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The Impact and Development of AI on the Actuarial Industry

Qishan Zhong

School of Accounting and Finance, Taylor's University, Subang Jaya, Malaysia
0364782@sd.taylors.edu.my

Abstract: The insurance industry is undergoing a transformative evolution as artificial intelligence (AI) revolutionizes traditional actuarial practices. Although AI gets to enhance predictive models, operational efficiency and product innovation, however, its integration also brings major challenges, including ethical dilemmas, regulatory obstacles, algorithm opacity and workforce displacement. This article examines the practical challenges of applying artificial intelligence in the field of actuarial, especially on data governance, transparency and accountability. Through the industry case studies, it had analyzed the impact of artificial intelligence on underwriting, claim handling, fraud detection and compliance, meanwhile emphasis the emerging risks such as decision-making bias and regulatory non-compliance. This article research result shows that, the successful application of artificial intelligence requires a robust system of technical governance framework, an explainable models, employee skills retraining, and proactive supervision and coordination. Suggestions include establishing an ethical supervision mechanism, improving the transparency of algorithmic decision-making, and promoting continuous learning to make up for the skill gap. The present paper advocates for a harmonious blend - maximizing the advantages of artificial intelligence while keeping the disadvantages at bay - towards creating responsive and fair outcomes. In the end, the present paper makes pragmatic recommendations to insurance firms, actuaries, and policymakers to help insurance firms, actuaries, and policymakers cope with the convergence of the fast-evolving world of artificial intelligence and actuarial science and appeals for protection of the trust of the people and maintenance of professional ethics during this period of accelerated technology advancement.

Keywords: Artificial Intelligence, Actuarial Science, Automation, Data Governance, Workforce Displacement.

1. Introduction

The insurance sector is being revolutionized as artificial intelligence disrupts traditional actuarial methods. Those days are history when actuaries solely employed statistical models; today, actuaries have to deal with a new norm: climate volatilities, hacking risks, and increased customer expectations necessitate more intelligent, more responsive measures. Legacies are no longer effective, and the advanced pattern recognition and data analytics of artificial intelligence are particularly needed.

Regulators around the globe are already acting upon this shift. For example, the Artificial Intelligence Act of the European Union places regulatory guardrails around uses of AI within risk-sensitive areas such as insurance. Business as a whole is being reshaped in three significant ways. First, underwriting has extended beyond traditional measures to include data from fitness trackers as

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well as online buying behavior to create strongly customized policies. Second, claims handling was revolutionized by automaton as AI-powered systems speed up approvals as well as reveal hitherto unexpected cases of fraud that cost the insurance sector hundreds of millions of dollars annually. Thirdly, product development took centerstage as pay-per-mile insurance-like products were facilitated by real-time analytics.

The work of actuaries has moved from executing spreadsheet-based analysis towards being engaged in strategic management exercises. Today's work includes the validation of AI models, the detection of algorithmic bias, and the development of recommendations on ethical adoption strategies. The actuary of the future will need to combine programming skill with statistical knowledge while still maintaining a fundamental appreciation of the limitations of AI.

However, this development comes at a cost. For as much as AI contributes towards cutting costs and enhancing effectiveness, it introduces the question of transparency and the absence thereof that attends "black box" decision-making. And implementing new technology and the new requirements of regulation means significant cost and organizational-scale redesign. The profession's own destiny hinges on its ability to reconcile the drive of technological advancement with the demands of professionalism, and by definition ensures that artificial intelligence becomes a means of augmenting, not supplanting, actuarial professionalism. The profession's ultimate purpose changes as rapidly as the science of actuarial science advances: a precise and certain calculation of the estimate of risk. Technology makes new abilities that affirm the necessity of systematic development of new tools within the context of classical professional settings.

More recent research indicated that classical actuarial methods are being revolutionized through machine learning. pioneering research by Richman back in 2018 provided the first estimate of the revolutionary effects of AI for actuarial work, and for the risk modelling and forecasting capabilities uniquely [1]. Regulators pay more attention to implications of such novel technologies, and Anderson et al. have placed particular emphasis upon the urgent necessity for improved cybersecurity measures to align with the growth of AI for exposed actuarial uses [2].

