Belgian Journal of Operations Research, Statistics and Computer Science, Vol 30, n° 1

THE DEMAND FOR CARS OF DIFFERENT SIZES IN BELGIUM A MARKET SHARE APPROACH

P. DE PELSMACKER

State University Centre Antwerp
Middelheimlaan 1
2020 Antwerp
Belgium

ABSTRACT

The paper focuses upon the modelisation of car demand structure. A market share model of car demand structure by size classes is defined and estimated for Belgian data for the period 1972-1986. The effect of various variables on market share evolution is calculated. A distinction is made between the effect on total demand and the effect on demand structure. A number of scenarios of future economic evolution are presented and the resulting new car demand and demand structure are calculated.

1. Introduction

Substantial effort in car market research has been devoted to the definition and the empirical estimation of models describing total demand, or important mechanisms on the car market as a whole (Madden (1988), De Pelsmacker (1990)). Only the last 15 years or so it has become apparent that not only total car demand as a whole is characterized by important shifts, due to changes in the economic environment, but that the structure of demand, i.e. the composition of demand for cars of different sizes, is susceptible to major changes too.

Understanding the determinants of demand structure, and their relative importance, is highly relevant both to industry and the government. New model design and marketing strategy in general require an exact assertion of the determinants of shifts in the structure of demand by size classes. The erroneous appreciation of the determinants of car demand structure by the American car industry in the seventies, as a result of which this industry has known a severe structural crisis, illustrate the importance of the problem to the car industry. Furthermore, the fact that profit margins are smaller for small cars (Rhys (1972), Cordtz (1974)) makes it necessary to predict as accurately as possible the structure of car demand by size classes.
The government too should be interested in the structure of car demand. A number of car related tax shemes are defined in terms of the size of the car, such as V.A.T. on car purchase

and registration tax. As small sized cars tend to use less fuel, government fuel tax income is affected by demand structure too. Active government regulation of fuel consumption requires an accurate picture of the effects on, amongst other things, car demand structure. Recent studies of the American example show that a clear understanding of the determining factors of demand structure could make government policy more effective (Kwoka (1983), Falvey e.a.(1986)).

As will become clear in section 2, most of the previous car demand models that take into account the structure of demand, try to describe demand evolution in a number of market segments (size classes), thereby neglecting the difference between the effects of a number of variables on total demand and the effects on demand structure. The specific contribution of this analysis lies in the separate modelisation of total demand and the definition of the demand structure model as a simultaneous system of market share equations. A much clearer insight in the different mechanisms on the car market results. This article focuses on the demand structure component of the model. In section 2 a review of the literature on car demand structure is given. The third section deals with the data used, the definition of the size classes, and the evolution of Belgian car demand structure. In section 4 an explanatory model is defined and estimated. In section 5 the effects of some possible scenarios of future economic evolution on car demand are calculated.

2. The determinants of car demand structure

The idea of approaching the car market as composed of a number of more or less homogeneous submarkets or segments is of course well known to marketers, and the study of demand structure has a long tradition.

Total car market can of course be segmented on a market basis, a product basis or a combination of both. As far as the first option is concerned, different segmentation variable categories, such as demographic and consumers' life style, have been used in previous research (Stewart and Hood (1981), Henscher (1985)). However, often the starting point of car market segmentation, and indeed the concern of this paper, is product based. As Funck (1963) has already noted, as consumers are not aware of the subtle differences between models, choices are made on the basis of obvious and very conspicuous car features, such as size, motor power and capacity. These objective features are not important in their own right, but rather serve as an indication of more essential differences between cars (Ginsburgh e.a. (1987)). The segmentation of total car demand on the basis of size variables is therefore considered legitimate and is very often used. Furthermore, as Rosenhek (1981) concludes, size-based segmentation results in an acceptable definition of market segments that are well identified in terms of market (consumer) characteristics too. A product/market based segmentation can apparently be derived from a product based definition of demand segments. Irvine (1983) concludes :

"the degree of substitutability between two models is a function of the closeness in their sizes".

Aggregate demand shifts between size-based market segments should, as a consequence, be limited. Nevertheless, demand structure is by no means rigid and inflexible. In recent years important shifts due to changes in the economic environment have been noticed, indicating that perhaps Irvine's statement still holds to a certain extent, but that the substitutability between models of different sizes has indeed become greater, and that a number of consumer groups have changed their buying habits as a result of the changes mentioned.

