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https://doi.org/10.15642/manova.v9i1

Asset Insurance Under Rising Disasters: Financial Value and Simulation Evidence

Received 14 December 2025
Revised 12 January 2026
Accepted 15 January 2026

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Abstract

Objective – This paper evaluates whether insuring public assets is financially beneficial under increasing disaster risk, with emphasis on the trade-off between expected cost and tail-risk protection relevant to public asset management.

Design/methodology/approach – The study integrates disaster-risk financing and insurance-demand theory with a Monte Carlo simulation of a representative public-asset portfolio over a 10-year horizon. The simulation models increasing hazard frequency, skewed loss severity, inflation, and a simplified insurance contract (deductible and limit). Outcomes are assessed using expected net present value (NPV) of total cost, downside risk (P95/P99), and the probability of breaching a fiscal-stress threshold.

Findings – Insurance increases expected NPV cost under plausible premium loadings, yet it materially reduces tail risk. In the base case, the P95 of total cost falls from 182.0 to 96.6 IDR bn, and the probability of NPV exceeding IDR 200 bn drops from 3.9% to 0.6%. Therefore, insurance can be financially rational when decision-makers value budget stability and service-continuity protection more than expected-cost minimisation.

Research limitations/implications – Quantitative outputs are illustrative because parameters are not calibrated to a specific ministry asset register, peril mix, and vulnerability. Future work should calibrate catastrophe models to BMN portfolios and incorporate premium dynamics under hardening reinsurance markets.

Practical implications – The framework supports risk appetite setting, deductible/limit optimisation, and integration of insurance with maintenance, retrofit, and contingency reserves.

Originality/value – The paper bridges public asset management and disaster-risk financing by translating insurance decisions into NPV and tail-risk metrics that are actionable for portfolio governance.

Jurnal Manajemen dan Inovasi
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DOI
https://doi.org/10.15642/manova.v9i1.2406

INTRODUCTION

Natural hazards have become a first-order variable in asset management, corporate finance, and public governance. In many jurisdictions, climate-related hazards are increasing in frequency and intensity, while exposure is rising due to urbanisation, asset densification, and the growing interdependence of infrastructure systems (Hallegatte et al., 2019; Mills, 2005; UNDRR, 2019). At the global level, this is reflected in persistently high catastrophe losses. For example, Swiss Re Institute estimates that natural catastrophes generated USD 280 billion of economic losses in 2023, of which USD 108 billion were insured, illustrating the continuing insurance protection gap (Swiss Re Institute, 2024).

In Indonesia, disaster risk is not an abstract externality; it is a recurring operational reality. BNPB maintains a national disaster dataset (DIBI) and publishes annual compilations of disaster events and impacts. The 2024 disaster data book reports thousands of disaster events in a single year, dominated by hydrometeorological hazards (BNPB, 2025). Such patterns imply a persistent stream of losses and interruptions to public services, and they place sustained pressure on fiscal resources earmarked for repair, rehabilitation, and reconstruction (OECD, 2012; OECD, 2024; World Bank, 2021).

Within this context, public asset owners face an increasingly strategic question: should assets be insured, and under what contract structures? For a ministry or public agency, this is not simply a procurement question. Insurance competes with other uses of scarce fiscal capacity, including routine maintenance, retrofit programs, preventive investments (e.g., flood mitigation), and contingency reserves (Arrow, 1971; Cummins & Mahul, 2009; World Bank, 2019). Moreover, the financial interpretation of 'benefit' is contested. In expected-value terms, insurance premiums usually exceed expected claims because insurers embed loadings for capital costs, uncertainty, distribution, taxes, and operating expenses (Dionne, 2013; Priest, 1987; Vaughan & Vaughan, 2014). Therefore, a narrow accounting view may label insurance as a net loss. Yet risk management logic suggests that insurance can be value-creating if it reduces fiscal volatility, prevents disruptive reallocation, and protects the continuity of essential services (ISO, 2018).

This paper addresses that decision problem in a manner aligned to management and innovation scholarship. It focuses on the financial logic of insuring assets amid rising disaster risk, using a simulation approach that quantifies both expected outcomes and tail risks. It contributes by translating the insurance decision into metrics that are familiar to financial management (NPV) and to risk management (P95/P99 and threshold breach probability). The analysis is positioned for policymakers, asset managers, and finance practitioners who need a defensible method to justify insurance budgets and to optimise contract structures.

Research questions

RQ1. Under rising disaster risk, when does insuring public assets reduce risk-adjusted financial burden compared with remaining uninsured?

RQ2. How do deductibles, limits, and premium loadings change the expected and tail-risk outcomes of asset insurance?

RQ3. What managerial and governance implications follow for integrating insurance into public asset management and disaster-risk financing strategies?

Contribution and paper structure

The paper contributes a replicable simulation framework that produces decision-grade outputs: expected NPV, P95/P99, and threshold-breach probability, and translates them into managerial implications for public asset governance. The remainder is organised as follows: Section 2 reviews the relevant literature; Section 3 sets the conceptual model; Section 4 describes the simulation design; Section 5 presents results; Section 6 discusses interpretation and implications for Indonesia's public asset governance; Section 7 concludes and outlines future research.

