Investigating the Potential for Clustering of Electric Vehicles

Daire McCoy [1,2] (daire.mccoy@esri.ie), **Dr Eleanor Denny** [2] (dennye@tcd.ie),
Dr Seán Lyons (sean.lyons@esri.ie) [1]

[1]Economic and Social Research Institute [2] Department of Economics, Trinity College Dublin

Introduction

- Electric Vehicles (EVs) are seen as crucial in decarbonising transport. The Irish government has set a goal of electrifying 10% of the transport fleet by 2020.
- High penetrations of EVs could put pressure on peak units and reduce the life of distribution network assets.
- This problem could be magnified in certain areas if we observe spatial dependencies in behaviour – the "neighbour effect". Even if there is low national penetration, this could be concentrated in relatively few places. We may even observe clusters in areas adjacent to others with very low penetrations.
- It is possible to infer the likely spatial distribution of EVs. This will be based on the characteristics of previous early adopters of hybrid and electric vehicles.

Table 1: Hybrid and Battery Electric Vehicle Purchaser Characteristics	
Age (25-59)	Location (Urban)
Sex (Male)	Vehicle ownership (2 or more)
Income (High)	Home ownership
Education (Degree and higher)	Technically Sophisticated

Cluster Analysis

- Cluster analysis of **Census 2011 Small Area Population Statistics (SAPS)** can identify areas with high proportions of these potential early adopters.
- SAPS are Census layers of 80-100 households; "The most detailed layer of population data ever available for Ireland" (CSO 2011).

