



Tree Augmented Naïve Bayesian Network Application on Multiplicative Premium Equation for Indonesian Passenger Vessels

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ABSTRACT

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Indonesian marine insurance is an emerging market in Indonesia, yet the risk management of its industry is crucial to be explored. The lack of understanding and experts in the field of marine insurance in Indonesia, along with tight operational costs, are causing problems for Indonesian marine insurance for passenger vessels. Following the rapid economic growth all over Indonesia, which causes tight schedules within the limited supply of passenger vessels, insurance, one of the options to transfer the risk, shall become a crucial business to protect against risks. The total premium produced could not accommodate the total claim exposed from the vessel's operation. Therefore, research for formulating proper premium calculation is crucial. This research identifies the Premium Contributor Factor (PCF) of Indonesian passenger vessels by interviewing a total of 20 experts in marine insurance from Indonesia and internationally. Accordingly, 31 respondents' data from Indonesian passenger vessel companies are used to construct the Base Premium (BP) and PCF Index. From the total 31 respondents' data, the BP is constructed from four respondents' data after two filtering processes. The application of Tree Augmented Naïve Bayesian Network (TAN-BN) analysis is used to define the Indonesian passenger vessel's PCF Index from 31 respondents' data and 45 accident reports from the Indonesian NTSC. The research, therefore, finds that Indonesian passenger's vessel premium is contributed by seven factors, namely: sailing time, vessel's age, navigation system, trading area, crew experience, vessel's classification, and the carrying object. The final Multiplicative Premium Equation (MPE) model is validated through comparison with market data, demonstrating that appropriate Indonesian Hull and Machinery (H&M) insurance premiums should be approximately 35% higher than the current market rate, while Indonesian Protection and Indemnity (P&I) insurance premiums should be 5% lower than the current market rate.

1. INTRODUCTION

The rapid logistic operation in Indonesia is reflected by the significant increase in port embarkment data as released by the Jakarta Statistic Center [1]. Furthermore, Puspa [2] also provided that in 2022, Indonesia is expected to reach 5.3% economic growth by the end of 2023. One of the main operations supporting Indonesian logistics systems is the operation of passenger vessels [3]. Indonesian culture to visit their family in other urban or suburban areas, whose access requires a long and multi-moded journey, causing passenger vessels to become a more favorable option that could consider the cost efficiency [4].

Indonesian passenger vessel state-owned company, PT. ASDP, updating their total fleet data and operation of 226 passenger vessels in 2025 [5]. PT. ASDP operates 41% of its fleet to serve remote access to reach remote inland areas, while 59% of its total fleet serves the commercial route to the big ports [5]. As shown in Figure 1, another Indonesian passenger

vessel state-owned company, PT. Pelayaran Nasional Indonesia (PT. PELNI) operates 26 passenger vessels and serves 76 ports and 1,058 routes all over Indonesia [6]. Based on the transportation release report by the Indonesian Transportation Ministry [7], there were a total of 475 passenger vessels serving Indonesia's logistics system.

At the time of a passenger vessel accident, the mass media will rapidly spread the news due to the human factors that become the main claimant [8]. Victoria [9] shared information that claims records for Indonesian general insurance are increasing by a total of 25.5% by year-on-year comparison on the Q3 data in 2022 and 2021. Meanwhile, the Indonesian Financial Regulator, Otoritas Jasa Keuangan (OJK) [10], also informs that the produced premiums for marine insurance and liability insurance in Indonesia contributes 5.40% (348 billion rupiahs) and 4.90% (319 billion rupiahs) to the national premium in 2020. Those amounts are not considered as a significant contributor to the national premium of a total of 6 trillion rupiahs per year [10]. Moreover, one of the reasons

why the Indonesian marine hull premium does not significantly produce the premium is that the OJK doesn't apply the standard minimum premium as it has applied to the other lines of insurance [11].

The understanding and ability to properly calculate the premium is a crucial expertise that shall be mastered by the underwriter [12] since the improper premium calculation leads to an unmanageable claim ratio [11]. In Indonesia, the produced premium of marine insurance in 2018 decreased

from 1,59 trillion rupiahs to 620 billion rupiahs [13]. The total produced premium cannot accommodate the recorded claim, causing the Indonesian marine insurance to become a nightmare for the insurance company [14]. Additionally, the lack of recorded data to capture real information of Indonesian marine insurance, including total production of premiums and the recorded claims, is also becoming another issue to be solved [11].

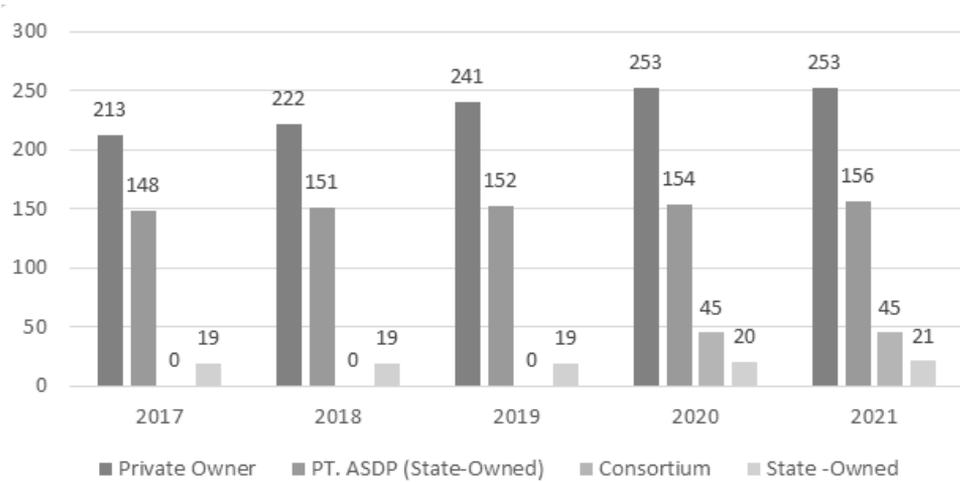


Figure 1. The total of passenger vessels in Indonesia and operators

Table 1. Literature summary of premium calculation

Author, Year, Topic	Research Methodology	Output
Hotti (2020) [15] Topic: Bayesian insurance pricing using informative prior estimation technique	Bayesian model approach on basic premium equation	Premium = Multiplicative Tarif of the basic premium
Anggraini et al. (2021) [16] Topic: Premium calculation on health insurance implementing deductible	Probability study using Kolmogorov-Smirnov and the exponential distribution	Proportional Hazard (PH) = Premium × Weighted Risk, where Weighted Risk = gen-der and Insurance Benefit
Wu (2022) [17] Topic: Poisson-Gamma mixture processes and applications to premium calculation	Non-linear integer programming formulation	Premium > Risk level that is covered by the insurance
Baione and Biancalan (2019) [18] Topic: An individual risk model for premium calculation based on quantile: A comparison between generalized linear models and quantile regression	General linear model and regression	Premium > Risk Margin Parameter = Gender and Age
Hossack et al. (1999) [19] Topic: Introductory Statistics with Application in General Insurance	Fundamental premium equation	FIE = MPE + LAE + UWE + UWP FIE = Fundamental Insurance Equation MPE = Multiplicative Premium Equation LAE = Losses Adjustment Expense UWE = Underwriter Expense UWP = Underwriter Profit Optimum Premium = Premium × 13 probabilistic variables as below:
Yeo et al. (2002) [20] Topic: A mathematical programming approach to optimise insurance premium pricing within a data mining framework	Non-linear integer programming formulation	<ol style="list-style-type: none"> 1. The age of policy holder 2. Gender 3. Parking area 4. Policy holder rank 5. Current year 6. The year of optimum rank 7. Total policy year 8. Vehicle category 9. Total sum insured 10. Total excess 11. Vehicle usage 12. Vehicle age 13. Leasing status of the vehicle

Hotti [15] formulated the equation of the premium as the calculation of the basis premium to be multiplied by certain factors as contributive factors to the claim. Several methods have been elaborated to determine the premium equation by identifying the contributing factors; one of the methods is using Multi-Criteria Decision Modeling (MCDM) [21]. Another model explored for premium calculation is using the Poisson Distribution Model to analyze the claim ratio and determine the contributing factors [15]. Markov chains are also one of the popular approaches to evaluate the premium in the insurance industry by exploring the concept of probability towards claims [22]. However, the previously mentioned methods require a sufficient database to be able to identify the contributing factors and develop, while databases on marine insurance in Indonesia are very limited and confidential [11]. As described above, multiple previous studies have explored premium calculation in insurance fields using several approaches, including the implementation of Bayesian Network (BN) and other MCDM models [23, 24]. Table 1 shows the summary of previous premium calculation studies that have been implemented in practical business.

