TRAFFIC EFFECTS OF LOCATING GROCERY STORES - environmental and economic effects of locating shopping centres outside of the C.B.D.

Risto Murto
Institution for Transportation Engineering
Tampere University of Technology

July 1996

Paper Prepared for “Trafikdage på Aalborg Universitet” 19.-20. August 1996

Abstract

Recent policy in Finland regarding retail trade for daily products has been to invest in large shopping centres and hypermarkets located outside main city areas, often close to traffic interchanges. This has led to a number of problems. Small local shops located in the city have had difficulties in surviving. Often these large shopping areas can only be reached by car, which causes problems for those without private transportation possibilities. For retailers, however, these centres represent a logistically efficient way to operate with respect to both goods supply and customer demand. Thus, the traffic effects and the economic and environmental efficiency of such strategies can be questioned. Is it from the vantage point of society better to make longer but less frequent trips compared to the older pattern of frequent local trips? This study examined different locational alternatives: large shopping areas outside the city versus shops located at various places throughout the city and an alternative, where shopping is partly done by electronic commerce with home deliveries. The aim was to measure and compare the traffic effects of these approaches. As a result it was found out that locating four new hypermarkets in the region would increase the yearly mileage of private car traffic and goods transport by 6 percent. The land-use alternative, where there were no hypermarkets, would decrease the yearly mileage by 25 percent and the land-use alternative of home shopping would decrease the yearly mileage by 17 percent.

1. Introduction

People have different opinions about large shopping centres and hypermarkets outside the city centre area. Those who are concerned about environment envision that locating shopping centres outside urban centres will lead to more mileage and increased pollution. They are also worried that shoppers without cars have difficulties reaching these locations. In contrast some others, like retailers, believe that it is better that people drive less often, say weekly, to buy bigger amounts at a same time. From a logistics standpoint they also think that it is better to deliver goods with large trucks to these larger units rather than have many small delivery vans driving around the city.

However, a question still facing the planners and political decision makers is what would be the best solution for the location of shopping centres from the environmental and economical point of view. In Finland the retail trade sector for daily products has several plans to invest on large shopping centres near traffic interchanges and outside city areas. Political decision makers have stated that a need for scientific research in this field is obvious. There is also a political problem, how much independence should municipalities be given regarding the decision making for planning on their area. In Finland the municipalities have a freerein concerning these decisions. This can cause problems, because municipalities are sometimes competing with each other and when making such decisions, for example, for hypermarkets they only consider what is best for their own community and not for the society as whole.

This paper studies whether it is better from an economic and environmental point of view to allow shopping centres to locate outside the city area or to guide city planning to locate grocery stores as small local shops spread over the city area. One way to look at these issues is to build a transport model, which can measure changes in the traffic networks caused by different land use alternatives. This model consists of a logitmodel for shopping trips, a transport model for goods transport and a forecast model for the whole city area.

As an application of the model, one Finnish city (Tampere) was examined in this a study. For modelling three different land-use alternatives were created. In the first alternative there will be four new hypermarkets located outside the city centre near the major traffic interchanges. In the second alternative there is a number of smaller shops (supermarkets) around the city area instead of these hypermarkets. In the third alternative 20 percent of the people do their shopping using electronic commerce, where the ordered products are delivered home by private companies. In figure 1 can be seen the structure of

Tampere city area and the location of grocery stores in all these land-use alternatives.

