La transformation numérique du secteur français de l'assurance non-vie : fondements, défis et perspectives de recherche en économie des services

Digital transformation in non-life insurance: Foundations, challenges and research agenda in the economics of service

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RÉSUMÉ
La transformation numérique des services d'assurance non-vie en France s'accélère en raison notamment de l'adoption de l'intelligence artificielle et l'émergence des solutions insurtech. Si ces technologies augmentent la productivité et contribuent à réduire les coûts opérationnels, elles soulèvent simultanément des enjeux stratégiques, financiers et éthiques substantiels. Pour appréhender ces dynamiques, nous mobilisons le cadre systémique d'Ivanov et Webster (2019) qui articule les mutations technologiques avec les réorganisations intra-organisationnelles et les reconfigurations écosystémiques. Cette approche permet d'examiner l'architecture fonctionnelle de l'entreprise assurantielle (en particulier les fonctions susceptibles d'externalisation ou de maintien en interne) tout en interrogeant les rapports qu'elle entretient avec les autres acteurs du secteur (assureurs concurrents, prestataires d'IA, entreprises insurtech et GAFAM). Notre analyse établit que l'IA et les solutions insurtech induisent une reconfiguration structurelle majeure de l'écosystème assurantiel. Cette reconfiguration se manifeste par trois inflexions principales : le passage d'une logique d'indemnisation ex-post à une logique de prévention ex-ante, l'évolution de la tarification segmentaire vers une tarification comportementale, la transition d'une gestion rétrospective des risques vers une gestion prospective. Nous identifions également les obstacles substantiels à cette adoption et proposons un agenda de recherche visant à documenter précisément l'impact effectif de ces transformations sur les organisations assurantielles et sur la structure d'ensemble du secteur.

ABSTRACT
The digital transformation of non-life insurance services in France is a prime example of the technological disruption that is reshaping the financial services sector. Driven primarily by the adoption of artificial intelligence and the emergence of insurtech solutions, this transformation presents a complex interplay between operational gains and systemic challenges. While AI has the potential to significantly enhance productivity and reduce operational costs, its implementation raises important questions about strategic positioning, financial sustainability and ethical governance. To elucidate these dynamics, we employ the systemic framework proposed by Ivanov and Webster (2019), which links technological change to organisational restructuring and ecosystem reconfiguration. This framework allows us to examine the functional architecture of insurance enterprises, identifying which capabilities are candidates for externalisation versus internal retention, whilst also accounting for the firm's relational dynamics with ecosystem participants, including competing insurers, artificial intelligence providers, insurtech enterprises and technology giants. Our analysis reveals that AI and insurtech solutions catalyse profound structural reconfiguration within the insurance ecosystem. This manifests as three principal transformations: migration from ex-post indemnification to ex-ante risk prevention; evolution of pricing mechanisms from segmentation-based to behaviourally informed; and transition of risk management from retrospective to prospective orientation. Through this institutional lens, we identify the barriers that constrain rapid adoption and outline a research agenda to advance the empirical understanding of how these technological and organisational changes are reshaping insurance enterprises and the broader sectoral architecture.

MOTS-CLÉS. Assurance, Assurance non-vie, Service, numérique, Intelligence artificielle, Insurtech, Ecosystème, Innovation, Cycle de vie du produit inversé.
KEYWORDS. Insurance, Non-life insurance, service, digital, Artificial intelligence, Insurtech, Ecosystem, Innovation, Reverse product cycle.

In recent years, the insurance sector has faced profound structural changes [CAP 18] [STO 18] [VAN 18]. Beyond the growing impacts of climate change [SWI 20] and demographic aging, the industry must

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also comply with increasingly stringent regulations (e.g. Solvency II, GDPR), challenging its traditional business model of pooling individual risks across large portfolios [BAR 20]. Theses transformations are further compounded by outdated IT, limited innovative product offerings, slow digitalisation of distribution channels, and deeply embedded organisational routines, all of which constrain agility and innovation in the sector [BRA 25a].

Artificial intelligence (AI) and the adoption of emerging technologies in insurance (insurtech) represent some of the most transformative developments currently shaping the sector. According to a recent study by EIOPA [EIO 24], 50% of European property and casualty (P&C) insurers reported using AI in 2024, compared to only 24% in life insurance. An additional 30% (39% in life insurance plan to adopt such technologies within three years. By contrast, in 2019, only 31% of P&C insures had begun exploring AI applications, often limited to early-stage proof-of-concept initiatives. Simultaneously, many insurers are now partnering with or leveraging the services of numerous insurtech firms operating across the market.

Several factors explain the growing strategic relevance of AI and insurtech. First, these new technologies mark a major technological paradigm shift, potentially reshaping how risks are assessed and managed by insurers that fail to adopt these innovations [BOH 19] ; [FRI 21] ; [NEA 25] ; [WAN 25], and by enabling more dynamic pricing mechanisms and personalised insurance offerings through fine-grained, real-time data analysis. Advances in big data analytics, machine and learning and artificial intelligence are already beginning to redefine core practices within insurance sector [ELI 24].

AI may challenge core insurance principles [ELI 22a], notably by individualizing risk profiles and contributing to the potential demutualisation of pooling mechanisms. A major concern lies in the possible reversal of traditional information asymmetries in favor of insurers. AI and insurtech solutions enhance capabilities for ex ante risk prevention, large-scale fraud detection, and parametric insurance mechanisms that allow for immediate, data-driven claims settlement. By leveraging advanced data analytics, insurers can infer increasingly granular statistical information, thus altering the informational balance that historically favoured policyholders and helped mitigate adverse selection [BRU 22]. However, these developments also raise significant ethical and regulatory concerns [ELI 24] - particularly for French mutual insurers operating under solidarity-based models.

Simultaneously, AI and insurtech open new opportunities to reimagine value delivery to policyholders [BRA 25b]. These technological solutions offer potential to enhance commercial and legal interactions while streamlining customer-facing processes and improving the overall service experience [ELI 18].

Finally, AI and insurtech are reshaping the insurance ecosystem [ELI 22a], business models [BAR 20] ; [ZEI 18] and market structures [BRA 25a]. These technologies challenge the historically role of insurers within a wider network of reinsurers, wholesalers, brokers, service providers, and Big Tech firms. This shift leads to a reconfiguration of organisational arrangements, positioning insurers within interconnected networks at the core of the sector’s organisational processes. AI and insurtech are expected to drive significant reshuffling among established players and new entrants alike, with new market participants entering by introducing innovative products or services, or by enhancing operational efficiency of incumbent insurers.

However, insurers’ adoption of AI and insurtech faces significant barriers, both structural and regulatory. Structural challenges include legacy IT infrastructure, organisational resistance, entrenched cultural practices, switching costs, uncertain return on investment, algorithmic biases, and concerns regarding sensitive personal data use. Regulatory constraints encompass Solvency II, GDPR (General Data Protection Regulation), the IA Act, and the Digital Service Act, which together restrict broad deployment. Moreover, many policyholders — particularly in the EU where data privacy is tightly regulated — often refuse insurers access to personal data, despite the potential benefits of innovative services [REG 17] ; [BEN 18] ; [ELI 24]. The European AI Act in 2024 has further reinforced these constraints. As the world’s first comprehensive, binding AI framework, it imposes stringent

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requirements of transparency, explainability, and non-discrimination. Crucially, it classifies AI systems for risk assessment and pricing in life and health insurance as *high-risk*, thereby subjecting them to strict conformity, monitoring, and disclosure obligations.

In this context, the central challenge facing the insurance industry is to reconcile technological innovation with the preservation of foundational insurance principles, while addressing evolving policyholder expectations and broader structural pressures — economic, demographic, climatic and institutional. This tension echoes the classic innovator's dilemma [CHR 97], in which incumbent insurers must choose between modernizing long-established practices or pursuing disruptive strategies to harness AI and insurtech potential [CHA 25a]. However, significant difficulties faced by incumbent insurers in scaling AI and insurtech solutions internally highlight the fragility of this balance. These challenges are compounded by the fact that improved accuracy in risk classification methods, enabled by AI and access to new data sources, does not always incentivise insurers to offer more granular or equitable risk categories [ELI 24].

Additionally, the high costs of digital transformation, uncertain ROI, and growing dependence on external technology providers (Big Tech and insurtech) constrain traditional insurers' strategic flexibility. Many advance cautiously, with limited capabilities and unclear roadmaps. The struggles of structurally unprofitable insurtech "unicorns" underscore the broader challenge of achieving sustainable profitability in this evolving landscape, particularly given that the on-demand insurance and insurtech still represent a relatively marginal share of total market volume and investment [ZEI 18].

While AI and insurtech are reshaping certain insurance industry segments, their transformative impact remains limited to date. In practice, traditional insurers and insurtech start-ups maintain a complementary relationship: the latter contribute innovation capacity and organisational agility, while the former provide sectoral expertise, financial solidity, and access to large markets. Traditional insurers increasingly invest in IT architecture modernisation, data enhancement capabilities and blockchain applications. Insurtech start-ups recognised as innovation laboratories that co-evolve alongside incumbents, occasionally competing IT directly by offering customer-centric innovations, capturing underserved niche markets, or attracting talent through their more agile organisational models [BRA 25b] ; [BRA 25a]. This "coopetitive" dynamic is evident in insurtech startups financing which has grown significantly in recent years [GAL 25]. Meanwhile, despite their technological, data and digital platforms expertise providing strategic advantage, big tech firms continue to play a limited role in current insurance ecosystem reconfiguration [CHA 25a]. As Braun and Jia ([BRA 25b, 2]) note, "*the rise of the InsurTech sector underscores a crucial reality: the future of insurance is not a solitary journey but a collaborative endeavour*".

In this inherently uncertain, a central question arises: are traditional industry players still best positioned to withstand the ongoing upheavals? Are the features that once underpinned incumbent insurers' strength now becoming structural handicaps in an increasingly open and innovation-driven insurance ecosystem? More fundamentally, as Eling et al. [ELI 22a] argue, are incumbent insurers genuinely at risk of diverging from traditional paradigms that have shaped the sector — or might they prefer preserving legacy practices while costs associated with digital, IA and insurtech transformations remains high?

Paradoxically, why do these concerns seem less salient in the insurance industry? Recent studies [ALB 19]; [BOH 19]; [ECK 20]; [WAN 25] demonstrate that the most digitally committed insurers [ELI 18] have also created the most value for their shareholders. Conversely, insurers delaying digital investments have generally underperformed in customer satisfaction and sales growth [FRI 21].

In economics, the limited attention to insurance service innovation is evident. Early literature examined the adoption of information and communication technologies developed outside the sector [GAL 91]. It was only in the 1990s that studies specifically addressing insurance innovation began to

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emerge [GAD 94] ; [PEA 97]. In the 2000s, scholarly interest shifted toward digital technologies' role in this industry [BOH 19]. Today, despite AI and insurtech's vast applications and transformative potential, research on their emergence and adoption by insurers remain fragmented and insufficiently developed.

Building on this contextual analysis, this incipient "great transformation" (to paraphrase Karl Polanyi) of insurance market raises several underexplored research questions warranting systematic investigation. First, to what extent are AI and digital technologies genuinely reshaping the insurance value chain? Second, does innovation in insurance services still conform to Barras [BAR 86] traditional "reversed product life cycle model"[1], or do insurtech developments and AI increasingly blur boundaries between established innovation forms? Third, are novel business models in the insurance sector [BRA 25a] following AI and insurtech fundamentally redefining relationships between insurers and policyholders, and by extension, insurers' role within their broader ecosystem? Finally, how do insurers, insurtech start-ups and big tech firms interact within this evolving and increasing reticulated ecosystem, where data dependency and API mastery are becoming critical strategic issues?

This paper pursues multiple objectives. By integrating sector analysis with theoretical inquiry, we seek to elucidate the dynamics reshaping the contemporary insurance industry. Our empirical focus is on the non-life insurance market — including motor, health, property damage, civil liability and transport insurance — which offers a fertile case study for three reasons. First, the universal nature of the risks covered. Second, the coexistence of complex processes, data challenges and regulatory constraints[2] that generate a distinctive innovation ecosystem. Third, the dual potential for automation and hyper-personalisation provides a paradigmatic illustration of AI's disruptive impact in services.

In this triple perspective, this paper is structured as follows. Section 1 outlines our methodology. Section 2 situates our analysis within the property & casualty (P&C) sector and its evolving technological landscape. Section 3 examines insurance services' specificities and innovation patterns, challenging conventional frameworks. Section 4 assesses AI's transformative potential across key functions. Section 5 introduces an integrative framework for analysing AI-driven and insurtech dynamics, synthesizing innovation economics with insurtech mechanisms. This framework captures the sector's idiosyncrasies while providing methodological guidance for future research (Section 6). Finally, Section 7 concludes by underscoring the contribution's added value.

