DTU Transport
Department of Transport

Electromobility+

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Procurement intentions of electric vehicles in the commercial sector: a model based on the theory of planned behaviour

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SELECT
Suitable ELEctromobility
for Commercial Transport

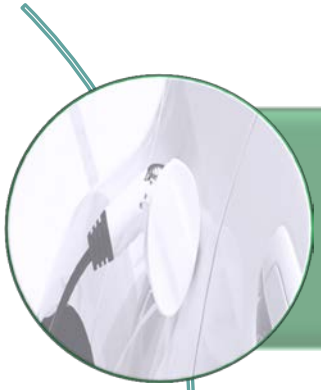
Introduction

- **ECVs can be a problem in the city because of** (Feng and Figliozzi, 2012):
  - The high share of sales of light vehicles
  - The fast-growing share of commercial vehicles
  - The high travel expenses compared to the use of the household
  - The pollutant emissions: sulfur oxides, particulate matter, and nitrogen
- **Commercial vehicle fleets for small and medium-sized enterprises are considered good candidates for early adoption of ECVs due** (Nesbitt and Sperling, 2001):
  - Their autocratic rule options
  - High openness to innovative changes, risk provisions and government encouragement

Introduction

- **Previous research focused on the factors underlying the market penetration of EVs in households.**
- **Only a few recent studies focused on firms:**
  - Aggregated analysis to understand the proportion of market penetration at the national level as a function of financial incentives, infrastructure and production facilities (Sierzchula et al., 2014)
  - Analysis of the usage patterns of 174 electric cars, and the driving experience in terms of user satisfaction and confidence (Wikström et al., (2014)
  - A qualitative study of 14 firms to understand the effect of the willingness to test of new technologies, national funding and improving the public image of the firm as motivators for the purchase of ECVs(Sierzchula, 2014)

