HOW VULNERABLE TO OIL ARE NET OIL IMPORTING COUNTRIES IN EUROPE?

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Index

- Motivation
- Methodology
- Data
- Discussion of results
- Conclusions
Motivation

➢ Aim:

➢ Measure the vulnerability to oil of net oil importing countries;
➢ Analyse changes in efficiency/technological progress;
➢ Evaluate robustness of the results obtained.
Motivation

➢ Research questions:
  ➢ Which *countries* have the highest level of vulnerability to oil supply?
  ➢ Which *factors* had the greatest influence on the level of vulnerability of each country?
  ➢ Are the results obtained *robust* in the event of disturbances in the values of the evaluation factors used?
  ➢ Which factors contributed the most to the *productivity* gains recorded?
Methodology

WRDDM (Weighted Russell Directional Distance Model):

\[
\max \beta^R_0 = \max (w_y (\sum_r \omega_y^r \alpha_0^r) + w_x (\sum_i \omega_x^i \zeta_0^i)) \\
\text{s.t. } \sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro}^c + \alpha_0^r g_{yr}, \ r = 1, \ldots, s, \\
\sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{io} - \zeta_0^i g_{xi}, \ i = 1, \ldots, m, \\
\sum_{j=1}^{n} \lambda_j = 1, \\
\lambda_j \geq 0 \ (\forall j),
\]

- **Non-radial and non-oriented model;**
- **Allows the assignment of different weights to the various valuation factors.**
Methodology

WRDDM (Weighted Russell Directional Distance Model):

\[
\text{max } \sum_r s_r^+ + \sum_i s_i^-
\]

s.t. \(\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{ro} + \alpha_{0}^{r*} g_{yr}, r = 1,\ldots, s,\)

\(\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{io} - \zeta_{0}^{i*} g_{xi}, i = 1,\ldots, m,\)

\(\sum_{j=1}^{n} \lambda_j = 1, \lambda_j \geq 0 (\forall j),\)

\(s_r^+ \geq 0 (\forall r),\)

\(s_i^- \geq 0 (\forall i)\)

➢ Allows identifying benchmarks
Methodology

WRDDM (Weighted Russell Directional Distance Model):

\[
\max \left( w_y \left( \sum_r \alpha_y^r \frac{s_r^+}{g_{yr}} \right) + w_x \left( \sum_i \alpha_x^i \frac{s_i^-}{g_{xi}} \right) \right)
\]

s.t. \( \sum_{j=1}^n \lambda_j y_{rj} = y_{ro} + s_r^+, \ r = 1, \ldots, s, \)

\( \sum_{j=1}^n \lambda_j x_{ij} = x_{io} - s_i^-, \ i = 1, \ldots, m, \)

\( \sum_{j=1}^n \lambda_j z_{uj} = z_{uo} - s_u^-, \ u = 1, \ldots, q, \)

\( \sum_{j=1}^n \lambda_j = 1, \ \lambda_j \geq 0, \ j = 1, \ldots, n, \)

\( s_r^+ \geq 0 \ (\forall_r), \ s_i^- \geq 0 \ (\forall_i), \ s_u^- \geq 0 \ (\forall_u) \)

- If \((s_r^+*, s_i^-*, s_u^-, \lambda_j^*)\) is the optimal solution to original problem, then the overall measure of inefficiency obtained from the WRDDM method is given by:

\[
(w_y \left( \sum_r \alpha_o^{r*} \frac{s_r^+}{g_{yr}} \right) + w_x \left( \sum_i \zeta_o^{i*} \frac{s_i^-}{g_{xi}} \right), \)

where \( \alpha_o^{r*} = \alpha_y^r \frac{g_{yr}}{g_{yr}} \) and \( \zeta_o^{i*} = \alpha_x^i \frac{g_{xi}}{g_{xi}}. \)

- Allows identifying the contribution of each factor to the inefficiency
Methodology

WRDDM (Weighted Russell Directional Distance Model):

\[
\max \beta^L = \max \left( w_y (\sum_{r \in 0} \omega^r_y \alpha^r_o) + w_x (\sum_{i \in I} \omega^i_x \zeta^i_o) \right)
\]
\[
s.t. \sum_{j \neq 0} \lambda_j y_{rj}^L \geq y_{r0}^L + \alpha^r_o g_{yr}, r = 1, ..., s,
\]
\[
\sum_{j \neq 0} \lambda_j x_{ij}^L \leq x_{i0}^L - \zeta^i_o g_{xi}, i = 1, ..., m,
\]
\[
\sum_{j \neq 0} \lambda_j z_{uj}^L \leq z_{u0}^L, u = 1, ..., q,
\]
\[
\sum_{j \neq 0} \lambda_j = 1, \lambda_j \geq 0, j = 1, ..., n.
\]

