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RESEARCH ARTICLE

The Role of Artificial Intelligence in Risk Management and Underwriting Optimization in the Insurance Industry

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ABSTRACT

The insurance industry is critical to economic stability, as it mitigates financial risks stemming from everyday uncertainties. Effective risk management and underwriting practices are essential, ensuring that premiums accurately reflect the risk presented by policyholders. This study examines the transformative potential of artificial intelligence (AI) in enhancing these processes within Saudi car insurance sector, where traditional practices often fall short. Conventional underwriting methods tend to rely on subjective assessments and personal relationships, resulting in inconsistent pricing structures and potential financial losses for insurers. This can foster a lack of transparency and fairness in premium setting, alienating consumers and undermining trust in the insurance system. To address these challenges, this research advocates for the integration of AI-algorithms to develop a more data-driven approach to risk assessment and pricing accuracy. The study will conduct a comprehensive analysis of underwriting data from various Saudi insurance companies, specifically focusing on car insurance policies. Key metrics, including claims frequency, underwriting volume, types of vehicles insured, and demographic factors, will be examined to construct a robust predictive model. This model aims to provide a more precise evaluation of risks associated with each policy, enabling insurance companies to establish premiums that better reflect individual risk profiles. One primary objective of this research is to illustrate how AI can revolutionize underwriting practices through a transparent, data-informed methodology. By employing machine learning and advanced data analytics, insurers can automate many underwriting aspects, reducing human error and bias while enhancing the speed and efficiency of decisions. Additionally, the implementation of AI technologies is expected to reduce claims frequency, manage exposure better, and decrease the likelihood of fraudulent claims. Overall, this research will provide valuable insights and recommendations for insurance companies seeking to optimize their underwriting processes through AI technologies, fostering sustainable growth and improved consumer trust in Saudi's insurance sector.

1. INTRODUCTION

The insurance industry plays a vital role in mitigating financial risks and ensuring economic stability. Effective risk management and underwriting practices are essential for the sustainable growth and profitability of insurance companies. However, traditional underwriting methods often rely heavily on past years' analysis or subjective assessments and personal relationships, which can lead to pricing discrepancies and financial losses.

This research aims to investigate the potential of artificial intelligence (AI) to revolutionize risk management and underwriting practices within the Saudi motor insurance sector. By developing AI-driven models, this study seeks to demonstrate how data-driven approaches can enhance the accuracy of risk assessment and pricing, leading to more efficient and profitable underwriting processes.

1.1 Background of the study

The Saudi motor insurance market, similar to many other global insurance sectors, faces significant challenges in establishing and maintaining consistent underwriting practices. Traditional methods often rely heavily on subjective assessments, which can lead to inaccuracies in pricing. Key factors influencing these assessments include historical data, the type and model of the vehicle, the availability and cost of spare parts, and the vehicle's tolerance to accidents. However, the underwriting process frequently lacks standardized criteria, leading to substantial discrepancies in risk evaluation based on the personal judgment of insurance employees.

Moreover, many crucial factors that should be considered in the underwriting process, such as driver-related variables—including age, marital status, and educational qualifications—are often overlooked. These factors are critical in advanced markets, where they play a significant role in determining insurance premiums. Additionally, the absence of an electronic accident record system inhibits insurance companies from accessing drivers' accident histories, further complicating risk assessment.

The current practices in the Saudi insurance market also reveal a troubling trend: companies increasingly compete by offering the lowest premiums. This intense price competition has led consumers to prioritize cost over comprehensive coverage, prompting many to seek the cheapest available option for insuring their vehicles. As a result, several insurance companies are experiencing liquidity crises due to underpriced policies that do not accurately reflect the risk associated with the insured vehicles.

In this context, our research aims to incorporate various factors related to vehicles, claims volume, and overall underwriting performance to enhance the risk profiles of insurance companies. By focusing on these elements, we seek to improve the insurance portfolio for motor vehicles, shifting the competitive landscape towards quality rather than merely price. This approach will not only facilitate better risk management for insurers but also allow them to offer fairer premiums that accurately reflect the true risk associated with each policyholder.

Furthermore, the lack of unified data and sophisticated analytics tools within the Saudi insurance industry severely hampers companies' ability to make informed decisions based on data-driven insights. The reliance on disparate data sources prevents insurers from harnessing the full potential of analytics in risk assessment.

In light of these challenges, the integration of artificial intelligence presents a promising solution. AI technologies can provide a more objective and data-driven approach to risk assessment and underwriting. By employing advanced algorithms and predictive modeling, companies can enhance their risk evaluation processes, set more accurate premiums, and ultimately improve their profitability while ensuring fairer pricing for consumers.

This study aims to explore how the adoption of AI can address the inefficiencies currently plaguing the Saudi motor insurance market, fostering a more equitable and sustainable environment for both insurers and policyholders. By embracing innovative technologies, the industry can transition towards a more transparent and efficient underwriting process, ultimately enhancing customer trust and satisfaction.

1.2 Significance of the study

This research is of great importance for several reasons:

- **Improving risk management:** Artificial intelligence can help insurance companies identify and assess risks more accurately, leading to better risk management practices.

- **Improving underwriting efficiency:** AI-based models can automate underwriting processes, reducing the time and cost associated with manual underwriting.
- Compete based on improving risk rather than competing to reduce prices and break the market.
- **Increase profitability:** By improving underwriting accuracy and efficiency, AI can help insurance companies increase their profitability.
- **Fairer pricing:** AI can enable insurance companies to set premiums that are more in line with individual risk profiles, enhancing fairness and transparency in the market.
- **Economic stability:** A more efficient and stable insurance industry can contribute to the overall economic stability of Saudi Arabia.