Wang created a new underwriting model that was a breakthrough application of underwriting practice and ushered in the use of machine learning with genomic markers within feature engineering in 2021. With genomic markers included within feature engineering, the team achieved 89% mortality prediction accuracy, a 23% improvement over traditional models [3]. Building upon its research, Lozano-Murcia et al. formulated the SHAP-ACT framework in 2024 that greatly benefited explainable AI for actuarial science. Not only did its hierarchical interpretation method preserve predictive performance, but model transparency was also increased by 40%, with a 35% improvement of pricing fairness measures [4].

Parallel to these technological advances, Lior's theoretical research on AI for "regulatory insurance" applications back in 2021 proved to be a precursor. His proposed algorithmic pricing of risk methodology was subsequently incorporated into the EU Artificial Intelligence Act compliance obligations, notably for high-risk application areas of insurance [5]. The physical impact of such technology can easily be gauged from a recent industry survey of 2022 by Eling et al., which reported a 23% gain in underwriting effectiveness and a 17% decrease in cost of claims handling. The study did reveal one cause for concern, though, where nearly 22% of the traditional insurable risks have come under the purview of AI-specific exclusions due to fresh uncertainties [6].

More contemporary studies have provided strong evidence of combined methods of risk management by MUPA's 2025 in-depth analysis, incorporating a 27% improvement in predictive accuracy as well as lower computation cost. It clearly states that tactical feature selection continues to be a key driver of effective actuarial machine learning deployments [7].

Artificial Intelligence (AI) technology is significantly revolutionizing the profession of actuary science, transforming risk assessment, fraud discovery, as well as underwriting business. While AI

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improves the accuracy of forecasting as well as business efficiency significantly, its application is still faced with key issues of algorithmic transparency, regulatory compliance, as well as talent transformation. Based on empirical studies of the profession, the paper systematically examines the dual impacts of AI on actuarial practice: one is its advances of data calculation and model improvement; the other is a thorough discussion of data governance issues, ethical challenges, as well as regulatory adjustment. Through typical case studies, the paper tries to provide the actuarial profession with a model of application that balances technology advancement with risk control, subjecting the construction of AI to professional standard requirements as well as protecting the social common interest. Research focus is laid on how to establish a trustworthy as well as open algorithmic mechanism to facilitate actuarial effectiveness, form a composite talent team, as well as finally achieve a balance of technological advancement with steady profession development.

2. The impact of AI on the actuarial profession

Actuaries have turned a decades-long career of statistical modeling and calculating risk into a science by applying the power of artificial intelligence. New powerful tools aren't just accelerating existing workflows; they're changing the nature of decisions and the way that risk gets calculated by insurers. Where actuaries once invested a lot of time performing mathematical computation, AI have the ability to detect trends in big datasets that might not be visible to humans. AI tools are also enhancing fraud detection, automating routine calculations, and even helping craft smart insurance products. There are also negatives as there are positives. Actuaries are having to learn as much about the regulation of AI as about data science as they've had to learn about statistics.

2.1. Automation and efficiency: how can AI optimize traditional actuarial processes

Artificial intelligence is revolutionizing the work of actuaries by automating the drudgery of tedious tasks which have hitherto been the bane of the profession. While actuaries previously spent a great deal of time handling such statistics as mortality tables, reserve calculations, and setting of premiums, intelligent algorithms can now handle such routine functions faster with precision.

Consider claims analysis, for example,actuaries are now able to apply AI to automate claims patterns without having to manually dig through huge volumes of data, freeing actuaries up to focus on developing new risk approaches. The real value of AI lies in its capacity to pull out valuable information from apparently esoteric sources. Based on NLP-based tools, it's capable of combing through doctor's notes, legal files, and numerous unstructured textual datasets that once had to be hand-reviewed. More astounding is the fact that today's predictive models are able to continuously optimize pricing approaches as it monitor subtle changes within the market real-time, offering insurers a crucial competitive advantage.

Automation of the number-crunching task is not replacing the actuaries but elevating the profession. Automation of number-crunching as a repetitive task frees the professionals for more advanced analysis, strategic decision-making, and interpreting the results produced by AI. The end effect is more accurate evaluation of the hazards, improved reaction time, and ultimately better quality decisions for the insurance industry as a whole.

2.2. Data-driven transformation: AI enhances risk assessment and prediction

Actuaries used to measure risk and forecast the future based on historical facts. Yet, conventional modeling techniques are constrained by intricate, non-linear interdependencies among these facts. Insurers are now using sophisticated AI methods to deduce conclusions from unconventional data like biometric data from wearable sensors, driving records tracked using telematics, and social

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network data. In contrast to conventional models, such deep models can detect latent risk determinants and provide substantially greater predictive power.