Research objectives

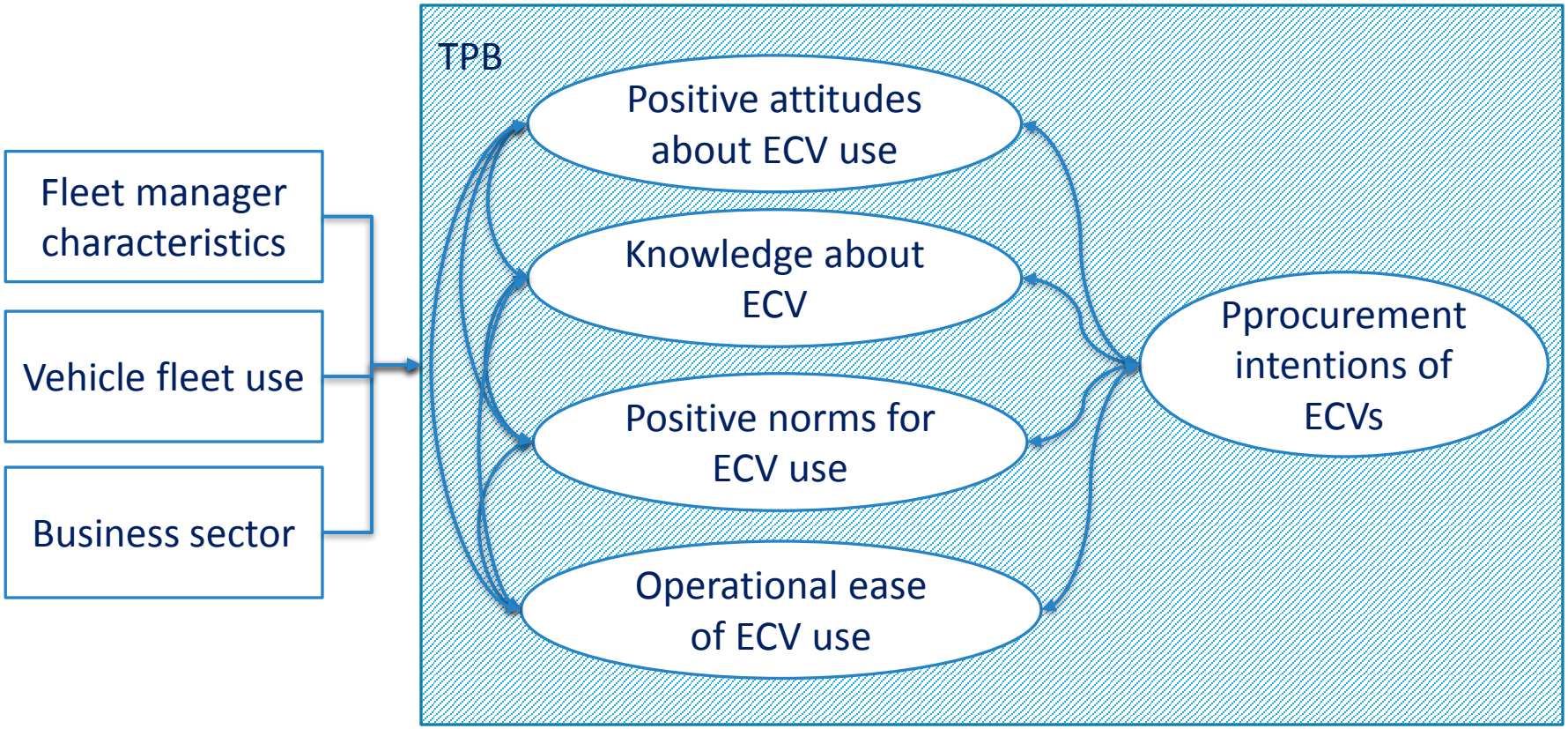


To propose a behavioral framework for the procurement intentions of ECVs at the firm level

To estimate a statistical model on a large data sample from firms to validate behavioral frame

Behavioral framework

- The model is based on the "Theory of Planned Behavior" (Ajzen, 1991):



Estimated model

- The model was estimated using **"structural equation model"**
  - Measurement equations:

$$I_{rn} = Z^{*}_{ln}\alpha_r + \upsilon_{rn} \quad and \quad \upsilon_n \sim N\left(0, \Sigma_{\upsilon}\right) \quad for\ r = 1, \ldots, R$$

  - The structural equations linking the latent attitudinal constructs to fleet manager and firm characteristics:

$$Z^{*}_{ln} = FM_{ln}\beta_l + FI_{\ln} + \omega_{ln} \quad and \quad \omega_n \sim N\left(0, \Sigma_{\omega}\right) \quad for\ l = 1, \ldots, L$$

  - The structural equations linking the latent attitudinal constructs to ECV procurement intentions:

$$PI^{*}_{in} = Z^{*}_{ln}\beta_z + \xi_{in} \quad and \quad \xi_n \sim N\left(0, \Sigma_{\xi}\right) \quad for\ i = 1, \ldots, I$$

- The model is estimated using Maximum Likelihood with Huber-White covariance adjustment for calculating the standard deviation
- **Goodness-of-fit** is calculated by comparative Fit Index (CFI), the standardized root mean residual (SRMR) and the Root Mean Square of Approximation (RMSEA)

Data collection

- Web-based tailor-made questionnaire in German and Danish
- Questions related to:
  - ✓ Company size and number of employees
  - ✓ Industrial sector
  - ✓ Fleet size and use pattern
  - ✓ Purchase intentions of ECVs
  - ✓ Personal attitude of fleet managers towards ECVs
  - ✓ Interest of the fleet managers towards ECVs,
  - ✓ Subjective norms among companies in the sector
  - ✓ Incentives for the use of ECVs.

Data collection

- The survey was administered in Denmark, Germany and Austria during July to October 2014 to a representative sample of 65,000.
- 1,443 complete responses, with a response rate ranging between 1.0-3.4%.
- Firm location:
  - Austria: 14.3%
  - Denmark: 46.9%
  - Germany: 38.8%
- The sectors with the highest participation rates are health services (25.2%), retail (16.1%), Transport and storage (12.8%), and administration and support services (16.0%).

Data collection

What are the characteristics of tours in your area of responsability?

A tour is a vehicle movement from leaving the company or residential site until returning to the company or residential site. A tour can contain several stops (e.g. for delivering a parcel or visiting a patient). One vehicle can be used for several tours per day, e.g. when returning to the company site between two runs.

