



Modernizing Solvency Regulation in Algeria: A Comparative Study of Static and Stochastic Approaches**Toufik Ait Ouali**^{1*} , **Djamila Mendil**² Higher School of Computer Science and Digital Technologies (ESTIN), Bejaia, Algeria¹Department of Economic Sciences, Abderrahmane Mira University, Bejaia, Algeria²

Info ArticlesHistory Article:
Submitted 11 August 2025
Revised 9 April 2026
Accepted 11 May 2026Keywords:
Solvency Standards;
Insurance; Solvency I;
Stochastic Differential
Equations; Algeria.

JEL: G22 ; G28 ; C52

Abstract**Purpose:** This study examines whether Algeria could transition from its current prudential solvency framework, largely based on the outdated Solvency I directive, to a more dynamic solvency assessment approach grounded in stochastic differential equations (SDEs).**Methodology:** Using an analytical and comparative methodology, the paper contrasts the Algerian Solvency I-based framework with a stochastic solvency model proposed by Wang and Zhu (2021), highlighting their conceptual foundations, regulatory implications, and risk management capabilities.**Findings:** Solvency I framework relies on static capital requirements that insufficiently capture market volatility, evolving insurance risks, and extreme events. In contrast, the stochastic model incorporates randomness, dynamically manages capital flows between different financial states, and adjusts solvency levels in real time in response to market and claims fluctuations. This results in a more accurate and forward-looking assessment of insurers' financial resilience.**Practical Implications:** Adopting a stochastic solvency framework could enhance the stability and risk management capacity of Algerian insurance companies. However, such a transition would require gradual regulatory reforms, institutional capacity building, and close coordination between insurers and supervisory authorities.**Originality/Value:** This paper contributes to the literature by providing the first structured comparison, in the Algerian context, between the Solvency I framework and a stochastic differential equation-based solvency model, thereby enriching the ongoing debate on the modernization of insurance prudential regulation in emerging markets.**Paper Type:** Research Paper.

^{*} Address Correspondence:E-mail: aitouali@estin.dz ¹djamila.mendil@univ-bejaia.dz ²

INTRODUCTION

Prudential regulation in the insurance sector plays a central role in maintaining the financial soundness of insurance companies, protecting policyholders, and preserving overall economic stability. By requiring insurers to hold sufficient capital relative to the risks they underwrite, prudential frameworks aim to ensure that claims obligations can be met even under adverse economic and financial conditions.

Traditionally, insurance companies are required to maintain a minimum level of own funds, commonly referred to as the solvency margin. This margin serves as a financial buffer designed to absorb unexpected losses arising from underwriting risk, market fluctuations, and operational uncertainties inherent to insurance activity.

In Algeria, the current prudential regulatory framework governing insurance companies is largely based on the former European Solvency I directive. While this framework represented an important step toward standardizing solvency requirements, it is increasingly considered inadequate in light of the growing complexity of insurance risks, financial market volatility, and the emergence of new risk sources. Solvency I relies primarily on static and quantitative indicators, offering a limited capacity to reflect dynamic interactions between assets, liabilities, and external shocks.

In contrast, recent advances in actuarial science and financial modelling have led to the development of dynamic solvency assessment approaches based on stochastic differential equations. These models allow for a continuous and probabilistic representation of insurers' financial positions by explicitly incorporating randomness, market volatility, and the evolution of claims and investment returns over time. As a result, stochastic models provide a more realistic and forward-looking assessment of solvency compared to traditional static frameworks.

Several international studies have demonstrated that stochastic solvency models improve insurers' ability to anticipate extreme events, optimize capital allocation, and strengthen enterprise risk management practices. However, despite their growing adoption in advanced regulatory environments, such approaches remain largely unexplored in emerging insurance markets, particularly in the Algerian context.

This gap is especially relevant given the structural characteristics of the Algerian insurance sector, which remains dominated by traditional products and a regulatory framework that has not fully integrated modern risk-based solvency principles. To date, there is limited academic work that systematically evaluates the feasibility and potential benefits of transitioning from the Solvency I framework to a dynamic stochastic solvency model in Algeria.

Against this backdrop, the present study seeks to address the following research question:

Is it feasible for Algeria to adopt a dynamic solvency framework for insurance companies based on stochastic differential equations, and what advantages would such a transition offer compared to the current Solvency I-based system?

To answer this question, the paper adopts an analytical and comparative approach. It first presents the existing prudential standards governing insurance solvency in Algeria. It then reviews relevant literature on insurance solvency and stochastic modelling. Subsequently, it introduces a stochastic solvency model based on stochastic differential equations proposed by Wang and Zhu (2021). Finally, a comparative discussion highlights the limitations of the Solvency I framework and the potential benefits of adopting a dynamic stochastic approach within the Algerian regulatory environment.

