A Risk Management Based Econometric Modelling of Insurance Underwriting in Engineering Projects

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Abstract

Pricing is very crucial for every underwriter in insurance industry. The premium rate set by an underwriter must obtain profit for the company considering that the insurance policy is at risk of numerous numbers of covered perils. Also on this note, the price should be at the rate that motivates people to purchase the service. The depth of this research is how to update the current pricing of insurance for engineering projects that will benefit the insurance company. There are various models with various parameters considered for setting the premium rate of the insurance of engineering projects. These were examined to become more compatible on the insurance of engineering projects. The outcome shows that premium rate will increase from 5% to 15% of the existing rate. Better insurers' premium to loss ratio will be easily attained with this scenario. But on the side on the insured this is something that they would consider before getting the insurance. So, with this scenario the insurer should always be flexible to the wants of the insured and make the necessary adjustments for the benefit of the insured and insurer.

Keywords
pricing, risk, premium, underwriter, flexible

1. Introduction

Finance Service Industry is the elixir for every business structure. It encompasses a broad range of organizations that deal with the management of money. It influences all sections of the society and sectors of the economy. These are the industries that support a company or an individual in case a loss will incur. Among these organizations are banks, credit card companies, consumer finance, investment funds, insurance companies, stock brokerages and some government sponsored enterprises.

Insurance instruments are only one of many options in risk management. The first, and arguably the highest priority in risk management, is to invest here to preventing or mitigating human and economic losses.

The concept of insurance is a transfer of risk between the insured and an insurer. An insured will pay the appropriate premium to the insurer and the insurer will assume some risks from the insured, which will be defined within an insurance policy. The peak of this risk transfer comes when the insured suffers a covered loss and the insurance company should pay its absolute amount of claim.

A significant research has been done to see the impact of property-casualty claims handling on the insurers operations, more specifically as it pertains to the insurer's productivity and profitability (Epermis and Harrington, 2006). This was very close to engineering insurance. They both belong in the group of non-life insurance category. These claims will be a big factor that may make or break an insurer's profit in engineering insurance considering these are big accounts.

Another study has been done to validate the deductible of personal home owners insurance in the United States. This is to check if the underwriters are giving the proper deductible to every policyholder that would benefit the insured and insurer (Braun, 2006).

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2. Methods

2.1. Data Collection

Data used for the study were primarily based on the premium and issued accounts gathered from Philippine Machinery Management Services Corp. The information gathered here were the primary sources of this study. These data were extracted from its current system of FoxPro. These were the historical data of the company. Gathering historical data was a method that examines historical events in order to create explanations that were valid beyond a particular time and place, either by direct comparison to other historical events, theory building, or reference to the present day.

The study also conducted interview that was validated on the factors of risk management that will served as an input to the existing model. As mentioned the two types of interviews were semi-structured and unstructured interviews provides the opportunity to probe the validity of the factors that the study is evaluating. A semi-structured or unstructured interview will undoubtedly be the most advantageous approach to obtain data where the questions are either complex or open ended, where the order of logic of questioning was needed to be varied (Saunders, Lewis & Thornhill, 2000).

A certain data from year 2014 was the main focus of this study. The data procured from PMMSC was used to run the real world scenario of the new model in insurance in engineering projects. The table below shows the summary of data in year 2014.

Table 1. Monthly summary of premium production and claim in car & ear policy

	Contractor's All Risk (CAR)		**Erection All Risk (EAR)**	
Month	**Premium**	**Paid Claim**	**Premium**	**Paid Claim**
January	27,303,428.65	90,000.00	9,764,523.51	-
February	18,723,772.81	20,000.00	1,331,149.90	-
March	33,247,735.63	926,000.00	2,814,371.14	1,910,000.00
April	32,441,527.57	2,892,000.00	6,676,010.07	-
May	25,010,417.74	8,510,000.00	8,254,666.36	500,000.00
June	21,910,367.85	-	3,750,442.50	40,000.00
July	37,422,391.17	474,000.00	3,310,189.87	515,000.00
August	17,927,774.12	2,023,800.00	5,863,296.99	1,000,000.00
September	29,064,233.14	14,662,000.00	11,518,046.89	300,000.00
October	19,929,830.02	5,502,560.00	8,292,490.06	-
November	21,681,561.73	20,645,000.00	8,464,664.68	-
December	14,565,395.11	9,916,000.00	3,982,611.98	-
TOTAL	**299,228,435.54**	**65,661,360.00**	**74,022,463.95**	**4,265,000.00**

2.2. Statistical Analysis

The aim of this research was to find the most suitable model for pricing the insurance of engineering projects. In this way, the study simulated the models of insurance pricing found from related literature and applied the risk management factors to the real world scenario. The models were modified by considering additional variables which were not considered in the two theories presented on related literature. These studies were statistical and mathematical inclined, and have demonstrated the used of additional parameters in the models. The table below shows the procedure for this data analysis.

