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Nedzad Lajka *

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Article

Quantifying the Economic Impact of Risk: The R-Index Approach

Nedzad Lajka

Faculty of Business Economics and Law, University of Adriatik, Bar, Montenegro; necko@t-com.me

Abstract

This study introduces the R-index as a novel framework for quantifying the economic impact of risk through realized deviations from expected performance. In contrast to traditional risk measures that rely on probabilistic or volatility-based approaches, the proposed index captures risk as an outcome-based phenomenon directly linked to firm-level performance. The R-index is constructed as a normalized measure of deviation between actual and expected values and is further extended to a multidimensional setting, allowing for aggregation across different performance indicators. The empirical analysis is conducted using longitudinal financial data from three firms operating in distinct sectors of the Montenegrin economy—telecommunications, retail, and tourism—over the period 2015–2024. The results reveal substantial heterogeneity in the realization of risk across firms, even under identical macroeconomic conditions. While some firms exhibit stable performance and limited deviations, others demonstrate pronounced volatility and sensitivity to external shocks, particularly during the COVID-19 period. These findings suggest that risk is not uniformly transmitted but is instead shaped by firm-specific characteristics, including operational structure and adaptive capacity. The study contributes to the literature by redefining risk as a realized economic phenomenon and by proposing a scalable and interpretable metric that bridges risk measurement and performance evaluation. The R-index offers practical relevance for managerial decision-making and provides a foundation for future research on the relationship between risk and firm value.

Keywords: risk measurement; R-index; firm performance; economic impact of risk; enterprise risk management; financial analysis

1. Introduction

In an increasingly uncertain and complex business environment, risk has become a central determinant of firm performance and value. Market volatility, technological disruption, and systemic shocks continuously reshape the conditions under which firms operate, making risk management a critical component of strategic decision-making (Damodaran, 2012; Kaplan & Mikes, 2012). Over the past decades, Enterprise Risk Management (ERM) has emerged as a dominant framework for addressing these challenges by promoting an integrated and organization-wide approach to risk (COSO, 2017; ISO, 2018).

Despite these advances, a fundamental limitation persists in both theory and practice: the absence of a unified and operational measure that captures the aggregate economic impact of risk at the firm level. Existing approaches predominantly rely on probabilistic models, such as Value at Risk (VaR), or focus on individual categories of risk, including market, credit, and operational risks (Jorion, 2007). While these methods are useful for assessing exposure, they do not capture how risk is ultimately realized in firm performance. As a result, a significant gap remains between theoretical risk constructs and observable financial outcomes.

This limitation becomes particularly evident in the context of systemic shocks. Events such as the COVID-19 pandemic affect a wide range of firms simultaneously, yet their economic consequences are far from uniform (Baker et al., 2020). Firms exposed to identical external conditions often exhibit significantly different performance outcomes, suggesting that risk is not only driven by

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exogenous factors but also shaped by firm-specific characteristics, internal structures, and the effectiveness of risk management practices (Gormsen & Koijen, 2020). This heterogeneity challenges traditional approaches to risk measurement and highlights the need for a framework that captures realized, rather than potential, risk.

In response to this gap, this study introduces a novel Aggregate Risk Index (R-index), designed to quantify the economic manifestation of risk through observable deviations in key financial performance indicators. Unlike conventional ex ante models based on probability distributions, the R-index adopts an ex post perspective, measuring how risk materializes through deviations from expected performance. By operationalizing risk as a function of realized outcomes, the proposed approach provides a direct link between risk and firm value.

Furthermore, the study extends the analysis beyond individual firm-level measurement by conceptualizing the R-index as a distributional phenomenon. The distribution of R across firms reflects the heterogeneity of economic outcomes, revealing patterns of asymmetry, dispersion, and macroeconomic shifts. This perspective enables a deeper understanding of how risk propagates through the economy and how aggregate conditions influence, but do not determine, firm-level performance.

The empirical analysis is conducted using longitudinal data from three firms operating in different sectors, all exposed to a common external shock. This setting allows for a comparative assessment of firm-level responses under identical macroeconomic conditions, providing a robust basis for evaluating the proposed index. The results demonstrate that similar shocks generate fundamentally different economic impacts across firms, thereby confirming the hypothesis that risk is inherently firm-specific in its manifestation.

