# Household shopping trips: exploring travel patterns and links to the built environment

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## Abstract

Shopping is one of the most common trip purposes. Shopping also holds significant potential for active mode use as trip distances tend to be (or could be) short. However, the relationship between shopping behavior and built environment characteristics has received limited research attention so far. Shopping, as a maintenance task, is usually distributed within households. Therefore, this study aims to identify different shopping behavior typologies at the household level and investigates factors associated with these patterns. Using trip data from the 2022 German Mobility Panel, a nationwide and representative 7-day travel diary survey, we conduct a cluster analysis. Key variables to capture transport-related aspects of shopping behavior include mode choice, trip distance, trip frequency, and trip chaining. The analysis reveals six distinct household shopping patterns: No shopping trips, car-shoppers, frequent shoppers, active travelers, shopping after work and few long shopping trips. A multinomial regression analysis is performed to identify the individual, household, and spatial determinants of cluster membership. While few sociodemographic factors are related to cluster membership, the residential location is found to be strongly related to the probability of belonging to the active traveler cluster.

## Keywords

Shopping; travel behavior; built environment; cluster analysis; travel patterns

## Preferred citation

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# 1 Introduction

Shopping represents one of the most frequently traveled trip purposes (Hook et al., 2023). Usually, a high share of travel for shopping is made by car. However, as shopping trips are short on average, a high potential for lowering car usage exists. Household travel for shopping is influenced by a variety of external factors, including the residential location and the proximity to (different) shopping destinations (Smith et al., 2023). Further, shopping behavior is strongly shaped by individual attitudes (Mokhtarian et al., 2009). Shopping trips also depend on how shopping as a maintenance task is distributed within households (Wiese et al., 2015).

Shopping as a trip purpose has received comparatively little research attention (Hook et al., 2023). To date, there are few studies investigating clusters in shopping travel behavior that identify built-environment determinants of certain behavioral patterns. Further, shopping trip patterns have frequently been analyzed from an individual perspective. The emergence of different patterns of household shopping behavior has not been sufficiently understood in the context of residential environments and household compositions. In this study, we aim to identify distinct typologies of household shopping behavior and the determinants of these patterns including spatial and accessibility-related factors. We aim for a household perspective to account for the intra-household division of tasks. To the authors' knowledge, no study has yet determined clusters of similar household shopping behavior in a nationwide and representative sample. There are only few data sources available that allow to analyze shopping behavior over a week (e.g., the Mobidrive dataset collected over 6 weeks in Germany in 1999 (Axhausen et al., 2002)). Shorter timeframes hold major limitations as shopping is usually not performed daily and thus might be missed in the collected data. Further, a high share of studies has been conducted in the US, where active mode shares are low and built environment effects on travel behavior are not directly comparable to a European setting (Buehler, 2011).

The analysis of this study is conducted in several steps: First, we perform a cluster analysis of households in Germany using the German Mobility Panel (MOP) 2022, a nationwide and representative 7-day travel diary survey. In this study, shopping trips include grocery shopping as well as shopping for medium- and long-term goods. We select variables that are able to describe the transport-related characteristics of shopping behavior. Multinomial (MNL) regression is used to model cluster membership and to identify spatial factors associated with the observed patterns of grocery shopping behavior, while controlling for household and sociodemographic characteristics.

# 2 Literature Review

Certain characteristics distinguish shopping-related trips from other trip purposes. Overall, shopping trips tend to be comparatively short. In Germany and the Netherlands, shopping trips are about 5 km long on average (Nobis and Kuhnimhof, 2018, p. 62; Hoogendoorn-Lanser et al., 2019). In the US, shopping trip distances average 7.1 miles ~ 11.4 km (McGuckin and Fucci, 2018). The majority of shopping trips tend to be conducted by car (infas, 2019).

The necessity to perform shopping activities for food and other daily goods regularly promotes the emergence of routines and habits (Wiese et al., 2015). Kahn and Schmittlein (1989) found evidence for 7-day cycles between shopping trips due to preferences for a certain day of the week to go shopping. Alternatively, one long shopping trip per week is combined with one or more complementary, smaller trips. Further, Rauh and Rauch (2024) observed trip chaining for 42.5% of shopping trips in a sample collected in Germany. 56.1% of respondents frequently combine shopping with a different activity, mainly commute trips.