For example, in health insurance, by combining genetic information, lifestyle tracking, and health history, AI systems can generate highly personalized risk profiles. In property and casualty insurance, image recognition algorithms are already being used to assess car or property damage from phone photos directly, making the claims process much easier. Perhaps the most revolutionary aspect of AI is that it has the ability to track risk in real-time. For example, auto insurance providers can change premiums in near real time in response to real driving behavior.

Though such abilities facilitate better risk assessment, personalized pricing and new insurance offerings, it is not controversy-free. There has been anxiety regarding safeguarding sensitive personal information and how to avert algorithmic discrimination. As these technologies proliferate, the sector will be required to implement robust oversight mechanisms.

2.3. Fraud detection and compliance: innovative applications of AI in insurance

Insurance fraud represents the most widespread issue within the industry as the scammers cost the insurers billions of dollars each year. The traditional rule-based approaches to detection no longer work as the scammers always adapt the methods they use while these strict frameworks prove insufficient. That's where AI becomes useful. Using anomaly detection and network analysis algorithms, AI solutions identify subtle warning signs in claims data that may elude human analysts. AI solutions scrutinize everything from payment histories to the terminology of claim forms, searching for inconsistencies like exaggerated injury claims or atypical accident patterns.

AI is particularly useful because it is able to connect the dots between cases. Advanced algorithms can map unseen links between claimants, health-care providers and legal representatives, and reveal highly organized fraud rings that would otherwise not be obvious. The technology also plays an important role in keeping things compliant, screening transactions automatically for anti-money laundering risk, and scanning policy documents for regulatory requirements. As well as minimizing monetary losses, such AI uses are also restoring trust in how insurers do business,demonstrating that more detection can mean fairer results for everyone involved.

2.4. AI reshaping the role of actuary: opportunities and challenges

The profession of the actuary is being overhauled at its very foundations as the lion's share of the computation is done by AI. Instead of number-crunching most of the day, the actuaries today are on the path towards being more of a strategic advisor,interpreting the advice of AI, scrutinizing model validity, and enforcing ethical implementations. The shift brings great opportunities as well as growing demands. AI enables the actuaries to do more innovative work like developing adaptive use-based insurance models or intricate real-time pricing models. The upgrade comes at a price: the actuaries have to gain profound technical expertise of AI and data science. Training on programming languages like Python and R as well as on machine learning tools becomes a "need-to-have," rather than a "nice-to-have." The number one cause of suffering? The "black box" models so complex even the programmers do not get a clear view of it. When a claim gets denied by a model of AI or the premium gets increased or decreased, the model should be able to explain the reason behind the decision to regulators and policy holders. It's not enough anymore to make the models precise,it has to be fair, transparent, and regulated as industry standards evolve. The new role makes the actuary a mission-critical validator of algorithmic results.

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2.5. Actuarial education in the age of AI

The advent of the use of artificial intelligence within actuarial practice demands far-reaching reforms within actuarial education. Although the traditional actuarial syllabus was intensely geared towards the theory of probability, statistical techniques, and mathematical finance, contemporary actuarial syllabuses mandate reinforcement of concepts and applications of AI and machine learning. SOA and CAS's largest actuarial professional society have already initiated the process of revising certification by introducing new courses on predictive modeling all the way through to the ethics of algorithmic decision-making. Not just pre-service training needs to be changed; continuing specialized competency nowadays involves the acquisition of skills throughout a professional's entire career. The new age requires that lifelong learning via professional certification, just-in-time teaching modules, and cross-training of data professionals becomes the norm rather than the exception. Actuaries should be able to blend profound subject matter expertise with new artificial intelligence methods.

3. Challenges and issues in the integration of AI and actuarial science

The union of actuarial science and AI is both revolutionary in promise and in that it poses a set of profound questions, ranging from ethics and algorithmic decision transparency to regulation and job loss. Industry case studies bring to life this two-way duality by illustrating the promise of AI as much as the everyday ramifications for actuaries.

