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Three Horizons of Technical Skills in Artificial Intelligence for the Sustainability of Insurance Companies

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Abstract: Insurance companies are experiencing unprecedented growth due to several emerging technology functionalities that have transformed the industry's operations. Through the Three Horizons framework, this study explores the technical skills required to use artificial intelligence (AI) for the sustainability of insurance companies. Methodologically, it was carried out in two stages: First, defining the state-of-the-art, which included analysis of the current situation and studying technological surveillance. Second, technical skills and their strategic prevalence were identified for the design of each horizon. As a result, the adoption of AI in insurance companies allows them to transform their personal and data-intensive processes into engines of efficiency and knowledge, redefining the way companies in the sector offer their services. This study identifies the immediate benefits of AI in insurance companies. It provides a strategic framework for future innovation, emphasizing the importance of developing AI competencies to ensure long-term sustainability.

Keywords: three horizon framework; artificial intelligence; technical skills; insurance companies; sustainability

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1. Introduction

The digitalization of the insurance sector has transformed how these companies offer their services (Eckert and Osterrieder 2020). The new needs of customers, who are now more digital and therefore demand speed, authenticity, and personalization in all the services they use, have boosted a sector that until now has been considered traditional. Thus, among the emerging technologies, artificial intelligence (AI) has positioned itself as the most disruptive for its operations (Eling et al. 2022).

AI has become a highly relevant tool for the insurance sector. This technology, which involves the simulation of human intelligence processes by machines, has the potential to transform the way insurance companies operate and provide services (Erem Ceylan 2022). Implementing AI enables automating administrative tasks, analyzing large volumes of data to detect fraud, and improving customer experience. However, its implementation also poses challenges regarding ethics and risks associated with using this technology (Singh and Chivukula 2020).

The Three Horizons framework, a strategic planning tool, is used to systematize the adoption of AI across different timelines. This framework enables organizations to identify and analyze emerging trends, anticipate disruptions, and plan the future (Curry and Hodgson 2008). The framework is divided into three horizons: Horizon 1 (H1) focuses on maintaining and optimizing current systems, Horizon 2 (H2) explores emerging innovations that can disrupt current systems, and Horizon 3 (H3) envisions radical transformations that redefine industry practices (Sharpe 2014).

The application of AI in the insurance sector has been extensively studied. AI techniques have been utilized for various purposes, including risk assessment, fraud detection, and enhancing customer service. For instance, AI can analyze vast amounts of data to predict risks more accurately and detect fraudulent activities more efficiently (Cheng et al. 2020). Additionally, AI allows for the personalization of insurance products, significantly improving user experience (Arumugam and Bhargavi 2023).

Recent studies have shown that the integration of AI can lead to significant improvements in operational efficiency and decision-making processes within insurance companies (Majeed and Lee 2020). However, the adoption of AI also raises important ethical and transparency issues that need to be addressed to ensure customer trust and regulatory compliance (Eitel-Porter 2021; Erdmann et al. 2021).

Moreover, the evolution of AI has introduced generative AI (GAI), which focuses on creating original content from existing data. GAI has gained relevance for its ability to generate text, audio, images, and video, offering innovative possibilities for the insurance industry. Despite its benefits, GAI presents challenges such as limited knowledge, potential biases, and ethical concerns (Lin and Ruan 2023; Pelau et al. 2021).

Adopting AI in the insurance sector offers numerous benefits that extend to all industry players. Thanks to this technology and its ability to analyze large amounts of data quickly and accurately, companies can make informed decisions about insurance portfolios and offer more personalized solutions to their customers, creating unique experiences. Processes such as risk identification, fraud detection, claims management, and even underwriting and data analysis can be streamlined and optimized through AI to improve customer service and internal operations (Kajwang 2022).

However, despite the expectations and excitement swirling around artificial intelligence, there has also been a surge of fear about the negative impact it can have on our lives (Eling et al. 2022). Its use can indeed generate some complex risks, such as bias, ethics, performance, reliability of information, or intellectual property, which need to be managed in the right way to use it safely (Pisoni and Díaz-Rodríguez 2023).

Similarly, and more recently, the evolution of AI has allowed us to witness the emergence of generative artificial intelligence (GAI). This branch of AI goes one step further and focuses on the generation of original content from existing data. This means that, through natural language processing, it can generate content in the form of text, audio, images, video, and more. GAI has gained a lot of relevance in a short time, as it redefines the rules of the game and gives rise to a whole range of innovative possibilities for businesses (Lin and Ruan 2023). However, these systems have some limitations that must be considered when using them, especially in an industry as complex and sensitive as this one.

Therefore, it should be kept in mind that GAI systems have limited knowledge of the world since they can only learn from the available data, so they may be biased or inaccurate. In addition, GAI systems are not suitable for complex underwriting involving many human variables (Pelau et al. 2021). It is difficult for AI systems to understand the subtleties of human behavior (Teleaba et al. 2021). Also, GAI systems raise some ethical concerns. They lack empathy, which can be a problem when addressing customer concerns (Sai et al. 2024). Finally, as GAI evolves and becomes more widespread, governments will attempt to regulate it with new legislation (Lin and Ruan 2023). This could prove costly for an insurance company.

Still, despite the challenges it presents, GAI is a technology that offers numerous benefits for the sustainability of insurance companies. In the coming years, we are likely to see increasing adoption of this branch of AI for the sustainability of the industry, as insurers look to continually improve their operations and offer a better experience to their customers.

Based on the above, this study seeks to explore the technical skills required in AI for the sustainability of insurance companies by applying the Three Horizon framework. To achieve this objective, the study was conducted in two stages; first, the definition of the state-of-the-art, which included analysis of the current situation and the study of

technology surveillance; and second, the identification of the technical skills and their strategic prevalence for the design of each horizon.

This study makes a valuable contribution by systematically identifying the key technical skills necessary for the sustainable adoption of artificial intelligence in the insurance sector, utilizing the Three Horizons framework. By closely examining the integration of AI into insurance operations, the study underscores the immediate benefits of AI in enhancing operational efficiency and customer service. It also outlines a strategic pathway to navigate future innovations and challenges. The findings serve as a crucial resource for industry practitioners and academics, highlighting the importance of developing and integrating AI technical skills to ensure the continued growth and sustainability of insurance companies in an ever-evolving technological landscape.