Mean number of tours per day	
Mean total tour duration in hours	
Mean number of pick-up/drop-off/rest stops per tour	

We are interested in the length of the tours (from leaving the company or residential site until returning to company or residential site).

Please distribute 100% of all tours relative to the following groups of tour lengths (Input without %-sign):

Tours up to 49 km length	
Tours 50-99 km length	
Tours 100-149 km length	
Tours 150-199 km length	
Tours 200-299 km length	
Tours 300-399 km length	
Tours 400+ km length	

Data indsamling

Has your company* already considered the procurement of an electric vehicle?
(* or yourself in case you are a self-employed driver)

- ○ No, we are not considering electric vehicles
- ○ We are not considering electric vehicles at the moment, but maybe in the future
- ○ We are at the preliminary stage or thinking about using electric vehicles
- ○ We are at advanced stage or thinking about using electric vehicles
- ○ We are preparing a bid for procurement of electric vehicles
- ○ Yes, We have already procured at least one electric vehicles
- ○ Don't know

Data collection

We are interested in your general view of electric vehicles. Please state your level of agreement with the following questions.

	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree	Don't know
I am aware of the current developments in the field of electric mobility	○	○	○	○	○	○
Electric vehicles are generally cool and pleasent to drive	○	○	○	○	○	○
Electric vehicles are suitable to take over transport tasks in my commercial sector	○	○	○	○	○	○
I am updated with the current capabilities (i.e., range, speed) of electric vehicles	○	○	○	○	○	○
Electric vehicles are a temporary trend	○	○	○	○	○	○
Electric vehicles are beneficial in the long-term for cost saving in my sector	○	○	○	○	○	○
I am personally interested in electric mobility	○	○	○	○	○	○
Electric vehicles are beneficial in the long-term for protecting the environment	○	○	○	○	○	○
My company is interested in electric mobility	○	○	○	○	○	○

