Trip generation of grocery shopping trips using survey data:
A case study in the Netherlands

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ABSTRACT
Although grocery shopping is one of the main travel purposes in urban traffic, relatively little is known about this purpose. In this paper, we aggregated reported trips from a survey in the Dutch city of Almelo to study the generation rate of home bound grocery shopping trips. The results show that both socio-economic characteristics of the households and urbanization levels have little influence on trip rates. Only shoppers in single households show lower trip rates. There is however a clear relation between the distance to the nearest supermarket and trip rate. People that live nearby a supermarket will make more shopping trips. Most of these trips are made by bike or foot. It is obvious that the share of the car in the modal split increases with the distance to the nearest supermarket. The data actually also shows that the average trip rate by car increases with this distance, despite the overall reduction in shopping trips over longer distances. This result suggests that relocation of supermarkets to the periphery of urban areas may lead to a higher car use for this travel purpose and therefore to more nuisance. The results can help to quantify the negative effects of such relocations. The results do also contribute to a better understanding of grocery trips and the way to model them.

KEY WORDS
Trip rate, supermarket, car use, aggregated approach

WORD COUNT
4,788 words, 4 figures and 2 tables

1. INTRODUCTION

The understanding of traffic flows in an urban environment is an important issue with reference to policy making. Problems with traffic nuisance and air quality are increasingly seen as being a threat to the livability in Dutch cities. Inhabitants of the Dutch, medium-sized city of Almelo (n=4224) stated that the biggest neighborhood problems are related to traffic nuisance (*1*). Over forty percent of the population in Dutch cities indicated that they experience traffic nuisance as an impediment to the livability of residential areas (*2*).

A better insight to traffic flows will help local policy makers to implement better policies regarding urban traffic. This requires reliable data on the different trip purposes. According to the Dutch National Travel Survey (NTS), more trips are made to shops (23%) than to work (21%). The survey indicates that 72% of all shopping trips are related to grocery shopping (*3*). A good description of trip generation and distribution for these trips is therefore important.

However, data on traffic volumes and travel behavior concerning grocery shopping are scarce and often inaccurate. Existing studies show large discrepancies. According to the Swedish national travel survey for example, a person makes 0.2 shopping trips per day (*4*). In the United States, based on the NTS (*5*), a daily trip frequency of about 0.6 was found. Whether these results are inaccurate or travel behavior in Sweden and the US is very different, remains to be seen. We do know that collecting complete data on short non-commuting trips like grocery shopping trips is quite hard, and those trips tend to be underreported in national travel surveys (e.g. *6 and 7*). Hence, the conclusion is that more knowledge on grocery shopping trips is needed.

In the past decades, supermarkets became larger. Besides physical limitations for expansion (*8*) of supermarkets, city centers faced increasing land prices and decreasing accessibility (*9*). Therefore, many supermarkets relocated to the periphery of the urban areas. This often led to increasing distances between supermarkets and residences. At the same time, supermarkets became more accessible by car, e.g. because they got large number of (free) parking places (*10*). As a result, the share of the car in the modal split for grocery shopping trips has increased over the years (*8*). The question, which we will address in this paper, is what the effect might have been on the total number of car trips, by taking into account the spatial dispersion of supermarkets.

In this paper, we use high resolution city wide survey data from the Dutch city of Almelo to estimate the trip generation of grocery shopping trips. In section 2, we describe the data. In section 3, we describe the applied methodology and in section 4 we show the most important results. Section 5 provides conclusions. In another paper (*11*), we use data from the same survey to describe trip distribution.

2. DATA

In the Netherlands and in many other countries, data from National Travel Surveys (NTS) are used to describe travel behavior. The Dutch NTS (MON) is a large household survey which is carried out throughout each year. In the questionnaire of the MON household members are asked to fill in which trips they have made at a given day. The MON survey, however, is not very suitable for estimating the trip generation of grocery shopping trips. Firstly, short non-commuting trips are underreported, because in these kinds of surveys, short trips are more easily forgotten by respondents (*6*), (*7*). Secondly, since origins and destinations are registered on a relatively course zonal level (on average 2.2 km^2 in cities), the survey is less suitable to study the influence of spatial factors like the dispersion of supermarkets on trip rates.

