Impact of Spatial Variables on Shopping Trips

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Conference paper STRC 2005

STRC | 5th Swiss Transport Research Conference
Monte Verità / Ascona, March 9-11, 2005

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March 2005

Keywords

shopping trips – neighbourhood – shopping destinations - spatial variables – modal split

Abstract

In the past 30 years, retail business in Switzerland has undergone a basic change from a dense network of small retail stores in the neighborhood to a few large shopping centres at periphal sites. Neverteless, certain studies showed[1,2], that shopping in the neighbourhood is still important for small daily purchases, whereas shopping centres are especially visited for doing bulk purchases. Since shopping centres are mainly car-oriented, the ongoing concentration process of retail business is critical in respect of traffic generation. Therefore, the exploration of the impact of the neighbourhood shopping supply on the generation, modal split and distance of shopping trips is judged by the authors to be important for future planning.

The data used in this study was taken form the *Swiss national travel survey* (Mikrozensus zum Verkehrsverhalten BFS/ARE), which contains individual information on the socioeconomic status and the travel behaviour of approximately 30'000 people. Since the dataset provides also geocoded information on the households, it was enlarged with spatial variables such as the location of stores, the availability of motorway connections and public transport stops, the number of inhabitants and others. Complementary, another dataset was used. The *Continuous survey on passenger transportation* (Kontinuierliche Erhebung des Personenverkehrs SBB) adds further shopping trips, although none shorter than 3km.

The results of the descriptive analyses in the first part of this study indicated, that most shopping trips neither lead to cities nor shopping centres, which was judged as a first clue to the importance of stores in the neighbourhood or at the place of work for daily purchases. Indeed, further results showed, that the bigger the sales area in the neighbourhood, the less shopping trips are made to cities or shopping centres. In addition, there seemed to be a negative relationship beween the sales area in the neighbourhood and the shopping trips by car.

The results of the binary logistic regression in the second part suggested a relatively low impact of spatial variables in the neighbourhood on shopping trips by car. The highest impact on mode choice, respectively on trips by public transport seem to have spatial attributes of shopping destinations such as the availability of an express train station and the non-availability of a motorway connection.

[1] Verkehrsclub der Schweiz (VCS) (Ed.) (2001) Einkaufszentrum konra Einkauf im Zentrum. Verkehrs- und raumplanerische Grundsätze für eine umweltverträglich Standortwahl. Bern.

[2] Stab Verkehr der Stadt Zürich (2004) Mobilitätsstrategie der Stadt Zürich. Teilstrategie Einkaufs- und Freizeitverkehr. Beschlossen vom Stab Verkehr am 26. Januar 2004.

1. Introduction

During the last 30 years, the development of retail business has turned into a concentration process. Since 1970, more than half of the retail stores in Switzerland have vanished, while the sales area of the remaining stores has quadrupled. Especially small retail stores in the neighbourhood have been affected by these rationalisation measures in retail business. Therefore, neighbourhood shopping supply has become worse and people have become forced to go to alternative shopping facilities outside the residential area such as peripheral shopping centres.[3] The simultaneous development of traffic problems such as congestions and deficiencies of parking space at large shopping centres and the concentration process in retail business, suggest relationships between the quality of neighbourhood supply and shopping trip generation. Therefore, the authors of this paper aim to identify crucial spatial characteristics of neighbourhoods and of shopping destinations, which have an impact on the distance, destination and modal split of shopping trips.

In the first part of this paper, results from literature studies concerning the characteristics of shopping trips, shopping trip destinations and neighbourhood shopping supply are presented. The second part provides the results from descriptive analyses on the differences between shopping trips to cities and shopping centres and of the relationship between the quality of neighbourhood shopping supply and the characteristics of the shopping trip destination. Finally, the results of a binary logistic regression are presented exploring the impact of spatial variables on the modal split of shopping trips.