Table 2. Data Analysis Procedure

Input	**Process**	**Output**
Current System parameters used in underwriting	Correlate the data given	Problems in underwriting encountered
Premium at Risk and Issued Accounts to Member Companies of PMMSC	Evaluate the parameters using multiple regression	Established the New Variables will be used in underwriting

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Existing Variable plus the new variables	Validate the applicable model from the related literature	Econometric Model for Underwriting of Insurance of Engineering Projects

Table 2 shows the process of how the research questions and objectives of the study were answered on the succeeding sections. The first step was to examine the current system parameters used in underwriting of insurance for engineering projects. The data were coming from 2013 to 2014 issued accounts for CAR and EAR policy of PMMSC. Homogeneity/Normality Test was going to be used to determine if the data set was well modelled by a normal distribution. These were correlated with the data from claims occurred from these years.

The statistical method used was the multiple regression to find the significant factors that inclined to risk management and econometrics of insurance. Before doing the multiple regression, the data were should be tested first in normality test to determine if a data set the goodness of fit of a normal model to the data. Based on the first step and second step, the new found factors together with the existing parameters were the new input to the modified premium strategy.

3. Results

As discussed on the statistical analysis, the first step is to use Normality Test on data gathered to determine whether sample data has been drawn from a normally distributed data. The study used an Anderson Darling Normality Test to determine the p-value for hypothesis testing. For the CAR policy, the normal probability plot and the overall number of data for premium production of CAR policy which has 2838 samples with a mean of 105,797 and standard deviation of 463,244. The obtained P-value is much lower than 0.05, therefore, the null hypothesis is rejected. The implication of rejecting the null hypothesis explains that it is statistically significant on the part of the insurer. The claims in 2014 for CAR were also tested on normality test which has an outcome as follows. While on CAR policy claims paid, the normal probability plot of the claim in 2014 of CAR Policy. The data contained 53 samples with a mean of 1,238,894 and standard deviation of 2,299,744. The P-value was much lower than 0.05 consequently, thus, the null hypothesis was rejected. This means that the paid claim is statistically significant on part of the insurer because this establish how good is the underwriting terms set by the underwriters.

The normal probability plot of premium production of EAR Policy in the year 2014 contained 702 numbers of samples with a mean of 105,445 and standard deviation of 437,464. The obtained p-value from the normality test was lower than 0.05, therefore, the null hypothesis was rejected. With this scenario, it is statistically significant that the premium production of EAR policy on the part of the insurer. The same outcomes were obtained from premium production of CAR policy and EAR policy. It is valuable on the part of the insurer since they use these funds to repay the insured from the covered peril of the policy. For the claims paid of EAR policy, the normal probability plot of data of paid claim in 2014 of EAR policy. The number of samples is 39 with a mean of 307,564 and standard deviation of 255,598. The p-value of the result was below 0.05 so the null hypothesis was rejected. Accordingly, it was statistically significant on part of the insurer. The same results were yielded on the claim on CAR policy. These paid claims were the test to determine if the insured engineering project were properly evaluated by the underwriters.

After doing the normality test for each data, the outcome was the same on all data throughout the test which signifies that it was normally distributed. Correlation was used to analyze the strength of association between two variables of premium productions and claim in each kind of engineering insurance. For CAR policy, the Pearson correlation coefficient (r) obtained was -0.222 and has a p-value of 0.489. The value signifies that if one variable decreases when the other increases but the amount is not consistent. These relationships demonstrate how the paid claim behaves in CAR policy. The insured can claim the maximum amount of insured contract value in policy but the insurer should be aware of its maximum exposure for each risk. In EAR policy, the value of Pearson correlation coefficient (r) was -0.314 with p-value of 0.219. The resulted value also implies that if one variable decreases the other increases but the amount is not consistent. The same result was yielded with the CAR policy, both has the same pattern when it comes to premium production and claims. This mean that underwriting a certain risk was very crucial on part of the insurer. The proper parameters should be set so that when a claim will arise to a covered peril, the insurer will not suffer severely from these claims.

