

## **Systemic Risk and Financial Contagion in the Energy Sector: A Multi-Method Analysis of Asymmetric Exposure and Institutional Dependence**

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**Introdução**

The energy sector occupies a foundational role in national economic structures, acting not only as an input to industrial production but also as a strategic axis for development policy and macroeconomic stability (Bolton & Kacperczyk, 2023). This study investigates the transmission of systemic risk from Brazil's primary stock index (IBOVESPA) to publicly listed energy firms on the B3 exchange in the post-pandemic period, from May 2023 to May 2025.

**Problema de Pesquisa e Objetivo**

The strategic importance of this sector transcends energy provision alone. It contributes nearly 4% to Brazil's GDP and sustains over one million jobs, directly and indirectly (EPE, 2023). The low short-term elasticity of electricity demand underscores its irreplaceability across productive systems, magnifying the macro-financial risks associated with sectoral instability (Mukanjari & Sterner, 2024). Within this environment, "Which listed energy firms in Brazil are most sensitive to fluctuations in IBOVESPA, and what is the magnitude and direction of this systemic risk transmission?"

**Fundamentação Teórica**

Drawing on Institutional, Agency, and Resource Dependence theories, the research explores how ownership structure, regulatory embeddedness, and inter-organisational dependencies influence firms' susceptibility to market-wide shocks. In another words, the theoretical framework integrates Agency Theory, Institutional Theory, and Resource Dependency Theory to explain how structural factors shape systemic exposure.

**Metodologia**

The sample comprises 11 energy companies listed on B3 (Eletrobras, Engie, Cemig, CPFL, Copel, Neoenergia, Energisa, Equatorial, Alupar, Taesa, and Petrobras). Quantile regression was used to estimate VaR and CoVaR based on daily returns between 05/05/2023 and 05/19/2025.  $\Delta$ CoVaR and %CoVaR were used to measure each firm's incremental contribution to systemic risk at different quantiles (1%, 5%, 10%).

**Análise dos Resultados**

The results reveal considerable asymmetry and heterogeneity in risk transmission. State-influenced and vertically integrated firms, such as Petrobras and Neoenergia, exhibit pronounced tail-risk sensitivity, consistent with agency-related inefficiencies and institutional exposure. In contrast, transmission-specialised firms such as Taesa and Alupar display lower CoVaR metrics, suggesting a more buffered position in the systemic risk network.

**Conclusão**

The findings challenge homogenous sectoral treatments in macroprudential oversight and underscore the importance of disaggregated, firm-level analysis. From a practical standpoint, the results offer valuable insights for investors constructing risk-hedged portfolios and for policymakers formulating targeted regulatory safeguards in Brazil's energy sector.

**Contribuição / Impacto**

The study offers two principal contributions. First, it advances theoretical understanding by demonstrating how inter-organisational dependence and institutional arrangements jointly shape systemic vulnerability in emerging market infrastructure sectors. Second, it provides actionable evidence for investors, regulators, and policymakers seeking to mitigate contagion effects and foster resilience in strategic industries.

**Referências Bibliográficas**

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