Energy Efficiency in Grocery Distribution in Denmark - 1960 to the Present

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Synopsis

An analysis of the post-war development of grocery distribution in Denmark, focusing on transport demand and fuel consumption, and investigating the role of the motor vehicle.

Abstract

The development of the energy efficiency of Danish grocery distribution from 1960 to the present is analysed, covering both the supply system (to the retail shops) and the shopping transport (from shops to individual homes). This period has been characterised by fundamental restructuring of the retail sector, including the grocery sector, and by thorough changes in consumption and shopping patterns. During the same period, the large-scale introduction of the motor vehicles (passenger cars, vans, trucks) took place in Denmark, and therefore, the changes have been closely linked to the motorisation of grocery distribution.

From 1960 to the present, the number of grocery retail shops has been reduced by about 60%, and also the shop types and locations have changed fundamentally. In addition, the loyalty of the consumers towards the nearest shops has declined considerably.

In a study carried out by the author, the transport, energy and environmental effects of those changes have been analysed. Between 1960 and 1993, the transport demand for grocery distribution has been found to have increased nearly 4 times on the shopping side (passenger transport) and nearly 3 times on the supply side (freight transport), while the fuel consumption (and CO2-emissions) has increased 2,5 times. Only about 40% of the increase can be explained by grocery consumption growth, whereas the remainder can be termed as deterioration of the distribution efficiency.

1. Introduction

The post-war period in Denmark has been characterised by profound changes of both structures and behavioural patterns of the grocery sector. In the 1950s, the sector to a great extent consisted of decentralised structures based on neighbourhood specialist shops, whereas today the structure is much more centralised, being made up of fewer and larger shops, each aimed at a broader range of needs and each serving much greater areas. A similar centralisation trend can be seen in the manufacturing and wholesale trade of groceries. The development has two main aspects, namely structural changes on the one side and changes in lifestyles and consumer behaviour on the other, and it has been closely linked to the technological development of both retail shop equipment and transport technologies.

This is the background for the project, “Energy and Environmental Impacts of Grocery Distribution” (Jørgensen 1995), which this paper is based on. The objective of this project, which was carried out between 1992 and 1995, was to investigate the overall energy and environmental effects of grocery distribution, using existing data. Both the distribution between suppliers and retail shops (termed “wholesale distribution”) and the distribution between shops and consumers (“shopping transport”) were covered by the project.

2. Changes in the Grocery Sector since the 1950s

The background for the development of the grocery sector is profound changes in post-war Denmark, notably in the household structures (declining household sizes, increased shares of married women working outside the home) and land use and localisation patterns (more owner-occupied single family houses, a movement from rural to urban areas and from city centres to suburbs). Moreover, there has been strong economic growth and increased private and public spending, resulting in declining fractions of the total consumption being spent on basic goods, such as groceries. There has been a rapid expansion in the possession of durable consumer goods, such as refrigerators, freezers and automobiles. There has been a strong growth in energy consumption and traffic, linked to a combination of changes in social structures and lifestyle. The structural changes in the post-war society have promoted very distance-intensive lifestyles and distribution systems, and vice versa - similarly to the development in other industrialised countries (Vilhelmson 1990, Knoflacher 1993). In this development, the large-scale introduction of the motor vehicle has played a key role as catalyst.

The restructuring of the Danish grocery sector during the post-war period can be characterised by two keywords: concentration at all levels (manufacturing, wholesale and retail sale) and integration at the retail level. Today, most retail shops participate in chains, buying associations or the like, and consequently the individual retail shops are linked much closer to specific wholesalers than used to be the case (Monopoltilsynet 1988; Stockman 1992; Jørgensen 1995).

The turning point was around 1960, before which the grocery distribution networks were mainly locally based, with retail outlets serving their immediate neighbourhoods, and wholesalers, and to some extent even manufacturers, serving bounded geographical areas - i.e. a structure based on decentralised networks, centred around towns and cities. In contrast, the present distribution network is a nation-wide and centralised structure, with the major part of the manufacturing and wholesale taking place through organisations covering Denmark as a whole, and with retail outlets being increasingly disconnected from their local communities.

In the following, four important structural development trends are outlined: (1) concentration on fewer and larger outlets; (2) the development of new shop types; (3) the development of competition between shops; and (4) the virtual disappearance of the independent grocer's shop (Jørgensen 1995).

