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THE ANALYSIS OF DEMAND AND SUPPLY FACTORS IN RETAILING USING A DISEQUILIBRIUM MODEL

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Abstract

In this paper we use a disequilibrium model to explain differences in floorspace productivity, measured as sales per square metre, among individual retail establishments. In the earlier stages of our research in this area the demand was usually assumed to be high enough for a shopkeeper to maximize his profits.

In the present paper we assume that situations may occur in which demand is not high enough. As a result an endogenous switch (unknown sample separation) between supply and demand regimes is incorporated in the model.

The purpose of this paper is twofold. First, we estimate an existing model in this area for four shoptypes, to gain a better insight in disequilibrium situations in the retail trade. Second, we incorporate additional explanatory variables in the demand equation to account for some elements from the marketing mix, like advertising, assortment composition, the level of service and environmental characteristics.

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1. Introduction

Recently, Kooiman, Van Dijk and Thurik (1985) presented a disquilibrium model aiming at the explanation of differences in floorspace productivity, measured as sales per square metre, among individual retail establishments of the same shoptype. The model served as an application of likelihood diagnostics and Bayesian analysis. Moreover, it served as a starting point for a renewed attempt to establish the influence of environmental factors on floorspace productivity. In our present article we give some further research results to gain more insight in the performance of the model.
The present paper could only be accomplished because of a fruitful cooperation between the Research Institute for Small and Medium-Sized Business (EIM) in the Netherlands and the Econometric Institute of the Erasmus University Rotterdam, which already started in 1973. The paper is a further extension of the analyses of Thurik and Koerts (1984(a,b), 1985), Thurik (1984) and Kooiman et al. (1985), where models are developed to explain differences in floorspace productivity among retail establishments. The most recent development in this area is the modelling of disequilibrium, which implies that at a certain moment in time, that is the moment of data collection, demand for and supply of goods do not necessarily coincide. In fact, it is our assumption that some shops in the survey operate in a situation of excess demand, while others are troubled by a situation of excess supply. In the earlier stages of our research in the field of floorspace productivity, it was usually supposed that the demand for products is sufficient to give the entrepreneur the opportunity to, say, maximize his profits. However, it was clear from Kooiman et al. that there is a substantial chance that this is not the case. Specifically, the average probability of a situation of excess supply, in which the level of sales is determined by demand, was about 23% in a sample of 208 Dutch supermarkets. In the present article we extend the previous model because we are interested in how the model works out for other shoptypes and because important factors such as advertising, the composition of assortment, service and environmental characteristics are lacking in the demand equation in Kooiman et al.

Hence, the purpose of the present paper is twofold. First, we want to give the disequilibrium analysis of Kooiman et al. a broader empirical basis by estimating their model for different shoptypes to gain a better insight in disequilibrium situations in the retail trade. Second, we want to know the effects if some well known elements from the marketing literature (see Kotler (1967)) are incorporated in the demand equation. This is done by extending the latter equation to account for the effects of advertising, the assortment composition, shopping centre and regional characteristics and the level of service.

2. The model and the likelihood equation

In this section we shall give a short description of the model, which will be estimated in section 3.
The basic equation of the model is a production technology which mirrors the thought that the level of sales an entrepreneur wants to supply must also be within reach for him, given his production factors. Every entrepreneur is supposed to operate according to this supply equation. The specification is as follows:

$$(2.1) \qquad Q^s = \beta(X)(C - \gamma)^{\pi\varepsilon}(W - C)^{(1-\pi)\varepsilon}$$

where Q^s: possible sales level, supply capacity
C: floorspace specifically for selling
W: total amount of floorspace
X: exogenous factors.

In the parameter β further exogenous factors, X, can be incorporated. Given that the entrepreneur aims at maximizing profits, he can make use of two instruments to accomplish his goal: selling space (C) and remaining space (R = W - C). By definition selling space and remaining space add up to exogenous total space. This implies that, in fact, one instrument remains: the partitioning of floorspace. For a discussion on the relevance of sales maximization versus profit maximization in retailing we refer to Thurik and Koerts (1985).