THEORETICAL BACKGROUND AND RESEARCH MODEL

Disaster-risk financing (DRF) and fiscal resilience

Disaster-risk financing refers to the set of ex-ante and ex-post financial instruments used to manage the fiscal impacts of shocks (Cummins & Mahul, 2009; OECD, 2012; World Bank, 2019). Ex-ante instruments include reserve funds, budget contingencies, insurance, reinsurance, catastrophe bonds, and contingent credit lines. Ex-post instruments include budget reallocations, emergency borrowing, and donor support (OECD, 2012; World Bank, 2021). A core lesson of the DRF literature is that no single instrument is sufficient; effective strategies layer instruments according to the frequency–severity profile of losses. This idea is often represented by a risk-layering approach: retain high-frequency low-severity losses (self-insurance), and transfer low-frequency high-severity losses (insurance/reinsurance/capital markets) (Cummins & Mahul, 2009; OECD, 2012).

From a managerial perspective, the significance of DRF lies in the time value of liquidity. When an organisation lacks pre-arranged financing, post-disaster recovery may be delayed, raising indirect costs such as service interruption, reputational damage, and political consequences (Kunreuther & Michel-Kerjan, 2011; Hallegatte et al., 2019). These indirect costs are often under-measured in financial appraisal but can dominate the welfare impact for critical public services (e.g., hospitals, schools, data centres, roads) (UNDRR, 2019; Hallegatte et al., 2019).

Insurance demand: expected utility, risk aversion, and contract design

Insurance economics explains that, under risk aversion and uncertainty, decision-makers are willing to pay a premium above expected loss to reduce variance and tail risk (Arrow, 1971; Schlesinger, 1999). Ehrlich and Becker distinguish between market insurance (risk transfer), self-insurance (risk retention via reserves), and self-protection (risk reduction) (Ehrlich & Becker, 1972). Their framework highlights that insurance interacts with prevention: contract features such as deductibles and experience rating can preserve incentives to invest in mitigation, while overly generous coverage can create moral hazard (Shavell, 1979; Ehrlich & Becker, 1972). Schlesinger's survey of insurance demand further clarifies that deductible choice is a core lever: higher deductibles lower premiums but increase retained tail risk (Schlesinger, 1999).

Beyond classic expected utility, modern organisations often evaluate risk using metrics such as Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR) (Lane, 2000; Paudel, 2012). For public entities, a useful analogue is the probability of exceeding an annual or multi-year fiscal stress threshold. This aligns with budget governance: even if expected losses are manageable, a single extreme event can breach fiscal limits and trigger costly reallocations or emergency financing (Froot, 2001; von Peter et al., 2012).

Insurance pricing, loadings, and the 'negative expected value' perception

The common perception that insurance is 'always a loss' arises because the premium is generally greater than the actuarially fair expected payout (Vaughan & Vaughan, 2014). Insurers charge loadings to cover acquisition costs, administration, taxes, reinsurance, capital costs, and profit margins (Dionne, 2013; Priest, 1987). In catastrophe lines, loadings also reflect model uncertainty and the cost of capital required to support tail exposure (Lane, 2000; Froot, 2001). Therefore, the buyer's value proposition depends on risk preferences and constraints, not on expected value alone.

Public asset management and the special case of government portfolios

Public asset portfolios differ from corporate assets in three ways. First, many public assets generate non-market benefits (public goods), making indirect costs of failure substantial (Hallegatte et al., 2019). Second, budget processes can be rigid, creating liquidity constraints that increase the cost of unplanned shocks (OECD, 2024). Third, the state can pool risks across geographies and asset classes, which in theory supports self-insurance (Arrow, 1971; OECD, 2024). However, political economy and earmarking constraints often limit the practical effectiveness of pooling (Kunreuther & Michel-Kerjan, 2011; World Bank, 2019).

In Indonesia, BMN governance emphasises safeguarding and utilisation. Insurance is increasingly framed as an instrument to protect state assets and to ensure continuity of service delivery (World Bank, 2021). Regulatory developments (including updated ministerial regulations on BMN insurance) signal institutionalisation of risk transfer (Indonesia, Ministry of Finance, 2025). At the same time, insurance procurement must be justified against competing priorities such as maintenance backlogs, retrofit needs, and digitalisation of asset registers (OJK, 2024).

Research gap

Despite extensive work on catastrophe insurance, there is limited operational guidance translating insurance decisions for public assets into familiar portfolio metrics that combine expected cost and tail-risk protection (Cummins & Mahul, 2009; OECD, 2024). Existing discussions often remain qualitative, or they focus on household insurance uptake rather than institutional portfolios (Michel-Kerjan & Kousky, 2010; Botzen & van den Bergh, 2009). This paper fills that gap by developing a replicable simulation framework that produces NPV, tail quantiles, and fiscal-stress probabilities, and by demonstrating how contract design (deductible/loading) alters outcomes (Lane, 2000; Paudel, 2012).

Decision objective: expected cost versus risk-adjusted cost

The insurance decision is modelled as a choice between two strategies: (i) remain uninsured and fund losses through the budget (ex-post financing), or (ii) insure and pay premiums in exchange for reduced retained losses (Arrow, 1971; Cummins & Mahul, 2009). The objective function can be expressed in two ways:

(a) Expected-cost criterion: choose the strategy that minimises expected NPV of total cost.

(b) Risk-adjusted criterion: choose the strategy that balances expected NPV with tail-risk measures (e.g., minimise a weighted sum of expected NPV and CVaR, or meet an acceptable probability of exceeding a fiscal threshold).