The correlation coefficient between premium production and claims of CAR and EAR policy were all negative. If the premium production decreases, then the claim will increase. This signifies that there were problems encountered

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during the underwriting period of an insurer. There were missing factors that an underwriting could lead to a catastrophic loss if these will not be addressed on the assessment of engineering projects. The data from year 2014 were run through mini tab software to determine the additional factors on premium rate that are vital to the study. The statistical tool used was multiple regression to find the relationship between one or more predictor variables and the response variable. Some of the data procured from the Fox Pro program of the company was in nominal value like the type of risk and location. This was converted to ordinal value with the following relative weights.

Table 3. Relative weight of exposure

Type of Exposure	Scale
Risky	1
Slightly more Risky	2
Obviously more Risky	3
Strongly more Risky	4
Extremely more Risky	5

The type of risk and location were ranked on the above relative weights. As a result, the following were the samples for CAR and EAR data.

Table 4. Sample data for car policy issued accounts

Type Risk for CAR		Location		Duration (days)	Section I - Material Damage: Total Sum Insured	Section II - Third Party Liability	Premium Rate
Object Code (Nominal Value)	Ordinal Value (Relative Weights)	Location Code (Nominal Value)	Ordinal Value (Relative Weights)				
5200	3	101510	3	1	45,326,916.34	200,000.00	0.0012
5200	3	101510	3	1	181,867,777.88	200,000.00	0.0012
2100	3	107000	3	339	78,000,000.00	500,000.00	0.0020
5200	3	125300	3	1	9,481,276.86	200,000.00	0.0020
2170	3	104901	3	87	18,421,973.24	500,000.00	0.0010
3220	4	42307	3	261	1,227,737.50	10,000,000.00	0.0030
3220	4	4514	3	261	319,994.00	10,000,000.00	0.0047
3220	4	46204	3	261	1,438,930.75	10,000,000.00	0.0030
2121	2	4514	3	130	473,220.00	50,000.00	0.0032
1000	1	42307	3	86	7,680,000.00	1,000,000.00	0.0021
2131	2	4516	3	260	7,846,958.00	500,000.00	0.0018
2100	3	11201	4	261	33,978,121.34	500,000.00	0.0012
2100	3	4515	3	1059	212,086,035.00	26,250,000.00	0.0014

The table above shows the sample data of CAR Policy that used multiple regressions. It was composed of type of risk, location, duration; section I – material damage and section II – third party liability. These will be the predictors while the response variable will be the premium rate. The whole data is placed on the appendices. On the other hand, below was the data for EAR Policy issued accounts.

Table 5. Sample data for ear policy issued accounts

Type Risk for EAR		Location		Duration (days)	Section I - Material Damage: Total Sum Insured	Section II - Third Party Liability	Premium Rate
Object Code (Nominal Value)	Ordinal Value (Relative Weights)	Location Code (Nominal Value)	Ordinal Value (Relative Weights)				
2603	4	45814	3	365	8,969,428.57	5,000,000.00	0.0025
1703	3	46002	2	549	3,495,684.00	1,000,000.00	0.0017
1703	3	11201	3	547	1,822,555.60	1,000,000.00	0.0017
1703	3	23412	2	549	3,953,608.00	1,000,000.00	0.0016
1703	3	46023	2	549	3,372,595.60	1,000,000.00	0.0016
1703	3	13201	3	549	2,539,448.00	1,000,000.00	0.0017
1703	3	61802	4	549	3,879,548.00	1,000,000.00	0.0016
1703	3	72401	3	558	2,013,032.00	1,000,000.00	0.0016
1703	3	72401	3	549	19,183,200.00	1,000,000.00	0.0017
1703	3	63301	4	549	2,166,992.00	1,000,000.00	0.0016
1703	3	104901	3	549	1,725,142.40	1,000,000.00	0.0016
1703	3	4503	2	549	13,56,197.60	1,000,000.00	0.0017

Table 5 shows the sample data for EAR Policy issued accounts used for multiple regression. The parameters set as predictors were the type of risk, location, duration, section I– material damage and section II – third party liability. Together with these was the premium rate that was set as the response variable. The whole data can be seen on the appendices. After doing some conversion on the data, these were simulated on mini tab software. In view of this, below were the results on premium rate of CAR Policy using multiple regression