1. Methodology and conceptual approach

From a methodological standpoint, this contribution is based on three pillars: i) A systematic review of academic and professional literature covering the period 2015–2024; ii) An analysis of sector reports from leading organisations (such as EIOPA, Swiss Re Institute and ACPR); iii) An initial series of ongoing semi-structured interviews with insurance and insurance technology professionals. This methodological triangulation follows established practices in innovation studies [EIS 89] and provides a

[1] The Barras model is characterised by the fact that, in the insurance sector in particular, process innovations precede and facilitate the emergence of product innovations.

[2] In contrast to life and health insurance subsectors — explicitly categorised as high-risk AI systems under the EU AI Act due to their impacts on vital interests — the P&C market benefits from a more flexible regulatory regime. This differential classification (high vs. limited risk), anchored in the Act's proportionality principle, creates distinct innovation pathways for insurtech adoption. This risk-based approach clearly demarcates subsectors: AI for risk assessment and pricing in life and health insurance is subject to strict conformity assessments and continuous monitoring, whereas P&C applications face lighter requirements — except when processing highly sensitive personal data or significantly affecting access to essential services.

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comprehensive understanding of the complex dynamics at work in the digital transformation of the insurance sector. Our literature review encompasses both peer-reviewed academic publications and "gray" literature from industry practitioners, ensuring theoretical rigor while maintaining practical relevance.

This methodological approach aims to develop an "appreciative theory" [NEL 02], adapted to the subject under study and considering its context (economic, social, political, etc.), and therefore its history [MAL 99]. It is particularly well suited to analysing emerging phenomena in the economics of innovation, where established theoretical frameworks may be inadequate for understanding the complexity of technological and organisational change [PAV 05] ; [FAG 12]. This inductive, constructivist approach seeks to address a specific question or to gain an understanding of a concrete, non-theoretical phenomenon. It typically begins with intuitions, observations and/or stylised facts. These allow us to formulate realistic or reasonable hypotheses. Following the tradition of evolutionary economics and innovation studies [DOS 88] ; [LUN 92], we adopt an abductive reasoning approach, allowing new theoretical perspectives to emerge from empirical observations while remaining grounded in existing theoretical foundations.

These hypotheses enable the conceptualisation and/or modelling (formal or informal) of relevant causal models, which are then subjected to empirical validation using reasoned investigative procedures. Confronting these models with reality enables us to refine hypotheses, concepts and models, testing them using observable data and progressing towards better-founded and ultimately more defensible representations. This iterative process aligns with the principles of grounded theory methodology [GLA 67] and enables the development of context-sensitive theoretical contributions that can inform academic understanding and practical decision-making in the insurance industry. This methodology is therefore based on an ongoing dialogue between facts, hypotheses, theorisation and empirical verification, in line with the pragmatic tradition of economic research which emphasises the practical utility of theoretical constructs [HOD 04] ; [WIT 08].

2. Insurance: a secular sector in the throes of change

With its long history closely linked to economic development, the insurance sector is now at a turning point. As major economic players in the protection of individuals and companies [ZWE 12], insurers are facing profound changes that are calling into question their traditional models and profitability [ELI 22a]. The aim of this first section is to understand how this sector, faced with climatic, demographic and technological upheavals, must rethink the way it operates while preserving its central role in the economy. We begin by examining the economic weight of insurers (2.1), then describe the singular actuarial principles that structure their activities (2.2). Finally, we examine the reasons for the erosion of the sector's profitability (2.3). This analysis will shed light on the context in which AI and insurtech promise to reconfigure insurers' innovation process.

2.1. *Insurers: key players in the economy*

Historically, insurance is consubstantial with the development of trade (particularly from the Renaissance period) and has thus played a key role in successive industrial revolutions. Today's leading insurance companies are the descendants of this multi-century history[3], which has made insurance one of today's leading economic sectors. In fact, on an international scale, total premiums paid to insurers today account for over 7% of global GDP[4], while insurers are among the world's largest financial

[3] Historically, the earliest proto-insurance treaties date back over four millennia to the ancient Babylon.

[4] In 2024, global non-life insurance premiums (primary P&C insurance and medical) reached US$ 4.8 trillion, while global life insurance premiums totalled US$3.4 trillion [SWI 25b]. In France, insurance (life and non-life) accounts for 10% of GDP [ACP 24] [OEC 24]. The French market ranks first in EU and 5th worldwide [SWI 23b]: in life insurance, it represents 18.1% of the European market and 5.6% of the global market; in non-life insurance, 15.3% of the European market and 2.6% globally.

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investors [5].

This preponderance of the insurance sector can be explained by the historic role of insurers in financing the economy, and by a regulatory framework that has gradually made numerous insurance coverages compulsory[6]. These investments naturally play a crucial role in financing the real economy and contribute to the financial stability of many countries [ACP 24]. Finally, the insurance sector is characterised by an oligopolistic concentration of its market among a small number of players, often constituted as insurance groups, whose status and economic and financial goals often diverge widely (see table 1 for France, for example[7]).

Cumulative market shares	Personal insurance	Property and liability insurance
Leader	15,1 % (Crédit Agricole Assurances)	13,9 % (Covéa : GMF-MAAF-MMA)
Top 3	34,1 % (leader + CNP + Axa)	36,2 % (leader + Axa + Groupama-GAN)
Top 5	51.2 % (top 3 + Crédit Mutuel + BNP Paribas Cardiff)	51,0 % (top 3 + Allianz + Aéma Groupe [MACIF, AESIO, Abeille Assurances])
Top 10	78,8 % (top 5 + BCPE + Société Générale Assurances + Generali + Allianz)	73,5 % (top 5 + Crédit Agricole Assurances + MAIF + Generali + Crédit Mutuel + SGAM BTP

Table 1: *Concentration of the French insurance market (in % of premiums paid in 2023), Sources: Authors based on France Assureurs [FRA 24a]*

This concentration has intensified in recent years, with a wave of mergers and acquisitions driven by the search for economies of scale, regulatory requirements (Solvency 2 in Europe) and the need to invest in digital technologies[8]. This intensification of competition has resulted, on the one hand, in a banalisation of offerings between the various players (which often leads to a lack of differentiation in the eyes of policyholders), and, on the other, in the arrival of new players with aggressive pricing policies and a convergence of practices.

2.2. *Insurance: a business based on specific principles*

However, the insurance industry is not a business like any other. It is based on specific principles that help to characterise it:

A financial claim: The fundamental nature of insurance distinguishes it from conventional services through its unique temporal and functional characteristics. Unlike traditional services acquired for immediate consumption, insurance operates as a financial instrument — specifically, a contingent claim

[5] In 2020, insurers and pension funds managed €58,000 billion in financial assets, or 29% of global financial assets [ALL 21b]. In France, half of all insurers' investments are in France [FRA 24a].

[6] This is particularly the case in France, where the insurance sector protects more than 58 million vehicles, nearly 38 million homes, more than 4 million businesses and nearly 96% of the French population for health insurance [FRA 24a]. In 2023, total insurance premiums paid represented 252.8 billion euros, including 182.3 billion euros for personal insurance (life insurance, pension capitalisation, health and welfare insurance) and 70.5 billion euros for property and liability insurance (motor, personal and professional property damage, civil liability, construction, natural disasters, transport, legal protection, assistance, credit and Bond insurance, cyber...) [FRA 24a]. In return, the total benefits paid out by French insurers to their policyholders in the event of a claim represented 224.9 billion euros in 2023, including 172.8 billion euros in life and health insurance and 52.1 billion euros in property and liability insurance [FRA 24a].

[7] In France, insurance providers fall into three categories: for-profit insurers, non-profit mutuals and provident and supplementary pension institutions. In 2023, there numbers were 302, 324 and 34 respectively [ACP 24].

[8] The number of insurance organisations operating in France fell by 28% between 2013 and 2023 [ACP 24].

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— designed to transfer risk from individuals to institutional risk pools ([ARR 70] [LOU 25]). This distinctive feature necessitates an inverted production cycle that fundamentally shapes the sector's operational logic.

The inverted production cycle: The insurer sets the price (tariff or premium) of its service and collects payment (premium) even before the slightest claim (possibly) occurs, at a cost that is unknown ex ante (benefits). The insurance business model is thus based on the possibility of ex-post, hypothetical compensation for (monetary) losses incurred by policyholders who provide proof of loss. What's more, the insurer has a cash surplus (working capital capacity) which it places on the financial markets in anticipation of having to deal with potential claims. In fact, an insurer's accounting income comes from both an underwriting process (difference between earned premiums and expenses incurred by the insurer: acquisition costs, underwriting expenses, claims costs, claims handling expenses, prevention...) and an investment process (capital gains from investing premiums on the financial markets) [DES 13].

Risk pooling: Individual risk is diluted within a multitude of risks (the law of large numbers and probabilistic regularities). Insurance thus transforms individual uncertainty into an aggregate risk that is both measurable [BAR 20] and insurable [BER 82]. Based on past claims for similar risks, insurers can estimate the distribution of claims (frequency and cost) for a pool of policyholders [CEV 22]. In this context, "good risks pay for bad risks": those paying premiums without claims effectively compensate those who suffer losses. Risk is shared both socially—across policyholders—and temporally, as accumulated premiums over time finance future claims. This socialisation of risks ensures broad accessibility to insurance but presupposes a critical size to spread fixed costs and benefit from economies of scale [KAT 98] ; [DIA 02] ; [FEN 08] ; [DES 13]. Risk pooling also requires historical depth in claim data and is therefore unsuitable for insuring emerging risks or those marked by statistical ruptures.

Risk segmentation: Policyholders are divided into homogeneous classes according to "discriminatory" (in the statistical sense) criteria (age, state of health, place of residence, type of vehicle, etc.) and their history. Segmentation refers to a situation in which several homogeneous policyholders share the same probability of making a claim [LEH 11]. Risk is thus distributed within a segment, but not between segments. The principle of segmentation is based on the mechanism of risk transfer [CEV 22], whereby each group of policyholders transfers a specific risk to the insurance company and pays a premium proportional to the risk transferred. This then enables insurers to price premiums more accurately and according to the different risk levels of each insured person [BAR 20]. It should be noted, however, that the less an insurer segments its portfolio (as is the case with non-profit insurers or mutuals), the more it forgoes an opportunity to be competitive [CEV 22].

Information asymmetries (moral hazard and anti-selection): Since insurers know policyholders less well than they know themselves ([ARR 63] ; [AKE 70]), insureds may exploit this asymmetry ([SPE 71] ; [PAU 74]), forcing insurers to cover "bad risks" [ROT 76]. To mitigate this, insurers must induce policyholders to reveal risk ex ante (e.g., deductibles) and/or to maintain prudent behaviour once insured (via contractual clauses, bonus/malus mechanism or preventive actions).

Prudential regulations: Insurers are subject to strict and often complex regulations due to the systemic nature of their financial commitments[9]. Insurers are required to have sufficient equity capital and to set aside sufficient technical reserves to cover any major actuarial risk (not correctly estimated ex ante) (the

[9] In recent years, new regulations have been imposed on the sector. These include Solvency 2 and IFRS 17, the ANI law of June 15, 2013 on the generalisation of company supplementary healthcare, the European Directive on Insurance Distribution (DDA) or the General Data Protection Regulation (RGPD). Regulations relating to the cybersecurity of information systems or the fight against money laundering and the financing of terrorism have also become tougher in recent years. A European directive on trustworthy AI finally has emerged in 2024.

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probability of an insurer going bankrupt must be less than 0.5%)[10]. Although necessary for the stability of the financial system, these prudential rules act as a brake on innovation in the sector [KLE 12]. The costs associated with compliance are significant, in terms of time resources to be allocated or investments to be made in control systems, risk management or anti-fraud systems. This regulatory burden weighs particularly heavily on medium-sized insurers and new entrants to the sector. Moreover, as insurance is an "expertise-driven" business [ALB 19], largely based on "expert opinion", its processes can only be partially automated. Prudential rules and the weight of expertise therefore naturally constitute strong barriers to market entry, which greatly protect traditional insurers from outsiders [ELI 18].

Long-term vision ("ultimate"): Prudential rules require insurers to set aside provisions for claims incurred (during the year) but not yet reported or settled (at the end of the year), and to project (predict) the cost until the case is closed (i.e. "ultimate"). This complex mechanism (certain claims may give rise to many provisions over several years) guarantees insurers' ability to meet their future commitments, while ensuring their own financial stability.

An often intermediated insurer-policyholder relationship: The sector is also characterised by a multifaceted distribution of these products involving intermediaries such as insurance agents (captive or independent), insurance brokers (unavoidable for complex insurance policies and insurance dedicated to businesses) or online insurance comparators [DES 13].

A low-tech industry: Since insurance requires a large amount of data and therefore major investment in storage and computing capacity, it is by its very nature a "technology-intensive sector" [NEA 25]. Since its origins (and even before the computer age), insurance has always used "technologies" to classify and allocate risks and liabilities between people, objects and goods[11] [MCF 18]. As such, it constitutes a "risk management technology" [BAR 23]. Paradoxically, the sector is not very R&D-intensive (according to the OECD classification), insofar as insurers devote less than 2-3% of their sales to it [SWI 11]. This does not necessarily mean that the sector is not innovative [FRA 04] ; [CAT 18a] ; [LAN 22] ; [OZC 24]). Insurance innovations are not generally the direct result of R&D spending and patenting (McShane et al., 2012), but often derive from other, more high-tech sectors [POT 09]. Indeed, while technological investment in the sector has risen considerably in recent years [SWI 23c][12], spending in this area has mainly been in the IT field, to modernise outdated information systems and develop new analytical capabilities [FRI 21].