1.1 The characteristics of shopping trips

The microcensus on travel behaviour in the year 2000 revealed that the average share of shopping trips on weekdays is 19%, and that 45% of all stages of shopping trips are made on foot, whereas 39% are made by car. 40% of all shopping trips on weekdays are shorter than 1 kilometre, whereas on Saturdays the average distance is 7 kilometres.[4] 80% of bulk shopping (non-perishables, cleaning and washing detergents etc.) is done by car, although these purchases are most frequently made in the neighbourhood.[5] Small purchases of food and other

[3] Schultz, B. & Schilter, R. (2003) Publikumsintensive Einrichtungen für Konsum und Freizeit. 1970 bis heute – mögliche Entwicklungen für die Zukunft. Werkstattbericht. Zürich: IRL, ETH Zürich.

[4] Bundesamt für Raumentwicklung, Bundesamt für Statistik (2000) Mobilität in der Schweiz, Ergebnisse des Mikrozensus 2000 zum Verkehrsverhalten. Bern und Neuenburg.

[5] Verkehrsclub der Schweiz (VCS) (Hrsg.) (2001) Einkaufszentrum kontra Einkauf im Zentrum. Verkehrs- und raumplanerische Grundsätze für eine umweltverträgliche Standortwahl. Bern: VCS.

goods of daily life are made several times a week mostly in the neighbourhood.[6]

1.2 The characteristics of shopping trip destinations

Shopping centres are those leisure and commercial facilities with the highest impact on traffic generation. With the growth of cities and the suburbanisation process, the largest sales area can be found in the agglomeration of cities. Most of the 63 largest shopping centres in Switzerland (> 5000m2) are located in the surroundings of Zurich, Geneva, Berne and Lucerne. These sites are close to motorway connections and therefore, they are easily accessible by car.[7]

The classification of shopping centres can be done either by the sales area, see Table 1, or by their trading area which is correlated with the sales area (see Table 2). These two classification schemes were combined for the descriptive analyses and the binary logistic regression in part two and part three of this paper.

Table 1 Classification of stores in Switzerland by the sales area according to the Schweizer Wirtschaftssystematik NOGA (Swiss classification of economic branches).

Sales area	Store classification
30-100m^2	Small stores
100-400m^2	Large stores
400-1000m^2	Small supermarket
1000-2500m^2	Large supermarket
> 2500m^2	Consumer markets

Table 2 Classification of shopping facilities according to the norm SN 641 of the Vereinigung Schweizer Strassenfachleute VSS (Association of Swiss Road Experts).

Trading area	Sales area
Neighbourhood	< 4000m2
Suburbs	4000-12’000m2
Regional	> 12’000m2

[6] Stab Verkehr der Stadt Zürich (2004) Mobilitätsstrategie der Stadt Zürich. Teilstrategie Einkaufs- und Freizeitverkehr. Beschlossen vom Stab Verkehr am 26. Januar 2004.

[7] Schultz, B. & Schilter, R. (2003) Publikumsintensive Einrichtung Konsum und Freizeit. 1970 bis heute – mögliche Entwicklungen für die Zukunft. Werkstattbericht. Zürich: Institu für Raum- und Landschaftsentwicklung IRL, ETH Zürich.

Due to the significant traffic generation function of city centres, they were also considered as important shopping trip destinations and therefore, included in the descriptive analyses in chapter 2 of this paper. City centres differ from shopping centres primarily in their good accessibility for pedestrians and by public transport, in the larger distances between stores and in the focus on goods of long- or middle-term supply such as clothes, shoes, books, records, watches, jewellery and specialties. Goods of short-term supply such as grocery are rarely bought in city centres.

1.3 The characteristics of neighbourhood supply

A good neighbourhood shopping supply and a good accessibility with public transport are very important preconditions for car-free living.[8] Basically goods of short-term supply have a very restricted trading area. The radius of the "neighbourhood supply perimeter" is empirically defined as the distance customers are willing to cover when they buy goods of short-term supply. Empirical data show that 80% of the customers of a local store live within the so called "five-minutes-zone" which corresponds approximately to an average distance of 300 metres.

There are several methods to define the quality of neighbourhood supply from customers' view. In this study, the quality of neighbourhood supply was defined as the total sales area inside a buffer of 300 metres from the household location. The total sales area was calculated by multiplying the mean sales area of the different store classes (see Table 1) by the number of stores of each store class in the neighbourhood, respectively inside the buffer of 300m from the household location.