The importance of such shifts in car demand structure for both government and business has lead to a number of car market analyses that are explicitely devoted to the study of the determinants of demand shifts. Most of these studies start from an explicit definition of demand structure in a number of size classes. This number of segments that is used in the analysis, and the specific variables, used to define the size factor, differs in the various authors, and is usually a matter of subjective appraisal and availability of the appropriate data. The distribution of car sizes is in fact continuous, and each segmentation definition implies a more or less arbitrary choice of the number of segments in one stage of the analysis or the other. In a number of studies, the "classical" U.S. car market division with 5 segments is used: subcompact, compact, intermediate, full-size and luxury (Carlson (1978), Carlson and Umble (1980), Falvey e.a. (1986)). The exact segmentation criteria are not

defined, but every car model on the U.S. market is conceived as belonging to one of these segments. Berkovec (1985) uses the same segmentation definition, but adds a sports category. Altschuler e.a. (1984) define 5 segments too, on the basis of motor capacity, wheel base and weight. Bhaskar (1980) defines 6 size classes, based on a subdivision of the market used by FORD to guide its European marketing effort. As in the U.S. example, every important car model on the market is assigned to one of the six segments. Greenlees (1980), Tishler (1982, 1983) and Broughton (1985) use a subdivision of the market in three size classes, based on the number of cylinders (Greenlees), and motor capacity (Tishler, Broughton). Blomqvist and Haessel (1978) start from the 5-segment U.S. definition, but after some trial and error, they settle for a two-segment model, the smaller of which contains only the subcompact cars.
The different number of segments and the various segmentation criteria do not seem to lead to fundamentally different research conclusions, as will become apparent from the review hereafter. There are indeed a number of differences between studies, but they do not seem to be attributable to differences in segmentation definition, but rather to differences in model and variable definition and estimation procedure.

Especially the first oil crisis triggered off the study of demand structure. The reaction of the public to increasing fuel prices was not only to put off replacement purchase but also to shift demand to smaller cars. A gradual rise in average car size up to that moment was suddenly interrupted by a severe shift in demand structure. A number of studies suggest that car driving habits were only marginally affected and that in fact shifts in the structure of demand were by far the most important consequence of fuel price fluctuations (Willenborg and Pitts (1977), Dahl (1979), Broughton (1985)). Of course, not only fuel price shocks cause shifts in demand, but shifts in other important economic factors could lead to important changes in demand structure too.

One of the first attempts to analyze systematically the determinants of demand structure by size classes was by Carlson (1978). Demand per person in each of five submarket is assumed to be dependent upon a number of variables: income, prices of new cars of the segment under study and of other segments, attitudes and expectations, secondhand prices, fuel prices, stock of cars on the road, and a number of dummy variables reflecting the net effect of the '73-'74 oil crisis and the effect of a period of strikes upon demand. Secondhand prices were not available in sufficient detail and cross-price variables had to be removed in order to avoid extreme multicollinearity. The Carlson-model is not very consistent. It is by no means evident why the lagged stock variable should be important only in the "compact" and "luxury" segment, why "consumer sentiment" replaces income in the "full" segments or why real fuel price evolution is important only in the luxury segment, whereas nominal prices are used in the other submarkets. Furthermore, one may wonder why an oil crisis dummy has to be used in a model that was intented to describe demand shifts resulting from that same crisis in the first place.

Carlson concludes that especially income and price effects shape demand structure. Especially the growth of demand for subcompact cars has to be attributed to the growth of disposable income. Price elasticity of demand increases as cars become larger. Carlson explains this elasticity structure by defining small cars as necessities and larger cars as luxury goods. The effect of fuel price shifts on demand structure is very marked. Demand for subcompacts, and to a lesser extent for compacts, increases as fuel price increases, whereas demand for the other cars decreases. The author concludes that especially income determines total demand, whereas purchase price and fuel price shape demand structure. A slightly modified version of the same model lead to roughly the same conclusions (Carlson and Umble (1980)). The validity of Carlson's conclusions is hampered by the inability to distinguish between the effects on total car demand and the effects on demand structure.

A number of Carlson's conclusions are confirmed in later studies, but some are contested too. On the basis of survey data Greenlees (1980) calculates the conditional probability of the purchase of certain types of cars. (4-, 6- and 8 cylinder). The author concludes that high fuel prices result in a consistently higher attractiveness of small and medium-sized vehicles. The income elasticity of demand is higher as cars become larger. This conclusion is at odds with Carlson's results but more acceptable. Large cars should indeed be considered as more income-elastic luxury goods. The interaction between a segmented new car market and the secondhand market is analyzed by Blomqvist and Haessel (1978). Although the consistency and the significance of the coefficients is not overwhelming, the surprising conclusion is, that cross-price elasticities between the new car size classes is substantial, as is the secondhand price effect on both small and large new car demand. The negative effect of fuel prices on large new car demand is confirmed.