The contribution of this study is threefold. First, it introduces a novel quantitative framework for measuring the aggregate economic impact of risk. Second, it provides empirical evidence on the heterogeneous effects of systemic shocks, contributing to the literature on risk and firm value. Third, it bridges the gap between ERM theory and observable financial outcomes, offering a practical and scalable tool for both researchers and practitioners.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature on risk, ERM, and firm value. Section 3 presents the methodological framework and the development of the R-index. Section 4 provides the empirical analysis and results. Section 5 discusses the findings and their implications, while Section 6 concludes the paper.

2. Literature Review

2.1. Risk and Firm Value

The relationship between risk and firm value represents a central issue in financial economics. Firm value is fundamentally determined by the present value of expected future cash flows, discounted at a rate reflecting their associated risk (Damodaran, 2012). Within this framework, risk influences value through both the variability of cash flows and the cost of capital.

Classical models, such as the Capital Asset Pricing Model (CAPM), emphasize systematic risk as the primary driver of expected returns, while idiosyncratic risk is assumed to be diversifiable (Sharpe, 1964). However, this perspective has been increasingly challenged by empirical evidence suggesting that firm-specific risks can have significant real effects on performance, particularly in the presence of market frictions, operational constraints, and strategic decision-making processes.

Recent literature has expanded the understanding of risk beyond financial market exposure, incorporating operational, strategic, and organizational dimensions. In this broader context, risk is not only a source of uncertainty but also a determinant of firm resilience and adaptability. This shift highlights the need for more comprehensive approaches to measuring and managing risk at the firm level.

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2.2. Enterprise Risk Management (ERM)

Enterprise Risk Management (ERM) has emerged as a holistic framework for addressing the multidimensional nature of risk. Unlike traditional approaches that treat risks in isolation, ERM integrates risk management processes across the organization and aligns them with strategic objectives (COSO, 2017; ISO, 2018).

The core premise of ERM is that coordinated risk management enhances decision-making, improves resource allocation, and ultimately contributes to value creation (Nocco & Stulz, 2006). Empirical studies provide evidence that firms adopting ERM frameworks tend to exhibit improved financial stability, reduced earnings volatility, and higher market valuation (Hoyt & Liebenberg, 2011).

Despite these benefits, measuring the effectiveness of ERM remains a persistent challenge. Most empirical research relies on indirect proxies, such as the presence of a Chief Risk Officer, the extent of risk disclosures, or survey-based assessments of risk practices (Beasley et al., 2008). While informative, these measures do not capture the actual economic impact of risk on firm performance, limiting their explanatory power.

2.3. Limitations of Existing Risk Measures

Traditional approaches to risk measurement are predominantly based on probabilistic models and disaggregated risk categories. Tools such as Value at Risk (VaR) estimate potential losses under specific confidence levels and time horizons (Jorion, 2007). However, these models are subject to well-known limitations, including sensitivity to assumptions, inability to capture extreme tail events, and limited applicability outside financial portfolios (Taleb, 2007).

In parallel, risk is often decomposed into categories such as market, credit, and operational risk, each analyzed separately (Lam, 2014). While this allows for detailed assessment, it neglects interactions and interdependencies between risks, leading to an incomplete understanding of their combined impact.

Moreover, empirical studies frequently rely on proxy variables, such as earnings volatility or leverage, to represent risk exposure. These proxies capture potential or perceived risk rather than its realized economic consequences, creating a disconnect between theoretical constructs and observable firm outcomes (Beasley et al., 2008).

These limitations become particularly evident during systemic shocks. Events such as the COVID-19 pandemic affect firms simultaneously, yet the resulting economic outcomes vary significantly across organizations (Baker et al., 2020). Traditional risk measures are not designed to explain such heterogeneity, as they focus on exposure rather than realized impact.

2.4. Research Gap

The existing literature highlights a fundamental gap in the measurement of risk at the firm level. While theoretical frameworks and empirical studies have advanced the understanding of risk and its management, there remains no unified and operational measure that captures the aggregate economic impact of risk on firm performance.

Specifically, current approaches fail to address three key limitations. First, they focus on ex ante probabilistic assessments rather than ex post realized outcomes. Second, they rely on disaggregated or proxy-based measures that do not reflect the combined effect of multiple risks. Third, they are unable to explain the heterogeneous responses of firms exposed to identical external conditions.

Addressing this gap requires a conceptual shift from viewing risk as a probabilistic exposure to understanding it as a realized economic phenomenon. In this context, risk should be measured through its observable impact on firm performance, particularly in terms of deviations from expected outcomes.