PRESENTATION OF THE CURRENT PRUDENTIAL STANDARDS IN ALGERIA

In Algeria, the regulatory oversight system for insurance companies is founded on the 'Solvency I' guideline. This regulation is now outdated, necessitating modifications to align with current and forthcoming solvency criteria. This paper outlines the prudential criteria for regulatory oversight in Algeria's insurance industry.

The required minimum share capital

The share capital of a company is the fixed sum provided by shareholders or partners through monetary or non-monetary contributions. It may increase via the inclusion of reserves or earnings and diminish through the reimbursement of contributions or as a result of losses. As per the Commercial Law, the capital of joint-stock companies must be entirely subscribed, with all contributions in kind fully released upon issuance and at least one-fourth of the nominal value released upon subscription for cash contributions. Law no. 06-04 mandates the complete cash payment of the share capital of insurance companies upon subscription.

The establishment of an insurance company necessitates a minimum capital, which is contingent upon

the specific sorts of insurance activities pursued. The minimum share capital requirements were originally established by the Executive Decree No. 95-344 and subsequently amended by the Executive Decree No. 09-375. The latter increased the funds to improve the financial soundness of insurance companies from their establishment.

The revised standards differ based on insurance and reinsurance activities, and noncompliance may lead to penalties.

Regulatory framework governing commitments

Regulatory and technical provisions related to an insurance company's operations constitute regulated commitments, evaluated and documented on the liabilities side of the balance sheet, in accordance with the double-entry accounting principle. The assets designated to represent these obligations are explicitly regulated to safeguard the interests of policyholders.

The insurer, aiming to optimize revenues via profitable investments, must adhere to investment mandates that guarantee the security, return, liquidity, and alignment of its assets. These mandates establish regulations for the allocation, distribution, and placement of investments. Government securities must comprise a minimum of 50% of regulated commitments, with defined limits for securities, real estate assets, and other investments.

The regulator intervenes by enforcing stringent regulations to guarantee that investments adhere to these mandates, encompassing allocation guidelines among asset classes, diversification to mitigate concentration risks, and geographic distribution. Eligible assets denoting controlled obligations comprise government securities, additional securities issued by solvent corporations, real estate assets, and diverse other investments adhering to prevailing legislation. In compliance with these regulations, companies may depict technical provisions by diminishing their amount by 60%, contingent upon this decrease not surpassing 15% of the company's total regulated commitments.

Pursuant to the Decree of March 31, 2013, insurance and reinsurance companies are required to cover their regulated commitments, mainly technical provisions, by recognizing representative assets on the balance sheet in order to ensure their solvency. In this framework, at least 50% of regulated commitments must be covered by government securities, half of which must be in the form of medium- and long-term instruments. The remaining portion is allocated among other eligible assets in accordance with the regulatory provisions in force.

Time deposits with the same financial institution must not surpass 25% of the total regulated obligations. Investments in securities issued by unlisted Algerian companies are restricted to 25% of the total regulated commitments. Investment in real estate in Algeria is limited to 10% of the regulated commitments, and the aggregate real estate assets must not surpass 40%.

Investment in securities issued by the same issuer, excluding those issued or guaranteed by the State, is restricted to 5% of the total value of regulated commitments. The involvement of an insurance or reinsurance company in the share capital of another entity must not surpass 50% of the share capital and 5% of the regulated obligations of the insurance or reinsurance company.

Representation of regulated commitments

The insurance company assumes obligations to policyholders to indemnify for losses and develops reasonable reserves to address these responsibilities. Nevertheless, even when implemented judiciously, these provisions may occasionally be inadequate. The insurance company must maintain a solvency margin, which serves as an additional buffer to technical provisions, to protect against unanticipated events and safeguard the interests of policyholders.

The solvency margin is defined as the collection of resources, including share capital and reserves that offer supplementary protection to the assets held against technical provisions.

The calculation of the solvency margin encompasses share capital or establishment fund, regulated or unregulated reserves, regulated provisions, and carryovers, whether debtor or creditor. The solvency buffer for property insurance must be a minimum of 15% of technical provisions and, at all times during the year, must not fall below 20% of premiums issued and/or accepted, net of taxes and cancellations. The parameters for life insurance differ by category, encompassing life-death, marriage-birth, and capitalization insurance.

If the solvency margin falls below the mandated minimum, the insurance company must rectify the situation within six months by either augmenting its share capital or establishment fund, or by providing a guarantee to the Treasury. The Insurance Supervision Commission determines the release of this guarantee once the situation has been rectified.