A somewhat different "user cost" approach is presented by Tishler (1982). In this analysis three size classes of new and used cars are considered, and the "service flow" of each of the six segments, defined as "new car" and "one-year-old-car"-equivalents, is defined as the dependent variable. The negative effect of fuel prices and the positive effect of income is larger in larger car segments and more substantial in new car demand equations. In a later study (Tishler (1983)) the effect of real new car prices is analyzed in more detail. Price effects tend to be more substantial in larger car segments. A disaggregate new car demand model, using the "user cost" approach was presented for the Australian market by Madden (1988). The demand for cars in each of three size classes was defined as a function of income, fuel price, "own" user cost of the segment under consideration, change in unemployment rate, and a number of dummy variables. The author concludes that income and fuel prices are the principal determinants of demand for cars of each size class. Fuel price effects are relatively inelastic and are the most important for medium-sized car demand, whereas income effects are more important in the small- and luxury car segments. The author concludes that this income effects structure supports the second car hypothesis.

In none of the analyses mentioned the difference between factors affecting total demand and factors influencing demand structure by size classes is made, nor is the possible difference between the magnitude of the effect of a variable on total demand and on demand structure analyzed. In a simulation approach of the British car market, Broughton (1985) does analyze both aspects. The author concludes that higher fuel prices result in a decrease in total demand as well as in a demand shift towards smaller cars, whereas an increase in new car prices results almost exlcusively in a shift of demand toward smaller cars. Broughton (1985) concludes that "the most sensitive aspect of the model was the composition of the car fleet by size".

In the following sections a model of new car demand structure will be constructed and tested for the Belgian market. Contrary to most approaches in the previous literature, the new car demand model will be considered here as being composed of two distinct mechanisms. The part describing total demand will be presented only briefly. The analysis, presented in section 4 will concentrate on explaining market share evolution of each size class. In that way a clear distinction can be made between effects on total demand and effects on demand structure. The relevance of variables that have been suggested in previous research, such as personal income, new car prices and fuel prices, will have to be reconsidered in that new framework. But other variables such as "credit terms" will be considered too. Before defining such a model in section 4, a short description of the Belgian car market and of the structure of new car demand is given in the following section.

3. The market for new cars in Belgium.

Total new car demand in Belgium has reached about 400000 units in recent years. The evolution of total demand can adequately be described by the model (De Pelsmacker (1990)):

$$\frac{D_t}{D_t^n} = 0.69\ P_t^{-1.12}\ PG_t^{-0.77} \left(\frac{Y_t}{Y_{t-4}}\right)^{0.79} e^{0.39K_1\ +\ 0.40K_2 + 0.08K_3} \qquad [1]$$

$R^2 = 0.93$
DW = 1.8

where : Dt :total new car demand in period t

D_t^n :"normal" or "structural" demand.

P_t :real new car price

PG_t :real car running cost evolution

Y_t :real national income per head

K_1, K_2, K_3 :quarterly dummy variables

The model was estimated for quarterly Belgian data for the period 1973-1986. All coefficients are significantly different from zero at the 95 % confidence level.

The variable D_t^n requires some further elaboration. In the tradition of Smith (1974) and Armstrong and Odling-Smee (1978) on the one hand and Tanner (1978) and O.E.C.D. (1983) on the other, "structural" or "long term normal" car demand has been defined and estimated as a combination of two basic mechanisms: a growth of motorization towards an externally

defined saturation level and a stable "echo" demand, resulting from the replacement of newly-bought vintages in the past. The details of the structural model definition are highlighted in De Pelsmacker (1990). Although short-run shifts in total demand largely remain unexplained, the general level is adequately predicted by the structural mechanisms. Deviations from this structural demand level are to a large extent explained by model [1].
Total demand is slightly car price elastic, but fuel price and income inelastic. There is a strong seasonal effect, resulting in 50% more sales in each of the first two quarters of each year, compared to the last quarter. No evidence of an effect of credit terms on demand, nor of the interaction of new car demand and the secondhand market could be found.

Although total demand does not seem very elastic, and is largely shaped by structural, long-term processes, demand structure has been subject to substantial shifts during the last decades. In order to study these demand shifts, total demand was divided into five size classes. As indicated earlier, the division into 5 segments is a very conventional one and is in fact used by the Belgian car industry in commercial practice. Starting from such a list (in fact a modification of the FORD-classification) in which most of the 1981 models on the Belgian market are attributed to one of the 5 segments, objective segment boundaries were defined by means of trial and error, in terms of capacity (CC), using motor power (MP) as a correction factor, and staying as closely as possible to the 1981 segmentation of models.

Starting from this unambiguous segment definition, based on the 1981 list, sales of all car models for the whole period under consideration (1972-1986) were attributed to the appropriate size class. The market segments are defined as follows:

1) very small cars :cc < 1111
2) small cars :1110 < cc < 1350 and HP < 75
3) medium-sized cars :1349 < cc < 1601 and HP < 86
and cc < 1350 and HP > 74
4) large cars :1600 < cc < 2351 and HP < 123
and cc < 1601 and PH > 85
5) very large cars :cc < 2350 and cc < 2351 and HP > 122

Up to the end of 1982 quarterly registration data were available for each of the major model categories. Sales could therefore be attributed to the segment of the most commonly sold motor versions of the particular model. The data allow a fairly adequate size subdivision of the car market, based on motor capacity. In 1983, a new registration practice was introduced. Registration data for each motor version of each model variant became available. As a result the registration of each major model category could be ventilated over a number of size classes, following the distribution of sales over the several motor capacity versions. It was not possible to convert these - in a way too detailed - data in order to make them comparable with the data for the period 1972-1982. As a result, demand structure for the period 1983-1986 is a rather too far stretched division of registrations by motor capacity, whereas the 1972-1982 structure reflects size class division of sales in a more acceptable way. In any case, the analysis will have to take this into consideration. Market share evolution of each of the 5 size classes is given in table 1.