For public governance, criterion (b) is often more realistic. Ministries may face explicit ceilings on annual spending, debt issuance, or contingency use. In this setting, avoiding rare but severe fiscal shocks is a legitimate objective (OECD, 2012; OECD, 2024; World Bank, 2019).

Cash-flow components

For each year t, total cost under the uninsured strategy includes: direct physical loss L_t(repair/replacement) and indirect disruption cost D_t(service interruption, temporary relocation, emergency procurement inefficiency) (Hallegatte et al., 2019; UNDRR, 2019). Under the insured strategy, total cost includes retained loss Rt (deductible plus any loss above limits), disruption cost Dt (still occurs), and premium Pt (Vaughan & Vaughan, 2014).

Insurance contract representation

An indemnity-style contract with annual deductible d and limit u is represented by insurer payout $I_t = min(max(L_t - d, 0), u)$ (Vaughan & Vaughan, 2014). Retained loss is $R_t = L_t - I_t$. Premium pricing is simplified as:

$$P_t = (1 + \alpha)E[I_t] + k$$

where α is a loading factor and k is a fixed cost component (Dionne, 2013; Lane, 2000). This is not intended to replicate market pricing precisely, but it captures the structural feature that insurance typically has a positive loading (Priest, 1987; Vaughan & Vaughan, 2014).

Risk appetite and 'fiscal shock' threshold

To operationalise risk appetite, the model evaluates the probability that the 10-year NPV of total cost exceeds a threshold T. In an applied setting, T should be selected based on budget capacity, reserve size, and the political tolerance for reallocation (OECD, 2012; World Bank, 2019). For demonstration, T is set to IDR 200 billion.

Propositions

P1. With positive loadings, insurance tends to raise expected NPV cost relative to being uninsured (Arrow, 1971; Vaughan & Vaughan, 2014).

P2. Insurance reduces tail risk (P95/P99) and the probability of threshold breach (Froot, 2001; Lane, 2000).

P3. The value of insurance increases with higher hazard trend, higher disruption costs, and greater budget rigidity (Kunreuther & Michel-Kerjan, 2011; Hallegatte et al., 2019).

P4. Optimal solutions frequently involve partial insurance (meaningful deductibles) combined with reserves and risk reduction investments (Ehrlich & Becker, 1972; Schlesinger, 1999).

RESEARCH METHODS

Research design

The paper employs a computational experiment (Monte Carlo simulation) supported by theoretical synthesis. Simulation is appropriate because disaster losses are stochastic, skewed, and fat-tailed, making closed-form evaluation difficult and potentially misleading (Lane, 2000; Paudel, 2012).

Portofolio and horizon

A representative portfolio is set with an initial replacement value of IDR 500 billion and a 10-year horizon, consistent with medium-term fiscal planning (OECD, 2024). Replacement values grow with inflation. Costs are discounted using a nominal discount rate representing an opportunity cost of public funds (Arrow, 1971).

Hazard frequency and severity

Annual event counts follow a Poisson process with increasing rate:

$$\lambda_t = \lambda_0(1+g)^\wedge t$$

where g captures increasing hazard frequency (Mills, 2005; UNDRR, 2019). Conditional on events, loss severity is modelled as lognormal loss ratios, reflecting many small losses and occasional large losses (Paudel, 2012). Annual losses aggregate multiple events and are capped at 100% of replacement value (Cummins & Mahul, 2009).

Indirect disruption costs

Indirect costs are approximated as a fixed proportion of the initial replacement value when any loss occurs. In practice, disruption costs vary by asset type and criticality; future work should estimate them empirically (e.g., downtime valuation). Nevertheless, including this term is essential because it prevents an overly narrow focus on repair costs alone (Hallegatte et al., 2019; Surminski, 2014).

Strategies compared

Three strategies are evaluated:

(S1) Uninsured: all losses are funded by the owner.

(S2) Insured: deductible d = IDR 5 bn, limit u = IDR 200 bn, premium loading α = 35%.

(S3) Hybrid: reserve fund of IDR 50 bn (incurring an opportunity cost), combined with higher deductible (IDR 20 bn) and the same limit. A financing penalty applies if retained loss exceeds the reserve

Outcome measures

Primary outputs are the distribution of 10-year NPV of total cost: mean, median, P90/P95/P99, and probability of exceeding IDR 200 bn. Secondary outputs include annual loss distributions and sensitivity to deductible and loading.

Validity, limitations, and replication

The experiment is internally consistent and replicable but externally illustrative. Calibration to Indonesian hazard models and BMN asset registers is necessary for policy application. The framework, however, is designed so that practitioners can replace parameter values without changing the modelling logic.

Table 1.
BASE-CASE ASSUMPTIONS (ILLUSTRATIVE)

Parameter	Value	Notes
Initial replacement value	IDR 500 bn	Representative portfolio / major asset
Horizon	10 years	Medium-term planning cycle
Inflation	4% p.a.	Replacement value growth
Discount rate	8% p.a.	Nominal discount (illustrative)
Event rate λ0	0.12	Baseline annual frequency
Frequency trend g	5% p.a.	Increasing hazard frequency
Severity	Lognormal (mean≈8%)	Loss ratio capped at 100%
Disruption cost	1.5% of value	Applied when any loss occurs
Deductible	IDR 5 bn	Insured strategy
Limit	IDR 200 bn	Insurer payout cap per year
Premium loading	35%	Simplified pricing margin

Source: Author's illustration following based on World Bank disaster risk-financing frameworks.