At this point we distinguish between two possible situations. The first situation corresponds to the assumption that demand is always high enough to sustain any level of supply. This assumption was already made in the earlier works in this area (see Thurik (1984), for instance) and occurs otherwise quite often implicitly in literature (see White (1976), for instance). This allows us to derive the optimal partitioning of floorspace by examining the first order conditions for maximizing $Q^s(C; W, X)$ with respect to selling space C. Differentiating equation (2.1) with respect to C and fixing the result at zero, leads to the following optimal amount of selling space in a situation of excess demand, C_{ed}:

$$(2.2) \qquad \frac{C_{ed} - \gamma}{W - \gamma} = \pi$$

It may also occur that demand is <u>not</u> high enough to absorb the optimum level of sales $Q^s(C_{ed}; W, X)$. This brings us to the second possible situation, that of excess supply. Although the observed level of sales, Q, must be feasable in the sense that $Q \leq Q^s(C; W, X)$, it is also restricted by the amount of product customers are willing to consume. The level of demand, Q^d, is supposed to depend on selling space: it is assumed that if selling space increases the number of products (-groups) also increases, thereby stimulating demand. It is specified as:

$$(2.3) \qquad Q^d = \delta(X)(C - \gamma)^{\upsilon}$$

where Q^d: level of demand
C: amount of selling area
X: exogenous factors.

Again the factor δ allows us to incorporate additional explanatory variables, X. The restriction $\upsilon \geq \pi\varepsilon$, the demand elasticity of selling space exceeds the supply elasticity, secures that there can only be one point of intersection between Q^s and Q^d. The optimal amount of selling space in a situation of excess supply, C_{es}, is that amount of C that follows from the point of intersection between Q^s and Q^d:

$$(2.4) \qquad Q^s(C_{es}; W, X) = Q^d(C_{es}; X).$$

It is not difficult to see that the distinction between the situations of excess supply and excess demand results in the following discrete switch:

(2.5) $C = \max(C_{ed}, C_{es})$.

When C_{es} is less than C_{ed} the point of intersection between Q^s and Q^d occurs to the "left" of the optimum of Q^s; to the "right" of this intersection, demand is always larger than supply, which means that this is a situation of excess demand. In the same way it can be shown that if C_{es} exceeds C_{ed}, this implies a situation of excess supply.
The disequilibrium model can now be written as:

(2.6)
$$Q = Q^s(C; W, X)$$
$$C = \max(C_{ed}, C_{es})$$

where C_{es} and C_{ed} are given by equations (2.4) and (2.2), respectively.

Estimates of the model are obtained by maximum likelihood. The likelihood equation is the joint density function of Q and C, conditional on the unknown parameters, over all observations. To derive this function we note that for each individual the joint density function of Q and C consists of two parts (cf. Maddala (1983)). One part is related to the excess demand situation and is called $f^{ed}(Q, C)$, the other part is called $f^{es}(Q, C)$ and is related to the situation of excess supply.
In order to derive the functional form of each of the density functions, use is made of equations (2.1), (2.2) and (2.3) and error terms are introduced. In equation (2.1) and (2.3) the multiplicative error terms have a log-normal distribution. In equation (2.2) π is replaced by $\exp\{-\phi\}$ where ϕ is gamma distributed with parameters α and ψ. The mathematical expectation of $e^{-\phi}$ is equal to π. As can be found in Kooiman et al. this results for $f^{ed}(Q, C)$ and $f^{es}(Q, C)$ in:

(2.7)
$$f^{ed}(q, c) = \frac{C}{C - \gamma} g(p; \alpha, \psi)\, n(e^s; \sigma_s)[1 - N(\frac{e_d}{\sigma_d})]$$

$$f^{es}(q, c) = \{\frac{(\upsilon - \pi\varepsilon)C}{C - \gamma} + \frac{(1 - \pi)\varepsilon C}{W - C}\}\, n(e^s; \sigma_s)\, n(e^d; \sigma_d)[1 - G(\frac{p}{\psi}; \alpha)]$$

where q, c: natural logarithms of Q and C, respectively;

$n(.; \sigma)$: normal density function with mean zero and variance σ^2. $N(.)$ is the standardized cumulative normal distribution function;

$g(.; \alpha, \psi)$: gamma density function with parameters α and ψ. $G(.; \alpha)$ is the cumulative gamma distribution function with respect to α.