[8] Spoerri, A. (2001) Autofreie Haushalte. Ein Drittel der Stadtzürcher lebt ohne eigenes Auto, 1/2001. Zürich: Tiefbauamt der Stadt Zürich. Abteilung Verkehrsplanung.

2. Descriptive analyses about the impact of spatial variables on shopping trips

The dataset used in this study was taken from the *Swiss national travel survey* (Mikrozensus zum Verkehrsverhalten ARE/BFS) which contains individual information on the socioeconomic status and travel behaviour of approximately 30'000 people. Additionally, this dataset includes address-specific information about the location of homes that facilitated the linkage with local spatial variables, e.g. of neighbourhood shopping supply and shopping detinations. Complementary, another dataset was used. The *Continuous survey on passenger transportation* (Kontinuierliche Erhebung des Personenverkehrs SBB) contains only trips which are longer than 3km and does not contain address-specific "geocodes", but it contains more cases for shopping trips. There is a description of these two surveys in Table 3.

Table 3 Methodical comparison of the Swiss survey of the population's travel behaviour 2000 (BFS/ARE) and the Continuous survey on passenger transportation 2001-2003 (SBB)

	Swiss national travel survey 2000 (Mikrozensus Verkehrsverhalten)	Continuous survey on passenger transportation 2001-2003 (Kontinuierliche Erhebung des Personenverkehrs KEP)
Data collector	Swiss Federal Statistical Office BFS & Federal Office for Spatial Development ARE	Federal railway company of Switzerland SBB
Year of survey	Every five years since 1974	Annually since 1980
Reference period	1 reference day for daily mobility 14 days for one-day-trips 4 months for journeys with overnight stay	7 days for daily mobility 14 days for one-day-trips 4 months for journey with overnight stay
Content	Stages > 25 meters	Trips > 3 kilometers (without trips on foot)
Sample size	29'000 Swiss residents	28'000 Swiss residents
Age limit	> 5 year-old	15-84 year-old

Both, the Microzensus and the KEP have weaknesses and strengths according to the different survey methods, see Table 4. For this reason, the suitability of the datasets differs for the focus of analysis. Due to the bigger sample size of shopping trips in the KEP, this dataset was used primarily for the investigation of shopping trips to certain cities and shopping centres. Contrarily, the geocoded dataset of the Microzensus allowed an examination of the impact of spatial attributes of the neighbourhood and of shopping trip destination on distances, destinations and modal split of shopping trips.

Table 4 Weaknesses and strengths of the Microcensus 2000 and the KEP 2001-2003 records.

	Microcensus 2000	KEP 2001-2003
Census frequency	every 5 years (-)	Annually (+)
Sample size for shopping trips	9924 (-)	27'570 (+)
Record of start and destination	Coordinates (+)	Postcode or public transport stop (-)
Record of trips and stages	stages on foot included (+) trips < 3km included (+) trips to/from abroad included (+)	Only trips by public transport or car (-) Only trips > 3km (-) No trips to/from abroad (-)

To make sure that the two surveys are comparable, a few modifications had to be done to the dataset of the Microcensus 2000. The datasets were filtered by:

- Age limit from 15 to 84 years
- Trips of 3 kilometers or longer
- Trips with only one vehicle (without trips on foot)
- Trips which do not end in themselves such as bike trips > 10km, official journeys and business trips
- No trips to and from abroad

After these modifications, the modal splits of the datasets were comparable (see Table 5). Therefore, the data from the Microzensus and the KEP were used complementary in this study, according to their weaknesses and strengths, as mentioned above.

Table 5 Comparison of the modal split forshopping trips between the data from the Microcensus 2000 before and after the modifications and the KEP 2001-2003.

	Microcensus 2000	Modified Microcensus 2000	KEP 2001-2003
Mean distance of trips (km)	6	12	11
Mean duration of trips (min)	19	29	-
% of distances by slow-modes	6	-	-
% of distances by cars	74	79	80
% of distances by public transport	19	20	20
% of trips by slow-modes	41	-	-
% of trips by car	48	81	81
% of trips by public transport	10	18	19

2.1 Comparison of shopping trips to cities and to shopping centres (KEP 200 record)

Since traffic problems in cities derive from various reasons, shopping trips by car attract less attention in cities than in the surrounding of shopping centres, especially the peripheral ones. Therefore, shopping centres are often considered as main causers of problems in the context of shopping traffic. This issue is explored in a series of descriptive analyses, described in this chapter.