2. Literature Review

2.1. Artificial Intelligence (AI)

Artificial intelligence refers to a field of study and development of technologies that aim to simulate human intelligence in machines and systems. AI refers to the ability of machines to perform tasks that, until recently, could only be performed by humans, such as learning, decision-making, and pattern identification (McCarthy et al. [1955] 2006). This implies the ability of machines to learn, reason, make decisions, and perform tasks autonomously, calculating in algorithms and machine learning models. A system can act intelligently in increasingly broad areas of knowledge (Nilsson 1983), correctly interpret external data, and use these teachings to achieve specific objectives and activities through a flexible configuration (Kaplan and Haenlein 2019).

The constant growth of AI techniques has radically penetrated human lives and business organizations. Companies have recognized relevant business opportunities derived from AI aimed at boosting operations, re-engineering products or services, or rethinking business strategies (Campbell et al. 2020). Although AI emerged as a discipline in the 1950s (McCarthy et al. [1955] 2006), the first business application of AI was in the 1980s, driven by the success of the expert system paradigm (Schoech et al. 1985).

Since then, AI is a field of technology that has evolved significantly in recent years and is transforming various industries. Its success has progressively accelerated thanks to the exponential growth of available computing power, as described by Moore (1965). Organizations now increasingly rely on AI and related machine learning (ML) models to improve human understanding of complex systems and automate decision-making, which also requires constant contributions from experts (Galanos 2019). The availability of large, varied, and fast-moving information assets, also known as Big Data, ensures great attention to AI techniques with substantial advances in computation, study, and design of methodologies based on intelligent algorithms impacting businesses and societies (Duan et al. 2019; Dwivedi et al. 2019).

2.2. AI Technical Skills

Currently, the biggest challenge for businesses is to make better use of the vast amount of data, establish immediate reaction patterns, make predictions, and improve user experience. This has a direct impact on training and the development of technical skills to retrieve, reproduce, store, and interpret data and information through information sharing and communication with AI applications.

In practice, it is difficult for disciplinary and emerging digital professionals to find solvent institutional and scientific references when it comes to thinking with intellectual rigor and high ethical demands, a catalog of specific skills, and approval at the international level (Russom 2011). These are technical skills that are being shaped as they go along (Leon et al. 2017).

In the context of AI in insurance companies, technical skills are critical to maintaining and improving a company's position vis-à-vis its competitors.

Therefore, AI technical skills in the insurance sector encompass the essential knowledge, skills, and abilities necessary for crafting, deploying, and overseeing AI systems. These skills are not only about understanding AI theoretically but also applying it practically to transform insurance services such as customer support, claim handling, risk evaluation, fraud detection, and tailoring insurance products (Gupta et al. 2022).

Fundamental skills include data management and analytics, vital for prepping and interpreting the vast data AI systems rely on. This foundational layer is complemented by skills in various machine learning methods for predictive modeling and problem-solving, alongside programming expertise in languages and tools like Python, R, and libraries such as TensorFlow and PyTorch (Koster et al. 2021).

Advanced skills delve into deeper AI technologies like deep learning, which addresses more complex challenges, including image and speech recognition, as well as natural language processing. Ethical governance is another critical competency, ensuring AI applications in insurance adhere to principles of fairness, transparency, and privacy (Eitel-Porter 2021). Moreover, AI integration and deployment skills cover the technical skills required to meld AI solutions seamlessly with existing technological infrastructures and the subsequent monitoring and maintenance of these systems (Abdelhalim and Ibrahim 2023).

On a strategic level, skills expand to include innovation and research and development, emphasizing the creation of new AI-driven insurance products and the importance of keeping pace with technological advancements. Additionally, effective change management and training are indispensable for adapting business processes and organizational culture to the incorporation of AI, ensuring staff are proficient in utilizing these technologies and that the company remains competitive and innovative in the dynamic insurance industry landscape (Kelley et al. 2018).

2.3. AI for the Sustainability of Insurance Companies

In insurance companies, AI is increasingly being used to improve process efficiency and service quality. From risk identification to fraud detection, AI is proving its ability to process large amounts of data quickly and accurately, enabling insurance companies to make more informed decisions and offer personalized solutions to their customers (Soliño-Fernandez et al. 2019). In short, AI is transforming the insurance industry and is essential to remaining competitive and sustainable in an ever-evolving market.

Thanks to data processing and analysis capabilities, it is now possible to predict risks more accurately and detect fraud more efficiently (Cheng et al. 2020).

It also allows insurance offers to be customized to each customer's profile and needs, significantly improving user experience. These technological advances are helping insurers make more informed decisions and offer more effective and affordable insurance solutions (Arumugam and Bhargavi 2023). AI is rapidly transforming the insurance industry and is proving to be a valuable tool for companies looking to improve their efficiency, quality of their services, and sustainability.

In risk assessment, AI has proven to be a valuable tool for the sustainability of insurance companies. By using machine learning models, insurance companies can analyze large amounts of data to identify patterns and trends that can indicate risks and predict potential customer claims (Majeed and Lee 2020; Serrano et al. 2018).

In terms of operational efficiency, insurers are using AI to improve the accuracy and speed of claims processes. Some insurers are using natural language processing to analyze claim descriptions and automatically determine their validity (Zhang et al. 2021). In addition, AI is also being used in fraud detection, such as recognizing suspicious patterns of behavior in claims data. Overall, AI is enabling insurers to be more efficient, accurate, and effective in claims handling (Abdelhalim and Ibrahim 2023).

However, with the increased adoption of AI, there is also a need to discuss and address ethical and transparency issues (Erdmann et al. 2021). Ethics and transparency are fundamental to the development and application of AI for the sustainability of the

insurance industry (Eitel-Porter 2021). First, AI relies on algorithms and data, which means that data quality and fairness are crucial to the success of AI. Incorrect or biased data can lead to unfair and discriminatory decisions (Guinney and Saez-Rodriguez 2018). It is therefore important to ensure that the data used in AI is accurate and representative.

In addition, transparency is crucial for customer trust. Consumers need to understand how AI is used in the insurance industry and how AI-based sustainable strategic decisions are made. Insurers must be transparent about how data is collected, stored, and used, and how AI-based decisions are made (Soni et al. 2023). Consumers should also be able to challenge and appeal any decisions made by AI (Tsagris 2021).