The stringent regulation of insurance companies is a significant concern for authorities globally. The main goal is to guarantee that these companies reliably meet their obligations to policyholders. Prudential regulation, centred on solvency, includes the precise evaluation of obligations, oversight of investments, and the stipulation of a solvency margin.

The Insurance Supervision Commission (CSA), created by the Ordinance No. 95-07, is essential for maintaining governmental monitoring of insurance and reinsurance operations. The CSA's objectives encompass overseeing insurance companies' adherence to legislative regulations, assessing their capacity to fulfil financial obligations, and doing comprehensive evaluations of funding sources. By executing these duties, the CSA significantly enhances integrity, stability, and legality within the insurance sector, hence bolstering public confidence in the insurance system.

Supervisory measures include off-site control, which involves analysing documents provided to the administration, and on-site control, a method focused on checking the consistency between reported information and the actual state of the company. Off-site control focuses on the meticulous analysis of administrative records, but on-site control entails direct inspection to verify the real conformity of the information supplied by the organization. Both methodologies are critical instruments to ensure transparency, legitimacy, and adherence of economic activity to specified criteria.

The Ministry of Finance is integral to the approval process for insurance companies, necessitating prior consent from the Minister to ascertain permissible activities. This duty entails formulating stringent standards for the professional credentials of insurance company administrators and executives. Consequently, the Ministry serves as a crucial regulatory function in assuring that insurance companies adhere to elevated standards of competence and integrity, so bolstering the robustness and dependability of the financial system.

Numerous alternative ways of regulation are vital in the insurance sector. The Auditor plays a vital function in validating account compliance and guaranteeing financial transparency. Actuaries, experts in statistical analysis, are essential for the accurate pricing of insurance products and the management of reserves. The Audit Committee concentrates on evaluating the veracity of accounting information and providing assessments of internal control, whereas the Risk Committee is tasked with formulating and revising the company's risk map. These control systems hold significant importance in the insurance company due to the inverse production cycle, wherein premiums are received well in advance of claims payments. This continuous oversight by authorities seeks to safeguard policyholders against uncertainties associated with insurance.

BRIEF LITERATURE REVIEW

This literature review examines research on the solvency of insurance in Algeria. Recent studies on the insurance industry in Algeria underscore several vital elements of its operation. In the context of Algeria's economic changes, risk management is of utmost significance, as indicated by Rezazi and Temam (2003), who advocate for international strategies to enhance risk management, particularly in light of the various challenges associated with risk diversity, which is essential for enterprises and national economies, especially during times of economic transformation. The necessity of risk management is apparent through proposed international strategies designed to enhance this management in response to the various issues associated with risk diversity. This emphasis notably underlines the significance of prudential oversight of insurance companies' solvency, underlining the requirement of such supervision to ensure the sector's proper operation and safeguard policyholders' interests (Abboura 2011).

Maintaining adequate reserves to meet obligations to policyholders is also crucial (Mohsen and Hani, 2017). The ramifications of regulatory reforms are examined, as demonstrated by Sadek and Boulouar (2018) in their examination of the 2006 prudential regulation reform's impact on the insurance sector in Algeria, emphasizing repercussions on public and private companies. The government's readiness to implement a new prudential framework aligned with international norms emphasizes the necessity of insurers' participation in this process to accurately represent the country's economic reality (Alouache et al. 2021).

Establishing a supervisory structure for insurance activities is essential, as highlighted by Riad et al. (2020), emphasizing the critical significance of solvency, particularly within the context of the 'Solvency II' regulation. They assert that substantial alterations in liability evaluation are consistently exposed to provisioning risk when determining solvency capital. The legal ramifications of the shift from Solvency I to Solvency II are examined by Lalaoui and Haffar (2022), who delineate implementation issues, including organizational transformation and the costs involved with adopting Solvency II. Bouabdallah and Oubelaid (2022) evaluate the implications of implementing the Solvency II standard formula on the capital requisites of an Algerian insurance company, highlighting the novel quantitative mandates established by Solvency II, such as the Solvency Capital Requirement (SCR) and the Minimum Capital Requirement (MCR).

Metchat and Boudaoud (2023) have conducted recent research that analyses emerging patterns in Algeria's insurance sector, underscoring the impact of constantly evolving prudential legislation. There is a critical necessity to keep sufficient solvency in response to increasing hazards. The analysis by Boucherak (2023) determines that the insurance company possesses sufficient equity to meet the necessary solvency

capital, highlighting the significant influence of risks associated with premiums and reserves, particularly in the automotive sector. The report recommends modernizing Algeria's solvency system to conform with Solvency II, thereby ensuring insurers' financial stability.