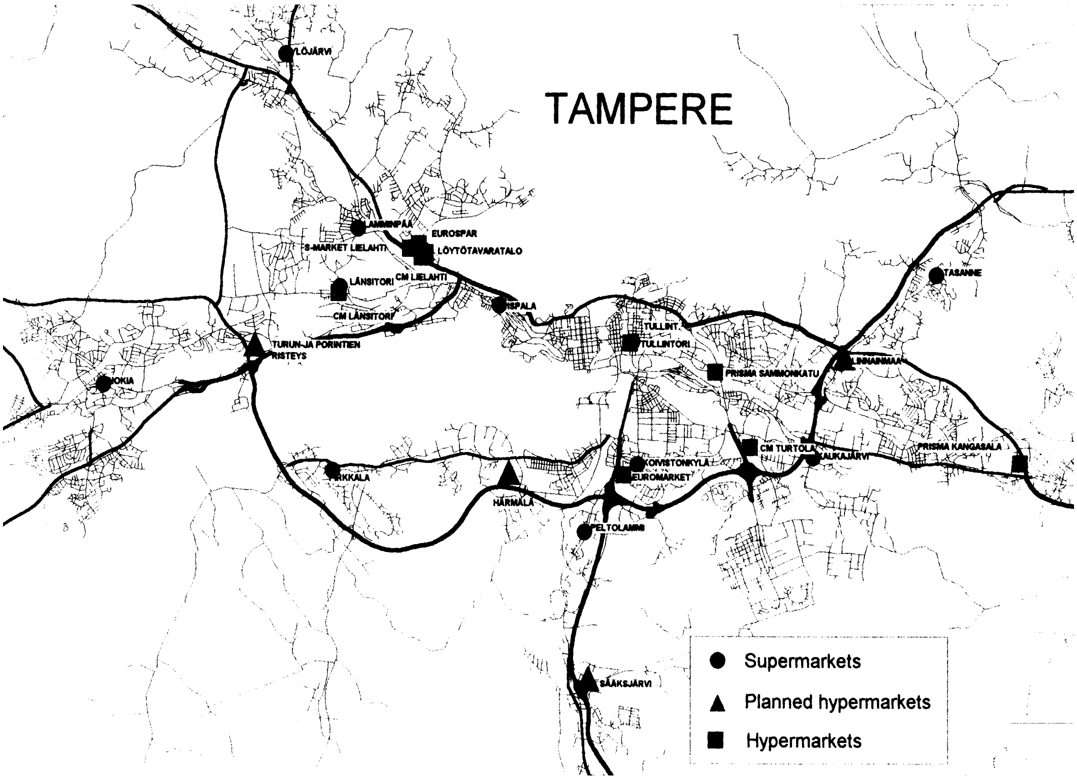

Figure 1. The location of grocery stores in different alternatives on the Tampere city area.

The project itself has been a joint project between the universities of technology in Stockholm and Tampere. The work has been done mostly in Tampere, with Lars-Göran Mattsson from the department of Regional planning in Stockholm providing guidance in the construction of the models.

2. Method

2.1 Description of method

One possible way to study the effects of locating the shopping centres and hypermarkets is to build a transport system model, which has submodels for shopping trips and goods transport. To assess which land-use alternative is best from the economic and environmental point of view, we have tried to estimate the shopping behavior and its effects on the transport network.

The traffic behavior data were collected by interviewing people in different types of grocery stores locating in the area. This method is so called choicebased sample, which has been taken into consideration when building the logit model for shopping trips. Altogether 1100 interviews were made. The model for goods transport of grocery stores was created by collecting transport data from the companies operating in the area. With the parameters from the logit model was built a forecast model for the whole city area in order to be able to calculate the differences between land-use alternatives.

The obtained results were e.g. changes in the travel times and volumes of different modes. With this information the economic and environmental effects of the land use alternatives can be calculated. The structure of the calculation is shown in figure 2.