Table 1 above describes the previous research studies of premium calculation from many insurance fields, including health insurance, property insurance, and motor vehicle insurance. However, research focusing on premium calculation for marine insurance needs to be explored. This research aims to formulate the proper marine insurance premium calculation in an academic approach and define the proper premium calculation guideline for professionals.

The limited availability of publicly disclosed Indonesian marine insurance data, as well as the high level of confidentiality inherent in insurance data, presents substantial challenges for initiating marine insurance premium research. Consequently, the appropriate research methodology is essential to reflect the constructive results from the very limited accessed data. Following the comparative review of previous research, the Tree Augmented Naïve Bayesian Network (TAN-BN) approach is applied to model the probabilistic relation between the identified Premium Contributor Factor (PCF) and the marine insurance premium and to construct the PCF Index as the main components of the Indonesian Multiplicative Premium Equation (MPE) as formulated by this research. TAN-BN is chosen as the method for this research as this method could accommodate the limited data provided and analyze the probabilistic data to be used for the main premium equation [11]. TAN-BN is also deployed to explore the interconnection between identified PCFs and the Financial Impact, which reflects the level of claims [25]. TAN model enhances the analysis of BN by being able to do effective analysis on the very limited data and showing the data in a precise result [26, 27]. The limited data of claim records, as well as the confidentiality of marine insurance and underwriter data, are becoming other challenges supporting the importance of this research to be completed.

The limited disclosure of marine insurance data in Indonesia, as well as the inconsistent data released in Indonesia, constitutes an additional challenge in validating the dataset used in this study and in ensuring that the findings accurately reflect the observed market condition. This research conducts a comparative calculation between the formulated premium level based on the research result and the current market premium, although the underlying market premium used for this comparison is subject to confidentiality constraints. This research is also willing to give appropriate,

valid guidelines for professionals by giving appropriate marine insurance premium calculation.

2. RESEARCH METHODOLOGY

This research explores both qualitative and quantitative approaches to identify the PCF and develop the MPE to be the reference for premium calculation of Indonesian passenger vessel marine insurance premiums. Interviews with marine insurance professionals from Indonesia and from international are conducted to get the proper points of view toward any risk on Indonesian passenger vessels, impacting the underwriter's consideration to provide the capacity toward Indonesian passenger vessels' insurance. Literature study is also carried out to dig into the premium equation alternatives and obtain the historical data of claims as the main consideration of the premium calculation over literature data [15]. Figure 2 below shows the research frameworks, including the methodology explored in this research.

The research analysis begins with the interviews with 20 marine insurance professionals, both local and international professionals, as well as exploring the literature review and accident report from NTSC to identify the Base Premium (BP) and PCF of Indonesian passenger vessels. Upon completion of the interviews and literature review, a structured questionnaire was developed to capture and calculate the PCF probability analysis using the risk register concept for 50 respondents (PCF Score). Additionally, the Bayesian Network with Tree Augmented Naïve Model (BN TAN) analysis of 45 accident reports of passenger vessels in Indonesia is explored to check the sensitivity of the BN of the PCF. The sensitivity BN score is used to convert the PCF score into the PCF Index. Finally, the BP and PCF are loaded to the MPE formulation of this research to formulate both the Hull and Machinery (H&M) and Protection and Indemnity (P&I) premiums of passenger vessels in Indonesia. The model is validated by calculating several scenarios, calculating and modifying the BN TAN to check several scenarios of the historical claim record.

The follow-up academic research on the marine insurance field is indeed important since there are still gaps between the business practices and the risk and technical aspects of academics. This research aims to provide an understanding of the proper and sufficient analysis of Indonesian marine insurance premiums, especially for the passenger vessels, as the main assets of the Indonesian logistics system.

2.1 Sample and data collection

This research identifies the PCF by interviewing 20 marine insurance professionals from both Indonesia and International insurance professionals, as well as exploring the literature study on marine insurance claims and their premium contributors. The quantitative analysis is also conducted by collecting data through online questionnaires from 50 respondents, including the shipowners, underwriters, brokers, surveyors, and other supporting parties in marine insurance. The structured questionnaire is developed to collect the frequency and the impact of each identified PCF on both H&M and P&I insurance of Indonesian passenger vessels. The claim analysis of 45 national passenger vessel accident reports from NTSC is also conducted to get the sensitivity analysis of the identified PCF to both H&M and P&I insurance.

Based on the transportation release report by the Indonesian

Transportation Ministry (2021), there are total of 475 passenger vessels owned by about 50 passenger vessel owners in Indonesia (companies), on which including the state-owned companies; PT. PELNI and PT. ASDP. Figure 3 below shows

that this research is targeting the sampling from about 30 – 60% from 50 companies or about 31 companies to reflect the point of view toward passenger’s vessel marine insurance risk in Indonesia.

