The White Elephant Just Left the Room: A Stochastic Assessment of OAKA's Post-Olympic Financial Sustainability

Veni Arakelian* and Konstantinos Chalioris**

*Council of Economic Advisors, Ministry of Finance, Hellenic Republic & UCL Center for Blockchain Technologies, UK
**Athens Olympic Sports Center - O.A.K.A. ``Spyros Louis

CRETE 2026

Disclaimer: The views expressed are those of the authors and do not necessarily reflect those of the Hellenic Ministry of Finance.

Motivation: Olympic Legacy and Infrastructure Sustainability

Olympic venues often generate substantial ex ante expectations regarding urban regeneration, economic benefits, and social legacy. Ex post evidence shows that many venues face persistent challenges:

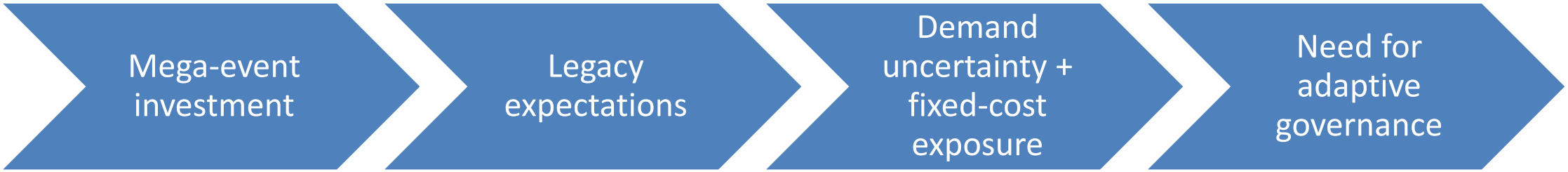
- ✓ insufficient post-event utilization
- ✓ high fixed operating costs
- ✓ demand uncertainty
- ✓ long-term maintenance obligations

These outcomes are frequently linked to:

- ✓ optimism bias and demand overestimation
- ✓ weak post-event governance structures
- ✓ insufficient integration into broader urban systems

Key literature: Flyvbjerg (2011, 2021) — infrastructure risk and optimism bias
Preuss (2004, 2015); Preuss & Plambeck (2020) — Olympic legacy and venue utilization
OECD (2020); IOC (2021) — sustainable legacy governance

Research Gap: From Legacy Assessment to Risk Modelling



Existing approaches often rely on deterministic assessments.

This study introduces:

- **stochastic operating risk** modelling
- **uncertainty propagation**
- **downside risk analysis**

Research Contributions

1. Monte Carlo framework for public infrastructure assets

2. Copula-based dependence modelling

3. PRCC decomposition of financial risk drivers

OAKA as an Empirical Case Study *(for the moment, hopefully…)*

- Athens 2004 Olympic legacy asset
- Deferred maintenance period
- Major rehabilitation after 2021

Question: financial resilience after reconstruction?

Economic Framework

Operating Result = Revenues – Costs

Key channels:

- Event income
- Rental income
- Electricity expenditure
- Maintenance costs, e.g.

Source: https://calatrava.com/projects/olympic-sports-complex-athens.html

Data

Administrative Financial Records OAKA (2014–2024)

Activity	Revenues
Sports events Cultural events	Event income Rental income Sponsorship
Operating Costs	**Financial Outcome**
Electricity use Energy prices Maintenance Staff	Net operating result

Calibration of Monte Carlo Simulation 2025-2035

The dataset **captures both the demand side (venue utilization) and the cost side (energy and maintenance)**, providing the basis for modelling long-term operating uncertainty.

Economic Model Underlying MC Simulation (1/3)

Revenue block: Total operating income is decomposed into event-related income, rental income, and sponsorship or other ancillary income

$$Y_t = E_t + R_t + S_t$$

Event-related income: Follows a structural growth component combined with a short-run demand factor:

$$E_t^{\text{path}} = E_{2025}^{\text{base}} \, (1 + g_E)^{\, t-2025},$$

$$E_t = E_t^{\text{path}} \exp(\gamma_E d_t).$$

g_E captures the structural capacity to increase event-related income.

S_t captures the sponsorships, is treated as exogenous and may be set to zero when not observed.

d_t represents a short-run demand shock arising from macroeconomic conditions, scheduling constraints, or temporary capacity limitations.

By construction, $d_t = 0$ corresponds to baseline demand conditions, $d_t > 0$ indicates above-trend demand, and $d_t < 0$ indicates demand shortfalls.

The parameter γ_E scales these deviations into proportional revenue changes.

Economic Model Underlying MC Simulation (2/3)

Rental income: Rental income evolves with its own structural growth rate and may be partially indexed to inflation

$$R_t^{\text{path}} = R_{2025}^{\text{base}} (1 + g_R)^{t-2025} \qquad R_t = R_t^{\text{path}} \exp(\alpha_R I_t)$$

Cost block: Total operating costs are decomposed into electricity cost, maintenance expenditure, and other operating expenditure (overheads)

$$C_t = K_t P_t + M_t + O_t$$

Inflation and energy price dynamics: Electricity prices evolve around baseline prices as:

$$P_t = P_t^{\text{base}} \exp\left(I_t + \varepsilon_t^P\right)$$

where I_t is the latent inflation–cost factor defined above, and ε_{Pt} captures idiosyncratic price variation unrelated to persistent inflationary pressures.