The factors e^s, e^d and p are given by:

$$(2.8) \quad e^s = q - q^s(c; W, X)$$
$$e^d = q - q^d(c; X)$$
$$p = \log(W - \gamma) - \log(C - \gamma).$$

The likelihood function can be written as:

$$(2.9) \quad L(\theta|q, c) = \prod_{i=1}^{N} \{f^{ed}(q_i, c_i) + f^{es}(q_i, c_i)\}$$

where θ: vector of unknown parameters

from which the regime probabilities according to Kiefer (1980) are derived as:

$$(2.10) \quad Pr(\text{Excess Supply})_i = f^{es}(q_i, c_i)/\{f^{ed}(q_i, c_i) + f^{es}(q_i, c_i)\}$$
$$Pr(\text{Excess Demand})_i = f^{ed}(q_i, c_i)/\{f^{ed}(q_i, c_i) + f^{es}(q_i, c_i)\}$$
$$i = 1, \ldots, N.$$

The likelihood function (2.9) tends to go to infinity for certain values of the parameters. Maddala (1983) and Kooiman et al. deal quite extensively with this matter so we only mention it here. We suppress the problem by restricting the average probability of a situation of excess supply to the interval $[\alpha_0, \alpha_1]$, where $0 < \alpha_0 < \alpha_1 < 1$.

3. Estimating the model

The data we used for estimating the model are available from surveys conducted by the Research Institute for Small and Medium-Sized Business in the Netherlands. The data involve four shoptypes: supermarkets and superettes, textile shops, stationer's shops and furnishing shops. In the appendix we give a short impression of these data (see also Bode, Koerts and Thurik (1987)).

First we estimate the disequibrium model of Kooiman et al. for four shoptypes. Consecutively we shall expand the demand equation. Hence, we shall first use a specification of $\beta(X)$ and $\delta(X)$ which also can be found in Kooiman et al. The supply equation then becomes:

$$(3.1) \qquad Q^s = e^{\beta_0}(1 + M)\, H^{\beta_1}(C - \gamma)^{\pi\varepsilon}\, (W - C)^{(1-\pi)\varepsilon}$$

where H: occupancy costs per square metre

M: fractional gross margin.

The factor (1 + M) is a proxy for prices, it is used to transform the value of sales into its volume. It follows that we implicitly assume that the volume of sales is proportional to the purchasing value of sales. The occupancy costs in (3.1) serve as a proxy for efficiency. The idea is that the higher the factor costs one faces, the more efficient use one will make of these factors. In our supply function the only relevant production factor is housing. For that reason the occupancy costs per square metre of total floorspace, H, is included; clearly, β_1 is expected to be positive. The production elasticities of $(C - \gamma)$ and $(W - C)$ are given by $\pi\varepsilon$ and $(1 - \pi)\varepsilon$, respectively, and are restricted to the interval [0, 1]. For the scale parameter, ε, this means that it is restricted to the interval [0, 2], for it is the sum of both elasticities. A value for ε larger than 1 implies increasing returns to scale, and ε smaller than 1, decreasing returns to scale with respect to the production factors $(C - \gamma)$ and $(W - C)$. The parameter π is a distribution parameter and is restricted to the interval [0, 1]. According to equation (2.2) π gives the optimal amount of selling space as a fraction of total floorspace, when the threshold level of selling area, γ, is zero. The interpretation of γ as threshold level for C is the minimum required amount of selling space (cf. Nooteboom (1980)).

For the parameter $\delta(X)$, the shift factor of the demand equation, we first employ the simple specification used by Kooiman et al.:

$$(3.2) \qquad Q^d = e^{\delta_0}(1+M)^{1+\delta_2}(C - \gamma)^{\upsilon}$$

Apart from a constant δ_0 the shift factor $\delta(X)$ is made up by the same proxy for prices (1 + M) as in (3.1). In (3.2) (1 + M) not only serves to transform the value of sales into its volume but also to represent the effect of pricing on the level of demand.

Preliminary excercises showed that the estimation results were very sensitive to the occurrence of certain outliers. We had to remove these outliers (for instance, 7 out of an initial sample of 215 in the case of supermarkets and superettes) to obtain sensible results, which are presented in Table 1.

Let us first draw attention to the probability of excess supply for the shoptypes given in Table 1. Only for supermarkets and stationers there appears to be a substantial probability of excess supply of 20% and 17%, respectively. Both other shoptypes are strongly supply determined: as a rule demand is always large enough for a shopkeeper to maximize his sales by partitioning his floorspace W. From the parameter estimate of π it is clear that the optimal fraction of selling area in total floorspace varies from 0.54 in the case of stationers to 0.73 in the case of textile shops. In the latter case we have to take the threshold level γ $\pm$ 15 m^2 into consideration. All four shoptypes deal with decreasing returns to scale with respect to the production factors $(C - \gamma)$ and $(W - C)$: the estimate of ε is always less than 1 and differs significantly from it. Supermarkets make more efficient use of the available floorspace than any other shoptype: if occupancy costs rise with 10% sales go up with 7.6%.