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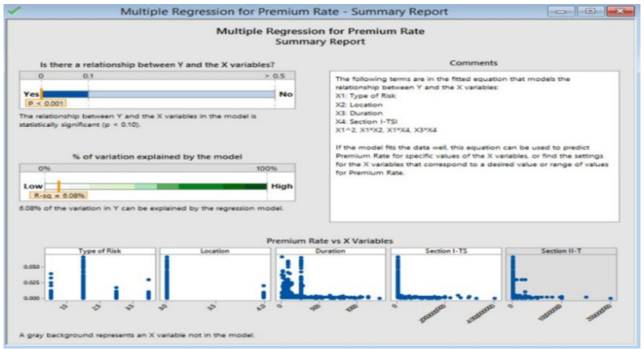

Figure 1. Multiple regression summary report for car policy premium rate

The predictors utilized on figure 1 were the type of risk (X1), location (X2), duration (X3), section I – material damage (X4) and section II–third party liability (X5) while its response variable was the premium rate (Y). After setting these parameters, the resulted p-value for the predictors and response variable on normality test of Anderson darling were less than 0.10 which denoted that the null hypothesis should be rejected. This implies that they were statistically significant. The outcome for r-squared value was 6.08% only. This represents low variation between the predictors and response variable. Though the resulted value was on the low side still there were strong relationships on its p-value. The mean of premium rate was measured versus all the predictors set on the regression model. The interaction between location and type of risk was significant, which indicates that the effect of one variable has on premium rate depends on the setting of the other variable. If the section I – material damage is set to a low setting of 4,000.00, increasing Type of Risk which increases the Premium Rate to 4,077,392,629.52.

The model building report of multiple regression for premium rate of CAR Policy were simulated. The type of risk has a longer bar between the five predictors which signifies it has more incremental impact on premium rate. This was really an issue on part of the insurer on how much they should be rating on each type of risk. This comes on how good is the underwriter to give the appropriate rate for each type of risk being offered by the company.

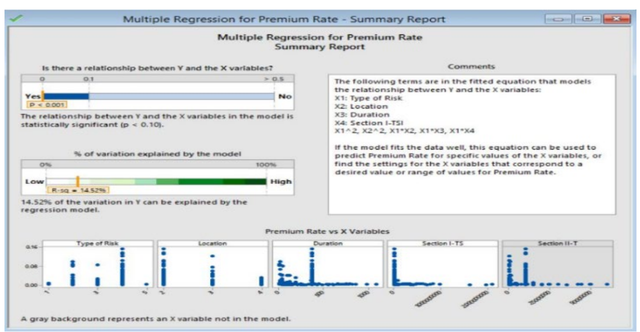

Figure 2. Multiple regression summary report for ear policy premium rate

Figure 2 above shows the result of multiple regression on EAR Policy premium rate. The predictors were the type of risk (X1), location (X2), duration (X3), section I – material damage (X4) and section II-third party liability (X5) while the response variable was the premium rate (Y). The predictors, using normality test of Anderson darling, were statically significant since their p-value outcome is much lower than 0.10. The r-squared value is 14.52% of the percentage of variation between predictors and response variable. This value was much higher than the CAR policy premium rate but still they were on the low side. The relationship between the type of risk and section I – material damage was significant, which indicates that the effect one variable has on premium rate depends on the setting of the other variable. If the section I – material damage was set to a low setting of 9,724.00, increasing Type of Risk increases the Premium Rate to 2,094,270,000.00. The final model equation fitted on premium rate of EAR Policy was simulated; the predictor that has the most incremental impact was the type of risk (X1). The type of risk was always an issue for

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projects with insurance that fall under EAR policy since it is susceptible to human error and acts of nature peril. Underwriter of this type of insurance should research on what must be considered for its terms and conditions.