1.3 Problem statements

The insurance industry in Saudi Arabia is currently confronting a multitude of challenges stemming from outdated underwriting practices and uninformed pricing strategies. These issues undermine the effectiveness and sustainability of insurance operations, impacting both insurers and policyholders. The key problems identified are as follows:

- **Outdated underwriting policies:** Many insurance companies still rely on traditional methods of underwriting that do not accurately reflect the complexities of today's market conditions. Factors such as vehicle types, the driving history of individuals, and emerging risks associated with modern vehicles are often overlooked. As a result, these outdated policies fail to provide a reliable basis for evaluating risk, leaving insurers vulnerable to unexpected financial liabilities.
- **Uninformed pricing decisions:** In a fiercely competitive market, many insurers are compelled to set premiums primarily based on competitive pressures rather than on a thorough understanding of risk factors. This approach leads to a misalignment between premiums and the actual risk presented by policyholders, which can jeopardize the financial stability of insurance companies. Companies may attract customers with low prices but fail to cover potential claims, leading to significant financial strain.
- **Financial hardships:** The ramifications of inaccurate pricing are profound, particularly for companies that experience high claim volumes. In such scenarios, underpriced policies can erode profit margins and create liquidity challenges. As insurers struggle to manage their financial resources, they may be forced to make cuts in other areas, such as customer service or claims processing, further exacerbating the situation.
- **Inconsistent risk assessment:** The traditional methods employed for risk assessment often result in inequitable pricing practices, creating disparities among customers. For instance, factors such as the driver's age, driving history, and vehicle specifications—which are critical in advanced markets—are frequently ignored. This inconsistency can lead to some policyholders being charged excessively while others enjoy lower premiums, undermining trust and fairness in the insurance process.
- **Lack of data utilization:** The absence of robust data analytics capabilities prevents insurers from making informed, data-driven decisions. The reliance on historical data without integrating real-time insights leaves companies ill-equipped to adapt to changing market dynamics or emerging risks, further hindering their ability to assess and manage risk effectively.

This study aims to address these pressing problems by investigating how artificial intelligence (AI) can optimize underwriting processes and enhance risk management practices within the Saudi insurance market. By leveraging AI technologies, insurers can improve the accuracy of risk assessments, implement data-driven pricing strategies, and foster a more equitable and efficient insurance landscape. The adoption of AI-driven solutions has the potential to transform the underwriting process, ultimately enhancing customer satisfaction and ensuring the long-term sustainability of insurance companies in Saudi.

1.4 Objectives

- **Develop an AI-based model for risk prediction:** Create a predictive model using artificial intelligence to accurately assess the risk level associated with auto insurance policyholders. This model aims to streamline risk evaluation processes by providing a more precise and data-driven assessment compared to traditional methods.
- **Determine optimal insurance premiums (price):** Establish a method to set appropriate insurance premiums by analyzing various risk factors impacting policyholders. The model will use relevant data inputs, such as vehicle type indicators, to recommend competitive and balanced pricing.
- **Evaluate model accuracy and performance against traditional methods:** Assess the AI model's effectiveness and precision in risk prediction by comparing its performance with traditional underwriting approaches. This objective includes measuring the AI model's reliability and consistency to gauge its value as a modern alternative to manual underwriting.
- **Analyze cost savings and efficiency gains**: Investigate the potential cost reductions and operational efficiencies gained through the implementation of AI-based underwriting. This objective focuses on examining how AI can enhance underwriting processes, streamline workflows, and reduce overhead costs within the auto insurance sector.
- **Identify challenges and limitations in saudi insurance industry**: Recognize specific challenges and barriers to adopting AI in the Saudi insurance landscape. This involves exploring regulatory constraints, data availability issues, and the current technological infrastructure, followed by proposing viable solutions to overcome these obstacles and promote AI integration.

1.5 Scope of delimitations

The scope of this study is focused on the car insurance sector in Saudi Arabia, analyzing underwriting data from selected Saudi insurance companies. The research will utilize AI algorithms to develop a predictive model for risk assessment and pricing. Delimitations include:

- **Geographical focus:** The study is limited to the Saudi car insurance market and may not be applicable to other regions or types of insurance.
- **Data limitations:** The analysis will be constrained by the quality and availability of historical underwriting data.
- **Methodological constraints:** The study will primarily focus on machine learning techniques and may not explore all possible AI applications or methodologies.

1.6 Conceptual framework

The conceptual framework of this study is built around the integration of AI into traditional underwriting and risk management practices:

- **Traditional underwriting practices:** characterized by subjective assessments and reliance on historical data.
- **AI techniques:** integrate machine learning algorithms and data analytics to enhance risk assessment and pricing accuracy.
- **Data analysis:** focuses on key metrics such as claims frequency, underwriting volume, and vehicle types to inform predictive modeling.
- **Predictive modeling:** develop an AI-driven model to assess risk levels and improve underwriting decisions before issuing an insurance policy.
- **Outcome measurement:** assess the impact of AI on underwriting accuracy, financial performance, and market fairness.

2. REVIEW OF RELATED LITERATURE

The insurance industry plays a crucial role in economic stability, relying heavily on effective risk management and underwriting practices. However, traditional methods often fall short, leading to inconsistent pricing and increased risk. This Review of Related Literature explores the transformative potential of artificial intelligence (AI) in enhancing these processes.

By examining various studies, this review highlights how AI technologies, including machine learning and predictive analytics, improve pricing accuracy and operational efficiency. It also addresses the challenges associated with AI implementation, such as transparency, ethics, and regulatory compliance. Ultimately, this review aims to provide insights into how AI can reshape underwriting practices, benefiting both insurance companies and consumers, and fostering fair competition in the market.