ANALYSIS AND RESEARCH RESULTS

Base-case comparison

Table 2 summarises the base-case trade-off. The insured strategy increases expected NPV cost because premiums include positive loadings. However, insurance materially compresses the right tail of the cost distribution, reducing severe fiscal shock outcomes.

Table 2 shows that the uninsured strategy has a lower expected NPV (57.53 IDR bn) but much worse tail outcomes (P95 = 182.01; P99 = 298.00). In contrast, the insured strategy has higher expected NPV (76.23) but much lower tail risk (P95 = 96.58; P99 = 157.46) and a lower probability of exceeding the IDR 200 bn threshold.

Table 2.
SIMULATION OUTCOMES: 10-YEAR NPV OF TOTAL COST

Strategy	Expected NPV cost (IDR bn)	Median (P50) (IDR bn)	P90 (IDR bn)	P95 (IDR bn)	P99 (IDR bn)	Prob NPV > 200 bn
Uninsured	57.53	39.05	139.00	182.01	298.00	0.04
Insured	76.23	72.50	89.54	96.58	157.46	0.01

Source: Author's simulation results.

Understanding the distributional effect

Figure 1 visualises the distribution of 10-year NPV cost under uninsured and insured strategies. The uninsured distribution is more right-skewed, reflecting rare but costly loss realizations. The insured distribution shifts some mass to higher routine cost (premiums) but reduces extreme outcomes.

Annual loss dynamics under rising hazard frequency

Tables 3 and 4 report annual loss distributions. Because event frequency increases over time, both mean losses and tail quantiles rise modestly across the horizon. This dynamic matters for contract design: fixed limits may become less effective as hazard intensity rises, while premiums may reprice upward if insurers adjust expected losses.

Table 3.
ANNUAL GROSS LOSS DISTRIBUTION (UNINSURED) – SUMMARY

Year	Mean loss (IDR bn)	P90 (IDR bn)	P95 (IDR bn)	P99 (IDR bn)	Prob loss>0
1.00	4.69	9.42	31.58	94.79	0.11
2.00	5.23	11.38	35.06	103.34	0.12
3.00	5.68	13.47	37.95	109.37	0.12
4.00	6.23	16.32	41.01	116.18	0.13
5.00	6.98	19.26	46.86	126.91	0.14
6.00	7.26	20.34	48.65	130.59	0.14
7.00	8.15	23.63	53.56	140.88	0.15
8.00	8.72	25.91	58.08	153.32	0.15
9.00	9.92	30.52	64.03	164.53	0.16
10.00	10.31	32.38	66.01	168.53	0.17

Source: Author's simulation results derived from stochastic loss modelling with increasing hazard frequency.

Table 4.
ANNUAL RETAINED LOSS DISTRIBUTION (INSURED) – SUMMARY

Year	Mean loss (IDR bn)	P90 (IDR bn)	P95 (IDR bn)	P99 (IDR bn)	Prob loss>0
1.00	0.67	5.00	5.00	5.00	0.11
2.00	0.75	5.00	5.00	5.00	0.12
3.00	0.82	5.00	5.00	5.00	0.12
4.00	0.87	5.00	5.00	5.00	0.13
5.00	0.97	5.00	5.00	5.00	0.14
6.00	0.99	5.00	5.00	5.00	0.14
7.00	1.13	5.00	5.00	5.00	0.15
8.00	1.19	5.00	5.00	5.00	0.15
9.00	1.47	5.00	5.00	5.00	0.16
10.00	1.47	5.00	5.00	5.00	0.17

Source: Author’s simulation results based on the insured loss structure described in Table 1.

Sensitivity to deductible and loading

Table 5 shows that expected NPV is sensitive to premium loading. Lower loadings can make insurance closer to break-even on an expected-value basis. Deductibles reduce premiums and expected NPV but increase retained tail risk. This is consistent with insurance-demand theory: deductibles are a mechanism to retain frequent small losses and transfer catastrophic layers.

Table 5.
SENSITIVITY ANALYSIS (LOADING × DEDUCTIBLE)

Loading	Deductible (IDR bn)	Expected NPV (IDR bn)	P95 (IDR bn)	P99 (IDR bn)	Prob NPV>200bn
15%	2.00	68.04	83.35	149.73	0.01
15%	5.00	67.61	87.96	148.85	0.00
15%	10.00	66.93	94.86	148.01	0.00
15%	20.00	65.78	106.22	150.61	0.00
35%	2.00	77.23	92.54	158.92	0.01
35%	5.00	76.23	96.58	157.46	0.01
35%	10.00	74.64	102.57	155.73	0.01
35%	20.00	71.94	112.39	156.78	0.01
60%	2.00	88.71	104.02	170.40	0.01
60%	5.00	87.00	107.35	168.24	0.01
60%	10.00	84.28	112.21	165.36	0.01
60%	20.00	79.66	120.10	164.49	0.01

Source: Author’s simulation-based sensitivity analysis.

