Adoption of Autonomous Trucks by Freight Organizations

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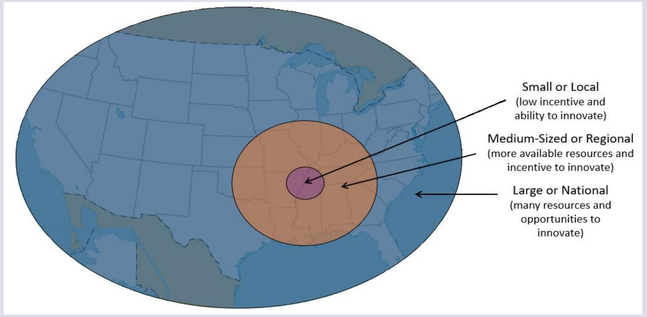
Introduction

- 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 (DoI) 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 less social behavior, but informal communication networks exist within industries, and so DoI is suitable for organizations.

Methodology

- The most common model used to describe DoI 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 (CoM), accounts for actions of an adopter's peers.
  - Independent variable: Coefficient of Innovation (CoN), accounts for personal innovativeness and influence from advertising or marketing.
- Early adopters exclusively adopt due to CoN forces.
- The CoM 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 CoN and CoM for the new innovation.
- CoN 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 several 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 CoN and CoM depending on their size and spheres of influence.
- Organizations with more employees and larger spheres of influence will possess higher parameter values.



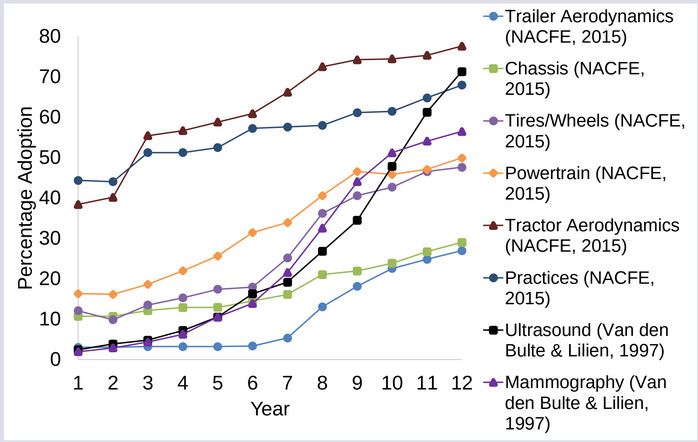
Organizational Ability to Innovate by Size and Spheres of Influence

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

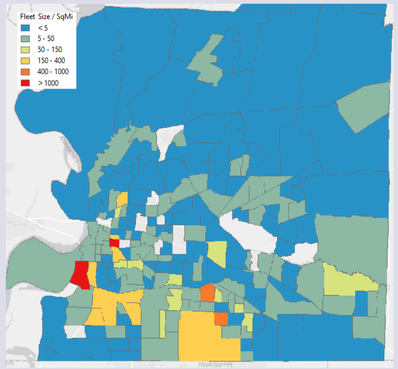
Sample of Collected Data

Innovation	CoN	CoM	Source
Trailer Aerodynamics	0.004306	0.192674	NACFE (2015)
Idle Reduction	0.012152	0.098373	NACFE (2015)
Tires/Wheels	0.003752	0.160528	NACFE (2015)
Mammography	0.028156	0.185773	Van den Bulte & Lilien (1997)
CT Scanner	0.028815	0.041372	Van den Bulte & Lilien (1997)
Oxygen Steel Furnace	0.019	0.4007	Sultan et al. (1990)
Retail Scanners	0.039	0.5725	Sultan et al. (1990)
Internet	0.006673	0.390604	Lavasani et al. (2016)
Electric Vehicles	0.0019	1.2513	Massiani and Gohs (2015)



Sample of Market Penetration Data for Organizational Innovations

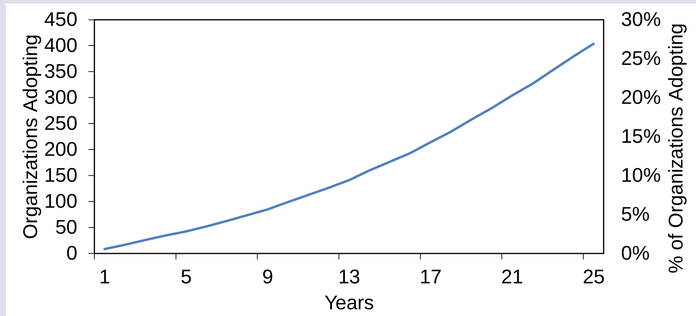
- R^2 values for the organizational parameters average 0.894, with the lowest value being 0.789.
- The CoN and CoM values for organizational adoption of CAVs are estimated to be 0.005 to 0.01 for CoN and 0.08 to 0.1 for CoM.
- Parameter values are distributed to 1,519 organizations within Tennessee based 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.



Organizations within Shelby County by Total Fleet Size

Results

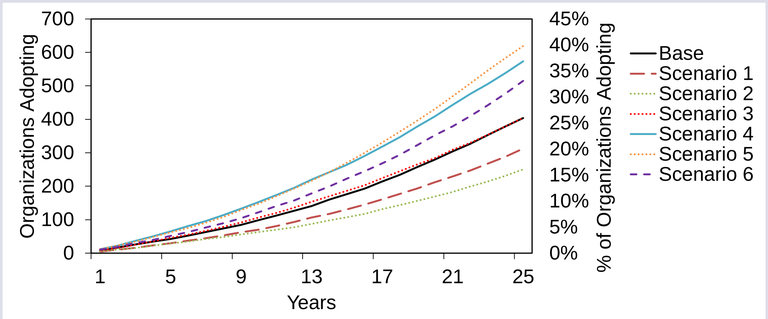
- The prediction adoption curve for CAVs by freight organizations shows that adoption is likely to be very slow compared to other innovations.
- This is reasonable due to the revolutionary nature of CAVs and the tendency of the freight industry to adopt innovations very slowly



Projected Market Penetration of CAVs by Freight Organizations

Sensitivity Analysis

Scenario	CoN	CoM
Scenario 1	Lower	Unchanged
Scenario 2	Lower	Lower
Scenario 3	Unchanged	Lower
Scenario 4	Higher	Unchanged
Scenario 5	Higher	Higher
Scenario 6	Unchanged	Higher



Organizational Adoption Varying Parameter Values

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

Acknowledgements

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