## 2.1 Determinants of shopping behavior

The residential location is associated with travel behavior for shopping: Residents in densely populated areas with a high quality of shopping supply conduct shorter and more frequent trips for shopping that are less often part of a trip chain, and active mode use is higher (Scheiner, 2010; Smith et al., 2023; Rauh and Rauch, 2024). Similar to other trip purposes, mode choice is also related to trip distance: Walking trips for shopping are found to be shorter (Schneider, 2015). Car availability is related to longer trip distances, higher shares of car travel and lower trip frequencies (Jiao et al., 2016, 2011).

The organization of shopping trips also depends on the household composition and sociodemographic characteristics: Women tend to spend more time for shopping compared to men (Procher and Vance, 2013). This difference is especially pronounced in families with children. Persons with lower household income and students were found to be more likely to walk for shopping trips (Schneider, 2015).

## 2.2 Typologies of shopping behavior

Various approaches to cluster shopping behavior have been conducted, but these were often used from a retail or consumer behavior perspective, see e.g., Rohm and Swaminathan (2004),

Swinyard and Smith (2003), Conlin and Labban (2019) and Eriksson and Stenius (2024). To this date, there are few applications in travel behavior studies and much effort has been dedicated to understanding the decision to shop online vs. in-store (Bönisch et al., 2021; Mateos-Mínguez et al., 2021; Shah et al. 2021; Shah and Carrel, 2024a; Hoogendoorn-Lanser et al., 2019). Mokhtarian et al. (2009) have identified 7 distinct patterns in attitudes towards shopping in-store vs. online and travel in general. They find that attitudes are related to shopping behavior and the attitudinal clusters represent different market segments.

A few studies identified distinct typologies of shoppers based on actual travel behavior: Kahn and Schmittlein (1989) identified two groups of frequent and infrequent shoppers. Shah et al. (2021) identified 4 groups of shopping behavior considering VMT, number of trips, duration and trip chaining through a latent class analysis using household data from the US. They observe a strong association between shopping patterns and socioeconomic factors, while urban form effects were much weaker. Shah and Carrel (2024b) identified individual modality styles based on mode use by number of trips and travel time, trip chaining and non-travel days. For grocery shopping trips, they find a negative relationship between the number of cars in a household and membership in the active traveler and transit rider groups, a positive relationship between household size and membership in the opportunistic carpooler group and a negative relationship between a suburban location and membership in the active traveler group.

Mattioli and Anable (2017) examined high polluters captured in the British NTS – households with high car usage for food shopping trips – to determine the travel patterns responsible for large shares of carbon emissions. They identified 4 clusters and find that high polluters do not have a lower grocery store accessibility compared to other respondents.

Bönisch et al. (2021) segmented a sample of survey respondents in Munich, Germany using latent class analysis depending on shopping frequency and distance, online shopping, car use and work/school trips, also including attitudes and the residential built environment. They determined 6 different classes of shopping behavior and find that frequent car-users tend to often shop online.

The findings of previous studies illustrate that travel behavior for shopping not only varies depending on the residential location and household characteristics but that different patterns of shopping behavior emerge that cannot be explained by these factors alone. To this date, there are few studies of household shopping patterns in a German setting and very few studies dealing with a representative national sample and trip diaries including at least 7 consecutive days.

# 3 Methodology

## 3.1 Data

The analysis is based on the MOP 2022, a travel survey conducted yearly in Germany from 1994 until 2022 which includes a 7-day travel diary (Ecke et al., 2023). For all trips during a week, trip purpose, all modes used during the trip, date, start and end time and the distance traveled were collected. In 2022, travel diaries were collected between September and early December – the majority in September and October.

In the 2022 wave, all adult members of 921 households filled out a trip diary, 1,561 persons in total. Based on all 32,577 trips collected in the diaries, we extracted 5,740 trips with the trip purpose "shopping, running errands". We do not have more specific information on the destination or type of shopping trip. However, the representative study Mobility in Germany (MiD) 2017 offers some insight into how these trips might be distributed: 66% of all shopping trips collected in the MiD were connected to the purchase of daily goods, 15% for other goods, 7% are shopping trips as a pastime, 1% services and 10% other/unclassified. Therefore, we assume that the respective category in the MOP data mainly includes shopping trips to buy daily goods as well. 43 households did not record a single shopping trip in the trip diary. As previous studies observed that grocery shopping can be a relatively infrequent activity, especially if in-store trips are complemented with online deliveries, this does not necessarily indicate that travel diaries are incomplete. Thus, we include these datasets in the analysis to understand the factors related to very infrequent travel for shopping.

## 3.2 Variables

We summarized all shopping trips conducted over all trip diaries for one household. Trips that were taken together by two or more persons are aggregated, based on trip purpose, mode and start and end times. Based on the preprocessed data on household level, we calculated several measures of shopping behavior (see Table A1) that characterize trip frequency, distance, trip distance variability and mode choice.