The concentration trend has resulted in a decline by about 60% in the number of grocery retail shops from the 1950s until today, cf. Figure 2-1. The only major exception from this decline has been the newspaper and magazine shops, which have roughly tripled in numbers since 1958, but this can be explained by a change in the role of these shops from specialist shops to a sort of small neighbourhood shops. Moreover, retail shops have been concentrated in city centres and shopping streets, at the expense of shops in the residential areas, villages and rural areas (Jørgensen 1995). This means that, on average, the distance from homes to shops has increased considerably during the period.

Secondly, a range of new shop types have been introduced, to the extent that most of the shop types dominating the scene in the 1990s have emerged from the 1950s onwards. The first of these new shop types to appear on the scene - and still the most important - was the supermarket, which was introduced at a small scale in the 1950s and spreading rapidly from the early sixties onwards. Indeed, most of the new shop types can be seen as variations on the supermarket. The new shop types are generally characterised by: (1) self-service; (2) their aim to cover, in principle, all grocery demands (leading to large assortments); (3) application of new technology in the shops; and (4) demand for higher turnovers.

The turnover of the supermarket of today typically is 20-40 times larger in fixed prices than the average grocer's shop of the 1950s, and the vary popular so-called "variety stores" (i.e. large supermarkets with a high non-food share) are typically 50-100 times larger than the 1950s shop. Therefore, the modern grocery shops inevitably serve much larger catchment areas.

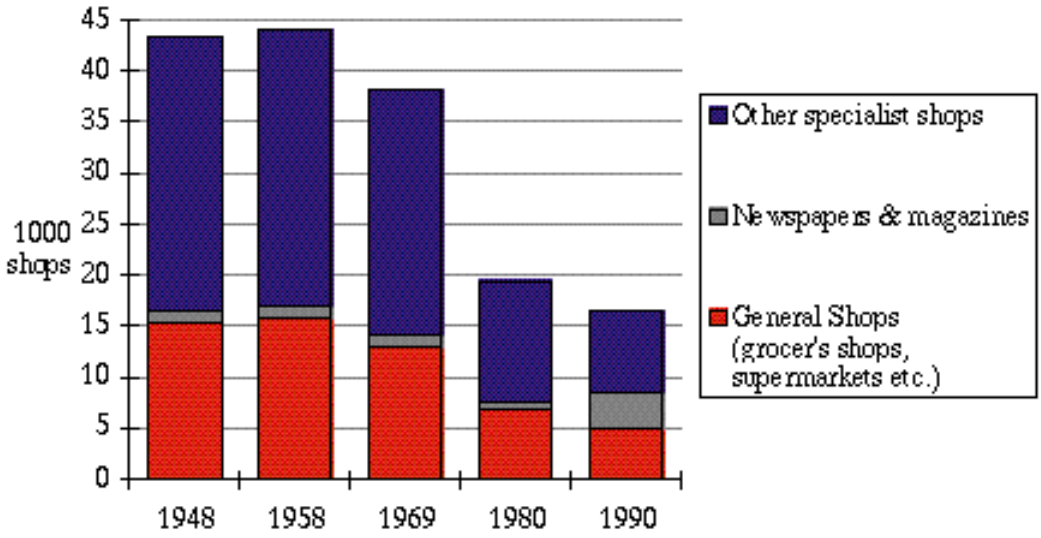

Figure 2-1. Grocery retail shops in Denmark and distribution on main shop categories.

Thirdly, since the 1950s competition has evolved both between grocery shops in different geographical areas and between different shop types. Until the 1950s, customers were almost 100% loyal towards their local shops (i.e. placed all of their shopping in the same shop). There was relatively little competition between different lines of business in the grocery sector, and the small catchment area typically served by each shop reduced the need for competition between shops. Hence, when the supermarkets emerged on the scene about 40 years ago they, in effect, introduced competition between shops, both geographically and between different shop types, replacing not only the traditional grocer's shops but also different specialist shops (bakeries, dairy shops etc.).

Today's retail shops may be divided into three main categories according to their market orientation: (1) shops on central locations serving local communities beyond the immediate neighbourhood (e.g. supermarkets); (2) shops with regional market orientation (distances of 25-50 km or more), frequently, though not necessarily, placed on out-of-town locations (hyper markets); and (3) neighbourhood shops serving the immediate surroundings (e.g. mini markets and newspaper shops). Roughly, the first-mentioned category accounts for about 70-75% of the grocery retail turnover in Denmark, while the second accounts for about 10% and the third for 15-20%.

