

## Accepted Manuscript

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PII: S0140-9883(18)30053-7  
DOI: [doi:10.1016/j.eneco.2018.02.003](https://doi.org/10.1016/j.eneco.2018.02.003)  
Reference: ENEECO 3912

To appear in:

Received date: 20 December 2017  
Revised date: 28 January 2018  
Accepted date: 6 February 2018

Please cite this article as: Toshiyuki Sueyoshi, Derek Wang , DEA Environmental Assessment on US Petroleum Industry: Non-radial Approach with Translation Invariance in Time Horizon. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. *Eneco*(2018), doi:[10.1016/j.eneco.2018.02.003](https://doi.org/10.1016/j.eneco.2018.02.003)

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# DEA Environmental Assessment on US Petroleum Industry: Non-radial Approach with Translation Invariance in Time Horizon

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**JEL:** C18, C61, Q54, Q56

**Abstract:** This study empirically assesses the performance of the petroleum industry, focusing upon independent companies, in the United States (US). For the empirical study, we use the Data Envelopment Analysis (DEA) that has been widely used for environmental assessment and performance measurement. The conventional use of DEA requests that all observations in the data set should be positive, prohibiting the occurrence of zero or negative values. The requirement of non-negative value is inconsistent with the reality of US petroleum industry, because many oil firms recently experience negative shocks in financial performance. To overcome the obstacle, this study discusses the property of “translation invariance” under undesirable congestion (e.g., capacity limit in the transportation pipeline network) and desirable congestion (e.g., green innovation) based on the non-radial models. The property implies that the unified efficiency measure should be not influenced even if production factors are shifted toward the same direction by adding or subtracting a specific real number. The property makes it possible that we can evaluate the performance of firms, whose production factors contain zero and/or negative values. This study is empirically concerned with practical implications of translation invariance from energy and environmental perspectives. In addition, this study examines the proposed environmental assessment in a time horizon. For the purpose, this study uses “window analysis” to examine an efficiency change along with a time shift. Our empirical investigation finds the following three implications. First, under the natural disposability, the oil firms’ efficiency growth rates have become less than unity, implying the industry-wide difficulty or inability to cut back their drilling and production operations. Second, all firms have been under regulatory and stakeholder pressures on air pollution. Therefore, the efficiency growth rates under managerial disposability have not exhibited a major change during the observed annual periods. Finally, such implications are statistically reconfirmed by regression analysis that examines how the change of energy price influences unified efficiencies under natural and managerial disposability. An exception can be found in the natural disposability where energy prices influence their efficiency growths. Thus, the increase in energy prices is important in maintaining a high level of efficiency growths in the US petroleum industry.

**Key Words:** Petroleum Industry, DEA Environmental Assessment, Translation Invariance, Non-Radial Approach

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