Table 6.
COMPARING STRATEGIES, INCLUDING A RESERVE–INSURANCE HYBRID

Strategy	Expected NPV cost (IDR bn)	Median (P50) (IDR bn)	P90 (IDR bn)	P95 (IDR bn)	P99 (IDR bn)	Prob NPV > 200 bn
Uninsured	57.53	39.05	139.00	182.01	298.00	0.04
Insured (ded=5bn)	76.23	72.50	89.54	96.58	157.46	0.01
Hybrid:	86.58	81.59	115.16	126.99	174.32	0.01

Reserve 50bn + ded=20bn

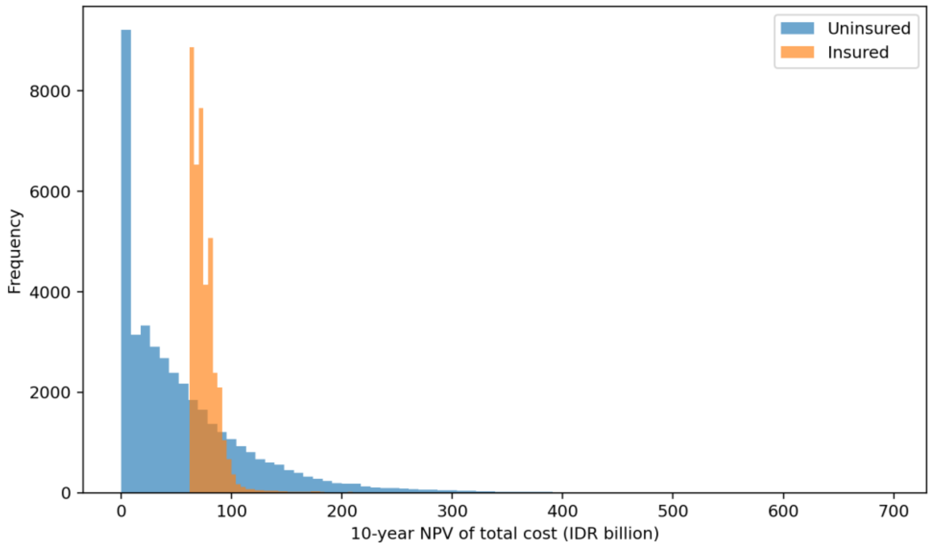
Source: Author’s simulation results comparing alternative risk-financing strategies.

Hybrid strategy

Many governments do not choose between ‘pure insurance’ and ‘no insurance’; they use mixed strategies. Table 6 shows a simple hybrid strategy combining a reserve fund with higher deductible. This approach can reduce expected premium spend while preserving protection against severe events. The result illustrates a governance insight: reserves and insurance are complements when structured via risk layering.

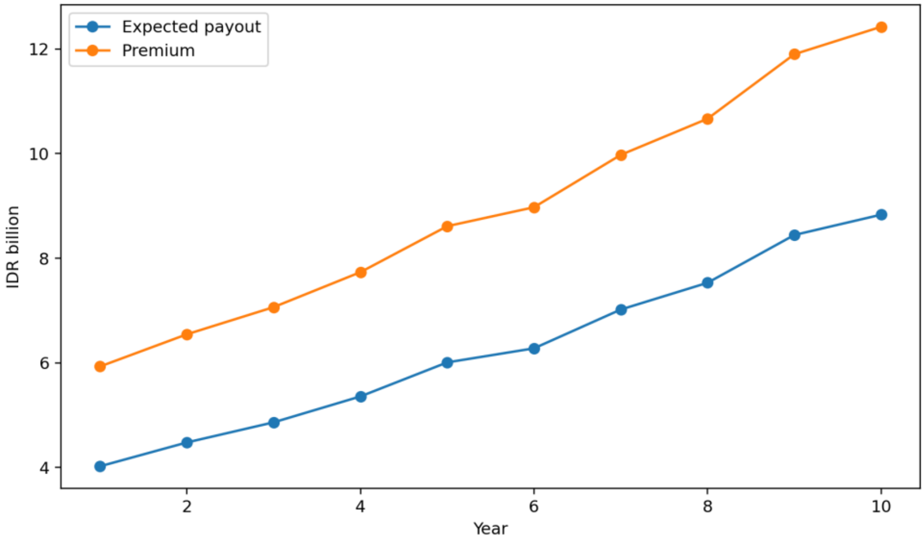
Visual summaries

Figures 2 and 3 show premium–payout dynamics and loss components over time. The premium tends to exceed expected payout due to the loading, yet the insurer payout meaningfully reduces retained losses, especially in high-loss years.

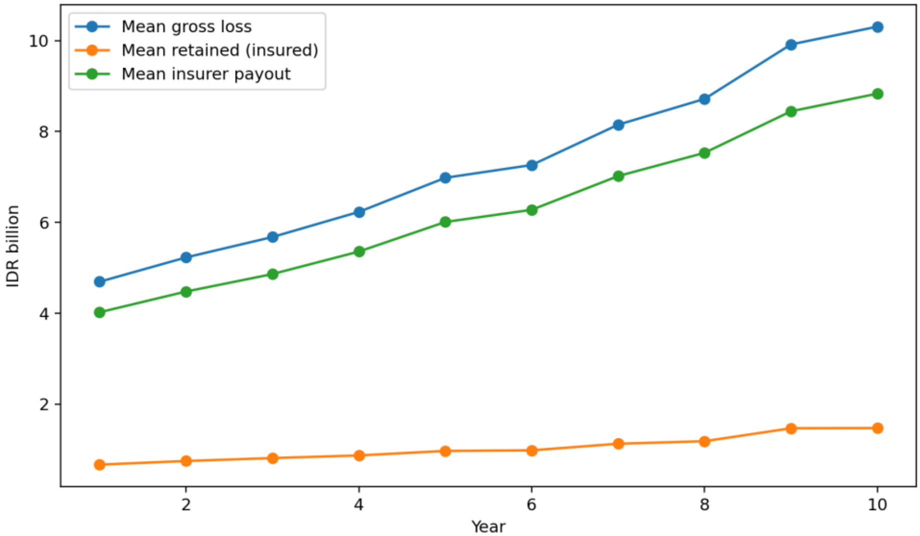


Source: Author simulation (N=40,000).