For the latter reason, we decided to use high resolution, good quality data from a local household survey, Omnibus, which has been conducted by the municipality of Almelo for many subsequent years (since 1985). The main objective of the Omnibus telephone survey is to acquire information on attitudes, opinions and behavior of the citizens on a wide number of policy relevant topics (*12*). As part of Omnibus, one person per household is asked which two supermarkets are visited most frequently, what their corresponding frequency rates are, and which mode of transport is used. Both the location of the households and the supermarkets are known on a Dutch postal 6 zone level (in Almelo 0.04 km^2 on average). This resolution is high enough for a reliable estimate of the influence of spatial factors on the

trip rate generation. In Figure 1, we show the spatial distribution of the population and the locations of the supermarkets in Almelo. The cross-section length of the figure is about 5 km.

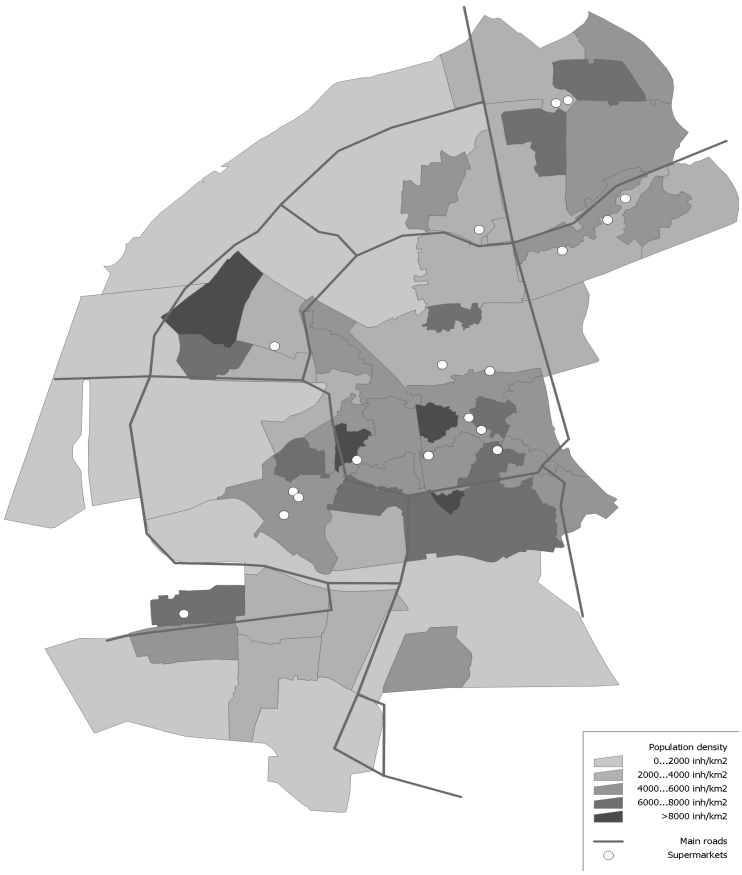

FIGURE 1 Distribution of population and location of supermarkets in the neighborhoods of Almelo

By combining the Omnibus databases from 2006 and 2007, we obtained a data set with nearly 3000 cases. This sample is large enough to compare the trip generation for different household types, urbanization levels and spatial configurations.

Despite the good quality of the data and the consistency in the survey methodology for many consecutive years, the Omnibus survey also has some drawbacks. Most neighborhoods and household types are equally represented, but students and foreigners are under represented, because many people in these groups do not have a land line telephone connection. To correct for under representation, the municipality applied correction factors for these population groups. With regards to grocery shopping, respondents are asked for their regular travel behavior, so incidental shopping trips are not reported. Also, it is not known whether respondents combine visits to supermarkets next to each other in one single trip. Furthermore, respondents can only indicate one travel mode per supermarket, while in reality they may use different modes. Finally, only one household member is interviewed. If this person does not do the grocery shopping, the respondent is asked to answer for the household member that does the shopping. The survey therefore yields trip rates per shopper rather than per person or household. The latter ones are usually used in traffic models.

A general remark on deploying Omnibus is that the findings are based on just one city, whereas we want to draw generic conclusions. We therefore applied other datasets to validate the results. The Omnibus survey data were firstly compared with results of a specific question in Omnibus 2004 regarding car trips made from home and with an additional survey to the time use survey of 1990 (*13*). Then, the data were compared with data from the Central Agency of Foods Business (CBL) and the so-called Super Parking Scan SPS (*10*).

