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Diversity in diversification: an analysis of shopping trips in six-week travel diary data*

Yi-lin SUN†[1], Ari TARIGAN[2], Owen WAYGOOD[3], Dian-hai WANG[1]

([1]*School of Civil Engineering and Architecture, Zhejiang University, Hangzhou 310058, China*)

([2]*Cofely Fabricom GDF Suez, Kanalsletta 3, Stavanger 4033, Norway*)

([3]*École supérieure d'aménagement du terroire et de development regional (ÉSAD), University Laval, Quebec QC G1V 0A6, Canada*)

†E-mail: yilinsun@zju.edu.cn

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Abstract: Diversification in shopping, a long-pursued subject in consumer behavior analysis, is approached from a broad perspective of the diversity in daily travel patterns, which may or may not involve shopping trips, as well as the diversity in shopping locations and frequency. The focus of this analysis is on the heterogeneity across individuals in the ways in which they each diversify their respective shopping behavior. This study explores differences across individuals in the variations of their shopping travel patterns across days. Treating the day-of-the-week evolution of shopping travel patterns as a stochastic process, characteristics of diversification are quantified for respective individuals. Finally, heterogeneity across individuals is identified using an array of statistical methods. The analysis, based on results of a six-week travel diary survey in Germany with geo-coded activity locations, reveals the effects of individual, household, and urban attributes on diversification in shopping behavior, including that full-time workers with medium incomes (4000–4999 Deutsche Mark per month) tend to have more variations in their shopping engagement.

Key words: Shopping behavior; Grocery shopping; Shopping locations and frequency; Shopping travel patterns; Shopping trips
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1 Introduction

The pattern of shopping activities in daily life varies across individuals; e.g., individuals are quite heterogeneous in terms of their shopping activity engagement, regular and irregular, frequent and infrequent in practice. For example, some may go grocery shopping every day, while others shop at regular intervals, buying the bulk of their groceries with one trip usually at the same time each week. Some people are very loyal to a particular store; others switch frequently. Some households try to limit the bulk of their shopping to Saturdays; others prefer a weekday or evening. There are related studies that have contributed substantially to the understanding of shopping behavior.

Some studies tried to identify the effects on shopping behavior from various factors, such as the individual and household socio-demographic attributes, level of related activity, transport system, and land use factors. Using a revised model of travel demand modelling, Robinson and Vickerman (1976) analyzed household cross-sectional data to demonstrate the effects on shopping trip generation of location factors. Using the utility maximization model, Doti and Sharir (1981) quantified the impact of household characteristics on the time spent in a grocery

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ORCID: Yi-lin SUN, http://orcid.org/0000-0002-8757-7261

store, the size of the purchase, and the number of such trips within a given period. Vickerman and Barmby (1984) deployed a similar approach to further highlight the importance of a joint decision between expenditure and the number of trips necessary to undertake the relevant expenditure. Blaylock (1989) found that the most important factors influencing a household's shopping frequency were the race of the shopper, household size, shopper's age, and factor influencing household food inventories and time availability in the United States. Handy (1996) provided empirical support for additional trip making for shopping purposes in high-density, mixed-use neighborhoods. If the number of shopping trips and activity episodes is higher in more urbanized environment, time spent per episode may be less. One reason for this is that need to buy as many goods as possible in a single shopping event is lower. In short, the duration of shopping episodes decreases as the degree of urbanization increases. Smith and Carsky (1996) focused on the relationship between the women's shopping behavior and the degree of involvement in grocery shopping. They found that the involvement scale of each individual was not significantly correlated with the number of times or number of different stores visited per week. However, those who were more involved in grocery-shopping related activity were found to be more likely to consider the economy and efficiency of their shopping. Levinson (1999) found that as residential densities increased and metropolitan areas became larger, people spent less time on the average duration of out-of-home activities. A few studies found that socio-economic household characteristics, built environment, and level-of-service attributes have impact on freight mobility of shopping trips (Boerkamps *et al*., 2000; Gonzalez-Feliu *et al*., 2010; Russo and Comi, 2010; Miodonski and Kawamura, 2012; Comi and Nuzzolo, 2014). Using city logistics analysis and simulation support system, Comi and Rosati (2015) implemented new advanced shopping demand models that allow to pointing out the effects due to changes in shopping behavior and shopping restocking.