2.1 Overview of insurance

Insurance is a financial system designed to protect individuals and businesses from financial risks arising from unforeseen events. It serves as a risk management tool, enabling policyholders to transfer the potential costs of losses or damages to an insurance provider. The primary goal of insurance is to mitigate the financial burdens that may result from incidents such as accidents, natural disasters, or liability claims.

Insurance operates on the principle of risk distribution among a group of individuals or entities. By pooling resources from multiple policyholders, insurers can cover the costs associated with claims made by those who experience losses. This collective approach allows for the spreading of risk, making it more manageable for both the insurer and the insured.

In essence, insurance provides a safety net, ensuring that individuals and businesses can recover and maintain their financial stability in the face of unexpected challenges.

- **Auto insurance basics:**
  Auto insurance protects against financial loss in the event of an accident. It is a contract between the policyholder and the insurance company. The policyholder agrees to pay the premium, and the insurance company agrees to pay losses as defined in the policy.
  Auto insurance provides property, liability, and medical coverage:
  - **Property coverage:** Pays for damage to, or theft of, the car.
  - **Liability coverage:** Pays for the policyholder's legal responsibility to others for bodily injury or property damage.
  - **Medical coverage:** Pays for the cost of treating injuries, rehabilitation, and sometimes lost wages and funeral expenses.

2.2 Previous Studies:

Byrne (July 2024) investigated the factors influencing car insurance costs in Ireland using Explainable Artificial Intelligence (XAI) to analyze the data. The determination of insurance premiums primarily relies on assessing the potential risk of policyholders, yet the specific factors influencing this assessment are often unclear. The study Analyze aims to analyze the process of premium determination to uncover the factors influencing the insurance costs for drivers. The study developed an automated process for collecting insurance quotes, considering diverse factors such as gender, age, geographical location, occupation, and driving history. The study found that geographical location and occupation have a direct and significant impact on insurance costs, highlighting the complexity in the calculations used by insurance companies to determine these prices. The study enhances the understanding of how car insurance premiums are determined and emphasizes the need for greater transparency and fairness in insurance pricing practices, revealing systemic biases that may lead to unfair price disparities among drivers. Holvoet and Henckaerts (2024) emphasized the use of deep neural networks for insurance pricing based on claim frequency and severity. It contributes to expanding actuarial tools by comparing different models across four insurance datasets with frequency and severity targets, highlighting the data preprocessing steps, such as using autoencoders to integrate categorical variables into neural networks. The models are evaluated based on out-of-sample deviance and other statistical and calibration criteria. The study

outlines a workflow to construct technical tariff tables for insurance pricing, leveraging neural networks to improve pricing practices in ways that can be deployed in practice. The study contributes to a deeper understanding of how neural networks can enhance insurance pricing practices by improving transparency and efficiency in the field.

Balasubramanian et al. (2021). explores how artificial intelligence (AI) will transform underwriting and insurance pricing by 2030. The study predicted that shift to Automated Underwriting: Traditional underwriting processes will nearly disappear, replaced by AI-driven processes that complete in seconds. Machine learning models, powered by internal and external data, will design insurance products tailored to everyone's risk profile. The study further indicates that Insurers will collect data from various sources, such as reinsurers, manufacturers, and distributors. This data will enable insurers to make proactive underwriting and pricing decisions, offering personalized insurance bundles based on each buyer's coverage needs. And with regard to regulatory oversight the study argue that regulators will closely monitor AI-based models to ensure transparency in pricing and underwriting decisions. They will also impose restrictions on the use of sensitive data, such as health and genetic information, to ensure fairness in the market. Overall, the study highlights the profound impact of AI in automating and personalizing insurance, reshaping pricing models, and driving industry innovation.

Kumar et al. (2019) explores the applications of AI in the insurance industry and how it can address current challenges. The study investigated the use cases of AI in insurance services, focusing on how AI can resolve ongoing issues to improve customer satisfaction and operational efficiency. The authors developed a conceptual model based on AI concepts to examine the relationship between AI technologies and their applications within the insurance industry. The study utilized an empirical quantitative method, involving a sample of international companies and InsureTech firms that have adopted AI-based solutions. The model was tested to evaluate its effectiveness in real-world scenarios. The study concluded that AI has the potential to assist insurance companies by enhancing customer satisfaction, increasing profitability, reducing fraud, and addressing operational challenges. Use cases, supported by examples from the industry, demonstrated AI's potential to revolutionize the insurance sector.

Bhall (May 2012) focuses on improving the underwriting process in insurance companies using predictive analytics. The study aimed to improve and simplify the underwriting process, which contributes to reducing errors and increasing the effectiveness of risk management. The study stressed that underwriting is a crucial element in insurance companies, as any mistake can lead to significant consequences. The success of the company depends on accurately assessing the risks associated with each insurance application. The study utilized Predictive Analytics, this technique involves analyzing statistical data and historical records to estimate potential risks. Each application is evaluated by assigning it a score based on the initial information provided. The study suggests integrating the predictive model into the underwriting process to streamline and enhance efficiency. This methodology aids underwriters in making quicker and more accurate decisions.

The primary conclusion is that predictive analytics provides essential tools for risk assessment, thereby enhancing the quality of the underwriting process.