The data of the CBL is based on a questionnaire which is carried out among shoppers (i.e. the person in the household who is responsible for doing the grocery shopping) and provides information on trip frequencies (*14*). The questionnaire is comparable to the Omnibus questionnaire. However, the scales in Omnibus and CBL are different. In Omnibus respondents were asked to indicate whether they go to the supermarket; daily, more than once per week (not daily), once per week, once per fortnight or once per month. The CBL provides the percentages of shoppers that visit the supermarket; once (or less), twice, three times, four times or five times (or more) per week. In Omnibus, intermediate frequencies (2 – 4 times a week) are thus aggregated in the group: more than once per week (not daily). We used the CBL to redistribute the trips in this group over the intermediate frequencies, by assuming that the average trip frequencies are equal for Omnibus and CBL. In the next section, we will show that this assumption appears to be valid.

The Super Parking Scan (*10*) estimates the number of paying customers of a supermarket based on its characteristics (e.g. size and service level). The model was developed by investigating a large number of supermarket receipts, complemented with information on the postal zone of the customer and the travel mode used. Hence, SPS is based on observed data from the attraction side (supermarkets) and therefore gives results from a different angle. We obtained SPS trips rates per household, by dividing the total number of customers of all supermarkets by the number of households in Almelo. These data were used in a comparison between trip rates per shopper (from Omnibus and CBL) and household trip rates (from SPS).

3. METHOD

There are several methods to estimate trip generation. We took an aggregated, descriptive approach, deploying category analysis. We made groups of similar household structure, urbanization levels and 'spatial configurations', and then compared the trip rates for the different groups. An alternative would have been to use a disaggregated approach. By describing individual choices the results could become more generic. However, the dataset is based on the city of Almelo and it is yet unclear whether the results can be applied to other cities. The advantage of the aggregated approach is that results directly follow from the observations, i.e. we did not need to make assumptions on shopping travel behavior.

Some studies, e.g., (*15*), (*16*), consider household size, household composition, income and age to be important factors that influence trip generation. Based on these studies we distinguished six household types: single households, elderly couples (age of the head of the household above 65 years), low income couples without children in the house, high income couples without children, low income families with children and high income families with children. For the urbanization level we distinguished four levels: the dense central region in the center, the older neighborhoods around the center (center ring), the residential areas in the suburbs (sub urban), and the rural areas in the outer region. Both the household variables and urbanization levels are standard zonal statistics in many countries, available through the internet. By using these variables for the categories the study results are better applicable.

The attractiveness of a shopping location is influenced by the presence of other shops in the proximity (*17*). Agglomeration of shops caters for higher number of trips compared to a similar shop outside a shopping area due to a possibility of combining different shopping purposes. These influences however are more from the perspective of trip attraction and therefore have a bigger influence on the distribution than on the generation of trips of a household. To model trip production of households indicators focusing on the spatial characteristics of households would be more useful. According to (*18*), shopping behavior is influenced by the spatial dispersion (i.e. the accessibility) of shops. There are several ways to define the spatial configuration. The distance to the nearest supermarket is the simplest measure.

In our paper on grocery shopping trip distribution (*11*), we show that most trips are made to nearby supermarkets. It is therefore plausible that the distance to the nearest supermarket is an important, if not the most important, measure for spatial configuration in this regard. We used the Euclidean distance as distance measure. For internal distances (when the residents and supermarket are in the same zone), the Euclidean distance was calculated by $0.5r$ with r being the radius of the postal 6 zone. The Euclidean distance is strongly correlated with network distance and travel time. The latter variables may be better indicators for the spatial configuration, but accurate estimates are far more difficult to obtain.

4. RESULTS

In this section the most important results are presented. In section 4.1, we compare the average trip rates for Omnibus, CBL, and SPS. In section 4.2, we show the relation between trip rate and spatial configuration, i.e. the distance between respondent and the nearest supermarket. In section 4.3, we compare the trip rates for different household types and urbanization levels.

4.1. Average trip rates

As mentioned in section 2, we validated the Omnibus data with other Omnibus car use data and an additional survey to the Dutch time use survey. In both instances the Omnibus data yield similar results. Next we compared Omnibus with CBL and SPS. In table 1 we compare the frequency of grocery shopping in Omnibus and CBL. According to the table, the trip frequencies are comparable. From this we conclude that Omnibus and CBL provide similar results.

TABLE 1 Percentage of shoppers visiting supermarkets with certain frequency: Omnibus vs. CBL

Frequency	Percentage of shoppers	
	Omnibus	**CBL**
Once a week or less	19%	21%
More than once per week	73%	68%
Daily	8%	11%

The average Omnibus and CBL trip rate is 2.6 visits per shopper per week (*19*). The SPS also provides an average trip rate. This rate was estimated by dividing the total number of paying customers of all supermarkets by the total number of households. The average SPS trip rate is 4.7 visits per household per week. The SPS estimate is thus significantly higher than that of CBL and Omnibus.

