Adoption of Autonomous Trucks by Freight Organizations

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Introduction

- CAVs (Connected Autonomous Vehicles) have the potential to revolutionize transportation, but there is insufficient research on the question of demand for CAVs within freight transportation.
- Accurate predictions of market penetration rates will be useful for both policymakers and manufacturers.
- Diffusion of Innovations (DiI) theory is a promising method for predicting the adoption rate of CAVs in freight transportation.
- Individuals and organizations adopt innovations at different times based on various factors, including resources, incentive, and innate innovativeness.
- As an innovation is adopted, its attractiveness increases due to social pressures, prompting further adoption.
- Organizations exhibit more social behavior, but informal communication networks exist within industries, and so DoI is suitable for organizations.

Methodology

- The most common model used to describe DiI is the Bass model.
- Bass estimates an innovation’s adoption rate with two variable forces: one that increases when others adopt, and one that is independent of the previous adopters.
- Dependent variable: Coefficient of Imitation (CoI), accounts for actions of an adopter’s peers.
- Independent variable: Coefficient of Innovation (CoI), accounts for personal innovativeness and influence from advertising or marketing.
- Early adopters exclusively adopt due to CoI forces.
- The CoI is very weak when adoption starts, but grows in strength as individuals or organizations start to adopt.
- One of the chief difficulties in using the Bass model equations for forecasting purposes is determining the values of CoI and CoM for the new innovation.
- CoI and CoM are traditionally calculated using regression methods after the innovation has been fully adopted.
- These values are well-documented for individually adopted innovations, but there are few studies providing data for organizational adoption parameters.
- Organizational adoption data is therefore gathered from multiple sources, and Bass parameters for a few organizational innovations are calculated using non-linear regression.
- Once these parameters are identified, a reasonable range of values for the Bass model parameters is estimated for CAV adoption.
- Organizations are highly heterogeneous, and so they have different values for CoI and CoM depending on their size and spheres of influence.
- Organizations with more employees and larger spheres of influence will possess higher parameter values.

Data

- Data on freight, medical, production, and commercial innovations is collected from multiple sources.
- The data is used to estimate the Bass model parameters of organizational adoption of CAVs.

Sample of Collected Data

<table>
<thead>
<tr>
<th>Innovation</th>
<th>CoI</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trailer Aerodynamics</td>
<td>0.004305</td>
<td>NACFE (2015)</td>
</tr>
<tr>
<td>Idle Reduction</td>
<td>0.021252</td>
<td>NACFE (2015)</td>
</tr>
<tr>
<td>Tires/Wheels</td>
<td>0.003752</td>
<td>NACFE (2015)</td>
</tr>
<tr>
<td>Mammography</td>
<td>0.028156</td>
<td>Van den Bulte &amp; Lilien (1997)</td>
</tr>
<tr>
<td>CT Scanner</td>
<td>0.020815</td>
<td>Van den Bulte &amp; Lilien (1997)</td>
</tr>
<tr>
<td>Oxygen Steel Furnace</td>
<td>0.0091</td>
<td>Sultan et al. (1990)</td>
</tr>
<tr>
<td>Retail Scanners</td>
<td>0.039</td>
<td>Sultan et al. (1990)</td>
</tr>
<tr>
<td>Internet</td>
<td>0.006673</td>
<td>Lavasani et al. (2016)</td>
</tr>
<tr>
<td>Electric Vehicles</td>
<td>0.00091</td>
<td>Massiani and Goh (2015)</td>
</tr>
</tbody>
</table>

Organizational Ability to Innovate by Size and Spheres of Influence

Results

- The prediction adoption curve for CAVs by freight organizations shows that adoption is likely to be very slow compared to other innovations.
- This is reasonable due to the revolutionary nature of CAVs and the tendency of the freight industry to adopt innovations very slowly.

Projected Market Penetration of CAVs by Freight Organizations

Sensitivity Analysis

- R² values for the organizational parameters average 0.894, with the lowest value being 0.789.
- The CoI and CoM values for organizational adoption of CAVs are estimated to be 0.005 to 0.01 for CoI and 0.08 to 0.1 for CoM.
- Parameter values are distributed to 1,519 organizations within Tennessee based on their fleet size and spheres of influence.
- Fleet size is estimated based on the average annual revenue of the organization and the yearly revenue generated from operating a single truck.

Organizational Adoption Varying Parameter Values

- Varying the CoI value has a much more substantial impact on the adoption rate than the CoM parameter.

Acknowledgements

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Sample of Market Penetration Data for Organizational Innovations

Organizations within Shelby County by Total Fleet Size

Base Scenario 1 Lower Unchanged
Scenario 2 Lower Lower
Scenario 3 Unchanged Lower
Scenario 4 Higher Unchanged
Scenario 5 Higher Higher
Scenario 6 Unchanged Higher