Table 1 : Evolution of the market share (%) of 5 size classes in total car demand in Belgium, 1972-1986.

Year \ size class	I	II	III	IV	V
72	31.1	27.8	11.2	27.5	2.4
73	28.9	26.5	16.8	24.5	3.3
74	38.5	29.1	11.1	18.5	2.8
75	37.6	31.0	11.1	17.5	2.9
76	30.4	37.2	8.4	19.4	3.4
77	29.7	33.2	10.2	23.1	3.8
78	23.3	30.4	18.3	22.8	5.1
79	28.9	26.5	17.6	21.7	5.2
80	28.9	28.7	17.8	19.9	4.7
81	26.4	32.6	19.2	18.3	3.4
82	25.1	29.0	26.5	15.2	4.2
83	19.0	26.4	20.6	26.4	7.7
84	16.2	24.4	23.3	28.6	7.5
85	15.8	23.6	21.5	31.1	8.0
86	16.5	20.6	21.2	33.8	7.9

Source: FEBIAC, Car registration data, Brussels, 1972-1986.

In the early seventies three segments were more or less equally important: very small cars, small cars and large cars. The very large cars were rather unimportant, and the medium-sized cars held a market share of about 11%. This picture was consideratly altered during the period under consideration. Especially the medium-sized car has gained market share, largely at the expense of its two "adjacent" classes, especially the larger one. The "pure capacity segmentation" picture (1983-1986) is fundamentally different. However, this period is too short to allow for stringent conclusions with respect to the direction of the shifts.

A remarkable evolution in Belgian car demand is the shift towards diesel engined models during the last decade. Unfortunately, the data available do not allow the incorporation of that aspect of the Belgian car market in a time series analysis. In table 2 the subdivision of the Belgian car park with respect to the fuel used is given for the period '83-'86. The increasing importance of diesel engines is evident. It has to be noted that, in order to arrive at such an increase in total car park, the share of diesel engines in new car demand has to be around 20%. In the following section an explanatory model of new car demand structure is defined and estimated for time series of quarterly Belgian data for the period 1972-1986.

Table 2 : Structure of the Belgian car park, following the type of fuel used (% each type of motor)

year / fuel	1983	1984	1985	1986
petrol	83.7	82.0	80.4	79.0
diesel	12.8	15.0	16.9	18.7
LPG	2.8	2.4	2.0	1.7
other	0.6	0.6	0.6	0.6

Source: FEBIAC, Annual report, Brussels, 1987, p.102.

4. A model for the new car demand structure in Belgium

To describe the market share evolution and its determinants, a logically consistent market share model has to be defined. In its most simple (and linear) form, such a market share model can be written as:

$$w_i = a_i + \sum_j b_{ij} X_j \qquad [2]$$

where: w_i : market share of product i
X_j : explanatory variables
a_i, b_{ij} : model coefficients

To be internally consistent, a market share model like [2] has to comply to a number of restrictions on the model parameters. Since calculated market shares in any period always have to sum to 1, the so called "adding-up constraints" have to be imposed:

$$\sum_i \alpha_i = 1 \qquad [3]$$

$$\sum_i b_{ij} = 0 \quad \forall_j \qquad [4]$$

Constraint [3] expresses that, apart from all influencing factors, the sum of market shares always equals 1. Constraints [4] imply that a shift in the explanatory variables results in offsetting shifts in market shares.
Other classes of market share models can be thought of (see e.g. Naert and Weverbergh (1985)). A number of them were tested here, but they all lead to roughly the same conclusions as the simple linear model [2]. The linear model

even results in a higher explanatory power. Therefore, only the results of this latter model are given here. Basically, each of the 5 equations of the market share model [2] (i=1,...5) can be explicitated as follows, taking the suggestions of previous research into account:

$$w_i = a_i + b_i PG + c_i Y + \sum_{j=1}^{5} d_{ij} PN_j \qquad [5]$$

where: PG : real unit car running cost

Y : real national income per head

PN_j : chain index number of real new car prices of segment j.