2.3. *An insurance industry whose profitability has deteriorated in recent years against a backdrop of profound change*

To be profitable, insurers need to be able to set their premiums ex ante, before knowing the exact state of their claims record ex post. Their profitability also depends on the amount of their management and marketing costs, as well as on the financial return on the premiums they place on the financial markets, and on their solvency ratio (which measures their risk exposure and the extent to which it is covered by their equity capital), as imposed by the sector's prudential rules. Put another way, the sector's profitability depends on the intensity of competition (and therefore on the degree of policyholder attrition and their innovation capacity), their claims record (in frequency and severity), the profitability requirements of their shareholders, the regulatory framework and economic conditions (the level of interest rates on the financial markets, the rate of inflation and the rate of economic growth).

[10] In France, insurers must be authorised by the ACPR (Autorité de Contrôle Prudentiel et de Résolution). Some categories of insurance (such mutual health insurance and life insurance) are subject to additional requirements.

[11] This leads [MCF 20] to assert that insurance « *is, in sum, an arcane, esoteric, yet quotidian and ubiquitous socio-political-economic technology and this – almost paradoxically – has made it an unattractive object of study in the humanities and social sciences* ».

[12] In France, insurers have thus invested more than 4.5 billion euros in digital transformation in 2023, or nearly 5% of their gross premiums [ACP 24].

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Recent deterioration in sector performance: Yet, in recent years, while insurers' return on equity (ROE) has averaged between 6.5% and 7.8% [SWI 18] (Swiss Re Institute, 2018), this is primarily due to a (cyclically) surplus financial result offsetting an increasingly (structurally) negative operating result[13]. Worse still, the sector's Total Shareholder Return (TSR) is lower on average than that of most other sectors and is often lower than the cost of equity capital [BCG 24]. At the same time, insurers' average combined ratio (which measures the ratio of claims and management expenses to earned premiums) has deteriorated in recent years, particularly in non-life insurance [ACP 24]. There are several possible explanations for this lower (operating) profitability in the insurance sector.

Climate change as a systemic risk: The risks associated with climate change are thus increasing in frequency and impact[14]. The number of weather-related events and their severity (number of victims, economic damage) have been increasing for several decades [SWI 20]. In France, weather-related losses are expected to rise by 35% to 120% by 2040, due to the increase in floods, hurricanes, cyclones and forest fires. Premiums for primary insurance cover are also set to rise by 30% to 60% by 2040 (excluding inflation). The share of natural catastrophe risk in property insurance premiums is even set to rise from 20% to 30% over this period. A study by France Assureurs [FRA 24c] predicts that the cumulative volume of natural catastrophe claims over 30 years will rise by 93% (from 74 billion euros between 1989 and 2019 to 170 billion euros between 2020 and 2050). Climate change now constitutes a systemic risk for the insurance sector, given both its undeniably anthropogenic nature [IPC 22] and contemporary socio-economic and demographic changes (population growth, increasing urbanisation, concentration of assets and wealth, accelerating penetration of non-life insurance in developing countries, rising value of insured residential and commercial property, increasing judicialisation...). Climate change thus has a negative impact on both the assets and liabilities sides of insurers' balance sheets [MIL 05], even though their forecasting models struggle to take account of the complexity of this phenomenon [SWI 20] and their socially and environmentally responsible investments are still insufficient. In this way, climate change contributes to reducing the scope of insurability. Finally, its impact (through a "snowball" effect) on other risks (health, geopolitics, demographics, infrastructures, etc.) gives it an undeniable systemic character [FRA 24b].

Demographic transitions and new consumer expectations: At the same time, longer life expectancy is changing consumption patterns (greater demand for leisure, mobility and health) and savings (financing the end of life), reshaping the logic of wealth transfer (later in life) and creating new needs (health, providence, retirement, dependency, etc.). This represents both a challenge and an opportunity for the insurance industry. This demographic change requires the adaptation of insurance products (mutual health insurance, life insurance, etc.), provisioning models (over longer periods) and risk management, while opening the way to new services (based on prevention and home assistance) and better consideration of seniors' needs. This phenomenon is also accompanied by a generational shift in insurance expectations. As in many other fields, we are witnessing the emergence of new consumer behaviors, which characterise the shift from an economy of possession to one of fractionated, personalised use.

Emergence of new risk: New risks are also emerging with the spread of computer viruses (cybersecurity, crypto-currency exchanges or IoT infrastructures) and biological threats (pandemic

[13] According to the ACPR [ACP 24], ROE in France reached 8.2% in 2023 (versus 7.1% in 2022, 5% in 2020 and 7.8% in 2018), thanks to a surplus technical result (15.6 B€), substantial financial income (9.8 B€) and very high shareholders' equity (the solvency ratio of French insurers was 238% in 2024, well above regulatory thresholds).

[14] By 2040, global premiums for property and casualty insurance are expected to reach $4,300 billion (versus $1,800 billion today), including $1,300 billion for property insurance (three times the current level) and $183 billion for climate risks (+22%) [SWI 21]. In 2024, insured losses from natural catastrophes amounted to US$146 billion (making it the fourth-highest annual amount reported) compared with $100 billion each year on average over the 2017-2021 period ($81 billion annually on average over the 2012-2021 period and less than $60 billion each year between 1992 and 2021) [SWI 23a] ; [SWI 25a].

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risks[15]) that insurers struggle to cover[16]. The emergence of these new risks necessitates a threefold transformation of traditional insurance approaches [FRA 24a] ; [ELI 25] ; [KRA 25]. First, insurers must develop innovative provisioning models that incorporate unconventional data sources, forward-looking scenarios, and advanced modelling techniques. Second, this evolution requires enhanced collaboration and risk-sharing arrangements among diverse stakeholders, including insurers, reinsurers, governments, and financial markets. Third, these operational changes demand corresponding adaptations of the regulatory framework to accommodate new risk categories and assessment methodologies. The rise of these new risks represents a particularly complex challenge for insurers. The main difficulty lies in assessing these risks, which are characterised by a high degree of information asymmetry, rapidly evolving threats and a potential for systemic losses [ELI 22a].

From digitalisation to IA transformation: New technologies are reshaping the insurance industry, accelerating its digitisation and datafication [ELI 18] ; [BOH 19] ; [BAR 20] ; [CAP 20] ; [ELI 22a] ; [LI 22b] ; [ELI 24] ; [BAR 23] ; [BRA 25a]. AI and insurtech naturally play a crucial role in this process [CHA 25b] ; [ELI 22b] ; [ELI 24] ; [HOL 25] and open new prospects for innovation, as we will show in later sections of this paper.

3. Specificity and nature of innovation in insurance services

While the preceding analysis has established the structural challenges facing the insurance sector, understanding the sector's innovation dynamics requires a deeper examination of the specific characteristics that distinguish insurance services from other economic activities. This investigation reveals that insurance innovation follows distinct patterns that challenge conventional service innovation frameworks. In this perspective, this second part aims to describe the distinctive characteristics of innovation in the insurance sector prior to the recent emergence of AI/insurtech. The insurance sector, long perceived as lacking in innovation, nonetheless displays specific (incremental) innovation dynamics, shaped by the very nature of the insurance service, its organisation and its ecosystem. This section explores these characteristics in three successive stages: the specific nature of insurance services and their implications for innovation (3.1); the growing importance of information and communication technologies in insurance innovation (3.2); the organisational and ecosystem dimensions that structure innovation dynamics in the insurance sector (3.3).

3.1. *Innovation in insurance services*

To examine the potential for innovation in the insurance industry, we first need to look at its specific characteristics as a service. Its value chain highlights the way in which the insurance service is based on coordination between several professions with sometimes contradictory missions (pricing/underwriting/marketing vs. reserving/claims management). As we saw earlier (cf. 1.2 above), insurance also differs from other services in its temporality: its consumption is disconnected from the act of purchase, and potentially hypothetical in the absence of a claim. Finally, the insurance service is strongly rooted in a shifting socio-economic-regulatory context, so that the boundaries of insurability are constantly evolving according to insurers' ability to quantify hazards and model them [ELI 18].

It can be complex to identify innovations in insurance services. It involves distinguishing the service (as a product) from its process. It also entails questioning the nature of the service itself. In this perspective, the work of Gadrey and Gallouj [GAD 94] makes it possible to distinguish forms of insurance innovation by highlighting the areas and potential for technological use which are specific to

[15] OECD has estimated the cost of one month's confinement at 1,700 B$ worldwide (91 B€ in France) [OEC 21].

[16] Covering these major risks requires pooling with other "risk carriers" (government, financial investors, self-insurance) [SCH 22]. However, AMRAE [AMR 21] has shown that only 0.0026% of VSEs/SMEs (very small, small or medium-sized enterprises) are covered against "cyber" risks (compared to 87% of large companies; the latter even create their own cyber insurance or reinsurance captives against this specific risk).

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the sector (*cf*. Table 2).

Innovation categories	Innovation type	Definition	Example
Service Product	Absolute	A new Product/Service	Parametric insurance, which automatically indemnifies the policyholder on the basis of an parameters or indices (e.g. weather, earthquake) rather than an actual loss.
	Relative	A new product/service that already exists in another company	An insurance company introducing mileage-based car insurance, already available elsewhere
	Customised	Product/Service to meet a specific demand (customer) or need (niche market, regulatory adaptation)	A cyber-risk insurance developed specifically for SMEs in the healthcare sector
Architectural	Combining an existing products and services	Creation of a packaged solution by combining existing products/services	An insurance combining home and connected objects to offer real-time risk monitoring
	Unbundling of products/services	Deconstructing an existing packaged solution for separate marketing	Travel insurance, where companies now make it possible to purchase separately cancellation cover, medical expenses cover or specific cover for lost luggage.
Product/service modification innovations	Modification of specifications, without modification of the final product/service	Addition of a choice category to the existing product/service.	A travel insurance with a special option covering pandemics.

Table 2: *The main forms of insurance service innovation - [GAD 94]*

3.2. *The gradual digitisation of the insurance industry*

At the same time, since insurance is a risk-measurement business, its information systems (IT) are at the heart of many processes (see 1.2 above). Consequently, the issue of innovation in insurance services fits naturally into the broader framework of the integration of information and communication technologies (ICT). Since the 1950s and 1960s, information technology has enabled insurance companies to optimise the various stages involved in designing, marketing and managing their insurance offering. From the 1980s-1990s, as in other sectors, IT went beyond being a simple management tool to become central to the business, in successive waves (digital marketing and online insurance in the years 2000-2010, telematics, data science and AI in the years 2010-2020...).

This adoption-integration of NICTs by service businesses (including the insurance sector) has been the subject of several significant studies in the literature. The pioneering work of Barras [BAR 86] showed that the different stages of computerisation (heavy computing, mini-computing, micro-computing and networks) follow an innovation life cycle that is reversed in services (process innovations preceding product innovations). At the same time, other authors have shown that insurance services follow a technological trajectory based on lower costs and informational networking [SOE 90]. In these studies, the insurance sector is relatively non-innovative, simply adopting innovations from other sectors or developing essentially incremental innovations. Finally, other studies (echoing R. Solow's seminal article [SOL 87] on the absence of productivity gains linked to the mass use of computers in services) have highlighted the inadequacy of productivity measurement tools in services. From this observation emerged a series of works highlighting the complex relationships existing between technological innovations and service companies [GAL 99]. In the light of these observations, research in this field then undertook an in-depth analysis of the relationships between industrial suppliers and service

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activities, examining the ambivalent effect of technologies in the main service sectors [LAM 98] ; [BAN 99]. It has then been established that these technologies can be the source of significant innovations in the content and organisation of service provision (development of the offer, new market opportunities: e-commerce, remote banking or insurance, etc.), as well as in the adaptation of organisation or the creation of new forms of organisation (networks). However, it has also been demonstrated that their impact depends largely on how NICTs are used [BAN 99] ; [BAR 02]. However, as Eling and Lehmann [ELI 18] rightly point out, the digitisation of the insurance industry has been slower than in other sectors, and has not fully exploited the potential of digital technologies, which were already timidly emerging with the advent of the Internet at the turn of the 20th and 21st centuries [MEY 99] ; [EAS 02] ; [GAR 02] ; [DUM 03] ; [BAR 07] ; [DES 13] ; [BOH 19].

3.3. *Innovation and organisation: evolution of the business model based on the evolution of technology.*

Innovation in the insurance sector can then be viewed through the dual prism of insurance as an organisation and the evolution of its business model. Technological innovations and their applications (linked to the development of information technology and the proliferation of telecommunications networks) have also induced or facilitated organisational innovations (new professions, new forms of company). These innovations have helped to transform the sector.

