RINGKASAN

Deni Kusumawardani, Program Pascasarjana Fakultas Ekonomi dan Bisnis, Universitas Airlangga, Surabaya, November 2020. **Analisis Eko-Efisiensi Industri Pengolahan di Indonesia: Studi Kasus pada Industri Intensif Energi**

Promotor: Dyah Wulansari
Ko-Promotor: Tri Haryanto

Tujuan utama penelitian ini adalah untuk menganalisis eko-efisiensi industri pengolahan di Indonesia dengan studi kasus pada industri intensif energi. Secara spesifik tujuan tersebut dibagi ke dalam empat kajian: (1) mengukur dan membandingkan eko-efisiensi; (2) mengukur dan membandingkan kesenjangan teknologi; (3) mendekomposisi sumber eko-inefisiensi; dan (4) mengidentifikasi determinan eko-inefisiensi. Pada penelitian ini industri intensif energi meliputi delapan jenis industri, yaitu pengolahan kelapa sawit, tekstil, pulp & kertas, kimia, pupuk, kaca & keramik, semen, dan logam & baja. Analisis dilakukan baik secara agregat terhadap industri intensif energi maupun menurut jenis industri menggunakan data mikro tingkat *firm* tahunan dari 2010 sampai dengan 2015.

Eko-efisiensi diukur menggunakan kerangka analisis *meta-frontier* yang mampu mengakomodasi heterogenitas dalam teknologi produksi antar jenis industri. *Data Envelopment Analysis* (DEA) diterapkan sebagai model estimasi *frontier* dan *Directional Distance Function* (DDF) *radial* sebagai metode pengukuran eko-efisiensi. *Meta-frontier* menghasilkan dua jenis pengukuran eko-efisiensi, yaitu eko-efisiensi terhadap *meta-frontier* (*MEE*) dan *group-frontier* (*GEE*). Kesenjangan teknologi diukur oleh rasio meta-teknologi (*MTR*) yang didefinisikan sebagai perbandingan MEE terhadap GEE. Perbedaan eko-efisiensi (MEE) dan kesenjangan teknologi antar jenis industri diuji secara statistik menggunakan *Kruskal-Wallis Test*. Lebih lanjut dalam kerangka *meta-frontier* eko-inefisiensi (MTI) dapat didekomposisikan ke dalam dua bagian, yaitu eko-inefisiensi yang disebabkan oleh kesenjangan teknologi (TGI) dan oleh kegagalan manajerial (GMI). Sementara itu, determinan eko-efisiensi diidentifikasi menggunakan Model Tobit Panel.

Penelitian ini menghasilkan beberapa kesimpulan. **Pertama**, rata-rata skor eko-efisiensi industri intensif energi terhadap *meta-frontier* (MEE) pada periode 2010-2015 sebesar 0,687. Menurut jenis industri, rata-rata skor MEE tertinggi dicapai oleh industri semen (0,802), sedangkan terendah oleh industri pupuk (0,681). Pada periode yang sama rata-rata skor eko-efisiensi industri intensif energi terhadap *group-frontier* (GEE) sebesar 0,687. Rata-rata skor GEE tertinggi dicapai oleh industri semen (0,962) dan terendah oleh industri tekstil (0,709). Hasil uji Kruskal-Wallis menunjukkan bahwa terdapat perbedaan signifikan skor eko-efisiensi antara jenis industri dalam kelompok industri intensif energi tersebut.

Kedua, rata-rata kesenjangan teknologi (MTR) industri intensif energi pada periode 2010-2015 sebesar 0,940. Menurut jenis industri rata-rata MTR tertinggi dicapai oleh industri tekstil (0,974) dan terendah oleh industri pulp & kertas (0,738). Hasil uji

Kruskal-Wallis menunjukkan bahwa terdapat perbedaan signifikan kesenjangan teknologi antara jenis industri.

Ketiga, 82,7% eko-inefisiensi industri intensif energi pada periode 2010-2015 bersumber dari kegagalan manajerial dalam bentuk kekurangan produksi dan kelebihan emisi CO_2, sedangkan sisanya sebesar 17,3% bersumber dari kesenjangan teknologi. Sementara itu, sumber eko-inefisiensi menurut jenis industri bervariasi. Pada industri pengolahan kelapa sawit, tekstil, kimia, kaca & keramik lebih didominasi oleh kegagalan manajerial dengan kontribusi masing-masing sebesar 68,3%, 92,4%, 64,4%, dan 84,2%. Sebaliknya pada industri pulp & kertas, pupuk, semen, dan logam & baja kesenjangan teknologi lebih dominan dengan kontribusi masing-masing sebesar 85,0%, 62,3%, 80,5%, dan 73,8%.

Keempat, hasil regresi Model Tobit Panel menunjukkan bahwa eko-efisiensi industri intensif energi dipengaruhi oleh investasi asing, efek skala, efek komposisi, intensitas energi, dan intensitas karbon. Menurut jenis industri faktor-faktor yang mempengaruhi eko-efisiensi adalah sebagai berikut: (1) pengolahan kelapa sawit (investasi asing, efek skala, dan efek komposisi); (2) tekstil (efek skala, efek komposisi, intensitas energi, dan intensitas karbon), (3) pulp & kertas (intensitas energi), (4) kimia (efek skala, efek komposisi, dan intensitas energi); (5) pupuk (efek komposisi, dan intensitas energi); (6) kaca & keramik (investasi asing, efek skala, efek komposisi, intensitas energi, dan intensitas karbon); (7) semen (tidak ada); dan (8) logam & baja (efek komposisi dan intensitas energi). Hasil estimasi dan pengujian statistik menunjukkan bahwa Hipotesis *Environmental Kuznets Curve* (EKC) tidak diterima baik pada industri intensif energi maupun semua jenis industri.