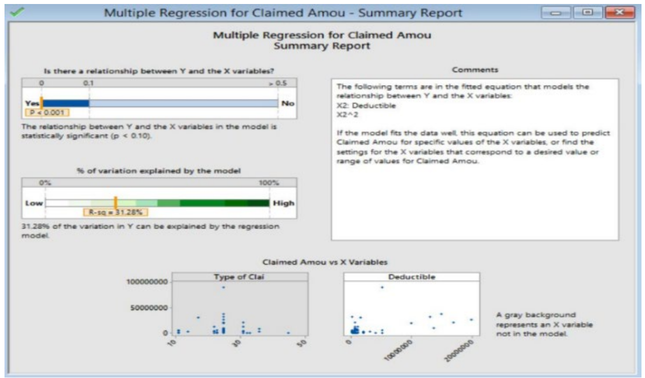

Figure 3. Multiple regression summary report for car policy paid claim

Figure 3 shows the multiple regression of Claim of CAR Policy, the type of claim (X1) and deductible (X2) were set as predictors while Claim Amount(Y) was response variable. The relationship between predictors and response variable were statistically significant because it has a p – value lower than 0.10 using normality test of Anderson darling. The percentage variation of r-squared is 31.28%. This represents still low response between predictors and response variable. These were because of the paid claim amount which has a limit of the contract value; it can be above or below the deductible. The incremental impact of deductible on the claim amount has contribute allot on the model. This was due to the increase in r-squared. The fitted line plot denoted the relationship between paid claimed amount and deductible. The deductible should be always a concern on part of the insurer because it will give them less liability on the insurance which they issued to the insured. Finally, below were the results for the multiple regression of EAR policy on its claim.

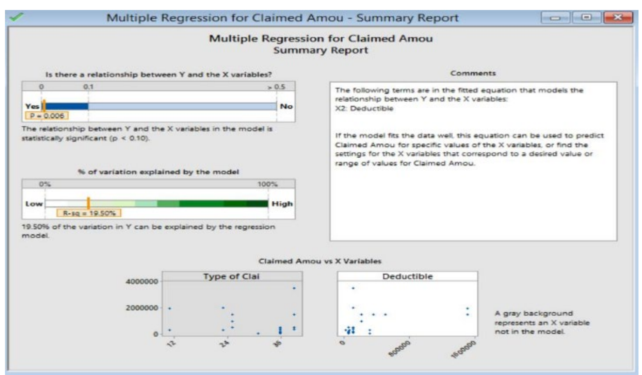

Figure 4. Multiple regression summary report for ear policy paid claim

The figure 4 shown above was the result of multiple regression on paid claim amount on EAR policy. The type of claim (X1) and deductible (X2) were set as predictors while the claim amount was the response variable. The result of p-value is 0.006 which is much lower than 0.10 using normality test of Anderson darling. This means that the relationship between X1 and X2 were statistically significant. The percentage of variation has an r-squared value of 19.50%. Again, it was consistently low for all types of response variable. This implies that there must be an adjustment on the predictors set for the projects insured by the insurer. In running the variables on multiple regression, it shows that the type of risk was the most significant among all the existing parameters of the company. This study further expounded to see other factors that contribute to a high premium to loss ratio incremental impact of deductible predictor dominates the type of claim.

According to Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA), the Philippines is visited by an average of 19 to 20 tropical cyclones every year because the country is located along the

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pacific typhoon belt where some of the most powerful tropical cyclones form and pass through (De Vera, 2013). The exposure for this kind of weather condition was very important. An interview was conducted with the experts from the top 10 ceding company of PMMSC. As an outcome, they say that underwriting at an average of 10% higher than the normal premium rate will produce about 87% to 90% of the volume of exposure. Using the formula on related literature it is solved as follows.

$$f(1.1P, P) = \overrightarrow{0.87} = \exp\left[\frac{\alpha(1.1P,P)}{p}\right]\vec{a} = 1.304 \qquad (1)$$

$$f(1.1P, P) = \overrightarrow{0.90} = \exp\left[\frac{\alpha(1.1P,P)}{p}\right]\vec{a} = 1.053 \qquad (2)$$

The value for volume of exposure should be only one, so get the average of the two which was equivalent to 1.2225. The methodology below was the more simplified equation for risk management based econometric modelling of insurance for engineering projects. After getting the value of α below were other variables to be used in this study.

Table 6. Summary of values of variables on econometric modeling

Volume of Exposure	at 87%	at 90%
Initial Wealth of the Company (W(0))	₱400,072,553.01	₱400,072,553.01
Finite Time Horizon (T)	1	1
Excess Return on Capital (α)	1.394	1.053
Interporal Discount Rate (β)	20%	20%
Constant Break Even Premium (π)	0.00000000002242	0.00000000002242
Initial Exposure (q(0))	₱891,692,200,529.25	₱891,692,200,529.25
Minimum Premium Rate (k)	0.09%	0.09%
Minimum Engineering Premium Rate	0.11%	0.12%

Table 6 shown above is the summary of all values on econometric modelling. These were based on interviews and company data of PMMSC. Due to confidentiality issues, companies that were interview would like to keep their identity unknown. After getting the values for econometric model, this was substituted on the new model of this study.

