Examining the impact of weather variability on non-commuters' daily activity-travel patterns in different regions of Sweden

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Note: the content in this abstract is identical to the ones in the online submission.

Extended Abstract: Although previous studies have found relationships between weather conditions and travel behaviours, the findings also indicate that the impacts of weather are far from straightforward. One of the plausible reasons for this is that most of the previous studies focused on the direct impact of weather on one specific travel indicator and ignored the indirect impact of the weather on other related activity-travel indicators.

Thus, this paper aims to build upon the growing literature regarding travel behaviour related to weather, by further considering the interaction between individuals' travel and activity indicators and between trip purposes, specifically routine and leisure activities[1]. This paper further investigates how these interactions and the impacts of weather vary across individuals who live in different geographical locations. The objective of this study is to: (1) examine the interactions among the activity-travel indicators of travellers who live in different geographical areas of Sweden, whilst also assessing the impacts of heterogeneous individual- and location-specific factors, and to (2) derive and compare the total effect of each weather variable on each activity-travel indicator for different groups of travellers who live in different geographical areas.

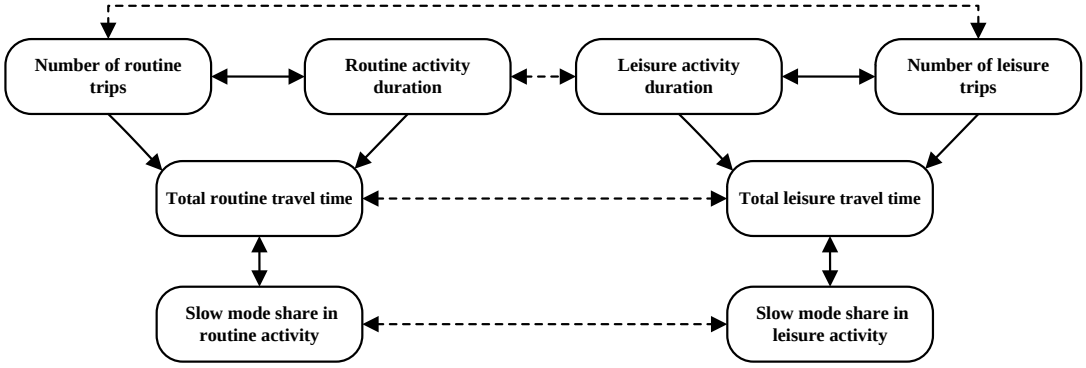
Combined weather and travel survey datasets from Swedish National Transport Survey that span a period of over 13 years were analysed. Since not all activities are carried out every day, the distributions of activity-travel indicators are truncated. Moreover, engaging in one type of activity influences individuals' decisions to participate in other types of activity due to time-space constraints. Only non-commuters are analysed in this study since previous studies (e.g. Liu et al. 2013) indicate that commuters' activity-travel patterns are less elastic to the changes in weather parameters due to their less flexible time-space constrains. A simultaneous Tobit model system is thus applied in order to cover: (1) a considerable number of zero observations of each activity-travel indicator, and (2) potential interactions and correlations among various activity-travel indicators. To better capture the unobserved differences among municipalities, an additional error term is also introduced into the model system. Meanwhile, the heterogeneity in time horizon is captured by the yearly dummy. The simultaneous Tobit models used in this paper can be formulated as follows:

[1] Routine activities refer daily maintenance activities such as children care, daily shopping, health care etc., whereas the leisure activities refer the activities of visiting friends/relatives, sports, eating out, religious etc.

$$y_i^* = Y_i\gamma_i + X_i\beta_i + \mu_i + \varepsilon_i \tag{1}$$

$$y_i = \begin{cases} L & \text{if } y_i^* \le L \\ y_i^* & \text{if } y_i^* \in (L,U) \\ U & \text{if } y_i^* \ge U \end{cases} \tag{2}$$

In the above equations, i is the index of the dependent variables, activity-travel indicators. y_i^* is the unobserved dependent variable while y_i is the observed dependent variable. The unobserved dependent variables of activity duration, number of trips and travel time are left-censored at 0, L=0 and U=+∞, while the unobserved dependent variables of slow-mode share are left-censored at 0 and right-censored at 1, L=0 and U=1. Y_i is the set of endogenous variables, while X_i represents the explanatory variables. γ_i and β_i are the corresponding coefficients of Y_i and X_i. ε_i is the random error term which is iid. A municipality-specific error term, μ_i, is introduced into the model system, allowing travellers in the same municipality to have a certain degree of unobserved similarities. The endogenous relationships between dependent variables are shown in Figure 1.