Electricity use: Electricity use responds to operating intensity and operational variability:

$$K_t = K_t^{\text{base}} (1 + \beta_D d_t)\, \eta_t$$

where β_D is the sensitivity of electricity consumption to short-run demand conditions,

η_t represents bounded operational variability reflecting factors such as weather conditions, occupancy intensity, and facility utilization efficiency.

In calibrations, d_t is scaled so that $1 + \beta_D d_t > 0$ with high probability, ensuring nonnegative electricity use.

Economic Model Underlying MC Simulation (3/3)

Maintenance expenditure: Modeled as the sum of a routine component and a shock component:

$$M_t^{\text{routine}} = M_t^{\text{base}} \exp(\alpha_M I_t)\, \xi_t,$$

$$M_t = M_t^{\text{routine}} + \mathbf{1}\{\text{shock}_t\} \cdot Z_t.$$

where ξ_t captures routine operational variability in maintenance needs,

Z_t represents the cost magnitude of infrequent, discrete maintenance interventions such as structural repairs or regulatory upgrades.

Other operating expenditure (overheads): To avoid understating operating costs that are not fully itemized in the data, the model includes an explicit overhead term:

$$O_t = \alpha_O + \beta_O N_t^{\text{base}}$$

where α_o denotes fixed annual overhead expenditure and β_o represents marginal operating costs per event.

Net operating result and break-even: $\Pi_t = Y_t - C_t.$

Operating break-even in year t occurs when $\Pi_t \geq 0$.

Over the projection horizon, the model evaluates both the annual operating balance and the likelihood of achieving break-even at least once.

Dependence Modeling via Copula

Let $\mathbf{X}_t = (d_t, \ I_t, \ \eta_t^{\mathrm{KWh}})$ denote the vector of stochastic drivers governing year-t operating conditions,

where

d_t is the short-run demand shock,
I_t is a latent inflation–cost factor, and
η_t^{KWh} captures operational variability in electricity consumption.

These variables represent the **primary channels** through which **joint uncertainty propagates into revenues and operating costs.**

Dependence is introduced via a latent **Gaussian Copula,** $\mathbf{Z}_t \sim \mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma})$

where the correlation matrix Σ encodes pairwise dependence among demand shocks, the inflation–cost, and operational variability in electricity consumption. The components of Z_t are mapped to the unit interval using the standard normal distribution function, $U_{it} = \Phi(Z_{it})$, and subsequently transformed into realizations of $(d_t, I_t, \eta_t^{\mathrm{KWh}})$ through the inverse marginal distribution functions.

Gaussian Copula Dependence Structure

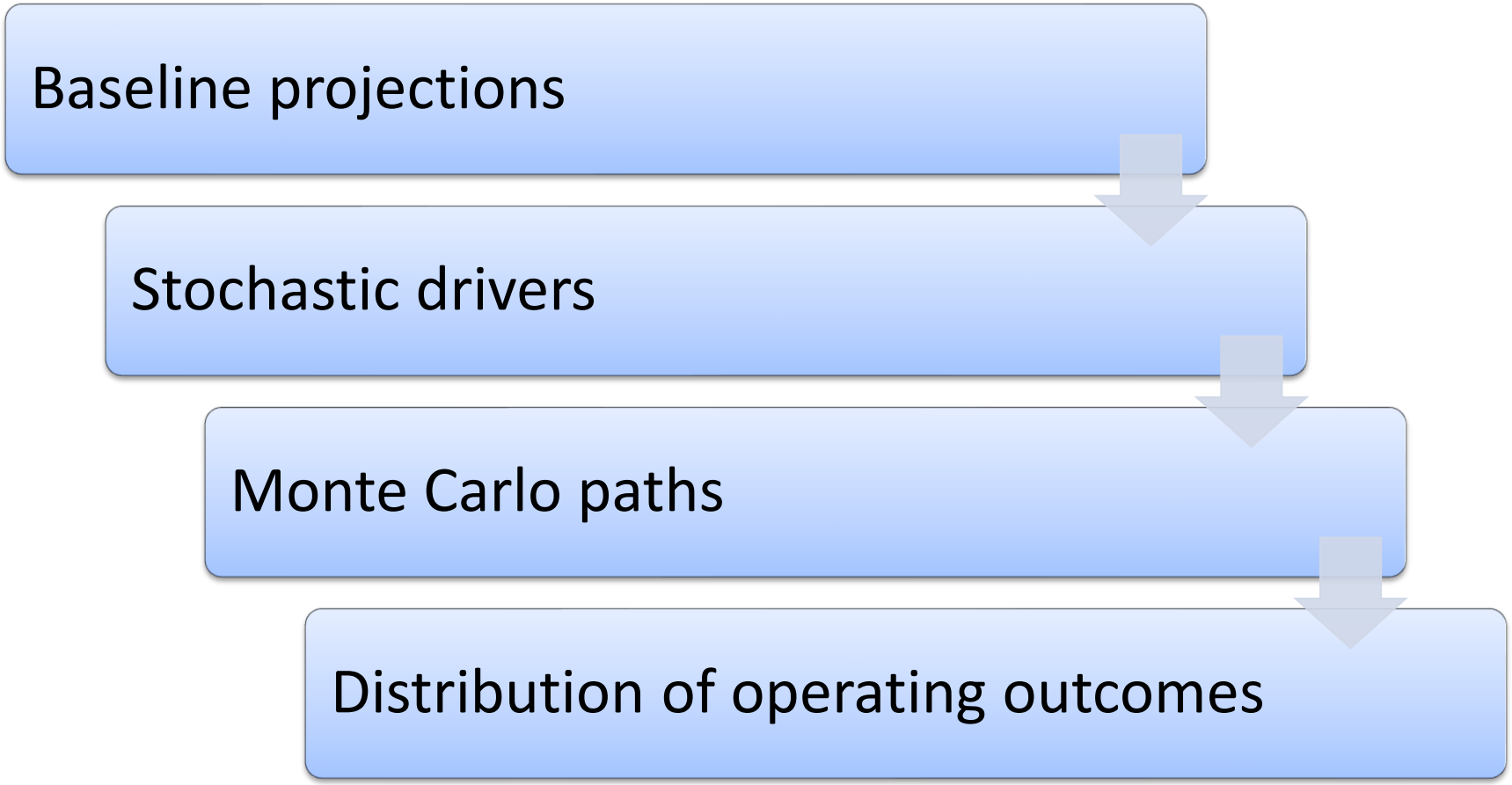
Captures correlated demand–energy–cost dynamics