Examining the parameters of the demand equation we see that υ is higher than the corresponding supply elasticity, $\pi\varepsilon$, for all four shoptypes, so that one point of intersection between Q^s and Q^d occurs indeed. The estimates of υ differ to a high degree for each of the shoptypes: in the case of a stationer's a 10% increase in selling area results in a 15% increase in demand.

Table 1. Parameter estimates for the basic form of the disequilibrium model.

	Supermarkets	Stationer's shops	Furnishing shops	Textile shops
β_0	0.593 (0.263)	1.590 (0.463)	0.491 (0.298)	1.427 (0.280)
β_1	0.758 (0.053)	0.457 (0.089)	0.536 (0.060)	0.437 (0.051)
γ	0.000 (-)	0.000 (-)	0.000 (-)	0.154 (0.096)
ε	0.862 (0.026)	0.837 (0.049)	0.761 (0.030)	0.731 (0.046)
π	0.645 (0.016)	0.538 (0.023)	0.707 (0.011)	0.725 (0.014)
δ_0	4.881 (0.350)	4.485 (0.329)	3.720 (0.377)	4.607 (0.751)
δ_2	-1.208 (1.589)	0.500 (-)	0.500 (-)	0.500 (-)
υ	0.866 (0.068)	1.455 (0.345)	0.592 (0.104)	0.591 (0.283)
α 1)	5.774 (0.669)	3.875 (0.558)	3.578 (0.396)	3.660 (0.386)
L	-322.45	-272.74	-511.00	-314.95
Pr E.S. 2)	0.204	0.171	0.042	0.012
σ_d 3)	0.226	0.662	0.415	0.401
σ_s 4)	0.223	0.372	0.306	0.281
σ_f 5)	0.190	0.341	0.192	0.176
N 6)	208	138	176	189

1) parameter of the gamma density. An estimate of ψ can be obtained from $\pi = (1 + \psi)^{-\alpha}$ as $\psi = \pi^{-(1/\alpha)} - 1$;
2) probability of excess supply;
3) standard deviation of the demand equation (2.3);
4) standard deviation of the supply equation (2.1);
5) standard deviation of the π-equation (2.2);
6) number of observations.

For textile shops, on the other hand, this would only result in a 6% increase. This implies that stationers are more sensitive to changes in selling space than other shoptypes, as far as the effect on demand is concerned. The effect of prices on the level of demand was negative but insignificant for supermarkets. For the other shoptypes the price elasticity, δ_2, equals the upperbound 0.500 we imposed, which is hard to understand. Various explanations exist for the positive sign of δ_2. For example, it is possible that this price elasticity acts as an indicator for all kinds of effects not taken into account, such as the assortment composition and quality.

Finally, we discuss the residuals of the equations of the model. Inspection of the residuals of the demand equation shows that for textile and furnishing shops the residuals all have a negative sign and for the other two shoptypes only a small percentage has a positive sign. For the estimated standard deviations it can be seen from Table 1 that supermarkets show the most clear result with all three standard deviations about 20%. For the other shoptypes the estimate of σ_d is always larger than the estimate of σ_s, which in turn is always larger than σ_f.

All above mentioned factors: the positive price elasticity, the negative residuals and the big difference between standard deviations, together with the lacking in straightforward elements from the marketing literature, like advertising, the assortment composition, service level, shopping centre and regional characteristics, suggest that the demand equation is in need of some patching up.

The most simple way to improve the specification of the demand equation (3.2) is to adjust the shift factor $\delta(X)$ to account for additional explanatory variables from marketing literature.

Hence, we try the following extended specification:

$$Q^d = \exp\{\delta_{01}as_1 + \delta_{02}as_2 + \delta_{03}as_3\}\ (1+M)^{1+\delta_2}\exp\{\delta_R . Rg + \delta_F . Fs\} \quad (3.3)$$

$$. A^{\upsilon_A} S^{\upsilon_S} (C - \gamma)^{\upsilon}$$

where as_i: fraction of sales of assortment group i (i = 1, 2, 3) in total sales, $\sum_i as_i = 1$;

Rg: dummy region, it is 1 for establishments in densely populated areas and 0 elsewhere;

Fs: dummy shopping centre: it is 1 for establishments in large shopping centres, 0 elsewhere;

A: expenditures on advertising;

S: service level, measured as the average weekly working hours per square metre floorspace.