Our examination of research into the existing prudential rules for monitoring the solvency of insurance companies in Algeria clearly indicates a consensus on the need to transition to the Solvency II directive. Nonetheless, literature analysing critiques of Solvency II demonstrates a variety of perspectives among expert scholars. Gunther and Richter (2015) identify a deficiency in the existing standard formula, asserting that it inadequately represents the liquidity-related catastrophic risk. This critique highlights the necessity for the regulatory framework's suppleness to accommodate market advances.

Rae et al. (2018) assert that Solvency II has not fulfilled its anticipated goals, indicating the necessity for modifications to rectify procyclicality and market inconsistencies. This analysis underscores the intricacy of the legislation and stresses the necessity for a more comprehensive approach. The research by Santomil et al. (2019) indicates that the Solvency II minimum capital requirement is inferior to that determined by the standard model. This observation underscores possible discrepancies in risk evaluation across various techniques.

The findings of Cooke et al. (2019) substantiate apprehensions by demonstrating that Solvency II attenuates the significance of the risk margin, thus diminishing the technical reserves of insurance companies. This observation prompts inquiries regarding the system's capacity to sustain sufficient coverage against related risks, a notion corroborated by Drenovak et al. (2020), who assert that the Solvency II regulatory framework results in diminished diversification within the bond portfolio, consequently heightening the credit risk faced by insurance companies. This comment underscores a vital element of risk management within the regulatory framework.

Pelkiewicz et al. (2020) contend that Solvency II overlooks the risk margin, demonstrating disproportionate sensitivity to fluctuations in interest rates, particularly concerning annuities. This assessment indicates that the regulatory framework may need modifications to more effectively address the intricacies of insurance operations. Scherer and Stahl (2020) adopt a nuanced stance, recognizing that the Solvency II standard formula exhibits greater sensitivity to risk than its predecessor, despite the stochastic model still encompassing significant uncertainty. This viewpoint emphasizes the necessity of achieving equilibrium between risk sensitivity and model stability.

The examination of these diverse criticisms uncovers several fundamental issues pertaining to Solvency II, encompassing portfolio management and the handling of risks. These observations indicate the necessity for continuous assessment of the regulatory framework to guarantee its efficacy and pertinence in a constantly changing financial landscape.

An analysis of the Solvency I and II directives reveals that both frameworks exhibit a degree of inertia. Consequently, it is clear that investigating a more dynamic model is essential, and the literature proposes alternative models grounded in mathematical and stochastic methodologies.

The investigation of stochastic differential equations within the insurance sector is still somewhat constrained. Paul (2007) employed an alternative viewpoint by treating the necessary solvency capital as a constraint, utilizing deterministic control theory to establish the optimal premium approach. Similarly, Delong and Gerrard (2007) utilized a stochastic differential equation grounded in Brownian motion to represent the fluctuations in claims intensity. Their methodology incorporated stochastic control theory to determine the optimal strategy, particularly when the insurance company's wealth diverges from the established profit solvency target.

Shi et al. (2008) employed an integrative strategy that amalgamated risk tolerance and utility attitude with decision-making objectives, utilizing Backward Stochastic Differential Equations (BSDE) to formulate a model and ascertain the precise pricing formula for unit-linked life insurance products.

Xiong (2011) enhanced the research by investigating the diffusion model and its relevance to risk and insurance theory. The anticipated discounted penalty function is a substantial enhancement of the chance of ruin, fulfilling an elliptic partial differential equation under specific starting boundary conditions. Delong's (2012) comprehensive analysis explored multiple dimensions, encompassing financial risk, systematic and non-systematic insurance loss (including longevity risk), along with potential interdependencies among these elements.

Finally, it should be noted that the work of Floryszczak et al. 2018 although not included in the provided text, could be incorporated into this presentation depending on its context or its relationship with the works mentioned previously.

SOLVENCY ASSESSMENT MODEL FOR INSURANCE COMPANIES BASED ON STOCHASTIC DIFFERENTIAL EQUATIONS

Upon examining the attributes and nuances of the prevailing solvency standard for insurance companies in Algeria and evaluating research on their advantages and disadvantages relative to the "Solvency II" directive, the primary conclusion is that neither of these directives employs a dynamic methodology in the computation of solvency ratios. This observation pertains to all insurance companies assessing their solvency threshold.

In our research on the solvency evaluation of Algerian insurance companies, we focused on the model of stochastic differential equations, influenced by the work of Wang and Zhu (2021). The researchers conducted a thorough review of the solvency framework of insurance companies in China. Their methodology employs a model utilizing stochastic differential equations to ascertain the critical conditions for sustaining the dynamic solvency of an insurance company. They analysed and modelled these conditions while suggesting solutions to maintain solvency amid anticipated external disruptions.

