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Blockchain Technology Adoption for Life Insurance: Risk, Readiness, and Relevance

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ABSTRACT

Blockchain technology has been widely discussed as a transformative solution for operational inefficiencies in the insurance sector, particularly in automating claims processing, enhancing transparency, and ensuring data immutability. However, adoption within the life insurance industry remains limited. This paper investigates the barriers and potential of blockchain implementation in life insurance through a mapping analysis using the People–Process–Technology (PPT) framework into risk, readiness, and relevance. The research identifies strategic misalignment with existing revenue models, regulatory compliance frictions, and organizational readiness gaps as key obstacles. A five-year cost comparison indicates that while blockchain incurs higher initial investment, it delivers lower operational costs in the long run—particularly in high-volume, deterministic insurance products. Architectural comparisons further highlight the operational advantages and integration challenges of blockchain-based systems over traditional IT infrastructures. The study concludes that although blockchain holds significant promise, its adoption depends on targeted use case selection, organizational transformation, and regulatory alignment.

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1. INTRODUCTION

Blockchain is a distributed ledger technology that enables secure, transparent, and tamper-proof recording of transactions without the need for central intermediaries [1], [2], [3]. Initially popularized through cryptocurrencies, blockchain has evolved into a foundational digital infrastructure applicable across industries, from logistics and healthcare to banking and insurance [2], [4], [5]. The core properties of blockchain—immutability, decentralization, and automation through smart contracts—have made it attractive for business applications that require secure record-keeping, auditability, and trustless interactions [1], [6], [7].

The insurance industry, long known for its reliance on trust, record integrity, and time-consuming manual processes, is considered a prime candidate for blockchain disruption [8][9], [10]. Use cases such as parametric insurance, reinsurance coordination, fraud prevention, and real-time claims processing have emerged as potential opportunities [11], [8], [12], [13]. Leading consultancies such as McKinsey and Deloitte highlight blockchain's ability to streamline multi-party processes, reduce administrative overhead, and enhance regulatory compliance within the insurance domain [10], [14].

In the life insurance sector, blockchain has been proposed to automate key processes like underwriting and claims settlement [7], [13]. A simplified use case would involve a smart contract embedded with policy terms. Upon verified proof of death from an external oracle (e.g., government registry), the contract could trigger automatic claim approval and disbursement—removing the need for manual validation, reducing fraud, and speeding up service to beneficiaries [13], [15]. However, despite such theoretical advantages, adoption remains minimal [16], [17].

This paper investigates the underlying reasons for the low adoption of blockchain in life insurance by using a literature review approach and the People–Process–Technology (PPT) framework [18]. The purpose is to explore blockchain's ability to solve problems in life insurance, assess organizational readiness, and examine the alignment of blockchain advantages with industry needs. To guide this investigation, the study addresses four key research questions focused on blockchain's problem-solving ability, the utilization of its core features, required organizational adjustments, and prioritization of adoption efforts.

This paper is organized into five chapters. Following this introduction, Chapter 2 provides a literature review covering blockchain fundamentals, life insurance processes, and analytical frameworks used. Chapter 3 details the research methodology based on a literature review. Chapter 4 presents the analysis using the Risk, Readiness, and Relevance structure derived from the PPT framework, including architectural and cost comparisons. Finally, Chapter 5 concludes with key findings aligned to the research questions and discusses implications for industry adoption.

2. LITERATURE STUDY

The literature identifies blockchain as a transformative tool for automating life insurance operations through smart contracts [15], [19], [20]. In a typical scenario, a policyholder's application is encoded into a smart contract that stores policy terms and conditions on a decentralized ledger [15], [19]. Once a qualifying event—such as death—is confirmed via a trusted oracle (e.g., civil registry), the smart contract autonomously executes the claim, transferring the agreed amount to the beneficiary [15], [20]. This process removes manual intermediaries, shortens claim times, and reduces fraud [10], [19], though concerns over oracle accuracy and contract complexity remain [6], [21].

2.1. A. Frameworks and Standards Used

The People–Process–Technology (PPT) framework is widely adopted for organizational change analysis [22].