In a first step, each Swiss city with more than 1 % of shopping trips in the KEP dataset was selected and considered for the comparison between shopping centres. The cities which fulfilled this criterion were Geneva, Lausanne, Biel, Berne, Basel, Lucerne, Zurich, Lugano, Winterthur and Saint Gall. The shopping trips to these cities were compared with the trips to shopping centres and with all shopping trips in the dataset in respect of modal split, travelled distance and gender ratio, see Table 6.

Table 6 Modal Split, trading area and gender ratio of the shopping trips to the 10 included cities, of the shopping trips to all shopping centres and of all shopping trips (Source: KEP2001-2003).

Shopping trips KEP 2001-2003 > 3 km							
Destination of shopping trips	Share in all shopping trips	Modal Split		Distance [km]		Gender ratio	
		Public transport	Car	On an average	Max.	Male	Female
Shopping trips to the 10 cities included	15.7% (N=4’325)	23.4%	76.6%	17.9	300	44.5%	55.5%
Shopping trips to shopping centres	20.1% (N=5’540)	5.3%	94.7%	11.8	200	43.2%	56.8%
All shopping trips	100% (N=27’570)	18.7%	80.8%	11.3	500	40.6%	59.4%

Regarding the average distance of the trading area in Table 6, one has to take into account that in the KEP dataset, only trips which are longer than 3 kilometres are recorded. This means, that the average distances are generally longer than in the non-modified dataset of the Microzensus with all distance classes. Nonetheless, the average trading area of the 10 analysed cities is larger than the one of shopping centres and all other shopping destinations.

As Table 6 shows, the share of shopping trips by car is generally higher than the share of shopping trips by public transport. The highest share (94.7%) of shopping trips by car is connected with trips to shopping centres. Noticeable is the fact that in the KEP record, most shopping trips (64.2%) neither lead to the 10 included cities (15.7%) nor to shopping centres

(20.1%). Compared to all shopping trips in the KEP dataset, the percentage of men going shopping in the 10 included cities (44.5%) or in shopping centres (43.2%) is above-average, whereas the percentage of women in these cities or shopping centres is below-average.

A detailed analysis of shopping trips to cities and to the respective shopping centres in the surroundings of these cities were only possible for the cities of Zurich, Berne and Lucerne due to the small number of shopping trips to the other cities and their peripheral shopping centres. The results in Table 7 reveal that the cities of Zurich, Berne and Lucerne were visited much more often for shopping than the shopping centres in their surroundings. The percentage of trips by public transport to these cities is generally higher than the one of all shopping trips in the KEP record (18.7%). The modal split of shopping trips to these cities seems to depend on the availabilty and quality of the public transport service in the particular city. While 52.7% of the shopping trips to Zurich were made by public transport, this percentage was quite low for trips to Lucerne (22.2%). One main reason may be the excellent public service in the greater Zurich area.

The percentage for car-trips (100%) to the selected shopping centres in the surrounding of the three cities seems to be too high, despite their peripheral and car-oriented site. Explications for this result may be that only trips which are longer than 3 kilometres are recorded in the KEP and the number of trips to these three shopping centres is fairly low. It can be assumed, that every interviewed person who chose these shopping centres during the reference period travelled by car.

The trading area of the three analysed cities and shopping centres is mainly regional, as the high percentage of distances below 20 kilometres suggests. Nevertheless more customers in these cities cover longer distances than 20 kilometres (approximately 35%) than customers of the shopping centres (approximately 16%).

Table 7 Modal split and trading area of shopping trips to the cities Zurich, Berne and Lucerne compared to the ones to the shopping centres in the surroundings of these cities (Source: KEP 2001-2003).