Allows realistic co-movement between operating risks

Avoids imposing unsupported extreme tail dependence

Suitable for identifying structural sustainability drivers

Simulation Architecture



Stochastic Assumptions: Three Operating Regimes

Scenario 1 — Baseline post-maintenance recovery

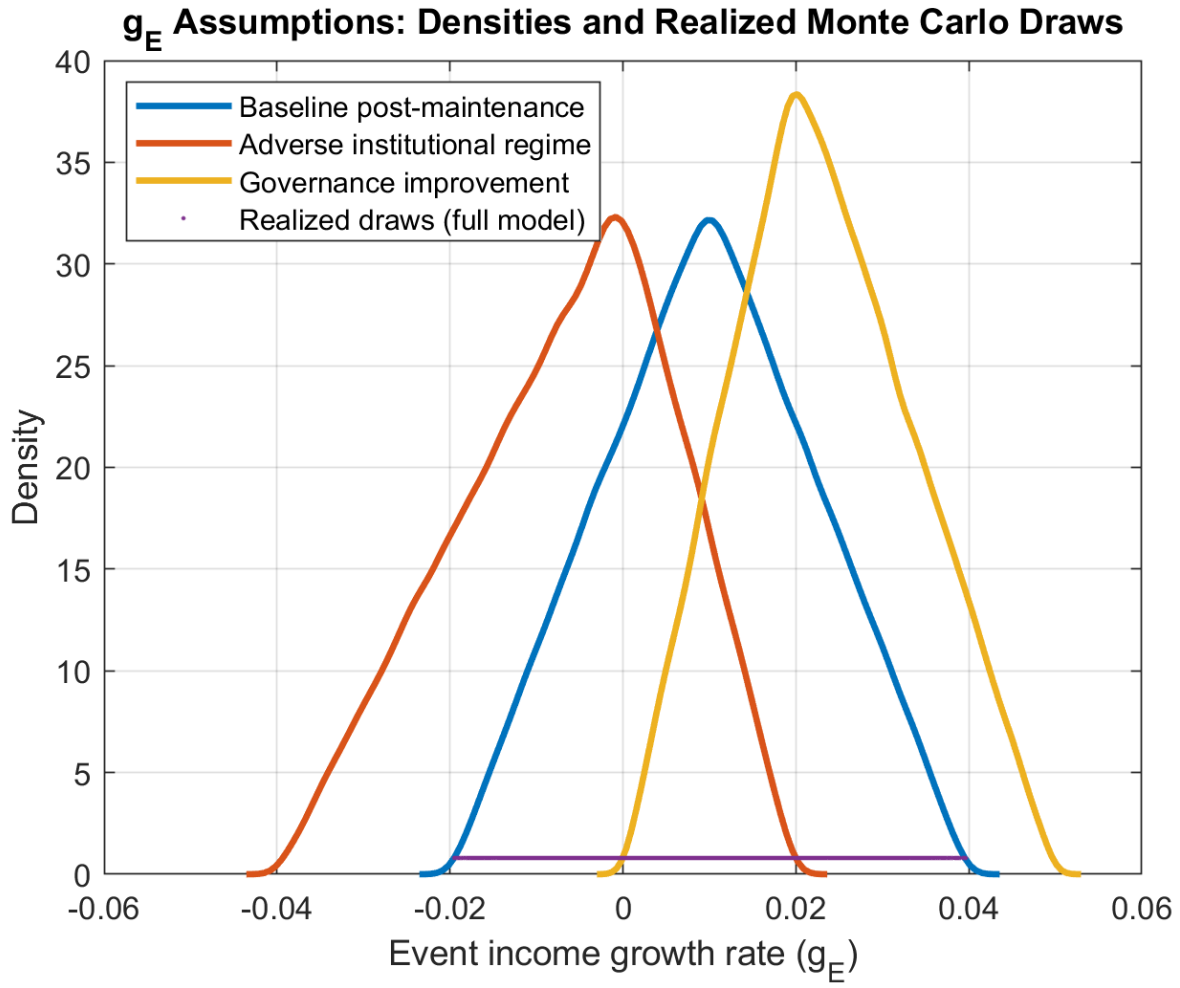
- Moderate event-income growth
- Current governance structure
- Persistent but manageable operating risks