1. People: Studies emphasize the skill gap among actuarial, compliance, and IT staff regarding blockchain fluency [16]. Cultural resistance to automation is another issue [20].
2. Process: Blockchain implementation requires reengineering of underwriting, policy management, and claims workflows from paper-based or batch systems to real-time processing [23].
3. Technology: The maturity of smart contracts, oracle design, and blockchain scalability remains a technical constraint [6], [24].

2.2. Architecture Reference

These questions frame the entire analysis and are directly addressed through the literature synthesis and architecture/cost comparisons presented in Chapter 4.

Traditional IT systems in life insurance rely on centralized relational databases and batch processing engines (e.g., COBOL mainframes) [12], [25]. By contrast, blockchain-based architecture replaces the centralized database with a distributed ledger and incorporates IPFS for secure document storage, along with smart contracts for automated transaction logic. Integration is enabled through blockchain oracles and interchain protocols [24], [26], [27].

2.3. Cost Modelling

Ernst & Young (EY) have analyzed total cost of ownership (TCO) for blockchain versus legacy IT [28]. While blockchain incurs higher upfront development and integration costs due to the complexity of smart contract development and legal audits, it offers lower operational costs

from year two onward due to reduced licensing, automation, and audit overheads. Most analysts estimate breakeven between year 4–5 under high policy volume [28], [29].

2.4. Regulatory Standards

The use of blockchain in life insurance must comply with data protection frameworks such as GDPR (Europe), HIPAA (US, for health-linked life insurance), and sectoral insurance regulations (e.g., Solvency II, Indonesia's POJK) [30]. Public blockchain use raises compliance concerns regarding data sovereignty and the right to be forgotten, leading many insurers to prefer permissioned blockchains [10].

2.5. Business Model Consideration

Blockchain challenges core life insurance revenue models, particularly those relying on investment income (float) and delayed payout cycles [10], [20]. Instant claims reduce the time capital is held and invested. Moreover, decentralization may reduce the insurer's role as a trusted intermediary. According to McKinsey, these disruptions are why blockchain may be seen as a threat rather than a tool unless integrated into new value-added services such as digital identity, dynamic pricing, or embedded insurance [23], [31].

2.6. Comparison with Traditional Life Insurance System

Traditional life insurance systems are characterized by centralized control, sequential workflows, and manual intervention across the policy lifecycle. Underwriting relies on siloed data systems and often requires paper-based health records, physical signatures, and long approval periods. Claims are validated through human assessors and are processed in batches, resulting in delays and potential inconsistencies [12].

From a technical perspective, legacy systems are built on monolithic architectures, often using COBOL-based policy administration platforms, relational databases, and middleware for limited integration. Data sharing across departments (e.g., underwriting, claims, finance) is typically done through periodic data exports or APIs with limited traceability. Fraud detection is reactive, and audit trails are not tamper-proof, increasing operational risk [25].

By contrast, blockchain-based systems introduce real-time, transparent data sharing, programmable contracts for claims and payouts, and cryptographic security for all records. While blockchain offers operational and trust advantages, it also imposes higher integration complexity and requires overhauling core IT and business processes. Therefore, while blockchain enables superior process automation, legacy systems continue to dominate due to their regulatory acceptance, organizational familiarity, and sunk investment.

3. RESEARCH METHOD

The research methodology used in this study was designed in three mutually continuous phases. The design of this research method was prepared to ensure a comprehensive and structured approach in achieving research objectives. Details of the research design can be seen in Figure 1.