In response, this study introduces a novel Aggregate Risk Index (R-index), designed to quantify the realized economic impact of risk using financial performance indicators. By linking risk directly

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to observable outcomes, the proposed approach provides a more coherent and empirically applicable framework for analyzing the relationship between risk and firm value.

3. Methodology

3.1. Conceptual Framework

This study is grounded in a reinterpretation of risk as a realized economic phenomenon rather than a purely probabilistic construct. Traditional financial theory defines risk as the variability of expected returns or the likelihood of adverse outcomes (Markowitz, 1952; Sharpe, 1964). While such an approach is suitable for modeling uncertainty ex ante, it does not directly capture how risk manifests in firm performance ex post.

In contrast, this study adopts the perspective that risk becomes economically relevant only when it materializes through deviations from expected outcomes. Accordingly, risk is conceptualized as the realized divergence between planned (or expected) and actual performance. This shift enables a direct linkage between risk and observable financial outcomes, thereby bridging the gap between theoretical constructs and empirical measurement.

Within this framework, identical external shocks may lead to heterogeneous outcomes across firms. These differences arise from variations in internal structures, strategic positioning, operational efficiency, and the effectiveness of risk management practices. As a result, risk is inherently firm-specific in its manifestation, even when its sources are common across firms.

This conceptualization forms the basis for the development of a performance-based measure of risk, referred to as the Aggregate Risk Index (R-index).

3.2. Mathematical Model of the R-Index

3.2.1. Basic Formulation

The R-index is designed to quantify the realized economic impact of risk by measuring deviations between expected and actual performance.

Let:

- A_t denote the actual realized value of a selected financial indicator in period t,
- S_t denote the expected (strategic or planned) value in the same period.

The R-index is defined as:

$$\mathrm{R_t} = \frac{\mathrm{A_t} - \mathrm{S_t}}{|\mathrm{S_t}|}$$

where:

- R_t - R-index at time t
- A_t - actual (realized) performance value
- S_t – expected (benchmark or planed) value

The normalization by $|S_t|$ ensures scale invariance and allows for meaningful comparison across different magnitudes and units.

The use of absolute values in the denominator ensures stability and comparability, particularly in cases where expected values may vary significantly across firms or periods.

3.2.2. Multi-Dimensional Extension

To account for the multidimensional nature of firm performance, the R-index can be generalized as:

$$R_t = \sum_{i=1}^{n} w_i \cdot \frac{A_{i,t} - S_{i,t}}{|S_{i,t}|}$$

where:

- R_t - R-index time t

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- A_i, t - actual value of dimension i
- S_i, t - expected value of dimension i
- w_i - weight assigned to dimension i
- n - number of dimensions

The weighting coefficients w_i allow the model to reflect the relative importance of different performance dimensions, enabling flexibility in adapting the R-index to industry-specific and firm-specific contexts. The normalization by $|S_i, t|$ ensures comparability across dimensions and prevents scale distortions.

This formulation enables the R-index to capture the aggregated effect of multidimensional deviations, thereby serving as a comprehensive, scalable, and empirically applicable proxy for firm-level risk exposure.

3.2.3. Economic Interpretation

The R-index provides a direct and intuitive interpretation of performance deviations:

- $R_t = 0$: realized performance equals expectations (no observable risk impact)
- $R_t < 0$: negative deviation (adverse economic impact of risk)
- $R_t > 0$: positive deviation (favorable or unexpected outcome)

The use of absolute values in the denominator ensures stability and comparability, particularly in cases where expected values may vary significantly across firms or periods.

3.2.4. Aggregate Risk Representation

The R-index can be interpreted as an aggregate measure of firm-level risk, capturing the cumulative effect of deviations across multiple dimensions.

Unlike traditional risk metrics that focus on volatility, the R-index directly measures realized deviations from expected performance, thereby linking risk to operational and financial outcomes.

This property makes the R-index particularly suitable for integration into enterprise risk management (ERM) frameworks and performance evaluation systems.

3.3. Robustness and Measurement Considerations

The empirical implementation of the R-index requires careful treatment of financial data, particularly in the presence of volatility, negative values, and extreme observations, which are common in firm-level datasets.

First, the use of absolute values in the denominator ensures that the index remains well-defined even when expected performance is negative. This normalization enhances scale invariance, prevents sign-related distortions, and preserves comparability across different financial conditions and economic cycles.