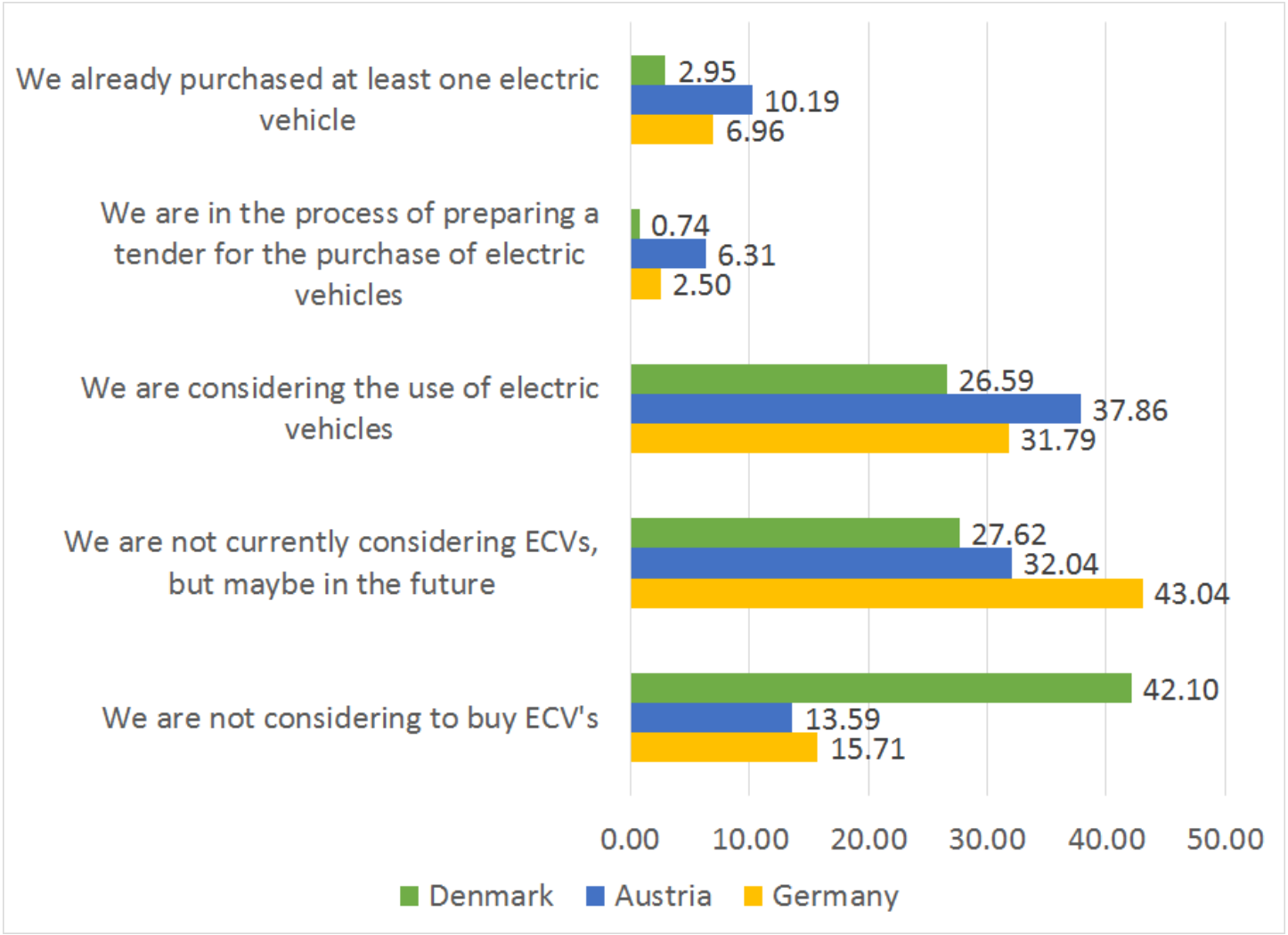
Data collection

How do the companies in your geographical area and industry sector perceive moving towards electro-mobility.
Please state your degree of agreement with the following statements:

	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree	Don't know
Some companies in my industrial sector are considering electric vehicles	○	○	○	○	○	○
Some companies in my geographical area are considering electric vehicles	○	○	○	○	○	○
Some fleet managers that I personally know are considering electric vehicles	○	○	○	○	○	○
The consideration of electric vehicles is viewed positively in my industrial sector	○	○	○	○	○	○
The consideration of electric vehicles is viewed positively in my geographical area	○	○	○	○	○	○
Professionals in my industrial sector talk about moving towards electro-mobility in the future	○	○	○	○	○	○
Professionals in my industrial sector talk about moving towards electro-mobility in the future	○	○	○	○	○	○
Companies moving towards electro-mobility have a good public image	○	○	○	○	○	○
Policy makers expect companies in my industrial sector to move towards electro-mobility	○	○	○	○	○	○
Policy makers expect companies in my geographical region to move towards electro-mobility	○	○	○	○	○	○

Results

- The distribution of firms' ECV procurement intentions (1,443 responses)



Results

- Factor analysis:

Description	Positive attitudes	Sector specific norms	Ppersonal knowledge on ECVs	Ease of use of ECVs
I think that electric vehicles are a benefit to the environment in the long term	**0.666**	0.120	0.109	0.080
I believe that electric vehicles will eventually result in cost savings within my industry	**0.601**	0.238	0.113	0.180
It is advantageous to use electric vehicles because of the low energy costs.	**0.594**	0.171	0.003	0.036
I believe that electric vehicles are only a temporary phenomenon (R)	**0.572**	0.116	0.085	0.146
I am interested in electric vehicles	**0.554**	0.218	0.356	0.232
Companies which use electric vehicles, have a good public image	**0.462**	0.333	0.081	0.115
I think that electric vehicles are generally cool and pleasant to drive	**0.431**	0.175	0.323	0.304
Free parking would make it easier to use electric vehicles	**0.395**	0.100	0.001	-0.206
The range of electric vehicles is sufficient for most daily trips	**0.312**	0.180	0.035	0.168
Business people in my industry are talking about switching to electric vehicles in the future	0.218	**0.759**	0.027	0.118
Companies within my industry are considering electric vehicles	0.180	**0.708**	0.071	0.102
In my industry electric vehicles are viewed positively	0.292	**0.666**	0.110	0.134
I know fleet managers who are considering electric vehicles	0.135	**0.589**	0.086	0.069
Policy makers expect the companies in my industry to use electric vehicles	0.128	**0.481**	0.020	-0.015
I am updated regarding electric vehicles technical properties, eg. range and speed	0.064	0.078	**0.826**	0.179
I follow the development of electric vehicles	0.179	0.118	**0.808**	0.027
There is not a service network for electric vehicles in our area (R)	0.042	0.142	0.029	**0.603**
Electric vehicles are not sufficiently reliable (R)	0.188	0.032	0.165	**0.527**
The purchase price for electric vehicles is too high (R)	0.031	0.109	0.003	**0.441**