The solid line represents the potential endogeneity within the same type of activity.
The dashed line represents the potential endogeneity between the two types of activities
A single-headed arrow denotes the direction of endogeneity from one indicator to another.
A double-headed arrow denotes a mutual endogeneity between two indicators.

FIGURE 1 Endogeneity relationships in these three regional models

The model parameters were estimated through a two-stage estimation procedure (Wooldbridge, 2002). The first stage of estimation is to estimate Eq. (1) through a random intercept linear model by replacing y^*_i with y_i. In the second stage, the predicted values of dependent variables generated through the first stage replace the counterparts in Y_i in the right hand side of Eq. (1) and the newly formed equations were estimated through maximum likelihood estimation. The model was estimated for non-commuters in southern, central and northern Sweden respectively.

Since the simultaneous Tobit model system involves endogeneity relationships, the mediation effects are hidden and cannot be interpreted through the estimated coefficients of explanatory variables βs. Thus the total marginal effect of each explanatory variable on each dependent variable is also derived.

The model results reveal the trade-offs between routine and leisure activities in terms of activity duration, number of trips and travel time, which clearly reveals the

time-space constraints. Positive mutual endogeneity was found between slow-mode share in routine and leisure trips, reflecting consistent mode choice preference in both routine and leisure trips. The results also highlight the trade-offs between routine and leisure activities under abnormal weather conditions. Indirect marginal effect is substantial and sometimes overwhelms the direct marginal effect, which confirms that a simultaneous model structure is necessary. Regional differences between weather effects are also substantial due to differences in direct, indirect and total marginal effects.

The estimated standard error of municipality specific error term σ_μ represents the variability between municipalities while that of iid error term σ_ε represents the variability within municipalities, after controlling for the variation in all explanatory variables. The estimated standard errors of the municipality specific error term σ_μ and the iid error term σ_ε are shown in Table 1.

TABLE 1 Comparison of regional difference of within and between municipality variability

Dependent variables		South	Central	North
Routine activity duration	Between σ_μ	17.05 (11.4%)	18.8 (12.1%)	13.28 (9.5%)
	Within: σ_ε	132.1 (88.6%)	136.5 (87.9%)	127.0 (90.5%)
Leisure activity duration	Between σ_μ	19.60 (9.3%)	22.18 (10.3%)	42.92 (18.2%)
	Within: σ_ε	190.8 (90.7%)	192.9 (89.7%)	193.4 (81.8%)
Number of routine trips	Between σ_μ	0.04 (1.8%)	0.10 (4.7%)	0.13 (5.4%)
	Within: σ_ε	2.08 (98.2%)	2.11 (95.3%)	2.33 (94.7%)
Number of leisure trips	Between σ_μ	0.09 (5.2%)	0.001 (0.04%)	0.002 (0.12%)
	Within: σ_ε	1.70 (94.8%)	1.62 (99.96%)	1.64 (99.88%)
Total routine travel time	Between σ_μ	8.58 (12.2%)	30.0 (32.8%)	4.07 (5.6%)
	Within: σ_ε	62.0 (87.8%)	61.5 (67.2%)	68.5 (94.4%)
Total leisure travel time	Between σ_μ	3.60 (6.1%)	7.26 (9.1%)	17.9 (18.9%)
	Within: σ_ε	55.0 (93.9%)	72.9 (90.9%)	76.9 (81.1%)

Between-municipality variability constitutes a considerable part of the variability in activity duration and travel time. Between-municipality variability in leisure activity duration and leisure travel time is larger in northern Sweden. Presumably this is because municipalities in northern Sweden have fewer residences and vary more significantly in terms of size and location, and thus there is more variation in terms of accessibility compared to central and southern Sweden. Between-municipality variability in routine activity duration and routine travel time is larger in central Sweden. Since routine activities are often of tighter space and time constraints than leisure activities, the variability of routine activity-travel patterns tends to be dependent less on geographical variability, but more on the social-economic variability, which is more apparent in central Sweden.

References

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