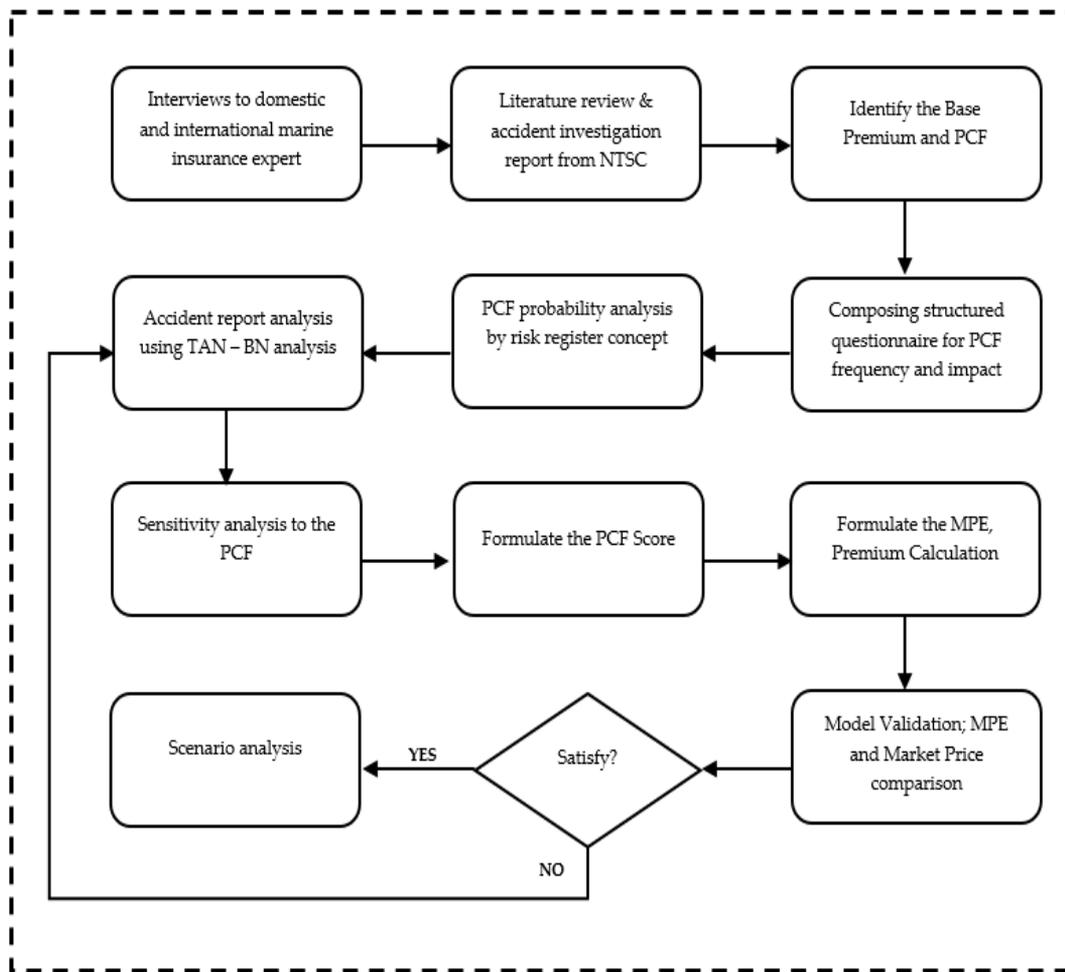


Figure 2. Research methodology and analysis

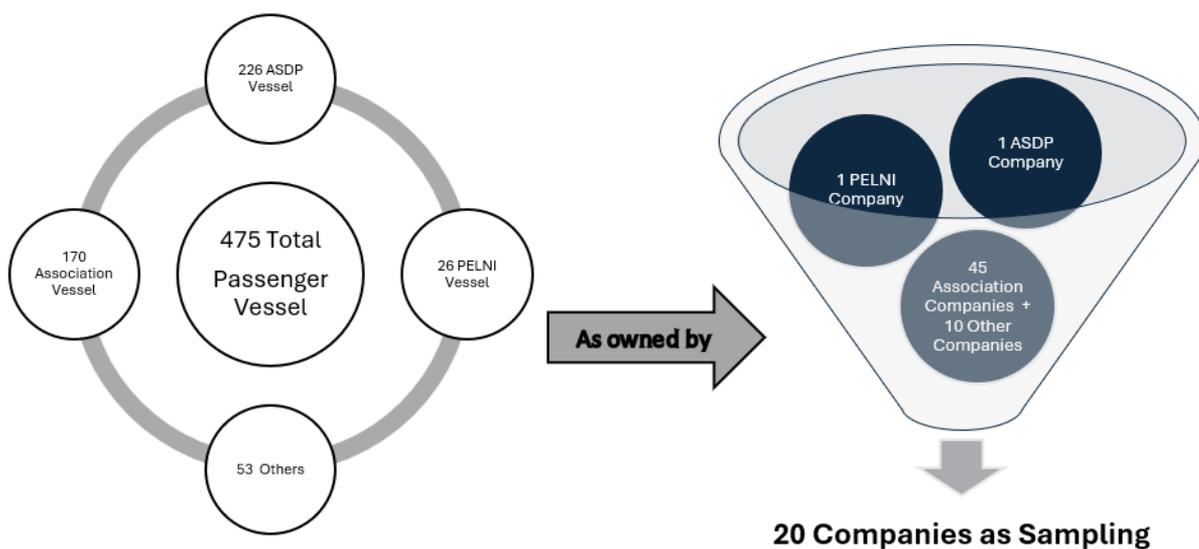


Figure 3. The research population and sampling for passenger’s vessel owners in Indonesia

This research is also conducting interviews with professionals in marine insurance, both in Indonesia and

internationally, for a pre-survey to explore the PCF. According to the Jakarta Statistic Center [1], there are 78 general insurances in Indonesia. However, the local insurance that could provide marine insurance capacity is very limited. According to the interview with the local insurance expert, only 10 insurances out of the 78 insurances have the capacity to support marine insurance in Indonesia. The capacity provides a limited share and cannot absorb the overall risk from Indonesia. Moreover, local insurance will transfer the risk to the international market. Considering the limited insurance from Indonesia, this research conducts interviews with 10 marine insurance professionals from Indonesia and 10 marine insurance professionals from International. Accordingly, the national data of Indonesian passenger vessel claims recorded 45 cases for the last 10 years [28]. The collected NTSC data is also analyzed to generate the TAN-BN analysis and obtain the sensitivity level of the identified PCF of this study.

2.2 Data collection

The data of this research is collected through interviews, a structured questionnaire is to be filled out by the companies and insurance professionals in Indonesia and internationally, as well as an analysis of the NTSC data of passenger vessel accidents over the last 10 years. The interviews are carried out from 2022 to 2024 in Indonesia, Singapore, and London with marine insurance professionals. The structured questions of interviews are also formulated to identify the contributing factors toward passenger vessel claims in Indonesia. The identified PCF from the interviews is used to develop a structured questionnaire for companies and the players of this research. The structured questionnaire is provided to the sample of this research to formulate the risk score of the identified PCF toward H&M and P&I insurance of passenger's vessel. Furthermore, this study also collects data from 45 accident cases from NTSC to generate the sensitivity analysis of the identified PCF.

2.3 Structured questionnaire with appropriate indicator and scale

The process of formulating the PCF using a probabilistic approach of risk register as the reference to develop a structured questionnaire considers the limited understanding of the respondents. This study is trying to find the most optimal ways to gather data from the limited historical data and the limited understanding of the Indonesian marine insurance field. The structured questionnaire is developed to capture the descriptive information of the respondents and to capture the frequency and impact of the identified PCF on each insurance product. The Likert scale, one to five, is used as the indicator for both frequency and impact factors.

The scale for frequency is divided by the total number of passenger vessel accidents for the last 10 years caused by the identified Sub-PCF. Frequency score one is if the accident caused by the Sub-PCF is below two accidents; frequency score two is if the accident caused by the Sub-PCF is two until three accidents; frequency score three is if the accident caused by the Sub-PCF is four until five accidents; frequency score four is if the accident caused by the Sub-PCF is six until eight accidents; frequency score five is if the accident caused by the Sub-PCF more than 10 accidents for the last 10 years.

The scale for impact is divided by the total financial loss

from passenger vessel accidents for the last 10 years, as caused by the identified Sub-PCF. Impact score one is if the accident caused by the Sub-PCF is having financial loss of less than IDR100,000,000.- per 10 year; impact score two is if the accident caused by the Sub-PCF is having financial loss of IDR100,000,000.- until IDR500,000,000.-; impact score three is if the accident caused by the Sub-PCF is having financial loss of IDR500,000,000.- until IDR1,000,000,000.-; impact score four is if the accident caused by the Sub-PCF is having financial loss of IDR1,000,000,000.- until IDR10,000,000,000.-; impact score five is if the accident caused by the Sub-PCF is having financial loss of more than IDR10,000,000,000.- for the last 10 years.

The collected questionnaire data of frequency and impact scores from each respondent is calculated using the risk register approach to get the probabilistic score of each PCF from each respondent. Accordingly, the average PCF scores from the overall respondents are calculated to define the PCF scores for both H&M and P&I insurance.