Results

RMSEA = 0.037
CFI = 0.931

- Factor: positive norms towards electric commercial vehicles

Element	Beskrivelse	Estimate	t-stat	p-value
MALE	Male	-0.245	-3.64	0.000
YAGE	60 years old or younger	0.459	3.19	0.001
BSA	Sector: agriculture, forestry, and fishing	-0.568	-3.93	0.000
BSH	Sector: transport and parcel delivery	-0.236	-3.02	0.003
BSO	Sector: public administration and defense, social Security	-0.818	-3.08	0.002
BSR	Sector: culture, recreation and sport	0.431	1.81	0.071
BSW	Sector: technology	0.309	1.74	0.083
VEL	Electric vehicles in the vehilce fleet of the firm	0.040	1.73	0.084
V12P	Atrucks over 12 tons the vehicle fleet of the firm	-0.007	-2.56	0.011
TDUR	Round tour duration with stops (average in hours)	-0.009	-2.15	0.032
STPL20	Less than 20% of the vehicle fleet with 30 minute stops	-0.158	-3.09	0.002

Results

- Factor: sector-specific positive norms towards electric commercial vehicles

Element	Beskrivelse	Estimate	t-stat	p-value
AGE5160	51-60 years old	0.142	2.81	0.005
DK	Firm located in Denmark	-0.190	-2.70	0.007
EDULO	Education:elemenatry school	-0.208	-2.03	0.043
EXP34	3-4 years of experience with vehicle fleet management and procurement	0.203	2.19	0.029
EXP1115	11-15 years of experience with vehicle fleet management and procurement	0.109	1.55	0.120
BSA	Sector: agriculture, forestry and fishing	-1.044	-6.20	0.000
BSN	Sector: administrative and support services	-0.204	-2.91	0.004
BSO	Sector: public administration and defense, social Security	-0.411	-1.88	0.060
BSW	Secor: technology	0.532	3.70	0.000
COV	Firm's vehicle fleet size of owned vehicles	0.003	3.21	0.001
TDUR	Round tour duration with stops (average in hours)	-0.007	-2.01	0.044
STPL20	Less than 20% of the vehicle fleet with 30 minute stops	-0.081	-1.67	0.095
TUR150P	Roundtour length of 150 km or more	-0.004	-4.43	0.000

Results

- Factor: personal knowledge of electric commercial vehicles

Element	Beskrivelse	Estimate	t-stat	p-value
MALE	Male	-0.619	-7.64	0.000
COV	firm's vehicle fleet size of owned vehicles	0.003	2.43	0.015
AGE5160	51-60 years old	0.126	1.94	0.052
EXPL2	1-2 years of experience with vehicle fleet management and procurement	-0.236	-3.05	0.002
BSA	Sector: agriculture, forestry, and fishing	-0.347	-2.13	0.034
BSC	Sector: manufacturing	0.280	1.49	0.136
BSD	Sector: energy including electricity, gas and steam	0.758	2.19	0.028
BSJ	Sector: Information og communication	0.401	2.05	0.040
BSO	Sector: public administration and defense, social Security	-0.979	-3.36	0.001
BSP	Sector: education	0.380	1.73	0.083
BSR	Sector: culture, recreation and sport	0.440	1.58	0.115
BSW	Sector: technology	0.748	4.03	0.000
TUR150P	Roundtour length of 150 km or more	-0.002	-1.78	0.075