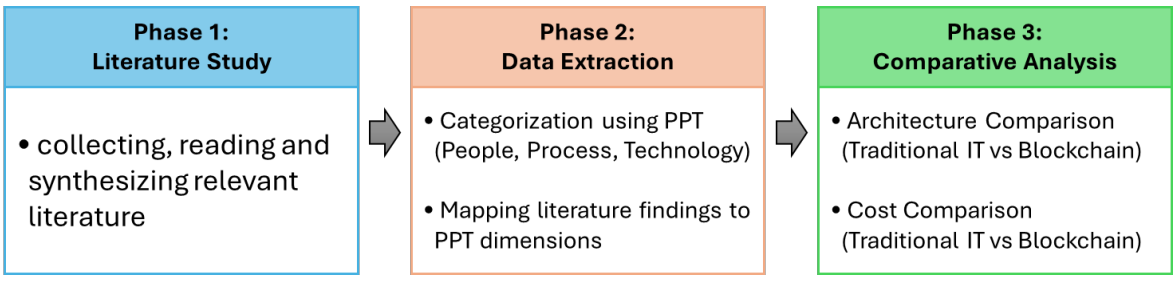


Figure 1. Research Methodology

3.1. Research Questions

In this research, 4 research questions will be created as below:

1. RQ1: Can blockchain solve the key operational problems in life insurance better than current IT systems?
2. RQ2: Are blockchain's core advantages (decentralization, transparency, immutability) fully leveraged in real use cases?
3. RQ3: Beyond technical innovation, what adjustments are required in the people and process dimensions for successful adoption?
4. RQ4: What should be prioritized to overcome the key barriers to adoption?

3.2. Literature Study

The literature study in this research was prepared using a narrative review approach, namely collecting, reading and synthesizing relevant literature. This approach was chosen because the research objective was not to carry out a comprehensive mapping of all academic publications, but rather to gain an in-depth understanding of the concepts, challenges and opportunities for implementing blockchain in the life insurance industry according to the People–Process–Technology (PPT) analytical context.

The literature review was carried out by reviewing academic journals, books, research reports, industry white papers, and publications from global consulting institutions such as McKinsey, Deloitte, EY, and PwC. These sources were selected based on their relevance to the three main research focuses: (1) blockchain's ability to address life insurance operational problems, (2) organizational readiness to adopt blockchain, and (3) relevance of blockchain's fundamental features to insurance business processes.

3.3. Data Extraction

Key data points were extracted and categorized using the PPT framework:

1. People: Skills, knowledge gaps, resistance to organizational change
2. Process: Workflow integration, claims automation, policy management
3. Technology: Blockchain architecture, smart contract maturity, system interoperability

The extracted findings were analyzed thematically and organized according to the Risk–Readiness–Relevance model to present a structured and comprehensive analysis of blockchain adoption in the life insurance domain.

3.4. Comparative Analysis

Comparative analysis in this research is used to compare the performance, risk, readiness and relevance between traditional insurance systems (legacy IT systems) and blockchain-based architecture. This analysis also aims to provide a concrete picture of the benefits and costs of blockchain adoption in the context of life insurance operations.

4. ANALYSIS AND RESULTS

Findings from the literature review are thematically synthesized using the Risk–Readiness–Relevance framework, aligned with the People–Process–Technology (PPT) model. This section explores the interplay between blockchain's technical capabilities, organizational readiness, and its potential to address operational challenges in life insurance.

4.1. Risk: Strategic, Operational, and Regulatory Tensions

1. Strategic Conflict with Legacy Revenue Models (RQ1, RQ4)

Multiple studies reveal that blockchain challenges the economic structure of life insurers. Smart contracts enable instant claims settlement, which contrasts with the traditional reliance on "float" — the interim holding of funds for investment. This disrupts a long-standing source of profitability and introduces strategic hesitation in deploying automation for deterministic claim products like term life insurance [2], [10].

2. Operational and Technological Risk Exposure (RQ1, RQ2)

Smart contract immutability and deterministic logic introduce vulnerability if upstream oracle data (e.g., death registries) is delayed or inaccurate. Literature highlights the potential for false-positive or denial of service when integration with public oracles is misconfigured [32].

Additionally, permissionless blockchain networks may struggle to meet throughput demands for high-volume policy portfolios due to consensus overhead [10].