2.4 Bayesian Network using Tree Augmented Naïve Bayes Modelling

This study generates the BN by using Tree Augmented Naïve Bayes (TAN Modeling) to assess the sensitivity level of each PCF impacting the financial loss of the shipowners from NTSC data of a total of 45 accident cases of passenger vessels from the last 10 years in Indonesia, as illustrated in Figure 4. According to Hotti [15], premium calculation is assessed by using a BN to understand the impact of contributing factors of claims on the financial loss. The general Bayesian model is shown in the calculation below.

$$P(A|B) = (P(B|A) P(A)) / P(B), \text{ where } P(B) \neq 0 \quad (1)$$

The BN model has been applied for premium calculation in previous research, including allocating a certain premium discount, considering the operational risk factors [23, 29]. This research applies the TAN model to assess the relationship between identified PCF and the financial impact faced by the insurance when the claim occurs. This research is using the software Netica 7.01 to run the TAN-BN analysis by filling out the spreadsheet data of 45 accident cases from NTSC. This research has reviewed the accident data as provided by NTSC and categorized the accident into the identified PCF as the contributing factor leading to the accident. The identified data was then automatically analyzed using Netica 7.01 network analysis to show the network of each PCF towards the financial impacts or the network between PCF(s).

Accordingly, the analysis of the sensitivity of each PCF is run to provide the sensitivity level of each PCF towards the financial impact. This research also conducts several TAN-BN analyses with different scenarios of claim cases, including fire, grounding, and sinking claim cases. The sensitivity analysis of each claim case category is also run.

2.5 Premium Contributor Factor and Multiplicative Premium Equation

This study has identified the PCF and PCF score of Indonesian marine insurance, both H&M and P&I, for the passenger vessels. Accordingly, the MPE for the Indonesian passenger's vessel marine insurance is generated by multiplying the BP by the PCF Index.

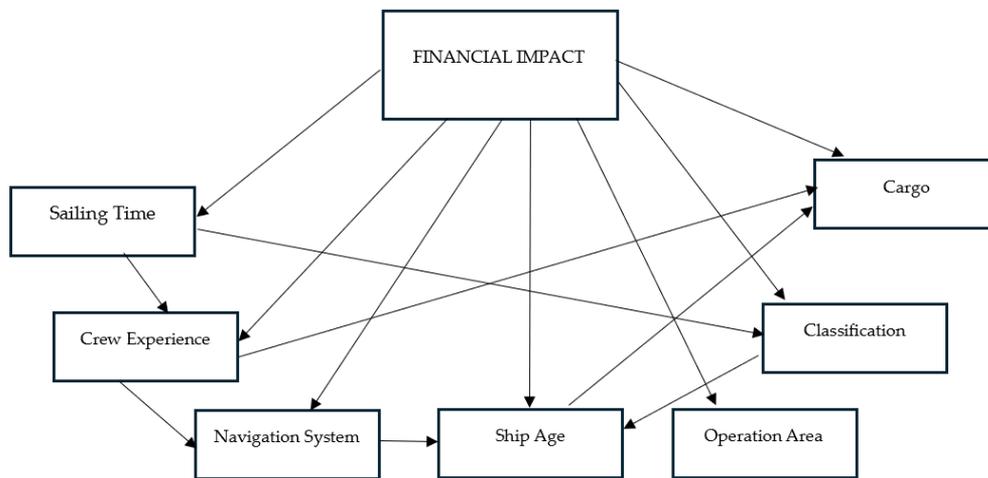


Figure 4. Tree Augmented Naïve Bayesian Network (TAN-BN) model of Indonesian passenger vessel claim record

After the BP is concluded, this research also generates the calculation for the PCF Index as a component of the MPE calculation. To calculate the PCF Index, this study considers the sensitivity BN score. The sensitivity BN score reflects the significant level of influence of the risk factors on the factors concerned [30]. In the marine insurance field, the sensitivity BN score could be used to reflect the significance level of the PCF based on the claim record data in the industry. In order to ensure the data used for the calculation reflects the normal data, this research computes the weighted score of the BN to calculate the PCF Index as follows:

$$\text{PCF Index} = (1 + \text{PCF Score})^{\text{Weighted Score}} \quad (2)$$

Once the PCF Index is defined, the MPE could be calculated by multiplying the BP by the PCF Index of the contributor factors.

$$\text{MPE} = \text{BP} \times \text{PCF Index}(s) \quad (3)$$

Thus, this research could reflect the risk of Indonesian passenger vessels' operation as the PCF Index(s) are calculated by the risk register profile of Indonesian passengers' vessel owners and players.

3. RESULTS

3.1 Premium Contributor Factors

This research identifies seven main PCFs with the respective sub-PCF from the interview with the marine insurance professionals, including the underwriter, surveyor, broker, and adjuster. This study, which involved a total of 31 respondents for this research, identified that marine insurance, both H&M and P&I insurance, is contributed by seven PCF: the sailing time, vessel's age, navigation system condition, trading area/ operation area, crew experience, classification body, as well as the cargo carried by the passenger vessels. Each PCF has a different level of frequency and impact on the claims, causing financial loss to the shipowners, as explored by the risk register approach. This research studies the contribution of each PCF toward the financial loss to shipowners, for both H&M and P&I insurance, as mentioned

in Table 2.

Table 2. The Premium Contributor Factor (PCF) score of Hull and Machinery (H&M) insurance for Indonesian passenger's vessel

PCF Code	H&M PCF	PCF Score
H&M CF 1.1	Sailing time < 1 hour	20%
H&M CF 1.2	Sailing time > 1 hour < 24 hours	33%
H&M CF 1.3	Sailing time > 24 hours	47%
H&M CF 2.1	Vessel Age 0 – 5 years	13%
H&M CF 2.2	Vessel Age 6 – 10 years	17%
H&M CF 2.3	Vessel Age 11 – 20 years	28%
H&M CF 2.4	Vessel Age > 20 years	42%
H&M CF 3.1	Navigation System in Order	39%
H&M CF 3.2	Navigation System Defective	61%
H&M CF 4.1	River Trading Area	56%
H&M CF 4.2	Non-River Trading Area	44%
H&M CF 5.1	Crew Experience < 5 years	44%
H&M CF 5.2	Crew Experience 6 – 10 years	32%
H&M CF 5.3	Crew Experience > 10 years	24%
H&M CF 6.1	IACS Class	39%
H&M CF 6.2	Non IACS Class	61%
H&M CF 7.1	Passenger Only Carrier	18%
H&M CF 7.2	Passenger and Car Carrier	29%
H&M CF 7.3	Passenger and Truck / Bus Carrier	32%
H&M CF 7.4	Passenger and Electrical Vehicle Carrier	22%

This study analyzed that H&M insurance premiums are more impacted by sailing time, more than 24 hours (47%). The older vessels, more than 20 years old, have a bigger possibility to contribute to the claim case of passenger vessels in Indonesia (42%). Obviously, the improper navigation system of the vessels contributes to the bigger accident possibilities rather than the vessels with a proper navigation system (61%). Trading operations in the river area also contribute more risk to the H&M claim (56%). The crew experience is also crucial. The study initially analyzed that the lower crew experience below 5 years is the biggest contributor to the passenger vessel claim (44%). The registration to the non-IACS classification is also impacting the condition of the vessels to be considered as riskier than the vessels that are registered to the IACS classification (61%). Lastly, the passenger vessel that is carrying the truck or bus altogether is also considered to have more risk than the vessel that is carrying the passenger only (32%).

This study also analyzes the contribution of identified PCF toward the P&I insurance and found the PCF score in Table 3.