Scenario 2 — Adverse regime

- Weak demand recovery
- Higher inflation and energy pressures
- More frequent maintenance shocks

Scenario 3 — Governance improvement

- Improved utilization and coordination
- Higher operational efficiency
- Reduced downside exposure



Scenario Calibration and Distributional Shifts

Following the infrastructure risk literature, growth assumptions are explicitly bounded to avoid systematic optimism bias.

Baseline scenario:

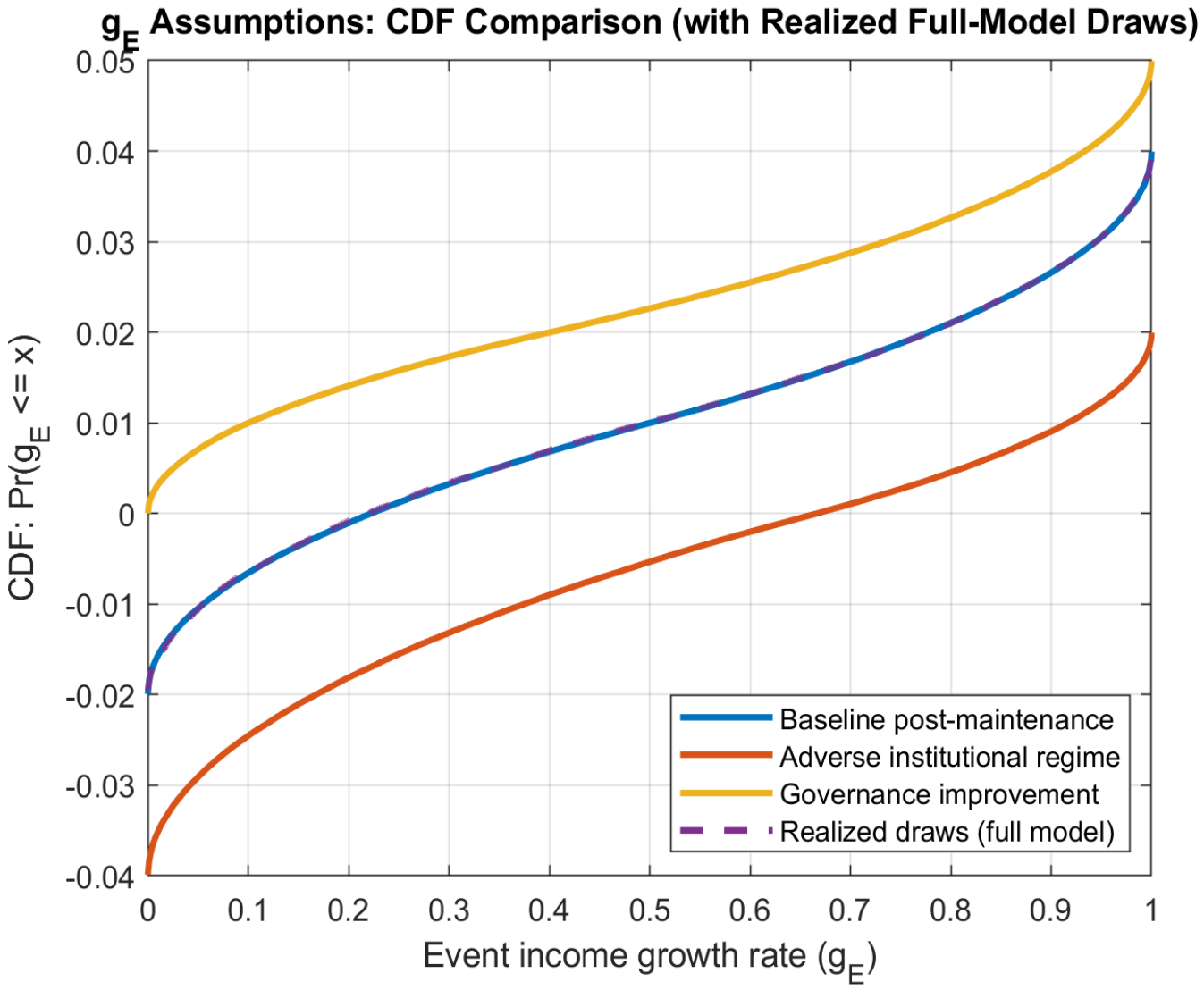
- moderate growth with remaining downside risk

Adverse scenario:

- probability mass shifts toward weak or negative growth

Governance scenario:

- improved utilization shifts the distribution rightward without assuming unrealistic expansion



Identifying Structural Drivers of Financial Risk

Monte Carlo simulations quantify uncertainty.