Innovations transforming the insurance organisation

In insurance companies, organisational structuring is inseparable from value creation. More than just a commercialised service, insurance is based on the interaction of various and interdependent skills that shape the sector's internal organisation. Innovation disrupts this organisation by modifying processes and redefining the roles of different departments within an insurance company. Moreover, insurance is founded on a contractual commitment, regulated by law and formalised through an insurance policy [GAD 91]. This framework structures the sector's essential functions, including actuarial services, claims management, compliance, and legal affairs, while also integrating transversal functions such as IT, marketing, and distribution. Each of these functions serves as a driver of innovation.

Similarly, the evolution of the regulatory framework has led to a continuous adaptation of practices, with monitoring and claims management tools optimising compliance and customer relations [DAV 20]. Information and Communication Technologies (ICTs) have also impacted contract distribution and management. The development of online platforms and mobile applications has recently transformed the customer experience by simplifying access to services and reducing processing times. The digitalisation of underwriting and claims processes thus reflects both technological and organisational innovation [POU 19]. Finally, the convergence between innovation and organisation is revealed in the management of interactions between different departments, as technological advancements have fostered better coordination and optimised internal value chains.

Innovation and the insurance ecosystem

Insurance is a complex service, built upon intricate value propositions. As such, the insurance sector provides a framework where innovation ecosystems generate significant added value [DAT 18]. From this perspective, innovation in insurance services is based on interactions between companies [ALL 21a] ; [BAR 15] ; [DEN 00]. This collective dynamic is not limited to the emergence of new offerings; it also transforms the processes of co-creating value for the customer by optimising interactions among stakeholders [RUB 12]. Service activities thus take place within a dynamic ecosystem, characterised by shifting boundaries, continuous adaptation among actors, integration of resources by these actors, and a shared institutional logic that fosters exchanges and leads to mutual value creation [BAR 16]. In this regard, insurance services can be considered as an archetype of a process-based innovation ecosystem [HEL 18]. Innovation should therefore be understood as an activity rather than a simple result [TOI 09],

and the customer should be seen as an active participant in the production process rather than purely a final beneficiary [LÜT 19] ; [HEL 18]. More extensively, the provision of insurance services requires resources from multiple actors—insurers, brokers, technology providers, regulatory institutions—each playing a key role in shaping both service offerings and innovation. This configuration creates a complex dynamic where cooperation and competition coexist, influencing how organisations respond to market demands and technological advances. Insurance companies often use similar software, frequently developed by the same IT providers, to ensure the digital and automated management of insurance contracts. Some companies even impose the use of specific tools for their partners and distributors. Thus, the technological advancements supporting insurance services are sometimes shared among competing companies. As a result, industry players must strengthen their collaborative capabilities. These challenges require innovative approaches that leverage the strengths of different ecosystem actors. This technological interdependence reflects a broader *phenomenon* in the insurance sector: coopetition. Despite competitive dynamics, companies in the industry are compelled to collaborate on strategic aspects such as technological development, risk management, and reinsurance. This configuration presents specific sectoral challenges that influence the industry's ability to innovate.

4. The promises of AI and insurtech for the insurance sector

Building upon our understanding of traditional innovation patterns in insurance, this section examines how artificial intelligence and insurtech are fundamentally reshaping the sector's transformation capabilities. This third section analyses the promises and limitations of contemporary new technologies in the insurance sector. AI and insurtech (4.1) are profoundly reshaping the insurance value chain (4.2) by optimising processes, developing new business models, and transforming the customer experience (4.3). This section is naturally structured around these three key areas.

4.1. *AI, a new general-purpose technology*

The emergence of AI as a transformative force in the insurance sector represents the outcome of more than seven decades of scientific progress. While AI's earliest developments date back over seventy-five years, the technology has experienced several "winters" during which progress stalled due to technical limitations. However, recent breakthrough in machine learning and deep learning, combined with the exponential growth of available data, have fundamentally altered this trajectory and have shifted AI from the era of theoretical discoveries to that of applied AI [LEE 18]. In other words, innovation in AI has recently transitioned from an exploration-driven logic to an exploitation-driven logic [MAR 91] [17].

- *Defining AI as a General-Purpose Technology:* AI can be defined, according to Craglia et al. [CRA 18, p. 19], as « *machines or agents that are capable of observing their environment, learning, and based on the knowledge and experience gained, taking intelligent action or proposing decisions* ». From this perspective, the scope of AI is universal and constitutes a « general purpose technology » [BRE 95], just as the steam engine or electricity were in the past [AGH 17]. More fundamentally, AI can also be seen as a (new) « *general-purpose invention of a (new) method of invention* » [COC 18]. AI thus combines underlying algorithms with large data sets (*big data*), where part of the data is used to train (learning process) the algorithms while the other part is generated by these algorithms (as this is the case with generative AI). AI is both the "oil" and the "internal combustion engine" of our era [LEE 18]. It encourages the development of complementary technologies and is strengthened by their integration. This phenomenon is particularly significant in the insurance sector, where AI and other technologies (insurtech) are fundamentally interrelated or, in other words, represent two sides of the same coin.

- *Paradigmatic Shift in Innovation Processes:* AI thus represents a paradigm shift in many fields by

[17] As Lee [LEE 18] notes, applied AI demands advanced skills: adjusting complex algorithms, managing massive datasets and solving intricate problems. It advances deep learning "step by step", the result of decades of research by leading scientists. Since the rise of deep learning, no innovation of comparable magnitude has emerged.

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changing the very nature of scientific and technical progress [COC 18]. Until now, science and engineering have been guided by a process of innovation based on the principle of parsimony and frugality, i.e. the identification of a relatively small number of causal factors based on an underlying theory. In contrast, AI is based on an alternative innovation process grounded in the principle of prodigality and the ability to predict complex, multi-causal phenomena. To achieve this, it employs a "black box" approach that ignores underlying causes - what Chris Anderson [AND 08] has called "the end of theory" - but which ultimately provides a relatively accurate picture of the phenomena under study. As a result, AI fosters the emergence of a computationally intensive and extractive industry that grants real economic and political power to those who master it and hold the data it both requires and produces [CRA 21] - and this independently from the network effects and economies of scale traditionally (according to the precepts of industrial economics) required to dominate this kind of activity [COC 18]. This market power conferred by AI, which varies according to the sector of activity, is potentially more important in "data-centric" sectors, and particularly in the insurance sector. In these sectors, we are witnessing an explosion of data made available by objects that are already connected (smartphones, cars, watches, bracelets, speakers...) or will be tomorrow (clothing, shoes, glasses, household appliances, medical devices...). At the same time, the volume of data generated by sensors in machines, robots, factories/premises, vehicles and other equipment will thus exceed the volume of personal data of corporate customers and employees [REI 17]. The democratisation of access to information (open data and open source), as well as the increase in computing power and data storage at near-marginal cost, also favour the dissemination of data, both within organisations (public and private) and between them. This explosion in data volume, coupled with high-performance algorithms and near-infinite, low-cost computing capacities, is expected to give rise to new products/processes, new forms of (personalised) pricing and real-time services [BAL 21].

- *The four waves of AI development:* Eventually, AI should enable productivity gains (via quantification, prediction and automation), a redistribution of market share and the development of the innovative capacity of those who adopt it. AI's multi-faceted potential will be gradual and has yet to be confirmed. On-line AI[18] (recommendation tools, automatic editing of written content, "online to offline" offers, etc.) and professional AI (optimisation of existing processes) are already at work, even if it is still difficult to measure their real effects statistically (often for lack of data). Perceptive AI, currently under development, could change the game by altering the boundary between the real and virtual worlds. With the help of sensors and smart devices, perceptive AI opens the way to the possibility, for example, facial recognition payments, automatic "driving" (by comparing the real-time stock in our refrigerator, our consumption habits and the week's schedule), AI-assisted (personalised) education or insurance fraud detection (via the connected vacuum cleaner). In the longer term, autonomous AI could revolutionise agriculture (robotic harvesters), industry (intelligent robots), housing (smart cities) or modes of transport (autonomous cars, autonomous drones).

4.2. *The impact of AI and insurtech on the insurance value chain*

According to major international consulting firms, investors and the most cutting-edge industrialists in the field (Big Tech and start-ups), AI and insurtech are likely to revolutionise every link in the insurance value chain, from the design of contractual warranties to claims settlement, via customer relations, pricing, fraud prevention or detection. As Eling et al. [ELI 22b] point out, the theoretical impact of AI and insurtech on the insurance value chain is twofold: on the one hand, these new technologies can help generate potentially significant productivity gains, and on the other, they are likely to create new revenue streams by transforming the insurance business model from loss compensation to loss prediction and prevention. Moreover, according to AI and insurtech thurifers, this transformation would not only change insurers' business models but also redefine their value proposition to customers and their positioning in the insurance ecosystem [BRA 25b].

[18] We adopt here Lee's [LEE 18] typology, which identifies four successive waves of AI: online AI, professional AI, perceptual AI and autonomous AI.

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Distribution channel revolution and customer experience enhancement

In the field of distribution, the insurance sector has only timidly embarked on the road to digitalisation [ACP 22] and today remains dependent on intermediaries[19]. In this context, AI and insurtech can help accelerate and thus improve the experience of purchasing an insurance policy, without policyholders having to fill in tedious forms and provide supporting documents (the data useful for their pricing and contractualisation being "embedded" in their "digital identity"). This transformation of distribution is particularly visible with the emergence of generative AI, which is revolutionizing customer interactions. According to a recent study, insurance companies that use generative AI in their customer relations (a chatbot, for example) see a significant improvement in customer satisfaction [IBM 24]. Allianz France has leveraged its Ask AI platform to develop two applications, Ask Mail and Ask Bot, designed to streamline interactions with customers and general agents. However, this study also reveals a major mismatch between insurers (who focus on enhancing their brand and products) and their customers (who primarily demand tailor-made products that meet their needs).

Embedded Insurance and Ecosystem Boundary Redefinition

Similarly, AI and insurtech are already helping to accelerate the development of so-called "embedded insurance", i.e. insurance directly integrated into third-party products or services (extended warranties, insurance against the breakage of electronic/appliance items...). Through customised micro-coverages that can be activated on demand or by usage (car insurance by the kilometre or by the journey by MMA, home insurance by the stay for Airbnb rentals...), this trend represents a major evolution in the distribution of insurance products. As Braun and Häusle [BRA 25a] explain, embedded insurance redefines sector boundaries by integrating insurance offerings within third-party products or services, creating new ecosystems where insurance becomes an invisible component of the customer experience. This approach not only reduces customer acquisition costs but also increases insurance penetration rates by reaching traditionally underinsured customer segments. However, it requires a sophisticated technological infrastructure, capable of integrating data from multiple sources in real time, and proposing dynamic pricing adapted to the context of use.

Parametric insurance and blockchain implementation experiences

AI is also currently driving the development of new parametric insurance products (crop insurance, travel insurance, breakdown insurance, etc.). Unlike conventional insurance which compensates real losses), parametric insurance pays as fixed, contractually agreed amount determined in advance. This amount is agreed upon in advance so that the payout is triggered automatically when the predefined threshold (temperature, rainfall, wind force, humidity level, flight delay, etc.) is exceeded. Parametric insurance is generally associated with a blockchain to objectivise its parameterisation and monitoring over time. AI combined with blockchain thus favours smart contracts, helping to reduce both the costs and delays involved in acquiring insurance background checks) and providing cover (compensation) for policyholders. Several insurance companies have already started to explore how they can use blockchain and smart contracts to improve their operations. For instance, the insurance company AXA has launched a product called 'Fizzy', which uses blockchain technology to automate passenger refunds in the event of flight delays. Fizzy uses a smart contract to automatically check flight data and trigger a refund without human intervention if the flight is delay. Parametric insurance represents a particularly promising innovation for covering emerging risks or risks that are difficult to insure using traditional methods. These products broaden the scope of insurance in areas where damage assessment is complex or costly (i.e. natural disasters, pandemics, cyber risks...). The effectiveness of parametric insurance relies on the accuracy of predictive models driven by AI, which establish correlations between measurable parameters

[19] Worldwide, 37% of insurance policies (life and non-life) are sold by brokers, independent agents or affinity insurance agents and 20% by bancassurers, compared with 38% by insurers (sales representatives and exclusive agents) and 6% online [BEW 22].

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and potential losses. However, only 10% of European insurers already offer parametric insurance products [EIO 24]. To explain this low uptake of parametric insurance in the sector, Eling et al. [ELI 22b] emphasise the risk of a mismatch between the fixed indemnity (scheduled benefit) and the actual losses amounts suffered by the insured.