Much attention has been focused on the role of the regionally oriented shops, which is appropriate since each of these shops can have a profound influence on both retail structure and shopping patterns. But these very large shops are only the tip of the iceberg, especially in Denmark where the development of hyper markets has to some extent been curbed by planning restrictions (Jørgensen 1995). The main problem from a transport planning point of view has been the elimination of neighbourhood shops (Cairns 1995a; Cairns 1995b).

Finally, the period has seen the virtual disappearance of the independent grocer's shops, dominating the scene in the 1950s. Today very few general grocer's shops do not participate in either an integrated chain (with joint ownership of the retail shops) or is linked to a wholesaler in one way or another.

3. Grocery Shopping Patterns

Grocery shopping is made up of different elements:

- the consumption patterns, i.e. the quantity (by weight and value) and product mix of the grocery consumption;
- he shopping patterns, i.e. the distribution of the grocery consumption on shops and shopping times;
- the shopping transportation patterns, i.e. the shopping journeys and transport modes.

3.1. Grocery Consumption and Shopping Patterns

The product assortment and consumption patterns have changed fundamentally from the 1950s until today. Then, the major part of the grocery consumption consisted of anonymous products sold by the pound, whereas today assortments are dominated by pre-packed products, with a higher percentage of proprietary articles. Generally, the product range has increased substantially, including various completely new product categories (notably refrigerated and frozen food). Thus, the product range has become one of the factors on which customers base their choice of shops, whereas 30-40 years ago proximity was the predominant decision criteria. Also the product range means that selecting the commodities has become a much more difficult and varied task, thus increasing the requirement for the customer to go to the shop rather than utilising distribution services.

The average Danish household (equivalent to 2,3 persons) consumes about 1800 kg of groceries at home annually plus about 4-500 kg of packing (Jørgensen 1995). Fresh, refrigerated food (dairy products, meat, fish etc.) accounts for nearly 30% of the grocery weight, whereas non-refrigerated beverages and fresh vegetables and fruit account for 23% and 14% respectively. Frozen food accounts for only 75 kg (5% of the total), in spite of the fact that Denmark is second only to the USA with respect to consumption of frozen food.

Although the changes in shopping patterns can be linked to the development the retail structure to a great extent, changes in consumers' preferences (criteria for selection of shops, increased mobility) play an equally significant role. In the 1950s, the consumer usually visited a number of shops, located within walking distance, to cover their need for groceries, while today most of the daily shopping needs are normally covered by means of much larger one-stop shops, located at a greater average distance to the home of the consumer. Hence, the changes have a dual nature:

- as a consequence of new options becoming available to some consumers through the access to motor vehicles;
- as changes being imposed on all consumers - whether possessing af car or not - as a result of the structural changes.

3.2. Grocery Shopping Transport Demand

In (Jørgensen 1995), the development of the grocery shopping transport demand from 1960 until the present has been calculated based on statistics. The results, naturally, should be treated with caution, especially those from the early part of the period. Still, the findings are quite clear-cut, and even substantial misjudgements in so far as the oldest data are concerned would not alter the conclusions substantially.

According to the study, the calculated transport demand linked to grocery shopping has increased 3,8 times from 1960 to the present, while car driving has increased almost 7 times, cf. Figure 3-1. In 1960, the average grocery shopping transport distance per capita was 3-400 metre, while today it is 1,2 kilometre.

An analysis of the development from 1981 to 1992 shows an increase in the shopping transport demand by almost 50%, which is much stronger than the transport sector average (Christensen & Jensen 1994; Christensen 1996). As could be expected, this is mainly due to longer average shopping trips, but, more surprisingly, the number of trips have not been reduced. Thus, the widespread perception that the longer travel distances in today's shopping are offset by better planning of the shopping on the part of the consumer is not borne out in practice. In addition, the percentage of shopping covered by cars continues to rise.

Moreover, the distribution services playing a significant role in the 1950s shopping patterns have virtually disappeared today, thus increasing the weight of the goods to be carried home by the consumer.