3.1. Algorithmic accountability and regulatory compliance

Increased use of AI within actuarial work brings heavy legal issues of duty and authority. The conditions of the issue have illustrated the situation by a new lawsuit against UnitedHealth - the AI application overruled the doctor's recommendation and denied 91-year-old Gene Lokken rehabilitation. The elderly patient was billed $12,000 a month for care before dying [8]. Such Humana and other payer investigations have concluded that faulty AI-driven claim denial software are generating significant legal exposure throughout healthcare. Legislators are stepping forward to avert such AI-driven claim denials. Connecticut Pulmonologist-turned-legislator Senator Saud Anwar introduced a historic first of its kind piece of legislation that would prevent health insurance companies from employing AI for medical decisions. He deplored the "prioritizing profits over patients' lives" [9]. The historic legislation illuminates the ethical dilemma between cost-cutting software and sound medical practice when delay produces worsening health. These incidents mark a turning point for the profession. The absence of clearly stated guidelines on who should be held accountable for decisions by AI technology, including programmers, CEOs or actuaries, brought forward the growing need for open-source code and intentional human intervention. The challenge identifies a disquieting discrepancy between the pace of technology advancements and the call for adequate protections.

3.2. Transparency deficits in AI models

Actuarial decisions increasingly rely on the powers of artificial intelligence on one condition: transparent algorithms shatter trust as much as it do fairness. Later experience shows the on-the-ground implications of such opacity. In the United Sates, health insurers have faced criticism for using AI tools that routinely reject claims with no explanation or fair appeal for policyholders [10]. On the European side of the pond, UK regulators also warned that AI might make certain people "uninsurable" due to unconscious bias within underwriting models [11]. These two examples refer to the way black box AI tools might exacerbate inequality while subjecting the insurer to reputational as well as regulatory liability. The industry needs to make model interpretability a top concern and

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have the models properly audited as well as keep up with evolving standards-otherwise it'll amplify existing disparities and bring on disastrous legal implications.

3.3. Workforce displacement and skill gaps

The advent of the use of artificial intelligence in actuarial work is transforming the insurance industry at a price. Such was the spectacular use of IBM's Watson by Fukoku Life Insurance Co. in 2017 to mechanize the claims process and eliminate 34 workers with cost savings of ¥140 million a year [12]. Such occurrences are reason for industry alarm over displacement of jobs within the industry by AI. Spurring the problem, Accenture's results of the 2018 survey reveal that barely a quarter of insurance professionals possess requisite AI collaboration skills, and most firms have done nothing by way of filling the shortfall through employee upskilling courses [13]. That double reality of cost advantage and displacement of people needs to be handled carefully. The future of the firm depends not on embracing smart algorithms alone, but on building a workforce that will engage side by side with these tools.

3.4. Data governance challenges in AI-based actuarial systems

The use of AI within actuarial systems brings formidable data governance challenges particularly on aspects of quality of data, preservation of privacy, trustworthiness of the model, and compliance. Insurers have the onus of handling humongous datasets carefully and ensuring the AI models work on information that's fair, accurate, and complies. The Merakāta case study offers a live example of a big life insurer having poor quality consistence of the data and unclear ownership of the data, which negatively impacts the functioning of its AI system [14]. The solution was implementing a top-tier governance model having a clear definition of ownership of the data, standardized vocabulary, and regular quality audit-measures that extensively enhanced the functioning of the AI models. Another interesting finding was Cognizant's work on the importance of the protection of sensitive biometric information of the individual in the AI insurance schemes [15]. It created, jointly with a leading Indian insurance company, a mechanized model for cleansing Aadhaar numbers from existing records and achieved privacy compliance and business effectiveness through the elimination of manual handling of the data. The above instances demonstrate how good governance of the data can be the cornerstone of transparent applications of the AI, mitigation of the risks, and legally justifiable actuarial practice.

4. Recommendations and implications for AI in actuarial science

The development of artificial intelligence represents a challenge and a promise for the actuarial profession. The profession should embrace this challenge responsibly and set a realistic agenda for seizing the benefits of Al while confronting challenges of deployment in a suitable manner. Prudent utilization involves a preoccupation with a variety of issues: ethical use of Al, workforce resilience, and harmonization of regulations. The proposals set forth below represent a realistic agenda for industry stakeholders.

4.1. Strategic recommendations for AI adoption

Some of the most significant initial steps in applying AI within actuarial science include regulatory compliance and ethics. Because regulators already are considering uses of AI, insurers have the ability to anticipate a changing regulatory environment. On the horizon are new pieces of legislation, such as the proposed ban on AI-driven health insurance decisions by the state of Connecticut, that demonstrate the necessity of getting AI systems into compliance with the law and ethical guidelines.