An obvious reason could be that the SPS estimate comprises the entire household rather than just one shopper. With the help of some new questions in Omnibus 2009 we investigated this. Table 1 gives an overview of who is doing the shopping in an Omnibus household. The obvious result is that in younger families the adults shop more separately than together at the same time. It can be deduced from the table that the average number of paying shoppers per household is 1.1. The average weekly household trip rate is 2.7, which is less than 110% of 2.6 visits. The reason for this result is that the trip rates per person for couples with or without children are substantially lower for households where they shop together. The trip rates per person for households where they shop separately is comparable to the trip rates for non-single households where one person in the household does the shopping. Hence, the difference between the Omnibus/CBL and SPS cannot be explained by differences in trip rates between shoppers and households.

TABLE 2 Responsibility grocery shopping per household type: Omnibus 2009 Almelo

Household type	Share	Responsible for shopping		
		One person	Two persons, but shop together	Two persons, separately
Single	28%	96%	2%*	2%*
Elder couples	17%	42%	45%	13%
Young couples	25%	51%	35%	14%
Families with children	30%	63%	20%	17%

* These shares are mainly a result of elderly singles who receive help with their shopping from other people

Another difference is that Omnibus and CBL are based on answers of respondents, while the SPS estimates are based on observed behavior. It is possible that respondents underestimate their trip rates. In particular, respondents may forget to report shopping trips that are not regular. On the other hand, the SPS gives an indirect estimate of the trip frequency with an unknown bias. The SPS estimates also include visitors that do not live in Almelo, although we believe, considering the spatial context, that this bias is marginal. Finally, it should be mentioned that the trip rates from CBL and Omnibus are still significantly larger than those from Dutch NTS data.

More detailed studies, possibly complemented with other data sources, are needed to get more reliable estimates on the average trip rates for the grocery shopping purpose.

4.2 Trip rate and spatial configuration

In section 3, we explained that we use the Euclidean distance to the nearest supermarket as a measure for the spatial configuration, as viewed from the origin of the resident. In Figure 2, we show the average trip rate for origins in different distance bins. We also show the shares of the different modes. The figure shows some interesting relations. The average trip rate over all modes decreases almost linear with the distance to the nearest supermarket. When the nearest supermarket is very nearby, the average trip rate is almost 3 trips per shopper per week. When there is no supermarket nearby, the average trip rate drops below the 2.5 trips per shopper per week.

We have checked whether the trend, i.e. the overall slope and the curves per mode, is not induced by a possible relation between distance to the nearest supermarket and household type or urbanization level. We therefore distinguished the different household types and urbanization levels as defined in the previous section. Although there are small differences in the Intercept, we find that all groups show the same slope as in Figure 2.

The negative slope can be explained in two ways. Although the figure does not provide information on the trip length distribution, we know that most grocery shopping trips are made to nearby supermarkets. The propensity to choose a supermarket sharply declines with distance. Thus, a supermarket in the proximity of a household may attract more trips from that household. Figure 2 also shows that slow modes become very attractive when the nearest supermarket is nearby. Since shoppers cannot transport many groceries by bike or foot, this may lead to more trips as well.

When the household types and their particular slopes are considered, we find comparable values. The high income families show a slightly shallower slope indicating they might be less affected by distance, but the difference is marginal and not significant. The intercept differs between the household types (as will be shown in Figure 3) but the differences in decay of the number of trips are minimal.

The share of car trips increases with distance to the nearest supermarket. In fact, the (absolute) car trip rate increases significantly as well. This is in accordance with observations that show that the number of car trips has increased due to the relocation of supermarkets to the periphery of urban areas (*8*).

