

TOWARDS HYBRID HUMAN-AI INSURANCE SYSTEMS

Conceptual Challenges for AI-Mediated Insurance

Abstract

Insurance is traditionally founded upon a delicate balance between uncertainty and predictability. AI increasingly disrupts this balance. Through a cross-disciplinary analysis of an AI-mediated driving scenario, this paper demonstrates how predictive and adaptive systems create tensions within the conceptual foundations of insurance itself. The resulting challenges cannot be adequately addressed within any single insurance discipline and instead emerge from their interaction.

Keywords: Artificial Intelligence, Insurance, Hybrid Human-AI Systems.

1. Introduction

Insurance emerged as a societal mechanism for managing uncertainty. Through the pooling of risks across large populations, insurers are able to transform individually unpredictable losses into collectively manageable events. Over time, this mechanism evolved into a highly sophisticated socio-technical system comprising mathematical, legal, economic, managerial, medical, engineering, and philosophical components. Although these components are often studied separately, the practical operation of insurance depends upon their continued interaction and mutual consistency.

Recent advances in Artificial Intelligence (AI), particularly when combined with Big Data, telematics, Internet-of-Things infrastructures, and autonomous decision-making systems, introduce new forms of agency into insurance environments. Unlike traditional information technologies, AI systems may continuously learn, adapt, and modify their behavior based on incoming data. As a consequence, the relationship between risk, prediction, responsibility, liability, and decision-making becomes increasingly complex.

This development raises a fundamental question: can the conceptual foundations upon which traditional insurance was built adequately describe hybrid Human-AI insurance systems?

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The present work argues that the introduction of AI into insurance does not merely create new operational challenges. Rather, it destabilizes several implicit assumptions that historically enabled insurance to function. These challenges extend beyond a single insurance discipline and instead affect the insurance system as a whole.

To illustrate this argument, the paper employs a running example involving an AI-mediated self-driving vehicle, a continuously monitored driver, and an insurer capable of processing large volumes of real-time behavioral and environmental data. Although initially appearing to be a straightforward motor insurance scenario, the example reveals consequences that extend into legal liability, actuarial modelling, healthcare, fraud prevention, economic incentives, enterprise operations, and regulatory compliance.

The paper proceeds as follows. First, insurance is presented as an interconnected system consisting of eight major disciplines. Second, the running example is introduced in its entirety. Third, the example is systematically decomposed through each insurance discipline in order to identify the assumptions challenged by AI-mediated environments. Fourth, the disciplinary analyses are synthesized into a systemic perspective. Finally, a conclusion to the paper is provided.

2. Insurance as an Interconnected System

Insurance is often discussed through specialized disciplines such as actuarial science, insurance law, management, economics, medicine, engineering, and fraud prevention. In practice, however, insurance functions as an interconnected socio-technical system whose operation depends upon the interaction of these domains rather than any individual discipline in isolation.¹⁾

The present work adopts eight disciplinary perspectives: Actuarial Science, Insurance Law, Philosophy of Insurance, Insurance Management, Insurance Economics, Insurance Criminology, Insurance Medicine, and Insurance Engineering. Actuarial Science addresses the quantification of risk and uncertainty. Insurance Law governs contractual relationships, liability, and regulation. The Philosophy of Insurance examines the conceptual foundations of risk sharing, fairness, and solidarity. Insurance Management focuses on organizational processes and operational decision-making. Insurance Economics considers the role of insurance within broader economic systems. Insurance Criminology addresses fraud, abuse, and the protection of insurance institutions. Insurance Medicine applies medical knowledge to insurance decision-making. Insurance Engineering focuses on technical risk assessment, prevention, and mitigation.

Although analytically distinct, these disciplines are highly interdependent. Actuarial assumptions influence underwriting decisions, legal frameworks affect pricing and claims handling, medical assessments shape risk classification, and engineering influences loss frequency and severity. Changes within one domain therefore frequently propagate throughout the broader insurance system.