This model utilizes capital flow analysis to evaluate the solvency of insurance companies. This approach considers financial dynamics across several stages, encompassing financial health, risk, and reserves, rather than simply delineating capital standards. The model defines an insurance company as a system driven by capital, wherein insurance premiums supply essential resources on one side, while claims expenditures safeguard policyholders on the other. The corporation concurrently employs its capital to yield profits via investments.

To better understand this dynamic, a compartmental model subdivides the company's funds into three distinct states: the health fund, the risk fund, and the reserve fund. Fund transfers between these states symbolize capital flows, as depicted in the figure below:

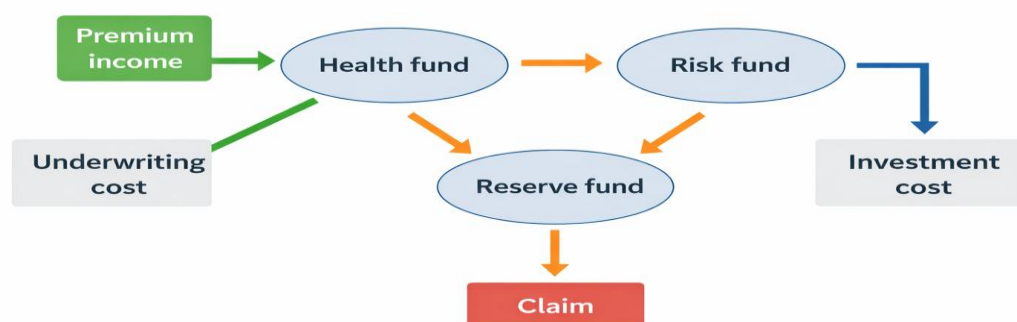


Figure 1. Organization of an insurance company

The SDE-based model conceptualizes an insurance company's capital flow as a dynamic system across three interconnected states: health state (premiums and underwriting), risk state (investments), and reserve state (claims provisioning). Solvency is assessed through the system's stability over time.

Model Specification and Dynamics

Health State (S(t)): This state reflects capital from collected premiums. Its growth is constrained by market capacity, and it is subject to stochastic fluctuations in premium income. Capital outflows include operating expenses, transfers to the risk state for investment, and allocations to the reserve state.

Risk State (I(t)): This state manages capital allocated for investments. Returns are subject to random market fluctuations. Outflows cover investment costs and further contributions to the reserve state.

Reserve State (R(t)): This state holds funds earmarked for future claim payments (compensations to policyholders). Inflows come from the health and risk states. Outflows are claim payments, which occur at stochastic intervals.

The dynamics are formally described by the following system of stochastic differential equations, where randomness is introduced via independent standard Brownian motions $B_1(t)$, $B_2(t)$, $B_3(t)$:

$$dS(t) = [S(t) + \lambda S(t)(1 - S(t)/K) - \beta S(t) - \omega S(t) - d_1 S(t)] dt + \sigma_1 S(t) dB_1(t) \quad (1)$$

$$dI(t) = [\beta S(t) + r I(t) - \mu I(t) - d_2 I(t)] dt + \sigma_2 I(t) dB_2(t) \quad (2)$$

$$dR(t) = [\omega S(t) + \mu I(t) - d^3 R(t)] dt + \sigma^3 R(t) dB^3(t) \quad (3)$$

where:

$S(t)$, $I(t)$, $R(t)$ — Capital levels in the health, risk, and reserve states at time t .

λ — Premium growth rate.

K — Carrying capacity (maximum attainable premium volume).

β , ω , μ — Transfer rates from health to risk state, health to reserve state, and risk to reserve state, respectively.

d_1 , d_2 , d_3 — Expense rate in the health state, cost rate in the risk state, and claims payment rate in the reserve state, respectively.

r — Expected rate of investment return.

σ_1 , σ_2 , σ_3 — Volatilities (standard deviations) of the capital flow fluctuations in each state.

Solvency Condition Derived from Stability Analysis

Following the stability analysis of the stochastic system by Wang and Zhu (2021), a sufficient condition for the long-term solvency of the insurance company — interpreted as the existence of a stable positive equilibrium — can be summarized by three constraints on the model parameters:

$$\lambda + 1 - (\beta + d_{3\omega} + d_1) > 0 \quad (4)$$

$$(\sigma_2)^2 \leq -2(r - d_2) - \beta + d_{3\mu} \quad (5)$$

$$(\sigma_3)^2 \leq d_3[(1 - \omega) + (1 + \mu)] \quad (6)$$

These conditions imply that solvency is sustainable if the premium growth is sufficiently high (4), the volatility of investment returns is bounded relative to their net performance (5), and the volatility of claim reserves is controlled relative to the funding from other states (6).