It is also important to consider the implications that AI may have on the workforce. In future positions in the insurance market, by automating certain tasks, AI may replace some jobs and reduce the demand for specific skills (Zarifis et al. 2023).

AI is also creating new employment opportunities in roles related to implementing and maintaining the technology, as well as interpreting and analyzing the data that is generated (Kelley et al. 2018).

Insurance workers must be prepared for the digital transformation of insurance and have the necessary skills to adapt to the new roles and opportunities that arise. Insurers also have an important role to play in training and upskilling their workforce, ensuring a smoother and more equitable transition to a more AI-based workforce (Gupta et al. 2022).

The application of AI in the insurance industry is constantly evolving and is expected to continue to grow in the future with an approach that is strong and sustainable. One of the most important trends is the personalization of insurance products through the collection of more detailed data and the use of advanced algorithms to assess each customer's risks (Zhavoronkov et al. 2021). AI is also expected to have an increasing impact on fraud detection and claims prevention, helping insurers save costs and improve efficiency. In addition, AI is expected to play an important role in improving customer experience through automating processes and reducing waiting times.

Importantly, AI is opening the door to new opportunities for innovation and growth for the sustainability of the insurance industry. For example, the application of AI in the collection and analysis of massive data can enable insurers to identify new customer needs and develop customized products that fit those needs. AI algorithms can also be used to optimize internal business processes and improve operational efficiency (Tsagris 2021).

However, as with any technology, the successful implementation of AI for the sustainability of an insurance company requires strategic decision-making for innovation, careful planning, and a well-defined strategy.

3. Materials and Methods

Methodologically, the study was conducted in two distinct stages, each designed to systematically explore and identify the technical skills required for the sustainability of insurance companies using AI within the framework of the Three Horizons.

3.1. Stage 1: Defining the State-of-the-Art

This stage involved a comprehensive analysis of the current situation in the insurance sector concerning AI technologies, utilizing technology surveillance to map the existing knowledge base.

3.1.1. Technology Surveillance

The technological surveillance study used the keyword co-occurrence method, which allowed the mapping of knowledge or scientific cartography. Keyword co-occurrence analysis (Callon et al. 1983; Spinak 1998) is one of the most used techniques when the objective is to represent the structure of a scientific field (Van Eck and Waltman 2010; Zupic and Čater 2014; Donthu et al. 2021). This analysis requires a process of normalization—i.e., determining how closely two objects match relative to the total number of matches for each object. A similarity measure called Strength of Association is used as it captures

the similarity effect—i.e., under equal conditions, more objects have more matches—and corrects for the size effect—i.e., if an object has more occurrences, it will have more matches with other objects (Van Eck and Waltman 2007; Waltman and Van Eck 2007).

3.1.2. Criteria for Publication Selection

Metadata extraction was carried out on 25 March 2024 from the main collection of the Web of Science (WoS) database. This database was chosen due to the high selectivity and relevance of its contents as well as the quality of its metadata. For the search strategy, terms related to artificial intelligence and the insurance sector were used. The search equation was ("artificial intelligence" OR "machine intelligence" OR "artificial neural network" OR "machine learning" OR deep learn OR "natural language process" OR "thinking computer system" OR "fuzzy expert system" OR "evolutionary computation" OR "hybrid intelligent system" OR "data learning" OR "fuzzy logic") AND (insurance OR "insurance technology" OR "insurance policy" OR "insurance company" OR "insurance industry" OR insurtech OR "insurtech company"). Only publications of type "Original article" and "Review" in the English language from the period 2014–2023 were considered.

3.1.3. Normalization Processes

The retrieved results were exported using the "Plain text" setting with "Full record and references cited". VOSviewer software (Van Eck and Waltman 2010) was used to construct and visualize bibliometric maps. For the construction of the research fronts network, a thesaurus file—a file where words with equivalent meanings are unified to avoid overrepresentation due to multiple locations in the network—was previously created in Excel and incorporated into VOSviewer. In addition, the 'full count' configuration was used as it was considered necessary to count the number of occurrences of keywords in each document. This methodology was chosen as it has a quantitative approach that significantly reduces author bias and/or subjectivity when analyzing the literature.

3.2. Stage 2: Identifying Technical Skills and Their Strategic Prevalence

In this stage, we applied the Three Horizons framework to identify and categorize the technical skills necessary for the sustainable adoption of AI in insurance companies. This framework helps us to understand the evolution and strategic importance of these skills over time.

Specific Steps for Applying the Three Horizons Framework

In rapidly evolving fields of knowledge, the keyword co-occurrence analysis method may not capture all research fronts (Leydesdorff 1997), which is why, in choosing the threshold for keyword occurrences, iterations were made to capture the highest number of relevant words in the period studied. The Three Horizons framework based on various articles is adopted in this study as a qualitative foresight tool to systematically explore the evolutionary trajectory of AI. It was applied as follows:

- **Horizon 1 (H1):** Analysis of the current dominant system or practice, its proven efficacy, and the sustainability of its underlying assumptions amidst evolving environmental and societal demands. The analysis encompasses an exploration of sustained innovations designed to strengthen the existing system without fundamentally changing its core principles.
- **Horizon 2 (H2):** Examination of transitional innovations and their role in shaping the trajectory towards a transformative future. It includes both H2− innovations, which extend the lifespan of H1 systems through incremental improvements, and H2+ innovations, which prepare the foundation for a fundamentally new system by challenging and eventually displacing the status quo.
- **Horizon 3 (H3):** Exploration of transformative visions proposing radical departures from H1 systems, focusing on their potential to address unmet needs and emerging challenges more effectively. The analysis aims to identify new actors, technologies,

and paradigms signaling a shift towards this future horizon while highlighting the conditions and drivers that could facilitate or hinder their realization.

This structured approach allowed us to map the technical skills required across different horizons, providing valuable insights for strategic planning in the insurance sector.

4. Results

In the first stage of the methodological process comprising the technology surveillance study using the keyword co-occurrence method, records were obtained for 1109 publications (1033 original articles and 76 reviews).