3.3. The Role of the Passenger Car

The restructuring of the grocery sector has coincided with the large-scale expansion of the motor vehicle in Denmark, and the form it has taken has been strongly influenced by the availability of higher-speed transportation means, leading to very distance-intensive structures and lifestyles. Indeed, the development would have been unthinkable in its present form without motor vehicles, and they play a key role in most decisions regarding

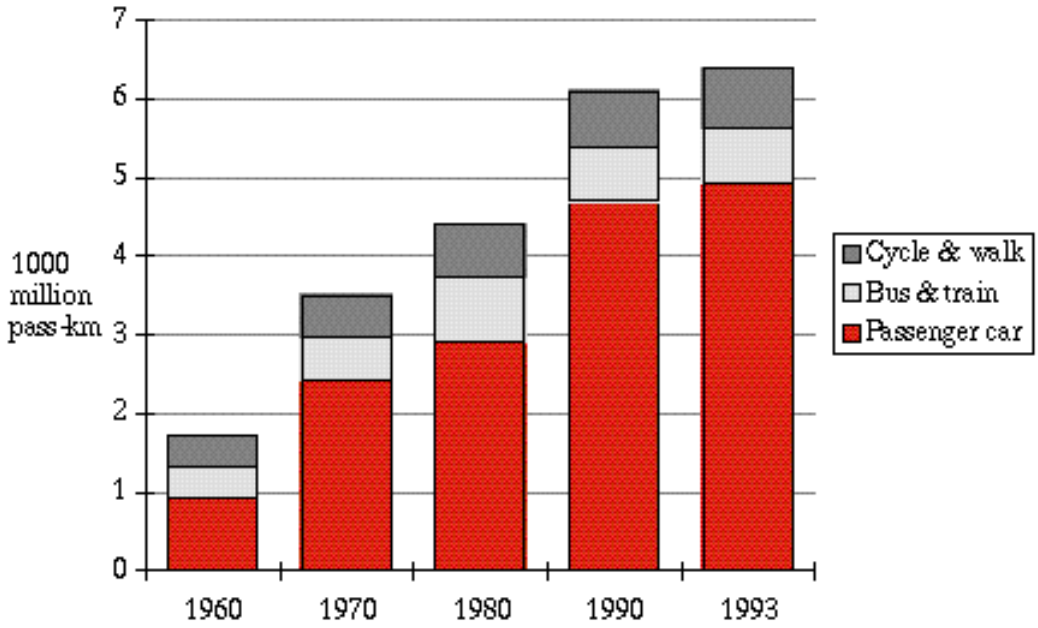

Figure 3-1. Consumers' shopping transport for grocery shopping (Jørgensen 1995).

establishment of new shops - in spite of the fact that only just over half of the households possess a car. Today the passenger car density is 310 per 1000 inhabitants, or just over half of the U.S. level, and the possession of cars is closely linked to the family structure and income. For instance, only about 30% of the single-parent families have car access.

Even so, the prevalence of the motor vehicles has profoundly influenced the grocery sector structure, and thereby the lifestyles connected to the car are imposed on everybody, whether having a car or not. In other words, the motor vehicle enabled the changes in structures and consumption patterns, and these changes in turn has turned the car into a necessity for many households.

The increase of the grocery shopping transport demand roughly corresponds to the increase in average travel speeds. In other words, the higher speeds, on average, are not utilised for time savings, but rather allows greater distances to be covered in the same time duration as before - thus confirming the thesis of constant travel time (Vilhelmson 1990; Tengström 1992; Knoflacher 1993). This is significant since one of the most common explanations given for buying cars is related to time savings on the background of tight - or perceived tight - time budget in many families, and the paradox of the car is that it is on the one hand perceived a necessity for many to save time, while on the other hand much time is used for earning the money to acquire and operate the car.

4. Wholesale Distribution

In this context, "wholesale distribution" designates the distribution of groceries from suppliers to the shops, whether actually carried out by the wholesalers or other agents. In addition to the wholesalers, the groceries may be distributed by the manufacturers or picked up by shop representatives at wholesale storages.

4.1. Distribution Network

The wholesale distribution network - determined by the development at both the manufacturing and the wholesale levels - has developed from being primarily a locally based structure, with the major part of the supply coming from wholesalers located relatively close to the retail shops - to a structure based on nation-wide distribution systems (Monopoltilsynet 1988; Stockmann 1992; Jørgensen 1995). Whereas twenty years ago, even relatively small towns had their own distribution terminals or depots, today each of the dominating wholesalers has one or

two terminals covering the whole of the country. Because the major part of the retail shops are attached to chains or buying associations, their choice of wholesalers is based on their affiliation rather than geographical proximity. An even more pronounced concentration process can be seen at the manufacturing level, both among the primary producers and in the food industry.