Some researchers were concerned with shopping behavior analysis, which examines the differences in shopping behavior among individuals. Kim and Park (1997) discussed motivations of irregular shoppers compared with regular shoppers, and developed a model to distinguish the shopping behavior of these two kinds of shoppers. They found clear differences between them in terms of several demographic and purchase behavioral characteristics. Axhausen *et al*. (2002) modeled the dynamics of inter-shopping duration and recognized that the likelihood of participation in a shopping activity depends on the length of elapsed time since the previous participation. Bhat (2001) found that when workers live in an urban neighborhood, they spend less time on shopping episodes, whereas workers who work in an urban neighborhood allocate more time to shopping episodes. Bhat and Steed (2002) used the same approach of latent segmentation by endogenously classifying random and routine shoppers based on their demographic and household location characteristics and also accommodating unobserved heterogeneity across individuals in their inter-shopping duration.

Multi-purpose shopping occurs when consumers are able to reduce their transport cost by grouping their purchases of different goods into fewer trips (Thill and Thomas, 1987). A multiple-stop shopping trip is where several physically different locations are visited on the same trip to obtain the desired goods (O'Kelly, 1981; Thill, 1985). O'Kelly (1983) analyzed household activity patterns and trip chaining and reported that single-stop grocery trips tend to be more concentrated near the home of the household than multiple-stop grocery trips. Ghosh and McLafferty (1984) used numerical simulations to determine the propensity for multi-purpose shopping behavior assuming cost minimization (cost pertaining to transportation, storage, and price). The results indicated that multi-purpose shopping behavior varies with relative locations of consumer, store, and price charged. A study on consumer tendencies by Dellaert *et al*. (1998) indicated that consumers do have a significant tendency to combine purchases, but this differed from category to category. Some shopping behavior studies used the utility-maximizing approach (Narula *et al*., 1983). Bacon (1995) developed a utility-maximizing model of optimum frequency of shopping that incorporates multi-purpose shopping trips as an alternative for individuals to reduce travel cost. Arentze and Timmermans (2001) derived the indicator to demonstrate the improvement of incorporating multi-purpose shopping trip in a multinomial logit model. Using shopping trip data collected from a

sample of 1704 households in the Netherlands, Arentze *et al*. (2005) found that agglomeration helps attract not only multi-purpose but also single-purpose trips.

Trends in store type and development can affect consumer behavior. Messinger and Narasimhan (1997) argued that during the previous few decades there had been a significant increase in one-stop shopping strategies, due to an increase in the assortment of goods available at supermarkets. Traditional grocery stores in Western Canada have been transformed to superstores, which provide consumers with opportunity to buy clothes, toys, and foods under the same roof. Other retailers have developed grocery outlets near to, or sometimes inside of, a shopping mall, thereby allowing shoppers to indulge in activities other than grocery shopping (Dellaert *et al*., 1998). However, Popkowski Leszczyc and Timmermans (2001) focused on how consumers in Western Canada organized their shopping trips when faced with an enlarged set of retail format alternatives. Their results showed that respondents preferred multi-stop shopping trips to specialty or convenience stores; single-stop shopping trips to a combination store were the least preferred. Thus, there is tension between development patterns by the stores and the preferences of shoppers. Popkowski Leszczyc *et al*. (2004) developed a model of household shopping behavior, which incorporates the effects of multi-purpose shopping trips on store choice, and provided a better understanding of the competitive market structure.

The increasing of e-shopping has imposed enormous pressure on traditional stores. Some research studied the relationship between traditional store shopping and e-shopping with the development of e-commerce (Farag *et al*., 2007; Hsiao, 2009; Barone *et al*., 2014). Mokhtarian (2004) concluded that neither type of shopping (traditional store shopping and e-shopping) uniformly dominates the other. Using the 2009 National Household Travel Survey (NHTS) data, Zhou and Wang (2014) found that both online shopping and traditional store shopping trips are influenced by exogenous factors such as shoppers' demographic features, regional specific factors, and household attributes. Ganesh *et al*. (2010) revealed that there are more similarities than differences among traditional and online store shoppers. However, there are a few unique shopper types present at online stores, attracted by the distinctive characteristics and attributes of the online retail environment. Cao *et al*. (2013) found the connections between spatial attributes and e-shopping. The influence of shopping accessibility on e-shopping depends on the locations of internet users. Findings of Crocco *et al*. (2013) showed that individual social and economic factors, consumer attitudes, and shopping mode characteristics influence the usage of online shopping.