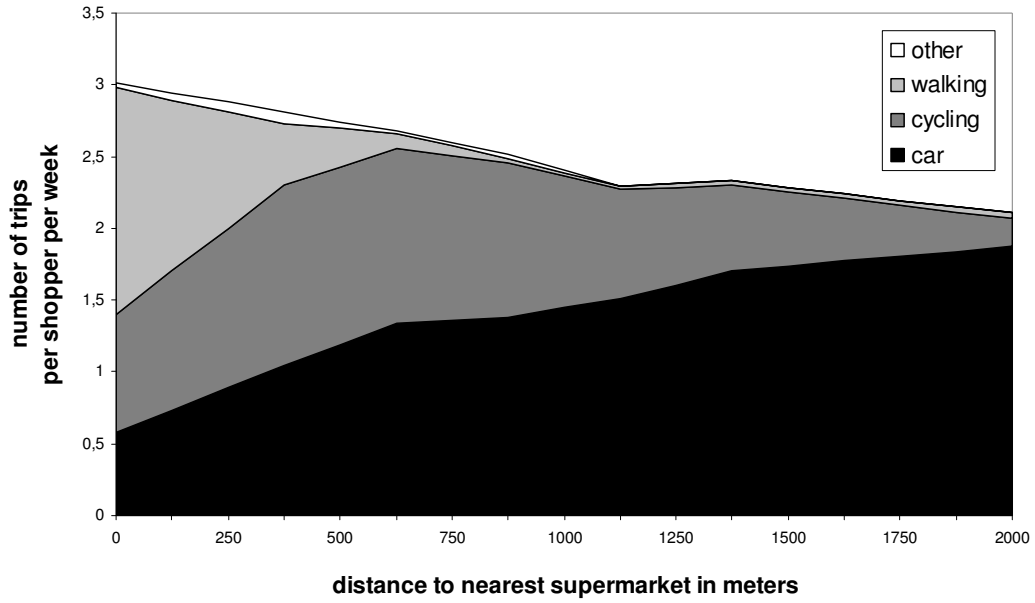

FIGURE 2 Relation between the distance to the nearest supermarket and the average grocery shopping trip rate (per shopper) per mode.

Figure 2 contains the average trip rates for the whole population of shoppers. If we only consider car users, we find an average trip rate of around 2 trips per shopper per week. This car trip rate is significantly lower than the average trip rate for shoppers that use slow modes. This rate is also independent of the location of the nearest supermarket. Figure 2 therefore actually illustrates how the fraction of car users increases with distance to the nearest supermarket. Measures, like stricter parking policies, might have an effect, but will probably not lead to a drastic reduction in car use. Offering more supermarkets in the proximity of residences will probably be more effective. This study can be used to quantify the effects of such measures on the generation of car trips.

We also looked at the slopes for different income groups. As expected, the slope for low income groups was steeper and therefore showed a stronger effect of distance to the nearest supermarket.

4.3 Household types and urbanization levels

In this subsection, we look at the average trip rates for different household types and urbanization levels. We take into account that the average distances to the nearest supermarket are not equal for all groups. In the city center, for example, supermarkets are more densely distributed. We used the relation in Figure 2 to correct for this effect. All trip rates are corrected such that they correspond with a distance to the nearest supermarket of 750 meters.

In Figure 3, we show the trips rates of shoppers for each household type. The bars indicate the averages and their bandwidth (2σ). The figure shows that the average trip rate is significantly lower for single households. If elderly were excluded from the singles category, the trip rate would even be lower. We have no explanation for this result yet. Larger households are expected to make more grocery shopping trips, but the figure shows the trip rate per shopper and not per household. In fact, according to the super parking scan data, the trip rate per household could be significantly larger. This would imply that the difference between single households and other households would become much larger if we consider the trip rate per household. As shown in Table 2 this effect is marginal. This could mean that differences in trip rates between the data sources are mainly caused by irregular trips. However, as mentioned before, we do not know exactly how we can compare the figures from the different data sources.

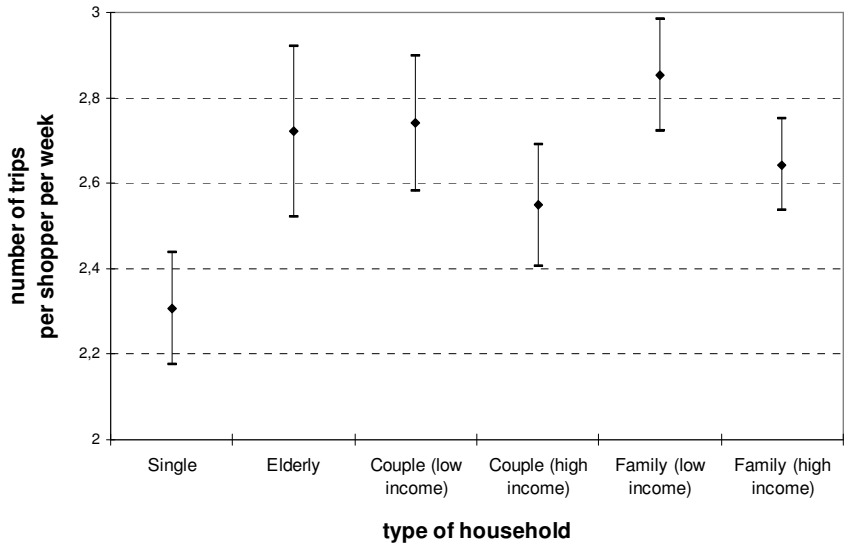

FIGURE 3 Average trip rate for shoppers from different household types

The trip rates of other household types do not differ significantly from each other. There appears to be some tendency for high income households to make slightly fewer trips (not significant). This result would not be unexpected, since car ownership is somewhat higher for high income groups, and because of other obligations (work) they have less time to do shopping.