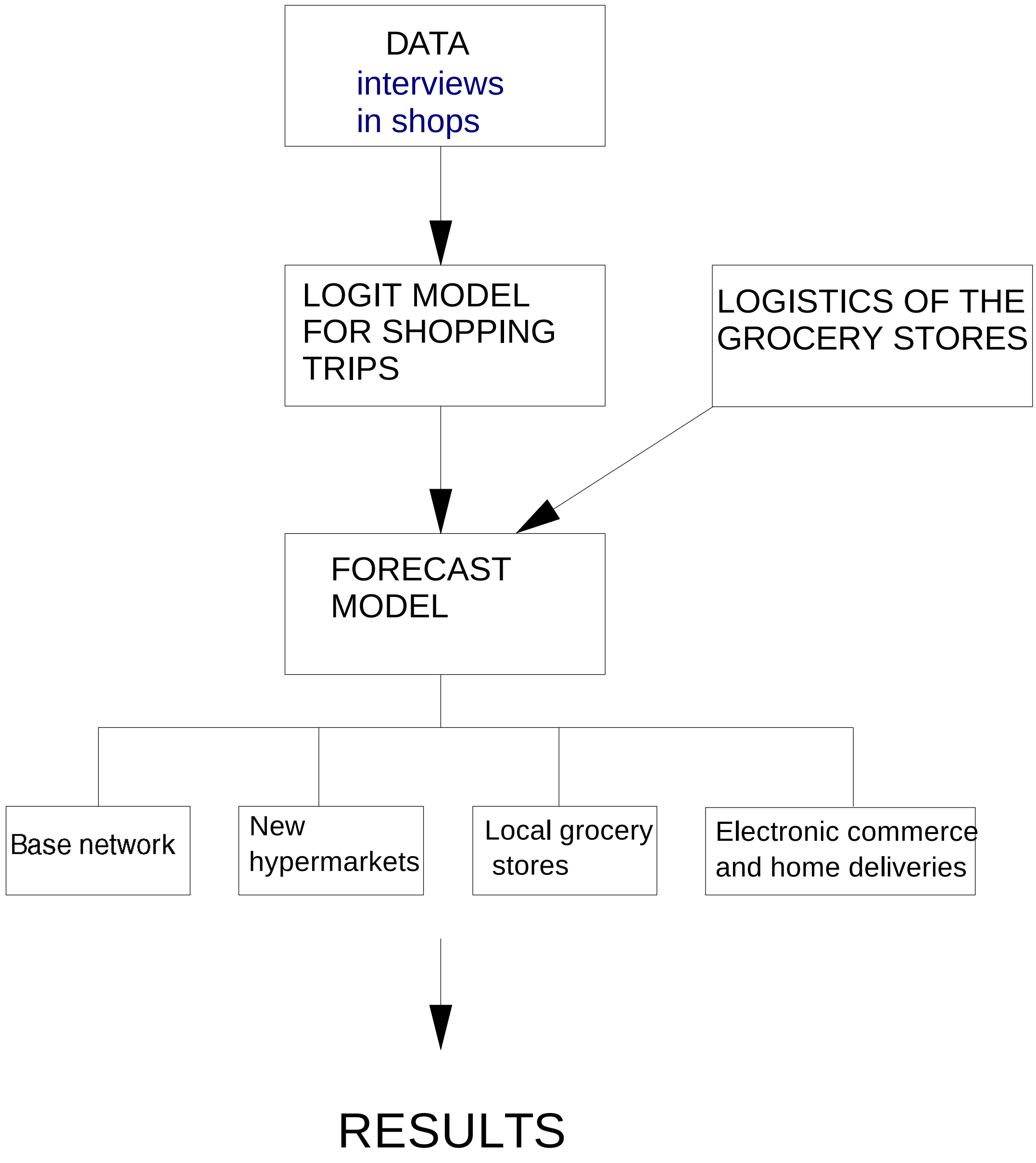

Figure 2. Structure of the method.

2.2 Logit model for shopping trips

In this study a logit model was built to estimate the shopping behavior. Usually people are relatively free to organize their shopping. When modelling the shopping trips the demand for goods, the choice of shopping strategy, the distribution of trips over the household members and the effects of time restrictions usually have to be taken into account.

The basic principle of a logit model is that people tend to behave rationally: they are constantly trying to maximize their utility. This utility can be described with a utility function divided into two components, which are the strict utility and a stochastic element. The utility function can be expressed as follows:

$$U(X_{in}) = V(X_i) + e_{in} \text{ ,}$$

where $V(X_i)$ = measurable attribute (strict utility)
e_{in} = stochastic element