Figure 1. DISTRIBUTION OF 10-YEAR NPV COST (INSURED VS UNINSURED)



Source: Author simulation (simplified pricing).
Figure 2. ANNUAL PREMIUM AND EXPECTED PAYOUT



Source: Author simulation.
Figure 3. MEAN ANNUAL LOSS COMPONENTS

DISCUSSION

This section discusses the findings explicitly in relation to the three research questions posed in the Introduction. First, it addresses under what conditions insuring public assets reduces the risk-adjusted financial burden relative to remaining uninsured (RQ1). Second, it examines how insurance contract design—including deductibles, coverage limits, and premium loadings—affects expected cost and tail-risk outcomes (RQ2). Third, it explores the managerial and governance implications for integrating insurance into public asset management and disaster-risk financing strategies (RQ3).

Insurance: Profit, Loss, and Risk Reduction

The results show that insuring public assets reduces the risk-adjusted financial burden when the governance objective extends beyond minimising expected cost to include fiscal stability, budget predictability, and protection against extreme downside outcomes.

If 'profit' is defined narrowly as a positive expected monetary return, insurance is usually not profitable because the premium embeds loadings. However, organisations rarely buy insurance to speculate; they buy it to hedge volatility and to protect solvency, liquidity, and service continuity (Arrow, 1971; Schlesinger, 1999; Vaughan & Vaughan, 2014). For public entities, the analogue is fiscal resilience: avoiding disruptive budget reallocation, safeguarding service delivery, and stabilising medium-term expenditure plans (OECD, 2012; World Bank, 2019).

The results support this trade-off. Table 2 shows that insurance raises expected NPV but substantially reduces tail risk. This is the core governance logic: insurance purchases stability rather than expected-value gain.

Translating tail-risk protection into managerial value

Tail-risk reduction matters when (a) the organisation has budget rigidities, (b) repair delays impose large welfare costs, or (c) funding after shocks is expensive or politically constrained. The simulation illustrates that insurance can reduce the probability of exceeding a critical fiscal threshold by a large margin. This provides a defensible narrative for decision-makers: premiums are not 'wasted', but exchanged for reduced probability of extreme fiscal shocks and service disruption.

From a managerial perspective, this framing provides a defensible narrative for decision-makers: premiums are not "wasted," but exchanged for a lower likelihood of disruptive fiscal shocks and prolonged service interruption.

Contract optimisation: deductible, limits, and layering

The results demonstrate that insurance outcomes are highly sensitive to contract design, particularly premium loadings and deductible levels. The sensitivity results in Table 5 confirm that contract design matters. Premium loading is a strong driver of expected NPV. Deductibles reduce premiums and expected NPV but increase retained volatility (Schlesinger, 1999; Vaughan & Vaughan, 2014).

From a governance perspective, the results imply that ministries should avoid paying high premiums for coverage that primarily compensates frequent, low-severity losses. Deductibles should instead be aligned with internal liquidity capacity—such as reserves and routine maintenance envelopes—while coverage limits should reflect the maximum tolerable retained loss in a single fiscal period. These findings directly address RQ2 by showing how deductible–loading trade-offs shape both expected and tail-risk outcomes.

Risk layering provides the conceptual foundation: retain the frequent layer (via budgets/reserves), transfer the catastrophic layer (via insurance/reinsurance or other instruments) (OECD, 2012; Cummins & Mahul, 2009).

Integration with self-protection (risk reduction)

Insurance should not crowd out prevention. Many hazards can be materially reduced through retrofit, drainage improvements, fire safety upgrades, and improved maintenance regimes (UNDRR, 2019; Hallegatte et al., 2019). From a cost-benefit standpoint, prevention reduces expected losses and can also lower premiums if insurers recognise the risk reduction (Ehrlich & Becker, 1972; Surminski, 2014). This creates a virtuous cycle: better asset condition improves insurability. This interaction reinforces RQ2 by highlighting that optimal insurance design depends not only on financial parameters but also on complementary investments in risk reduction.

Indonesia context: governance and public asset portfolios

The findings imply that public-asset insurance in Indonesia should be treated as a governance instrument rather than a narrow procurement decision. Indonesia's exposure profile makes public-asset insurance a governance issue rather than a narrow procurement decision (World Bank, 2021; BNPB, 2025). Many public assets are critical service platforms—tax offices, customs facilities, warehouses, data centres, and specialised facilities. These assets vary in criticality, exposure, and retrofit feasibility; therefore, a uniform “one size fits all” approach is unlikely to be efficient. Risk-based segmentation is needed to prioritise which assets should be insured and at what coverage depth (OECD, 2024; World Bank, 2019).

In the public sector, disruption costs are particularly consequential. Unlike private firms, which measure downtime as lost revenue, public agencies face delayed service delivery, welfare losses, and heightened political scrutiny (UNDRR, 2019; Hallegatte et al., 2019). These factors strengthen the case for pre-arranged financing and directly motivate the governance implications addressed in RQ3.