From risk transfer to risk prevention

Lastly, AI and insurtech are contributing to the emergence of new services related to insurance contracts: vehicle driving coaching (to reduce the risk of accidents or fuel consumption) by Axa (Axa Drive Coach App'), health and wellness coaching (sleep quality, stress, dietary advice, teleconsultation...) by Harmonie Mutuelle (Vivoptim App') or the French insurtech Alan (Alan Play App'), "all-inclusive" mobility offers (rental, parking, cleaning, maintenance) by Allianz France (Moovizy App'), redistribution of profits to charities by the French insurtech Wakam ("Wakam for Good" program'), etc. These new services, which have emerged in recent years, enhance the customer experience by multiplying interactions with policyholders and thus their satisfaction [EIS 21]. This move towards additional services reflects a paradigm shift in the insurer-policyholder relationship. As Charpentier and Vamparys [CHA 25b] observe, the insurance sector, like many others, has entered the service era, were customer satisfaction reigns supreme. This servitisation of insurance responds to growing consumer demand for more frequent and meaningful interactions with their insurers (beyond the simple payment of premiums and claims settlement). However, this approach also raises important questions about policyholder privacy and autonomy. As Cevolini and Esposito [CEV 22] point out, the connected devices that power these coaching services collect personal and even sensitive behavioural data that can be perceived as intrusive.

Underwriting process transformation and algorithmic decision-making

On the underwriting front, AI and insurtech also promise to revolutionise the insurance industry [BAL 21]. Traditionally, insurers' underwriting rules are governed by a few contractual restrictions (medical, age or gender criteria, for example) that slow down underwriting. Here too, new technologies are helping to speed up the process, for example through natural language processing techniques to automate the processing of documents to be submitted [BAL 21], image, sound or video analysis techniques (for example, to assess the condition of the roof of a building to be insured using a drone) or sentiment analysis techniques (to measure the sincerity of the policyholder when filling in the pre-underwriting questionnaire[20]) [WAJ 22]. Luko, for example, uses AI to detect document fraud: this French insurtech company, which is a subsidiary of Allianz, uses a software-as-a-service (SaaS) solution from Finovox to verify invoices and quotes provided by its customers. Similarly, the insurtech company Shift Technology offers AI underwriting solutions that are used by many insurers (Generali, Cegema…) to detect fraud and improve the reliability of risk selection while automating processes. AI and insurtech are thus helping to "de-ritualise" insurance purchasing, even if it means making it potentially impulsive. However, this transformation of underwriting by AI raises important ethical questions. The use of machine learning algorithms to assess risk can lead to discrimination if the training data contains historical biases [ELI 24]. To tackle this risk, regulators (such as the ACPR in France) now require insurers to be able to demonstrate the algorithmic fairness and explainability of their AI models. This is a technical challenge, however, as the most advanced deep learning models often function as "black boxes" whose decisions are difficult to interpret, even for their designers [CHA 25b].

Data ecosystem integration and real-time algorithmic pricing

At the same time, AI and insurtech open the possibility of innovating insurance pricing processes. From now on, pricing models can be fed by both internal data - provided that the insurer's IS is "de-

[20] In the EU, these techniques are prohibited (IA Act), in contrast to more permissive legislation in the world.

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siloed" - and external data. Supplied by third-party APIs (application programming interfaces) and data providers (insurance aggregators or comparators, general agents, brokers, assistance providers, healthcare networks, Big Tech, automakers, manufacturers, etc.), external data has in fact been multiplying in recent years and is challenging insurance companies' monopoly of data creation and possession. AI-enabled pricing can be enriched, automated and available in near-real time, thanks to deep learning models, whereas it has traditionally been standardised (based on the same criteria) and revised only very occasionally (based on a history of claims frequency and severity). It is within this context that French InsurTech company Akur8 has specialised in AI-assisted insurance pricing optimisation. Akur8 offers a solution that enables insurers to accelerate the development of their models and create transparent and explainable pricing models. Akur8 works with more than 300 insurers (mostly auto insurers) worldwide, including major insurers such as AXA, Generali, GMF, MMA, MAAF or MAIF. This shift towards more granular and dynamic pricing represents a fundamental change in the traditional actuarial approach. Machine learning models can integrate a much larger number of risk variables and capture complex interactions between these variables than the generalised linear models traditionally used in actuarial science [MEN 22]. This wealth of data, combined with the predictive power of AI algorithms, enables a much more accurate assessment of individual risk. However, as Charpentier and Vamparys [CHA 25b] point out, this increasing individualisation of pricing raises fundamental questions about the very nature of insurance, traditionally based on risk pooling. Over-fine segmentation could lead to progressive "demutualisation" (where high-risk individuals are offered prohibitively high premiums), calling into question the principle of solidarity inherent in insurance.

IoT-enabled proactive risk management and fraud detection

It is arguably in claims management that AI can have the greatest impact for insurers [BAL 21]. Already, claims reporting process can be streamlined[21], automated, documented and, ultimately, accelerated using sensors, smartphone or drone-captured photos and videos, or interactions with chatbot or voice assistants. Insurance services such as compensation, assistance, or repairs can therefore be significantly expedited. [BAL 21]. For example, the French InsurTech company Weather Claim Control (WCC) offers an AI-based tool that enables insurance managers to verify whether climate-related claims should be compensated based on actual weather conditions. The tool uses data from Météo France and partner algorithms. In the long term, the Internet of Things (IoT) could also grant insurance a proactive role, enabling real-time alerts to policyholders when a claimable event (e.g., a breakdown, accident, fire, or illness) occurs—or even before it does. Fraud detection and the enforcement of contractual compliance may likewise benefit from AI, with human intervention reserved for the most complex or contested cases [BAL 21] ; [ACP 22] ; [FRI 22]. Covéa Group uses the Tractable insurtech tool to match repair estimates with photos of damaged vehicles. The automation of claims management automation thus represents a major lever for improving insurers' operational efficiency [ELI 22a]. However, several obstacles still hinder full automation. Some complex or high-value claims continue to require human expertise to accurately assess damages and context. Furthermore, policyholders may experience a lack of empathy in a fully automated process, especially in emotionally charged situations such as serious accidents or major property losses [BRA 24].

4.3. *Insurance innovations driven by AI and insurTech*

Finally, innovations driven by AI and new insurance technologies are also the source of innovations that can take many forms.

Process innovations in back-office operations

In back-office operations, AI and insurtech can be the source of many forms of process innovations.

[21]Nearly 40% of French policyholders who have suffered a claim have already given up because of the cumbersome claims process [MAY 22]. And yet, the "bad" customer experience is the main cause of infra-annual cancellations (or tacit annual non-renewals).

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These innovations are especially useful in detecting and preventing fraudulent activity, thanks to their ability to analyse large volumes of data and identify anomalies. These innovations make it possible to spot false documents or inconsistencies in claims. The French company CertifiCall, for example, offers an AI-powered solution that can certify, timestamp and trace photos and videos of damage, thereby guaranteeing their authenticity without the need for a human expert. At the same time, the automation of routine, labor-intensive tasks, is a prime area of application for AI and insurtech, particularly in claims management and underwriting. For example, AXA uses Instabase technology to process complex car insurance claims involving medical records for bodily injury, first responder reports and third-party garage invoices, as well as life, disability and long-term care claims involving medical records, tax documents and death certificates. They then enable dynamic pricing (in near-real time) by adjusting insurance premiums according to various parameters and constantly changing data. Finally, actuarial methods are undergoing a significant evolution with AI and insurtech via the use of sophisticated analytical tools enabling actuaries to integrate new data sources (IoT, open data, weather...) and use predictive algorithms to improve risk assessment and management [LUC 22]. In short, the emergence of these process innovations is largely explained by the fact that traditional insurers are now facing major profitability challenges. Furthermore, this acceleration is driven by the tangible results achieved by early adopters (IBM, 2025). However, to avoid AI initiatives being deployed in silos (without a holistic vision), insurers need to adopt a holistic approach that integrates AI into a broader digital transformation strategy [ELI 22b]. Indeed, process innovations require not only technological investments in AI and insurtech, but also a rethinking of "business" processes and an evolution of insurers' organisational culture, as we now demonstrate.

Organisational innovations and business model transformation

At the same time, the rise of AI and insurtech drives organisational innovations redefining the relationship between insurer and insured [BRA 17]. In partnership with incumbents, insurtech players foster new business models that have emerged in recent years. Usage-based insurance (pay-as-you-drive or pay-how-you-drive) illustrates this organisational mutation by substituting a static actuarial logic (which remains predominant) with dynamic pricing based on telematic data [DES 13] ; [SCH 16]; [ELI 20] ; [GUI 07]. However, these emerging models, based on real-time analysis of policyholder behavior (mileage, driving style), require an overhaul of underwriting and risk management processes (IoT sensors, cloud platforms and predictive algorithms). Organisational and process innovations are thus intimately linked in the insurance sector. In this context, traditional insurers are forced to integrate technological ecosystems with partners specialised in data collection and processing. One example is Descartes Underwriting, a French insurtech company that uses AI to provide localised parametric flood insurance. This product is triggered when the physical water level at the insured property exceeds a certain threshold, as measured by sensors. At the same time, business models based on embedded insurance [BRA 25a] are redefining sector boundaries by integrating insurance offerings within third-party products or services. Wakam is a French insurance company and a key player in the creation of white-label, tailor-made, embedded insurance solutions for its distribution partners and customers, which it provides via its "Play & Plug" platform. This approach allows other companies, such as banks and travel companies, to integrate Wakam insurance products into their own customer journeys. Finally, P2P (peer-to-peer) insurance, online mutual aid, decentralised insurance and B2B2C (business-to-business-to-consumer) white-label models are gradually developing, driven by neo-insurers, retail and tech companies [ABD 22]. These organisational innovations reflect a profound shift in the very conception of insurance towards greater individualisation of products and services [CHA 25b]. This trend is of course not unique to the insurance sector but is part of a broader economic shift towards "mass customisation".

Product innovations and new services

In many cases, these new insurance business models complement rather than replace the traditional indemnity business model [BRA 17]. They do, however, enable insurance players to market new

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products and services. Thus, organisational and product innovations also work in tandem. So-called parametric insurance, for example, makes it possible to cover new emerging risks hitherto uncovered by the traditional insurance field [JER 23]. At the same time, on-demand insurance products offer flexible coverage that can be activated (and deactivated) according to the customer's needs (often via a mobile app), notably for specific activities (travel, occasional work, etc.) and based on pay-per-use [CHE 21] ; [ZEI 22]. MAIF's development of pay-per-minute car insurance through its subsidiary Altima is emblematic of the trend towards 'pay-as-you-go' insurance products, which use a Bluetooth device in the vehicle linked to a mobile app. Similarly, embedded insurance products make insurance services virtually painless, as they become integrated with products or services offered by non-insurance third parties (automakers, retailers, Big Tech, etc.). AXA markets an open API platform that enables partners, including distributors, lessors and mobility operators, to integrate its insurance products directly into their customer journeys. This includes rent guarantee insurance offered when signing a lease and cancellation insurance or travel assistance included in the purchase of a train or plane ticket or holiday package. Finally, the insurance sector is increasingly offering products focused on prevention and customer support. There are numerous use cases in this area. AXA France uses its Digital Commercial Platform to offer prevention services that use predictive data to identify policyholders at risk of forest fires. These policyholders receive personalised advice and alerts in real time, as well as support programmes for people with chronic illnesses. Similarly, Generali France provides its customers with digital tools to alert them to risks such as weather events and cyberattacks and offers personalised prevention programmes based on detailed analysis of policyholder data to provide information, alerts and recommendations for personal or family protection. Alan, an insurtech company, is also interesting as it was the first French insurer to offer innovative mental health solutions in France through its "Alan Mind" program. Insurers are in indeed capitalizing on huge masses of data that AI and insurtech solutions can convert into personalised advice (in health matters in particular), transforming their role from simple claims payers into genuine risk management partners [BRA 25a]. This move towards more flexible and personalised insurance products responds to a growing demand from policyholders (particularly the younger generations) for instant, usage-based services and products linked to new lifestyles or work patterns [ZEI 22]; This approach contrasts sharply with the traditional fixed-coverage annual insurance model. However, despite their apparent advantages, these innovative products are relatively under-subscribed [CEV 22]. This reluctance can be explained both by concerns about privacy, and by a lack of understanding of the concrete benefits offered by these new products.

5. A plea for a conceptual framework for innovation in insurance services

The preceding analysis of AI's promises and applications sets the foundation for developing a comprehensive analytical framework capable of capturing the complexity of innovation dynamics in the contemporary insurance ecosystem. As we have just pointed out, AI and insurtech represent a historic opportunity for insurance organisations. By using them to assess, prevent and manage risks, insurers can hope to improve their ability to anticipate events, reduce the financial losses incurred by unanticipated claims and offer more personalised services to their customers or policyholders. As AI use -cases and insurtech solutions expand, their importance in the insurance sector continues to grow, paving the way for insurance that is more innovative, efficient and adapted to society's changing needs. At the same time, we have emphasised the extent to which the spread of these new AI/insurtech technologies is accompanied by a transformation of the insurance ecosystem. The traditional framework for analysing the dynamics of strategic and organisational change in the insurance sector (which we described earlier) therefore needs to be revisited. A new conceptual framework of analysis is indeed essential to understand the new dynamics of innovation in the insurance sector in the age of AI and insurtech, and to answer the many research questions they raise. This is what we propose to outline in detail in this final section.