Incorporating the price evolution of all segments in each equation implies that the cars in each submarket are regarded as potential substitutes. This is not a very realistic assertion. When choosing a vehicle, the consumer probably only considers a limited number of size-classes of cars in the same order of magnitude, possibly on the basis of their relative price. Therefore one could argue that the market share of a particular segment is only influenced by its own price evolution and the price evolution of "adjacent" segments. As a result a number of price variables can be removed in each equation of model [5]. Furthermore, since PN_1,...PN5 are highly correlated as it is, estimation results benefit from this model simplification. Incorporating the conceptual and technical remarks into the model, the latter can be written explicitly as in [6].

$$
\begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \\ w_5 \end{bmatrix} =
\begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \\ (1-a_1-a_2 \\ -a_3-a_4) \end{bmatrix} +
\begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \\ (1-b_1-b_2 \\ -b_3-b_4) \end{bmatrix} PG +
\begin{bmatrix} c_1 \\ c_2 \\ c_3 \\ c_4 \\ (1-c_1-c_2 \\ -c_3-c_4) \end{bmatrix} Y +
\begin{bmatrix} d_{11} & d_{12} & 0 & 0 & 0 \\ -d_{11} & d_{22} & d_{23} & 0 & 0 \\ 0 & -(d_{12}+d_{22}) & d_{33} & d_{34} & 0 \\ 0 & 0 & -(d_{23}+d_{33}) & d_{44} & d_{45} \\ 0 & 0 & 0 & -(d_{34}+d_{44}) & -d_{45} \end{bmatrix}
\begin{bmatrix} PN_1 \\ PN_2 \\ PN_3 \\ PN_4 \\ PN_5 \end{bmatrix} \quad [6]
$$

To estimate this model one of the equations has to be left out and the remaining four have to be estimated simultaneously. Maximum likelihood estimates of each coefficient are garantueed, no matter which equation has been removed from the system (Barten (1987)). The coefficients of that equation can, after estimation of the system, be calculated by means of the cross equation constraints.

Before commenting on the estimation results, a number of remarks have to be formulated. A large number of variants of the same model [6] have been estimated. They did not only differ with respect to model structure (linear, semilog or loglinear), but also with respect to the definition of some of the variables. A number of model definitions have been estimated with the variables defined as "levels" and as "changes with respect to some previous period". All estimation results point in the direction of a better explanatory power of the model with the former definition of the variables. In most of the previous research a fuel price variable appeared in the model. Extensive testing has revealed that in most cases a more generally defined "running cost"-variable performed better. In the definition of PG, derived from the data gathered to calculate the Belgian retail price index number, fuel prices make up about 40 % of total running cost. In the whole, the PG-variable strongly reflects fuel cost changes, but the shocks do not have the same amplitude as the fuel price changes, and are sometimes offset by countervailing shifts in other running costs.

In table 3 the estimation results of model [6] are given, keeping the above-formulated remarks in mind. Equations 1-4 were estimated simultaneously, on the basis of quarterly data 1972-1982, whereas the coefficients of equation 5 were calculated from the cross-equation restrictions.

Table 3: Estimation results of the car demand structure model [6], 1972-1982.

variable / size class	Constant	PG	Y	PN_1	PN_2	PN_3	PN_4	PN_5
1	1.6015* (9.46)	0.2836* (2.91)	-0.8296* (-6.84)	-0.3942* (-2.81)	-0.4024* (-2.40)			
2	0.7509* (3.90)	0.1734 (1.26)	-0.4173* (-2.68)	0.3942* (2.81)	-1.1089* (-4.05)	0.5187 (1.70)		
3	-1.2475* (-5.70)	0.0572 (0.38)	0.9499* (5.62)		1.5113* (5.27)	-0.2443 (-0.78)	-0.8402* (-5.11)	
4	0.0210 (0.15)	-0.4551* (-5.83)	0.1571 (2.01)			-0.2744 (-1.53)	0.6445* (3.79)	0.0984* (2.72)
5	-0.1259* (-4.15)	-0.0591* (-3.25)	0.1399* (4.56)				0.1957* (3.58)	-0.0984* (2.72)

* significant at 5 % confidence level t-statistic between brackets.

Most of the coefficients are significantly different from zero and have the expected sign. The elasticities of market share, evaluated at 1980 values of the variables are given in table 4. An increase in unit running costs substantially increases the share of very small cars, largely at the expense of the large car share and, to a lesser extent, of the very large car share. Of course, very small cars and large cars are no direct substitutes. The shifts in market shares is the result of a process of "bumping", in which the share of segments 2 and 3 is not significantly affected. In other words, these segments more or less gain from segment 4 what they lose to segment 1. The less significant shift in very large car share can probably be explained by the less cost-sensitive attitude of most of the potential buyers of that kind of vehicle. The first column of table 4 shows that most market shares are rather cost-elastic, as was concluded in previous research (see section 2).