A map of keyword co-occurrence was drawn up, where 4535 keywords were initially retrieved, a minimum threshold of five occurrences was established and some words were excluded due to their obviousness—for example, "artificial intelligence" or "insurance"—or for not providing semantic value—such as "information", "cohort", "meta-analysis", etc. This left 212 keywords distributed in seven groups reflecting each research front, where the size of the nodes reflects the number of occurrences, and the thickness of the lines reflects the strength of association between them (Figure 1).

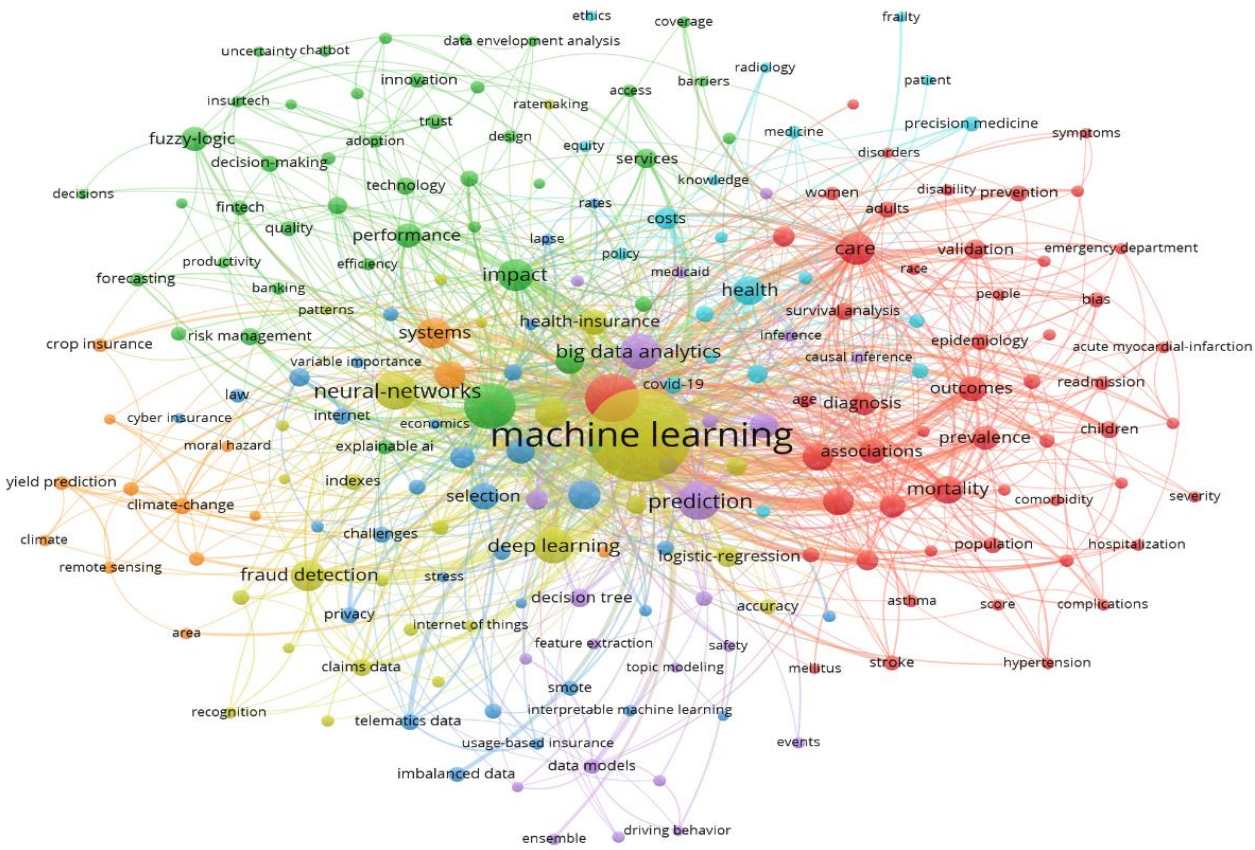

Figure 1. Map of keyword co-occurrence on the application of AI in insurance, period 2014–2023.

Next, to identify the research fronts, the conceptual relationships between the keywords (nodes) are interpreted considering three main criteria: their location in the network next to other words, their number of occurrences, and the strength of their relationships.

The research fronts identified are:

- **CLUSTER 1 (red): monitoring risk factors and prevalence of chronic diseases/use of epidemiological tools.**
  Where studies are developed to describe and analyze the prevalence—the proportion of people in a population who suffer from a specific disease or condition at a given time—of chronic diseases such as diabetes, hypertension, or cardiovascular disease.

- **CLUSTER 2 (green): use of AI algorithms for the optimization of insurance services.**
  This research front studies how the implementation of AI in financial and accounting management has radically transformed the way organizations in the insurance sector conduct their operations. For example, because of its ability to process large volumes of data quickly and accurately, AI streamlines tasks such as account reconciliation and real-time financial reporting. Similarly, AI algorithms enable effective automation and greater efficiency in critical areas such as anomaly and fraud detection.
- **CLUSTER 3 (blue): legal and coverage aspects in life and accident insurance.**
  Although life insurance and accident insurance are different products, both are related to financial protection in adverse situations.
  On the one hand, life insurance provides financial compensation to the beneficiaries designated by the policyholder in the event of his or her death (the cause of death does not matter, it can be for any reason). In addition to death coverage, life insurance can also include benefits for absolute and permanent disability.
  Regarding accident insurance, these insurances cover expenses arising from specific accidents, i.e., they are only activated if the insured's injuries or death are the result of an accident (depending on the coverage chosen in the policy). In addition to accidents, some accident insurance policies may also cover total or partial disability due to accidents, as well as temporary disability.
- **CLUSTER 4 (yellow): machine learning applied to claims management and fraud detection.**
  This research front explores how the insurance industry uses various statistically based methodologies and machine learning algorithms to analyze and detect fraudulent claims. These algorithms can identify anomalous patterns in financial data, helping to recognize suspicious activity and prevent fraud.
- **CLUSTER 5 (purple): use of big data for decision-making in healthcare.**
  The benefits of using big data in healthcare are reported in the field of diagnosis and prediction, where medium-to-high levels of accuracy have been recorded in the analysis of large datasets to diagnose and predict clinical outcomes and complications associated with chronic diseases such as diabetes mellitus and mental health disorders, including the prediction of suicidal behaviors; real-time support through big data analysis that allows healthcare professionals to assess patient data, medical literature, and best practices; and improvement of patient-centered care by contributing to the detection of health threats, improved disease monitoring, and reduced waste of resources.
  The intensive use of this technology presents some challenges such as the existence of fragmented or incompatible records, data security with sensitive patient information, and storage costs and data bias.
- **CLUSTER 6 (light blue): impact of digitization of health records on health policy (especially cancer management).**
  The digitalization of health records has a significant impact on healthcare and health policies. Examples include telemedicine and digital health applications that enable virtual consultations; the integration, collection, and analysis of large amounts of data and evidence-based decision-making; drug discovery and genomics; and cost reduction (electronic records speed up diagnosis and reduce the need for duplicate testing).
  In the specific context of cancer management, the digitalization of records enables more accurate patient monitoring, early identification of risks, and optimization of treatments.
- **CLUSTER 7 (orange): impact of climate change on agriculture and health, and the moral hazard involved.**
  This research front explores the implications of climate change on agriculture, which could create situations in which adaptation or mitigation measures create a moral hazard. For example, one possible scenario is that if farmers receive compensation for

