Carbon Efficiency of U.S. Colleges and Universities: A Nonparametric Assessment
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ABSTRACT

Under the American College and University Presidents’ Climate Commitment (ACUPCC), institutes of higher education have pledged to pursue a goal of carbon neutrality. We utilize emissions reported under the ACUPCC agreement and a nonparametric Data Envelopment Analysis (DEA) approach to evaluate the relative performance of signatories to the agreement in terms of producing their good outputs of teaching and research with the least greenhouse gas emissions (the bad outputs). We find that most signatory institutions are now producing their desirable outputs relatively efficiently in terms of carbon emissions. Our results also show that while many schools have moved closer to the efficiency frontier since signing, the frontier itself has remained quite stable.

INPUT/OUTPUT AGGREGATION: A VISUAL REPRESENTATION

We interpret this result as implying that, for many institutions, further reductions in emissions can only be made at the cost of reducing other outputs directly or reallocating resources that might be used for desirable outputs toward reducing emissions.

NB: “Efficient” in this context means that the institution could not produce higher levels of the good outputs without also having larger emissions levels; equivalently, it means that they could not achieve lower emissions without simultaneously sacrificing some of the good outputs.

4 MODELS OF INSTITUTIONAL BEHAVIOR

Signing the ACUPCC signals that the institution values not only teaching and research output but emissions reductions as well. Thus, a rational first step is for signatory institutions to identify the environmental efficiency frontier of their objective function. Using emissions reported under the ACUPCC agreement and a nonparametric Data Envelopment Analysis (DEA) approach, we evaluate the relative performance of signatories in terms of producing teaching and research with the least carbon emissions. Specifically, we consider the following four models of institutional behavior.

<table>
<thead>
<tr>
<th>MODEL</th>
<th>ASSUMPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Efficiency</td>
<td>The institution wishes to produce the maximum good outputs (teaching and research) with the least inputs, and ignores bad outputs (emissions) entirely. This may represent the situation prior to signing the ACUPCC, and provides a benchmark for evaluation.</td>
</tr>
<tr>
<td>Environmental Efficiency at Operational Efficiency</td>
<td>The institution wishes to become operationally efficient first, and then minimize emissions.</td>
</tr>
<tr>
<td>Environmental Efficiency at the Status Quo</td>
<td>The institution minimizes emissions given its current combination of inputs and good outputs.</td>
</tr>
<tr>
<td>Total Efficiency</td>
<td>Good and bad outputs are assigned equal importance. While this may be unrealistic given most institutions’ actual objectives, it provides an evaluation under perhaps an optimal scenario from a sustainability perspective.</td>
</tr>
</tbody>
</table>

SUMMARY OF MODEL RESULTS: EFFICIENCY ESTIMATION IN 2011

(NB: “Mean Efficiency” is that of the inefficient institutions)

<table>
<thead>
<tr>
<th></th>
<th>R1 rows</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>row.names</td>
<td>OpEff</td>
<td>EnvEff</td>
<td>EnvEffStatQuo</td>
<td>TotEff</td>
<td></td>
</tr>
<tr>
<td>R1 schools</td>
<td>Proportion efficient</td>
<td>0.29</td>
<td>0.97</td>
<td>0.90</td>
<td>0.61</td>
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<tr>
<td></td>
<td>Mean efficient</td>
<td>0.92</td>
<td>0.94</td>
<td>0.81</td>
<td>0.91</td>
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<td>R2 schools</td>
<td>Proportion efficient</td>
<td>0.11</td>
<td>1.00</td>
<td>0.83</td>
<td>0.67</td>
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<tr>
<td></td>
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<td>0.88</td>
<td>NaN</td>
<td>0.83</td>
<td>0.92</td>
</tr>
<tr>
<td>Lab Arts schools</td>
<td>Proportion efficient</td>
<td>0.50</td>
<td>0.95</td>
<td>0.82</td>
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</tr>
<tr>
<td></td>
<td>Mean efficient</td>
<td>0.88</td>
<td>0.98</td>
<td>0.90</td>
<td>0.90</td>
</tr>
</tbody>
</table>

SUMMARY OF MODEL RESULTS: CHANGES IN EFFICIENCY FROM 2007-2011

We also evaluate changes in environmental and technical efficiency over time. The table at the top of the next column illustrates the decomposition of a Malmquist productivity index into indices for the efficiency change (the movement toward the (moving) frontier) and the technical change (the shift in the frontier itself) for a snapshot of research schools in the data set. A number greater than 1 indicates progress, while a number less than 1 indicates regress.

CONCLUSIONS

- We find that most institutions are now producing their desirable outputs relatively efficiently in terms of carbon emissions, even if they are not operationally efficient.
- Our results also show that while many schools have moved closer to the efficiency frontier since signing, the frontier itself has remained quite stable.
- We interpret these results as implying that most of the “low-hanging fruit” with respect to emissions reductions has been picked, and that further reductions in emissions can only be made at the cost of reducing other outputs directly or reallocating resources that might be used for desirable outputs toward reducing emissions.

KEY REFERENCES