This interdependence becomes particularly important when considering Artificial Intelligence. AI does not enter a single insurance discipline.

Rather, it simultaneously affects risk assessment, liability attribution, operational processes, customer behavior, fraud prevention, healthcare-related decision-making, and technical risk management. Consequently, the implications of AI cannot be adequately understood through isolated disciplinary analysis.

To illustrate this challenge, the following section introduces a single AI-mediated insurance scenario that is subsequently examined through each disciplinary perspective. The most relevant legal documentation dealing with the context of the following scenario is the Regulation (EU) 2024/1689 (Artificial Intelligence Act)²⁾, specifically Articles 9 and 14, together with the UNECE Regulation No. 157 (Automated Lane Keeping Systems – ALKS)³⁾.

3. Running Example: AI-Mediated Mobility and Insurance

Consider an individual, Person A, who has consumed alcohol but remains below the legal driving limit. Although legally permitted to drive, their judgement and reaction time are partially impaired. At the same time, environmental conditions have reduced road traction in ways not readily visible to a human driver but detectable through connected sensors, telematics infrastructure, and environmental data sources.

Person A enters a self-driving vehicle equipped with an AI-mediated driving system. The vehicle continuously evaluates driver behavior, vehicle status, environmental conditions, and traffic information. Based on this assessment, the system offers to assume control of the vehicle and transport Person A safely to their destination.

While initially appearing beneficial, the scenario immediately raises questions of responsibility. If the AI assumes control, does responsibility remain with the driver, transfer to the AI system, or become distributed among the driver, manufacturer, software developer, and insurer? The situation becomes even more complex if the AI later encounters conditions exceeding its confidence threshold and relinquishes control to the driver. In such circumstances, safety mechanisms intended to reduce risk may themselves become sources of risk.

The scenario also highlights a broader transformation enabled by AI. Through continuous monitoring of behavioral, environmental, and operational data, insurers may increasingly predict not only the probability of future losses but also the circumstances under which those losses are likely to occur. As predictive capabilities improve, insurers may shift from compensating losses after they occur toward actively preventing losses before they materialize.

This development introduces significant questions. If insurers can reliably predict and prevent losses, what exactly is being insured? How should insurance products be valued when their primary function becomes behavioral guidance rather than post-loss compensation? What becomes of traditional risk pooling when risk assessment becomes increasingly individualized?

Although originating in a motor insurance context, these questions extend far beyond a single insurance product. The scenario simultaneously affects actuarial modelling, legal liability, healthcare-related decision-making,

organizational management, fraud prevention, economic incentives, and technical risk assessment. For this reason, it serves as a useful lens through which the broader implications of AI-mediated insurance systems may be examined.

4. Analytical Decomposition of the Running Example

The running example demonstrates that AI-mediated insurance systems challenge multiple insurance disciplines simultaneously. Although the underlying scenario remains unchanged, each discipline encounters a distinct manifestation of the same underlying transformation: the increasing ability of AI systems to predict, influence, and adapt to risk.

4. 1. Actuarial Science

Actuarial Science traditionally relies on a balance between uncertainty and predictability. While aggregate losses can be estimated statistically, individual losses remain uncertain. AI-mediated environments challenge this balance by enabling increasingly granular risk assessment based on behavioral, environmental, and operational data. As prediction improves, insurers move closer to estimating not only the probability of loss but also the circumstances under which losses are likely to occur. This development places pressure on traditional pooling mechanisms, premium structures, and the distinction between insurance and prevention.

4. 2. Insurance Law

Insurance Law traditionally assumes that responsibility can be attributed to identifiable actors through established legal frameworks. In the running example, responsibility becomes distributed across human and AI participants. The driver, vehicle manufacturer, software developer, and insurer may all contribute to the eventual outcome. As decisions increasingly emerge from interactions between human and AI agents, traditional concepts of causality, liability, and negligence become more difficult to apply. Legal systems may therefore require new approaches capable of addressing distributed forms of responsibility.