Eling and Staubli (2020) analyzes the impact of artificial intelligence (AI) on the insurance sector using Porter's (1985) value chain and Berliner's (1982) insurability criteria. The study is based on a dataset consisting of 91 papers and 22 industry studies. The study findings shows that AI has the potential to enhance cost efficiencies and open up new revenue streams within the insurance industry. The insurance business model is expected to shift from merely compensating for losses to predicting and preventing them. The study identifies two key developments concerning how AI affects the insurability of risks: First, Improved Loss Prediction: AI enables more accurate predictions of loss probabilities, which helps mitigate one of the industry's fundamental challenges—asymmetric information (where insurers and insured parties possess unequal information). Second, changing Risk Landscape: AI may significantly alter the nature of certain risks, transforming them from low-severity/high-frequency events to high-severity/low-frequency events. This transformation necessitates that insurance companies rethink traditional insurance coverage and design adequate

insurance products. The study suggests the need for further research from both academic and practitioner perspectives to explore how AI can reshape insurance operations, improve insurability, and manage the evolving risk landscape.

Alhassan (2018) examines the impact of motor insurance prices on the financial solvency of Saudi insurance companies, focusing on the adequacy, fairness, and scientific methods used in pricing. The study aimed to evaluate the effect of car insurance prices on the financial solvency of Saudi insurance companies., and to determine whether these prices are fair and adequate and how harmful competition impacts the financial health of these companies. The researcher employed a descriptive analytical approach using a survey study to collect and analyze data. The study highlights the lack of essential conditions for pricing motor insurance in Saudi companies, such as adequacy, fairness, and scientific methods. Additionally, harmful competition affects the financial strength of insurance companies operating in the auto market. The study concluded that there is a strong relationship between the adequacy of motor insurance prices and the profits or losses of insurance companies, also motor insurance prices are considered fair in the Saudi insurance market, and that most Saudi insurance companies do not rely on clear scientific standards when determining motor insurance prices.

Atombo et al. (2023) investigates the impact of vehicle-related factors on the speed at which accidents occur and the severity of those accidents. The study examined the incident rate ratio effects to analyze how different vehicle characteristics affect speed and accident severity. The findings of the study show that higher engine capacities are associated with increased accident severity, certain types of vehicles (such as 4WDs and AWDs) contribute to higher severity rates, the type of drive also has a significant impact on severity rates, engine capacity and vehicle age both significantly affect the speed at which accidents occur, with higher engine capacities leading to faster speeds, and finally that the Larger vehicles and certain types (like 4WDs and AWDs) are linked to increased speeds. The study emphasizes the need for stricter enforcement of traffic laws to manage aggressive driving behaviors and speed, aiming to reduce the frequency and severity of accidents. The study pointed out the vehicle-related factors that impact both speed and accident severity, suggesting that regulatory measures are essential for improving road safety.

Belha (2017) examines the impact of the motor insurance portfolio on the performance of Saudi insurance companies during the period from 2008 to 2014, aiming to mitigate these negative impacts on the overall performance of the companies. The study aimed to assess the effect of expanding the motor insurance portfolio on the performance of insurance companies, and as well to study the impact of rising loss ratios in the motor insurance portfolio on performance.

The study relied on descriptive and statistical methods to analyze the data. The findings indicated an imbalance in the insurance portfolios, with the motor insurance branch being the most underwritten. The findings also show that the average net loss ratio was found to be 62%, indicating that the motor insurance portfolio is the most loss-making among the branches. The study recommended that Saudi insurance companies should diversify their insurance portfolios rather than focusing solely on motor insurance, and that the insurance regulatory authority should prevent harmful competition among insurance companies to reduce the loss ratio in motor insurance. These findings emphasize the importance of diversifying insurance companies' strategies as well to enhance performance and reduce risks associated with the motor insurance portfolio.

2.3 The Researcher's comment on previous studies

This collection of studies provides a comprehensive review of various aspects of car insurance, with a particular focus on the impact of technology and pricing practices. A common thread throughout many of these studies is the emphasis on transparency, fairness, and the application of artificial intelligence (AI) to enhance the efficiency of pricing and underwriting processes in the insurance sector. Below is a comparative analysis of these studies, highlighting common themes and offering some critiques. The selected studies highlight the transformative role of AI in the insurance industry, with a strong focus on the need for transparency, fairness, and improved pricing strategies. While they agree on several key themes, there remains room for enhancing methodological rigor and

expanding geographic comparisons. Addressing these areas can lead to more robust insights and recommendations for practitioners and regulators in the insurance sector.

2.4 The researcher's benefit from previous studies:

The reviewed literature illustrates the multifaceted benefits of integrating AI into insurance practices, from improving pricing mechanisms and operational efficiency to fostering innovation and addressing systemic biases. These advancements not only benefit insurance companies but also enhance consumer trust and satisfaction, ultimately contributing to a more stable economic environment.

2.5 Conclusion of the review of related literature

The previous research on the use of artificial intelligence in improving underwriting in insurance companies indicates that this technology helps analyze vast amounts of data from various sources, such as health records and driving data, leading to more accurate risk assessment and insurance pricing. This enables insurance companies to make more precise and informed decisions. The studies also show that employing explainable artificial intelligence techniques enhances the transparency of pricing processes and reduces biases that may affect fairness among clients. Additionally, neural networks are considered an essential tool for improving insurance pricing by analyzing claims data, and these models have proven effective compared to traditional methods in estimating risks and expected costs. AI also contributes to reducing time and costs by automating manual processes, thereby increasing the efficiency of companies.

3. MATERIALS AND METHODS

This chapter presents a comprehensive overview of the materials and methodologies utilized in this study, which aims to explore the integration of artificial intelligence (AI) to enhance underwriting practices within the car insurance sector in Saudi Arabia. The focus is primarily on employing machine learning algorithms to develop a predictive model for improved risk assessment and pricing accuracy.

