Sociodynamic Discrete Choice on Networks: The Role of Utility Parameters and Connectivity in Emergent Outcomes

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Introduction

We explore the behavior of a travel demand model where a commuter's transportation mode choice is directly influenced by percentages of neighbours and socioeconomic peers making each choice. Such a specification is interesting because of the inherent dynamic that could arise if the choice model were to be applied repeatedly in successive time steps with the shares of decision-makers continuously updated as a result of the choice in the previous time step. The specification namely captures feedback between decision-makers that can potentially be reinforcing over the course of time. This feedback may have important implications for the prediction of (system-wide) results over time as it can potentially endogenously propel or hinder the adoption of a mode, depending on utility parameters for the evaluation of the choice alternatives.

Methodology

We present an experimental application of the model to transportation mode choice using pseudo-panel microdata collected by the Amsterdam Agency for Traffic, Transport and Infrastructure. Discrete-choice estimation results controlling overall mechanisms related to individual heterogeneous preferences are embedded in a multi-agent based simulation to be

able to observe the evolution of choice behavior over time with sociodynamic feedback. Due to the nature of available data, we consider aggregate agent interdependencies, with various hypothesized socio-geographic networks. The modelling principles are however extendable to the case of identifiable agent interactions, given suitable empirical data.
We extend earlier theoretical work (Brock, 2006) on multinomial choice with social interactions in three ways. First, *observed* heterogeneity is introduced in the model through socioeconomic characteristics of the commuters, individual-specific attributes of choice alternatives, and availability of alternatives. Second, we allow for the possibility of *unobserved* heterogeneity by accounting for common unobserved attributes of choice alternatives in the error structure through the use of the nested logit model. Third, we explicitly consider non-global interactions, whereby heterogeneity is *induced* by the varying modes shares perceived by different decision-makers within their own local reference groups.

Results

Example emergent outcomes for four network scenarios over multiple random seeds are shown in Figure 1. In all scenarios, the long-run mode shares move significantly away from the initial overall modal split (23.7% public transit; 26.7% bicycle/moped/motorcycle; 49.6% car driver/passenger), and the mode share for car strongly decreases. This is remarkable since the car mode has initially a share about twice as large as either of the other modes. We see that the feedback effect is thus significant in dynamically hindering the car mode. Important too, the feedback effect dynamically propels the transit mode in two of the scenarios, but dynamically propels the bicycle mode in the other two scenarios. We observe that if a feedback effect can be assumed, the details of the connectivity sociogeographic networks can matter!

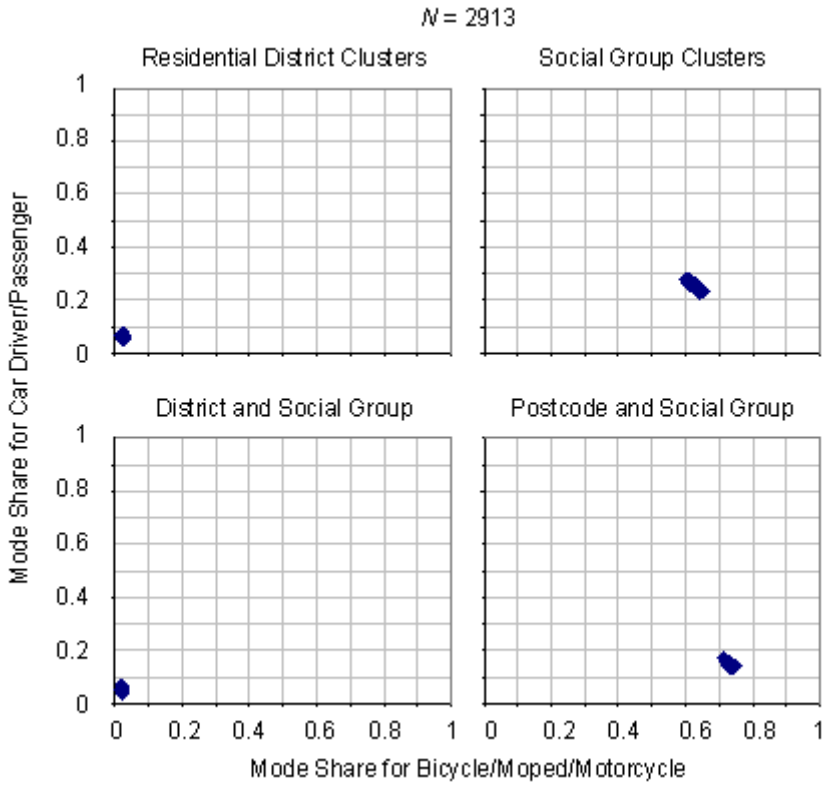

Figure 1. Observed long-run mode shares for multi-agent simulation of nested logit models with social feedback on different sociogeographic networks