crop losses due to climate change, they might not take preventive measures to reduce their vulnerability.

The second stage of the methodological process corresponds to the application of the Three Horizons framework. Below is a conceptual development of each horizon, including the technical skills required in AI for the sustainability of insurance companies.

Horizon 1 (H1). Adoption of AI to optimize and improve the efficiency of their current operations. Timeframe: present 1–3 years. For this H1, the following required technical skills were identified and defined:

- Analysis of results for personalization of insurance products and services. Creating insurance products and services for personalization falls within the first horizon, as the insurer incorporates AI-driven results analysis methods to gain opportunities by improving and extending its current offerings. In this context, insurers have incorporated AI into their product and service creation processes, enabling them to analyze large volumes of data and obtain the most important characteristics of their customers, allowing them to offer policies that can be tailored to the needs of the customers. Studies have highlighted the use of AI in insurance personalization, focusing on predicting client longevity and associated risks through the analysis of biomarkers and health data. This enables insurers to offer personalized health interventions, improving the quality of life for policyholders (Zhavoronkov et al. 2021). Another case is the implementation of usage-based insurance programs, where telematics devices installed in vehicles collect detailed data on driving habits, such as speed and braking. This data is analyzed to adjust insurance premiums, reward safe drivers with lower rates, and provide recommendations to improve road safety for higher-risk drivers (Adeoye et al. 2024). Both cases demonstrate how AI can optimize personalization and efficiency in the insurance industry, offering solutions tailored to individual needs.
- Techniques for risk prevention and management. The importance of managing risk for insurers is a priority, and the development of techniques to use AI to manage and prevent risks situates it in the first horizon. In this context, the use of technology to efficiently improve risk prevention and management allows insurers to achieve promising results. In the study by Serrano et al. (2018), predictive models were used to identify the risk of chronic social exclusion in various regions. They analyzed more than 16,000 cases using modeling techniques, achieving high precision in risk prediction. These models help social workers intervene early and prevent exclusion from becoming chronic, utilizing a tool that calculates risk on mobile devices. Majeed and Lee (2020) explored AI techniques to protect customer data privacy, essential for preventing data loss and improper disclosure. They examined how AI-based digital assistants can balance efficiency and privacy, addressing concerns about the ethical and secure use of AI in managing sensitive data. These cases highlight the importance of risk management in the insurance industry, focusing on both prevention and mitigation of associated risks.
- Techniques for claims management. Achieving operational efficiency using AI techniques for claims management also allows for the assessment of claims and options for their prevention. Therefore, the use of AI techniques for claims management focuses on improving precision and efficiency. Zhang et al. (2021) demonstrated that neural networks could detect gastric lesions with greater accuracy than traditional diagnostics, suggesting a potential application in medical claims evaluation. Abdelhalim and Ibrahim (2023) highlighted how intelligent algorithms and blockchain technology could detect fraud and enhance data integrity in the insurance sector, optimizing service quality. Guinney and Saez-Rodriguez (2018) developed advanced models for claims management and health risk assessment, emphasizing AI's ability to optimize these processes and prevent accidents. These studies illustrate how AI can transform the insurance industry by improving claims management and operational efficiency.

- AI learning methods applied to insurance subscriptions. Developing AI learning methods is important for insurers, as reflected in the subscription process, where it is necessary to understand the determining characteristics for obtaining the policy and learning from them. Arumugam and Bhargavi (2023) explored the use of AI to personalize the insurance subscription process, specifically in detecting aggressive driving behaviors. Using GPS and heart rate data, they developed a system to classify drivers as good, unhealthy, prone to road rage, and always bad. This allows for adjusting insurance premiums based on individual risk, improving the accuracy of risk assessment and driving practices. Guinney and Saez-Rodriguez (2018) presented advanced models for claims management and health risk assessment, highlighting AI's ability to optimize these processes and prevent accidents. These studies demonstrate how AI can transform the insurance sector by enhancing claims management and promoting safer driving.
- Advanced data analysis techniques for decision-making. The use of AI reinforces insurers' decision-making based on data, representing an important technical competency in H1. The study by Majeed and Lee (2020) highlights how the application of advanced data analysis techniques, focused on privacy, enables informed decision-making regarding data protection, an important aspect of improving insurance offerings to customers. These researchers developed a data anonymization algorithm that preserves community privacy by assessing the susceptibility of user attributes, thereby mitigating the risk of exposing sensitive information in published data. Meanwhile, Tsagris (2021) introduced a Bayesian network-based algorithm, called PCHC, which provides an efficient tool for interpreting complex economic data, aiding insurers in adapting and making decisions based on specific data. This approach not only enhances the accuracy of risk assessment but also optimizes the personalization of services. Both cases underscore the relevance of integrating advanced data analysis techniques and Bayesian networks to enhance decision-making and data protection in the insurance sector, illustrating the value of these technologies in improving operational efficiency and market competitiveness.