The logit model was built so that people had six alternative shops and four different modes (car, walking, cycling, public transport) to choose from. Thus totally 24 alternatives were possible. The chosen logit model is as follows:

$$P_{jm|i}^{k_1k_2k_3k_4k_5} = \frac{e^{\alpha_{q(j)m}+\beta_m d_{ie(j)}+\gamma_{q(j)}\ln S_j+\delta b_{q(j)m}^{k_5}+\eta c_{q(j)m}^{k_4}+\varphi f_{q(j)m}^{k_3}+\psi h_{q(j)m}^{k_3}+\omega a_{q(j)m}^{k_2}+\xi u_{q(j)m}^{k_1}}}{\sum_j\sum_m e^{\alpha_{q(j)m}+\beta_m d_{ie(j)}+\gamma_{q(j)}\ln S_j+\delta b_{q(j)m}^{k_5}+\eta c_{q(j)m}^{k_4}+\varphi f_{q(j)m}^{k_3}+\psi h_{q(j)m}^{k_3}+\omega a_{q(j)m}^{k_2}+\xi u_{q(j)m}^{k_1}}}$$

where
i= housing zone
j= grocery store
m= mode
s_j= turnover of grocery store
q(j)= type of grocery store
e(j)= EMME/2 zone
$\alpha_{q(j)m}$= coefficient for modal choice
β_m= coefficient for distance
$d_{ie(j)}$= distance from home to grocery store
$\gamma_{q(j)}$= coefficient for type of shop

δ= coefficient for family with children
η= coefficient for type of dwelling
φ,ψ= coefficients for shopping frequency
ω= coefficient for people without private car
ξ= coefficient for unemployment
b= family with children
c= type of dwelling (detached house)
f= low frequency in shopping
h= high frequency in shopping
a= households without private car
u= households with unemployed people
k_{1-5}= socioeconomic group of the household

Approximately 50 different modelstructures were tested, from which the model above had the best “rho-squared”-value = 0,4192. Also the t-test ratios filled the criteria for an acceptable model.

2.3 Model for goods transport

The goods transport model was built by interviewing companies operating in the city area. In figure 3 is schematically shown the goods transport system of grocery stores in Tampere region. It was found out that the volumes are very small compared to the total traffic in the area.

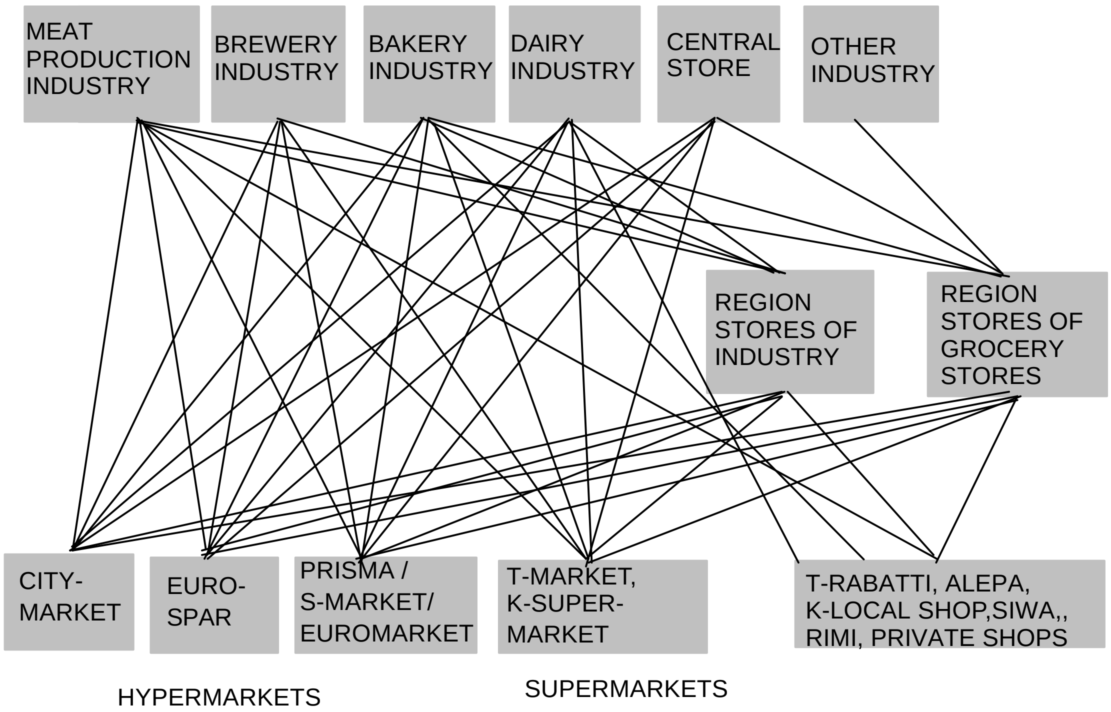

Figure 3. The goods transport system of grocery stores in Tampere region.