3. Regulatory Ambiguity and Compliance Misalignment (RQ2)

Public blockchains are inherently resistant to data modification or deletion [1]. This property conflicts with privacy frameworks like GDPR, HIPAA, or POJK, which emphasize revocation, correction, and localized storage [30]. Consequently, many pilots resort to private or consortium chains that forgo decentralization to satisfy compliance, effectively diluting the technology's unique advantages. The immutability of public ledgers clashes with data privacy regulations (e.g., GDPR's 'Right to be Forgotten'), forcing insurers to adopt permissioned architectures where data governance remains centralized [33].

4.2. Readiness: Organizational Maturity for Blockchain Integration

1. Skills and Change Management (People) (RQ3, RQ4)

The literature consistently emphasizes that blockchain fluency remains low among life insurance professionals, particularly in actuarial, claims, and legal departments. The transition to smart contracts and decentralized architectures demands new competencies in Solidity programming, cryptographic auditing, and oracle governance. Resistance is not purely technical—organizational inertia and fear of job redundancy inhibit internal advocacy for blockchain [34].

2. Workflow Compatibility (Process) (RQ1, RQ3)

Insurance operations are governed by legacy processes, often involving human adjudication, manual signatures, and offline identity verification [12]. Real-time automation via smart contracts is incompatible without reengineering [14]. Studies suggest that introducing blockchain without concurrent process redesign often leads to redundant duplication—blockchain becomes an audit layer, not a process transformer [17].

3. Technical Stack Integration (Technology) (RQ1, RQ4)

Integration of blockchain with core systems—Policy Administration System (PAS), Claims Management System (CMS), and Enterprise Data Warehouses—is technically feasible but complex [25]. Smart contract deployment must interface with customer databases, external APIs, and document verification systems[15]. In many jurisdictions, including Indonesia, the digitization of civil registration is often the bottleneck. Recent assessments of Indonesia’s Civil Registration and Vital Statistics (CRVS) system highlight that despite improvements, the national database (SIAK) continues to face challenges with mortality data completeness and reporting latency due to fragmented administrative procedures [35]. Consequently, the speed of settlement is not determined by the blockchain’s transaction throughput, but by the 'oracle's' ability to push reliable state changes to the ledger—a process currently hindered by the 'last-mile' gap in government data infrastructure.

4.3. Relevance: Alignment of Blockchain Capabilities with Insurance Functions

1. Utility of Blockchain Core Features (RQ2)

Although blockchain offers decentralization, transparency, and immutability, their relevance is conditional. Decentralization is underutilized due to regulatory pressure for centralized accountability [9]. Transparency is limited by privacy restrictions, making encrypted or permissioned records the default [1]. Immutability is useful for audit trails but hinders legal record amendments [6]. Thus, blockchain’s superiority is often compromised in practice [17].

2. Suitability Across Product Types (RQ1, RQ2)

Term life policies are ideal candidates due to deterministic triggers and fixed payouts [15], [20]. These can be codified via smart contracts using a single oracle (e.g., death certificate registry) [15], [19]. However, products like whole life or unit-linked insurance involve human advice, variable returns, and discretionary clauses—unsuitable for full automation [9] [12]. Therefore, blockchain is relevant for process-specific innovation but not product-wide transformation [17].

4.4. Architecture Comparison

Architecture comparison between a Traditional IT System and a Blockchain-Based System for life insurance, can be summarized in Table 1 and Table 2. Process flow comparison can be summarized in Table 3.

Table 1. Traditional IT (Legacy System)

Layer	Description
Frontend/UI	Web portal or mobile app for customer service and agent interfaces.
Business Logic Layer	Enterprise Service Bus (ESB) or middleware handling routing, logic, authentication.
Core Systems	- Policy Administration System (PAS) for underwriting, issuance, renewal. - Claims Management System (CMS) for intake and adjudication. - Customer Relationship Management (CRM) for managing a company's interactions with current and potential customers.
Database	Relational Databases (Oracle, SQL Server) managing policy, claim, and customer data
Integration	APIs or batch exports to external services (e.g., medical checks, bank payments)