Berdasarkan kesimpulan tersebut, penelitian ini merekomendasikan pengembangan kawasan industri dalam jangka panjang yang berlokasi di luar Jawa untuk mengurangi kesenjangan teknologi, terutama pada industri pulp & kertas, pupuk, semen, dan logam & baja. Selain itu, investasi pada teknologi produksi yang menghasilkan efisiensi energi, pengurangan ketergantungan pada energi fosil, dan pengembangan energi alternatif diperlukan untuk meningkatkan eko-efisiensi. Untuk penelitian lanjut disarankan untuk menggunakan *balanced panel data*, menggunakan indikator lingkungan lain, dan menerapkan pendekatan, model, dan teknik pengukuran yang berbeda.

ABSTRACT

Deni Kusumawardani, Postgraduate Program of Faculty of Economics and Business, Airlangga University, Surabaya, November 2020. **Eco-Efficiency Analysis of Manufacturing Industries in Indonesia: A Case Study of Energy-Intensive Industries**

Promotor: Dyah Wulansari
Co-Promotor: Tri Haryanto

The main objective of this research is to analyze the eco-efficiency of manufacturing industries in Indonesia with case study of energy-intensive industries. Specifically, these objectives are divided into four studies: (1) measuring and comparing eco-efficiency; (2) measuring and comparing technology gaps; (3) decomposing sources of eco-inefficiency; and (4) identifying the determinants of eco-inefficiency. In this research, the intensive industries include eight industries, namely palm oil processing, textiles, pulp & paper, chemicals, fertilizers, glass & ceramics, cement, and metal & steel. The analysis was carried out both on energy-intensive industry and by types of industry using annual firm-level micro data from 2010 to 2015.

Eco-efficiency is measured using a meta-frontier analysis framework that is able to accommodate heterogeneity in production technology between types of industries. Data Envelopment Analysis (DEA) is applied as a frontier estimation model and radial Directional Distance Function (DDF) as an eco-efficiency measurement method. The meta-frontier produces two types of eco-efficiency measures; those are the eco-efficiency with respect to meta-frontier (MEE) and to group-frontier (GEE). The technology gap is measured by meta-technology ratio (MTR) which is defined as the ratio of MEE to GEE. Difference in both eco-efficiency (MEE) and technological gaps between the types of industry were statistically tested using the Kruskal-Wallis Test. In addition, using meta-frontier framework eco-inefficiency (MTI) can be decomposed into two parts, namely eco-efficiency caused by technology gap (TGI) and by managerial failure (GMI). Meanwhile, the determinants of eco-efficiency were identified using the Panel Tobit Model.

This research resulted some conclusions. **First**, the average eco-efficiency score of energy-intensive industry with respect to the meta-frontier (MEE) in the period of 2010-2015 was 0.687. Based on the types of industries, the highest MEE score was achieved by the cement industry (0.802), while the lowest was by the fertilizer industry (0.681). In the same period, the average eco-efficiency score of energy-intensive industry with respect to the group-frontier (GEE) was 0.687. The highest average GEE score was achieved by the cement industry (0.962) and the lowest by the textile industry (0.709). The Kruskal-Wallis test result showed that there is a significant difference in the eco-efficiency score between the types of industries in the energy-intensive industry group.

Second, the average technology gap (MTR) of energy-intensive industry in the period of 2010-2015 was 0.940. Based on the types of industries, the highest average

MTR was achieved by the textile industry (0.975) and the lowest by the pulp & paper industry (0.738). The Kruskal-Wallis test result showed that there are significant differences in technology gaps between the types of industries.

Third, 82.7% of the eco-inefficiency of energy-intensive industry in the period of 2010-2015 originated from managerial failures in the form of production shortfall and CO_2 emissions excess, while the remaining 17.3% came from technology gaps. Meanwhile, the sources of eco-inefficiency by types of industries vary. In the palm oil processing industry, textiles, chemicals, glass & ceramics were more dominated by the managerial failures with contributions of 68.3%, 92.4%, 64.4%, and 84.2% respectively. In contrast to the pulp & paper, fertilizer, cement, and metal & steel industries the technology gaps were more dominant with a contribution of 85.0%, 62.3%, 80.5%, and 73.8% respectively. .

Fourth, the regression results of the Panel Tobit Model showed that the eco-efficiency of energy-intensive industry is affected by foreign investment, scale effect, composition effect, energy intensity, and carbon intensity. Based on the types of industries the factors affecting eco-efficiency are as follows: (1) palm oil processing (foreign investment, scale effect, and composition effect); (2) textiles (scale effect, composition effect, energy intensity, and carbon intensity), (3) pulp & paper (energy intensity), (4) chemistry (scale effect, composition effect, and energy intensity); (5) fertilizer (composition effect, and energy intensity); (6) glass & ceramics (foreign investment, scale effect, composition effect, energy intensity and carbon intensity); (7) cement (absent); and (8) metals & steel (composition effects and energy intensity). The estimation result and statistical test showed that the Environmental Kuznets Curve (EKC) Hypothesis is not accepted in both energy-intensive industries and all types of industries.

In relation to the conclusions, this research recommends development of industrial parks in the long-run located in outside of Java Island to reduce technology gaps, particularly in the pulp & paper, fertilizer, cement, and metal & steel industries. In addition, investment in production technology that results high energy efficiency rate, reduction of dependence on fossil energy, and development of alternative energies is needed to improve eco-efficiency. For further research it is recommended to exploit balanced paned data, explore other environmental indicators, and apply different approaches, models and measurement techniques.