Table 3. The Premium Contributor Factor (PCF) score of Protection and Indemnity (P&I) insurance for Indonesian passenger’s vessel

PCF Code	P&I PCF	PCF Score
P&I CF 1.1	Sailing time < 1 hour	22%
P&I CF 1.2	Sailing time > 1 hour < 24 hours	31%
P&I CF 1.3	Sailing time > 24 hours	47%
P&I CF 2.1	Vessel Age 0 – 5 years	14%
P&I CF 2.2	Vessel Age 6 – 10 years	19%
P&I CF 2.3	Vessel Age 11 – 20 years	26%
P&I CF 2.4	Vessel Age > 20 years	41%
P&I CF 3.1	Navigation System in Order	43%
P&I CF 3.2	Navigation System Defective	57%
P&I CF 4.1	River Trading Area	56%
P&I CF 4.2	Non-River Trading Area	44%
P&I CF 5.1	Crew Experience < 5 years	46%
P&I CF 5.2	Crew Experience 6 – 10 years	30%
P&I CF 5.3	Crew Experience > 10 years	24%
P&I CF 6.1	IACS Class	38%
P&I CF 6.2	Non IACS Class	62%
P&I CF 7.1	Passenger Only Carrier	17%
P&I CF 7.2	Passenger and Car Carrier	26%
P&I CF 7.3	Passenger and Truck/ Bus Carrier	32%
P&I CF 7.4	Passenger and Electrical Vehicle Carrier	25%

Talking about the P&I insurance, which has liability toward the third parties, this study analyzed that P&I insurance premiums are more impacted by sailing time, more than 24 hours (47%). The older vessels, more than 20 years old, have a higher possibility to contribute to the claim case of passenger vessels in Indonesia (41%), but slightly different from H&M. Obviously, the improper navigation system of the vessels contributes to the bigger accident possibilities rather than the vessels with a proper navigation system (57%). Trading

operations in the river area also contribute more risk to the H&M claim (56%). Same as H&M insurance, for P&I, the study initially found that the lower crew experience of less than five years is the biggest contributor to the passenger vessel claim (46%). The registration to the non-IACS classification is also impacting the condition of the vessels to be considered as riskier than the vessels that are registered to the IACS classification (62%). Lastly, the passenger vessel that is carrying the truck or bus altogether is also considered to have more risk than the vessel that is carrying the passenger only (32%).

The insurance regime considers the loss record data as a crucial aspect for the underwriter to write the risk. The obtained data from the respondents tells their loss experience but also reflects their expectation toward the financial loss when the claims happened. In order to get more appropriate data analysis, this research dig more data by obtaining the released accident reports from NTSC for the last 10 years. The data released from NTSC shows the trend of accident reports of Indonesian passenger’s vessel, including but not limited to the cases of sinking, fire, and grounding. The data from NTSC is analysed and categorized based on the identified PCF for data entry before the TAN-BN analysis of the PCF is carried out. Additionally, the analysis of PCF using TAN-BN is also considered to have the weighted score of each PCF from the sensitivity analysis of TAN-BN to calculate the PCF Index, as the main aspect of the MPE.

This research assesses the relationship between identified PCF toward the financial impact of claim happening to Indonesian passenger vessels. Each PCF might also have a relationship with the other PCF(s). TAN-BN analysis is conducted to total of 45 claims histories according to Indonesian NTSC, as well as on the specific claim type as detailed in Figure 5. Below is the figure showing the BN TAN Modeling of this study.

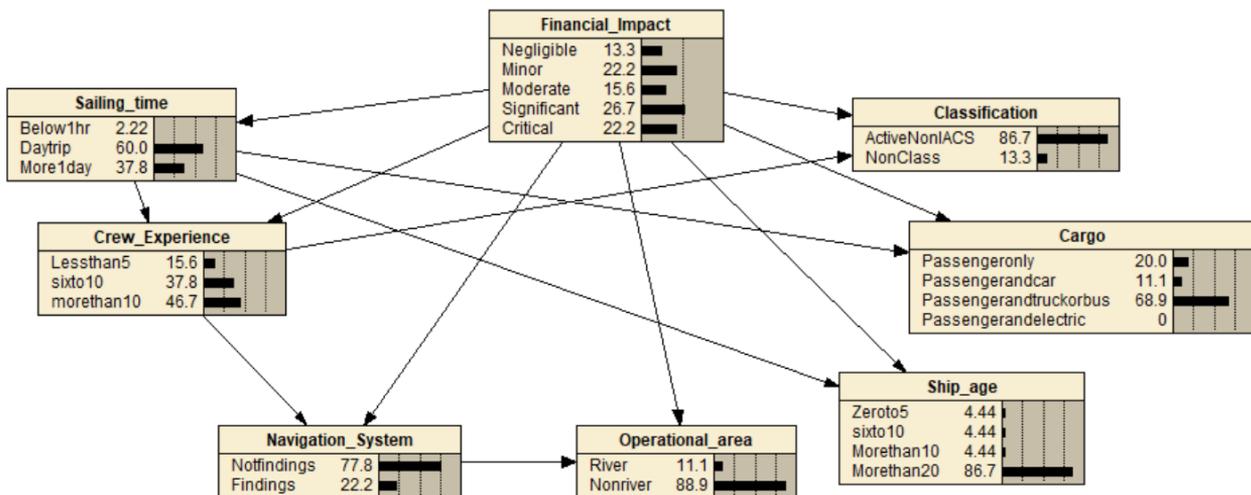


Figure 5. The probability of the Tree Augmented Naïve Bayesian Network (TAN-BN) model of Indonesian passenger vessel claim record

Moreover, the BN TAN Modeling shows the interesting result of the NTSC historical data, that financial loss as the premium consideration is more impacted by sailing time in a day trip (more than one hour but no more than 24 hours), which is not the same as the result from 31 respondents as collected from this study as well (60%). The older vessels,

more than 20 years old, have a higher possibility of contributing to the claim case of passenger vessels in Indonesia (86.7%). This study also found that in Indonesia, the passenger vessels have no findings in their navigation system condition, but 77.8% of them have an impact on the financial loss to the shipowners. Trading operations also show the

interesting result that the passenger vessels sail in non-river areas also contribute more risk toward claims (88.9%). The crew experience is also unique; this study demonstrates that the more crew experience over 10 years, the bigger contributor toward the passenger vessel claim (46.7%). The registration to the non-IACS classification is also impacting the condition of the vessels to be considered as riskier than the vessels that are registered to the IACS classification (86.7%). Lastly, the passenger vessel that is carrying the truck or bus altogether is also considered to have more risk than the vessel that is carrying passengers only (68.9%).

Table 4. Sensitivity of financial impact to the Premium Contributor Factor (PCF)

Node	Percent
Financial Impact	100
Sailing Time	4.08
Vessel Age	8.5
Trading Area (River / Non-River)	2.06
Crew Experience	5.24
Classification	4.09
Cargo Carried	5.47

This study conducted the Sensitivity Analysis totable the TAN-BN data as shown in Table 4 and revealed that vessel age, cargo carried by the vessels, as well as the crew experience, are more sensitive than the classifications body, sailing time, navigation system condition, and the operational area.

This study also generates several alternative analyses of the BN TAN Modeling that are focused on several claim/

accident, such as the grounding accident, fire accident, and sinking accident. For the grounding accident, the results are shown in Figure 6 and concluded that based on NTSC historical data, the financial loss as the premium consideration is more impacted by sailing time in a day trip (more than one hour but no more than 24 hours) (60%). The older vessels, more than 20 years old, have a higher possibility of contributing to the claim case of passenger vessels in Indonesia (86.7%). This study also found that in Indonesia, the passenger vessels have no findings in their navigation system condition, but 60% of them have an impact on the financial loss to the shipowners. Trading operations also reveal the interesting result that the passenger vessels sail in non-river areas also contribute more risk to the claim (80%). The crew experience is also unique; this study revealed that the more crew experience over 10 years, the bigger contributor toward the passenger vessel claim (46.7%). The registration to the non-IACS classification is also impacting the condition of the vessels to be considered as riskier than the vessels that are registered to the IACS classification (100%). Lastly, the passenger vessel that is carrying the truck or bus altogether is also considered to have more risk than the vessel that is carrying the passenger only (60%).

The sensitivity level for the particular-grounding accident is also different than the general claim that happens toward the passenger vessel NTSC data. As shown in Table 5, this study found that the main contributing factors for grounding cases are trading area, vessel age, and crew experience. The trading area highlights the result that it is very important to understand the location of the trading area towards the possibility of grounding cases happening.