3. Results

The main result of the study is the amount of shopping trips and their modal split in the area. Compared to the base situation the model estimates minor changes in the travel behavior, if more hypermarkets are built in the area. Also the private car traffic would increase only slightly, from 168 000 trips/week to 180 000 trips/week. However, more significant changes occur when there are no hypermarkets or part of the shopping is home shopping. The amount of private car trips would decrease to 127 000 trips/week in the local grocery stores alternative and to 131 000 trips/week in the home shopping alternative. The results are shown in figure 4.

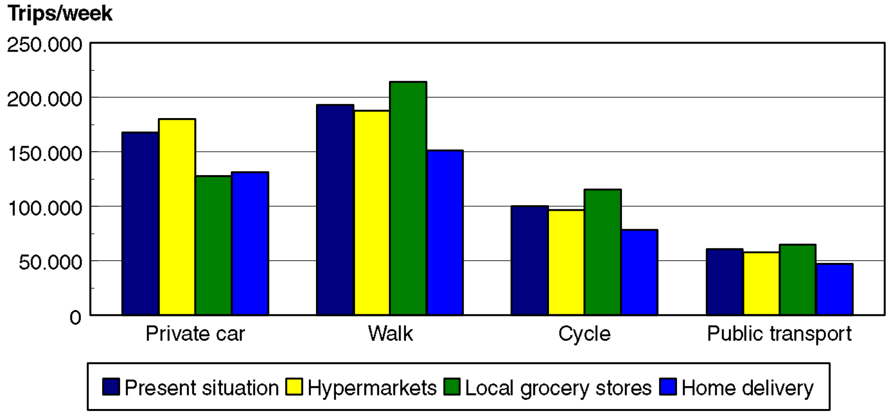

Figure 4. The amount of shopping trips to grocery stores by different modes in Tampere region.

The yearly mileage of shopping trips and the goods deliveries to grocery stores is shown in figure 5. New hypermarkets would increase the total mileage of shopping trips by 6 % while the land-use alternative with no hypermarkets would decrease the yearly mileage by 25 %. Home shopping would decrease the mileage by 17 %.

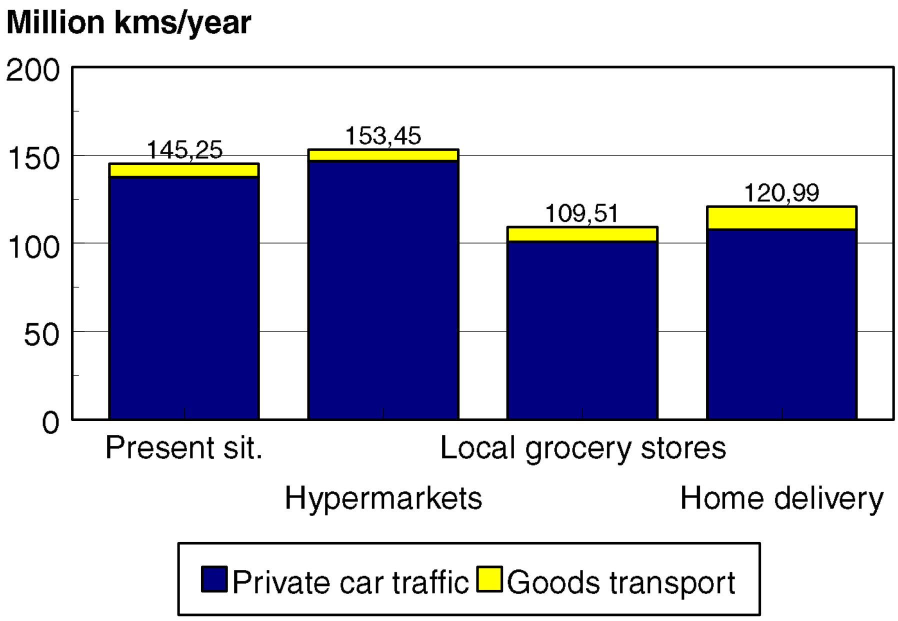

Figure 5. The mileage of shopping trips and goods transport to grocery stores in Tampere region.