Shopping trips KEP 2001-2003 > 3 km					
Shopping trip destination		No. of shopping trips (KEP)	Modal Split		Trading area
			Car	Public transport	Access distance < 20 km
Zurich	City	789	47.3%	52.7%	64.8%
	Shopping centre Spreitenbach	195	100%	0%	82.6%
Berne	City	493	57.2%	42.8%	67.2%
	Shopping centre Schönbühl	119	100%	0%	83.2%
Lucerne	City	279	77.8%	22.2%	61.7%
	Shopping centre Emmen	70	100%	0%	85.7%

2.2 Correlation between neighbourhood supply and the distance, destination and mode of shopping trips (Microcensus 2000 record)

In this chapter, the aim iss to explore the relationship between the quality of neighbourhood shopping supply and the distance, destination and modal split of shopping trips. For these analyses, the quality of neighbourhood shopping supply was equated with the total sales area in a buffer of 300m from household location. As already mentioned in chapter 1.3, the total sales area was calculated by multiplying the mean sales area of the different store classes (see Table 1) with the number of stores of each store class in the neighbourhood, respectively inside the buffer of 300m from the household location. The number of stores of the particular store classes were identified by merging the geocoded Swiss business census (Betriebszählung) from the year 1998 with the geocoded records of the Microcensus 2000.

Table 8 shows a relationship between the total sales area in the neighbourhood (buffer of 300m from household location) and the modal split of shopping trips. The classes of sales area correspond to the store classification in Table 1 and Table 2 in chapter 1.2. The bigger the sales area in the neighbourhood, the less trips are made by car but the more trips are made by public transport or by slow modes (walking and cycling).

Table 8 Relationship between the total sales area in the neighbourhood (buffer of 300m around household location) and the modal split of shopping trips. (Source: Microcensus 2000).

Total sales area in the neighbourhood [m2]	Car	Public Transport	Slow modes	Total
No retail store	62.1%	8.2%	28.9%	100% (N=3356)
30-100	55.3%	9.6%	34.5%	100% (N=1733)
100-400	44.2%	10.7%	44.6%	100% (N=1829)
400-1000	36.5%	13.0%	49.9%	100% (N=1115)
1000-2500	28.0%	14.8%	56.1%	100% (N=1137)
2500-4000	25.5%	12.1%	61.8%	100% (N=529)
4000-12’000	19.6%	10.2%	69.8%	100% (N=225)

A relationship between the sales area in the neighbourhood and the shopping trip distance is in Table 9. The mean shopping distances decrease with the increase of sales area in the neighbourhood. No clear relationship beween trips shorter than 300m and the total sales area in the neighborhood can be found in Table 9. One reason may be that a lot of short shopping trips are made around the place of work, for example at lunch time, and therefore are independent from the neighbourhood supply.

Table 9 Relationship between the total sales area in the neighbourhood (buffer of 300m around household location) and the distance of the shopping trip (Source: Microcensus 2000).

	Total sales area in the neighbourhood [m2]							
Distance	No retail store	30-100	100-400	400-1000	1000-2500	2500-4000	4000-12’000	total
Mean distance[km]	4.74	4.79	4.19	3.51	3.39	2.90	2.51	3.72
trips < 300m	27.7%	16.1%	20.3%	12.2%	13.6%	6.2%	3.9%	100% N=2616

More evident seems to be the impact of the neighbourhood shopping supply on shopping trips to cities and shopping centres, as shows Table 10. The better the quality of the neighbourhood shopping supply, which means, the bigger the sales area in the neighbourhood the less people go shopping in cities or shopping centres.

Table 10 Relationship between the total sales area in the neighbourhood (buffer of 300m around household location) and the destination of the shopping trip (Source: Microcensus 2000).

	Total sales area in the neighbourhood [m2]							
Shopping trip destination	No retail store	30-100	100-400	400-1000	1000-2500	2500-4000	4000-12'000	total
Shopping centre	33.4%	17.6%	18.1%	12.1%	9.2%	6.3%	3.4%	100% N=1589
City	21.1%	13.1%	19.9%	16.9%	17.3%	8.2%	3.5%	100% N=2875

3. Modelling the impact of spatial variables on mode choice for shopping trips

A binary logistic regression was carried out with the Microcensus 2000 record to identify the impact of spatial variables in the neighbourhood and at shopping trip destinations on mode choice. The most interesting issue was whether the number of stores and the distance to the nearest public transport stop in the neighbourhood were relevant for going shopping by car. Furthermore, the impact of shopping centres and express train stops at shopping destinations on mode choice was explored as well.

