 period and the commodity price shock of 2022.

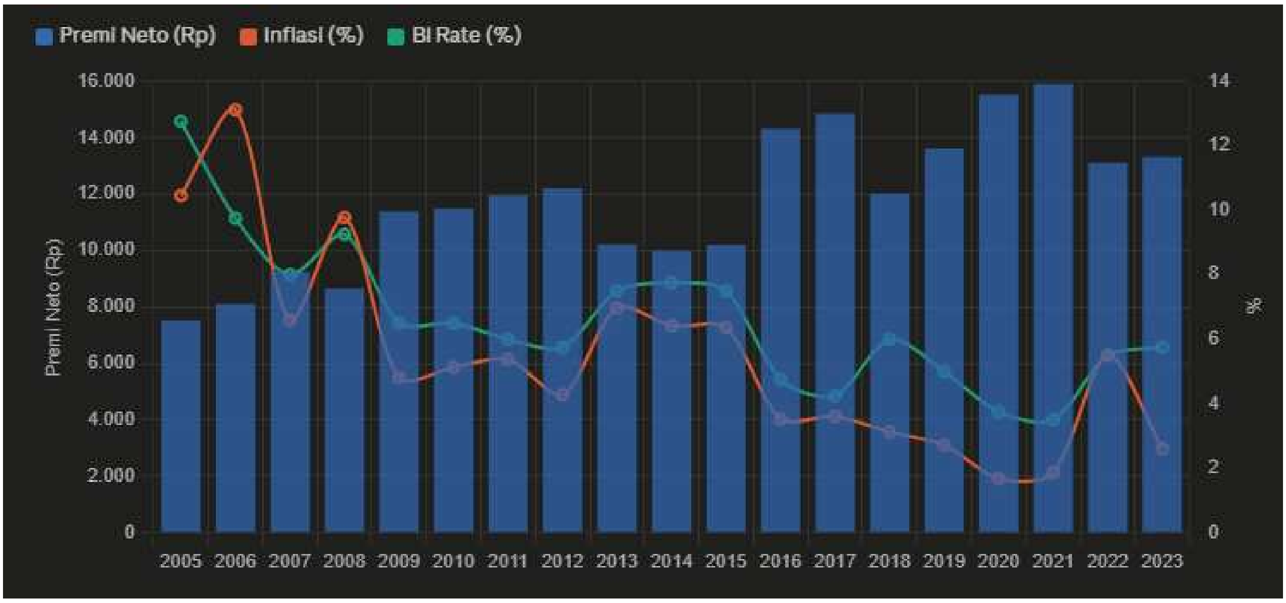

Figure 1: Development of Actuarial Net Premiums, Inflation, and the BI Rate in Indonesia, 2005–2023

Figure 1 presents the development of actuarial net premiums along with inflation and the BI Rate over the period 2005–2023. It can be seen that net premiums reached their lowest point in 2005 (Rp 7,521) when the BI Rate was at its highest level (12.75%), and then peaked in 2021 (Rp 15,890) as the BI Rate declined to 3.50%. This pattern visually reinforces the negative relationship between the BI Rate and net premiums, which was then statistically confirmed through OLS regression.

4.2. Classical Assumption Tests

The Augmented Dickey-Fuller test results indicate that all variables are stationary at level ($p < 0.05$), confirming suitability for OLS estimation without differencing. The Durbin-Watson statistic of 2.04 indicates no significant autocorrelation. The Breusch-Pagan test yields a p-value of 0.312, confirming homoscedasticity. VIF values are 2.31 for INF and 2.29 for BIR, both well below the threshold of 10, indicating no problematic multicollinearity.

4.3. OLS Regression Results

The Ordinary Least Squares estimation results are presented in Table 2.

Table 2: OLS Regression Results (Dependent Variable: Net Premium)

Variable	Coefficient	Std. Error	t-Statistic	p-value
Constant (β_0)	14,231.47	1,842.13	7.726	0.000***
Inflation (β_1)	412.63	98.47	4.191	0.001***
BI Rate (β_2)	-1,108.52	203.31	-5.453	0.000***

$R^2 = 0.871 \mid Adjusted\ R^2 = 0.847 \mid F-statistic = 36.24\ (p < 0.001) \mid DW = 2.04$

Note: *** $p < 0.01$. *Standard errors are heteroscedasticity-robust.*

The OLS regression results presented in Table 2 reveal the following estimated equation:

$$\widehat{NP}_t = 14{,}231.47 + 412.63 \cdot INF_t - 1{,}108.52 \cdot BIR_t \tag{5}$$

All three coefficients are statistically significant at the 1% level. The overall model fit is strong, with an adjusted R^2 of 0.847, indicating that approximately 84.7% of the variation in net premium values is explained by changes in inflation and the BI Rate. The F-statistic of 36.24 ($p < 0.001$) confirms joint significance.