To investigate whether shopping is done as part of a trip chain, we define the main purpose of round-trips similar to Shah et al. (2024). A round-trip is understood as a trip chain that starts and ends at the home location. We label round-trips that include at least one trip with the

purpose work, school, picking up/dropping off someone as commute trips. Round-trips including at least one trip for shopping, running errands or other private activities and no mandatory trip are labeled maintenance tours. We classified all shopping trips according to whether they belong to a commute or to a maintenance trip. Further variables collected in the MOP describing sociodemographic characteristics and travel resources of the household and the residential location are included in the analysis as well. Several of these variables were collected as categorical variables in the survey but were translated into numeric values using the mean values of each category (household income, settlement density).

## 3.3 Methods

Based on household shopping trips, we calculated a number of characteristics describing travel behavior for shopping (listed in Table A1). This includes travel distance and duration, mode use and trip chaining. We calculated correlations between all variables under consideration. We selected five variables to be used in the cluster analysis: The number of shopping trips, the median distance traveled per shopping trip, the share of the longest trip among the total distance traveled for shopping, the share of car trips and the share of shopping trips that are part of a commute trip chain. The chosen variables exhibit relatively low correlations and reflect different characteristics of shopping behavior.

We apply k-means clustering to identify patterns of similar household shopping behavior. Households that did not go shopping once during the 7-day diary were removed to not distort the cluster analysis and later added as an additional group to the results. We explored different numbers of clusters, ranging from k=3 to k=8. The final number of k=5 clusters was chosen based on interpretability and for achieving reasonable cluster sizes. An alternative approach using hierarchical clustering was implemented as well. This method always led to the classification of one extremely large cluster, while the remaining ones contained very few observations. Thus, we chose to use k-means clustering.

To investigate household and built environment characteristics that might be related to shopping behavior patterns, we model cluster membership using a multinomial logit model. As one cluster exhibits a remarkably low level of car use compared to all other groups, and thus allows to investigate factors related to higher/lower car use, we set this group as our reference group. Variables in the MNL model were selected based on AIC and significance to achieve a robust and parsimonious model structure. All analyses were carried out in R version 4.4.3.

# 4 Results

## 4.1 Cluster analysis

We identify 6 different clusters of household shopping behavior. Cluster sizes and mean values on the variables that the cluster analysis is based on are included in Table 1. The largest groups are *active travelers* and *car-shoppers* that exhibit similar trip frequencies and low shares of trip chaining as part of mandatory trips, but complementary shares of car travel. The third-largest group are *frequent shoppers* with an average number of almost 10 shopping trips per week. The cluster *shopping after work* contains respondents who mainly combine shopping with mandatory trips. The smallest cluster *few long shopping trips* is comprised of households who go shopping the least frequently per week and travel very long distances on average.

Table 1: Mean values for trip characteristics

| Variable | Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 | Cluster 5 | Cluster 6 |
|---|---|---|---|---|---|---|
| | Car-shoppers | Frequent shoppers | Active travelers | Shopping after work | Few long shopping trips | No shopping trips |
| Cluster size | 249 (27.0%) | 182 (19.8%) | 258 (28.0%) | 162 (17.6%) | 27 (2.9%) | 43 (4.7%) |
| Total number of shopping trips per household | 3.6 | 9.8 | 4.3 | 3.1 | 2.0 | 0.0 |
| Median distance traveled per shopping trip [km] | 4.5 | 2.6 | 1.5 | 3.8 | 23.5 | 0.0 |
| Share of longest trip among km traveled for shopping | 59.0% | 32.3% | 54.8% | 70.0% | 79.1% | - |
| Share of car trips for shopping | 89.0% | 53.0% | 10.2% | 71.1% | 90.4% | - |
| Share of shopping as part of a commute trip chain | 13.9% | 37.2% | 22.3% | 85.3% | 50.3% | - |

## 4.2 Multinomial logit model

In Table 2, the results of the MNL model are shown. The development of car-dependent shopping habits (*regular car-shoppers*) is most strongly and positively associated with car availability. Households living in areas with low settlement densities and a long distance to the closest store for daily needs are more likely to belong to this cluster. Further, higher income levels are positively associated with cluster membership as well.