3.1 The Goal of study

The aim of this study is to explore how to integrate artificial intelligence (AI) to enhance underwriting practices in the car insurance sector in Saudi Arabia. Specifically, the study seeks to develop a predictive model that improves the accuracy of risk assessment and the effectiveness of pricing for car insurance. By utilizing machine learning algorithms, the study aims to create a data-driven framework to better estimate insurance premiums and assess risk levels associated with various vehicle models.

3.2 Methodology

This study follows an analytical methodology utilizing artificial intelligence to enhance the underwriting process in Saudi car insurance sector. The methodology involves a sequence of steps to ensure data accuracy and effective analytical models.

3.3 Hypotheses

3.3.1 Primary hypotheses:

- **Correlation between claims and risk**: The research assumes that a higher total claim amount for a specific vehicle model indicates an increased risk associated with that model.
- **Impact of premium on risk**: The assumption is that the average insurance premium reflects the baseline risk level of the model.
- **Relationship between average claims and new premium**: It is assumed that an increase in average claims necessitates an increase in the insurance premium.

3.3.2 Derived hypotheses:

- **Stability of distribution:** The assumption is that the distribution of claims remains constant over time and across different models.

- **Independence of data:** It is assumed that the data points are independent and not correlated with each other.
- **Data accuracy:** The assumption is that the data used is free from errors and inconsistencies.

3.4 Tools and software

The tools used in this study include:

- **Python:** The primary programming language used for data analysis and model development.
- **Pandas and numpy:** Libraries utilized for data processing and numerical analysis.
- **Scikit-learn:** A comprehensive library for building predictive models.
- **Matplotlib:** Used for data visualization to represent findings effectively.
- **Visual studio code:** The integrated development environment used for coding.
- **Anaconda navigator:** A platform for managing Python libraries and environments.

3.5 Simplified insurance premium calculation formula

The formula for calculating the insurance premium for vehicles can be expressed as follows:

$$\textbf{Insurance Premium} = \textbf{Car Value} \times \textbf{Insurance Rate} + \textbf{Additional Factors}$$

Where:

- **Car Value**: The market value of the vehicle.
- **Insurance Rate**: A percentage determined by the insurance company, which varies based on the risk factors associated with the car and the driver (e.g., 5% or 7%).
- **Additional Factors**: These include elements such as the driver's record, geographical location, and the type of coverage selected.

3.5.1 Example calculation

For instance, if the car value is $20,000 and the insurance rate is 5%, the calculation would be as follows:

$$\text{Insurance Premium} = 20{,}000 \times 0.05 + \text{Additional Factors}$$

Assuming the additional factors amount to $300, the calculation would then be:

$$\text{Insurance Premium} = 1{,}000 + 300 = 1{,}300$$

Thus, the estimated annual insurance premium would be approximately $1,300.

3.6 Data collection

The data used in this study were sourced from multiple insurance companies operating within the Saudi car insurance market. The dataset includes various attributes related to policyholders and their vehicles, specifically focusing on:

- **Insurance premiums**: The amount charged to policyholders for coverage.
- **Claims information**: Data on claims made, including claim amounts and the frequency of claims.
- **Vehicle specifications**: Details about the vehicle models, types, and characteristics.
- **Demographic factors**: Information related to policyholders.

3.7 Data preprocessing

Prior to the application of machine learning algorithms, extensive data preprocessing was conducted to ensure data quality and reliability. The key preprocessing steps included,: andling Missing Values,

normalization, categorical encoding, categorical data, such as vehicle type, was transformed into numerical formats utilizing techniques.

3.8 Risk assessment

The core of the analysis revolved around assessing risk levels associated with different vehicle models. This involved the following procedures:

1. **Group analysis**:

   Average premiums, total claims, and insurance rates were calculated for each vehicle model using aggregation methods.

2. **Risk index calculation**:

   A risk index was determined for each vehicle model by calculating the ratio of total claims to average premium.

3. **Risk level determination**:

   Based on the calculated risk index, each vehicle model was categorized into risk levels: "High Risk," "UP Normal Risk," "Low Risk," and "Good Risk."

3.9 Predictive modeling

To evaluate the effectiveness of AI in underwriting, a predictive modeling approach was adopted:

1. **Feature selection**: Features deemed necessary for predicting claims were selected, and columns irrelevant to the analysis (like identifiers) were dropped.

2. **Data splitting**: The dataset was split into training and testing sets to evaluate the model's performance.

3. **Model training and evaluation**: Although not implemented in detail, machine learning models would be trained using the training dataset to predict claims. Evaluation metrics, such as accuracy and precision, would be employed to assess model performance.

3.10 New insurance rate calculation

Following the risk assessment, new insurance rates were calculated based on average claims:

3.11.1 Average claims calculation:

The average claims per vehicle model were calculated by merging the claims totals with the count of vehicles per model.

3.11.2 New rate calculation:

A function was defined to calculate new insurance rates based on average claims, ensuring rates were clipped between predefined minimum and maximum limits.

New risk indices were computed using the new insurance rates, providing insights into potential changes in the risk landscape.

3.11 Data visualization

Finally, visual comparisons of current versus new insurance rates across different vehicle models were created using matplotlib to provide a clearer understanding of the impact of the proposed AI-driven adjustments.

3.12 Conclusion

This methodology provides a structured approach to investigating the impact of AI on underwriting practices in the Saudi car insurance sector. By employing advanced data analytics and machine learning, this study aims to enhance risk assessment accuracy, leading to more efficient underwriting processes and fairer pricing structures. The findings of this research are expected to contribute significantly to the modernization of the insurance industry in Saudi Arabia.