Governance recommendations for public asset owners

The empirical message from the simulation is that insurance should be treated as part of portfolio governance, not as a standalone procurement decision. Because disaster losses are skewed and increasingly frequent, a public asset owner faces a trade-off between expected cost efficiency and tail-risk control. In practice, the key managerial objective is often to limit the probability of large fiscal shocks that force disruptive budget reallocations and delay service recovery

Accordingly, effective governance should combine clear risk appetite, risk layering, risk-based prioritisation, and feedback mechanisms so that coverage decisions remain adaptive as exposure, asset conditions, and insurance market pricing evolve.

1. Recommendation 1: Establish explicit risk appetite metrics (e.g., acceptable probability of exceeding a fiscal shock threshold) and report them alongside expected costs.
2. Recommendation 2: Adopt risk layering by combining reserves (for frequent losses) with insurance (for catastrophic layers).
3. Recommendation 3: Use portfolio segmentation: prioritise insurance for critical assets with high replacement cost and high hazard exposure.
4. Recommendation 4: Institutionalise data feedback loops: integrate claims, incident reports, and maintenance data into the asset register to refine risk models.
5. Recommendation 5: Strengthen procurement governance through multi-year planning and market engagement, recognising that catastrophe markets can harden and reprice.

Implementation Roadmap for a Ministry Asset Insurance Program

This section translates the analytical results into an implementation roadmap that can be adapted for a ministry-wide program. The roadmap is structured into six steps.

1. Step 1 – Portfolio diagnosis and risk segmentation. The asset register should be cleaned to ensure consistent identifiers, locations, and replacement values. Assets should be segmented by criticality (high/medium/low), hazard exposure (high/medium/low), and retrofit maturity. A simple segmentation produces a 3×3 matrix that immediately indicates which assets deserve priority in insurance procurement.
2. Step 2 – Risk appetite and fiscal metrics. The program should define risk appetite in measurable terms. Examples include: ‘annual probability of repair expenditure exceeding the maintenance and contingency envelope’, or ‘10-year probability of exceeding an NPV threshold’. Selecting a threshold is a governance choice, but it should be explicit and documented.
3. Step 3 – Risk layering and instrument mix. Based on segmentation and risk appetite, the program should decide what portion of risk is retained and what portion is transferred. High-frequency small losses can be retained via routine maintenance and minor works budgets, supported by an internal reserve or contingency. Catastrophic layers can be transferred via insurance, reinsurance, or—where feasible—parametric covers. This layering also helps manage moral hazard, because agencies still ‘feel’ the cost of small incidents.
4. Step 4 – Contract design and procurement strategy. Deductibles should be aligned with internal liquidity (reserve) and the agency’s ability to absorb losses. Limits should align with the maximum tolerable retained loss for a single year. Procurement can be executed in pooled form (aggregating assets across units) to reduce administrative cost, improve diversification, and strengthen bargaining power. Multi-year framework agreements can reduce transaction costs but must account for market repricing after catastrophe years.

5. Step 5 – Data feedback and performance monitoring. Insurance programs should not be 'buy-and-forget'. Claim histories, incident reports, near-misses, and retrofit actions should be fed back into the risk model and the asset register. Performance indicators include claim ratio, downtime reduction, speed of recovery, and the evolution of tail-risk metrics (e.g., P95 of annual retained losses).
6. Step 6 – Integration with mitigation and capital planning. The program should coordinate with capital works and maintenance planning. Investments that reduce hazard vulnerability (e.g., flood barriers, drainage, rooftop reinforcement, fire system upgrades) can produce double dividends: lower expected loss and improved insurability. A mature program uses insurance not as a substitute for mitigation, but as an incentive mechanism that supports disciplined asset stewardship.

Worked Example: When Does Insurance 'Break Even'?

Practitioners often ask for a simple 'break-even' explanation. While catastrophe risk is inherently stochastic, a useful approximation is to compare the present value (PV) of premiums with the PV of expected payouts plus the value of tail-risk reduction.

Expected-value break-even. If the annual premium equals $(1+\alpha)E[I_t] + k$, then by construction PV(premium) exceeds PV(expected payout) when $\alpha>0$. Therefore, under expected-value criteria alone, insurance is unlikely to break even unless loadings are low, premium subsidies exist, or the asset owner can secure favourable terms through pooling and risk reduction.

Risk-adjusted break-even. Consider a fiscal threshold T such that breaching it triggers an additional financing penalty (e.g., expensive emergency borrowing, delayed maintenance elsewhere, or political costs). Let π be the probability of breach under the uninsured strategy and π' under the insured strategy, with $\pi'<\pi$. Let C be the expected penalty cost conditional on breach. Insurance has positive managerial value if: PV(premium - expected payout)< PV($(\pi - \pi') \times C$). In words, the additional expected premium spend is justified if it is smaller than the expected avoided penalty from reducing the probability of fiscal shock.

This break-even logic is useful because it clarifies what decision-makers must estimate: (i) how much insurance reduces extreme-outcome probability, and (ii) how costly extreme outcomes are in the public governance context. The simulation provides (i). Estimating (ii) can be done via historical reconstruction delays, emergency procurement premiums, and impacts on service KPIs.