Second, in cases where expected values exhibit high volatility or approach zero, alternative benchmark definitions may be employed to ensure stability. These include moving averages, historical trends, or strategically defined target values. Such adjustments improve the robustness of the index by reducing sensitivity to short-term fluctuations and measurement noise.

Third, extreme values, which frequently occur during periods of systemic shocks or firm-specific disruptions, are explicitly retained in the analysis. Unlike conventional approaches based on trimming or winsorisation, this study treats extreme deviations as intrinsic manifestations of risk. Nevertheless, robustness checks are performed to ensure that empirical results are not disproportionately driven by a limited number of observations.

Finally, the selection of performance indicators (e.g., EBITDA, net income, or free cash flow) remains flexible and can be adapted to the empirical context. This flexibility enhances the generalizability of the R-index and enables its application across industries, time periods, and analytical frameworks.

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Taken together, these considerations ensure that the R-index remains both theoretically consistent and empirically robust, providing a reliable measure of firm-level risk under varying economic conditions.

4. Empirical Analysis

4.1. Data and Sample Description

The empirical analysis is based on longitudinal financial data from three firms operating in distinct sectors of the Montenegrin economy: telecommunications (MTEL), retail (Voli Trade), and tourism (Budvanska Rivijera). The observation period spans from 2015 to 2024, covering both stable economic conditions and a major systemic shock associated with the COVID-19 pandemic.

The sample is constructed using a purposeful selection strategy designed to capture heterogeneity in business models and exposure to external shocks. Although all firms operate within the same macroeconomic environment, they differ significantly in sectoral characteristics, operational structures, and demand sensitivity. This setting provides a suitable framework for examining firm-specific responses to identical external conditions.

Financial data are obtained from audited financial statements, ensuring consistency and reliability. EBITDA is used as the primary performance indicator for constructing the R-index, given its relevance as a proxy for operational performance and its comparability across sectors.

4.2. Firm-Level R-Index Analysis

The R-index is computed for each firm using year-over-year changes in EBITDA as a proxy for deviations from expected performance. This approach enables a consistent empirical implementation in the absence of explicitly reported benchmark targets.

MTEL

The R-index for MTEL exhibits relatively low variability throughout the observation period, indicating a high degree of operational stability. Deviations from expected performance remain moderate, including during periods of systemic shocks such as the COVID-19 pandemic. This pattern suggests a resilient operational structure and effective risk absorption capacity. As shown in Figure 1, fluctuations in the R-index are limited in magnitude, confirming the stability of realized economic outcomes.

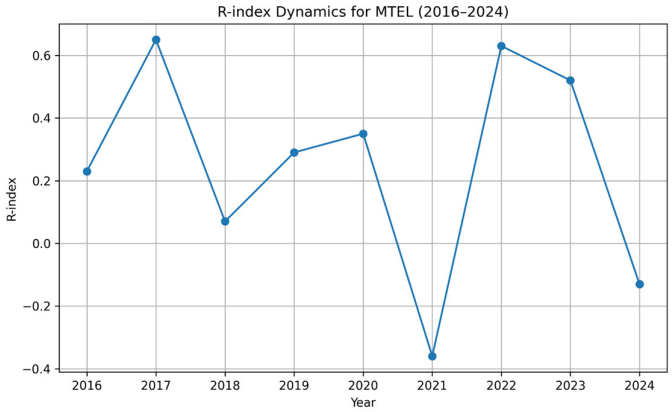

Figure 1.

The figure shows relatively low variability of the R-index, indicating stable operational performance resilience to external shocks.

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Voli Trade

Voli Trade demonstrates predominantly positive deviations throughout the observation period, reflecting sustained growth and operational efficiency. Although temporary fluctuations are observed during the pandemic period, the firm exhibits a rapid recovery and continued positive trajectory. This pattern suggests strong adaptive capacity and effective operational management. As illustrated in Figure 2, the R-index remains largely positive, with a noticeable increase in the post-pandemic period.