We use **Partial Rank Correlation Coefficients (PRCC)** to explain where this uncertainty comes from.

Therefore, PRCC

measures the conditional contribution of each input,

controls for correlations among stochastic drivers,

are robust to nonlinear monotonic relationships.

Applied to

event income growth,

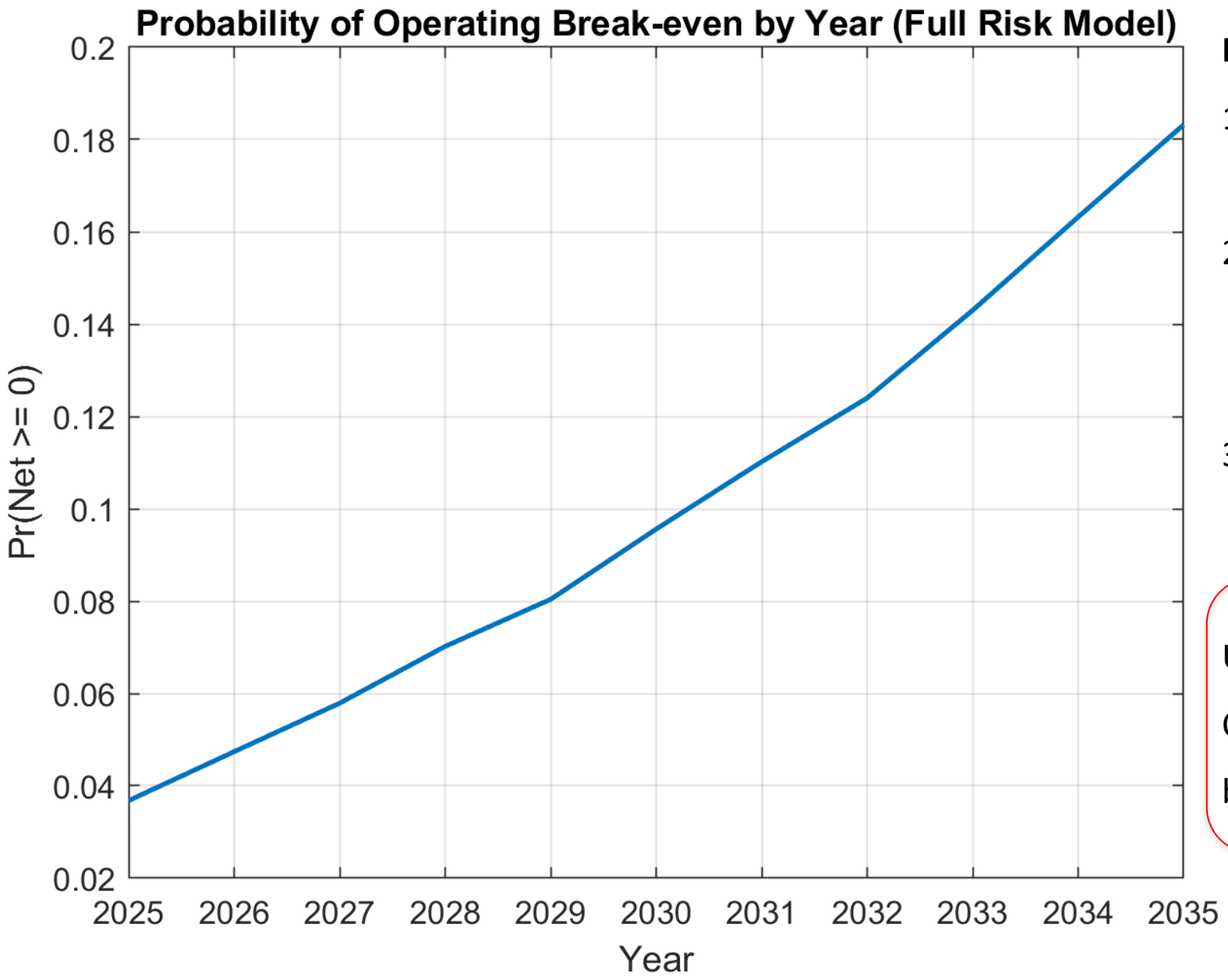
energy prices and consumption,

maintenance shocks,

operating costs.

Main question: Which factors determine the probability of long-term financial sustainability?

