

**THE ENVIRONMENTAL IMPACT OF SOYBEAN TRANSPORTATION IN BRAZIL:  
EVIDENCE OF AN N-SHAPED KUZNETS CURVE**

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### **Introdução**

This study examines the relationship between economic growth and environmental degradation in the context of Brazilian soybean transportation. The focus is on applying the Environmental Kuznets Curve (EKC) hypothesis to assess CO<sub>2</sub> emissions resulting from soy logistics. Given the significance of soybeans to Brazil's economy and the environmental impacts of their transportation, this study aims to verify whether the EKC hypothesis holds true for CO<sub>2</sub> emissions in this sector. The investigation centers on the predominance of road transport and its reliance on fossil fuels.

### **Problema de Pesquisa e Objetivo**

The research problem centers on the significant environmental impact of soybean transportation in Brazil, primarily due to CO<sub>2</sub> emissions from extensive road transport. The objective of this study is to analyze the Environmental Kuznets Curve (EKC) hypothesis within the context of Brazilian soy logistics, to determine if economic growth in this sector leads to initial increases in emissions followed by a decrease as income continues to rise. The study aims to provide insights for more sustainable agricultural transportation practices.

### **Fundamentação Teórica**

The theoretical framework is grounded in the Environmental Kuznets Curve (EKC) hypothesis, which posits an inverted U-shaped relationship between environmental degradation and economic growth. Initial stages of economic growth increase environmental impact, but after reaching a certain income level, further growth leads to environmental improvements. This study also incorporates theories related to agricultural logistics, CO<sub>2</sub> emissions, and the specific challenges of Brazil's transportation infrastructure, particularly the reliance on road transport for soybean exports.

### **Metodologia**

The study employs a network equilibrium model to calculate CO<sub>2</sub> emissions from soybean transportation across various Brazilian regions. Econometric models, including the Generalized Method of Moments (GMM), are used to validate the EKC hypothesis by analyzing panel data from 290 microregions over 16 years (2002-2017). The methodology includes examining quadratic and cubic relationships between soy income and emissions. Data sources include CEPEA, IBGE, and other national databases to ensure comprehensive and accurate analysis.

### **Análise dos Resultados**

The analysis reveals an "N" shaped Environmental Kuznets Curve for CO<sub>2</sub> emissions in Brazilian soybean transportation. This indicates that after an initial decline in emissions with rising income, emissions increase again at higher income levels. The study identifies significant regional disparities, with the South and Midwest regions showing higher emissions. Investments in road infrastructure are found to correlate with increased emissions, underscoring the need for sustainable logistics solutions, such as enhanced intermodal transport systems.

### **Conclusão**

The study concludes that the Environmental Kuznets Curve (EKC) for CO<sub>2</sub> emissions in Brazilian soybean transportation follows an "N" shape. This suggests that economic growth alone is insufficient to mitigate environmental impacts in the long term, and proactive measures are necessary. Enhancing intermodal transport and investing in sustainable infrastructure are critical to

reducing the environmental footprint of soybean logistics. The findings emphasize the need for balanced policies that promote both economic growth and environmental protection in the agricultural sector.

### **Referências Bibliográficas**

The references for this study include key academic and industry sources such as CEPEA (Center for Advanced Studies on Applied Economics), IBGE (Brazilian Institute of Geography and Statistics), and relevant literature on the Environmental Kuznets Curve (EKC) hypothesis, CO<sub>2</sub> emissions, and agricultural logistics. Specific studies by Grossman and Krueger (1991), Torras and Boyce (1998), and recent research on Brazilian agricultural transport and environmental impacts are cited to support the theoretical and empirical analysis conducted in this study.