$$EPR = RI[P(t) = k\bar{P}(t)] + [P(t) = k\bar{P}(t)] \qquad (3)$$

$$P(t) = W(0)\left(\frac{1\overline{e^{-(a+\beta)T}}}{a+\beta}\right) + \frac{kq(0)\bar{P}(0)}{a+a(1\bar{k}}\left(\frac{e^{(a(1-k)-\beta)T-1}}{a(1\bar{k})\overline{\beta}} - \left(\frac{1\overline{e^{-(a+\beta)T}}}{a+\beta}\right)\right) \qquad (4)$$

$$RI = \sum_{1=1}^{5} RRI_i \times E_i - \frac{q(0)\pi}{i+(1\bar{k})}\left(\frac{e^{(a(1-k)-\beta)T-1}}{a(1\bar{k})\bar{\beta}} - \frac{1\overline{e^{-(a+\beta)T}}}{a+\beta}\right. \qquad (5)$$

Where:

RRI = Relative Risk Index = (X1 + X2 + X3 + X4 + X5)/5
RI = Risk Index
X1 = Type of Risk
X2 = Location
X3 = Duration
X4 = Sum Insured for Section I – Material Damage
X5 = Sum Insured for Section II – Third Party Liability
q = Volume of exposure at time T

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P = Market Average Premium Rate
β = Interporal Discount Rate (subjective)
T = Finite Time Horizon
k = minimum premium rate

Using these equations for each type of risk for CAR and EAR policy will give us the following rate as per table 7 and 8.

Table 7. New premium rate for car policy

Object Code	Nature of Work or Type of Risk	Kind of Engineering Insurance	New Premium Rate
1000	Residential Buildings	CAR	0.15% to 0.23%
2100	Multi-storey Buildings	CAR	0.15% to 0.35%
2110	Office & Bank Buildings	CAR	0.15% to 0.23%
2120	Department Stores	CAR	0.15% to 0.23%
2130	Schools/Hostels/Kindergarten	CAR	0.15% to 0.20%
2140	Universities	CAR	0.15% to 0.20%
2150	Multi-storey Garages	CAR	0.15% to 0.20%
2160	Underground Garages	CAR	0.15% to 0.22%
2170	Hospitals, Sanatoriums	CAR	0.15% to 0.23%
2180	Railways & Airport Terminals	CAR	0.18% to 0.25%
2190	Hotels & Restaurants	CAR	0.20% to 0.35%
2200	Hall Buildings	CAR	0.15% to 0.20%
2210	Theatres/Cinema/Concert Hall	CAR	0.15% to 0.20%
2220	Exhibition & Assembly Halls	CAR	0.15% to 0.20%
2230	Churches	CAR	0.18% to 0.25%
2240	Gymnasiums	CAR	0.18% to 0.25%
2250	Indoor Swimming Centers	CAR	0.18% to 0.25%
2260	Sport Stadiums	CAR	0.20% to 0.35%

Table 8. New premium rate for ear policy

Object Code	Nature of Work or Type of Risk	Kind of Engineering Insurance	New Premium Rate
0100	Transportation & Traffic System	EAR	0.15% to 0.25%
0101	Conveyors	EAR	0.15% to 0.25%
0111	Assembly wagon/engine for 1-rail	EAR	0.15% to 0.25%
0112	Monorail Track Systems	EAR	0.15% to 0.25%
0120	Two-rail Systems	EAR	0.15% to 0.25%
0130	Cable Cars	EAR	0.25% to 0.35%
0140	Tramways	EAR	0.25% to 0.35%
0150	Subways	EAR	0.75% to 1.00%
0160	Cog Railways	EAR	0.75% to 1.00%
0170	Shipping-general	EAR	0.75% to 1.00%
0171	Port installations & equipment	EAR	0.20% to 0.35%
0172	Assembly of engines in craft	EAR	0.20% to 0.35%
0180	Aviation-general	EAR	0.20% to 0.35%
0181	Airport installation & equipment	EAR	0.20% to 0.35%
0182	Assembly of Aircraft	EAR	0.20% to 0.35%
0183	Assembly of Spacecraft	EAR	0.20% to 0.35%
0300	Mining Plants-general	EAR	0.75% to 1.00%
0310	U/ground Coal Mining Plants	EAR	0.75% to 1.00%
0330	U/ground Ore Mining Plants	EAR	0.75% to 1.00%
0350	Surface Mining Plants – gen	EAR	0.75% to 1.00%
0360	Surface Coal Mining Plants	EAR	0.75% to 1.00%
0380	Surface Ore Mining Plants	EAR	0.75% to 1.00%
0381	Heavy Dragging Mining Equip.	EAR	0.75% to 1.00%
0382	Ore Processing Plants	EAR	0.75% to 1.00%
0700	Graphical Industry – gen	EAR	0.15% to 0.25%
0701	Rotary Printing Press	EAR	0.15% to 0.25%