Membership in the *frequent shopper* cluster seems to be related to the amount of time available to household members: Households with a higher share of students among household members

are much more likely to belong to this cluster, whereas the likelihood is lower among households with a higher share of full-time employees. Even though household income positively (but weakly) correlates with the share of full-time employees, higher incomes are related to a higher likelihood of belonging to the *frequent shopper* cluster, compared to the *active traveler* cluster. Further, as about 50% of shopping trips in this cluster are made by car, car availability is significantly associated with cluster membership. Built environment characteristics are related to cluster membership in a similar way to cluster 1.

Only few variables are significantly related to cluster membership in the *shopping after work* group. Interestingly, the share of full-time employees among household members is not significantly related to the probability of belonging to this cluster. One reason for this could be that households might prefer to allocate a higher number of shopping tasks to a person working only part-time. As a high share of trips is made by car, car availability is significantly positively associated. Again, built environment effects are very similar to clusters 1 and 2.

Table 2: Estimated odds ratios in the MNL model (reference: cluster 3 active travelers)

| **Predictor** | **Cluster 1** | **Cluster 2** | **Cluster 4** | **Cluster 5** | **Cluster 6** |
|---|---|---|---|---|---|
| | Car-shoppers | Frequent shoppers | Shopping after work | Few long shopping trips | No shopping trips |
| Intercept | 0.02*** | 0.16*** | 0.15*** | 0.02** | 0.08** |
| Partner in household | 0.93 | 1.15 | 0.74 | 0.81 | 0.36* |
| Oldest household member 18-34 years | 2.16 | 2.46 | 2.02 | 4.59 | 3.24 |
| Oldest household member 35-49 years | 2.1 | 1.37 | 1.66 | 2.17 | 3.83* |
| Oldest household member 50-64 years | 1.52 | 1.39 | 1.4 | 1.15 | 1.07 |
| Child <18 years in household | 0.71 | 0.83 | 0.85 | 0.17 | 0.27 |
| Share of students among adult household members | 1.56 | 10.59* | 1.88 | 1.18 | 8.55 |
| Share of full-time employees among adult household members | 0.57 | 0.29*** | 1.6 | 1.9 | 1.14 |
| Household income | 1.27* | 1.5*** | 0.97 | 1.2 | 1.43* |
| Highest degree in household: tertiary education | 0.79 | 0.64 | 0.79 | 1.16 | 0.21*** |
| Car available in household | 41.22*** | 2.96*** | 6.85*** | 6.3 | 1.29 |
| Share of persons with mobility limitations among adult household members | 0.89 | 0.52 | 0.68 | 0.77 | 2.41 |
| Settlement density | 0.67*** | 0.76* | 0.72** | 0.44** | 0.76 |
| Distance to closest store for daily needs | 1.48*** | 1.32*** | 1.47*** | 1.61*** | 1.53*** |

Cluster membership in the *few long shopping trips* cluster is not significantly related to any sociodemographic household variables. In line with expectations, the distance to the closest store is the most important explanatory variable for cluster membership: households living far from the nearest store for daily needs are much more likely to belong to this group. Further higher settlement densities stand in a negative association with cluster membership.

Cluster membership in the *no shopping trips* cluster, compared to the *active traveler* cluster, is strongly related to the highest degree among household members: If at least one person holds a tertiary degree, the likelihood of belonging to the no shopping group decreases. In contrast, higher income increases the likelihood of belonging to this cluster. Households where partners cohabit have a lower likelihood of belonging to the *no shopping trips* cluster as well. As trips are summarized over households and there are more (adult) persons living in couple households, this finding is in line with expectations. Further, higher distances to the closest store for daily needs are related to a higher likelihood of belonging to the *no shopping trips* cluster.

# 5 Discussion

Overall, we observe that most household characteristics do not have a strong impact on the development of distinct shopping travel patterns. Most strikingly, the presence of children in the household does not make a difference while the number of shopping trips could have been expected to rise. Further, shopping trip patterns do not seem to depend on age. Thus, we find no evidence for generational differences in shopping behavior.

Education and income-related household characteristics are associated with different shopping patterns much more strongly: While this could point towards time constraints due to full-time occupation on the one hand, these variables might also correlate with car ownership that is strongly related to travel behavior patterns for shopping. As car ownership is the most important mediator of car use, cluster membership in car-heavy groups is strongly related to a car being available in the household. Car availability can also be an indicator of positive attitudes towards car travel that were not collected in the survey (Van Acker et al., 2014).

Controlling for different household characteristics, strong built environment effects remain. In line with expectations, dense neighborhoods are associated with more sustainable travel behavior patterns for shopping. We further control for the distance to the closest store for daily needs. Even though households do not necessarily visit the store located closest to them, the

distance can be a good indicator of the general level of store accessibility. As expected, there is a strong association between higher distances and less sustainable travel behavior.