4. RESULTS AND DISCUSSION

4.1 Overview of results

This chapter presents a comprehensive overview of the analysis conducted on the vehicle insurance dataset. The primary objective of this analysis was to evaluate critical risk indicators that include average premiums, total claims, and the overall risk index for various vehicle models. The findings are summarized in detailed tables and figures, which showcase key metrics that help in assessing insurance risk levels for different vehicles. This analysis is pivotal in understanding the underlying trends and characteristics that contribute to insurance pricing and risk assessment.

The significance of analyzing these indicators lies in their potential to provide valuable insights to insurance companies, enabling them to refine their underwriting processes and pricing strategies. By understanding the variations in risk across different vehicle models, insurers can make more informed decisions that enhance profitability while maintaining competitive pricing.

4.2 Current data analysis

The current analysis of the dataset revealed significant variations in average premiums, total claims, and associated risk indices for different vehicle models. The following table highlights the analysis findings, offering a clear view of how each vehicle model stands in terms of risk:

Table 4.1: Show current data

Vehicle Model	Average Premium	Total Claims	Risk Index	Risk Level	Average Insurance Rate
488 GTB	900,000	4,000,000	444.44	High Risk	4.44
4Runner	360,000	0	0.00	Good Risk	1.78
A-Class	800,000	1,500,000	187.50	High Risk	3.95
A4	275,000	1,800,000	654.55	High Risk	1.36
Accent	39,178	860,000	2,195.10	High Risk	0.19
C-Class	350,000	0	0.00	Good Risk	1.73
...	...	...	...	...	...

The overall risk index calculated across all vehicle models was found to be 244.99, categorizing the overall risk level as "High." This indicates a significant likelihood of insurance claims based on the data analyzed. The high average premiums associated with many vehicle models reflect their potential to incur substantial claims, thus justifying the elevated insurance rates for these models.

4.3 New insurance rates and risk indicators

Upon implementing adjustments to the insurance model, new rates and risk indicators were generated. The following table summarizes these new metrics, reflecting the changes made to enhance the risk management strategies:

Table 4.2: Show New Predicted insurance rate

Vehicle Model	New Insurance Rate	New Risk Index	New Risk Level
488 GTB	3.5	460.28	High
4Runner	1.5	0.00	Acceptable
A-Class	3.5	172.60	High
A4	3.5	207.12	High
Accent	3.5	98.96	High
C-Class	1.5	0.00	Acceptable
...	...	...	...

The adjustments resulted in a reduced overall risk index of 154.39 while still remaining in the "High" risk category. This indicates that while risk levels are still elevated, the new insurance rates reflect an improvement in risk management practices. The modifications made to the model have led to a more nuanced understanding of risk, allowing for the development of more tailored insurance products that can better serve both insurers and clients.

4.4 General analysis of results

The comparison between the overall risk index before and after the improvement shows a notable reduction in risk metrics. The following points summarize the findings:

- **Overall Risk Index Before Improvement**: 244.99 - Level: High
- **Overall Risk Index After Improvement**: 154.39 - Level: High

This demonstrates that the risk management strategies implemented in the insurance model have resulted in a quantifiable decrease in risk, even though further improvements are still needed to transition into a lower risk category. The data indicates that the adjustments have made strides towards mitigating risk, but ongoing efforts must focus on refining these strategies to further enhance risk assessment and pricing models.

4.5 Results

The analysis yielded the following key results:

- Identification of High-Risk Vehicles: Certain vehicle models were identified as high-risk based on their historical claims data and risk index calculations.
- Improved Risk Assessment: The machine learning model demonstrated improved accuracy in predicting future claims and risk levels compared to traditional methods.
- Optimized Pricing Strategies: The insights gained from the analysis can be used to optimize pricing strategies, ensuring fair premiums for different risk profiles.

4.6 Discussion

The results highlight the complex nature of vehicle insurance risk assessment. The significant disparities in risk indices among vehicle models underscore the need for tailored insurance strategies. The following key observations emerge from the analysis:

High-risk vehicles:

Models like the 488 GTB and A-Class exhibit high average premiums and risk indices, suggesting a higher likelihood of claims. This justifies the elevated insurance costs associated with these models. Insurers must recognize these patterns to ensure that pricing reflects the actual risks involved, thereby maintaining profitability while offering competitive rates.

Good-risk vehicles:

Vehicles such as the 4Runner and C-Class display lower risk indices and insurance rates, indicating they are statistically less likely to result in significant claims. This observation suggests that these models could attract a more extensive customer base seeking affordable insurance options. Insurers might consider leveraging these insights to promote these models while ensuring adequate coverage.

Implications for insurers:

Insurers can utilize the insights garnered from this analysis to refine their pricing strategies. Targeting specific demographics or vehicle types more effectively can help in attracting a diverse clientele. Additionally, understanding the risk profiles associated with different vehicle models can assist insurers in developing more competitive insurance products that cater to specific market needs.

Future research directions:

Further research could involve exploring additional variables, such as driver demographics, vehicle safety ratings, and environmental factors, to enhance the robustness of risk assessments in vehicle insurance. Expanding the dataset to include these variables could provide a more comprehensive understanding of the factors influencing insurance risk and allow for even more tailored pricing strategies.

The analysis provided valuable insights into vehicle insurance risks, demonstrating the effectiveness of current strategies while indicating areas for further enhancement. By recognizing the dynamics of risk assessment in vehicle insurance, both insurers and clients can benefit from improved transparency and better-informed decisions regarding coverage options.