DISCUSSION: COMPARATIVE ANALYSIS AND FEASIBILITY FOR THE ALGERIAN CONTEXT

Building upon the analytical framework presented in the previous section, this discussion provides a comparative analysis of the Solvency I-based approach and the stochastic differential equation (SDE) model. The aim is to evaluate their respective merits and limitations in light of the research objectives: assessing the feasibility of a transition for Algeria and identifying the potential benefits.

Comparative Analysis of Core Principles

A fundamental divergence lies in the philosophical approach to risk. The Solvency I-inspired framework is fundamentally static and factor-based. It employs predetermined, deterministic formulas (e.g., a percentage of technical provisions or premiums) to calculate a solvency margin. While this ensures simplicity and ease of regulatory oversight, its major limitation is its insensitivity to the specific risk profile of an individual insurer and to dynamic market conditions. It cannot capture non-linear correlations between risks or simulate the impact of extreme "tail events."

In stark contrast, the SDE-based model is inherently dynamic and stochastic. As formulated by Wang and Zhu (2021) and presented in Section 3, it models key financial variables (reserves, asset returns, claim processes) as continuous-time processes subject to random shocks (Brownian motions $B_i(t)$). This allows for a forward-looking, risk-sensitive assessment. The model can simulate thousands of potential future economic and claim scenarios, estimating the probability of insolvency over a given time horizon rather than providing a single, static capital figure.

Addressing the Research Objectives: Feasibility, Comparison, and Benefits

Objective 1 & 2: Feasibility of Transition and Direct Comparison

The feasibility of adopting an SDE model in Algeria must be evaluated against key practical criteria, which also serve as points of comparison:

Data Requirements: Solvency I requires primarily accounting and volume data. The SDE model demands high-quality, granular historical data on investments, claims, and macroeconomic variables to calibrate parameters (σ_i , r , λ , K) reliably. This represents a significant initial hurdle for Algerian insurers and

the regulator.

Computational & Expertise Complexity: Implementing Solvency I is computationally straightforward. The SDE model requires advanced actuarial software and, crucially, specialized expertise in stochastic calculus, statistical estimation, and model validation—a skillset currently in short supply in the local market.

Regulatory Oversight: Supervising a standardized ratio (Solvency I) is simpler than validating the internal stochastic models of multiple insurers, which would require the Algerian regulatory authority to build significant new technical capacity.

Objective 3: Potential Benefits of a Dynamic Framework

Despite the challenges, the potential benefits of moving towards a dynamic framework are substantial and justify a strategic, phased exploration:

Enhanced Risk Sensitivity: Capital requirements would be aligned with the insurer's actual risk exposure, promoting more efficient capital allocation. Less risky insurers would be rewarded, incentivizing sound risk management.

Proactive Risk Management: The ability to run stress tests and scenario analyses (e.g., simulating a market crash coupled with a spike in health claims) would empower both insurers and regulators to identify vulnerabilities before they crystallize.

Policyholder Protection & Systemic Stability: A more accurate assessment of solvency strengthens the entire financial system by reducing the likelihood of unexpected insolvencies, thereby offering superior long-term protection for policyholders — a core regulatory goal.

Alignment with International Best Practices: While a full leap to Solvency II may be premature, exploring dynamic models positions Algeria on a pathway aligned with global regulatory evolution, potentially improving the international perception of its insurance market.

A Proposed Pathway for Algeria

A sudden, wholesale replacement of the current system is neither feasible nor advisable. A pragmatic, incremental pathway is recommended:

Pilot Studies: The regulator could initiate pilot projects with the largest, most sophisticated insurers to develop and test SDE models for specific lines of business (e.g., life insurance).

Capacity Building: Parallel investment in training for actuaries, regulators, and data scientists is essential. Partnerships with universities and international bodies could be sought.

Hybrid Approach: In a transitional phase, Algeria could consider a "tiered approach" where the standard Solvency I rules apply, but insurers demonstrating advanced modelling capabilities are allowed to use approved internal (SDE-based) models for part of their capital calculation, subject to strict validation.

Stakeholder Engagement: As noted in prior literature (Aissat-Leghima and Belkadi-Attab 2019), a continuous dialogue between insurers, the regulator, and academia is vital to build consensus and tailor the model's complexity to the local context.

CONCLUSION

This study set out to explore the potential for Algeria to transition from its current Solvency I-based prudential framework to a more dynamic model grounded in stochastic differential equations. Through a comparative analytical approach, the paper has addressed its three core objectives.

First, regarding the feasibility of such a shift, the analysis concludes that while a full, immediate adoption is challenged by significant requirements in data infrastructure, technical expertise, and regulatory capacity, a phased and strategic exploration is both possible and desirable. Initial steps should focus on pilot studies and capacity building.