We observe that about 5% of households in the sample do not go shopping once over the course of 7 days. One explanation for this might lie in the increasing online availability of daily goods. Shah et al. (2021) observed that shoppers who did not make a single in-store shopping trip during one reporting day frequently ordered online. Thus, it is possible to almost exclusively order online or to complement infrequent in-store trips with more frequent online deliveries.

Even though the used dataset is one of very few capturing household travel behavior over a week and therefore holds important advantages for the analysis of shopping behavior, there are certain limitations to the analysis. In the survey, no attitudinal statements on travel or shopping were included. Thus, we cannot account for the underlying effects of attitudes that would allow for a more in-depth understanding of the observed patterns and their determinants. As attitudes were found to be related to travel as well as shopping behavior, it can be assumed that the observed patterns correlate with certain attitudes (Mokhtarian et al., 2009). Further, attitudes might also be an underlying factor influencing car ownership and the residential built environment (residential self-selection) that were associated with cluster membership.

Further, online deliveries were not captured in the survey, but are strongly linked to physical shopping trips. Information on the number of online deliveries would also allow to understand the *no shopping trips* cluster better. However, it has been shown that online shopping does not necessarily substitute shopping trips but may rather complement them. In Germany, no association between the distances traveled for shopping and the amount of online deliveries has been found in a representative study (Follmer, 2025).

# 6 Conclusions

In this study, we examined household shopping behavior collected in 7-day trip diaries to identify clusters of similar behavior. Subsequently, we investigate possible sociodemographic as well as spatial determinants of these patterns.

The results point to the existence of several distinct groups that exhibit a certain type of shopping behavior regarding frequency and distance traveled for shopping, mode choice and trip-chaining behavior. We identify six clusters: *Regular car-shoppers, frequent shoppers, shopping after work, few long shopping trips* and *no shopping trips*. Among household

characteristics, household income and car availability are most strongly related to different patterns of shopping behavior, while age and the presence of children do not have a measurable impact. Further, travel patterns for shopping are strongly related to the built environment. Living in dense areas with good accessibility of shopping destinations enables households to perform almost all their shopping activities by active modes.

Further analyses could look at how shopping is distributed within households and how this is related to cluster membership. It would be interesting to investigate whether household members tend to exhibit similar or different travel behavior regarding mode choice and travel distances.

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# A Appendix

Table A1: Descriptive statistics (in bold: shopping behavior characteristics used for clustering)

| Variable | Share/mean (standard deviation) |
|---|---|
| Shopping behavior | Shopping behavior |
| **Number of shopping trips** | 4.72 (3.37) |
| Total distance traveled for shopping [km] | 21.62 (27.75) |
| Total time traveled for shopping [min] | 61.47 (51.92) |
| **Median distance traveled per shopping trip [km]** | 3.50 (4.67) |
| **Share of longest trip among km traveled for shopping [%]** | 54.87 (24.09) |
| Number of shopping trips traveled by car | 2.45 (2.69) |
| Number of shopping trips by walking | 1.43 (2.27) |
| Number of shopping trips by bike | 0.76 (1.69) |
| Number of shopping trips by public transport | 0.07 (0.41) |
| **Share of car trips for shopping [%]** | 55.12 (40.51) |
| Share of trips by walking for shopping [%] | 27.69 (34.44%) |
| Share of trips by bike for shopping [%] | 15.00 (27.59%) |
| Share of trips by public transport for shopping [%] | 1.75 (9.22%) |
| **Share of shopping as part of commute trip chain [%]** | 35.50 (34.35%) |
| Share of shopping trips to just one destination [%] | 48.30 (35.53%) |
| Household composition (binary) | |
| Partner in household | 39.63% |
| Child <18 years in household | 16.50% |
| Household age: age of oldest household member | |
| 18-34 years | 3.58% |
| 35-49 years | 18.02% |
| 50-64 years | 40.83% |
| 65+ years | 37.57% |
| Share among adult household members | |
| Full-time employees [%] | 40.79 (42.84) |
| Students [%] | 2.68 (11.12) |
| Persons with mobility limitations [%] | 9.63 (26.36) |
| Household income [in 1,000 €] | 3.53 (1.49) |
| Tertiary degree among household members (binary) | 56.35% |
| Car available in household (binary) | 83.39% |
| Built environment | |
| Settlement density [in 1,000 inhabitants/km2] | 2.44 (1.02) |
| Distance to closest store for daily needs [in km] | 2.15 (2.62) |