Horizon 2 (H2). Use of AI to introduce novel and efficient services. Timeframe: transition 3–5 years. For this horizon H2, the following required technical skills were identified and defined:

- Advanced algorithms for fraud prevention. Fraud prevention demonstrates the capability to interpret complex risk dynamics, enabling the detection of anomalies. Agarwal (2023), in his study on fraud detection in medical insurance, uses machine learning algorithms such as K-means clustering to identify fraud patterns. This method allows for the classification of medical claims as legitimate or potentially fraudulent, improving detection accuracy and reducing false positives. Ming et al. (2024) propose a novel approach for fraud detection in auto insurance and credit card transactions, integrating convolutional neural networks (CNNs) with machine learning algorithms such as SVM, KNN, and decision trees. This integration enables deeper feature extraction and greater accuracy in fraud detection. Cheng et al. (2020) present an innovative approach to assess the probability of ruin in risk models using intelligent algorithms. Although not directly focused on fraud prevention, this study emphasizes the importance of identifying unconventional risk patterns, which are crucial for detecting fraudulent behaviors in insurers. This approach is situated in H2, demonstrating the transition towards incorporating emerging technologies and more complex analysis methods.
- Models for customer loyalty and retention. Utilizing AI models to satisfy and retain customers falls within H2, as it also emphasizes the application of emerging technologies to meet insurers' requirements. Soliño-Fernandez et al. (2019) highlight how wearable devices, integrated with AI, can promote healthier lifestyles, which is crucial for customer loyalty and retention in the insurance sector. These devices enable real-time health monitoring and offer personalized feedback, aligning the health goals of clients with those of insurers, thereby strengthening the relationship

between both parties. This not only improves the well-being of the insured but also increases customer loyalty by ensuring relevant and beneficial health interventions. Soni et al. (2023) emphasize the importance of transparency in AI decision-making in healthcare, particularly in understanding how AI models reach their conclusions. This transparency is essential for building trust among the insured, ensuring that AI-driven decisions, such as those related to health insurance claims or premium adjustments, are based on clear and understandable criteria. This approach not only enhances customer satisfaction but also reinforces their loyalty to the service. Together, these studies demonstrate how the integration of advanced AI technologies in insurance can significantly improve customer loyalty and retention, ensuring clear and transparent communication that fosters customer trust and satisfaction.

- Ethical governance. Addressing challenges and ethical considerations, and how to confront them with AI, are relevant for insurers in H2. The study by Erdmann et al. (2021), focusing on precision measurement, indicates the most important ethical issues, such as data privacy and customer consent, emphasizing the need to handle insured individuals' health data with great care to ensure their protection and ethical use in developing new AI-based insurance products and services. Furthermore, Eitel-Porter (2021) highlights the importance of establishing ethical boundaries for those who develop and apply AI in the insurance industry. Therefore, these insurers applying AI in their processes indicate the need to integrate ethical considerations into technological innovation processes, promoting a balance between the adoption of emerging technologies and the ethical challenges facing the company.
- Automation of customer services. From the perspective of H2, the technical capabilities of AI in insurers are aimed at continuously enhancing automation and customer services, underscoring their pivotal role in customer experience. The study presented by Maedche et al. (2019) highlights the extensive opportunities and challenges associated with AI-based digital assistants, emphasizing their potential to enhance customer relationships through chatbots and virtual assistants. These assistants are designed to better understand user needs, enabling more efficient and personalized interactions. The study discussion emphasized the necessity of addressing not only the design and behavior of these AI-based digital assistants but also their interconnections and their impact on user experience. Cheng et al. (2020) present a case in which the application of computer vision for detecting automobile damage facilitates the automation of claims processing. This approach not only improves accuracy in damage assessment but also streamlines the claims management process, resulting in significantly improved customer experience. These findings demonstrate how automating customer service through the integration of AI can enhance the efficiency, accuracy, and personalization of services, significantly elevating the overall customer experience.

Horizon 3 (H3). Exploring how AI could redefine industry. Timeframe: future 5–7 years. For this horizon H3, the following required technical skills were identified and defined:

- Automation in parametric insurance. Automation in parametric insurance represents a disruptive transformation in how processes are managed by insurers. Volosovych et al. (2021) highlight the rapid adoption of parametric insurance during the COVID-19 pandemic, noting how AI algorithms facilitate the automatic activation of payments based on predefined parameters. This approach not only improves the speed and efficiency of the claims process but also ensures transparency and customer satisfaction by eliminating the typical uncertainty and subjectivity in individual claims evaluation. Pang and Choi (2022) employ a deep sigma point process, a Bayesian neural network technique, to enhance the accuracy of risk models in parametric insurance, using residential internet connectivity disruptions in the U.S. as a case study. Their research demonstrates that combining multiple climatic factors enables the construction of highly accurate risk models, which is particularly relevant in the context of climate change. These innovations underscore how integrating advanced technologies, such

as machine learning and AI, is redefining the operational models of insurers, providing more agile and forward-looking solutions for risk management and claims processing.

- Regulation and compliance. Adhering to regulatory requirements is a crucial domain where AI plays a transformative role. Böffel (2023) examines how insurance regulation and financial innovation can effectively converge with the incorporation of emerging technologies such as AI. Although regulations are designed to protect consumers, integrating AI into insurance processes can facilitate compliance with these regulations, enhancing transparency and operational efficiency. The reform of laws such as California's rate-making law, which seeks to balance innovation with the protection of proprietary information, illustrates how insurers can use AI to adapt to new regulatory demands more smoothly and effectively. Rousset and Ducruet (2020), while focusing on the impact of external shocks on maritime networks, provide valuable insight into the role of AI in quickly adapting to regulatory changes and crises. AI's ability to analyze large volumes of data and forecast risks enables insurers to respond with greater agility and precision, ensuring regulatory compliance and improving resilience to unforeseen events. These innovations not only facilitate adherence to existing regulations but also prepare insurers for future regulatory challenges, promoting a culture of compliance and proactivity in risk management. This positive outlook highlights how AI can be a crucial tool for meeting regulatory requirements more efficiently, protecting both the company and consumers.
- Cybersecurity is an emerging pillar particularly evident in protection against cyberattacks in an increasingly digitized era. The study by Singh and Akhilesh (2019) examines the cybersecurity challenges faced by the insurance industry, highlighting the crucial role of artificial intelligence (AI) in detecting and preventing digital risks. The implementation of AI enables insurers to anticipate potential cyberattacks, thereby enhancing digital security for both customers and providers. This approach is essential for maintaining trust and integrity in insurers' operations, representing a significant advancement in future risk management. Similarly, Talesh and Cunningham (2021) present an empirical study that explores how big data and emerging technologies are transforming the insurance sector, particularly in the areas of cybersecurity and privacy. Their research, which is based on interviews and quantitative data analysis, reveals that the "technologization of insurance" is changing how insurers underwrite policies, set prices, and manage risks. These studies underscore that proactive adoption of AI in cybersecurity is not only necessary for insurers in the digital age but also provides a significant competitive advantage. This approach has the potential to deeply transform industry practices and products, ensuring a safer and more reliable environment for all stakeholders involved.