The day-of-the-week effect on shopping activity was analyzed in several studies. Hirsh *et al*. (1986) demonstrated the potential biases from the omission of interdependencies among days of the week in shopping activity. Kitamura (1988) used the Dutch national mobility panel data to indicate that the shopping participation of a given day is strongly and positively correlated with preceding days. Yun and O'Kelly (1997) examined the hypothesis that shopping activity choice behavior is dependent on the day of the week. They found substantial differences between parameter estimates and statistical significance across each day in their day-of-the-week model. Using data from over 2000 convenience store customers within and outside London, Susilo *et al*. (2013) found that the day of the week, the location's density, and the shopping types are not significant in influencing travel modes.

The main objective of this study is to characterize this diversity of the above issues in shopping behavior. Using a continuous six-week travel survey from the cities of Halle and Karlsruhe in Germany, differences across individuals in the variations in shopping locations and frequency across days are analyzed. Shopping locations in this paper refer to locations of grocery stores. This study focuses on the heterogeneity across individuals in the ways that they each diversify their respective shopping behavior.

2 Data description

The data source used for this analysis is the Mobidrive data set, which contains the results of a continuous six-week travel diary survey conducted in the German cities of Halle and Karlsruhe in the spring and autumn of 1999, respectively. Detailed description

of the survey context can be found in Axhausen *et al*. (2002). The survey was carried out with the aim of obtaining a more detailed picture of mobility patterns and to develop methodological approaches to capture temporal behavioral variability.

The 232 individuals from 126 households are analyzed. Of these, 116 individuals from 64 households in Karlsruhe, and 116 individuals from 62 households in Halle participated in the survey. Both the pretest and main survey were contacted in two waves in order to capture the seasonal variation. The additional information on socio-demographic of individual and his household, car size and composition and attributes toward different modes of transport are provided.

The study explores differences across individuals in the variations in shopping travel patterns across days as well as in their shopping locations and timing. The effects of individual and household socio-demographic characteristics and trip making characteristics on diversification in shopping behavior are also analyzed.

This study is concerned with only grocery shopping behavior. Grocery shopping can be considered as a shopping activity which has higher temporal and spatial flexibility than other types of shopping (e.g., durable goods shopping). Attractive points of studying the grocery shopping behavior are that frequency and heterogeneity of grocery shopping are higher than those of durable goods shopping.

With respect to individual heterogeneity, the sample is divided into three subgroups including: workers, part-time workers, and non-workers. Due to the problems in estimation over groups of individuals with substantially different attributes, in particular the amount of constraints, it is seemed reasonable to classify the observations by work hours (as a measured and regular time constraint). Thus, the study comparatively examines the shopping behavior across these subgroups.

Most respondents who reported themselves as full-time workers have working hours that range from 35 h to 60 h per week. The sample was divided into these groups: the first group (full-time workers) comprises 137 individuals who worked at least 35 h per week, the second group (part-time workers) comprises 43 individuals who worked less than 35 h per week, and the last group (non-workers) comprises 181 individuals who were not employed.

3 Day-of-the-week evolution of grocery shopping trips

Differences in shopping behavior among different groups of individuals, such as working status, sex, marriage, residential area, city, age, and household income, can be roughly observed by the mean number of grocery shopping locations over six weeks made by individuals. Descriptive statistics of each group is presented in Table 1.

