Estimating the Rebound Effect of the US Road Freight Transport

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**Background**

- The United States (US) road freight sector has continued to expand over the past decades.
- Road freight activities have resulted in increased energy consumption and greenhouse gases (GHG) emissions by product.
- Policies i.e., the Energy Independence and Security Act in 2007 and the Clean Air Act in 2012 are implemented.
- However, the effects of the efforts to lower energy consumption and GHG emissions are unclear due to the Rebound Effect.
- Improvement in technology and efficiency for energy service may lower the variability of carriers’ responses to price changes.
- The 1980-2016 time series data used for analysis are generated from a variety of public domain resources.
- D1 dummy variable captures the potential influence of the Clean Air Act 2012 and D2 accounts for the impact of ultra-low sulfur diesel (ULSD) imposition in freight transport since 2006.
- Manufacturing share of GDP is considered to account for the potential decoupling of freight from GDP.

**Objectives**

- To identify the rebound effect for US road freight transport given government policies that aimed at reducing energy consumption and GHGs emissions.
- To complement the related literature by considering the asymmetric energy price responses in the estimate of the rebound effects.

**Method and Data**

- Eight fuel cost models are used considering their static and dynamic versions with different combinations of some selected variables.
- Two-stage least squares (2SLS) log-log regressions with heteroskedastic and autocorrelation consistent (HAC) robust corrections are adopted.
- Asymmetric energy price responses (Prec: Price Recovery, Pdec: Price Decrease) are decomposed following Gately & Huntington (2002).
- Robust Data envelopment analysis (DEA) is applied to determine the annual rebound effect in the US road freight sector.
- The 1980-2016 time series data used for analysis are generated from a variety of public domain resources.
- D1 dummy variable captures the potential influence of the Clean Air Act 2012 and D2 accounts for the impact of ultra-low sulfur diesel (ULSD) imposition in freight transport since 2006.
- Manufacturing share of GDP is considered to account for the potential decoupling of freight from GDP.

**Result and Discussion**

- Table 1 shows the avg. rebound effect for the static models is 8.8%, whereas for dynamic models is 6.6%.
- A 1% increase in fuel efficiency decreases fuel consumption by 0.88% and 0.66% in short-run and long-run, respectively.
- The asymmetric rebound effects: price recovery = 17% and 27.5% decrease, price decrease = 8% and 2.9% increase in short-run and long-run.
- The overall results also suggest that reliance upon only static models could lead to larger price elasticities.

**Conclusion**

- Our estimated rebound effects imply that a proportion of the potential energy and carbon savings from the improved efficiency in US road freight has been partially offset by increased freight activity (more TKM).
- Rebound effects from asymmetric price responses suggest that freight carriers use less energy with a price increase, and vice-versa.
- Rebound effect proves to be a deterrent to the energy efficiency policies’ goals.
- A systematic cap-and-trade scheme, a sector-specific energy or environmental tax, e.g., carbon tax, could serve as an alternative strategy in mitigating the rebound effect.

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**TABLE 1 Overall Estimated Results**

<table>
<thead>
<tr>
<th>Models</th>
<th>ln (GDP)</th>
<th>ln (S/Fuel TKM)</th>
<th>ln (Lag Term)</th>
<th>ln (MS)</th>
<th>1</th>
<th>2</th>
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<tbody>
<tr>
<td>Static 1</td>
<td>0.52***</td>
<td>-0.14***</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Static 2</td>
<td>0.58***</td>
<td>-0.06***</td>
<td>--</td>
<td>--</td>
<td>-0.23***</td>
<td>--</td>
</tr>
<tr>
<td>Static 3</td>
<td>0.79***</td>
<td>-0.12***</td>
<td>0.37***</td>
<td>-0.22***</td>
<td>--</td>
<td>8.8% (17% decrease)</td>
</tr>
<tr>
<td>Static 4</td>
<td>0.75***</td>
<td>-0.08***</td>
<td>--</td>
<td>0.31***</td>
<td>-0.22***</td>
<td>-0.03</td>
</tr>
<tr>
<td>Dyna. 1</td>
<td>0.12</td>
<td>-0.06</td>
<td>0.24***</td>
<td>--</td>
<td>--</td>
<td>7.30% (8% increase)</td>
</tr>
<tr>
<td>Dyna. 2</td>
<td>0.43***</td>
<td>-0.05***</td>
<td>0.27***</td>
<td>--</td>
<td>-0.18***</td>
<td>--</td>
</tr>
<tr>
<td>Dyna. 3</td>
<td>0.62***</td>
<td>-0.08***</td>
<td>0.22</td>
<td>0.31***</td>
<td>-0.18***</td>
<td>--</td>
</tr>
<tr>
<td>Dyna. 4</td>
<td>0.65***</td>
<td>-0.05***</td>
<td>0.18**</td>
<td>0.28***</td>
<td>-0.19***</td>
<td>-0.04</td>
</tr>
</tbody>
</table>

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**Figure 1: Graphical Representation of the Rebound Effect**

**Figure 2: Annual Rebound Effect of the US Road Freight Transport from 1980 to 2016**

- The estimated annual rebound effect is presented in Figure 2. It shows high variability with a boost in the later years (21% - 26% range).
- It could be potentially related to the Clean Air Act 2012 that requires higher fuel efficiency vehicles for freight.
- The variability in the rebound effect over time could also be linked to several factors such as commodity types, shipping distance, and modal share.