3.1 Method

The dependence of a dichotomous variable (variable with two mutually excluding attributes) of covariates with different scales can be analysed using a binary logistic regression. In this study, mode choice was defined as the dichotomous variable, whereas the quality of neighbourhood supply, the sales area of shopping destinations, the distance to and presence of public transport stops were considered as the covariates. The analyses were carried out with the Microzensus data only, due to the included spatial variables which allowed the exploration of the spatial and modal correlations mentioned above.

The impact of spatial variables in the neighbourhood and those at the shopping trip destinations were analysed separately. The impact analysis of spatial variables in the neighbourhood included only shopping trips which were shorter or equal 3 kilometres and which were made by slow modes or car. Since the descriptive analyses showed no significant correlation between neighbourhood supply and public transport use, public transport was excluded as mode choice option. Therefore, the dependent variable “mode choice” turned into a dichotomous variable with the attributes going by car or not. The probability of going on foot/by bike or not is therefore given indirectly.

Whereas the analysis of the impact of spatial characteristics of shopping destinations included shopping trips which were longer than 3 kilometres and made by public transport or car. Due to the longer distances in this data selection, slow modes were not considered as mode choice option. In this case, the dependent variable „mode choice“ turned into a dichotomous variable as well, but with the attributes choosing public transport or not. Again, the probability of taking the car is calculated indirectly.

As explained above, the two attrubutes of the dichotomous variable are events that can occur or not. In this study, they represent mode choice between slow modes and car in the first case and the mode choice between public transports and car in the second case. With a binary

logistic regression, the probability of each of these specifications can be calculated in dependency of the covariates mentioned above.

The probability of one of the attributes of the dichotomous variable, e.g. going shopping on foot, is given by:

$$p = \frac{1}{1 + e^{-z}}, \text{ while } z = b_1 \cdot x_1 + b_2 \cdot x_2 + \ldots + b_n \cdot x_n + a$$

x_i are the independent variables (covariates), b_i are the coefficients of these covariates calculated by the binary logistic regression and a is a constant. If the probability of an event p is lower than 0.5, the event is assumed not to occur. On the contrary, if the probability of an event p is higher than 0.5 the event will most probably occur.[9] The aim of a binary logistic regression is to estimate the coefficients in such a way, that the two attributes of the dichotomous variable are separated clearly. The magnitude of the coefficients b_i indicates how clear these attributes are separated. The greater the coefficients b_i, the better the two attributes of the dichotomous variable are separated.[10]

3.2 Results

The results of the binary logistic regression analysis on the impact of spatial neighbourhood variables and shopping trip destination variables on mode choice are presented separately in the following two chapters.

3.2.1 The impact of spatial variables in the neighbourhood on mode choice

In a first step, a selection of neighbourhood variables was done by a correlation analysis among the neighbourhood variables in the enriched Microcensus 2000 dataset. The variables characterising the neighbourhood in this dataset were the following. Except the accessible sales area and the sum of distances to the next services, all variables refer to a buffer of 300 m around the household location.

- The number of inhabitants within the catchment area
- The accessible sales area inside a five-kilometre-buffer around the household location
- The sum of distances from the household location to the nearest service facilities (post office, bank, doctor, pharmacy)

[9] Bühl, A. & Zöfel, P. (2002) SPSS 11, Einführung in die moderne Datenanalyse unter Windows, 8. überarbeitete und erweiterte Auflage. München: Pearson Studium.

[10] Backhaus, K. et al. (2000) Multivariate Analysemethoden: eine anwendungsorientierte Einführung, 9. überarbeitete und erweiterte Auflage. Tokio: Springer.