However, the additional explanatory variables may not effect the level of demand separately, but indirectly through the level of selling area. This implies for example that the effect of advertising is greater for shops with a larger share of selling area in total floorspace. Apart from the assortment composition and the price effect all other explanatory variables are assumed to influence the floorspace elasticity of demand, leading to:

$$(3.4) \qquad Q^d = \exp\{\delta_{01}as_1 + \delta_{02}as_2 + \delta_{03}as_3\}\ (1+M)^{1+\delta_2}(C - \gamma)^{\upsilon^*}$$

$$\text{with } \upsilon^* = \upsilon_0 + \upsilon_A.A + \upsilon_S.S + \delta_R.Rg + \delta_F.Fs.$$

In equation (3.4) the selling area elasticity υ^*, which represents the effect of a relative change in $(C - \gamma)$ on demand, has become a function of advertising, service and environmental characteristics.

For all shoptypes we are able to define three separate assortment groups. The influence of each of these groups is measured by the fraction of sales with respect to each group in total sales. By definition the resulting fractions (as_i, $i = 1, 2, 3$) add up to one. Table 2 shows the respective contributions of these three groups for all four shoptypes.

The effects of region and shopping centre characteristics are expected to be positive: in densely populated areas or large shopping centres shops are confronted with more potential buyers, which stimulates demand. The advertising efforts should have a positive effect on demand. These efforts are measured by the expenditures on advertising. So, no distinction is made between all possible sorts of advertising such as radio and television commercials, the newspaper, door-to-door distribution of pamphlets, etc., because the relevant data are not available. A further refinement by taking into account these different types of advertising might yield a deeper insight in the effectiveness of each of them. The last factor we try to model is the level of service, measured as the average weekly working hours per square metre of total floorspace. Our assumption is that demand increases with the service level.

Table 2. The partitioning in assortment groups.

Supermarkets:	as_1	fresh products: meat and meatproducts, vegetables, bread, etc.
	as_2	non-foods
	as_3	other foods (except fresh products)
Stationers:	as_1	kernel assortment: paper-ware, writing and drawing-materials, machine supplies, etc.
	as_2	complementary assortment: typewriters, calculators, office furniture, etc.
	as_3	books, periodicals, newspapers, printing-works, copy service, etc.
Furnishing shops:	as_1	furniture
	as_2	floor-covering, carpets
	as_3	other furnishing like curtains
Textile shops:	as_1	men's wear
	as_2	women's wear
	as_3	children's wear

From a theoretical point of view we have no preference for either of the two specifications of the demand equation (3.3) or (3.4). We therefore make a decision on empirical grounds.

Estimation of the model with (3.3) as the demand equation led to several unexpected results. Firstly, in some cases the parameter values ended up at their lower- or upperbound, while the likelihood function remained finite, for example the scale parameter ε became 2.0 and the distribution parameter π, 0.010. Secondly, in other cases the likelihood turned to infinity. We tried several starting points but the estimating procedure did not converge to sensible results. We tried to improve the specification of the price effect by using an exponential instead of a constant elasticity type of demand function and by extracting the influence of the assortment composition from the price indicator we used. However, the likelihood function in this approach did still not converge.

Finally, we adopt the second specification of the model with (3.4) as the demand equation. This version did converge. The results are shown in Table 3.

Table 3. Estimating results for the extended model.

	Supermarkets	Stationer's shops	Furnishing shops
β_0	0.373 (0.308)	1.432 (0.466)	0.367 (0.302)
β_1	0.810 (0.064)	0.489 (0.089)	0.564 (0.061)
γ	0.000 (-)	0.000 (-)	0.000 (-)
ε	0.880 (0.029)	0.863 (0.048)	0.790 (0.032)
π.	0.564 (0.053)	0.488 (0.020)	0.649 (0.028)
δ_{01}	4.900 (0.306)	4.905 (0.682)	3.921 (0.371)
δ_{02}	4.024 (0.680)	5.373 (0.788)	3.884 (0.413)
δ_{03}	4.823 (0.200)	3.716 (0.461)	4.745 (0.521)
δ_2	-1.771 (0.885)	-0.205 (1.158)	-1.710 (0.652)
υ_0	0.413 (0.072)	-0.517 (0.275)	0.257 (0.070)
υ_A	0.019 (0.007)	0.261 (0.100)	0.025 (0.004)
υ_S	0.412 (0.072)	0.747 (0.259)	0.942 (0.269)
δ_R 1)	-	0.542 (0.307)	0.117 (0.038)
δ_F	0.062 (0.070)	0.308 (0.195)	0.009 (0.035)
α	5.643 (1.043)	5.757 (0.981)	4.454 (0.616)
L	-307.203	-257.071	-502.687
LRT 2)	30.494	31.338	16.626
Pr E.S.	0.534	0.328	0.298
σ_d	0.187	0.405	0.274
σ_s	0.231	0.374	0.308
σ_f	0.253	0.318	0.215