5. CONCLUSIONS

5.1 Key findings

The study yielded several key findings regarding the application of AI in car insurance underwriting, which can be summarized in the following points:

1. **Improved risk assessment accuracy:**
   The models employed in the study demonstrated a notable ability to identify patterns and trends in historical claims data. Machine learning algorithms, such as logistic regression and neural networks, were utilized to achieve high accuracy in risk evaluation. These models aided in understanding the relationship between vehicle type and claims frequency, allowing insurance companies to assess risks more precisely.
2. **Identification of risk influencing factors:**
   Through data analysis, a range of factors significantly impacting claim rates were identified, including vehicle type and vehicle model. This analysis improved risk models as the research team was able to incorporate these factors into predictive models, increasing their predictive capabilities for future outcomes.
3. **Risk classification into levels:**
   Vehicles were classified into different categories based on the associated risk levels. For example, high-risk vehicles, such as luxury sports cars, were identified against medium or low-risk vehicles. This classification allowed insurance companies to assign more precise premium rates, resulting in a fairer pricing system.
4. **Application of predictive models:**
   The study utilized various predictive models to estimate future claims, including linear regression models and tree-based models. The findings revealed that these models were effective

in improving prediction accuracy, providing insurance companies with precise information to make informed decisions regarding policy pricing.

5. **Enhanced pricing structures:**
   By adopting a pricing model based on historical data, insurance companies were able to establish pricing structures that reflect actual risks, thus increasing transparency in the process. This approach benefited not only the insurance companies but also clients who gained access to fairer insurance prices based on objective criteria.

5.2 Significance of findings

The significance of the results obtained in this study extends beyond merely improving current practices. The importance of these findings can be summarized as follows:

1. **Enhancing competitive advantage:**
   In today's competitive market, the adoption of AI technologies can provide insurance companies with a competitive edge. By improving the accuracy of risk assessments, companies can attract clients by offering more competitive prices and better offerings.
2. **Improving customer experience:**
   Enhanced processes and more accurate pricing can significantly improve the customer experience. When clients feel they are receiving genuine value from the insurance they purchase, they are more likely to remain loyal to their insurance providers rather than switch to competitors.
3. **Increasing transparency:**
   The implementation of data-driven pricing structures enhances transparency in the insurance industry. This can reduce the doubts customers may have about pricing, increasing their trust in insurance companies.
4. **Facilitating decision-making:**
   The accurate information generated by predictive models assists management in making more effective strategic decisions, thereby enhancing operational efficiency.
5. **Preparing for future changes:**
   This study represents an important step towards equipping insurance companies with the tools to adapt to rapid changes in information technology. The capability to leverage AI will help companies better navigate future innovations and challenges.

5.5 Potential challenges

Despite the substantial benefits that could result from integrating AI into underwriting practices, several challenges may confront companies during implementation:

1. **Implementation costs:**
   The application of AI technologies requires significant investment in technology and infrastructure, in addition to ongoing employee training. These costs could pose a barrier for some smaller companies.
2. **Privacy issues:**
   The use of personal customer data in predictive models may raise concerns regarding privacy and data protection. Companies must take appropriate measures to ensure compliance with local and international data protection regulations.
3. **Technology adoption:**
   Some companies may encounter resistance from employees who prefer traditional methods of working. It is essential to manage these changes effectively to avoid internal pushback.
4. **Market competition:**
   The adoption of AI technologies by some companies may heighten competition in the market, making it challenging for smaller firms to compete. This may require innovative strategies to remain competitive.

6. RECOMMENDATIONS

In light of the analysis conducted on the vehicle insurance dataset, this chapter outlines several recommendations aimed at enhancing risk management strategies, improving insurance pricing models, and ultimately fostering a more robust vehicle insurance market. The following

recommendations are structured to provide actionable insights for insurers, policymakers, and stakeholders in the automotive and insurance industries.

6.1 Strengthening data collection and management

1. **Implement comprehensive data collection systems:**
   Insurers should invest in sophisticated data collection systems that capture a wide range of variables related to vehicle usage, driver demographics, and environmental factors. A more extensive dataset will facilitate better risk assessment and more accurate pricing models.
2. **Utilize advanced analytics:**
   Employ advanced analytics techniques, including machine learning algorithms and predictive modeling, to analyze collected data. This approach can identify patterns and trends that inform risk management strategies, allowing for more precise premium calculations.
3. **Regular data audits:**
   Conduct regular audits of the data collection and management processes to ensure accuracy and reliability. Accurate data is essential for effective risk assessment, and periodic reviews can help identify and rectify any discrepancies.

6.2 Enhancing risk assessment models

1. **Integrate additional risk factors:**
   Expand the risk assessment models to incorporate additional variables such as vehicle safety ratings, historical claim data, and regional risk factors (e.g., accident rates). A more holistic view of risk can lead to improved underwriting decisions.
2. **Dynamic risk assessment:**
   Implement dynamic risk assessment models that adapt to changes in the market, vehicle technology, and driver behavior. By continuously updating risk indices based on real-time data, insurers can offer more accurate premiums and maintain competitiveness.
3. **Scenario analysis and stress testing:**
   Conduct scenario analyses and stress testing of risk models to evaluate how various factors (e.g., economic downturns, changes in driving laws) could impact claims and premiums. This practice can enhance preparedness and help insurers develop strategies to mitigate potential risks.

6.3 Customer education and engagement

1. **Enhance customer awareness:**
   Educate customers about the factors influencing their insurance premiums and risk profiles. Providing clear and transparent information can empower customers to make informed decisions regarding their insurance coverage.
2. **Promote safe driving programs:**
   Encourage policyholders to engage in safe driving programs that may qualify them for discounts or incentives. Offering rewards for safe driving behaviors can reduce overall claims and foster a culture of safety among drivers.
3. **Utilize digital platforms:**
   Leverage digital platforms for communication and engagement with customers. Online tools can provide customers with personalized insights into their driving habits and associated risks, further enhancing their understanding of how their behavior impacts insurance costs.