Table 4: Elasticity of market share of each size class with respect to running cost, income and car prices

variable / size class	PG	Y	PN_1	PN_2	PN_3	PN_4	PN_5
1	0.9807	-2.8687	-1.3631	-1.3915			
2	0.6048	-1.4556	1.3750	-3.8679	1.8093		
3	0.3220	5.3470		8.5072	-1.3752	-4.7295	
4	-2.2851	0.7888			-1.3778	3.2361	0.4941
5	-1.2495	2.9577				4.1314	-2.0803

An increase in per capita income results in a severe decrease of market share of the very small cars and, to a lesser extent, of small cars, largely to the benefit of, surprisingly, the medium-sized cars. The effect on the very large car share is significant too, whereas the large car share remains largely unaffected. The income elasticity of market share is, on the whole, very substantial.

A remarkable conclusion must be that demand structure reacts most vigorously to income changes, and less intensively to running cost shifts. The reason for the often noted gradual rise in average car size must therefore be explained by the constantly rising income and the negligible change in real running costs up to the mid-seventies. The overall picture between '72 and '82 is, as has been noted earlier, that of an increase in the medium-sized car share at the expense of the large car share. As can be seen, this general shift can be attributed to the combination of increased running costs and, despite a couple of recessions, still further increasing income in this period.

Four out of five own-price coefficients have the expected negative sign, and three of them are significantly different from zero. Five out of nine cross-price coefficients have the right positive sign, four out of which are significantly different from zero. Price elasticity of market share is generally quite considerable. A number of price variable coefficients have the wrong sign and are nevertheless significantly different from zero. Incorporating several car price variables in a demand structure model often results in severe problems of multicollinearity. The reason for this is that the prices of several car models of the same manufacturer are in fact institutionally linked to one another to indeed give a signal to the market that the different models are to be regarded as belonging to different market segments (Ginsburgh e.a. (1987)). Therefore, in most demand structure analyses, cross-price effects are left out (Carlson (1978)) or defined in a different way (Tishler (1982, 1983)). But even then, the problems remain (see also De Pelsmacker (1988a) for an illustration of the same problem in a different context).

As a result, nothing much can be concluded on the basis of the price coefficient estimates. Prices of various segments are correlated, and price competition is probably more important between models of the same segment than between segments. One solution is put forward by Carlson (1978) who only incorporates the own price variable in each segment equation. In our model definition, this would be internally inconsistent. Another approach is to leave out a number of irrelevant cross-price effects (as is done here), or to define the price effects differently. Therefore, a number of other model definitions were tested too, but they did not result in more acceptable results either. Introducing a trend variable in some of the equations reduces the problem to just one significant cross-price effect with the wrong sign, but introduces some other anomalies, especially when used for forecasting demand structure. All in all, the fact that in this model definition most significant price coefficients have the expected sign, is a promising result.

It was pointed out in the previous section that the terms of consumer credit dit not in any way influence total demand. Nevertheless one could argue that changes in the consumer credit terms could influence the size of the car bought, rather than the timing of this purchase. A number of credit variables were tested here. As can be seen in table 5, only the ratio of minimal down payment (in %) to maximum maturity (in months), both legally imposed, lead to a significant, though small, effect on demand structure.

Table 5: Estimation results of car demand structure model [6], with additional credit term variables in segments 3 and 4, 1972-1982

variable / size class	Constant	PG	Y	PN_1	PN_2	PN_3	PN_4	PN_5	K
1	1.5843* (9.55)	0.2770* (2.90)	-0.8015* (-6.72)	-0.4637* (-3.29)	-0.3370* (-2.02)				
2	0.7644* (3.88)	0.1620 (1.14)	-0.4235* (-2.66)	0.4637* (3.29)	-1.1290* (-4.03)	0.4734 (1.52)			
3	-1.4316* (-6.05)	0.1013 (0.66)	0.9858* (5.67)		1.4660* (5.00)	0.0497 (0.15)	-0.9944* (-6.04)		0.0130* (2.43)
4	0.2083 (1.35)	-0.4852* (-6.65)	0.1078 (1.40)			-0.5231* (-2.68)	0.7804* (4.65)	0.1110* (3.09)	-0.0130* (2.43)
5	-0.1254* (-4.09)	-0.0569* (-3.13)	0.1313* (4.22)				0.2140* (3.94)	-0.1110* (-3.09)	

Tighter credit restrictions lead to a significant shift in demand from the large car segment to the medium-sized segment. The demand shift as a result of changing credit conditions is fairly substantial. For instance, a return to the very tight conditions of 1974 (a minimal down payment of 50% and a maximum maturity of 24 months) would cause a shift in market share between the two submarkets of 2.3 procent-points. It can be noted that price, income and fuel effects are not substantially altered by the modification of the model. This is an indication of the stability of the estimated effects.

Up to now, estimation results were based on the observation period 1972-1982. In table 6 the same model was estimated on the basis of the '72-'86 data. To take into account the different definition of segmentation criteria for the period 1983-1986, 5 dummy variables were introduced, taking the value one in the latter period and zero in '72-'82.