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Lines on tables 7 and 8 were the simulated formula of Engineering Premium Rate with Relative Risk Index factors like type of foundation, number of storey and basement, exposure to acts of nature, type of soil and surrounding property. For the risk index, the factors were the history of the principal, history of the contractor, duration, location and nature of work. To rate the Risk Index and Relative Risk Index the study used scaling method for risk assessment to determine the degree of exposure to each factors. These will decrease the premium to loss ratio up to 9.55% which was close to the target of PMMSC of 10% premium to loss ratio. The decrease in premium to loss ratio denotes more profit will be gained if the proper underwriting was made to the insured engineering projects.

4. Discussion

Engineering Insurance market in the Philippines is so vague when it comes to pricing because this was the only insurance which has no tariff on it. The underwriters have the responsibility to set the proper pricing together with its terms and conditions of policy. In the business of insurance industry in the Philippines, every insurance company should be flexible to adopt the needs of the insured. However, this note should also mean that the insurance company will gain some profit on the risk gave by the insured. For this to happen, below is the proposed contingency plan that should the theoretical outcome of this study would not be taken up by the insured.

Table 8. Risk Assessment of Engineering Insurance

Identification of Risk	Analysis of Relevant Risk	Evaluation of Risk
• Identifying the nature of work to be done on the project • Activity on site of the project • Safety Measures to be implemented on the project • Duration of the Project • Site of Construction or Erection	• Past history on underwriting this type of risk • Munich Re guidelines • Market Research and Analysis • Proven prototype of the project • Use of MRPC tool for underwriting	• Consequences of the given premium rate, deductible and policy endorsements • Occurrence of covered peril during claims

Table 8 shows the risk assessment of engineering insurance per process. In every organization, there is a continuous exposure to an endless number of new or changing threats and vulnerabilities that may affect its operation or the fulfillment of its objectives. Identification, analysis and evaluation of these threats and vulnerabilities are the only way to understand and measure the impact of the risk involved and hence to decide on the appropriate measures and controls to manage them. Below is the process involved in risk assessment.

a. Identification of Risk - This is the phase where threats, vulnerabilities and the associated risks are identified. The steps on identifying the risk is as follows:

- Identifying the nature of work to be done on the project – This is to establish the nature of risk that the insurer will be insured. The underwriter should fully understand the engineering project into details for underwriting purposes.
- Activity on site of the project – The underwriter should check the experiences of the contractor and the methodology on how the project is to be done.
- Safety Measures to be implemented on the project – This should always be checked by the underwriter so that it could minimized the loss due third party liability of the insurer.
- Duration of the Project – In every underwriting consideration, this is a very important factor to consider. The underwriter should request on the Bar Chart or Time Schedule to check on what is the main activity on the site and how long there were going to accomplish the project.
- Site of Construction or Erection – The site has a very vital role on underwriting engineering insurance. The Philippines has so many typhoons every year, the underwriter should consider the history of typhoon on the location that they were insuring for them to give the appropriate underwriting terms and conditions.

b. Analysis of Relevant Risks - Risk analysis is the phase where the level of the risk and its nature are assessed and understood. The paces on the analysis of relevant risks on engineering insurance are as follow.

- Past history on underwriting the type of risk – In every insurance company, this should be considered and updated to the various covered claims that arise in an insurance policy.
- Munich Re guidelines – As part of the company, the guidelines of the reinsurer should be always considered in all times so that if a covered claim will arise, they will not question on how the underwriting process was done before it became an insurance policy.

- Market Research and Analysis–Competition is always present in every market the insurance company should make an analysis of what is the current premium rating per every nature of work on the market so that they can adjust the premium rating and make the necessary changes for it to be acceptable on part of the company.
- Proven prototype of the project – This is for the unusual engineering projects; during the underwriting stage this should be a requirement for the underwriter to know what could be their risk exposure.
- Use of MRPC tool for underwriting – This is a software to gauge what could be the underwriting terms and conditions for the unusual engineering projects.

c. Evaluation of Risk - During the risk evaluation phase decisions have to be made concerning which risks need adjustment on premium rate and which do not, as well as concerning on the adjustment priorities. Below is the requirement for this evaluation of risk.