It can be seen from Table 1 that part-time workers have a higher mean number of grocery shopping locations compared with non-workers and full-time workers over six-week period. Women reported a greater number of visits to grocery stores than men. There is no obvious difference in the mean number of grocery shopping locations between married people and unmarried people. People who lived in the central business district (CBD) or the inner city tend to visit more grocery stores than people who lived in the suburbs on average. Karlsruhe residents visited a higher variation of grocery shopping locations than Halle residents. Middle-aged and elderly people (who aged 35–65) tend to visit more grocery stores than younger age groups (who aged 18–34) on average. This finding is similar to the results that the shifting of middle age into later age could result in an increase in shopping trips to nearby shops, mainly to small and medium-size retail outlets (Nuzzolo and Comi, 2014). An interesting result is that both the low- and high-income households show a high mean number of grocery shopping locations over six-week period.

Distribution of the number of shopping days per week is presented in Fig. 1. There are 1057 person-weeks observed. More than 50% of subjects go shopping one or two days per week. The number of shopping days per week varies substantially.

The standard deviation of the number of shopping days per week per individual is shown in Fig. 2. The smaller is the standard deviation of the number of shopping days per week, the more stable is the weekly frequency of shopping trips. Individuals who have a larger standard deviation of the number of shopping days per week, have less stable weekly frequency of

Table 1 Number of grocery shopping locations over six-week period

Variable		Number of samples	Number of grocery shopping locations			
			Mean	Minimum	Maximum	Std. deviation
Working status	Full-time workers	111	4.86	0	21	3.58
	Non-workers	76	6.45	1	15	3.91
	Part-time workers	35	7.29	1	23	3.95
Gender	Male	113	4.92	0	21	3.81
	Female	119	6.51	0	23	3.83
Marriage	Married	147	5.99	0	23	3.99
	Unmarried	85	5.29	0	16	3.71
Residential area	CBD resident	16	6.25	1	13	4.03
	Inner city resident	61	6.16	0	16	3.77
	Suburban resident	153	5.43	0	23	3.90
City	Karlsruhe	116	6.43	0	23	4.24
	Halle	116	5.04	0	15	3.40
Age	18–24 years old	25	4.72	1	15	3.57
	25–34 years old	33	5.94	1	13	3.36
	35–44 years old	61	6.28	0	16	3.81
	45–54 years old	57	5.53	0	23	4.63
	55–65 years old	56	5.70	0	14	3.64
Household income per month	≤1799 DEM	14	6.83	1	15	2.99
	1800–2499 DEM	18	6.61	0	13	3.74
	2500–2999 DEM	30	4.97	1	13	2.71
	3000–3999 DEM	45	5.22	1	16	3.21
	4000–4999 DEM	49	5.20	0	15	3.69
	5000–7499 DEM	31	6.00	0	15	3.96
	≥7500 DEM	21	7.14	0	23	5.82

DEM: Deutsche Mark

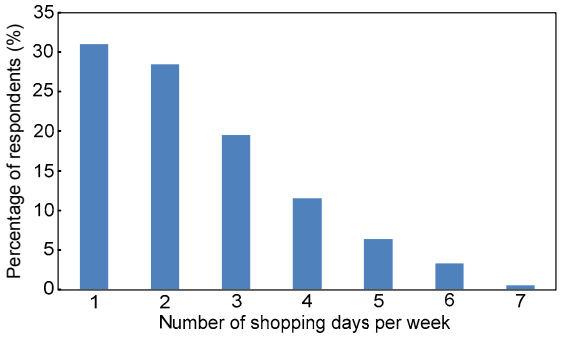

Fig. 1 Average numbers of days when a grocery shopping trip occurred (average of the pooled six weeks)

shopping trips (e.g., the number of shopping trips they do each week has a greater variation week-in week-out). In the sample, 58.62% of the individuals have stable weekly frequency of shopping trips where standard deviation of the number of shopping days per week is less than 1.00.

Thus, for this sample, the descriptive analysis (Table 1) tells us that differences likely exist in the variety of stores visited by work status, gender, age, residential area, and city. Further, from the two figures presented, we can see that most individuals have stable (Fig. 2) and low-frequency (Fig. 1) shopping patterns.

4 Diversity in shopping locations and frequency

The descriptive analyses helped us answer questions such as: Does shopping behavior vary according to individual, household, or urban attributes? How many shopping locations do people visit? How many times do people go shopping over a week? However, in order to understand the relative influence of the explanatory variables on location (1) and

frequency (2) regression models are developed (Table 2). The category variables and their labels in the regression model are shown in Table 2.