Table 6: Estimation results of car demand structure model [6], with additional credit term variables in segments 3 and 4, 1972-1986

variable / size class	Constant	PG	Y	PN_1	PN_2	PN_3	PN_4	PN_5	K	DUM
1	1.1941* (8.22)	-0.0194 (-0.31)	-0.4578* (-6.02)	-0.4357* (-3.38)	-0.0258 (-0.20)					-0.0525* (-4.31)
2	0.7485* (4.47)	-0.0280 (-0.44)	-0.2040* (-2.78)	0.4357* (3.38)	-0.7456* (-4.78)	0.1052 (0.49)				-0.0310* (-2.59)
3	-1.1964* (-6.57)	0.3113* (4.66)	0.6630* (8.04)		0.7714* (4.52)	0.0647 (0.31)	-0.4281* (-3.65)		0.0104* (2.05)	-0.0034 (-0.29)
4	0.3133* (2.04)	-0.2449* (-4.61)	-0.0827 (-1.34)			-0.1699 (-1.07)	0.2571* (2.08)	0.1219* (4.19)	-0.0104* (-2.05)	0.0575* (5.56)
5	-0.0595* (-2.17)	-0.0190 (-1.51)	0.0815* (4.08)				0.1710* (3.59)	-0.1219* (-4.19)		0.0297* (2.45)

The conclusions are roughly the same, except for the effect of the running cost variable. Whereas in the '72-'82 model increasing costs lead to a shift towards small cars, in the '72-'86 model the share of medium-sized cars increases. In view of the more homogeneous data set one would nevertheless be tempted to conclude that the '72-'82 results are the more reliable.

In table 7 the cost- and income-elasticities of total demand for cars of different sizes are presented. They have been calculated on the basis of the total demand model [1] and the results in table 5.

Table 7 : Cost and income elasticities of total demand for cars of each size class

Size class	elasticity of total demand		elasticity of market share		elasticity of total demand in each size class	
	cost	income	cost	income	cost	income
1			0.98	-2.87	0.21	-2.08
2			0.61	-1.46	-0.16	-0.67
3	-0.77	0.79	0.32	5.35	-0.45	6.14
4			-2.29	0.79	-3.06	1.58
5			-1.25	2.96	-2.02	3.75

An increase in running cost results in a drop in sales in all size classes but one. The large car segment suffers the most. An increase in income results in increased sales for especially the medium-sized car segment and, to a lesser extent, for the very large car segment. Especially very small car sales suffer substantially from a rise in disposable income.

In the last section a number of scenarios with respect to the future economic evolution are developed and their effect on demand structure is highlighted.

5. Some scenarios of future car demand structure in Belgium

Given the probable evolution of the determining factors of car demand and demand structure, a number of scenarios can be built and future demand structure can be forecast. In table 8 the predicted demand structure for a number of possible scenarios is shown. The scenarios are based on the total car demand model [1] and the demand structure model in table 6. Although model [5] (1972-1982) was considered to describe more accurately the effects on demand structure, model [6] (1972-1986) was chosen as the basis for forecasting, since these results relate more closely to the existing new segmentation on pure motor capacity criteria. Credit terms and relative prices are considered to remain unchanged, and the Belgian population is supposed to decrease as is predicted by the Belgian Statistical Institute.

Five different scenarios (until the year 2000) are considered:

1) An unchanged real income, a real yearly increase of car prices by 1% and unchanged unit running costs.
2) A real yearly income growth of 1%, unchanged car prices and unchanged unit running cost.
3) A real yearly income growth of 1%, unchanged car prices and an increase of unit running cost by 10% in 1989, followed by a status quo during four years and a fall by 9.1% in 1994.
4) A real yearly income growth of 2%, a yearly increase of car prices by 1% and unchanged unit

running costs.

5) A real yearly income growth of 2%, an annual fall of car prices and unit running costs by 1% during four years, followed by a status quo.

The negative market share of segment 1 in both the last scenarios indicates that a linear market share model is not appropriate for the description of future evolution accurately in every situation.

Table 8 : Some scenarios of future car demand structure in Belgium.

Year	Car ownership (total number of cars on the road at the end of the year)	New car demand	demand structure % of demand in segments				
			1	2	3	4	5
Scenario 1							
1993	3566274	267147	13.0	20.7	23.7	33.5	9.0
1996	3576406	240401	13.0	20.7	23.7	33.5	9.0
2000	3574354	205080	13.0	20.7	23.7	33.5	9.0
Scenario 2							
1993	3577735	290731	9.5	19.2	28.8	32.9	9.6
1996	3587193	268432	7.9	18.5	31.1	32.6	9.9
2000	3583555	237266	5.7	17.5	34.3	32.2	10.3
Scenario 3							
1993	3575657	263724	9.4	18.9	31.1	30.9	9.5
1996	3587193	253805	7.9	18.5	31.1	32.6	9.9
2000	3583555	222868	5.7	17.5	34.3	32.2	10.3
Scenario 4							
1993	3586390	276478	5.8	17.5	34.1	32.2	10.3
1996	3595403	250502	2.4	16.0	39.1	31.6	10.9
2000	3590328	215458	(-2.5)	13.8	46.2	30.7	11.8
Scenario 5							
1993	3588908	332017	5.9	17.6	33.1	33.0	10.4
1996	3596913	319844	2.5	16.1	38.1	32.4	11.0
2000	3591106	299899	(-2.5)	13.9	45.2	31.5	11.9