Second, the comparison between the two models reveals a fundamental trade-off. The existing framework offers simplicity and ease of supervision but lacks risk sensitivity. The SDE-based model offers a superior, forward-looking assessment of solvency by incorporating randomness and dynamic interactions, but at the cost of complexity and higher implementation demands.

Third, the potential benefits of moving towards a dynamic framework are compelling. They include more efficient capital allocation, proactive risk management through scenario analysis, enhanced policyholder protection, and better long-term alignment with international regulatory trends. These benefits suggest that the SDE model represents a more robust conceptual foundation for solvency assessment in a complex financial world.

In light of these findings, the primary recommendation for Algerian policymakers is not an abrupt regulatory change, but the initiation of a structured transition program. This program should prioritize investments in data systems and human capital, foster collaboration between industry and academia, and consider a tiered regulatory approach that allows advanced models to be introduced gradually. Such a pathway would enable Algeria to modernize its solvency regime in a manner that is both prudent and

progressive, ultimately strengthening the resilience of its national insurance sector.

Acknowledgments

The authors would like to thank everyone who contributed directly or indirectly to the completion of this research, as well as for their support and assistance.

Funding

The authors declare that this research received no external funding.

Data Availability Statement

The data used in this study are available from the corresponding author upon reasonable request.

Conflict of Interest

The authors declare no conflict of interest.

AI Tools Statement

AI-based language editing tools were used to improve grammar and clarity. All intellectual content, interpretation, and conclusions are solely the responsibility of the authors.

Author Contributions

- Conceptualization: AIT OUALI Toufik
- Methodology: MENDIL Djamila
- Software: AIT OUALI Toufik
- Validation: MENDIL Djamila
- Formal analysis: MENDIL Djamila
- Investigation: AIT OUALI Toufik
- Resources: AIT OUALI Toufik
- Data curation: AIT OUALI Toufik
- Writing – original draft: AIT OUALI Toufik
- Writing – review & editing: MENDIL Djamila
- Visualization: MENDIL Djamila
- Supervision: MENDIL Djamila
- Project administration: MENDIL Djamila

REFERENCES

- Abboura, K. 2011. Le contrôle de la solvabilité des compagnies d'assurance [The supervision of the solvency of insurance companies]. *Les sociétés d'Assurances Takaful et les sociétés d'assurances Traditionnelles Entre la Théorie et l'Expérience Pratique [Takaful Insurance Companies and Traditional Insurance Companies: Between Theory and Practical Experience]*. Sétif, 38 Avril.
- Aissat-Leghima, A., and S. Belkadi-Attab. 2019. Solvabilité II : les nouvelles règles et la gestion des risques [The New Rules and Risk Management]. *Gestion des organisations et systèmes financiers: Quel modèle pour l'Afrique du 21^e siècle? [Management of Organizations and Financial Systems: Which Model for 21st-Century Africa?]*, Dakar.
- Alouache, S., S. Fekarcha, and R. Athmania. 2021. Vers un nouveau cadre prudentiel pour le secteur des assurances en Algérie [Towards a New Prudential Framework for the Insurance Sector in Algeria]. *Revue des recherches en sciences financières et comptables [Review of Research in Financial and Accounting Sciences]*, 6(2): 576-592.
- Bouabdallah, R., and H. Oubelaid. 2022. L'impact du passage de Solvabilité I à Solvabilité II sur les exigences en fonds propres d'une compagnie d'assurance [The Impact of the Transition from Solvency I to Solvency II on the Capital Requirements of an Insurance Company]. *Revue des Sciences commerciales et de gestion ([Review of Commercial and Management Sciences]*, 8(1): 96-124.
- Boucherak, I. 2023. Capital de solvabilité requis pour le risque de primes et de réserves en assurance non vie sous solvabilité II [Solvency Capital Requirement for Premium and Reserve Risk in Non-Life Insurance under Solvency II]. *Revue des Réformes Économiques et Intégration En Économie Mondiale [Review of Economic Reforms and Integration into the Global Economy]*, 71(17): 204-217.
- Cooke, J., A. Scott, D. Smith, A. Rogan, R. Cooper, S. Morgan, A. Plotnek, N. Kenyon, and S. Bhalla. 2019. Recalculation of the Solvency II transitional measures on technical provisions. *British Actuarial Journal*, 24: 1–87. <https://doi.org/10.1017/S1357321718000302>
- Delong, L. 2012. An optimal investment strategy for a stream of liabilities generated by a step process in a financial market driven by a Lévy process. *Insurance: Mathematics and Economics*, 47(3): 278–293. <https://doi.org/10.1016/j.insmatheco.2010.07.003>
- Delong, L., and R. Gerrard. 2007. Mean-variance portfolio selection for a non-life insurance company. *Mathematical Methods of Operations Research*, 66(2): 339–367. <https://doi.org/10.1007/s00186-007-0152-2>
- Drenovak, M., V. Rankovic, B. Urosevic, and R. Jelic. 2020. Bond Portfolio Management Under Solvency