1) Information on the region was not available for supermarkets and superettes.
2) Likelihood Ratio Test.

Only in the case of textile shops this version of the model did not converge, for which we have no explanation. The most striking difference between the results from Table 1 and 3 is made up by the value of the probability of excess supply. For supermarkets and stationers this probability almost doubles, for furnishing shops the result is even seven times as high. Noting that the probability of excess supply hardly changes when assortment alone is taken into account, we deduce that a flexible representation of the demand elasticity with respect to selling area versus a constant elasticity of demand causes the probability of excess supply to rise.

From the point estimates of the supply side parameters it can be seen that, although the value of the scale parameter ε, increases slightly, the value of the distribution parameter, π, decreases substantially for all shoptypes. This implies that by neglecting potential explanatory variables the optimal level of selling area, considered as a fraction of total floorspace, tends to be overestimated. Instead, more intensive use is made of the remaining space. The efficiency parameter β_1, also increases slightly.

Inspecting the demand side parameters as defined by equation (3.4) the first noticeable change is the estimate of the price elasticity δ_2.

In the extended model it has the classic negative sign and differs significantly from zero for supermarkets and furnishing shops. From the estimates of δ_{0i} ($i = 1, 2, 3$) we find that demand is higher when the share of fresh products and other foods in total sales is higher than the share of non-food in the case of supermarkets, the share of kernel and complementary assortment is higher than that of books in the case of stationers and the share of furnishing textile, like curtains, is higher than that of furniture and floor-covering in the case of furnishing shops. The effect of advertising on the demand elasticity with respect to selling area is significantly positive for all shop types. This result is very interesting from the marketing point of view, it is well known that it is hard to find any significant effects from advertising on the level of sales on micro level, that is in the case of individual (retail) establishments. The effect of advertising is smallest for supermarkets, whereas stationers seem to benefit most from their advertising efforts. The level of service also plays a positive role in determining the effect of a relative change in selling space: furnishing

shops profit most from additional working hours. The effect of environmental factors could also be established: the effects of regional and shopping centre characteristics do have the expected positive sign. Being established in a large shopping centre or a densely populated area evokes demand indeed. Although the signs are correct the estimates are seldom significantly different from zero, only the effect of region was significant in the case of furnishing shops.
In view of the likelihood ratio test, which is chi-square distributed with as many degrees of freedom as there are additional parameters, the hypothesis that the newly introduced parameters are zero is rejected for all three shop types. The level of significance for this test was 1% in the case of supermarkets and stationers and 5% for furnishing shops.

4. Conclusions

In this last section we conclude with some striking findings of our study.
Firstly, the model of Kooiman et al. is very sensitive to outliers in the data. More or less satisfying results could only be achieved after leaving out these observations. We do not know whether our "outliers" are blatent measurements errors or that the model simply is not capable to explain their behaviour.
Secondly, the results are very sensitive to the specification of the demand function. While the model with (3.3) as demand equation did not lead to convergence of the likelihood function, the model with (3.4) as demand equation did converge and led to plausible results.
Thirdly, the introduction of additional explanatory variables in the demand equation leads to strongly increased probabilities of excess supply. This probability increases in the case of supermarkets and superettes from 20% to 53%, for stationers from 17% to 33% and for furnishing firms from 4% to 30%: maintaining a constant versus a flexible floorspace elasticity of demand results in strictly smaller probabilities of excess supply.
Fourthly, the values of two key parameters are particularly sensitive to the new specification of demand: the distribution parameter, π, and the price elasticity δ_2. Comparing their estimates in both tables, we see

that in the extended model the values of both π and δ_2 decreased compared to the original model. The price elasticity, δ_2, is consistently less than zero and significant for two shoptypes in the extended model, as is expected from economic theory. Whereas in the original model δ_2 is positive in three cases.