Results are shown in Table 3. Full-time workers do not visit many grocery shopping places and do not have enough time to go grocery shopping than part-time workers and non-workers. The results in Table 3 showed that females go grocery shopping more frequently and visit more grocery shopping places than males, and males keep the grocery shopping places.

Compared with people of other ages, 35–44 years old people go grocery shopping more frequently than other age groups. This may be because of the differences of family lifecycles. Main family members of families of people aged 35–44 are children, so there is greater demand on grocery shopping of families of people aged 35–44 than other age groups. Adults (people aged 35–44) generally complete the grocery shopping needs in their families, so people aged 35–44 go grocery shopping more frequently. Similar results showed that middle-aged people increase the number of trips to medium-size retail outlets and the use of car (Nuzzolo and Comi, 2014). The demographic of age changes can thus lead to more shopping trips, mainly to small and medium retail

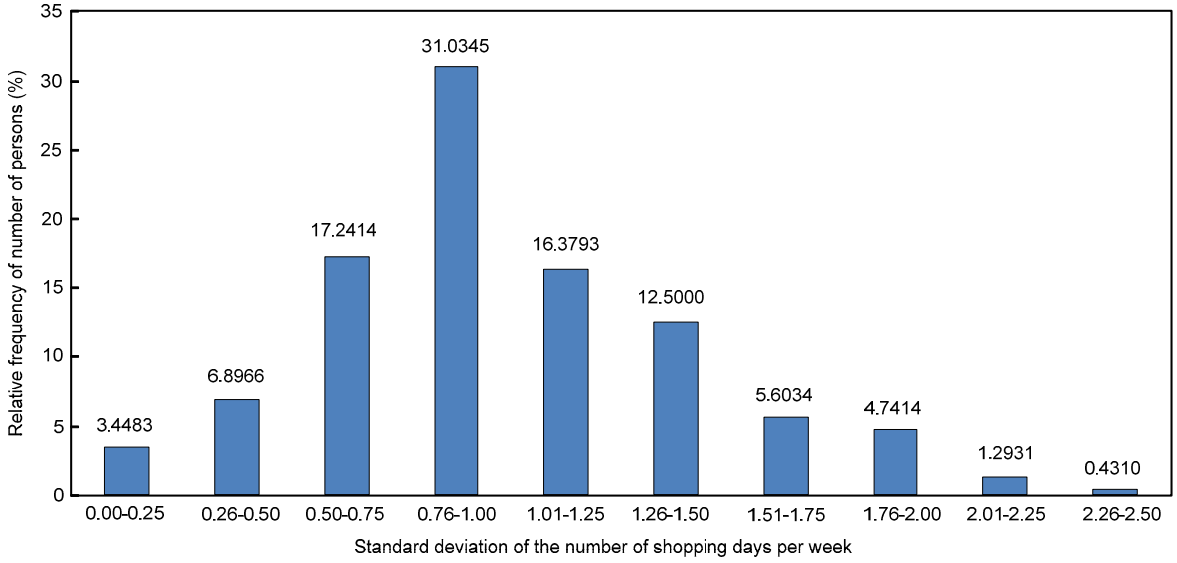

Fig. 2 Distributions across individuals of the standard deviation of the number of shopping days per week

Table 2 Variables and their labels in the regression model

Variable			Label
Dependent variable			(1) Number of the locations where people go shopping in six weeks; (2) number of shopping days per week in six weeks
Explanatory variable (dummy variable)	Individual attribute	Working status	Full-time worker, non-worker, part-time worker
		Gender	Male, female
		Age	18–24, 25–34, 35–44, 45–54, 55–65
		Marriage	Married, unmarried
	Household attribute	Household size	1, 2, 3, ≥4
		Household income (DEM per month)	≤1799, 1800–2499, 2500–2999, 3000–3999, 4000–4999, 5000–7499, ≥7500
		Cars number in household	0, 1, ≥2
	Urban attribute	Residential location	CBD, inner city, suburban
		City	Karlsruhe, Halle