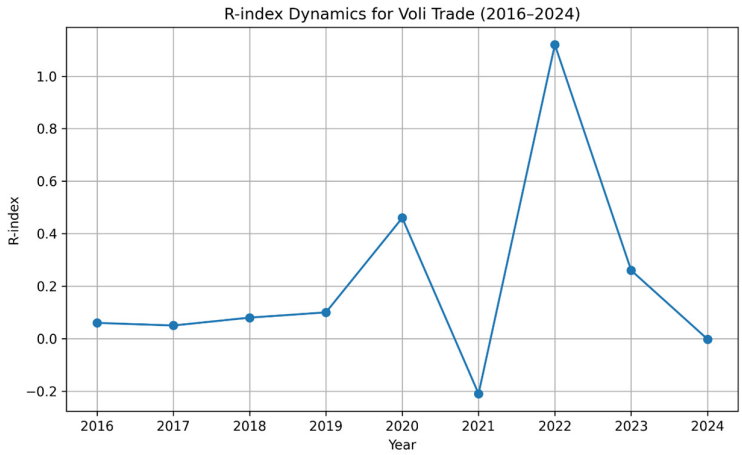

Figure 2.

The figure illustrates predominantly positive R-index values, reflecting sustained growth and efficient operational performance, with a strong post-pandemic rebound.

Budvanska Rivijera

Budvanska Rivijera exhibits a markedly different pattern characterized by high volatility and pronounced sensitivity to external shocks. The firm experiences a substantial negative deviation during the COVID-19 period, followed by a rapid and significant recovery. This dynamic reflects the structural exposure of the tourism sector to exogenous risks and highlights the cyclical nature of its performance. As shown in Figure 3, the R-index displays extreme fluctuations, capturing both the depth of the negative shock and the intensity of the recovery phase.

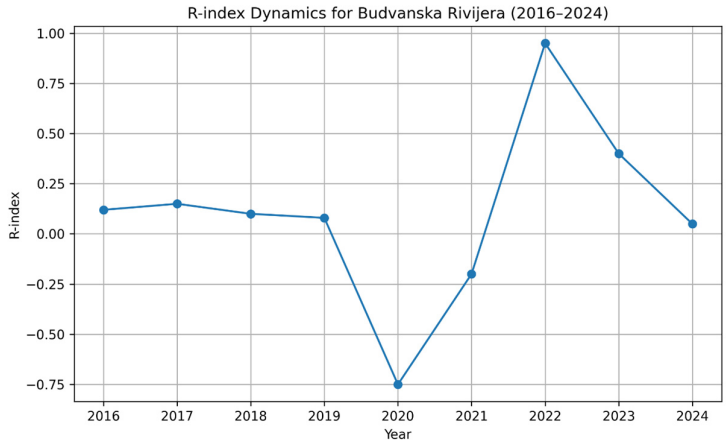

Figure 3.

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The figure captures sharp negative deviation during the COVID-19 period, followed by a strong recovery, highlighting the sensitivity of tourism to external shocks.

4.3. Comparative Analysis

A comparative analysis across the three firms reveals substantial heterogeneity in the realized economic impact of risk. Despite exposure to identical macroeconomic conditions and systemic shocks, the firms exhibit fundamentally different R-index trajectories.

MTEL maintains relatively stable performance, Voli Trade demonstrates sustained positive deviations, while Budvanska Rivijera exhibits high volatility driven by external shocks and subsequent recovery dynamics. As presented in Figure 4, these differences indicate that risk is not uniformly transmitted across firms, but instead manifests through firm-specific outcomes shaped by sectoral characteristics, operational structures, and adaptive capacity.

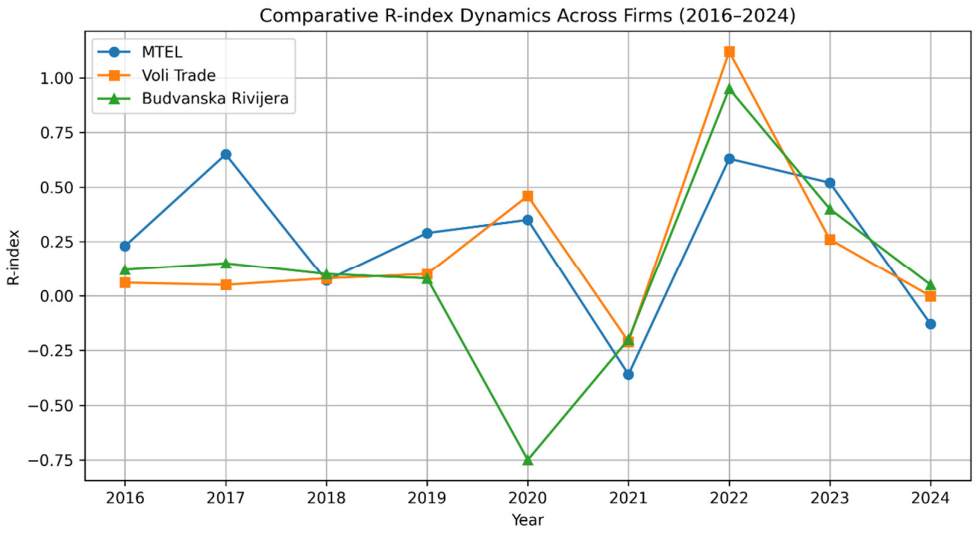

Figure 4.