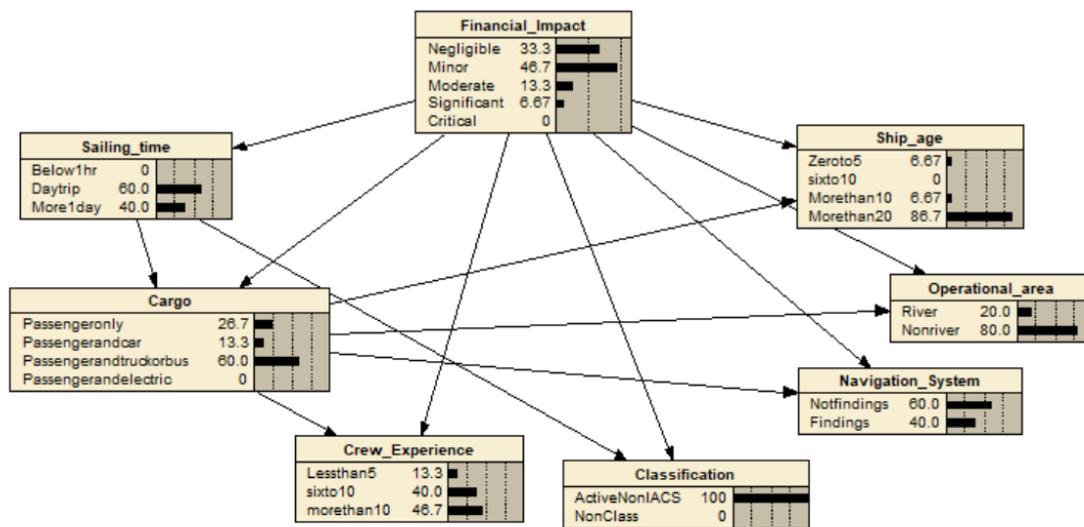


Figure 6. The probability of the Tree Augmented Naïve Bayesian Network (TAN-BN) model of Indonesian passenger vessel claim record – grounding claim

Table 5. Sensitivity of financial impact to the Premium Contributor Factor (PCF) for the grounding claim record

Node	Percent
Financial Impact	100
Sailing Time	11.1
Vessel Age	19.3
Navigation System Condition	16
Trading Area (River / Non-River)	20.6
Crew Experience	16.5
Classification	0
Cargo Carried	14.1

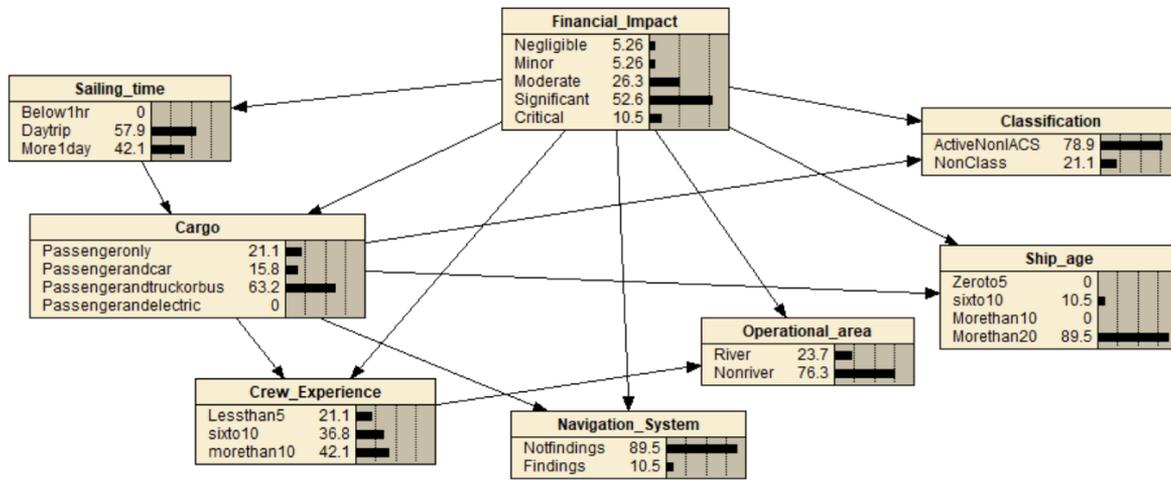


Figure 7. The probability of the Tree Augmented Naïve Bayesian Network (TAN-BN) model of Indonesian passenger vessel claim record – fire claim

The BN TAN Modeling, as shown in Figure 7 above, is focused on fire accidents and found that, from NTSC historical data, financial loss as the premium consideration is more impacted by sailing time in a day trip (more than one hour but no more than 24 hours) (57.9%). The older vessels, more than 20 years old, have a higher possibility of contributing to the claim case of passenger vessels in Indonesia (89.5%). This study also found that in Indonesia, the passenger vessels have no findings in their navigation system condition, but 89.5% of them have an impact on the financial loss to the shipowners. Trading operations also showed the interesting result that the passenger vessels sail in non-river areas also contribute more risk to the claim (76.3%). The crew experience is also unique; this study revealed that the more crew experience over 10 years, the bigger contributor toward the passenger vessel claim (42.1%). The registration to the non-IACS classification is also impacting the condition of the vessels to be considered as riskier than the vessels that are registered to the IACS

classification (78.9%). Lastly, the passenger vessel that is carrying the truck or bus altogether is also considered to have more risk than the vessel that is carrying the passenger only (63.2%).

Table 6. Sensitivity of financial impact to the Premium Contributor Factor (PCF) for fire claim record

Node	Percent
Financial Impact	100
Sailing Time	12.1
Vessel Age	2.73
Navigation System Condition	5.92
Trading Area (River / Non-River)	4.07
Crew Experience	26.5
Classification	14.4
Cargo Carried	16.6

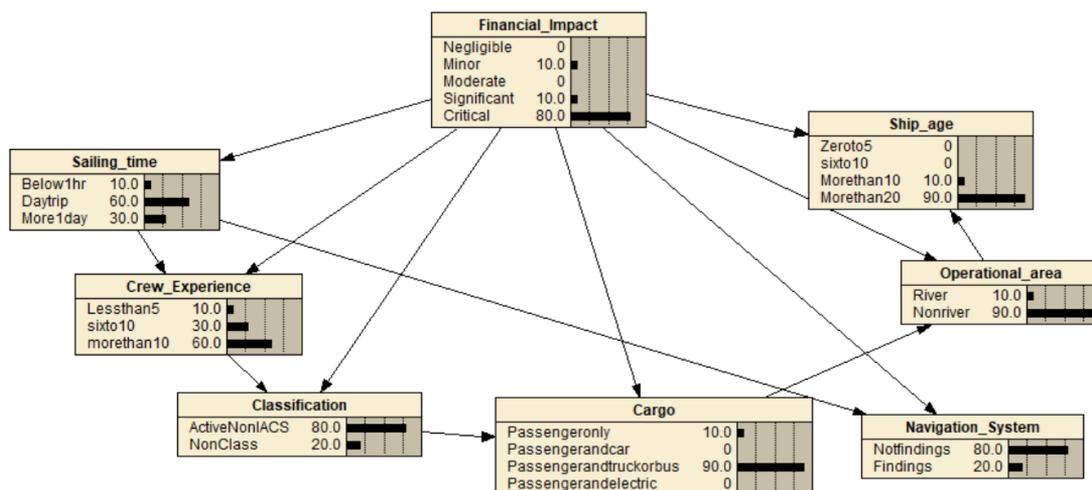


Figure 8. The probability of the Tree Augmented Naïve Bayesian Network (TAN-BN) model of Indonesian passenger vessel claim record – sinking claim

The sensitivity level for the fire accident, as shown in Table 6, is also different than the general claim that happens toward the passenger vessel NTSC data. The study analyzed that the

main contributing factors for fire cases are crew experience, cargo carried, and classification. This study also talks about the interesting result that the cargo carried has an impact on

the source of fire and the machinery condition of the vessels, as proven by the classification, also increasing the possibility of the source of fire. However, the crew experience is also taking into account the crucial factors when the crew needs to understand how to mitigate and handle the fire during the accident.