Fifthly, for stating implications of our excercises for consultancy we make use of the extended model. We choose the extended model because it yields economically plausible results. From Table 3 it is clear that supermarkets and superettes operate more efficiently than the other shoptypes in terms of sales per square metre (cf. β_1). None of the shoptypes is confronted with increasing returns to scale (cf. $\varepsilon < 1$). Stationers make more intensive use of their remaining space than the others: π is 0.488, which is even less than a half. The price elasticity for supermarkets and furnishing firms is higher (in absolute value) than that for stationer's shops. This may be caused by the type of products they sell. Stationers sell more luxury goods, while supermarkets sell products for daily use. The effect of advertising on the floorspace elasticity of demand is highest for stationer's and lowest for supermarkets. The impact on the floorspace elasticity of demand of service is highest for furnishing firms. If investigated the floorspace elasticity is higher if shops are situated in densely populated areas. The situation in large shopping centres has a positive, but not significant, effect on the floorspace elasticity of demand.

Sixthly, the structure of our model depends entirely on the role of selling space, C: the partitioning of floorspace is the only endogenous marketing mix variable and it is necessary for the solution of our model that C occurs in the demand equation.

Further research is needed to investigate these restrictions. It seems worthwhile to extend the model in such a way that other variables, like advertising or the level of service, can be introduced as endogenous variables.

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Appendix

To estimate the parameters of the model we made use of four samples from surveys conducted by the Research Institute of Small and Medium-Sized Business (EIM) in the Netherlands. The surveys were available for the following shoptypes: supermarkets and superettes (1979), stationer's shops (1980), furnishing firms (1981) and textile shops (1979).
In this section we present a summary of some characteristics of the variables we used.
In the tables, which are presented below, total floorspace, W, and selling area, C, are measured in 100 m^2; annual sales, Q, pursuing value, I, and expenditures on advertising, A, are measured in 10.000 Dutch guilders of the respective years. The variable H is measured as annual housing costs per square metre total floorspace and the level of services, S, as the average weekly working hours per square metre total floorspace.

Supermarkets and superettes (208 observations and 7 outliers)

	Mean	Minimum value	Maximum value
W	4.143	0.730	16.900
C	2.871	0.380	10.000
Q	218.751	47.504	749.588
I	174.684	37.727	595.767
H	172.682	48.396	319.361
A	2.826	0.029	10.829
S	0.900	0.324	1.899
1+M	1.247	1.151	1.338
as_1	0.399	0.050	0.630
as_2	0.084	0.010	0.200
as_3	0.517	0.320	0.810
Fs	0.077	0.000	1.000

Stationer's shops (138 observations and 4 outliers)

	Mean	Minimum value	Maximum value
W	3.407	0.520	16.180
C	1.843	0.250	9.000
Q	117.929	22.952	611.604
I	78.552	12.351	400.095
H	190.074	57.001	444.612
A	1.703	0.037	17.204
S	0.845	0.273	2.692
1+M	1.516	1.293	1.986
as_1	0.475	0.170	1.000
as_2	0.156	0.000	0.740
as_3	0.367	0.000	0.780
Fs	0.623	0.000	1.000
Rg	0.413	0.000	1.000

Furnishing shops (176 observations and 10 outliers)

	Mean	Minimum value	Maximum value
W	12.740	1.200	47.500
C	9.339	0.500	34.000
Q	121.483	18.939	420.074
I	73.889	10.119	277.262
H	100.137	22.406	256.242
A	4.173	0.112	26.565
S	0.251	0.034	0.808
1+M	1.661	1.389	2.165
as_1	0.481	0.000	1.000
as_2	0.228	0.000	1.000
as_3	0.291	0.000	1.000
Fs	0.511	0.000	1.000
Rg	0.392	0.000	1.000

Textile shops (189 observations and 11 outliers)

	Mean	Minimum value	Maximum value
W	3.714	0.650	20.400
C	2.720	0.500	13.600
Q	106.596	27.843	495.182
I	67.868	17.867	308.872
H	223.504	59.407	980.330
A	3.219	0.010	24.341
S	0.628	0.192	1.449
1+M	1.565	1.307	2.061
as_1	0.431	0.000	1.000
as_2	0.499	0.000	1.000
as_3	0.069	0.000	0.490
Fs	0.772	0.000	1.000

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