4. 3. Philosophy of Insurance

Insurance historically developed as a mechanism for sharing uncertain losses across a community. The increasing predictive capabilities of AI challenge this foundation. If losses can be predicted and prevented before they occur, the role of insurance may gradually shift from compensation toward prevention and behavioral coordination. This raises fundamental questions concerning the purpose of insurance, the meaning of solidarity, and the fairness of highly individualized risk assessment.

4. 4. Insurance Management

Traditional insurance operations are largely organized around discrete events such as underwriting decisions and claims handling. AI-mediated en-

vironments introduce continuous streams of behavioral and environmental information that transform risk assessment into an ongoing activity. Insurers may increasingly be expected to monitor, evaluate, and respond to changing risk conditions in real time. As a result, organizational structures designed for periodic decision-making may require significant adaptation.

4. 5. Insurance Economics

Insurance contributes to economic stability by transferring uncertainty and enabling economic activity. AI challenges this model by increasing the insurer's ability to influence behavior before losses occur. Rather than functioning solely as a risk-transfer mechanism, the insurer increasingly becomes a coordinator of risk-reducing behavior. This transformation raises questions regarding the valuation of preventative services, information asymmetries between insurers and customers, and the future viability of traditional risk-pooling arrangements.

4. 6. Insurance Criminology

The protection of insurance systems has traditionally focused on fraud, abuse, and manipulation of policies and claims. AI-mediated environments expand the scope of protection to include datasets, models, algorithms, and automated decision-making systems. While AI may significantly improve fraud detection capabilities, it also introduces new attack surfaces and opportunities for manipulation. Consequently, fraud prevention increasingly overlaps with cybersecurity, data governance, and AI governance.

4. 7. Insurance Medicine

Insurance Medicine traditionally evaluates health-related risks at specific points in time through medical examinations and actuarial classifications. AI-mediated systems enable continuous monitoring of behavioral and physiological indicators, allowing insurers to identify potential health risks before adverse outcomes occur. As predictive capabilities improve, the distinction between insurer and healthcare provider becomes increasingly blurred, raising questions concerning privacy, consent, legitimacy, and professional responsibility.

4. 8. Insurance Engineering

Insurance Engineering seeks to reduce losses through technical controls, inspections, and risk-prevention mechanisms. The running example introduces a fundamentally different challenge: the insured object itself becomes adaptive. Unlike traditional engineered systems, AI-mediated systems may continuously learn and modify their behavior over time. Consequently, engineering assessment must increasingly address dynamic rather than static forms of risk, requiring methods capable of evaluating evolving system behavior.

5. Cross-Disciplinary Synthesis

The preceding analysis demonstrates that the running example cannot be adequately explained through any single insurance discipline. Although each perspective identifies a distinct challenge, these challenges emerge from the same underlying transformation: the introduction of AI systems capable of predicting, influencing, and adapting to risk.

From an actuarial perspective, AI alters the relationship between uncertainty and prediction. From a legal perspective, it complicates the attribution of responsibility. From a philosophical perspective, it challenges the traditional purpose of insurance as a mechanism for sharing uncertain losses. From a managerial perspective, it transforms risk assessment from a periodic activity into a continuous process. From an economic perspective, it shifts insurance toward behavioral coordination and prevention. From a criminological perspective, it expands the objects requiring protection to include digital assets and automated decision-making systems. From a medical perspective, it blurs the distinction between insurer and healthcare provider. From an engineering perspective, it introduces insured systems whose behavior may evolve over time.

Importantly, these developments do not occur independently. Legal uncertainty affects actuarial modelling. Actuarial changes influence product design and pricing. Product design shapes customer behavior. Customer behavior affects medical outcomes and economic incentives. Economic incentives influence organizational structures and technological architectures. Technological architectures create new security vulnerabilities and regulatory obligations.

The resulting challenge is therefore not merely technical, legal, actuarial, or organizational. It is systemic.