Results

- Factor: operational ease of electric commercial vehicles

Element	Beskrivelse	Estimate	t-stat	p-value
MALE	Male	-0.169	-4.02	0.000
AGE3160	31-60 years old	0.128	2.47	0.013
BSA	Sector: agriculture, forestry, and fishing	-0.166	-1.77	0.076
BSE	Sector: water supply, sewerage, soil and groundwater	-0.488	-1.39	0.164
BSN	Sector: administrative and support service	-0.133	-2.81	0.005
DE	The firm is located in Germany	-0.179	-3.27	0.001
DK	The firm is located in Denmark	-0.522	-8.09	0.000
VEL	The firm has electric vehicles	0.062	5.83	0.000
VHY	The firm has hybrid vehicles	-0.051	-3.14	0.002
EXTCON	The firm uses external consultant for vehicle procurement	0.065	1.32	0.186
STPL20	Less than 20% of the vehicle fleet with 30 minute stops	-0.108	-3.33	0.001
TUR150P	Roundtour length of 150 km or more	-0.002	-3.25	0.001

Results

- The effect of the factors on ECV procurement intentions:

Faktor	Beskrivelse	Estimate	t-stat	p-value
F1	Positive attitudes towards electric vehicles	0.544	29.06	0.000
F2	Sector-specific positive norms towards electric vehicles	0.326	16.38	0.000
F3	Percieved personal knowledge on electric vehicles	0.397	15.58	0.000
F4	Operational ease of use of electric vehicles	0.163	8.74	0.000
DE	The firm is located in Germany	-0.248	-2.41	0.016
DK	The firm is located in Denmark	-0.769	-8.25	0.000

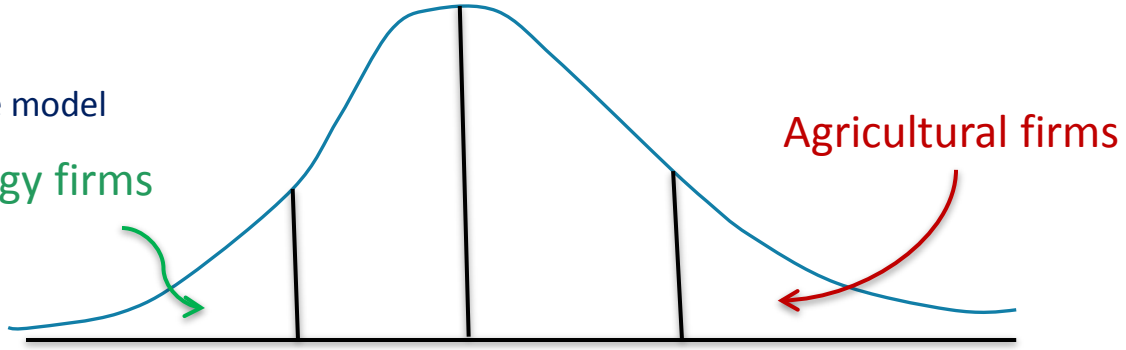
Conclusions

- The results show that firms' purchase intentions of ECVs have a positive and significant relationship with personal and interpersonal factors.
- The factors are significantly related to :
  - Fleet manager characteristics (e.g., gender, age, experience),
  - Firm attributes (e.g., sector, use of external consultants),
  - The firm's vehicle fleet (number of vehicles, use of ECVs or hybrid vehicles),
  - Vehicle use patterns (e.g., tour duration, length and number of stops).
- Vehicle range is only a barrier, when the daily driving mileage is greater than 150 km. Another challenge is the proportion of vehicles make a 30 minutes stop during their daily tours.

Conclusions

- Experience with electric vehicles has a positive correlation with positive attitudes and perceived operational ease of use of electric cars. Experience with hybrid vehicles has a negative correlation with perceived operational ease of use of electric cars.
- Companies in the technology sector have a positive correlation with positive attitudes, norms, and personal knowledge towards ECVs. Agricultural companies a have negative correlation with positive attitudes and norms, personal knowledge and operational ease of electric vehicles.

Moore's technology life-cycle model



Thank you for your attention!

Questions and comments are welcome!