The figure compares R-index trajectories across firms exposed to identical macroeconomic conditions, revealing substantial heterogeneity in the realized economic impact of risk.

4.4. Distributional Analysis of the R-Index

In addition to firm-level analysis, the R-index is examined as a distributional phenomenon across observations. The empirical distribution of R-values reveals important structural characteristics of risk realization.

The distribution is centered around values close to zero, indicating that most observations cluster near expected performance levels. However, it exhibits noticeable asymmetry, with a right-skewed shape driven by a smaller number of observations with large positive deviations. This suggests that favorable outcomes, although less frequent, tend to be more pronounced in magnitude.

For visualization purposes, extreme values are partially trimmed; however, all observations are retained in the analytical framework to preserve the full representation of risk realization. As shown in Figure 5, the distribution remains concentrated around zero and displays positive skewness, confirming the asymmetric nature of economic outcomes.

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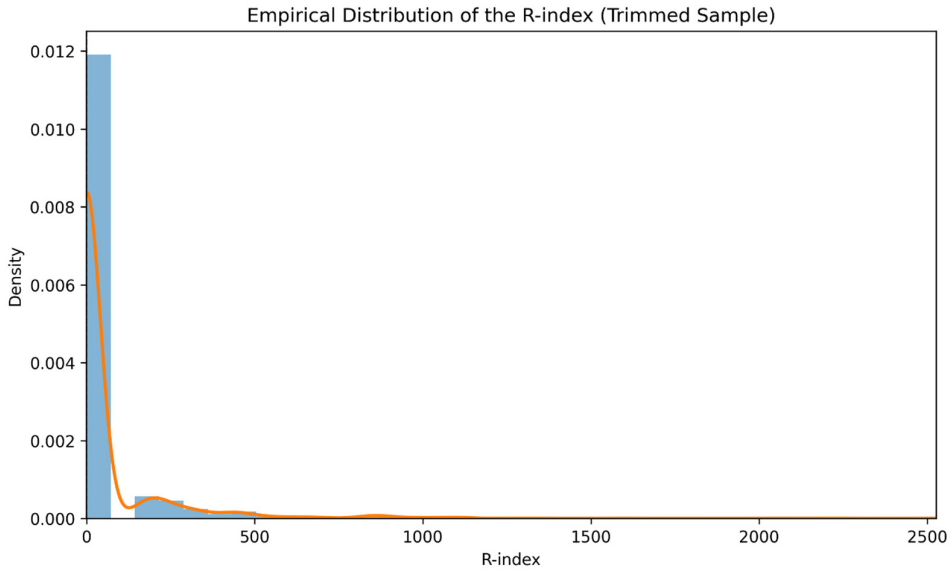

Figure 5.

The figure presents the empirical distribution of the R-index. While trimmed for visualization, the full dataset is used in the analysis. The distribution is concentrated around zero and exhibits positive skewness.

4.5. Empirical Implications

The empirical findings provide several important insights.

First, they demonstrate that risk cannot be adequately understood as a purely probabilistic concept. Its economic relevance lies in its realized impact on firm performance.

Second, the results highlight the importance of firm-specific factors in shaping risk outcomes. Even under identical external conditions, firms exhibit significantly different performance trajectories, emphasizing the role of internal structures and managerial practices.

Third, the distributional analysis indicates that risk should be interpreted not only at the individual firm level but also as a systemic phenomenon reflected in the overall shape of the R-index distribution.

Overall, the empirical evidence supports the validity of the R-index as a tool for quantifying the economic impact of risk and provides a solid foundation for its theoretical and managerial implications.

A more detailed distributional analysis of the R-index, including formal probabilistic modeling, is left for future research.