5.1. *Theoretical foundation: Adapting the RAISA framework to insurance*

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For this purpose, the work of Ivanov and Webster (2019) [IVA 19] is mobilised. These authors defend the idea that the adoption of artificial intelligence technologies is part of a dynamic of profound transformation in service sectors. Applied to the tourism, hotel and catering sectors, their model proposes a systemic reading of the adoption of so-called RAISA technologies (Robots, Artificial Intelligence and Service Automation) by integrating three levels of analysis: internal company dynamics (notably managerial and employee postures), interactions with external stakeholders (customers, technology suppliers, competitors) and macro-environment influences (regulations, societal and technological developments, cultural perceptions). This analytical framework thus enables us to think of AI adoption not simply as a technological issue, but more as an organisational, social and strategic process with structuring effects. Their work highlights the tensions, resistances and opportunities associated with the adoption of these technologies, while underlining the need to analyse the implications for both organisational processes and the global ecosystem in which companies operate. From this perspective, internal players play an ambivalent role: managers (as decision-makers) carry out a cost-benefit analysis, while employees may be reticent about the risks of deskilling or substitution (unless they perceive a clear benefit in terms of work enhancement or comfort gain). At the same time, customers play a key role in the acceptability of these technologies, and are influenced by their past experiences, current representations and the promises made by RAISA suppliers. In turn, the adoption of these technologies has an impact on service design, work organisation, financial performance and, ultimately, the global competitiveness of insurers.

Inspired by this systemic approach, we propose here to adapt this conceptual framework to the insurance sector. This field, although very different in its fundamental missions from those of tourism, hotels and catering, shares certain structural characteristics with these latter: it is a service based on long-term customer relationship management, which is information-intensive and for which the ecosystem is currently marked by technological, regulatory and competitive transformations. This adaptation of Ivanov and Webster's [IVA 19] conceptual framework to the insurance sector aims to better understand how AI and insurtech technologies are transforming insurance organisations, both internally (adoption, acceptance, process transformation, human impacts) and externally (customer relations, interactions with insurtech and big tech, redefining the insurance value chain). Our analysis framework also mobilises dimensions specific to insurance: the nature of the risk covered, ethical and regulatory constraints linked to personal data, as well as the specificities of insurance structures (private companies, mutual insurance companies, provident institutions...). Ultimately, this ecosystemic analytical framework enables us to capture the dynamics at work in the adoption and implementation of AI/insurtech in insurance services, considering both organisational particularities, ecosystem logics, as well as the cultural and ethical dimensions (figure 1).

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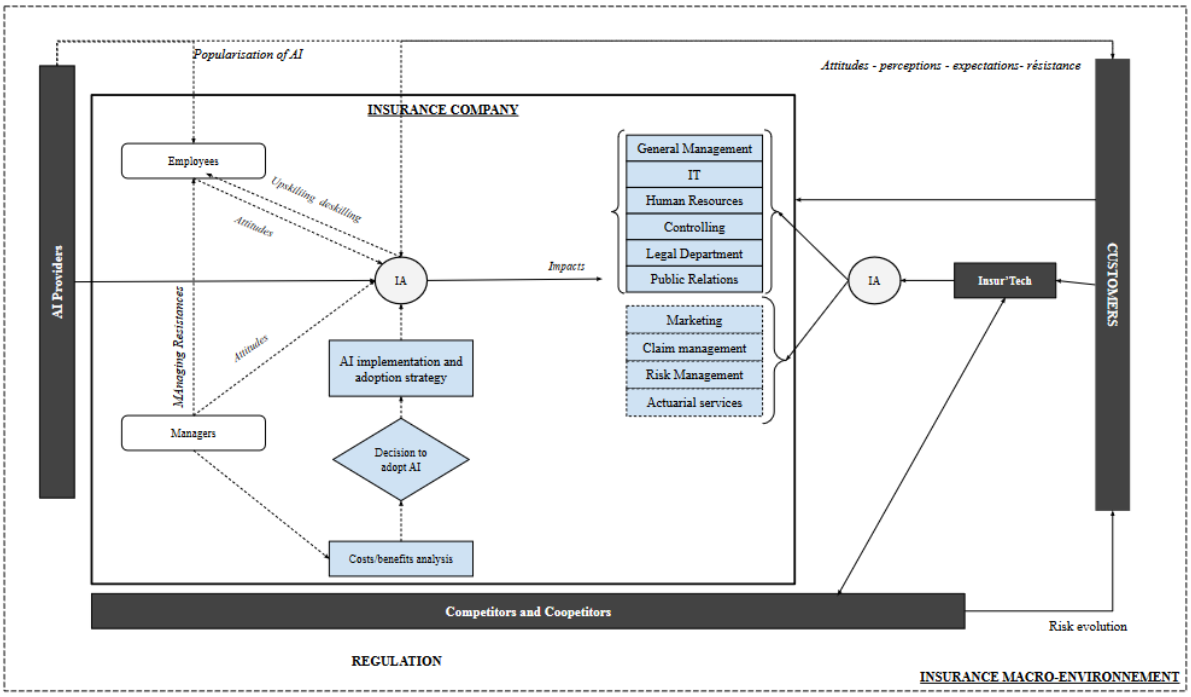

Figure 1. *Conceptual framework for AI in insurance, inspired by Ivanov and Webster (2019)*

NB: In this model, solid arrows illustrate economic flows: these can be data flows, financial flows or service flows. Dotted arrows illustrate relational dynamics: relationships, attitudes or behaviors

The insurance ecosystem is becoming increasingly complex. While traditional players tend to consolidate, the systemic nature of the service, combined with technological innovations, has paved the way for a multitude of new entrants. Insurtech companies are now involved in an expanding number of stages within the value chain. They offer or co-develop tailored solutions for multiple insurers and are gradually moving beyond their role as solution providers to become fully-fledged actors in the ecosystem. Figure 2 illustrates the insurance ecosystem and its new players.

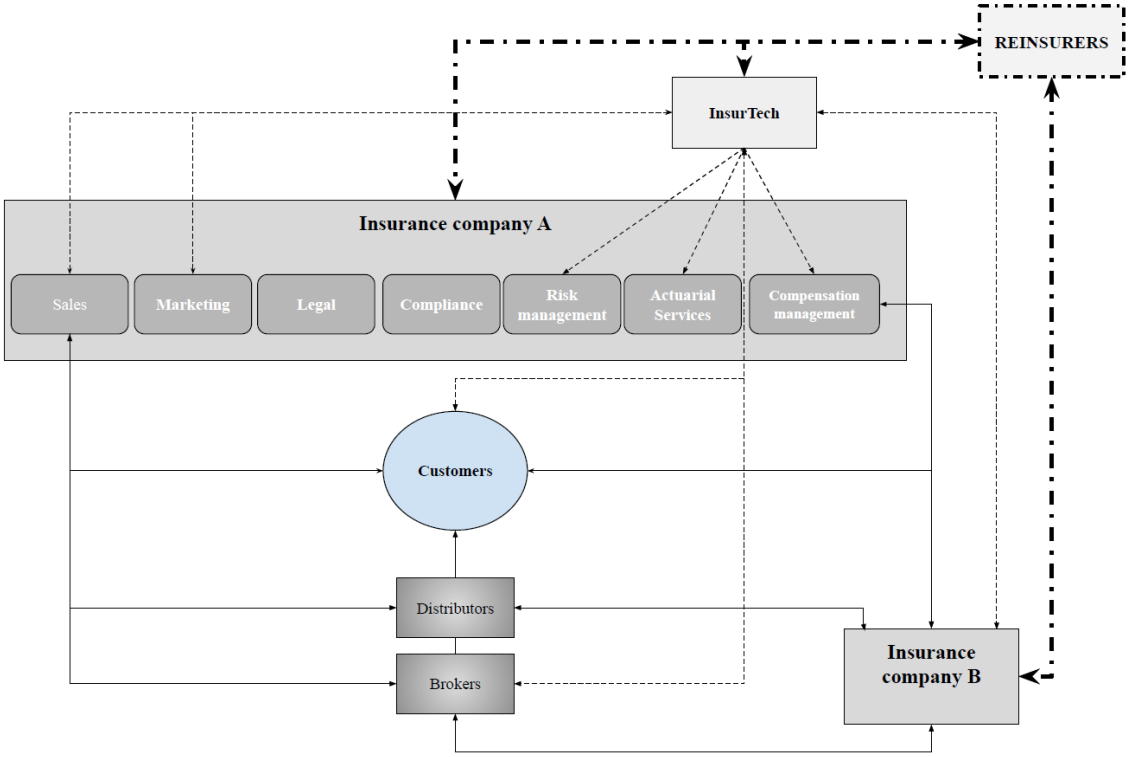

Figure 2: *The insurance ecosystem: traditional and new players*

5.2. *Evolutionary and ecosystem perspectives on innovation trajectories*

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However, the adoption of AI and insurtech by insurance companies is not taking place uniformly. It is part of differentiated trajectories, influenced by organisational routines, past choices and learning dynamics specific to each company. From this perspective, an evolutionary analysis also shows how insurance organisations are gradually integrating AI according to their history, resources and skills.

At the same time, the integration of AI and insurtech in the insurance sector cannot be analysed without considering the interdependencies between players. Adner's emphasises that the value of an innovation depends on the coordination of an adoption chain that includes suppliers, partners, customers and regulators [AND 17]. Insurance, as a sector structured around an extended value chain, is particularly concerned by these systemic dynamics.

5.3. *Service innovation life cycle and transformational phases*

Finally, our analytical framework builds on Barras' seminal model [BAR 86], which outlined the dynamics of innovation in services through three successive phases. Adapted to the today's context in the insurance sector, Barras' innovation life cycle model seems more relevant than ever. In the first phase, AI and insurtech are leveraged primarily to improve operational efficiency, through task automation and cost reduction. In the second phase, these technologies are mobilised to enhance service quality. Finally, in a third phase, they enable more radical innovations, including the development of new offerings, business models, and forms of intermediation. Today, AI and insurtech appear to be approaching—or even crossing—this critical threshold, contributing to a profound transformation of practices, organisational structures and interfirm interactions within the insurance ecosystem.

5.4. *Integrative framework for insurance ecosystem analysis*

It is precisely from this threefold theoretical perspective - ecosystemic, evolutionary and service-oriented - that our contribution is based. This conceptual framework focuses on the insurance organisation (the insurance company or mutual). Schematically, the various activities in its value chain are divided into two distinct parts: those that can be outsourced and those that remain in-house. From this perspective, insurtech start-ups are often key strategic service providers, acting as the interface between the insurer and its customers and prospects. Other insurers (strict competitors and cooperators), AI-providing service providers (not exclusive to the insurance sector) and neo-insurers make up the rest of the external players in this ecosystem. Within the insurance organisation, internal players (employees and managers) are at the heart of the use of AI and insurtech solutions. They decide, implement, use AI and assess its impact on insurance activities. The macro-environment of the insurance business is also subject to two major influences: the evolution of risks (in intensity, frequency and perception) and the regulatory framework. These regulations may relate both to the conditions governing the use of AI — such as the implementation of AI Act in EU — and to developments specific to the insurance sector, notably the enforcement of the 2016 Insurance Distribution Directive. The choices made by different actors are often constrained by path dependencies, organisational routines and specific learning processes. Finally, there is a diversity of business models and organisational forms [ALL 21a]. However, one element common to these different structures lies in the need to mobilise a variety of actors, including those outside the company itself.

Thus, the insurance service, based on data and knowledge, relies on technological developments shared by the entire sector. For example, insurance customer management systems are often created by the same specialised IT providers. Therefore, although insurance companies strongly compete to gain and retain market shares, they also cooperate to innovate and create value for the whole industry. Moreover, InsurTech start-ups gradually became a significant third-party in in the service ecosystem, allowing traditional companies to improve their process while contributing to the emergence of new business models and the transformation of the insurance value chain. They also develop business

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solutions able to compete traditional insurance companies at some specific levels, like sales or risk management. The more actors there are, the more complex the interactions in the ecosystem become (Figure 3).

