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Predicting whole-system consumer behaviour in online grocery delivery through data fusion of survey data with geographic socio-demographic classifications

At present, there is an urgent need to reduce global greenhouse gas emissions, and transport now accounts for more of the UK's greenhouse gas emissions than any other industry sector. Online home delivery of supermarket groceries is a growth area, and such operations account for an increasing proportion of the UK's transport emissions footprint. Online home delivery operations are implemented by individual supermarket fleets with no horizontal co-ordination involved; as a result, daily loading and routing patterns for delivery vans are often highly sub-optimal when viewed as a system, even if each individual retailer's fleet is optimised to minimise its own costs. Therefore, significant carbon and cost savings can be identified by building simulations that operate at a whole-system level and using them to appraise the emissions reduction potential of horizontal collaboration and/or co-ordination activities.

Drop densities for every operation need to be estimated well enough to show where inefficient operational practices between retailers are most likely to occur: this requires simulation of likely order patterns and drop densities according to the profile of each retailer included in such an analysis. In general, achieving this through obtaining historic order data from every UK supermarket retailer will be a prohibitively difficult task. We address whether there are alternative ways to simulate such an overall picture in the absence of fully furnished order data from every retailer.

Our approach tries to ascertain if overall whole system drop density estimates can instead be approximated through use of a consumer survey designed to establish patterns of behaviour in online home delivery activities. The survey was specifically commissioned for the Centre for Sustainable Road Freight (SRF), with each of over 2000 respondents providing a profile of their shopping habits with respect to a range of specific UK supermarkets. In addition, most survey respondents provided location data that was sufficiently accurate to cross-reference against the map of socio-economic categories compiled by the UK's Office for National Statistics (ONS) following the 2011 Census.

We use the survey responses to identify sub-populations of affinity to each of six different UK supermarkets offering online home delivery services, by filtering to respondents who claim to use such a supermarket or its online services at least once per month. This sub-population admits a distribution of socio-economic category memberships that can be compared to that of all respondents: that is, affinity to a supermarket may be correlated with higher than expected numbers in a collection of social groups. We then use Bayes' theorem to infer the solution to the inverse problem: how to predict supermarket affinity given membership of a socio-economic group. Importantly, the process can be repeated with all the major UK supermarkets included in the study, and allows an estimation of order densities without the necessity of gathering historic order data from each supermarket in turn.

We present results for a selection of UK retailers, and compare to historic order data received from a partner retailer in the SRF consortium. We show the extent to which the significant geographic variances in drop density, often present in real order data, can be reproduced with the predictive model.