The centralised distribution networks mean longer distribution paths - due to the reduction of nodal points (manufacturers, wholesalers, terminals etc.) in the network - being made even longer by the specialisation of manufacturing plants, and by the links between shops and wholesalers. In other words, the distances between the nodal points increase, and the closest nodal point is not necessarily chosen. In principle, there are opportunities for better planning of the distribution, but generally these are not exploited very well, due to other considerations being given higher priority. An example of this is the aim to reduce storages at the shops as much as possible, which means that more frequent deliveries are required.

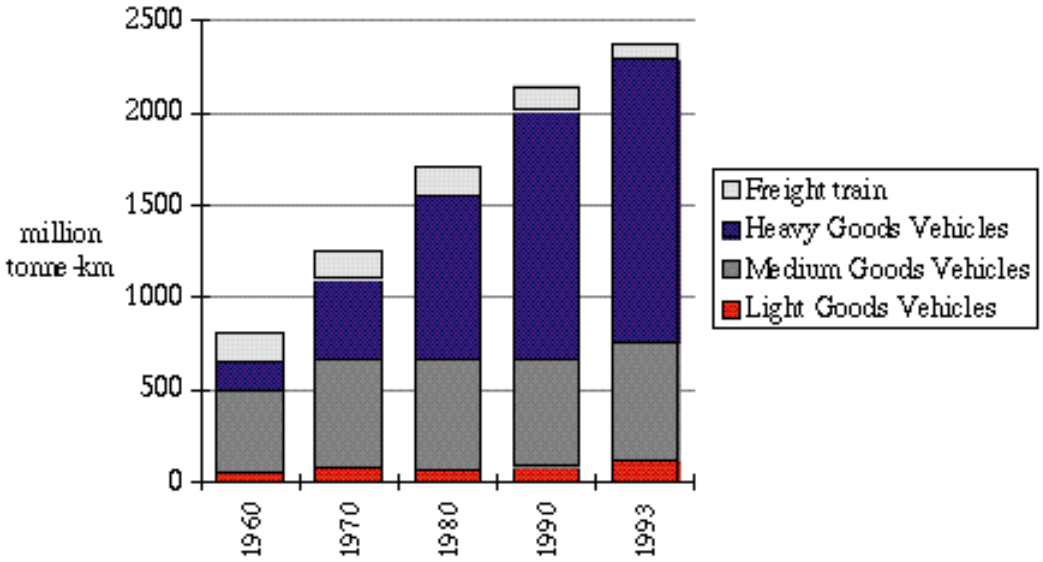

Figure 4-1. Wholesale transport demand (from supplier to retail shops) for grocery distribution in Denmark.

4.2. Wholesale Distribution Transport Demand

Figure 4-1 shows the development of the calculated transport demand in the wholesale distribution, covering national transport from Danish suppliers to retail shops only (i.e. excluding import transport). The total transport demand of wholesale distribution has increased 2,4 times from 1960 to 1993.

A common daily driving pattern of one of the big wholesale dealers or a manufacturer is a total driving distance of 200 to 300 km, of which about 30-40% is local distribution driving, with the journeys to and from the area accounting for the remaining 60-70%. On average, the grocery commodities are transported an estimated 180-200 km from their Danish suppliers to the retail shops, that is excluding transport in conjunction with import (Krarup 1986; Danmarks Statistik 1995; Jørgensen 1995).

4.3. The Role of the Truck

Road vehicles for freight transport - vans and trucks - have played an equally important role in wholesale transport as that of the passenger cars in shopping, as can be seen from Figure 4-1. These vehicles have taken more than the entire increase of the wholesale transport demand of grocery distribution. In addition, the increased door-to-door speeds of the distribution have influenced the distribution structure, resulting in greater centralisation of the distribution processes (Knoflacher 1993; Jørgensen 1995).