Beyond indemnity insurance: parametric, contingent credit, and capital markets

Indemnity insurance is only one DRF option (OECD, 2012; World Bank, 2019). For portfolios with high data quality and exposure to correlated hazards, parametric solutions can provide faster liquidity because payouts are linked to measurable triggers (e.g., rainfall thresholds, earthquake magnitude). Parametric products reduce loss-adjustment friction but introduce basis risk: payouts may not match actual losses (Paudel, 2012; Kousky, 2018). Therefore, they are often suitable for liquidity and emergency response, while indemnity insurance is better for repair and reconstruction funding.

Contingent credit lines can complement insurance by providing rapid access to funds, especially for layers where insurance is expensive (Cummins & Mahul, 2009; OECD, 2024). However, credit increases liabilities and may be constrained by debt ceilings. Capital-market instruments such as catastrophe bonds can transfer tail risk at multi-year tenors, but they require sophisticated structuring and sufficient scale.

For a ministry, the practical implication is that insurance should be evaluated as part of an instrument portfolio. The correct question is not 'insurance or no insurance', but 'what is the best mix of retention, transfer, and risk reduction given the portfolio's loss profile and the government's fiscal constraints?'

Implications for innovation

This paper positions asset insurance as a managerial innovation: it operationalises risk transfer as a measurable portfolio strategy and frames procurement as part of a broader risk governance system. Future research could test how organisational capabilities (data, governance, risk culture) moderate the success of insurance programs, and how incentives influence investments in prevention

CONCLUSION

This paper examined whether insuring public assets is financially beneficial under rising disaster risk. The central insight is a disciplined restatement of the insurance trade-off in public governance terms: insurance is rarely an "expected-value profit" instrument under positive premium loadings, but it can be financially rational as a fiscal-stability hedge when decision-makers explicitly value tail-risk protection, budget predictability, and service continuity.

Using a Monte Carlo simulation of a representative public-asset portfolio over a 10-year horizon, the analysis demonstrated that the uninsured strategy yields a lower expected net present value (NPV) of cost, but exposes the portfolio to substantial right-tail outcomes. In the base case, the uninsured option produced an expected NPV of IDR 57.53 bn with severe tail exposure (P95 = IDR 182.01 bn; P99 = IDR 298.00 bn) and a non-trivial probability of breaching a fiscal-stress threshold (NPV > IDR 200 bn). The insured strategy increased expected NPV (IDR 76.23 bn) due to premium loadings, yet materially reduced tail risk (P95 = IDR 96.58 bn; P99 = IDR 157.46 bn) and lowered the probability of exceeding the threshold. This pattern is consistent with insurance economics: the buyer "pays" in expected value to obtain a meaningful reduction in extreme outcomes.

Answering the research questions, the findings support three conclusions. First (RQ1), insuring public assets reduces the risk-adjusted financial burden when the governance objective includes controlling downside exposure—particularly when fiscal rules, procurement rigidity, or service-disruption costs make extreme-loss scenarios disproportionately costly. Second (RQ2), contract design is decisive. Sensitivity testing indicates that premium loading is a primary determinant of expected NPV outcomes, while deductible choice governs the degree of retained volatility. A higher deductible can lower expected cost but increases the portion of losses borne by the budget; therefore, deductible and limit levels should be aligned with internal liquidity capacity (reserves and contingency envelopes) and the maximum tolerable retained loss. Third (RQ3), the managerial implication is that asset insurance should be embedded in an integrated disaster-risk financing strategy based on risk layering—retaining frequent, low-severity losses through maintenance budgets and reserves while transferring catastrophic layers through insurance (and, where appropriate, parametric liquidity instruments or contingent credit).

For Indonesia's public asset governance, the results reaffirm that disaster risk is a portfolio-management issue rather than a purely operational incident risk (World Bank, 2021; BNPB, 2025). Public assets serve as platforms for essential services (e.g., offices, logistics facilities, data centres, and specialised infrastructure). Consequently, the value of insurance cannot be assessed solely by comparing premiums against expected claims; it must be evaluated in terms of the extent to which risk transfer stabilises expenditure paths, reduces disruptive reallocation, and protects service delivery. In practice, a ministry-wide program should prioritise insurance using a risk-based segmentation of assets (criticality × hazard exposure × retrofit maturity), set an explicit risk appetite metric (e.g., acceptable probability of breaching a multi-year fiscal threshold), and implement contracts that preserve incentives for maintenance and risk reduction through meaningful deductibles and governance-linked performance monitoring.

This study offers three contributions. Conceptually, it bridges disaster-risk financing and insurance-demand theory by translating insurance decisions into decision-grade metrics familiar to financial management (NPV) and risk governance (tail percentiles and breach probabilities). Methodologically, it provides a replicable simulation framework that can be recalibrated to specific BMN portfolios and peril mixes. Practically, it delivers an actionable logic for policy and procurement: insurance is justified not as a profit-seeking choice, but as a tool to reduce the probability and severity of fiscal shocks.

Limitations

The quantitative results are illustrative because they are not calibrated to a specific Indonesian ministry asset portfolio, hazard maps, and vulnerability functions. Further, the model abstracts from spatial correlation of losses across assets, changing building codes, and market repricing after large catastrophe years.

Future research

Future work should: (i) calibrate hazard frequency and severity to Indonesian perils and regions using BNPB/DIBI and catastrophe modelling, (ii) estimate asset-class-specific disruption costs using service-delivery data, (iii) compare indemnity insurance with parametric solutions and contingent credit, and (iv) evaluate institutional arrangements for pooled procurement across agencies to reduce administrative cost and improve bargaining power.

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