In Figure 4, we show the trip rates for different urbanization levels. We corrected for the fact that the density of supermarkets and the mix of household types are not the same in all areas. After this correction, we find that differences between urban areas are marginal. There is an indication that residents in the city center make fewer grocery shopping trips, although this result is not significant in the statistical sense. A possible explanation for a lower trip rate in the city center could be the presence of specialized food shops and shops with a food department.

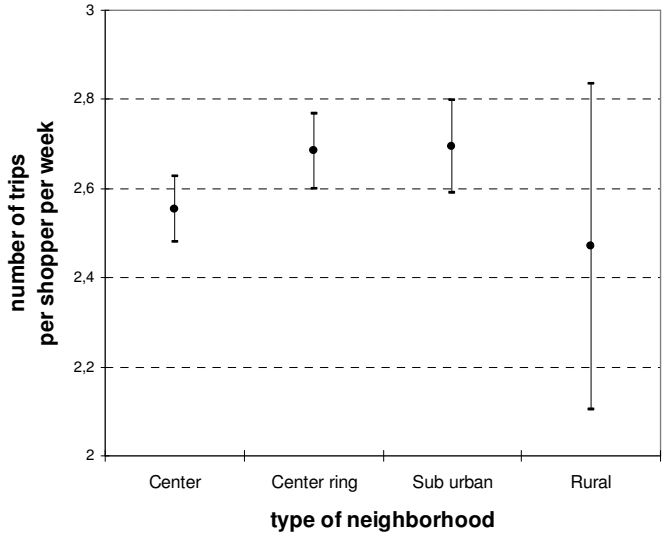

FIGURE 4 Average trip rate for shoppers from different residential areas

5. CONCLUSIONS

This paper shows the main results from a study of the trip generation of grocery shopping trips in a medium-sized Dutch city.

We find that the average trip rate is about 2.6 trips per shopper per week. This may be an underestimation due to the fact that irregular trips could be underreported. It should be noted, however, that the Dutch NTS, which provides a basis for traffic modeling, arrives to lower trip rates. A more detailed study, including other data sources, might provide more reliable estimates, that can lead to more accurate modeling of grocery trips..

Despite the uncertainty, this study discovered some important relative trends between different groups of shoppers. We used an aggregated approach to distinguish different household types and urbanization levels. We find that shoppers in single households make significant fewer trips. There is also some indication that shoppers in high income groups make slightly fewer shopping trips, but this result was not significant. The same applies for the trip rates for residents in the city center. A small negative, but not statistical significant, difference was found between the trip rates in the central and outer regions of Almelo. We can conclude that, in general, trip rates are quite comparable between different household types and urbanization levels.

The distance to the nearest supermarket, on the contrary, proved to be the strongest determinant for the trip rate of grocery shopping. The trip rate declines when the distance between the residential area and its nearest supermarket increases. This relation is similar for the different household types. However, this picture changes completely, if we distinguish between transport modes. For car trips, the average trip rate per shopper increases strongly with distance to the nearest supermarket. This result can be attributed to the fact that the number of car users becomes larger when the distance to the nearest supermarket increases. The trip rate of car users is independent of the location of the nearest supermarket.

The variable distance to the nearest supermarket is easy to obtain. The Euclidean distance between the centre of a neighborhood and the nearest supermarket can be calculated from maps or with the help of GIS. With results like the ones presented in Figure 2, the amount of grocery traffic can be calculated and traffic impact effects can be assessed. We think that the results are therefore politically relevant.

The research also confirms that the relocation of large supermarkets will lead to a higher car use in grocery shopping. Small grocery stores in the neighborhoods can be an enrichment for the social environment, but will also lead to positive traffic effects, which can be quantified by this study. Bringing the supermarkets back to the customers will reduce the traffic nuisance caused by grocery shoppers.

ACKNOWLEGDEMENT

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