5. Discussion and Contribution

5.1. Interpretation of Findings

The empirical results provide strong support for the central premise of this study: risk is most meaningfully understood through its realized economic impact rather than solely through probabilistic measures.

The application of the R-index across firms operating in different sectors reveals substantial heterogeneity in performance deviations, even under identical macroeconomic conditions. This finding suggests that risk is not uniformly transmitted but is instead mediated by firm-specific characteristics, including operational structure, sectoral exposure, and adaptive capacity.

In particular, the contrasting patterns observed across MTEL, Voli Trade, and Budvanska Rivijera highlight that stability, growth, and volatility represent distinct manifestations of risk

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realization. These differences cannot be fully captured by traditional variance-based or probability-based risk measures, underscoring the need for alternative approaches such as the R-index.

5.2. Theoretical Contribution

This study contributes to the literature by introducing a novel conceptualization of risk as a realized deviation from expected performance. Unlike traditional approaches that treat risk as uncertainty or variability, the R-index directly quantifies the economic consequences of risk through observable performance outcomes.

The proposed framework extends existing perspectives in risk management and financial analysis in several ways.

First, it bridges the gap between risk and performance by embedding risk measurement directly within economic outcomes. This contrasts with conventional models where risk and performance are treated as separate constructs.

Second, the R-index provides a unified metric that is both scalable and adaptable across different industries and analytical contexts. Its normalization structure enables comparability, while its multidimensional extension allows for integration into complex performance systems.

Third, the model introduces a shift from probabilistic to outcome-based risk measurement, aligning more closely with managerial decision-making processes and real-world business dynamics.

5.3. Managerial Implications

The findings have important implications for managerial practice.

First, the R-index offers a practical tool for monitoring and evaluating performance deviations in real time. By translating deviations into a standardized metric, managers can more effectively identify areas of underperformance and assess the magnitude of associated risks.

Second, the ability to decompose the R-index across multiple dimensions enables targeted analysis of specific operational or financial drivers. This supports more informed decision-making and enhances the effectiveness of risk management strategies.

Third, the empirical evidence suggests that resilience to external shocks is strongly linked to firm-specific characteristics. This highlights the importance of internal capabilities, organizational flexibility, and adaptive management in mitigating the economic impact of risk.

5.4. Implications for Future Research

While the present study establishes the R-index as a robust tool for measuring the economic impact of risk, several avenues for further research remain.

Future studies may extend the analysis by exploring the distributional properties of the R-index in greater depth, including its behavior under extreme conditions and its relationship with downside risk measures.

In addition, empirical applications across larger samples and different economic environments would provide further validation of the model and enhance its generalizability.

Finally, integrating the R-index into firm valuation frameworks and examining its relationship with financial performance indicators such as profitability, investment efficiency, and market value represents a promising direction for future research.

6. Conclusions

This study introduces the R-index as a novel approach to quantifying the economic impact of risk through realized deviations from expected performance. By shifting the focus from probabilistic measures of uncertainty to outcome-based evaluation, the proposed framework provides a more direct and operationally relevant understanding of risk.

The empirical analysis, based on firm-level data from different sectors of the Montenegrin economy, demonstrates that risk manifests in heterogeneous ways across firms, even under identical

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macroeconomic conditions. The findings highlight that firm-specific characteristics, including sectoral exposure, operational structure, and adaptive capacity, play a critical role in shaping the economic outcomes of risk.

The results confirm that the R-index offers a consistent, scalable, and interpretable measure of risk that can be applied across industries and time periods. Its ability to capture both the magnitude and direction of performance deviations makes it particularly suitable for integration into performance evaluation systems and enterprise risk management frameworks.

Despite these contributions, the study is subject to certain limitations. The empirical analysis is based on a relatively small sample of firms, and the use of proxy measures for expected performance may introduce measurement constraints. Future research should extend the analysis to larger datasets, explore the distributional properties of the R-index in greater depth, and examine its relationship with firm value and financial performance indicators.

Overall, the R-index provides a robust foundation for rethinking risk as an economically grounded concept, offering both theoretical insight and practical relevance for researchers and practitioners.

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Author Biography: Nedzad Lajka is affiliated with the Faculty of Business Economics and Law, University of Adriatik (Bar, Montenegro). He is also the founder and CEO of SN Electronics, active in telecommunications since 2004 and a long-term partner of major telecom companies in the region. His research focuses on enterprise risk management (ERM), firm value, and quantitative measurement of the economic impact of risk.

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