The BN TAN Modeling, as shown in Figure 8, is focusing on sinking accidents, which reveals that from NTSC historical data, financial loss as the premium consideration is more impacted by sailing time in a day trip (more than one hour but no more than 24 hours) (60%). The older vessels, more than 20 years old, have a higher possibility of contributing to the claim case of passenger vessels in Indonesia (90%). This study also found that in Indonesia, the passenger vessels have no findings in their navigation system condition, but 80% of them have an impact on the financial loss to the shipowners. Trading operations also provided the interesting result that the passenger vessels sail in non-river areas also contribute more risk to the claim (90%). The crew experience is also unique, as this study found that the more crew experience over 10 years, the bigger the contribution to the passenger vessel claim (60%). The registration to the non-IACS classification is also impacting the condition of the vessels to be considered as riskier than the vessels that are registered to the IACS classification (80%). Lastly, the passenger vessel that is carrying the truck or bus altogether is also considered to have more risk than the vessel that is carrying the passenger only (90%).

Table 7. Sensitivity of financial impact to the Premium Contributor Factor (PCF) for the sinking claim record

Node	Percent
Financial Impact	100
Sailing Time	18.5
Vessel Age	3.7
Navigation System Condition	31.1
Trading Area (River / Non-River)	3.7
Crew Experience	27.8
Classification	7.91
Cargo Carried	3.7

Table 7 shows that the sensitivity level for the sinking accident is also different than the other type of claim that happens toward the passenger vessel NTSC data. The study

showed that the main contributing factors for sinking cases are navigation vessel condition, crew experience, and sailing time. This finding is an interesting result since the facts show that there are no findings on Indonesian passenger vessels' navigation system condition, but the claim is indeed happening. This result proves that the proper survey condition for passenger vessels is indeed required to verify the real condition of the vessel.

3.2 Multiplicative Premium Equation of Indonesian passenger's vessel marine insurance

In order to calculate the MPE, this study initially concludes the BP for both H&M and P&I insurance for passenger vessels from the collected questionnaire data, as shown in the table.

Of the 31 respondents total, there are 14 respondents filling out the BP data. This study calculates the average result from the respondent data as concluded in Table 8. This research does some filtering on the data to ensure that the data is valid, representing the real conditions of the BP for both H&M and P&I insurance, as shown in Table 9. From the total of 14 respondents, only four respondents' data could be used to conclude the H&M and P&I insurance, as the rest of the data is not complete and the result is out of similarity.

Table 8. The Base Premium (BP) for Hull and Machinery (H&M) and Protection and Indemnity (P&I) insurance of Indonesian passenger's vessel (prior to filter)

GT Range	H&M Base Premium	P&I Base Premium
0 – 1000 GT	Rp310,494,223.43	Rp52,165,387.86
1001 – 5000 GT	Rp375,033,424.29	Rp107,209,512.86
5001 – 10000 GT	Rp699,805,702.86	Rp334,834,084.29
More than 10000 GT	Rp1,011,229,825.43	Rp466,802,262.86

Table 9. The Base Premium (BP) for Hull and Machinery (H&M) and Protection and Indemnity (P&I) insurance of Indonesian passenger's vessel (post-filter)

GT Range	H&M Base Premium	P&I Base Premium
0 – 1000 GT	Rp451,687,500.00	Rp31,356,187.50
1001 – 5000 GT	Rp548,625,000.00	Rp79,591,875.00
5001 – 10000 GT	Rp756,937,500.00	Rp281,040,375.00
More than 10000 GT	Rp954,937,500.00	Rp396,841,500.00

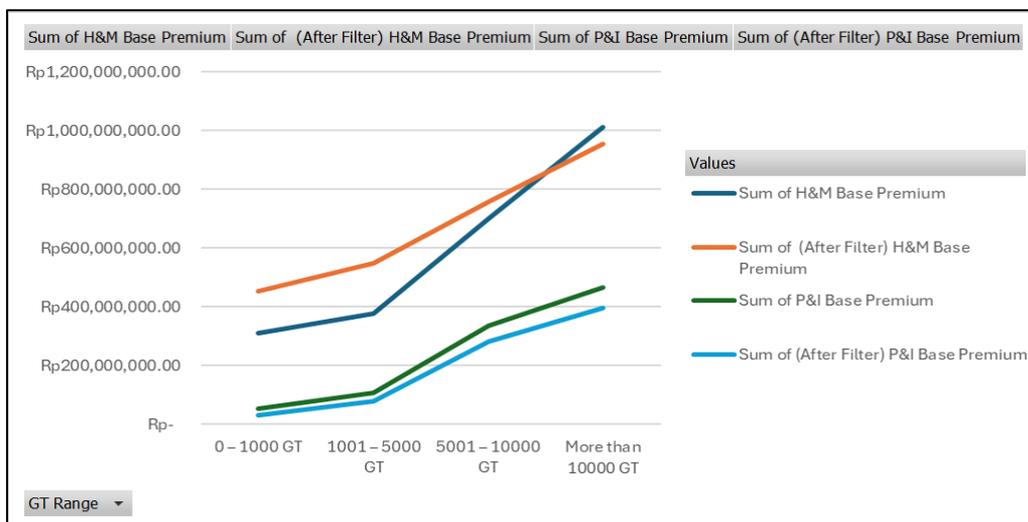


Figure 9. Hull and Machinery (H&M) and Protection and Indemnity (P&I) Base Premium (BP) before and after filtering process

Table 10. Scenario of Multiplicative Premium Equation (MPE) of Hull and Machinery (H&M) insurance for Indonesian passenger vessel

Vessel PCF Scenario	PCF Code	PCF Score	Sensitivity Bayesian Network (BN)	Weighted Score	PCF Index
Sailing Time > 24 hours	H&M CF 1.3	47%	4.08	0.128991464	1.05
YOB 1990; Vessel Age > 20 years	H&M CF 2.4	42%	8.5	0.268732216	1.10
Navigation System in Order	H&M CF 3.1	39%	2.19	0.069238065	1.02
Non-River Trading Area	H&M CF 4.2	44%	2.06	0.065128043	1.02
6 years; Crew Experience 6 – 10 years	H&M CF 5.2	32%	5.24	0.165665507	1.05
BKI Class; Non IACS Class	H&M CF 6.2	61%	4.09	0.129307619	1.06
Passenger and Truck / Bus Carrier	H&M CF 7.3	32%	5.47	0.172937085	1.05

Table 11. Scenario of Multiplicative Premium Equation (MPE) of Protection and Indemnity (P&I) insurance for Indonesian passenger vessel

Vessel PCF Scenario	PCF Code	PCF Score	Sensitivity BN	Weighted Score	PCF Index
Sailing time > 24 hours	P&I CF 1.3	47%	4.08	0.128991464	1.05
YOB 1990; Vessel Age > 20 years	P&I CF 2.4	41%	8.5	0.268732216	1.10
Navigation System in Order	P&I CF 3.1	43%	2.19	0.069238065	1.03
Non-River Trading Area	P&I CF 4.2	44%	2.06	0.065128043	1.02
6 years; Crew Experience 6 – 10 years	P&I CF 5.2	30%	5.24	0.165665507	1.04
BKI Class; Non IACS Class	P&I CF 6.2	62%	4.09	0.129307619	1.06
Passenger and Truck / Bus Carrier	P&I CF 7.3	32%	5.47	0.172937085	1.05

The filtering process proves that the players in Indonesian marine insurance players have a limited understanding and access to calculate the BP. The confidentiality of the premium data and the limited understanding of the H&M and P&I risk in Indonesian passenger vessels are also other challenges for this research, yet the main reason for the need for research in this field. Figure 9 shows the comparison line between H&M BP and P&I BP, before and after the filtering process.