Traditionally, the wholesale transport demand has be divided into inter-regional/national, regional and local distribution, each being covered by different vehicle sizes, but today these divisions are to a great extent being blurred by means of the elimination of local terminals, leading to the same vehicles (typically delivery trucks) being used for the whole of the journey from central storage to the individual shops. As a result, over-sized vehicles are employed in local distribution, resulting in either poor capacity utilisation or longer journeys to pick up the payload. Although larger vehicles are generally more energy-efficient per payload capacity, for a given payload in absolute terms a larger vehicle always has a higher specific fuel consumption.

On the basis of transport demand, the predominant distribution vehicle is the heavy goods vehicles (>24 tonnes of gross vehicle weight), used mainly in long distance transport. This clearly reflects the structural development of the sector. Based on tonnes or trips, the lighter vehicles play a much more significant role, however, and the medium-sized delivery truck (gross vehicle weight in the range 6-24 tonnes) has been particularly important in the development of the grocery sector. Light goods vehicles (less than 6 tonnes) cover only about 5% of the grocery sector freight transport demand, but play a significant role in local distribution. Their contribution to the environmental problems of grocery distribution is much higher than their share of the transport demand, though. For example, they account for nearly 30% of the fuel consumption on the wholesale side.

5. Fuel Consumption of Grocery Distribution from 1960 to the Present

Figure 5-1 shows the development of the calculated fuel consumption of grocery distribution in Denmark and its distribution on wholesale transport, delivery services and consumers' shopping transport (excluding import transport). The fuel consumption has been calculated by combining the calculated transport demand and split on transport modes with technology data (Jørgensen 1997).

The total fuel consumption has increased about 2,5 times from 1960 to 1993, with a particularly strong growth on the shopping side. The fuel consumption on the wholesale side has grown also, however, thus confounding the thesis that the more centralised grocery sector structure fuel savings on the distribution side, due to the possibility of more efficient distribution patterns.

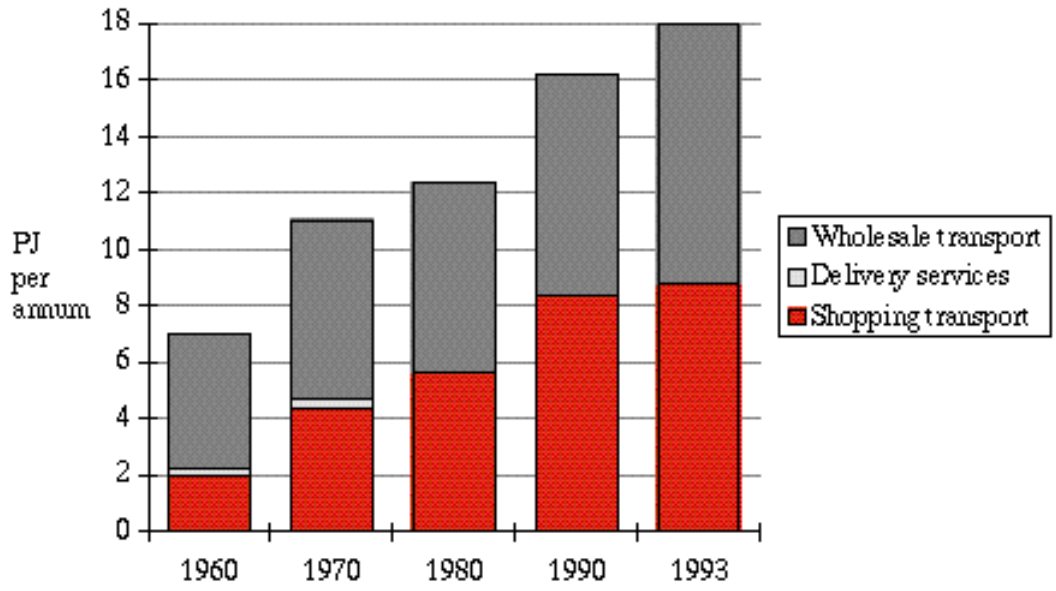

Figure 5-1. Calculated fuel consumption for grocery distribution in Denmark (Jørgensen 1995).

The annual grocery consumption of an average 1993 household (2,3 persons) has been calculated to require a fuel consumption of 3,8 GJ on the shopping side and 3,9 GJ on the wholesale side - i.e. a total of 7,7 GJ/a. The resulting CO2 emissions are 550 kg/a per household. In 1960, the equivalent figures for the then average household (3,2 persons) were 1,4 GJ on the shopping side and 3,2 GJ on the wholesale side - a total of 4,6 GJ/a and 335 kg CO2/a per household.