Baseline Scenario Results (1/3)

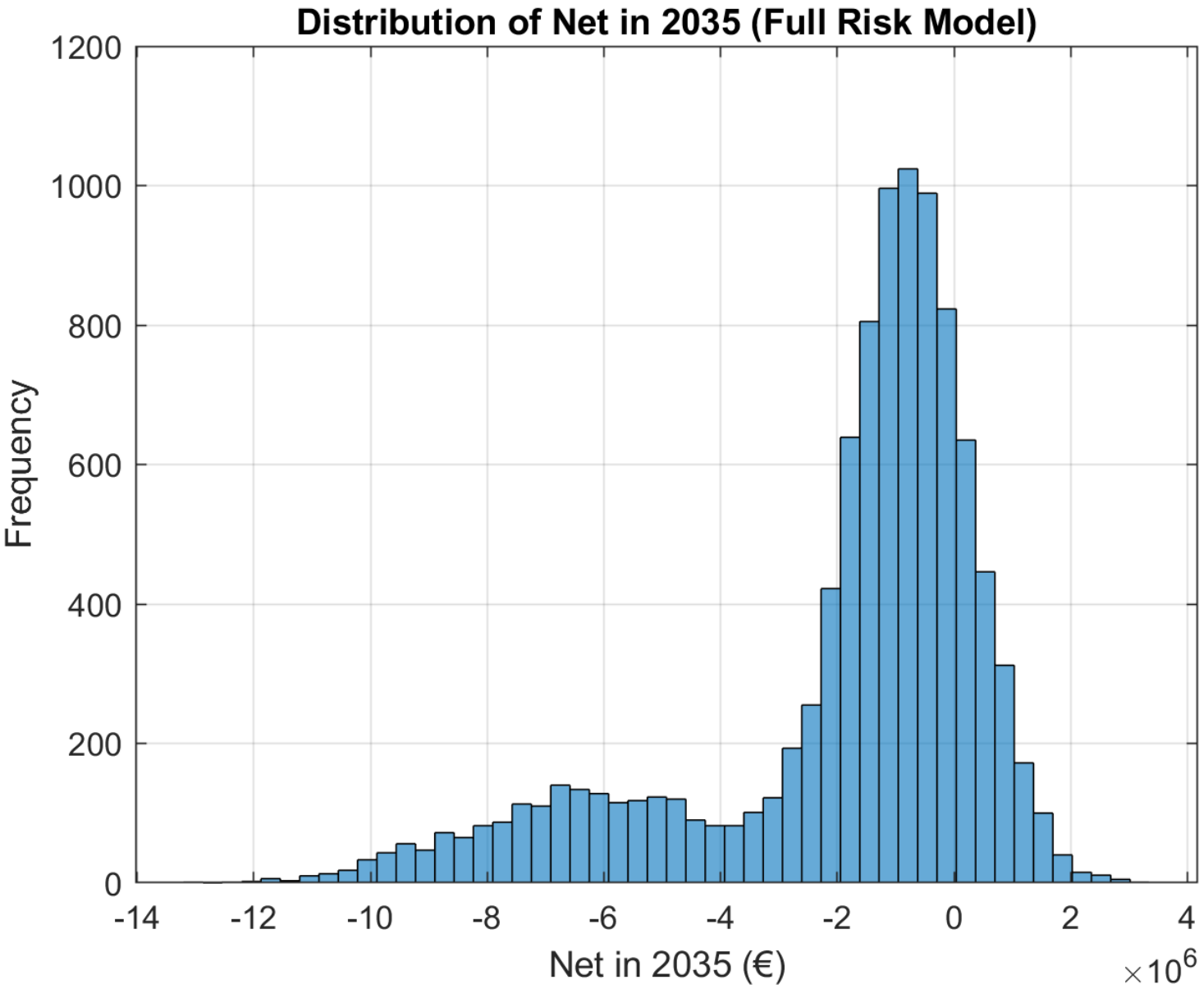


FINDINGS

1. The **probability of break-even improves gradually over time**.
2. This reflects the recovery of event activity after completion of rehabilitation works.
3. However, the probability does not immediately converge to certainty.

Under current institutional arrangements, OAKA moves toward financial stabilization but remains exposed to operating risk.

Baseline Scenario Results (2/3)



The density represents the full Monte Carlo distribution of Π_{2035}

rather than a single forecast.

FINDINGS

1. Outcomes are **distributed around the break-even region**.
2. **Positive outcomes** are **possible**, but the **left tail** remains relevant.
3. The **asymmetry reflects the economics of large venues**:
   - revenues depend on demand activation;
   - costs remain persistent.

Main message: The baseline case is not a failure scenario, but a fragile equilibrium: sustainability depends on maintaining utilization.