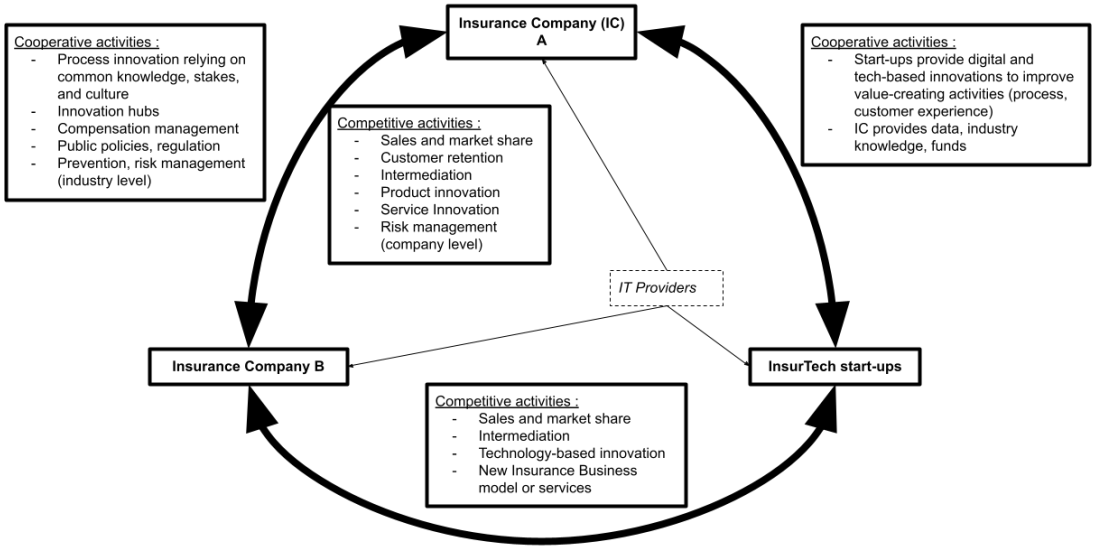

Figure 3 : *A schematic representation of cooperative dynamics in insurance inspired by Ivanov and Webster (2019)* [IVA 19]

In insurance, the relationships and dynamics between stakeholders are thus more complex and diversified than in traditional partnership arrangements. Each player plays a key role in the design and distribution of the service. However, whatever their specificities, insurance companies share a common need: to mobilise various stakeholders, including those external to the company. The relationships and dynamics between stakeholders are more complex and varied than in traditional partnerships in other sectors.

6. Towards a research agenda on insurance innovation

However, while the conceptual model we propose in this contribution provides an accurate picture of the new dynamics of insurance innovation, it still avoids some of the questions that are currently being asked with acuity. In our view, the adoption of AI in insurance companies and its impact are the most pressing issues. Indeed, they constitute the two main and first pillars of the research program in insurance services economics that we are now describing.

6.1. *The complex landscape of AI adoption*

According to Enholm et al; [ENH 22], the decision to adopt an AI strategy can be facilitated or hindered by three sets of factors. Technological factors are based first and foremost on the infrastructures (IT in particular) of insurance organisations, as well as on the data available to these organisations and their ability to manage it. Organisational factors then relate to corporate culture (including the culture of innovation), management and staff motivation, and structural readiness. Finally, environmental factors represent moral and ethical aspects, regulatory constraints and social pressure. For our part, we identify at least five sets of obstacles that may limit the spread of AI and insurtech in the insurance sector.

Regulatory barriers and compliance constraints: The first barrier to the spread of AI and insurtech is regulatory. In the insurance sector, regulators (the ACPR) are responsible for certifying new pricing

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and/or reserving models based on AI - so that they are “actuarially equivalent” to traditional models [BAL 21]. These regulatory requirements can act as a barrier to innovation by imposing significant technical and operational constraints on insurers [ELI 24]. For example, the requirement for explainability in algorithmic decisions may limit the use of certain deep learning models that are particularly effective but difficult to interpret. Similarly, restrictions on the use of certain sensitive data can reduce the accuracy of predictive models. This tension between innovation and regulation represents a major challenge for insurers, who must find a balance between regulatory compliance and technological competitiveness.

A crucial strategic and organisational transformations: At the same time, the insurance world’s shift towards AI and technology implies a strategic and organisational transformation for insurance companies. AI is largely forcing traditional insurers to reinvent themselves to overcome the lock-in [ART 89] that is hampering their transformation. To do so, they will undoubtedly have to question their “raison d’être” and therefore their service offering, as well as the transparency of their prices and service offering. Insurers must also accelerate their digital transition [ACP 22], which represents both an opportunity (market share gains) and a threat (exposure to new risks: cyber, fraud, deployment of next-generation AI-based algorithms...). In addition, incumbent need to break down their traditional silo organisation to put the policyholder (and his or her data) at the heart of their process [CHA 20]. Decentralised models, which enable greater team autonomy and faster experimentation, seem particularly suited to the rapid innovation environment characteristic of the AI era [IBM 24]. More fundamentally, it is all or part of their value chain that risks being re-segmented to the benefit of new entrants (insurtech, Big Tech, digital brokers, “direct” insurers...). Insurers’ dependence on reinsurers is also expected to increase, as evidenced by the growing number of capital alliances in this field, as well as by reinsurers’ investments in numerous insurtech.

Technological infrastructure and investment challenges: In the same vein, the transition towards AI and insurtech within the insurance entails substantial investment, largely due to the cumbersome and fragmented nature of incumbent IT architectures. Their centralised and closed legacy IT systems remain ill-suited to the widespread adoption of APIs and cloud technologies— unlike the decentralised, agile, and open information systems used by insurtech start-ups and Big Tech. More fundamentally, the uncertain ROI associated with AI and insurtech, combined with the high switchwing costs linked to IT system modernisation, encourages traditional insurers to proceed cautiously. As a result, many are focusing on use cases or proofs of concept rather than pursuing comprehensive, data- or IA centric transformation strategies. Currently, AI and insurtech are often being deployed in silos, without inducing systemic changes to insurers’ core IT infrastructure.

Policyholder adoption and changing expectations: The future of AI in insurance then depends on policyholders’ ability to adopt these new uses, technologies and ways of consuming insurance. Policyholders’ expectations are already starting to change, especially since the recent Covid-19 health crisis. A recent survey (EIS, 2021) shows that the three main services desired by policyholders are the ability to buy products/services online, the possibility of benefiting from dynamic rates based on their specific needs, and the availability of an easy-to-use mobile application to manage their contract. Policyholders thus are looking for both service quality and ease of use [NAU 18]. However, customer satisfaction surveys show that customers are dissatisfied and doubtful about their insurer’s ability to meet their needs. Traditionally, insurers have had a product-centric vision (the product must be actuarially profitable from the outset) such that each insurance policy is a unique sales line. More fundamentally, policyholders are increasingly looking for insurance that adapts to their lifestyles [EIS 21]. From this point of view, the generational shift currently at work, particularly in emerging countries, could well accelerate this shift in insurance towards a customer-centric vision via AI and insurtech.

Ecosystem dynamics and strategic partnerships: Finally, the insurance industry’s switch to AI and new technologies depends fundamentally on the ability of other stakeholders in the insurance ecosystem to offer solutions (products, services, processes) that are truly in line with the sector’s needs. Owing to their greater agility, openness, learning capacity, and innovative capabilities, insurtech start-ups and Big

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Tech firms have increasingly become essential partners for incumbent insurers. Insurtech start-ups play the role of innovation laboratories (service providers or catalysts for new solutions). However, few insurtech start-ups can remain completely independent from insurers, due to regulatory requirements, high capital requirements and/or the importance of reputation capital (brand awareness) in the sector [ALB 19]. Thus, traditional insurers and insurtech start-ups enjoy a complementary relationship. Insurtech start-ups contribute innovation and flexibility—particularly through technologies such as AI, blockchain, and the Internet of Things—while incumbent insurers provide industry expertise, financial stability, and established market access. However, the current offerings of insurtech start-ups and Big Tech firms typically address only specific segments of the insurance value chain or target niche markets. Thus, over 40% of current insurtech start-ups restrict themselves to the role of service provider for incumbent insurers [CAT 18b]. The remaining insurtech start-ups distribute their own insurance products either under a white-label model in a B2C (business to consumer) context, or more commonly through B2B arrangements, in which they operate as insurance brokers or distributors intermediaries. However, they generally distribute their products without being the risk-bearers (this is known as MGA insurtech), which is the core business of traditional insurers and reinsurers [WIL 21][22]. Meanwhile, Big Tech plays a minor (but growing) role in the insurance ecosystem. Their mastery of data, technologies and platforms gives them a strategic advantage. However, their involvement remains targeted and fragmented (niches) for the time being (cloud, integrated insurance...). In this context, traditional insurers and reinsurers are currently building their own networks of alliances, either through strategic partnerships with the most cutting-edge insurtech / Big tech, or by investing in the most promising startups (via their own seed funds, investment funds or incubators), or by launching their own insurtech start-ups [ELI 18] ; [SWI 23c]. On the opposite, insurtech takeovers by traditional insurers are relatively rare (in fact, the reverse is exceptional), unlike capital-intensive mergers between insurtech start-ups. Insurtech tart-ups and big techs are building their own networks of alliances with traditional insurers and brokers, as well as with banks and fintech start-ups. The entire insurance ecosystem is thus being reconfigured around these networks of alliances, business ecosystems and digital platforms [PWC 22]. However, this reconfiguration of the insurance ecosystem presents risks for traditional insurers. In particular, the rise of digital platforms and digital ecosystems could lead to a gradual disintermediation: insurers would be relegated to the role of mere risk carriers, while the customer relationship would be captured by new players with better mastery of data and user interfaces [ELI 22a].

All these obstacles to the diffusion of AI and insurtech in the insurance sector naturally vary according to geographical context, the nature of the insured risks and the specific characteristics of insurers. This diversity makes the topic a particularly promising starting point for research agenda, especially as the existing literature still struggles to fully account for the range of contexts and institutional configurations involved.

6.2. *Measuring AI impact: From organisational ROI to ecosystem reconfiguration*

At the same time, the impact of AI in insurance services arises at two levels: organisational performance, and relationships among stakeholders in the insurance value chain.

Organisational Performance and Value Creation Through AI Adoption: Typically, firms adopt AI with the objective of creating value. This value can be assessed through various dimensions, including improvements in organisational performance, perceived utility and impact on work practices [PET 08] Net benefits — such as productivity gains, revenue growth, market efficiency, enhanced customer satisfaction, job creation and broader economic — are often mediated by behavioral intention and actual system usage [PET 08] (Petter et al., 2008). From this perspective, the insurance sector appears well-positioned to leverage AI to enhance operational efficiency and transform traditional processes. AI-based

[22] In France, only a few insurtech start-ups (Seyna, Alan, Acheel, Mila, Descartes Underwriting...) have recently received ACPR authorisation to operate as “full-stack” insurers, managing their own risk portfolios.

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solutions offer potential gains across the entire insurance value chain, from improving data reliability and business performance to enabling cost reductions through automation in key operational areas such as underwriting, pricing, and claims processing [SHE 22]. Furthermore, AI can enhance fraud detection and enable the development of more personalised insurance products, contributing to revenue diversification and growth. However, as Vannuccini and Prytkova (2021) [VAN 21] argue, the diffusion of AI technologies may be far less extensive than is often claimed by consultants, institutional reports, venture capitalists' narratives, or media accounts. Empirical research suggests that, despite its many possible applications, AI adoption remains limited in scope and scale ([BEK 18] ; [PER 19] ; [ACE 20]. Regardless of the metric — whether in terms of capital or labor inputs, job postings, types of tasks affected, or firm-level adoption — AI penetration is still superficial across most sectors [VAN 21]. Its current applications are concentrated in a narrow set of automatable tasks — estimated to range between 8% and 50% depending on the study [LEE 18] — and in a few data-intensive sectors such as information and communication technologies, professional services, and finance and insurance. These activities are typically marked by the generation of "massive" datasets — both as inputs and outputs of AI applications [COC 18] ; [BRE 19] — as well as their high "monetisability" [COC 18] ; [BRE 19], either as intermediate goods in the production process or as final B2B or B2C offerings. In this context, accurately measuring the return on investment (ROI) and the effectiveness of AI- and insurtech-driven projects becomes a critical challenge for insurers. Despite its strategic importance, the sector still struggles to operationalise this measurement in a concrete and systematic manner. This issue constitutes a second key avenue for future research. While quantitative metrics — such as claims costs, pricing competitiveness, and commercial performance — remain essential, there is also a pressing need to develop frameworks capable of capturing the intangible outcomes of AI adoption, including process efficiencies, knowledge creation, and managerial innovation. A more holistic approach to evaluating AI's impact could help better guide strategic decision-making and foster a more robust and sustainable integration of AI in the insurance sector.