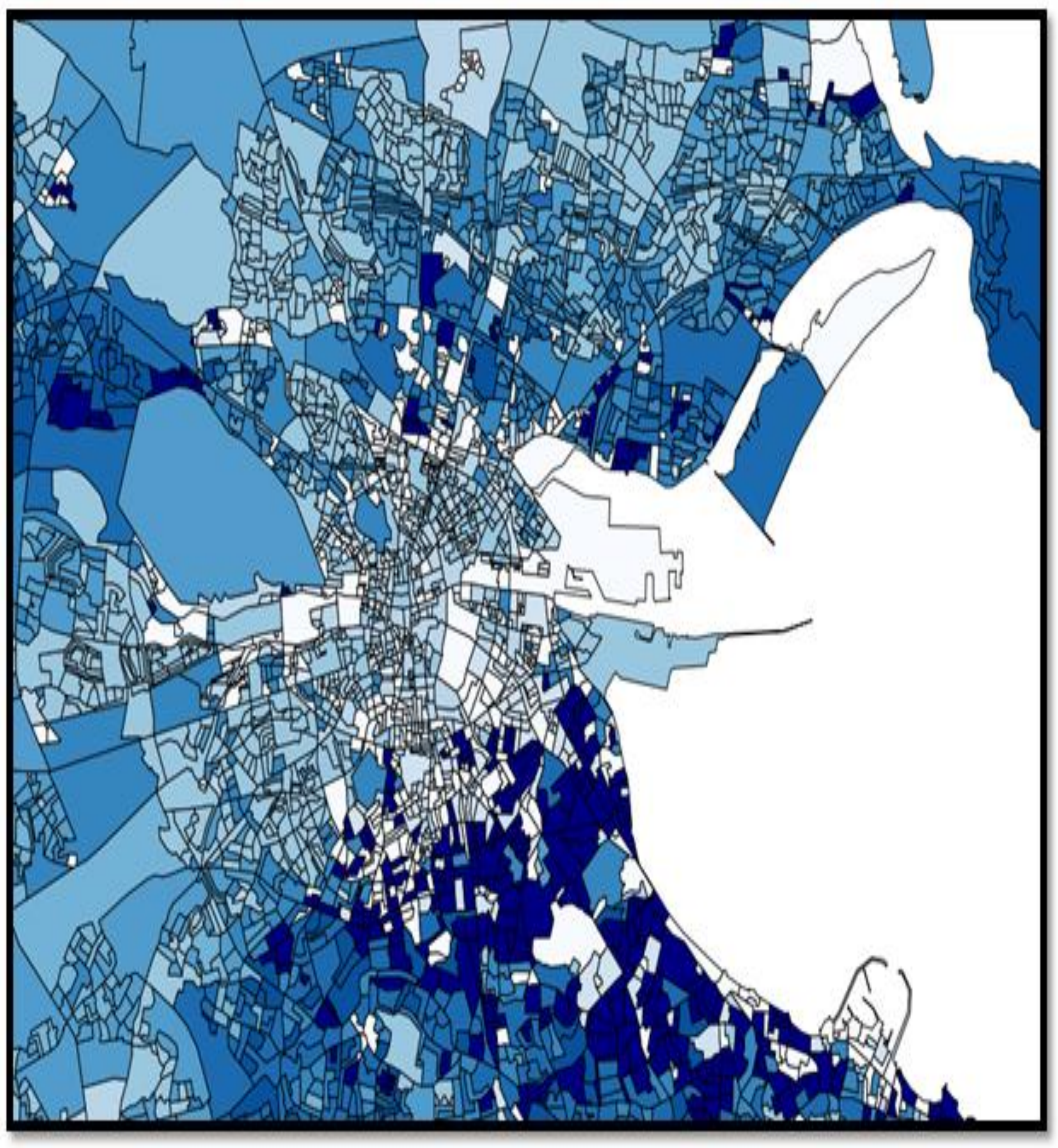

Fig.1 Spatial distribution of likely adopters in Dublin City. Dark blue areas have a high proportion of potential adopters. Source Census 2011 data

Agent Based Microsimulation

- Once we have identified the relevant areas, we can run simulations to determine the degree of clustering.
- To select the agents we use a sampling algorithm to pick households from the **CER Smart Metering Customer Behaviour Trial** that best match the relevant SAPS.
- We use a threshold model of innovation diffusion to simulate adoption profiles for various SAPS areas. Agents adopt when their utility (U) exceeds a certain threshold (T); $U_i(t) \geq T_i(t)$
- Agent's utility is determined by a weighting of personal preferences (*p*), peer effects (*g*) and social norms (*s*); $U_i(t) = \alpha_i p_i + \beta_i g_i(t) + \gamma_i s(t)$
- where $\alpha_i + \beta_i + \gamma_i = 1$

Table 2: Parameters and data requirements		
Model Parameter	**Explanation**	**Data Source**
Threshold (θ)	Household barriers to adopting EVs (Tenure type, house type, location, charging infrastructure etc)	Smart Metering, SAPS, ESB E-car
Personal benefit (p)	Likely economic and personal benefit to adopting (Observed adoption of energy saving technology, environmental attitudes, income)	Smart Metering, SAPS
Relative weighting of preferences (α,β,γ)	Determines how individualistic agents are	Experiment with different combinations
Social Network properties (g,s)	Role of peer groups in agent decision making	Literature on social networks - Experiment with different combinations

Results

- Initial results using SAPS in Dublin have identified areas where we might expect higher penetrations of EVs. Mainly to the south of the city and along the coastline, but pockets of potential adopters appear across the city – coloured dark blue in Fig. 1.
- Simulations will explore the likelihood of clusters forming in these areas.

Table 3: Census Small Area Proportions									
Electoral District	Population	Bungalow/ detached	Home Owner	Employed	AB Social class	Degree Educated or higher	Drive a car to work	Own 2 or more cars	Have Broadband
Blackrock-Carysfort	135	100%	80%	64%	55%	72%	37%	67%	91%
Castleknock-Knockmaroon	128	65%	64%	72%	51%	62%	54%	63%	86%

Overall Objectives

- Generate spatially representative adoption profiles for electric vehicles.
- Simulate where clusters might occur and generate probability distributions for their density.
- Inform future distribution network upgrades.

Acknowledgement

This work was conducted in the Department of Economics, Trinity College Dublin and the Economic and Social Research Institute, Dublin. It is undertaken in conjunction with the Electricity Research Centre, University College Dublin, Ireland, which is supported by Bord Gáis Energy, Bord na Móna Energy, the Commission for Energy Regulation, Cylon Controls, EirGrid, Electric Ireland, the Electric Power Research Institute (EPRI) (US), Energia, ESB International, ESB Networks, Gaelectric, Intel, SSE Renewables, and United Technologies Research Centre, Ireland (UTRCI).

Daire McCoy is supported by Science Foundation Ireland under Grant Number SFI/09/SRC/E1780.