From Vulnerability to Resilience: A Portfolio-Based Model of Hotel Room Revenue under Weather Shocks

Giuseppina Lo Mascolo[1],
PhD Candidate
Department of Economics, Business and Statistics,
University of Palermo,
giuseppina.lomascolo@unipa.it

Apostolos Ampountolas, PhD
Associate Professor
School of Hospitality Administration,
Boston University,
aampount@bu.edu

Abstract

Risk governance plays a crucial role in managing the uncertainty associated with urban planning, public finance, and disaster management. It refers to the institutional and policy processes through which societies assess, regulate, and respond to risks, requiring multi-stakeholder collaboration to ensure collective decision-making [4]. Within this framework, the need for effective governance has intensified the frequency of extreme and compound weather events driven by climate change increases [2]. Local governments often lack the capacity and resources needed to implement adequate mitigation measures, while responsibilities are increasingly being shifted to individuals and communities.

In tourism, climate-related risk governance has become essential, as changing weather patterns disrupt demand and revenue stability. Resilience represents a central pillar of adaptive strategies, involving actions that enable destinations to absorb and recover from climate shocks [1]. Effective governance in hospitality must therefore integrate sustainability practices, stakeholder engagement, and quantitative climate-risk assessments to support preparedness and operational continuity.

To address this need, this study introduces a quantitative framework that measures resilience in the hospitality sector using hotel performance data

[1] Speaker: Giuseppina Lo Mascolo, giuseppina.lomascolo@unipa.it,
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(RevPAR) and meteorological variables. Adapting the Markowitz mean–variance portfolio theory, the method constructs indicators of vulnerability and resilience that capture expected performance and volatility under climate stress. Applying this approach to urban and airport areas in Florida's major city markets (Miami, Orlando, Tampa) enables temporal and seasonal assessments of resilience dynamics. The findings provide actionable key performance metrics that can inform decision-making, support infrastructure investments, and improve revenue strategies in climate-exposed destinations.

Markowitz's mean–variance portfolio theory revolutionized risk governance by demonstrating how diversification can optimize the balance between expected return and risk. The efficient frontier identifies portfolios offering the highest return per unit of risk, encouraging allocation toward assets with low or negative correlations [3]. This approach has expanded into crisis resilience studies, demonstrating that optimized diversification enhance performance stability during market disruptions, making it applicable to tourism sectors subject to environmental uncertainty.

Florida's hospitality market is increasingly exposed to extreme weather events driven by warming tropical Atlantic sea surface temperatures, which fuel more intense hurricanes and prolonged rainfall. These hazards disrupt tourism flows, inflict infrastructure losses, and affect destination reputation, threatening short- and long-term revenue. Economic resilience varies regionally, with areas possessing stronger pre-storm fundamentals recovering more quickly, while others require crisis response and coordinated recovery efforts.

In this evolving climate context, applying portfolio theory to tourism enables destination managers to quantify vulnerability and resilience by measuring performance volatility under shock conditions. Understanding how different sub-markets within a destination react to climate stress, such as airport areas versus urban cores, supports strategic diversification, more resilient investment decisions, and dynamic pricing and communication strategies.

This quantitative risk governance approach provides hospitality stakeholders with actionable insights, enabling them to anticipate seasonal exposure to climate hazards, enhance preparedness, and maintain revenue continuity amid growing environmental uncertainty.

This study integrates two primary daily datasets: hotel performance data from STR Global and meteorological records from the National Oceanic and Atmospheric Administration (NOAA) within two main periods, pre-COVID (2017-2019) and post-COVID (2022-2024). STR provides Revenue per Available Room (RevPAR) across hotels in Miami, Orlando, and Tampa,

distinguishing between Urban and Airport sub-markets. As a composite metric of both Average Daily Rate (ADR) and occupancy, RevPAR captures operational and demand adjustments in response to shocks, offering an immediate measure of financial exposure to extreme weather events [5].
To assess resilience to climate-induced disturbances, we compute a suite of Key Performance Metrics (KPMs) based on risk–return principles. Metrics are evaluated at multiple temporal scales, monthly, weekday vs. weekend, and quarterly, to capture segment-specific and seasonal variability in adaptive behaviour:

- Climate Resilience Index (CRI):

$$CRI = \frac{\mu}{\sigma}$$

  Indicates stability during shock periods.
- Adjusted Sharpe Ratio:

$$SR_{adj} = \frac{\mu - \mu_b}{\sigma}$$

  Evaluates performance relative to a no-shock baseline.
- Maximum Drawdown (MDD):

$$MDD = \max_{t \in T} \left(\frac{P_{peak} - P_t}{P_{peak}} \right)$$

  Measures the steepest revenue drop following weather disruptions.
- Time to Recovery (TTR):

$$TTR = min\{\Delta t : P_{t+\Delta t} \geq P_{baseline}\}$$

  Assesses how long RevPAR takes to return to pre-event levels.
- Diversification Benefit Index (DBI):

$$DBI = 1 - \frac{\sigma_p}{\sum_{i=1}^{N} w_i \sigma_i}$$

  Quantifies resilience gains from combining sub-markets through variance reduction.

This framework enables a comprehensive evaluation of vulnerability and adaptive capacity in Florida's hospitality sector under increasing climate stress. The analysis reveals a clear shift in resilience dynamics after COVID-19. Overall volatility and drawdown severity intensified, particularly during

hurricane season, yet recovery times accelerated in the airport sub-markets, indicating a more rapid rebound despite heightened exposure. Spatial differences are evident: Orlando is consistently the most vulnerable destination, due to its heavy reliance on weather-sensitive leisure tourism; Tampa maintains the steadiest resilience profile with bounded downturns and relatively fast recoveries; while Miami shows dual behaviour, with strong stability in the urban core but heightened fragility in airport-based demand post-pandemic.

Efficient frontier simulations further demonstrate a structural reconfiguration in the risk–return landscape. Before the pandemic, urban hotels dominated the profitability risk trade-off, operating within a regime of absorptive resilience in which higher returns predictably compensated for volatility. After 2022, the risk-return curve flattened, and greater exposure to uncertainty no longer guaranteed proportional gains, and Airport areas increasingly emerged as the most efficient hedging assets at the destination scale, providing diversification benefits that enhance system-level stability.

These findings indicate a broader resilience transition: from stability driven by cohesive and uniform demand patterns to stability driven by differentiation and adaptive flexibility. Resilience in the post-COVID climate is no longer rooted in continuity but in the capacity to redistribute risk spatially, diversify demand structures, and adjust operations dynamically.

Accordingly, revenue strategies must evolve beyond traditional demand-optimization logic. At the destination level, portfolio-based coordination can maintain aggregate revenue continuity during disruptions. At the hotel level, operators should prioritize risk-adjusted pricing and inventory strategies, deploy scenario-based early warning intelligence, and reinforce weather-continuity assurances to sustain booking confidence during extreme events.

By integrating daily RevPAR data with risk metrics grounded in portfolio theory, this study advances the quantitative assessment of climate resilience in the hospitality industry. Through the joint use of financial indicators, such as maximum drawdown, the Climate Resilience Index, and the Diversification Benefit Index, together with efficient frontier simulations, the analysis shows that climate uncertainty is fundamentally reshaping the risk–return balance in tourism markets: increasing volatility is no longer compensated by proportional revenue gains. These results shift resilience measurement toward a risk-adjusted, continuously monitored framework and demonstrate the methodological value of transferring financial optimization principles into hospitality analysis to guide more informed, adaptive revenue management in destinations facing growing environmental volatility. Overall, Florida’s future

competitiveness under intensifying climate volatility will depend on adaptive flexibility, strategic diversification across sub-markets, and proactive resilience intelligence that enables operators and destination managers to safeguard performance while enhancing long-term sustainability.

Despite its contributions, the study has several limitations. The analysis is restricted to selected weather variables and specific hotel sub-markets, without explicitly incorporating behavioural reactions such as changes in perceived risk or booking displacement. Future research should integrate scenario-based forecasting, dynamic climate projections, and behavioural analytics to capture better tourism system responses to compounding climate risks, including extreme heat, flooding, and clustered storm events. Extending the framework to assess inter-destination spillovers and to support climate-informed insurance and pricing strategies would further enhance managerial and policy applicability.

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