This study generates a scenario calculation to show the process of MPE by calculating the weighted score of the sensitivity BN score of the respective PCF. After the weighted score of each PCF is calculated, the study calculates the PCF Index using the equation above, for H&M insurance, as also detailed in Table 10.

The vessel data above has a GT of 9456 GT; therefore, the H&M BP is Rp756,937,500.00. Accordingly, by adding the PCF scores to the BP of the said case of vessel, this research revealed the MPE score of 9456 GT passenger vessel carrying truck and bus, with BKI class, operated by six years experienced crew, sailing in non-river area, when the navigation system is in order, the 35 years old of vessels that is sailing more than 24 hours per trip need to be covered by H&M insurance premium at least of Rp1,069,926,706.95. The calculation of MPE is shown below:

$$\text{MPE} = \text{Rp}756,937,500.00 \times 1.05 \times 1.10 \times 1.02 \times 1.02 \times 1.05 \times 1.06 \times 1.05 = \text{Rp}1,069,926,706.95 \quad (4)$$

The calculation scenario is also conducted for the P&I premium equation as detailed in Table 11. The weighted score of the sensitivity BN score of the respective P&I PCF is also calculated to define the PCF Index of P&I insurance, as detailed in the table below.

The vessel data above has a GT of 9456 GT, therefore, by adding the PCF scores to the BP of the said case of vessel, this research revealed the MPE score of 9456 GT passenger vessel carrying truck and bus, with the BKI classed, operated by 6 years experienced crew, sailing in non-river area, when the navigation system is in order, the 35 years old of vessels that is sailing more than 24 hours per trip need to be covered by P&I insurance premium at least of Rp396,588,656.95. The

calculation of MPE is as follows:

$$\text{MPE} = \text{Rp}281,040,375.00 \times 1.05 \times 1.10 \times 1.03 \times 1.02 \times 1.04 \times 1.06 \times 1.05 = \text{Rp}396,588,656.95 \quad (5)$$

4. DISCUSSION

The research on premium calculation in general insurance, particularly for marine insurance, is very limited. Most of the previous journals and research focus on health, life, and motor vehicle insurance [29, 30]. The confidentiality of the underwriting data is another challenge to generating the calculation for this specific research. As predicted, this research shows the interesting facts that in marine insurance businesses, especially for Indonesian passenger vessels, the ability to properly assess the risk is required. During the process of interview with the marine insurance expert on the Indonesian passenger's vessel industry, as well as the literature review on marine insurance, the passenger's vessel risk is complex; it is not only about the passenger as the carrier, but also the overall operation during the sailing time. In the process of calculating the marine insurance, it is also challenging as the Indonesian underwriter transfers the risk into the international market and just follows the international final premium. According to National Reinsurance Data in 2020, only 1%-5% of H&M premiums accounted for a total of about IDR 330,000,000,000 per year is absorbed by the local underwriter, while the rest of the premium goes to the international market. Meanwhile, for the P&I, since there is no P&I company established in Indonesia, 100% of the premium is predicted to be IDR 495,000,000,000 per year goes to the International Club. The importance of understanding the marine insurance premium becomes the requirement to ensure the sustainability of the passenger vessel industry in Indonesia and to support the logistics system of Indonesia [31].

4.1 Proper Base Premium for Indonesian passenger vessel insurance

The importance of determining the BP using the proper

criteria is also crucial. The limited data collection from the interview process shows the high level of confidentiality toward premium matters, while the limited data collection during questionnaires shows the limited understanding of the players of the premium. The level of filtering carried out in this research on formatting the base of premium for both H&M and P&I insurance is the academic approach to capture the rational BP for H&M and P&I insurance of passenger vessels in Indonesia.

4.2 Formulating the Premium Contributor Factor Index using Bayesian Network with Tree Augmented Naïve Model and formulating the Multiplicative Premium Equation

This study faces the challenges of converting the PCF score into the PCF Index without losing the objectivity of data representative of reality. BN, especially the BN TAN approach, is used in responding to the limited collected data, but could give a detailed meaning to the research. BN TAN analysis is carried out using the NTSC data of 45 passenger vessel accidents during the last 10 years in Indonesia. BN TAN provided the sensitivity analysis on which the result is converted into a weighted score to be used for the PCF Index equation, as mentioned in the results. The MPE equation is also developed by considering several previous studies and journals of premium equations and modifying the approach according to the data of this research. The MPE equations, as detailed in the results part, show that the Indonesian passenger vessels' premium equation is composed of the BP to be multiplied by the PCF Index.

4.3 Model validation and scenario

This research conducts the model validation of the formulated MPE by doing several scenario analyses, both in MPE calculation and the PCF Index modification, to analyze the response of the data toward market price. The market price is defined as the premium level prevailing in the market and is considered by the stakeholders of the Indonesian marine insurance industry as a reference for fair and acceptable pricing. The market price for a specific vessel scenario is compared with the MPE result from the BP and PCF Index calculation. The result shows that the MPE calculation for H&M premium is 35% higher than the market price of H&M premium for passenger vessels in Indonesia. This data shows that the current H&M premium is not sufficient to accommodate the risk profile of Indonesian passenger vessels.

In contrast, for the P&I insurance, the calculated premium using the MPE equation of this study reveals a lower premium of 5% from the market price of P&I premium in Indonesia. This condition states that, due to the risk of P&I is 100% covered by the international market, which requires the vessels to undergo a survey condition as per the international underwriter standard, the insurance could maintain the risk properly and gain the profit from the premium, causing the underwriter to provide a discount on premiums without facing huge claims.

5. CONCLUSIONS

This research found that the calculated MPE for H&M premiums for passenger vessel insurance in Indonesia is 35%

higher than the current market price of H&M premiums in the Indonesian market. This data indicates that the market price of H&M premiums is insufficient to cover the risk profile of Indonesian passenger vessels. Conversely, for P&I insurance, premiums calculated using the MPE in this study are 5% lower than the market price of P&I premium of Indonesian passenger vessels. This situation indicates that because P&I risks are fully covered by the international market, which requires the vessel to undergo a survey condition prior to the attachment of the policy, according to international insurance underwriting standards, insurers could effectively manage risks and profit from premiums. This allows underwriters to offer premium discounts without facing large claims.

This research also elaborates the improved methodology to combine the qualitative and quantitative data from the Indonesian passenger's vessel industry as the data set to formulate the MPE by defining the BP and PCF Index. The interview with the professionals is explored to identify the PCF and BP, the questionnaire data is analysed using the risk register to get the probabilistic score, while the claim record data from NTSC is also evaluated by using Netica 7.01 software to get the sensitivity analysis score for altering the PCF score into the PCF Index.

The confidentiality of underwriting data is another limitation for this research in formulating premium calculations for passenger vessel insurance in Indonesia. Therefore, the combined methodology to be used for this research is the initial solution. Finally, the academic result must be bridged to the professional application so that the industry of Indonesian marine insurance and passenger vessels can maintain the safety level. The discussion with the government is also crucial to enforce the academic research application to be positive regulation.

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NOMENCLATURE

P&I	Protection and Indemnity
H&M	Hull and Machinery
MPE	Multiplicative Premium Equation

BP Base Premium
PCF Premium Contributor Factor
TAN Tree Augmented Naïve

BN Bayesian Network
BN TAN Bayesian Network with Tree Augmented Naïve Model