\[
\max \beta^U = \max \left( w_y (\sum_{r \in 0} \omega^r_y \alpha^r_o) + w_x (\sum_{i \in I} \omega^i_x \zeta^i_o) \right)
\]
\[
s.t. \sum_{j \neq 0} \lambda_j y_{rj}^U \geq y_{r0}^L + \alpha^r_o g_{yr}, r = 1, ..., s,
\]
\[
\sum_{j \neq 0} \lambda_j x_{ij}^L \leq x_{i0}^L - \zeta^i_o g_{xi}, i = 1, ..., m,
\]
\[
\sum_{j \neq 0} \lambda_j z_{uj}^L \leq z_{u0}^L, u = 1, ..., q,
\]
\[
\sum_{j \neq 0} \lambda_j = 1, \lambda_j \geq 0, j = 1, ..., n.
\]

➢ Allows performing the robustness analysis
Methodology

WRDDM (Weighted Russell Directional Distance Model):

\[
TECHCH_t^{t+1} = \frac{1}{2}\left\{\overline{D}^{t+1}(x^t_k, y^t_k, b^t_k) + \overline{D}^{t+1}(x^{t+1}_k, y^{t+1}_k, b^{t+1}_k) - \overline{D}^t(x^t_k, y^t_k, b^t_k) - \overline{D}^t(x^{t+1}_k, y^{t+1}_k, b^{t+1}_k)\right\},
\]

\[
EFFCH_t^{t+1} = \overline{D}^t(x^t_k, y^t_k, b^t_k) - \overline{D}^{t+1}(x^{t+1}_k, y^{t+1}_k, b^{t+1}_k),
\]

\[
TFP_t^{t+1} = TECHCH_t^{t+1} + EFFCH_t^{t+1}.
\]

➢ Allows performing productivity analysis (i.e., Efficiency changes and TP)
## Data

Indicators used in the DEA model.

<table>
<thead>
<tr>
<th>Designation</th>
<th>Definition</th>
<th>Unit of Measure</th>
<th>Reference</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STOCKS</strong> (controllable output)</td>
<td>Strategic oil reserves</td>
<td>Number of consumption days each country has in terms of strategic reserves</td>
<td>Nordaus (1974), Taylor and Doren (2005), Ren and Yumeng (2015), Guo et al. (2020)</td>
<td>IEA</td>
</tr>
<tr>
<td><strong>PRICE</strong> (Non-controllable Input)</td>
<td>Price of oil delivered at the border of the importing country, which includes all charges relating to insurance and freight to the destination</td>
<td>CIF Price ($/t)</td>
<td>Zhang et al. (2013)</td>
<td>UE - European Commission UK - IEA</td>
</tr>
<tr>
<td><strong>OIL IN ENERGY MIX</strong> (controllable input)</td>
<td>Weight of oil in total primary energy sources (energy mix)</td>
<td>%</td>
<td>Zeng et al. (2017)</td>
<td>Eurostat</td>
</tr>
<tr>
<td><strong>SHANNON INDEX</strong> (bad input)</td>
<td>Shannon-Wiener Index weighted by an index of political stability and absence of terrorism</td>
<td>Dimensionless</td>
<td>Chalvatzis and Loannidis (2017)</td>
<td>Imports - European Commission, Political stability index and absence of terrorism - WorldBank</td>
</tr>
</tbody>
</table>
Discussion of results

- Ranking of the countries studied, according to their geographical location:
Discussion of results

➢ Decomposition of the inefficiency of the countries studied:
Discussion of results

- Robustness analysis:
Discussion of results

➢ Productivity analysis:

Contribution to TFP from 2013 to 2014

Contribution to TFP from 2014 to 2019
Discussion of results

➢ Productivity analysis:

TFP change from 2013 to 2014 by each input/output variable

TFP change from 2014 to 2019 by each input/output variable
Conclusions

➢ Which **countries** have the highest level of vulnerability to oil supply?

➢ Slovakia, Czech Republic and Sweden on the podium of the most efficient countries in terms of security in oil supply;

➢ On the contrary, Hungary, Poland and Portugal had the worst results.
Conclusions

➢ Which factors had the greatest influence on the level of vulnerability of each country?

➢ Regarding the countries that obtained better scores, the significant influence of the **low weight of oil on the energy mix** stands out;

➢ On the contrary, the **low level of diversity of suppliers** was the predominant factor for countries that recorded the worst scores.
Conclusions

➢ Are the results obtained robust in the event of disturbances in the values of the evaluation factors used?

➢ Despite the good results obtained for Slovakia, through robustness analysis, it was possible to assess that these are not robust in the event of disturbances in the indicators used.
Conclusions

➢ Which factors contributed the most to the *productivity* gains recorded?

➢ It was possible to conclude that technological progress made the greatest contribution to increasing total productivity;

➢ The factor that made the greatest contribution to technological progress was the “SHANNON INDEX”. 
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