- II Regulation. *The European Journal of Finance*, 26: 1-23. <https://dx.doi.org/10.2139/ssrn.3319426>
- Floryszczak, A., J. Levy Vehel, and M. Majri. 2019. A conditional equity risk model for regulatory assessment. *Astin Bulletin*, 49(1): 217–242. <https://doi.org/10.1017/asb.2018.35>
- Gunther, K., and A. Richter. 2015. Insurance regulation and life catastrophe risk: treatment of life catastrophe risk under the SCR standard formula of solvency II and the necessity of partial internal models. *Geneva Papers on Risk and Insurance - Issues and Practice*, 40(2): 256–278. <https://dx.doi.org/10.2139/ssrn.1976261>
- Wang, K., and L. Zhu. 2021. Solvency evaluation model of insurance company based on stochastic differential equation. *Complexity* 5594619, 12 pages, 2021. <https://doi.org/10.1155/2021/5594619>
- Lalaoui, K., and A. Haffar. 2022. De solvabilité i vers solvabilité ii, enjeux juridiques et perspectives en termes de gestion et de communication financière, pour le marché algérien des assurances [From Solvency I to Solvency II: Legal Challenges and Perspectives in Terms of Management and Financial Communication for the Algerian Insurance Market]. *Revue des études juridiques et politiques [Review of Legal and Political Studies]*, 8(1): 535-554.
- Metchat, K., and S. Boudaoud. 2023. Solvabilité et gestion des risques : les nouvelles tendances qui façonnent l'industrie de l'assurance [Solvency and Risk Management: New Trends Shaping the Insurance Industry]. *Al Bashaer Economic Journal*, 9(2): 650-664.
- Mohsen, Z., and M. Hani. 2017. Provisions techniques des sociétés d'assurance cas d'Algérie [Technical Provisions of Insurance Companies: The Case of Algeria]. *Economic Development Review*: 379-392.
- Paul, E. 2007. Pricing general insurance with constraints. *Mathematics and Economics*, 40(2): 335–355. <https://ssrn.com/abstract=961579>
- Pelkiewicz, A., S. Ahmed, P. Fulcher, L. Johnson, S. Reynolds, R. Schneider, and A. Scott. 2020. A review of the risk margin – Solvency II and beyond. *British Actuarial Journal*, 25: 1–72. <https://doi.org/10.1017/S135732172000001X>
- Rae, R. A., A. Barrett, D. Brooks, M. Chotai, A. Pelkiewicz, and C. Wang. 2018. A review of Solvency II: Has it met its objectives? *British Actuarial Journal*, 23(4): 1-72. <https://doi.org/10.1017/asb.2018.35>
- Rezazi, O., and S. Temam. 2003. La gestion des risques d'assurance [Insurance Risk Management]. *Revue administration et développement pour les recherches et les études [Review of Administration and Development for Research and Studies]*: 24-34.
- Riad, M., A. Akhenak, and B. Djelouli. 2020. Analyse de la solvabilité en assurance dommages dans le cadre référentiel « Solvency II »: Méthodes de provisionnement [Solvency Analysis in Non-Life Insurance under the 'Solvency II' Framework: Provisioning Methods]. *The Future Journal of In-depth Economic Studies*, 3(1): 79-87.
- Sadek, T., and B. Boulenouar. 2018. Les effets de la réforme de la réglementation prudentielle engagée en 2006 sur l'activité de l'assurance en Algérie [The Effects of the Prudential Regulatory Reform Initiated in 2006 on Insurance Activity in Algeria]. *Revue Algérienne d'Economie de gestion [Algerian Journal of Economics and Management]*, 20: 69-81.
- Santomil, P. D., L. González, O. Cunill, and A. Gil-Lafuente. 2019. Property risk under solvency II: Effects of different unsmoothing techniques. *Technological and Economic Development of Economy*, 25(1): 1-19. <https://doi.org/10.3846/tede.2019.6213>
- Scherer, M., and G. Stahl. 2020. The standard formula of solvency II: a critical discussion. *European Actuarial Journal*, 11:13–31. <https://doi.org/10.1007/s13385-020-00252-z>
- Shi, Y., D. Zhao, and L. Hou. 2008. Arbitrage free life insurance pricing model based on individual equity principle. *International Conference on Management Science and Engineering 15th Annual Conference Proceedings*, China, 205–210. <https://doi.org/10.1109/ICMSE.2008.4668917>
- Xiong, S. 2011. Stochastic Differential Equations: Some Risk and Insurance Applications. *Temple University*, Philadelphia, PA, USA.