- Number of consumer markets (sales area > 2500m2)
- Number of large (1000-2500m2) and small (400-1000m2) super markets
- Number of large (100-400m2) and small stores (< 100m2)
- Number of retail stores (30m2) such as bakeries, butcheries, greengroceries, dairies etc.
- Availability of a public transport stop within the buffer of 300m
- Sum of all stores in the neighbourhood

The initial regression model showed quite a good fit, since the included variables explained nearly 12 percent of the variation in mode choice (Nagelkerke R Square), see Table 11. But the number of habitants, the number of consumer markets and the number of small stores turned out not to be significant for the decision whether to go shopping by car or not, see Table 12.

Table 11 Fit of the binary logistic regression model including all neighbourhood variables in the Microcensus 2000 dataset.

-2 Log Likelihood	Cox & Snell R Square	Nagelkerke R Square
5917.776	.081	.117

Table 12 Significance, direction (b-value) and strength (exp b) of the impact of spatial variables in the neighbourhood on choosing the car for doing purchases.

Neighbourhood variable	b-value (direction of impact)	Significance	Exp b (strength of impact)
Number of inhabitants	.000	.978	1.000
Accessible sales area	.000	.000	1.000
Sum of distances to services	.000	.025	1.000
Number of consumer markets	-.266	.124	.766
Number of large supermarkets	-.306	.008	.737
Number of small supermarkets	-.496	.000	.609
Number of large stores	-.320	.000	.726
Number of small stores	-.035	.579	.965
Number of retail stores	-.049	.019	.952
Availability of public transport stop	-.268	.000	.765
Constant	.042	.635	1.043

Therefore, another binary logistic regression analysis was done with a reduced set of variables, excluding the non-significant variables and variables with b-values of 0 in Table 12. The excluded variables were the number of inhabitants, the accessible sales area, the sum of distances to services, the number of consumer markets and the number of small stores.

The fit of the reduced regression model, which included only five of the initial neighbourhood variables, had decreased surprisingly. The remaining variables explained hardly 10 percent of the variation in mode choice (Nagelkerke R Square), see Table 13. Nonetheless, the five remaining variables turned out to have a significant impact on mode choice, more precisely on doing purchases by car. Their negative b-values indicate a negative relatinship to shopping trips by car. That means that the availability of a public transport stop and a high number of supermarkets, large stores and retail stores in the neighbourhood seem to prevent people from doing their purchases by car, provided that they have access to a car. Facing the relatively low b-values and strength of impact, the findings show only tendencies and may not be taken as assured.

Table 13 Fit of the binary logistic regression model excluding the non-significant neighbourhood variables from the initial model.

-2 Log Likelihood	Cox & Snell R Square	Nagelkerke R Square
5988.897	.069	.099

Table 14 Significance, direction (b-value) and strength (exp b) of the impact of the remaining neighbourhood variables on choosing the car to go shopping.

Neighbourhood variable	b-value (direction of impact)	Significance	Exp b (strength of impact)
Number of large supermarkets	-.354	.002	.702
Number of small supermarkets	-.486	.000	.615
Number of large stores	-.359	.000	.698
Number of retail stores	-.113	.000	.893
Availability of public transport stop	-.373	.000	.688
Constant	-.214	.001	.808

3.2.2 The impact of spatial variables of shopping trip destinations on mode choice

The same analysis was done with the spatial variables of shopping trip destinations. Before performing a binary logistic regression analysis, a selection of variables describing spatial characteristics of the shopping trip destination in the Microcensus 2000 dataset was done by a binary correlation analysis (Pearson's squared). Spatial attributes such as the municipality area, the inhabitants, employees or the settlement area in the municipality were highly correlated to the total sales area or the availability of an express train stop in the municipality. Therefore, these specific spatial attributes of municipalities were excluded from the logistic regression. Since the total food sales area was highly correlated to the total sales area, this variable was also excluded from further analyses. The remaining spatial variables of shopping

trip destinations which were included in the binary logistic regression model were the following:

- Distance to the next big agglomeration
- Distance to the nearest agglomeration
- Total sales area
- Express train stop
- Availability of motorway connection
- Shopping trip destination was a shopping centre (yes/no)

The fit of the initial binary logistic regression model was remarkably good, since the included variables explained 28 percent of the variation in mode choice (Nagelkerke R Square), see Table 15. Nonetheless, whether the shopping trip destination was a shopping centre or not seems to have no significant impact on mode choice, more precisely on doing purchases by public transport. Although the total sales area and the distance to the nearest central area and to the nearest agglomeration were highly significant, their b-values of 0 and their strength of impact of 1 indicated that these variables had no influence on mode choice. Therefore, these four variables were excluded from a second logistic regression, see Table 18.