The fuel consumption has grown slightly less than the total transport demand (shopping and wholesale transport) due to higher efficiency of the vehicles, especially in the wholesale transport.

6. Grocery Distribution Efficiency

The “grocery distribution effiency” compares the fuel consumption and environmental effects to the demands covered by the operation. Here the weight of the goods distributed (in kg) is used as a measure of the demand. Thus, the fuel efficiency is measured as MJ per kg groceries, and the transport efficiency is given as transport demand - passenger kilometre or tonne-kilometre per kg groceries.

Figure 6-1 illustrates this. As can be seen, only a minor part of the growth in transport demand and fuel consumption - 35-40% - can be attributed to a growth in the quantities of groceries distributed. The remainder of the increases - the greater part - must be counted as deterioration of the systems efficiency of grocery distribution.

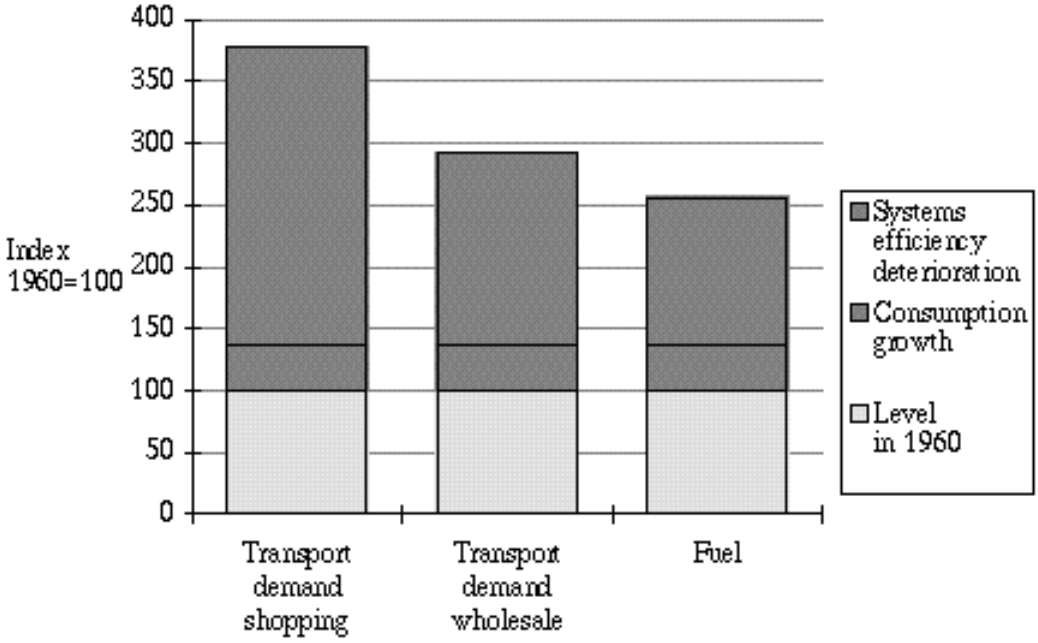

Figure 6-1. Indexed development of transport demand and fuel consumption distributed on the share that can be attributed to growth in the consumption of groceries (by weight) and the impact of deteriorated system efficiency.

It can be seen from Figure 6-1 that the transport efficiency has deteriorated by a factor 2,7 as far as the shopping transport is concerned and a factor 2,1 for the wholesale transport. In other words, the total transport demand required to consume one kilogram of groceries has increased between 2,1 and 2,7 times from 1960 to the present. The fuel efficiency has deteriorated by a factor 1,9.

7. Conclusions

The application of motor vehicles has lead to substantial increases in the fuel consumption of grocery distribution, indicating a poorer systems efficiency of the distribution. It has enabled structural and behavioural changes, resulting in longer distances on both the wholesale and the shopping side of the distribution system. These changes have not been offset by better trip planning (i.e. by a reduction in the number of trips), and on the shopping side there has even been a moderate increase in the number of trips.

Therefore, the development has not only been characterised by the passenger car replacing earlier transportation means, but also by substantial increases of the total transport demand. In other words, the development has moved in the direction of a distance intensive organisations. Families with cars have offset the greater distances by higher traffic speeds, but families without car do not have this option, and hence they are forced to spend more time on shopping.

Acknowledgements

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