This observation reveals a limitation of many contemporary discussions concerning AI in insurance. Existing approaches frequently examine AI within individual functions such as underwriting, claims handling, fraud detection, or customer service. While valuable, such analyses often treat insurance disciplines as largely independent domains. The running example demonstrates that AI-mediated systems generate effects that propagate across disciplinary boundaries and create feedback loops spanning the insurance system as a whole.

The central challenge introduced by AI is therefore not the automation of existing insurance processes. Rather, it is the destabilization of several assumptions that historically linked the major disciplines of insurance into a coherent system. Traditional insurance concepts evolved within environments characterized by relatively stable relationships between human actors, technological artefacts, and institutional structures. Hybrid Human-AI Insurance Systems introduce adaptive agents capable of influencing, predicting, and modifying the very risks they are intended to manage.

Insurance must therefore increasingly be understood as an interconnected socio-technical system whose components co-evolve alongside advances in artificial intelligence. Addressing the challenges introduced by AI consequently requires more than isolated disciplinary solutions. It requires

conceptual frameworks capable of describing, analyzing, and governing hybrid Human-AI insurance environments as integrated systems.

6. Conclusion

This paper examined the implications of Artificial Intelligence for insurance through the concept of Hybrid Human-AI Insurance Systems. Using a running example involving an AI-mediated vehicle, behavioral monitoring, and predictive risk assessment, the analysis demonstrated that AI does not merely improve existing insurance processes. Rather, it alters fundamental relationships between risk, prediction, responsibility, liability, and decision-making.

By examining the scenario through eight major insurance disciplines, the paper showed that AI creates challenges extending far beyond any individual insurance function. Actuarial assumptions, legal frameworks, organizational structures, economic incentives, fraud prevention mechanisms, medical assessment practices, and engineering approaches are all affected by the increasing ability of AI systems to predict and influence future outcomes.

The principal contribution of this work is the argument that these developments should be understood as systemic rather than disciplinary. The introduction of AI does not simply create isolated operational challenges. It affects the assumptions linking the major disciplines of insurance and thereby challenges the coherence of the insurance system as a whole.

As AI becomes increasingly embedded within insurance products, organizational processes, and customer interactions, the ability to reason about Hybrid Human-AI Insurance Systems will become increasingly important. Future research should therefore focus on developing conceptual, modelling, governance, and architectural approaches capable of describing and managing adaptive socio-technical insurance environments.

Ultimately, the long-term challenge facing insurance is not merely the adoption of artificial intelligence. It is the evolution of insurance concepts, institutions, and governance mechanisms to accommodate systems in which human and artificial agents jointly participate in the creation, prediction, and management of risk.

References

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- 2) Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act) (Text with EEA relevance), Articles 9 and 14, EUR-LEX Website, 28th of June, 2026;
- 3) UN Regulation No 157 – Uniform provisions concerning the approval of vehicles with regards to Automated Lane Keeping Systems [2021/389], EUR-Lex Website, 28th of June, 2026.

KA HIBRIDNOM SISTEMU OSIGURANJA KOJI KOMBINUJE LJUDE I VEŠTAČKU INTELIGENCIJU

Konceptualni izazovi za osiguranje posredovano
veštačkom inteligencijom

Apstrakt:

Osiguranje se tradicionalno zasniva na delikatnoj ravnoteži između neizvesnosti i predvidljivosti. Veštačka inteligencija sve više narušava ovu ravnotežu. Kroz interdisciplinarnu analizu scenarija vožnje posredovanog veštačkom inteligencijom, ovaj rad pokazuje kako prediktivni i adaptivni sistemi stvaraju tenzije unutar konceptualnih osnova samog osiguranja. Rezultujući izazovi ne mogu se adekvatno rešiti u okviru bilo koje pojedinačne discipline osiguranja, već proizlaze iz njihove interakcije.

Ključne reči: Veštačka inteligencija, osiguranje, hibridni sistemi ljudi
– veštačka inteligencija