Table 15 Fit of the binary logistic regression model including seven out of 14 spatial shopping trip destination variables in the Microcensus 2000 dataset.

-2 Log Likelihood	Cox & Snell R Square	Nagelkerke R Square
3011.941	.171	.280

Table 16 Significance, direction (b-value) and strength (exp b) of the impact of seven out of 14 spatial shopping trip destination variables on the public transport mode choice.

Destination variable	b-value (direction of impact)	Significance	Exp b (strength of impact)
Distance to the nearest central area	.000	.000	1.000
Distance to the nearest agglomeration	.000	.011	1.000
Total sales area	.000	.000	1.000
Express train stop	1.141	.000	3.131
Availability of motorway connection	.391	.000	1.478
Shopping centre (yes/no)	-.169	.176	.845
Constant	-2.308	.000	.100

The Nagelkerke R Square of the reduced model was lower than in the initial one. The variables of the reduced second binary logistic regression model explained only 22%, which is still a quite good quality. The b-values and the directions of impact of the express train stop and the availability of a motorway connection had even improved. Thus, these two variables

seem to be the most important ones for doing purchases by public transport instead of doing them by car.

Table 17 Fit of the binary logistic regression model including seven out of 14 spatial shopping trip destination variables in the Microcensus 2000 dataset.

-2 Log Likelihood	Cox & Snell R Square	Nagelkerke R Square
3177.130	.136	.222

Table 18 Significance, direction (b-value) and strength (exp b) of the impact of seven out of 14 spatial shopping trip destination variables on the public transport mode choice.

Destination variable	b-value (direction of impact)	Significance	Exp b (strength of impact)
Express train stop	1.912	.000	6.768
Availability of motorway connection	.623	.000	1.865
Constant	-2.977	.000	.051

4. Summary and Conclusion

The descriptive analyses of the KEP dataset in chapter 2.1 showed that the trading areas of bigger cities are generally larger than the trading areas of shopping centres. The share of shopping trips by car was generally higher in the KEP dataset than the share of shopping trips by public transport. But the highest share (94.7%) of shopping trips by car lead to shopping centres. A noticeable result was, that in the KEP record, most shopping trips (64.2%) neither lead to cities nor to shopping centres. This could be judged as a clue to the importance of retail stores in the home municipality.

The exploration of the Microzensus dataset in chapter 2.2 revealed a relationship between the total sales area in the neighbourhood and the modal split of shopping trips. The bigger the sales area in the neighbourhood, the less trips are made by car but the more trips are made by public transport or by slow modes. No clear relationship could be seen between trips which are shorter than 300m and the total sales area in the buffer of 300m around the household location. But the descriptive analyses showed that there seems to be a relationship between the sales area in the neighborhood and the shopping trips to cities or shopping centres. The larger the sales area in the buffer of 300m around the household location, the less people go shopping in cities or shopping centres.

The results of the binary logistic regression in chapter 3 suggest that the number of supermarkets, large stores and retail stores in the neighbourhood may prevent people from going shopping by car, given that they have access to a car. But since the b-values and strength of impact of these variables were relatively low, the results may only show tendencies. Whereas an express train stop or the availability of a motorway connection at the shopping trip destination (municipality) seem to have a high impact on the decision to go shopping by public transport. In other words, the probability of going shopping by public transport increases with the availability fo an express train stop and the non-availability of a motorway connection in the destination municipality of the shopping trip.

Although the descriptive analyses suggested a relationship between the sales area in the neighborhood and the distance, destination and mode of shopping trips, the binary logistic regression revealed that spatial variables of the shopping destination, more precisely the availability of an express train stop or a motorway connection have a higher impact on mode choice than neighbourhood variables. Nonetheless, the binary logistic regression suggests at least a low negative relationship between the quality of the neighbourhood shopping supply and shopping trips by car.