Both scenario 1 and scenario 4 are pessimistic as far as the evolution of total demand is concerned. The rather substantial growth of income and the absence of running cost increases lead to a very high market share of the medium-sized car segment by the end of the century. The combination of falling car prices and unit running cost and the growth of income (scenario 5) leads to a similar demand structure, but also to a much higher level of total demand. Scenario 3 reflects a moderately severe oil crisis. Compared to scenario 2, total demand is seriously affected. The oil crisis scenario results in a temporarely increased share of the medium-sized car segment and a substantial fall in the segment 4 share.

It can be concluded that a considerable income growth will be needed to keep total demand at the high actual level. The most probable scenarios of moderately high income growth and stable unit running costs result in a considerable growth of the segment 3 share at the expense of the small and especially the very small cars.

REFERENCES.

Altschuler A, Anderson M, Jones D, Roos D, Womack J (1984) The future of the automobile, George Allen and Unwin, London.

Armstrong A, Odling-Smee J (1978) The demand for new cars I-a theoretical model of replacement demand, Oxford Bulletin of Economics and Statistics, 40: 281-302.

Barten A (1987) Models of the rational consumer, Vereniging voor Economie, Brussel.

Bhaskar K (1980) The future of the world motor industry, Kogan Page, London.

Broughton J (1985) A simulation of the car market, Transport and Road Research Laboratory, research report 15, Crowthorne.

Carlson R (1978) Seemingly unrelated regression and the demand for automobiles of different sizes 1965-75: a disaggregate approach, Journal of Business, 51: 243-262.

Carlson R, Umble M (1980) Statistical demand functions for automobiles and their use for forecasting in an energy crisis, Journal of Business, 53: 193-204.

Cordtz D (1974) What lies ahead down small car lane ?, Fortune, 90: 80-160.

Dahl C (1979) Consumer adjustment to a gasoline tax, Review of Economics and Statistics, 61: 427-432.

De Pelsmacker P (1988a) Marketing, expenditure and quality-adjusted price effects on market share evolution in a segmented Belgian car market (1972 - 1981), Applied Economics, 20: 15-30.

De Pelsmacker P (1988b) De geaggregeerde vraag naar personenwagens in België (The aggregate demand for cars in Belgium), doctoral dissertation, Gent.

De Pelsmacker P (1990) A structural model of the demand for cars in Belgium, Applied Economics, forthcoming.

Falvey F, Friend J, Babunovic M (1986) Fuel economy standards and automobile prices, Journal of Transport Economics and Policy, 20: 31-45.

Funck B (1963) Aspects de la formation des prix sur le marché automobile (1re partie), Recherches Economiques de Louvain, 29: 592-593.

Ginsburgh V, Macleod B, Weber S (1987) Price discrimination and product line rivalry, CORE working paper, Louvain-La-Neuve.

Henscher D (1985) Empirical vehicle choice and usage models in the household sector: a review, International Journal of Transport Economics, 12: 231-260.

Irvine O (1983) Demand equations for individual new car models estimated using transaction prices with implications for regulatory issues, Southern Economic Journal, 49: 353-379.

Kwoka J (1983) The limits of market-oriented regulatory techniques: the case of automobile fuel economy, Quarterly Journal of Economics, 93: 695-704.

Madden G (1988) Aggregate studies of automobile demand: a review, International Journal of Transport Economics, 15: 129-158.

O.E.C.D. (1983) Long-term outlook for the world automobile industry, OECD, Paris.

Rhys D (1972) The motor industry: an economic survey, Butterworth, London.

Rosenhek W (1981) Segmenten in de markt voor personenwagens, Cahiers Economiques de Bruxelles, 23: 123-139.

Smith R (1974) A note on car replacement, Review of Economic Studies, 64: 567-570.

Stewart D, Hood N (1981) A methodology for the evaluation of segmentation policy: an empirical application in the car industry, Journal of the Market Research Society, 23: 137-149.

Tanner J (1978) Long-term forecasting of vehicle ownership and road traffic, Journal of the Royal Statistical Society, 141A: 14-63.

Tishler A (1982) The demand for cars and the price of gasoline: the user cost approach, Review of Economics and Statistics, 64: 184-190.

Tishler A (1983) The demand for cars and gasoline. A simultaneous approach, European Economic Review, 20: 271-287.