Table 3 Results of the regression model on weekly shopping behavior

Item	Number of locations		Number of shopping days	
	B coefficient	*t*-statistic	*B* coefficient	*t*-statistic
Constant	3.631	2.310**	9.155	2.804***
Full-time worker	−1.196	−1.842*	−3.005	−2.228**
Part-time worker	0.615	0.744	0.638	0.371
Non-worker	0	–	0	–
Male	−0.966	−1.739*	−0.526	−0.456
Female	0	–	0	–
Age (18–24)	−0.802	−0.712	−3.039	−1.299
Age (25–34)	0.509	0.521	2.714	1.337
Age (35–44)	0.991	1.186	3.412	1.967*
Age (45–54)	0.178	0.225	1.424	0.866
Age (55–65)	0	–	0	–
Married	0.857	1.198	0.557	0.375
Unmarried	0	–	0	–
1 household member	0	–	0	–
2 household members	0.232	0.248	−1.082	−0.556
3 household members	−0.062	−0.060	−0.681	−0.320
≥4 household members	0.024	0.022	−1.053	−0.472
Household income per month				
≤1799 DEM	3.089	2.163**	1.115	0.376
1800–2499 DEM	1.296	1.120	3.925	1.633
2500–2999 DEM	−1.150	−1.204	3.839	1.936*
3000–3999 DEM	−0.010	−0.012	0.914	0.531
4000–4999 DEM	−0.708	−0.891	−0.382	−0.231
5000–7499 DEM	−0.068	−0.076	3.086	1.680*
≥7500 DEM	0	–	0	–
0 car	0	–	0	–
1 car	1.373	1.246	1.230	0.537
≥2 cars	0.733	0.600	−0.544	−0.214
CBD	1.341	1.260	1.221	0.552
Inner city	0.922	1.507	3.110	2.449**
Suburban	0	–	0	–
Karlsruhe	1.535	2.780***	0.276	0.241
Halle	0	–	0	–
F-test	2.292***		2.205***	
R^2	0.194		0.188	

***: significant coefficient value $p<0.01$; **: $p<0.05$; *: $p<0.1$. *B* coefficient: parameter vector; R^2: coefficient of determination of a linear regression

outlets, with a consequent increase in car kilometers. Interesting results show that low household income people (household income less than 1799 DEM per month) tend to visit more grocery shops. People with moderate and low income group (household income per month between 2500 and 2999 DEM) show higher shopping frequency than other groups during six weeks. People who lived in inner city show higher shopping frequency than people who lived in central business district and suburban in six weeks. Even though there are not so many location choices in inner city compared with central business district, people who lived in the inner city show higher shopping frequency. Residents who lived in Karlsruhe visit more grocery shopping places than residents who lived in Halle.

5 Binary logistic regression analysis on regular shopping travel pattern

If an individual goes shopping, during the six weeks, on the same day of the week for at least 5 times, then we consider his or her shopping behavior to be regular. Binary logistic regression analysis was used to find who the people are with a regular shopping behavior. Dependent variable is regularity, which is a dummy variable in the binary logistic regression analysis. If a person goes grocery shopping on the same day of the week for at least 5 times during the six weeks, grocery shopping travel pattern of this person is regular, and regularity is shown as 1. Conversely, regularity is shown as 0. Category variables and their labels of explanatory variables in the binary logistic regression model are the same with the regression model, which are presented in Table 2.

Results are shown in Table 4. Full-time workers are less likely to have a fixed day for shopping in comparison with part-time workers and non-workers. Males were found to have more irregular shopping