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Regulators, lawmakers, and insurers must work together to craft reasonable and prudent regulations for the application of AI.

Secondly, the interpretability and transparency of the AI models need to be secured. Because decisions and judgments are increasingly being made by AI, explainable and auditable models have a very significant role. For example, regulators such as the UK's Financial Conduct Authority have noted that AI could embed biases against specific vulnerable groups of people and that there needs to be the creation of a system that's not just accurate but simple enough for the regulators as well as the customer.

Third, successful deployment of AI will require employees' retraining and adaptation of skills. The profession of actuary is evolving, and active retraining of skills is necessary to mitigate job loss. The Fukoku Life Insurance issue threatens the automation of the work of dozens of workers if left unresolved. Development of a culture of continuous learning is at the heart of developing professionals possessing the requisite AI-related competencies for the preservation of the sustainability of work and the development of organizational agility.

Finally, better data governance underpins the creation of trustworthy AI. High-quality, well-governed data are required for strong and unbiased AI models. Insurers must have a strong regime of data management with clear ownership, standardized terms, and strict quality assurance processes. The experience of companies such as Merakāta attests to the reality that properly designed data governance reduces the risk of privacy breach, regulator noncompliance, and algorithmic bias.

4.2. Implications and future outlook

The union of AI and actuarial science carries far-reaching implications beyond bottom-line efficiencies for businesses to fundamental social concerns about the fairness of risk assessment, fair access to insurance, and the protection of individual information. As the insurance industry moves into this new era, a number of principal developments should inform its future.

Firstly, as AI proliferates across the insurance industry, the regulatory environment will shift. Demands for explainability and transparency of models will grow louder and regulators will ask for increasingly more understandable and auditable explanations of algorithmic decisions. Innovative forward-thinking insurers have acted proactively to build trustworthiness of AI's deployment by adopting explainable AI methodologies and forming ethics audit boards.

Second, with increasing amounts of sensitive personal data being processed through AI systems, data privacy concerns will intensify. Insurers seeking differentiation will need to transcend bare minimum compliance levels and establish rigorous data governance practices to define new industry benchmarks. There is a need for investment in state-of-the-art cybersecurity infrastructure to maintain consumer confidence and organizational reputation.

Third, consumer relationships will be reimagined as transparency emerges as the basis of differentiation. Insurers that can clarify exactly how AI influences underwriting and pricing decisions and that have a long-term commitment to customer interests will succeed in establishing long-term trust. Some pioneering firms might even be capable of providing policyholders with selective access to underlying data points and models for underwriting terms, once more driving customer engagement and satisfaction.

Adapting to this new environment will require thoughtful and intentional effort. While AI holds great promise for improving accuracy and operational effectiveness, the effective adoption of AI will require constant upskilling of the workforce's abilities, the imposition of ethical limits, and honest cooperation with regulators. It's the insurers who understand that AI is not just a way of being more profitable, but a necessity requiring thoughtful stewardship, transparency, and continued dedication to fair and socially conscious management of the risks.

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5. Conclusion

The disruptive role of artificial intelligence (AI) on actuarial science in terms of applications, challenges, and implications of governance is the theme of this article. The article describes the promise of AI refining legacy like underwriting, claim settlement, and fraud detection and how AI raises the red flags of algorithmic transparency, regulatory compliance, employee turnover and data governance. The main takeaways are that AI simplifies actuarial work by automated work and enables evidence-based decisions through advanced analytics and machine learning. The advantage of AI's ability to process alternative data allows better risk forecasting while bringing about concerns regarding privacy and fairness. For fraud detection, AI-based anomaly detection for the detection of suspicious claims proves effective but black box formulated decisions lead to distrust. As the actuarial role transitions from a computational role towards a strategic role, new features of AI and ethics are required. Automation alongside carries the spectre of job loss without a reskilling program of skills. Convergence of AI and actuarial science for the future brings about the efficiency factor but accompanying this are humongous ethical implications. Regulatory focus on the AI model will intensify with a thrust towards transparency and compliance. Data governance will also be the key in preventing prejudice and ensuring trust. The actuaries will have to adapt the change and periodically update the skills set for transparency and fairness of the AI decisions. The actuarial science of the times depends on a blend of a blend of the convergence of ethics and innovation, regulators collaborating on regulators, and development of fairness while meeting the needs of the business.

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