- Consequences of the given premium rate, deductible and policy endorsements – This should be aligned to the covered claims that company is encountering so that it could immediately adjust on the underwriting process.
- Occurrence of covered peril during claims – The number of occurrence of covered peril should be checked and updated in the underwriting terms and conditions so that if it would happen again, the insurer would lessen their liability on the claim.

After establishing this risk assessment on the different engineering projects, if the clients do not accept the proposal, below is the contingency plan for the insurer.

Table 10. Contingency plan

Scenario	Type of Coverage	Plan of Action
The insured wants lower premium rate	Standard Coverage	The underwriter should increase the deductible for about 5 to 10 times the premium that was lost
The insured wants lower premium rate and lower deductible	Standard Coverage	The underwriter should think how much will he/she should accept from the risk
The insured wants lower premium rate	Complex Coverage	The underwriter should increase the deductible for about 8 to 12 times computed the premium that was lost
The insured wants lower premium rate and lower deductible	Complex Coverage	The underwriter should think how much will he/she should accept from the risk

The above was the plan of action if the broker or the insured insisted on their request to either lower the premium rate or lower the deductible of the project that they are going to seek insurance on that engineering project. The solution to this scenario is that make the lost amount multiplied by a certain factor and add this to the premium rate or deductible to compensate the requirements of the insured provided that only a standard coverage was being offered to them. If they want both premium rate and deductible to be lowered, the underwriter should take only a certain percentage to be retained under the treaty to lessen the risk of exposure from that insured engineering project.

5. Conclusion

This research provides an in depth analysis of a risk management based econometric modeling of insurance underwriting in engineering projects. The application of this model was only focused on two types of engineering insurance which are the Contractors All Risk (CAR) and Erection All Risk (EAR). These two have the same types of risk. It is just a matter of composition of which contract works were dominant between civil works and installation works. To test the data from the real world scenario, the study used the records of accounts of PMMSC. Different statistical tools were used to determine the relationship between the existing factors of the company, risk factors and econometric factors. The outcomes of the factors were all statistically significant using normality tests. This indicates that all the given data were normally distributed. During the correlation of variables between the premium production of CAR policy and EAR policy versus its claims, it was illustrated that the premium was not sufficient enough to pay the claims. As a result, the premium to loss ratio required by the PMMSC was not attained. These were shown on graph that as the claims were increased, the premium productions were decreased. Underwriting was the main reason for this occurrence. It means that there were factors that were not included on the premium rate evaluation. Another

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test was made to determine the additional factors that would give low premium to loss ratio. Multiple regression was used to single out what would be the additional factors on underwriting insurance of engineering projects. The outcome pointed that the type of risk was very essential on underwriting. The type of risk was expounded to give another perspective of the premium. The new factors found were based on the document that the company asks from the insured. For CAR, the factors were the type of foundation, surrounding property, type of soil, exposure to acts of nature peril and number of storey and basement. In EAR, the factors were the type of equipment or machines to be installed, degree of exposure of the equipment or machine to human error, exposure to acts of nature perils, type of foundation. This was applied to the risk assessment made on the previous data of CAR policy and EAR policy including its previous parameters. As a modification to the existing formula of premium rate on the literature, the study combined the risk management and econometric modeling to make it applicable to the insurance of engineering projects. Econometric factors were also included on the formula like volume of exposure at time, market average premium rate, interposal discount rate (subjective), finite time horizon and range of premium rate. These factors were utilized on the engineering premium rate formula to make it more applicable to insurance of engineering projects. After simulating the new factors and existing factors, it was evident that there was a decrease in premium to loss ratio of the company which was close to the standard of PMMSC.

The new found formula can be modified again by the insurance company who will use it. The factors can be increased in the risk management formula of this study as long as it would follow the rules of multiplication of matrices. Underwriting profit will increase using the new model. This will create a big impact on underwriting insurance for engineering projects. The underwriters can now simulate a given risk and update their guidelines using these formulas as their basis. The insurance company can gain additional profit from this revised premium rate. The outcome was also reliant on the external environmental factors which will be significant on the underwriting these kind of risk. The underwriters should always be updated on what acts of nature will come, so that they can put some warranty or clauses that will help to reduce catastrophic claims.

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