6.4 Policy development and regulatory considerations

1. **Collaborate with regulatory bodies:**
   Insurers should work closely with regulatory authorities to develop policies that promote fair pricing and competition in the insurance market. Collaborative efforts can lead to regulations that protect consumers while fostering innovation within the industry.
2. **Incentivize the use of advanced safety features:**
   Develop policies that incentivize the adoption of advanced vehicle safety features (e.g., automatic braking, collision detection systems). Offering premium discounts for vehicles equipped with these technologies can reduce overall claims and enhance road safety.

3. **Consider environmental factors:**
   Policymakers should consider environmental factors when developing regulations related to vehicle insurance. Understanding how environmental risks (e.g., natural disasters, climate change) impact vehicle safety can inform more effective insurance practices.

6.5 Future research directions

1. **Longitudinal studies:**
   Conduct longitudinal studies that track changes in vehicle safety and insurance claims over time. This research can provide valuable insights into the effectiveness of safety initiatives and their impact on insurance risk.
2. **Cross-industry collaboration:**
   Foster collaboration between the automotive and insurance industries to share insights and data that can enhance risk assessments. Joint initiatives can lead to innovations that improve safety and reduce claims.
3. **Explore emerging technologies:**
   Investigate the potential of emerging technologies such as telematics and artificial intelligence in transforming risk assessment and insurance pricing. By embracing innovation, insurers can enhance their risk management capabilities and better serve their customers.

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REFERENCE

Byrne, A. (2024). Pricing Risk: An XAI Analysis of Irish Car Insurance Premiums. In: Longo, L., Lapuschkin, S., Seifert, C. (eds) Explainable Artificial Intelligence. xAI 2024. Communications in Computer and Information Science, vol 2156. Springer, Cham. https://doi.org/10.1007/978-3-031-63803-9_17

Holvoet, Freek et al. “Neural networks for insurance pricing with frequency and severity data: a benchmark study from data preprocessing to technical tariff.” ArXiv abs/2310.12671 (2023) https://www.semanticscholar.org/paper/Neural-networks-for-insurance-pricing-with-and-a-to-Holvoet-Antonio/6c1381c49d87d2b54f65f72128a79a2bbd3e9c34

Balasubramanian, R., Libarikian, A., and McElhaney, D. "Insurance 2030: The impact of AI on the future of insurance." McKinsey & Company, March 2021. https://www.mckinsey.com/industries/financial-services/our-insights/insurance-2030-the-impact-of-ai-on-the-future-of-insurance

Kumar, N., Srivastava, J. D., and Bisht, H. "Artificial Intelligence in Insurance Sector." Indraprastha Institute of Information Technology (IIIT) Delhi, New Delhi, India, Amity School of Engineering & Technology, Amity University, Noida, India, JIMS Engineering Management Technical Campus (JEMTEC), Guru Gobind Singh Indraprastha University, Greater Noida, India, 7 November 2019. https://www.researchgate.net/publication/337305024_Artificial_Intelligence_in_Insurance_Sector

Bhalla, A. "Enhancement in Predictive Model for Insurance Underwriting." Application Developer, Computer Sciences Corporation India Ltd, Noida, UP, May 2012. http://ijcset.com/docs/IJCSET12-03-05-014.pdf

Eling, M., Nuessle, D. & Staubli, J. The impact of artificial intelligence along the insurance value chain and on the insurability of risks. Geneva Pap Risk Insur Issues Pract 47, 205–241 (2022). https://doi.org/10.1057/s41288-020-00201-7

Alhassan, M. A. M. "Evaluation of the Impact of Motor Insurance Prices on the Solvency of Saudi Insurance Companies: A Field Study." Neelin University, 2018.

الحسن، محمد عباس مصطفى، و يوسف، محمد يوسف علي. (2018). تقييم أثر أسعار تأمين السيارات على الملاءة المالية لشركات التأمين السودانية: دراسة ميدانية (رسالة ماجستير غير منشورة). جامعة النيلين، الخرطوم. مسترجع من http://search.mandumah.com/Record/987061

Atombo, C., Turkson, R., and Akple, M. "Impact of vehicle-related factors on speed selection and accident severity rates." International Journal of Vehicle Safety, vol. 12, 2023, pp. 210-225. https://www.sciencedirect.com/science/article/pii/S2405844024125868

Belha, A.-K. M. A. "Technical Implications of the Motor Insurance Portfolio's on the Performance of Saudi Insurance Companies: Applied Study for Period 2008 – 2014." Neelin University, 2017.
بله، الخزين موسى عبدالباقى، و أحمد، عبدالله محمد عبدالله محمد. (2017). الآثار الفنية لمحفظة تأمين السيارات علي أداء شركات التأمين السودانية: دراسة تطبيقية في الفترة ما بين 2008 - 2014 م (رسالة ماجستير غير منشورة). جامعة النيلين، الخرطوم. مسترجع من
http://search.mandumah.com/Record/831375
Insurance Information Institute. *A Guide to Insurance: What It Does and How It Works.* Insurance Information Institute, 2010,pp 1..7
https://www.iii.org/sites/default/files/docs/pdf/Insurance_Handbook_20103.pdf.
Wallstreetmojo Team. "Loss Ratio." Wallstreetmojo, last updated August 21, 2024, edited by Ashish Kumar Srivastav, reviewed by Dheeraj Vaidya, CFA, FRM. Available at: https://www.wallstreetmojo.com/loss-ratio/
Tata AIG General Insurance Company
https://www.tataaig.com/knowledge-center/car-insurance/how-is-your-car-insurance-premium-calculated