We note further that there are two stages in the model where the socio-geographic networks enter:

- In the econometric estimation, determining the value of the utility parameters
- In the multi-agent based simulation, determining the course of the spread of influence.

To gain some insight which stage drives the results in this particular case study, we run a hypothetical simulation experiment with socio-geographic networks swapped, while holding the utility parameters fixed. Example results for different random seeds are shown in Figure 2. We find that only in the case of the social group parameters did the connectivity of the network seem to have some slight effect on the outcome of the multi-agent simulation. We conclude that the strength of the feedback effect rela-

tive to the other components of the utility is the dominant factor in generating the long-run results, and the connectivity appears not to be so relevant at the transmission stage in this particular case study. Additional research is necessary to determine whether this perhaps surprising finding holds in general.

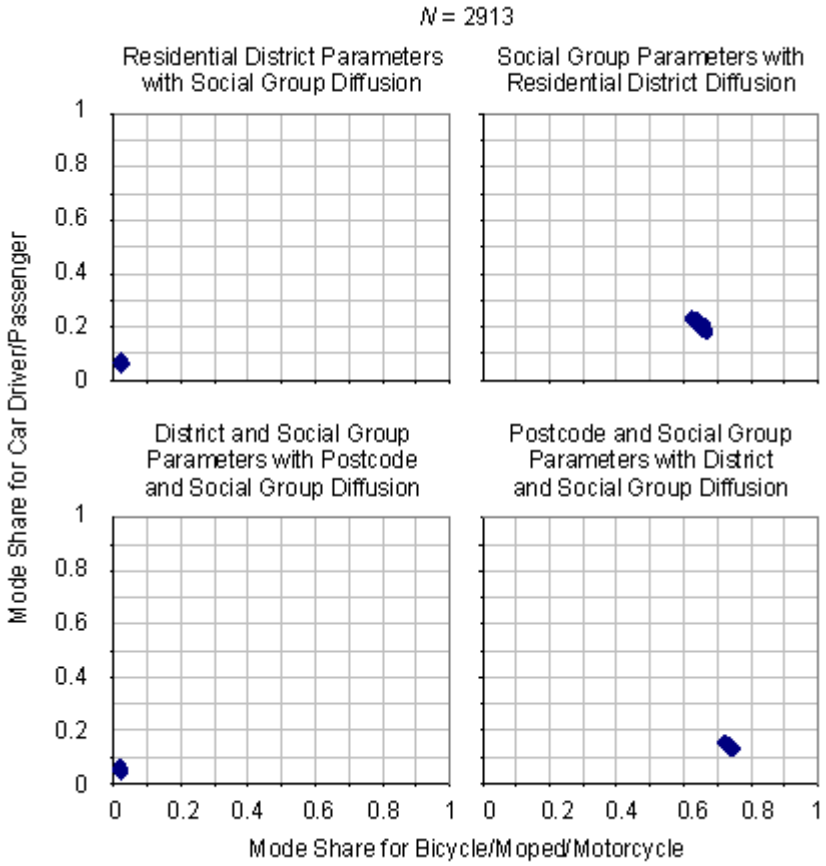

Figure 2. Observed long-run mode shares for hypothetical experiment with multi-agent simulation of nested logit models where estimated utility parameters and sociogeographic networks are swapped

Implications for research/policy

We hope that researchers, practitioners and policy-makers will start to pay more attention to the importance and consequences of agent interdependence. Our findings underscore the need for more empirical research to understand actual sociogeographic influence networks. In particular we would be enthused to see more temporal social network and location data collected via novel means such as mobile phone applications with the aim towards understanding endogenous feedback effects.

References

Brock W., Durlauf S., Multinomial choice with social interactions. In L. Blume, S. Durlauf (eds). The Economy as an Evolving Complex System III. Oxford University Press, New York, 2006.