ABSTRACT

Travel behavior models have traditionally treated individuals as the decision-making unit, even though the behaviour of individuals is contingent on interactions among household members. Literature suggests that interactions at the household-level are observed not just in long-term decisions such as vehicle ownership and residential location choices but also in day-to-day activity-travel patterns. Therefore, the thesis aims to investigate the impacts of intra-household interactions on household members' activity-travel behavior within the framework of modelling short-term mobility decisions. Among the short-term decisions, this particular work focuses on decisions related to out-of-home activity participation, time allocation, travel party composition, mode choice, and destination choice decisions. The contributions of the thesis to international literature are as follows. *First*, the thesis accounts for the joint activity-travel patterns of all adults (age > 18 years) household members. In contrast, previous studies considered the interaction between spouses/household heads or parents and children. This adds a new 'layer of interactions' to the existing activity-based travel demand models. *Second*, the interactions among household members are treated as context-dependent, i.e., it is influenced by socio-demographic attributes, built-environment factors, attitudes and perceptions of household members, and choice situations. This approach of embedding context and situation effects while analyzing intra-household interactions reflects the realistic nature of day-to-day activity-travel patterns. *Third*, in contrast to the current literature on joint travel, which mainly focuses on direct family members, the present thesis incorporates social utility by considering extended family members and members from social circles and their influence on household utility. This is achieved by developing a typology of joint household tour patterns embedding activity types, joint travel arrangements in the presence of direct, extended, and social members, and mode choice, thereby accounting for the heterogeneity in activity-travel patterns. *Fourth*, the thesis accounts for repetitive visits to multiple activity destinations and adds a time budget dimension to the discrete choice set by examining the aggregated time spent at multiple activity locations during a particular time interval of a day. This accounts for the heterogeneity in activity participation and time allocation behavior.

This thesis utilizes the primary household activity-travel survey data collected in Bhubaneswar city, India, in three phases across April-May 2019, September-October 2019, and February-March 2020, to capture the heterogeneity in the interactions among household members across – i) activity participation and time-allocation decisions, ii) activity task allocation and travel

party composition, iii) mode choice decisions, and iv) activity destination choice. The dependent variables associated with these choice decisions are either discrete/ordinal in nature or have a continuous dimension with upper and lower limits or a combination of discrete and continuous variables. Consequently, multivariate methods such as censored regression techniques, integrated choice latent variable (ICLV) and multiple discrete-continuous (MDC) models were applied in the research. From a methodological standpoint, the work expands the existing modelling practices by i) estimating multivariate frameworks allowing for correlations across alternatives and households to examine the nature of inter- and intra-household interactions, ii) the application of composite marginal likelihood (CML) method compared to traditional maximum simulated likelihood (MSL) while optimizing multivariate models, iii) defining a two-level nested framework of tour typologies in terms of activity type, travel partners and mode choice, and iv) introducing a flexible time budget constraint defined at the household-level for an MDC framework.

The thesis finds that the nature of the interaction between spouses while participating in out-of-home non-work activities is more pronounced as compared to time allocation decisions. The inter-person variation for activity participation and time allocation decisions of spouses was reported to be substitutive in nature. In contrast, the intra-person variation for these decisions is gender dependent. Regarding task allocation and touring party composition, the error correlation matrix suggests significant inter-group substitution effects across the four accompaniment types (traveling alone, with immediate family members, extended family, or social members) for different non-work activities. The intra-group effects are complementary in the case of joint pursuits highlighting the likelihood of adult household members adhering to the same accompanying group. The model coefficients suggest that the effect of individual characteristics, household socio-demographics, and seasonal and temporal characteristics are more impactful than vehicle ownership and built environment features. The tour typologies concerning mode choice decisions reveal that the nature of intra-household interaction in a developing country is more pronounced (as 64% of total tours in the sample are joint) compared to a developed region (e.g., Sydney household travel survey data had 52% joint tours). The results from the structural model of the ICLV framework indicate that household head characteristics and built environment variables significantly influence the attitudes and perceptions of adult household members. By including the latent factors in the nested ICLV model estimation, a substantial part of the intrinsic taste (or distaste) variability associated with mode choice decision was captured that was previously ascribed to alternative specific

constants. Additionally, the thesis contributed to the literature by deriving distinct values of travel time savings for public and personal modes for different tour typologies, as there would be different trade-off preferences across activity types and accompanying person arrangements. The heterogeneity in activity destination choice decisions across three-time intervals on a weekday is measured through a temporal repetition index (TRI). It revealed that recreational activity locations have the highest median TRI value in a day, whereas shopping trips have the lowest. The former indicates minimal variation in departure time to recreational destinations, whereas the latter reveals a higher variation in departure time in case of shopping locations. The variance-covariance matrix of the mixed MDCEV model suggested the need to incorporate inter-household variations while modeling the frequency of visits to activity locations. Among the explanatory variables, household socio-demographic and trip attributes are significant determinants of repeated trips to multiple activity destinations. The thesis also discusses the broad policy implications of selected control variables across these short-term decisions.