Table 2. Blockchain Based

Layer	Description
Frontend/UI	Same as legacy: customer portal or agent app.
Smart Contract Layer	Encodes policy terms, automates underwriting and claim rules.
Blockchain Network	Distributed Ledger storing policies and claim records. Permissioned (e.g., Hyperledger) or Public (e.g., Ethereum L2).
Oracle Layer	Trusted data feeds for external events (e.g., death certificate registry, identity validation).
Decentralized Storage	IPFS or similar used to store policy documents, death certificates securely.
Integration Layer	API Gateway to legacy systems Oracle governance & off-chain data bridges (e.g., Chainlink, Band Protocol)

Table 3. Architecture Comparison

Process Flow	Traditional IT (Legacy System)	Blockchain Based
Customer applies	Data stored in PAS.	Smart contract deployed.
Manual underwriting	Decision stored in CRM	Oracle fetches medical/death data.
Claim raised	CMS triggers manual review	Oracle triggers claim logic. Claim executed automatically via smart contract
Claim paid	After human validation	Payment made directly to beneficiary wallet or bank via API

Based on architecture and process flow above, the difference between traditional IT (legacy system) and Blockchain based can be illustrated in Figure 2 as below.

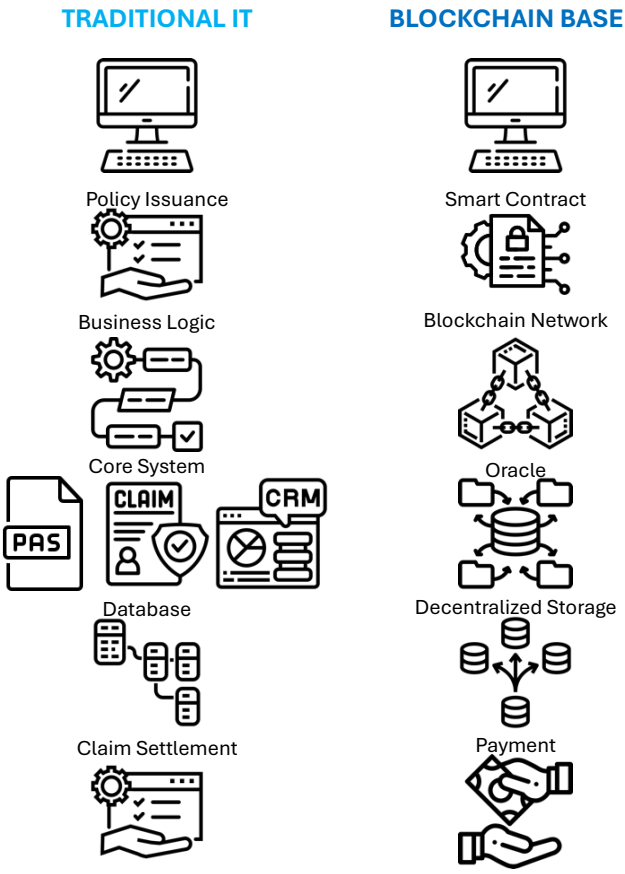


Figure 2. Architecture Comparison

4.5. Cost (Investment and Operational) Comparison

To evaluate the economic viability of blockchain adoption in life insurance, a comparative total cost of ownership (TCO) analysis was conducted over a 5-year period. The cost model includes both capital expenditure (CAPEX) for initial development and infrastructure, and operational expenditure (OPEX) for licensing, maintenance, and staffing. Cost estimates are informed by industry studies validated case studies and benchmarking data from Deloitte and EY [14], [36].

The initial investment in a blockchain-based system is higher due to smart contract development, oracle configuration, legal audits, and infrastructure provisioning. However, long-term savings arise from automation of claims workflows, reduced licensing dependency, and lower audit overhead. A permissioned blockchain (e.g., Hyperledger Fabric) was assumed in this model due to regulatory compliance needs. Total Cost can be seen in Table 4.

Table 4. Blockchain Based Total Cost

Cost Component in K USD	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Development & Deployment	450	-	-	-	-	450
Infrastructure & Nodes	120	80	80	80	80	440
Licensing (Oracle, APIs)	20	30	30	30	30	140
Staff Training & Change Management	50	25	25	25	25	150
Maintenance & Support	50	60	60	60	60	290
Total	**690**	**195**	**195**	**195**	**195**	**1470**

Traditional systems incur lower upfront development costs due to reliance on licensed, off-the-shelf platforms (e.g., PAS or CMS). However, they exhibit higher recurring costs from

software licensing, limited automation, manual claims processing, and internal audit support. Total Cost can be seen in Table 5.