Ecosystem Reconfiguration and Value Chain Transformation: The rise of insurTech also prompts a critical reexamination of the transformation of the insurance value chain and the question of data access. The integration of new technologies, processes, and AI-driven services increasingly involves actors from outside traditional insurance organisations, thereby reshaping the composition and dynamics of the sector. While collaborative interactions between insurers, distributors, and other stakeholders have long existed, the proliferation of new entrants and specialised service providers is further intensifying this trend. As a result, the insurance value chain is becoming more fragmented and complex, marked by emerging cooperative configurations and strategic alliances that redefine the structure of the innovation ecosystem. This evolution signals a departure from the traditional, vertically integrated and closed model of insurance provision toward a more open, agile, and collaborative ecosystem. The competitive landscape is thus expanding to include a growing diversity of actors — both incumbents and newcomers — seeking to capture value at various points along the value chain. High-value activities are increasingly concentrated at both ends of the chain: upstream, in risk analysis and capital management, and downstream, in customer interface and engagement. This development echoes the logic of the "smile curve" in the insurance sector, which underscores the strategic importance of mastering these critical segments. For incumbent insurers, the central challenge lies in their capacity to rapidly integrate AI and insurtech into their operations while safeguarding the foundational principles of insurance, such as mutualisation, solidarity, and long-term risk pooling. In this context, the future of the industry likely resides in hybrid ecosystems, characterised by strategic partnerships between established players and emerging innovators. Success will hinge on the ability of market participants to strike a delicate balance between technological advancement and the core social functions of insurance — between personalisation and mutualisation, and between operational efficiency and the human dimension of customer relations. Insurers that embrace a holistic approach to digital transformation — viewing AI not as an end, but as a lever to reinforce their fundamental mission of risk protection and long-term security — are likely to emerge as leaders in this evolving landscape. Ultimately, this redefinition of the insurance ecosystem constitutes a third promising and underexplored avenue for future research, offering fertile

ground for further investigation into the interplay between innovation, collaboration, and sectoral transformation.

6.3. *Operationalizing the research agenda: Seven priority research questions and methodological approaches*

From this perspective, operationalising these two programmatic pillars requires formulating *hierarchically* structured research questions (RQ) according to their foundational, strategic or contextual nature. These questions must be accompanied by rigorous methodological protocols that enable the phenomena under investigation to be apprehended empirically.

RQ1: How do insurance organisations adopt AI, and what are the measurable impacts?

This foundational research question explores the ways in which heterogeneity manifests in technological trajectories within the insurance sector. It also raises the question of the identification of the causal mechanisms underlying the observed differences in the diffusion of artificial intelligence, depending on whether one considers organisational configurations distinguished by their size, structure or competitive positioning. To answer this question empirically, a sequential mixed-methods strategy must be employed, comprising an exploratory qualitative investigation based on in-depth semi-structured interviews with executives and information systems managers, followed by a quantitative verification phase utilising fixed-effects econometric models on firm panel data. Complementary longitudinal analysis methods would be required for this approach, particularly duration models or event history analysis, to capture the temporal and processual dimensions of adoption phenomena.

RQ2: To what extent does AI genuinely transform the insurance value chain?

This second foundational question requires an analysis of empirically observable structural reconfigurations and the identification of new inter-organisational coordination mechanisms. The investigation would focus on characterising the new forms of vertical disintegration and functional specialisation that have emerged alongside insurtech and Big Tech companies. Network analysis techniques and ecosystem mapping would be employed, complemented by multiple case studies following theoretical replication logic to identify recurrent transformation patterns. Methodologically, it would be necessary to develop frameworks capable of capturing the scope and depth of value chain transformations across different insurance segments.

RQ3: Does innovation in insurance services still follow Barras's traditional model?

This third, strategic question interrogates the empirical validity of Barras's traditional service innovation model, which is characterised by a progressive sequence of efficiency improvement followed by quality enhancement before leading to new services. The question examines whether the integration of artificial intelligence and insurtech technologies respects this sequential trajectory or induces ruptures in sectoral innovation logics. This issue necessitates a longitudinal analysis of innovation trajectories, using event history analysis methods to capture the temporal and processual dimensions of transformations, as well as patent analysis approaches to document the evolution of technological capabilities within the sector.

RQ4: How can the ROI of AI/insurtech projects be measured systematically?

This question is central to the methodology, as it involves constructing conceptual frameworks that integrate traditional financial metrics with the intangible benefits generated by AI implementation. The research will focus on developing measurement instruments that avoid the pitfall of 'calculative

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framework crystallisation' and capture the multidimensional nature of value creation. This approach requires the design of integrated measurement systems that combine financial and operational indicators within longitudinal monitoring. It also requires the use of multi-criteria decision-making methods to address evaluative complexity.

RQ5: How do insurers, insurtech and Big Tech interact within the evolving ecosystem?

This fifth question analyses the formation and evolution of new strategic alliance networks among these three categories of actors. It will examine the emerging collaborative governance mechanisms and new forms of inter-organisational coordination that characterise these hybrid ecosystems. Network analysis approaches would be used to map emerging partnership configurations and identify different actors' strategic positions. Business ecosystem analysis methods would complement this to help understand collective value creation and capture logics. The methodological approach integrates social network analysis with organisational ecology perspectives to capture ecosystem dynamics.

RQ6: Do new business models fundamentally change the nature of insurance?

This question explores the mechanisms through which the integration of AI redefines the value propositions, revenue structures and organisational architectures of insurance companies. It examines the evolution from traditional risk mutualisation models towards more complex configurations that integrate personalisation, prevention and ancillary services. In-depth longitudinal case studies would be required to document transformation trajectories and identify success or failure factors. Business Model Canvas approaches adapted to sector-specificities would also be employed to model new organisational configurations.

RQ7: How do territorial and regulatory contexts shape AI adoption?

This seventh question examines how national and regional institutional variables, such as regulatory frameworks, local innovation cultures and financing ecosystems, exert moderating effects on technological adoption and diffusion processes. It examines the mechanisms through which national institutional specifics (the differentiated regulatory approaches of the ACPR, BaFin and the Prudential Regulation Authority) influence sectoral innovation trajectories. An international comparative approach would be required for this, based on a multi-country analysis of sectoral trajectories, using spatial econometric methods to capture geographical and institutional proximity effects, as well as comparative institutional analysis techniques to identify the regulatory configurations that are most favourable to insurance innovation.

7. Conclusion

Finally, in a context marked by the intensification of insured risks and the emergence of new, complex threats, our sector-specific conceptual framework proposed in this contribution may also serve to address questions that extend beyond strategic and organisational considerations. One such question concerns the broader environmental impact of AI adoption within the insurance industry. Given that insurance plays a key role in fostering individual and organisational resilience, it is pertinent to examine how AI integration could enhance collective resilience in the face of increasingly volatile risk landscapes. This inquiry aligns with our framework's first fundamental dimension — the unique nature of insurance services, characterised by long-term commitments and contingent liabilities, which shapes how insurers deploy AI for proactive risk prevention and sustainable environmental outcomes.

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Furthermore, incorporating a territorial lens into these analyses offers valuable insights. Risk perception is inherently shaped by economic, social, and cultural conditions that vary across regions, while insurance contracts remain bound by diverse regulatory and insurability constraints. Our framework's second fundamental dimension —specific regulatory constraints — enables researchers to systematically compare how regional regulations (e.g., Solvency II, GDPR, AI Act) influence AI-driven innovation and its local economic viability [COL 17]. In the context of a globalised economy, these local specificities represent both challenges and essential interpretive keys for insurers and researchers alike.

From this broader geopolitical perspective, three largely divergent — sometimes irreconcilable — visions of AI and insurtech currently compete on the global stage [KOE 19]. The Chinese model reflects a collectivist logic, with BATX tech conglomerates operating under state endorsement and surveillance. The American model pursues a dual ambition — ethical and technical — leading to what some describe as an expiatory AI. By contrast, the European model promotes "trusted AI," prioritising data protection and ethical safeguards, though often at the expense of competitiveness given its restrictive regulation. These approaches help explain the rapid adoption of AI by Chinese insurers, the vibrant US insurtech ecosystem, and the more cautious European stance. This regulatory divergence is further compounded in Europe by the absence of open insurance frameworks—unlike the open banking sector—that would allow insurance data to be shared with and accessed by third-party providers. The lack of such provisions represents a significant barrier to market entry for potential newcomers. In this regard, the EU's recently adopted AI Act imposes stringent requirements related to transparency, explicability, and non-discrimination, further shaping the operational landscape for AI adoption in the insurance sector. Our framework's third fundamental dimension — the ethical implications of potential demutualisation of risk pooling — provides the analytical tools to assess how each geopolitical model balances individualisation and solidarity, preserving insurance's social function while fostering innovation.

Ultimately, this contribution has highlighted the transformative potential of AI and insurtech in refining insurer' understanding of policyholders, personalizing offerings, and enhance the overall customer experience. These innovations accelerate the servicisation of insurance, where perceived value stems not only from risk coverage but also from preventive and complementary services. This evolution fosters a more adaptive, preventive and customer-centric insurance industry. Not all innovations are exclusively techno-centric: new product-service configurations shaped by emerging customer needs, or simplified premium payment processes, illustrate the non-technological side of neo-insurance. While AI and insurtech enable greater personalisation, optimised pricing, improved claims processing, enhanced customer experience, and better risk management [WAJ 22], they also provide insurers with a means of moving beyond their historically actuarial and regulatory identity—often limited to the role of claims registration and settlement platforms.

At a deeper level, we show that AI and insurtech enable a threefold paradigm shift: from ex-post curation to an ex-ante prevention; from segmentation-based to behavioral-driven pricing; and from retrospective to prospective risk management. Realising this triple shift, however, demands overcoming persistent structural, organisational, and regulatory barriers that still hinder the widespread diffusion of AI and insurtech.

Concurrently, these innovations are reshaping the industrial and strategic organisation of the insurance industry by fostering the rise of non-traditional actors—insurtech start-ups, Big Tech firms, and incumbent players —who are increasingly assuming strategic roles. This development amplifies the risk of disintermediation through the platformisation of insurance, which tends to reduce traditional insurers to mere risk carriers. More critically, the increased segmentation of insurance markets driven by these new technologies raises concerns about the erosion of the fundamental principle of risk pooling — a cornerstone of insurance business models. In response, incumbent insurers must leverage our framework to rethink their business models, pursuing either diversification or specialisation to remain competitiveness without sacrificing the sector's social mission.

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More fundamentally, by moving beyond the analysis of isolated practical applications, our analytically rigorous insurance-tailored framework offers tools for assessing and interpreting AI-driven transformation as a cohesive phenomenon. For researchers, it provides a deeper understanding of how the nature of insurance services, regulatory constraints and ethical considerations jointly shape AI adoption trajectories. For practitioners, it serves as a strategic guide to design, implement and govern AI initiatives that balance technological innovation with insurance's core principles of mutualisation and long-term security

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Annex: Glossary of technical terms and key insurance concepts

ACPR (Autorité de Contrôle Prudentiel et de Résolution): The French supervisory authority responsible for overseeing banks and insurance companies, ensuring regulatory compliance and consumer protection.

Actuarially equivalent: Refers to AI-based pricing or reserving models that produce the same financial soundness as traditional actuarial models.

Algorithmic explainability: A regulatory requirement that mandates the ability to understand and explain decisions made by AI algorithms to clients and regulators.

API (Application Programming Interface): A programming interface that enables different software systems to communicate with each other and facilitates the integration of external services into existing insurance systems.

Big Tech: Large technology companies (e.g. Google, Amazon, Microsoft and Apple) that use their data and technological capabilities to enter the insurance market.

Business ecosystem: An interconnected network of organisations that collaborate to create and deliver value within the insurance sector.

Claims processing: The process of managing insurance claims, including reporting, assessment, investigation and settlement of covered damages.

Customer-centric vision: A strategic approach that prioritises customer needs and experiences over insurance products, in contrast to the traditional product-centric vision.

Digital platforms: Technological infrastructures that enable different stakeholders to interact and exchange services within the insurance ecosystem, creating value.

Disintermediation: The process by which traditional intermediaries (brokers and agents) risk being bypassed by new actors with superior data and customer interface capabilities.

Dynamic pricing: A pricing strategy that uses AI to automatically adjust insurance premiums based on real-time policyholder behaviour and market conditions.

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Embedded insurance: Insurance that is integrated directly into the purchase of another product or service and is often offered by non-traditional insurance providers.

Full-stack insurers: Insurance companies that manage the entire value chain, from product design to financial risk bearing, without intermediaries.

Hybrid ecosystems: Business environments that combine traditional insurers and new technological companies in strategic partnerships to drive innovation.

Insurtech: A mix of 'insurance' and 'technology', it refers to companies using technology to innovate within the insurance sector.

Legacy IT systems: Outdated information systems that are still used by traditional insurers and are often difficult to modify or integrate with new AI technologies.

Long-term risk pooling: A fundamental insurance principle involving the mutualisation of risks over the long term to ensure financial stability.

MGA (Managing General Agent): An insurance intermediary with extensive powers to underwrite risks on behalf of an insurer without bearing the financial risk themselves.

Mutualisation: A fundamental insurance principle consisting of distributing risks among all insured parties within the same group, which creates a fundamental conflict with AI-enabled personalisation.

Policyholders: Individuals or entities that have subscribed to an insurance policy.

ROE (Return on Equity): A key financial metric used to evaluate the profitability of insurance companies by calculating the ratio of net income to shareholders' equity. It is particularly important in the insurance sector due to the sector's unique production cycle, where premiums are collected before potential claims are paid.

ROI (Return on Investment): A critical financial indicator used to measure the profitability of AI and technology investments in insurance. These investments are often difficult to evaluate due to their intangible benefits.

Underwriting: The process of evaluating the risks posed by a potential insurance customer to determine whether they can be insured and, if so, on what terms.

Value chain: The set of activities that an insurer performs to design, produce, market and distribute its products.

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