Table 1 shows that consistency exists between the research fronts identified in the literature and the Three Horizons framework.

Table 1. Clusters/horizons relationship.

Horizons	Research Fronts
Horizon 1 Adoption of AI to optimize and improve the efficiency of their current operations	CLUSTER 1 CLUSTER 5 CLUSTER 6
Horizon 2 Use of AI to introduce novel and efficient services	CLUSTER 2 CLUSTER 3 CLUSTER 4
Horizon 3 Exploring how AI could redefine industry	CLUSTER 7

The three horizons provide an important framework for thinking about the technical skills required for AI in insurance companies, based on the grouping of the seven clusters

identified. Furthermore, it allows us to establish in time frames how AI technical skills will be introduced and implemented in an industry that is actively shaping the future today (Figure 2). By drawing a timeline from the perspective of the three horizons, value can be brought to each of them in a generative way to establish a better understanding and awareness of the future as a basis for collaborative action and transformative innovation driven by AI.

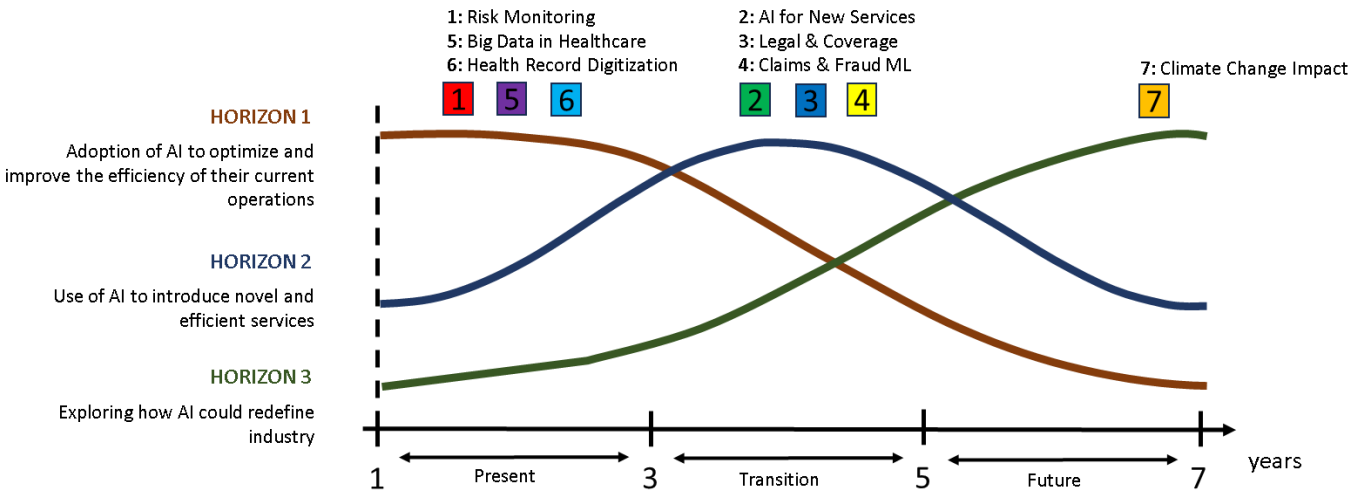

Figure 2. Timeline of technical skills required for AI use in insurance companies.

5. Findings and Discussion

The findings of this study underscore the critical role of AI in transforming the operational dynamics of the insurance industry. This research, leveraging the Three Horizons framework, provides a systematic approach to identifying and categorizing the technical skills necessary for the sustainable adoption of AI. When comparing these results with the existing literature, several important observations emerge.

First, identifying essential technical skills in this study aligns with previous research emphasizing the need for robust data management and analytical capabilities within the insurance sector. Cheng et al. (2020) and Zhang et al. (2021) have underscored the importance of AI-driven data analysis in enhancing risk assessment and fraud detection. The findings extend this understanding by offering a structured roadmap for developing these skills across different time horizons, providing a clearer strategic perspective. This approach also reflects the insights of Duan et al. (2019), who highlighted the increasing reliance on AI for decision-making processes in the era of big data.

Second, the study's focus on the evolving role of AI in customer service and operational efficiency resonates with the work of Eling et al. (2022) and Eitel-Porter (2021), which noted the potential of AI to enhance personalized services and streamline claims processing. However, this research goes further by delineating the specific skills required at each stage of AI adoption, offering a more detailed framework for practitioners. This is consistent with the findings of Soliño-Fernandez et al. (2019), who explored the integration of AI with wearable devices to promote customer health and engagement, further emphasizing the critical role of AI in improving customer relations.

Additionally, this study addresses gaps in the literature regarding the ethical implications of AI use in insurance. While previous research has touched on ethical concerns (Erdmann et al. 2021; Eitel-Porter 2021), our findings emphasize the importance of ethical governance as a distinct area requiring dedicated skills and strategies. This focus provides a crucial foundation for future studies aiming to balance technological advancement with ethical integrity, as also suggested by Böffel (2023) in the context of AI regulation.

Moreover, the study highlights the potential long-term impacts of AI on the insurance workforce. Although this aspect has been briefly mentioned in previous literature (Singh

and Chivukula 2020; Zarifis et al. 2023), our research explores it in depth, particularly focusing on the need for continuous training and technical skills enhancement of employees. The strategic roadmap offered by the Three Horizons framework helps anticipate and prepare for these changes, ensuring that the workforce can adapt to and thrive in an increasingly AI-driven environment. This aligns with the insights of Kelley et al. (2018), who emphasized the importance of workforce adaptability in response to AI-driven changes in the insurance sector.