The difference in the exhaust gas emissions is very small when the hypermarket alternative is compared to the base situation. E.g. the amount of CO emissions would increase from 1224 tons/year to 1339 tons/year. Greater effects are achieved in land-use alternatives with no hypermarkets and home shopping. The amount of CO emissions would decrease respectively to 808 tons/year and 958 tons/year. The results are shown in figure 6.

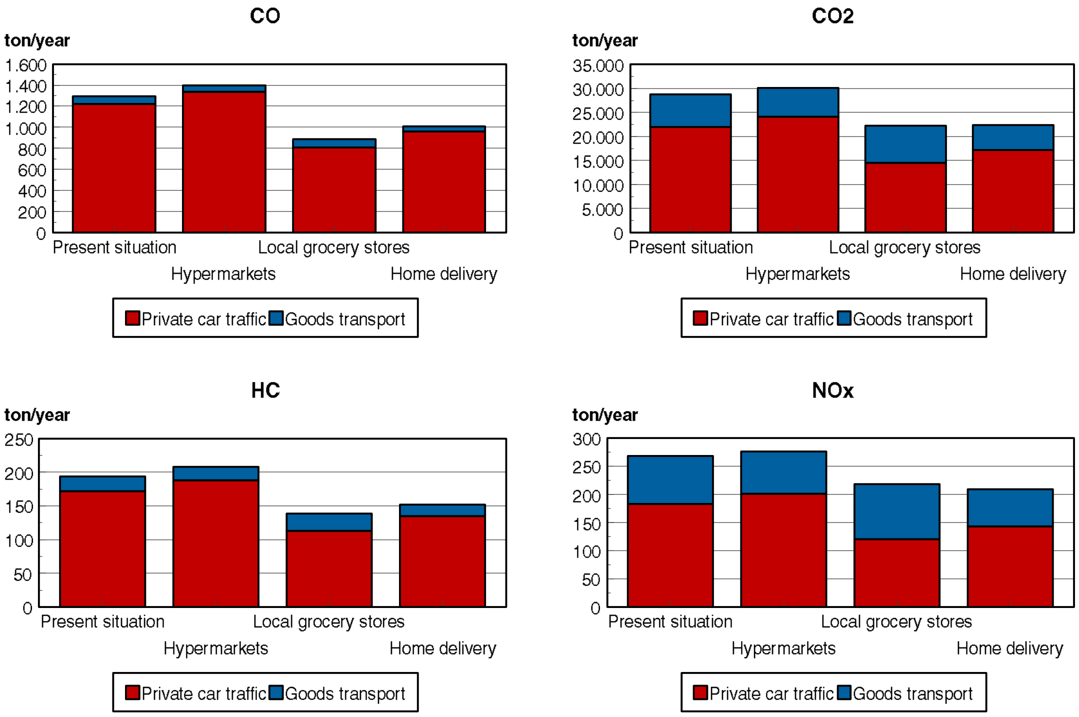

Figure 6. The effects on emissions.

4. Discussion

The dominant mode on shopping trips is walking. This means that most of the shopping trips in Tampere region are made to local shops by walking or cycling. Private car is the second largest mode with about 167 000 trips/week. The main purpose of the study was to examine the traffic effects of locating grocery stores, of which the most interesting are the effects on private car traffic and goods transport to grocery stores.

According to the results It is obvious that new hypermarkets would increase the total mileage of shopping trips and the benefits from more efficient goods transport wouldn´t compensate the increased mileage. However, when there already are hypermarkets, new markets would increase the total amount of private car traffic only a little. People seem to choose the “local” hypermarket as their first shopping place instead of driving to a hypermarket at a longer distance.

Greater effects on private car traffic are gained in land-use alternatives of no hypermarkets and home shopping. However, compared to the total traffic in the area, these effects are relatively small. This causes difficult problems for the political decision making. It is easy to say that the location of new hypermarkets has a minor effect on the amount of private car traffic, but on the other hand the emissions of private car traffic would be smaller in the situation, where there are no hypermarkets.