Baseline Scenario Results (3/3)

PRCC decomposes uncertainty in:

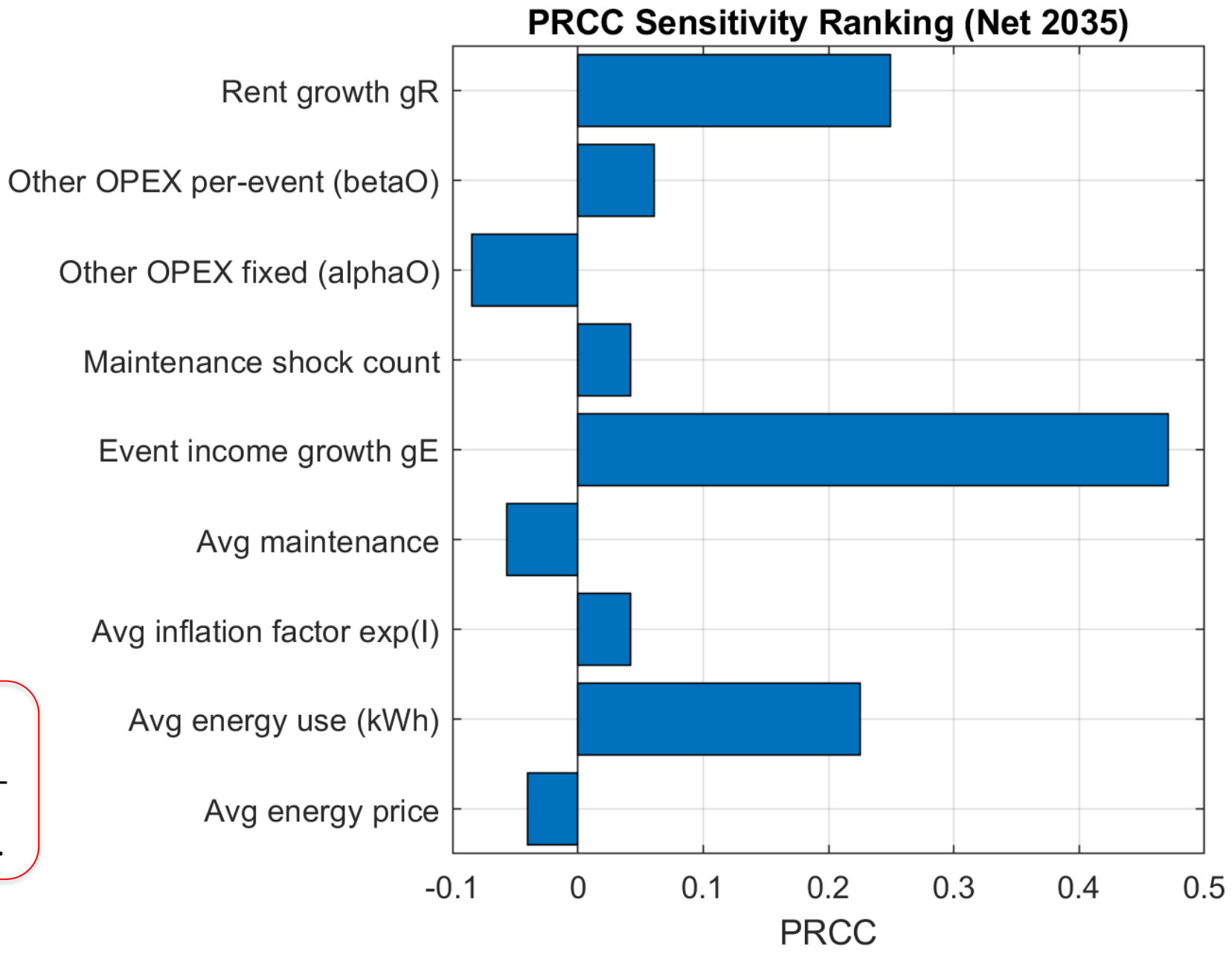
Positive drivers

1. **Event income**
2. **Rental income growth**

Negative drivers

1. **Maintenance costs**
2. **Energy prices**

Main message: OAKA's long-term sustainability is primarily demand-constrained, not cost-constrained.



Summary of Scenario 1 Findings

- ❑ Can OAKA break even? → **Yes**, probability improves, but uncertainty remains.
- ❑ What does uncertainty look like? → The **distribution** is close to sustainability but **fragile**.
- ❑ What determines success? → **Demand** activation **dominates**; **costs affect downside risk**.

Scenario 2: Adverse Institutional–Macroeconomic Regime

The **adverse scenario** combines:

weaker event-income recovery

stronger inflation and energy-cost persistence

higher probability and severity of maintenance shocks.

Key findings

Break-even probability remains close to zero across most of the projection horizon.

The 2035 distribution shifts substantially to the left, indicating persistent operating deficits.

PRCC results show that demand remains the dominant driver, but cost rigidities become more important.

Interpretation: Under adverse conditions, improving utilization alone becomes insufficient. Fixed costs, energy exposure, and deferred maintenance amplify financial vulnerability.

Main message: Consistent with infrastructure risk literature, downside outcomes arise from the interaction between demand uncertainty and asymmetric cost exposure, not from isolated shocks.

Scenario 3: Governance and Efficiency Improvement

The governance scenario introduces:

stronger event activation

improved coordination among stakeholders

better cost and energy management

more efficient maintenance planning.