Table 5. Traditional IT Based Total Cost

Cost Component in K USD	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Software Licensing	200	120	120	120	120	680
Infrastructure (Cloud/VM)	100	100	100	100	100	500
IT Staff & Admin Labor	80	100	100	100	100	480
Audit & Compliance Overhead	50	50	50	50	50	250
System Maintenance	30	50	50	50	50	230
Total	460	420	420	420	420	2140

Based on Table 4 and Table 5, Blockchain Based has TCO 1440K USD and Traditional IT has TCO 2140K USD. The blockchain solution demonstrates a 5-year TCO reduction of approximately 31%, primarily driven by long-term savings in operational labor, licensing, and audit processes. However, this advantage is contingent on sufficient policy volume and successful integration of smart contracts with claims workflows. The traditional IT system, while mature and compliant, incurs higher repetitive costs and less scalability in terms of automation.

While the current Total Cost of Ownership (TCO) analysis projects a 31% cost reduction, it is important to note that this model assumes a steady-state implementation. The analysis does not account for the transitional financial burden of running parallel infrastructures (specifically, the simultaneous maintenance of legacy systems alongside the new blockchain architecture) which is typical during the migration phase and may temporarily offset operational savings. Furthermore, the model focuses primarily on administrative and operational efficiencies; it does not factor in the 'hidden cost' of diminished float income. The shift toward instant payouts via smart contracts, while beneficial for customer satisfaction, inevitably reduces the duration funds are held and invested, thereby impacting the insurer's investment income stream. Future economic models should incorporate these transitional costs and opportunity costs to provide a more holistic financial projection.

5. CONCLUSION

This study explored the adoption of blockchain technology in the life insurance sector through a literature review, guided by the People–Process–Technology (PPT) framework and structured under the dimensions of Risk, Readiness, and Relevance. Findings reveal that while blockchain offers credible advantages—such as automated claims processing, data immutability, and fraud prevention—its adoption in life insurance remains limited due to deep-rooted structural and organizational constraints.

From a technological perspective, blockchain demonstrates the capability to address inefficiencies in traditional IT systems, particularly in deterministic policy types like term life insurance. Smart contracts, when integrated with reliable oracles, can streamline claims processing, reduce operational overhead, and enhance transparency. However, challenges such as scalability, oracle dependency, and integration with legacy infrastructure persist.

In terms of organizational readiness, life insurers face a notable skills gap and process rigidity. Most institutions lack internal blockchain expertise, and their workflows are heavily reliant on manual adjudication, paper-based documentation, and batch processing. Successful blockchain implementation would require not only system integration but a comprehensive process redesign and change management effort.

The relevance of blockchain depends significantly on the product type and regulatory environment. While decentralized automation is suitable for fixed-benefit claims, it is less applicable to complex or investment-linked products. Additionally, many of blockchain’s native strengths are constrained by regulatory compliance needs, forcing institutions to opt for permissioned implementations that dilute decentralization and transparency.

The architectural comparison confirms that blockchain can deliver long-term cost savings through automation and audit efficiency. The 5-year TCO analysis shows a potential 31% cost reduction over traditional systems, assuming sufficient transaction volume and process alignment.

In summary, this study addressed four core research questions. First, blockchain was found capable of solving key inefficiencies in life insurance processes, particularly through smart contract automation (RQ1). Second, while blockchain offers decentralization, immutability, and transparency, these advantages are often underutilized due to regulatory and architectural constraints (RQ2). Third, adoption challenges extend beyond technology and require substantial adjustment in human resources and organizational workflows (RQ3). Finally, to overcome these barriers, insurers must prioritize governance restructuring, staff upskilling, and process redesign to align blockchain capabilities with practical insurance operations (RQ4).

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