Table 4 Results of binary logistic regression model

Variable	Coefficient	Wald statistic
Constant	−2.153*	3.703
Full-time worker	−1.145**	6.293
Part-time worker	−0.169	0.099
Non-worker	0	–
Male	−0.667*	3.077
Female	0	–
Age (18–24)	−1.696*	3.228
Age (25–34)	0.380	0.334
Age (35–44)	0.919*	2.438
Age (45–54)	0.329	0.350
Age (55–65)	0	–
Married	0.232	0.217
Unmarried	0	–
1 household member	0	–
2 household members	0.381	0.334
3 household members	0.252	0.116
≥4 household members	0.193	0.065
Household income per month		
≤1799 DEM	0.207	0.048
1800–2499 DEM	2.352***	8.014
2500–2999 DEM	0.488	0.625
3000–3999 DEM	0.116	0.044
4000–4999 DEM	−0.436	0.656
5000–7499 DEM	0.512	0.791
≥7500 DEM	0	–
0 car	0	–
1 car	1.004	1.566
≥2 cars	1.048	1.391
CBD	0.945	1.919
Inner city	0.529	1.797
Suburban	0	–
Karlsruhe	0.392	1.070
Halle	0	–
Chi-square	50.535***	
R^2	0.283	

***: $p<0.01$; **: $p<0.05$; *: $p<0.1$

behavior than females. Young people whose ages are from 18 to 24 are less likely to have a fixed shopping day, while people aged 35–44 tend to shop on a fixed day of the week. People with moderate and low income groups (household income per month between 1800 to 2499 DEM) are most likely to have regular shopping behavior. No differences were found for being married, household size, cars number in household or urban context.

6 Conclusions

Diversification in shopping is a long-pursued subject in consumer behavior analysis. There is a need, therefore, for studying diversification in grocery shopping locations and frequency that can correctly guide consumer demand and provide the basis for the urban planning. This paper studies the diversification in grocery shopping trips of consumer behavior analysis, as well as the diversity in shopping locations and frequency. Using statistical analysis methods, this study explores the heterogeneity across individuals in the variations of their grocery shopping travel patterns across days.

In general, the statistics presented in this study reveal what influences the stability and the variability in grocery shopping behavior of individuals. Individuals in Halle and Karlsruhe prefer more to engage in once or twice a week frequent grocery shopping. Standard deviations show that most individuals have a stable weekly grocery shopping trip frequency. The variety of grocery shopping destinations was positively influenced by having a low income and living in Karlsruhe, while it was negatively influenced by working full-time and being male. The number of grocery shopping trips during six weeks was positively influenced by being in the age range of 35–44, having either an income of 2500–2999 DEM (just below average of 3100 DEM per month) or 5000–7499 DEM as compared with having the highest income (equal to or greater than 7500 DEM per month), and living in the inner city.

Shopping behavior varies substantially across people. Intra-person variability is also substantial. The number of shopping days per week varies from week to week for a given individual during the six-week survey period. Variability of the day-of-the-week shopping travel patterns varies from person to person. Some show great variability across weeks, some do not. Diversities in shopping locations and frequency vary across individuals with individual attributes and residential location in systematic ways.

The above findings of this study confirm a need for further research, especially of the heterogeneity across individuals in the variations in shopping locations and frequency across days. This study is still very preliminary and further research must be carried out to understand the diversity in shopping duration and elapsed time of grocery shopping trips across individuals across days.

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中文概要

题　目： 多元化的多样性：连续 6 周交通日志的购物出行分析

目　的： 探究个人的购物出行模式随时间的变化差异性。探讨个人在星期中的天变化，量化多样化的特征和识别个体间的异质性。

创新点： 1. 使用连续 6 周的数据进行动态交通行为分析；2. 建立二元逻辑回归模型，识别个体间购物出行模式的异质性。

方　法： 1. 通过描述性统计分析，解析不同群体之间的购物行为的差异、每周购物天数的分布以及每周每人购物天数的标准偏差（表 1、图 1 和 2）；2. 通过回归模型分析，得出解释变量对购物地点和频率的影响结论（表 2 和 3）；3. 构建二元逻辑回归模型，识别个体间购物出行模式的异质性，找出具有常规购物行为的群体（表 4）。

结　论： 1. 低收入和卡尔斯鲁厄居住地对日常购物目的地的多样性呈正影响关系，而全职工作和男性对日常购物目的地的多样性呈负影响关系；2. 连续 6 周的日常购物出行次数受到 35~44 岁的年龄范围、2500~2999 德国马克的家庭月收入以及市中心居住地区的积极影响；3. 购物地点和频率的多样性是随着个人属性和居住地点以系统的方式变化。

关键词： 购物行为；日常购物；购物地点和频率；购物出行模式；购物出行