This study contributes to the existing body of knowledge by reinforcing previous findings and offering a structured approach to the sustainable adoption of AI in insurance companies. The comparison with previous literature highlights both the alignment with existing knowledge and the unique contributions of this research, particularly in the areas of technical skill development, ethical governance, and workforce adaptation. Future research should continue to build on these findings, exploring the broader implications of AI across different insurance contexts and addressing the ethical and operational challenges that lie ahead.

On the other hand, the findings of this study highlight the significant impact of AI on the operational dynamics of the insurance sector. The adoption of AI presents numerous opportunities for improving efficiency, enhancing customer service, and providing personalized insurance products. However, AI also poses several challenges and limitations that need to be addressed to maximize its potential benefits (Kelley et al. 2018).

One of the primary challenges is the ethical implications of AI. As AI systems rely heavily on data, issues related to data privacy, security, and potential biases arise. Ensuring that AI systems are transparent and fair is crucial for maintaining customer trust and regulatory compliance. For instance, biased data can lead to discriminatory outcomes, which can harm customers and damage the reputation of insurance companies. Therefore, developing ethical guidelines and robust data governance frameworks is essential for the responsible use of AI in the insurance sector (Fjeld et al. 2020).

Another significant challenge is the potential impact of AI on the workforce. The automation of tasks traditionally performed by humans could lead to job displacement, necessitating the reskilling and upskilling of employees. While AI creates new opportunities for innovation and growth, insurance companies must invest in training programs that help employees adapt to new roles and responsibilities in an AI-driven environment.

The study also identified the strategic importance of technical skills across the three horizons. In Horizon 1, the focus is on refining existing operations through AI, which requires skills in data analysis, risk management, and claims processing. Horizon 2 emphasizes the introduction of innovative services, highlighting the need for advanced skills in fraud detection, customer loyalty, and ethical governance. Horizon 3 envisions a transformative future, necessitating skills in parametric insurance, regulatory compliance, and cybersecurity.

The application of the Three Horizons framework in this study provides a structured approach to understanding the evolutionary trajectory of AI in the insurance sector. It allows for the identification of key technical skills required at different stages of AI adoption, offering valuable insights for strategic planning and decision-making, although its use will likely always need to be complemented by other tools (Sharpe 2014).

The use of this Three Horizons model in a variety of applications has proven capable of enabling the understanding of relatively rich futures and estimating the evolution of technical requirements in a dynamic knowledge field. It connects with more dispassionate approaches commonly used in conventional scenario generation (especially in Europe and North America). Likewise, it promotes the consideration of emerging issues that can only be identified through a flexible mental model, which in this case, showed consistency with the research fronts identified from an exploration of technological surveillance. It also has the advantage of being quite accessible to non-practitioners, that is, it is relatively easy to assimilate and use (Curry and Hodgson 2008).

6. Conclusions

This study underscores the significant impact of artificial intelligence (AI) on insurance companies, particularly through the systematic identification of the essential technical skills required for its sustainable adoption. By applying the Three Horizons framework, the study offers a structured approach that addresses immediate operational improvements and anticipates future challenges and innovations. While the study contributes valuable insights, it recognizes certain limitations, such as its focus on a specific set of technical skills and the potential variability of these findings across different market contexts and industries.

The integration of AI within the insurance sector heralds a transformative era characterized by unprecedented efficiency, enhanced customer service, and highly personalized products. This study highlights the pivotal role of AI in leveraging vast datasets to streamline decision-making processes across various operational facets, including insurance portfolio management, risk identification, fraud detection, claims handling, and customer personalization. These advancements are instrumental in crafting bespoke client experiences driven by the systematic cultivation of technical skills across three progressive horizons.

Horizon 1 emphasizes refining existing operations through AI. This involves customizing insurance offerings, mitigating risks, optimizing claims processes, and enhancing decision-making capabilities. These technical skills are crucial for insurance entities aiming to elevate their service quality and secure a competitive advantage.

Horizon 2 explores AI's role in introducing innovative and efficient service modalities. This includes advanced fraud detection, enhancing customer satisfaction and retention, and navigating the ethical and operational challenges associated with AI integration. This phase signals a transition towards more intricate analytical methodologies and the assimilation of emerging technologies, requiring advanced skills in these areas.

Horizon 3 envisions AI's capacity to fundamentally transform the insurance landscape. Innovations such as parametric insurance, advancements in regulation and compliance, and improvements in cybersecurity indicate a future where AI-induced transformations could substantially alter insurance practices. Profound shifts are anticipated to redefine business models and promise novel avenues for growth and innovation. The strategic importance of developing skills in these areas cannot be overstated, as they will be critical in navigating the transformative changes expected in the industry.

Despite the considerable enthusiasm for AI, concerns regarding its ethical implications, potential biases, and impact on the workforce persist. The study acknowledges these challenges, underscoring the importance of ethical stewardship, transparency, and the judicious application of AI technologies. Addressing these issues through robust data governance frameworks and ethical guidelines is essential for maintaining customer trust and regulatory compliance.

Furthermore, the potential impact of AI on the workforce necessitates proactive measures. Insurance companies must invest in training programs to help employees adapt to new roles and responsibilities in an AI-driven environment, thereby ensuring a smoother transition and maintaining a competitive edge.

Further research is recommended to explore the broader implications of AI integration across various insurance environments, to engage more deeply with the ethical considerations associated with AI, and to assess the long-term effects on workforce dynamics. The findings presented here provide a foundation for industry practitioners to strategically develop AI technical skills, thereby maintaining competitive advantage and ensuring organizational resilience in an increasingly AI-driven industry.

In summary, AI holds immense potential to revolutionize the insurance sector, promising enhanced operational efficiencies, enriched customer experiences, and innovative service offerings. However, realizing this potential requires a strategic approach focused on developing AI technical skills, addressing ethical dilemmas conscientiously, and preparing for future challenges and opportunities. As the insurance industry navigates this AI-driven

renaissance, its success will depend on a harmonious blend of technological adeptness, ethical integrity, strategic foresight, and sustainability.

Finally, the study has some limitations. Although quantitative methods were used to explore technological surveillance, the identification of research fronts is an interpretation of the authors that could be debatable; however, this is consistent with the specialized literature and their thematic domain. On the other hand, the proposal of this type of analysis has benefits such as practicality and clarity to understand the evolution of the technical skills required for AI use in insurance companies; however, for a more robust approach, it is recommended that they be complemented with other methods of foresight analysis.

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