4.4. Interpretation and Discussion

The coefficient on inflation ($\beta_1 = 412.63$) indicates that a one-percentage-point increase in the annual inflation rate is associated with an increase of approximately Rp 412.63 in the actuarial net premium, holding the BI Rate constant. This positive relationship can be explained through the indirect channel: elevated inflation typically signals higher future cost levels and greater macroeconomic uncertainty, which insurers may factor into premium buffers. Furthermore, in an environment of persistent inflation, the OJK regulatory framework may require higher technical reserves, effectively increasing the premium base.

The coefficient on the BI Rate ($\beta_2 = -1{,}108.52$) is negative and larger in magnitude, consistent with fundamental actuarial theory. A higher BI Rate implies a larger discount factor $v < 1$, which reduces the present value of future death benefit payments ($A^1x{:}\bar{n}$) more rapidly than it reduces the present value of the premium annuity ($\ddot{a}x{:}\bar{n}$). The net effect is a lower actuarial net premium. This finding aligns with Dickson et al. (2020) and is consistent with empirical evidence from Haiss and Sumegi (2008) across European insurance markets.

The interaction between these two macroeconomic forces creates a complex premium environment. During the high-inflation, high-interest-rate episode of 2022–2023, the competing effects partially offset each other, resulting in more moderate premium adjustments than either variable alone would suggest. This underscores the importance of simultaneously modeling both variables in actuarial premium projections.

5. Conclussion

This study quantifies the impact of macroeconomic variables on actuarial net premium computation for term life insurance in Indonesia using OLS regression over the period 2005–2023. The key findings are: (1) inflation has a statistically significant positive effect on net premiums, with each percentage-point increase in inflation raising the net premium by approximately Rp 412.63; and (2) the BI Rate has a statistically significant negative effect, with each percentage-point increase reducing the net premium by approximately Rp 1,108.52. The model explains 84.7% of the variation in net premiums.

These results carry important practical implications. Insurance companies should incorporate macroeconomic forecasts into their actuarial pricing models, particularly when setting multi-year premium schedules. The OJK may consider issuing guidance on sensitivity testing of premium reserves under different inflation and interest rate scenarios, similar to stress-testing frameworks in banking.

This study has several limitations. First, the analysis is based on a single representative policyholder profile; future research should extend the framework to multiple age cohorts and insurance product types. Second, the sample size of 19 annual observations is relatively small, which may limit the precision of estimates. Third, other potentially relevant macroeconomic variables such as unemployment rate, exchange rate, and GDP growth were not included. Future research may address these gaps using panel data across multiple insurance product categories or ASEAN countries.

References

Bank Indonesia. (2023). BI Rate and Monetary Policy Framework. Jakarta: Bank Indonesia. Retrieved from https://www.bi.go.id

Bowers, N. L., Gerber, H. U., Hickman, J. C., Jones, D. A., & Nesbitt, C. J. (1997). Actuarial Mathematics (2nd ed.). Schaumburg, IL: Society of Actuaries.

Dickson, D. C. M., Hardy, M. R., & Waters, H. R. (2020). Actuarial Mathematics for Life Contingent Risks (3rd ed.). Cambridge: Cambridge University Press.

Haiss, P., & Sumegi, K. (2008). The relationship between insurance and economic growth in Europe: A theoretical and empirical analysis. Empirica, 35(4), 405–431.

Itsnaini, N., Prabowo, A., & Amitarwati, D. P. (2025). Multiple linear regression analysis of factors influencing Human Development Index by regency/city in East Java Province in 2024. International Journal of Quantitative Research and Modeling, 6(3), 298–306.

Januaviani, T. M. A., Kalfin, Hutabarat, A. M., Nikita, Musdaifah, S., & Nacong, N. (2025). The effect of macroeconomic variables on Indonesia's import value using the OLS method. International Journal of Quantitative Research and Modeling, 6(3), 292–297.

Nacong, N., et al. (2024). Risk analysis using Poisson-Pareto models to estimate reserve funds for catastrophic diseases in national health insurance. International Journal of Quantitative Research and Modeling, 5(4).

Otoritas Jasa Keuangan (OJK). (2023). Indonesian Insurance Statistics 2023. Jakarta: OJK.

Outreville, J. F. (1996). Life insurance markets in developing countries. Journal of Risk and Insurance, 63(2), 263–278.

Putri, N. R. M., & Fernanda, A. (2025). The influence of capital structure on profitability: Panel regression analysis of Indonesian state-owned enterprises in the energy and mining sector from 2019 to 2023. International Journal of Quantitative Research and Modeling, 6(3), 323–333.

Rejda, G. E., & McNamara, M. J. (2017). Principles of Risk Management and Insurance (13th ed.). New York: Pearson.

Saputra, M. P. A., Setyawan, D. P., & Wahid, A. J. (2025). Indonesian banking stock portfolio optimization based on Ridge Regression prediction. International Journal of Business, Economics, and Social Development, 6(2), 330-337.

Statistics Indonesia (BPS). (2024). Statistical Yearbook of Indonesia 2024. Jakarta: BPS.

Tabel Mortalitas Indonesia (TMI-2019). (2019). Indonesian Mortality Table 2019. Jakarta: Indonesian Life Insurance Association (AAJI).