Key findings

Break-even probability increases substantially over time.

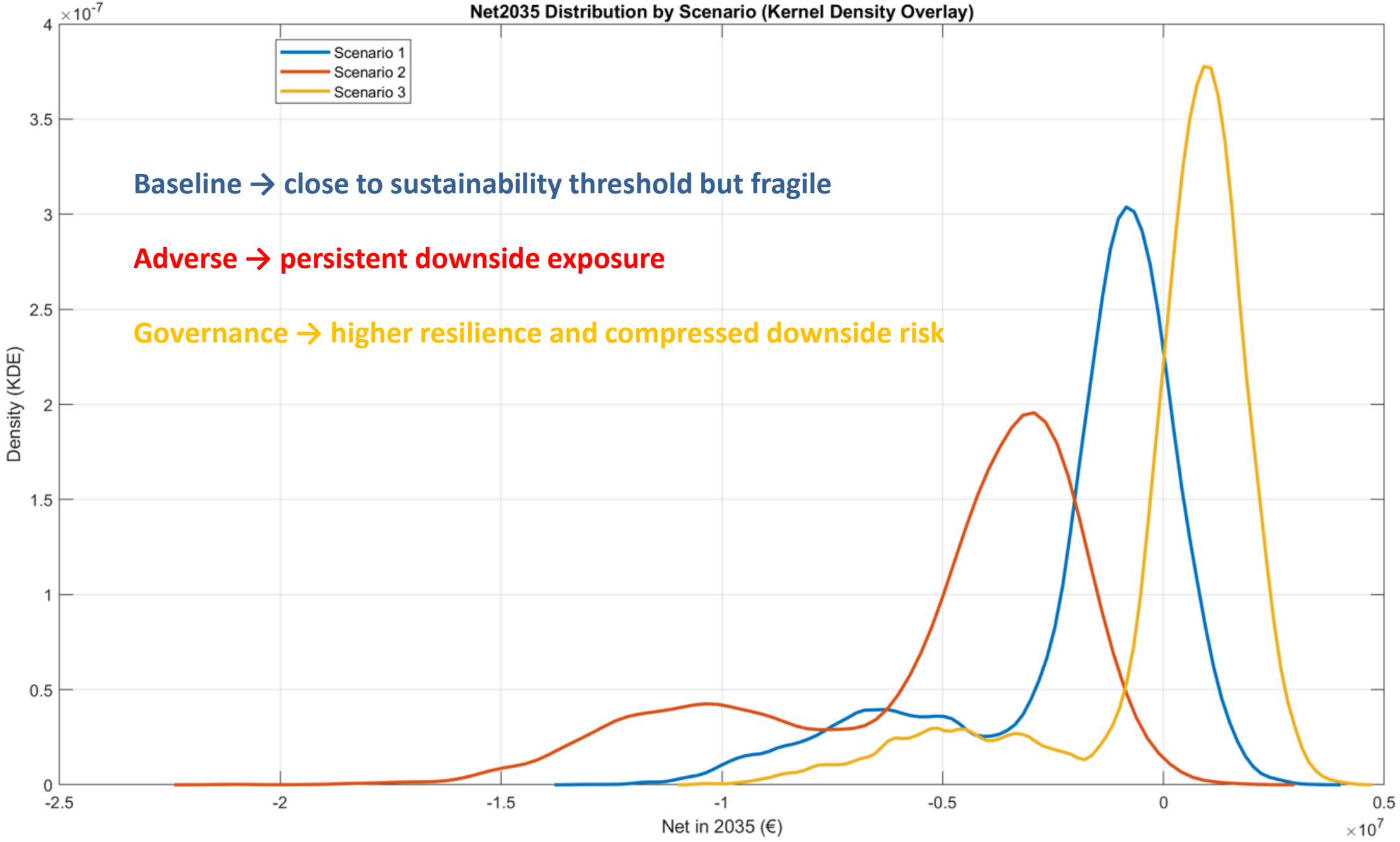
The 2035 distribution shifts to the right and downside risk declines.

Event-income growth becomes even more influential in the PRCC ranking.

Interpretation: Governance reforms improve resilience mainly by stabilizing demand and reducing left-tail risk, rather than by eliminating uncertainty.

Main message: The transition from a fragile to a sustainable operating regime depends less on optimistic revenue assumptions and more on institutional capacity to manage uncertainty.

Cross-Scenario Comparison

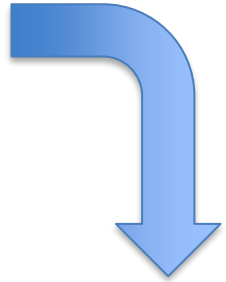


Main findings

Demand dominates long-run sustainability

Energy and maintenance shape downside risk

Governance reduces fragility



Policy and Management Implications

Demand activation strategy

Energy resilience

Maintenance planning

Institutional coordination

Future Research

From deterministic break-even assessment to probabilistic public asset management

Extensions: AI models, climate risk, digital twins